

PLASTIC PROCESSING OPERATOR

NSQF LEVEL - 3

TRADE THEORY

SECTOR: CHEMICALS AND PETROCHEMICALS

(As per revised syllabus July 2022 - 1200Hrs)



Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA



**NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI**

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : Chemicals and Petrochemicals

Duration : 1 Year

Trade : Plastic Processing Operator - Trade Theory - NSQF Level - 3 (Revised 2022)

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Plastic Processing Operator Trade Theory NSQF Level - 3 (Revised 2022) in Chemicals and Petrochemicals Sector**. The NSQF Level - 3 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, I.A.S.,

Secretary

Ministry of Skill Development & Entrepreneurship,
Government of India.

September 2024

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labor and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVET/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032

EXECUTIVE DIRECTOR

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organizations to bring out this Instructional Material (**Trade Theory**) for the trade of **Plastic Processing Operator NSQF Level - 3 (Revised 2022)** under **Chemicals and Petrochemicals** Sector for ITIs.

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NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted service's in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Plastic Processing Operator** Trade supplemented and supported by instructions/ information's to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level- 3 (Revised 2022) syllabus are covered. This manual is divided into Seventeen modules.

Module 1	Safety and workshop Practice
Module 2	Drilling, Tapping and Dieing
Module 3	Basic Electrical
Module 4	Identification of Plastics & Testing
Module 5	Injection Moulding Process
Module 6	Microprocessor Control and PLC Injection Moulding Process
Module 7	Compression Moulding Process
Module 8	Processing of Fiber Reinforced Plastic (FRP)
Module 9	Blow Moulding Process
Module 10	Pneumatic System
Module 11	Extrusion Blow Film Process
Module 12	Extrusion Pipe Process
Module 13	Extrusion Reprocessing
Module 14	Thermoforming Process
Module 15	Roto Moulding Process
Module 16	Pre-drying Process
Module 17	Machining Operation on Plastic Sheet and Block

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However, the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the course of the **Plastic Processing Operator** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptual capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self-learning and should be considered as supplementary to class room instruction.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	Check and perform measuring, marking, Hack sawing, filling by using various measuring, marking, cutting and finishing tools following safety precautions. RSC/N4801,CPC/N0113	1.1.01 - 1.1.13
2	Check and perform drilling, tapping, dyeing by using different related tools. RSC/N4801,CPC/N0113	1.2.14 - 1.2.27
3	Test and perform basic electrical earthlings with the accessories fittings on board. RSC/N4801,CPC/N0113	1.3.28 - 1.3.34
4	Identify different plastic materials and test the properties of material by using various test apparatus. RSC/N4801,RSC/N4802, CPC/N0114	1.4.35 - 1.4.46
5	Identify, set and produce good quality of injection moulding items and check the defects. RSC/N4801,CPC/N0109	1.5.47 - 1.5.61
6	Identify, set, maintain and produce good quality of injection moulding items by using automatic injection moulding machine with the application of Microprocessor control and PLC. RSC/N4801,RSC/N4807, CPC/N0115	1.6.62 - 1.6.81
7	Produce good quality of compression moulded items and check the defects by using compression moulding machine. RSC/N4801, RSC/N4807, CPC/N0115	1.7.82 - 1.7.93
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11	Identify different parts, set and operate the blown film plant. RSC/N4801,RSC/N4808, CPC/N0115	1.11.112 - 1.11.130
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13	Operate the reprocessing plant and produce reprocessed granules. RSC/N4801,RSC/N4808, CPC/N0115	1.13.137 - 1.13.146
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15	Produce good quality of rotomoulding product and check the defects. RSC/N4801,RSC/N4808, CPC/N0116	1.15.159 - 1.15.166
16	Identify and Perform predrying process using different materials. RSC/N4801,RSC/N4808, CPC/N0116	1.16.167 - 1.16.171
17	Carry out different machining operations on plastic sheets/blocks. RSC/N4801,RSC/N4808, CPC/N0116	1.17.172 - 1.17.175

Craftsmen Training Scheme (CTS)

Objective: At the end of this lesson you shall be able to

- explain the departmental training schemes (CTS /ATS).

Craftsmen Training Scheme (CTS)

The Craftsmen Training Scheme (CTS) was introduced by the Government of India in year 1950 to ensure a steady flow of skilled workers in different trades for the domestic industry, to raise quantitatively and qualitatively the industrial production by systematic training, to reduce unemployment among the educated youth by providing them employable skills, to cultivate and nurture a technical and industrial attitude in the minds of younger generation. The Scheme is the most important in the field of Vocational Training, has been shaping craftsmen to meet the existing as well as future manpower need, through the vast network of ITIs spread over various States/Union Territories in the country. The day-to- day administration of ITIs under the Craftsmen Training Scheme was transferred to the State Governments/ Union Territory administrations with effect from the year 1956. From 1st April 1969, the financial control of the Industrial Training Institutes in the States as well as in the Union Territories was transferred to the respective State Governments / Union Territory. The financial assistance was granted to them in the form of bulk grant in consultation with the erstwhile Planning Commission and the Ministry of Finance.

Vocational Training is a concurrent subject of both Central and State Governments. The development of training schemes at National level, the evolution of policy, laying of training standard, norms, conducting of examinations, certification, , etc. are the responsibilities

of the central government, whereas, day to day administration including an admission in ITIs rests with the respective State Governments/UTs.

Presently, training courses under the Craftsmen Training Scheme are being offered through a network of 14955 ITIs (Govt. 3248 + Private 11707) located all over the country with total trainees enrolled 26.58 lakhs (in the trades of 1 year and 2 year durations) on NCVT MIS portal with an objective to provide skilled workforce to the industry in 150 NSQF compliant trades.

Apprenticeship Training Scheme

In India, the system of formal Apprenticeship was introduced in the Apprentices Act 1961, which requires employers in notified Industry to engage apprentices in specified ratios in relation to the workforce. The programme of training of Apprentices is regulated in the Industries so as to conform to the prescribed syllabi / approved programme, period of training etc. as laid down by the Central Apprenticeship Council.

ITI passed trainees (National Trade Certificate holder) by registering their name in Government Related Instruction Centre's (RIC) and by attending campus interview get apprenticeship training in private sectors. In public sector establishment apprentice trainees are selected through Employment Exchanges. In the year 2014 - 2015, 9563 trainees underwent apprenticeship training and 5484 trainees appeared in the All India Trade Test for Apprentices.

Importants of trade trainings

Objective: At the end of this lesson you shall be able to

- **list the importance of trade training.**

Importance of Trade training

The role of a plastic processing operator is crucial in the manufacturing industry, especially in the field of plastics. The plastic processing operator trade involves the operation and maintenance of machinery used in the production of plastic products. Here are some key points highlighting the importance of this trade:

Skill in Operating Machinery

Plastic processing operators are skilled in operating various types of machinery used in the production of plastic goods. This includes injection molding machines, extruders, blow molding machines, and more. Their expertise ensures efficient and accurate production processes.

Quality Control

These operators play a vital role in maintaining product quality. They are responsible for setting up and adjusting machines to produce products that meet specific quality standards. This includes monitoring factors such as temperature, pressure, and cycle times to ensure consistency.

Efficiency and Productivity

Plastic processing operators contribute to the efficiency and productivity of the manufacturing process. Their knowledge of machine settings and process optimization helps in maximizing output while minimizing waste.

Troubleshooting and Maintenance

When issues arise during the production process, plastic processing operators are trained to troubleshoot and resolve problems quickly. They also play a role in the routine maintenance of machinery, helping to prevent breakdowns and ensuring the longevity of equipment.

Adherence to Safety Protocols

Safety is a paramount concern in any manufacturing setting. Plastic processing operators are trained to follow safety protocols to prevent accidents and ensure a secure working environment. This includes proper handling of materials, machinery, and adherence to safety guidelines.

Adaptability

The plastic processing industry is dynamic, with new materials and technologies continually emerging. Plastic processing operators need to stay updated on industry trends and be adaptable to changes in processes and machinery.

Contribution to Innovation

As technology evolves, plastic processing operators may contribute to the implementation of new manufacturing techniques and technologies. Their knowledge and experience can be valuable in adopting innovations that enhance the efficiency and sustainability of plastic production.

Importants of safety and rules

Objectives: At the end of this lesson you shall be able to

- explain the necessity of adopting the safety rules
- list the safety rules to be followed by the PPO
- explain how to treat a person for electric shock/injury.

Necessity of safety rules: Safety consciousness is one of the essential attitudes required for any job. A skilled electrician always should strive to form safe working habits. Safe working habits always save men, money and material. Unsafe working habits always end up in loss of production and profits, personal injury and even death. The safety hints given below should be followed by Electrician to avoid accidents and electrical shocks as his job involves a lot of occupational hazards.

The listed safety rules should be learnt, remembered and practiced by every electrician. Here a electrician should remember the famous proverb, “**Electricity is a good servant but a bad master**”.

Safety rules

- Only qualified persons should do electrical work.
- Do not work on live circuits;
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- When soldering, place the hot soldering irons in their stand.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs, switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI). Necessity of using BIS(ISI) marked accessories is explained under standardization.
- Stand on rubber mats while working/operating switch panels, control gears etc.
- Position the ladder, on firm ground.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display ‘Men on line’ board on the switchboard.
- Do not connect ear thing to the water pipe lines.

- Discharge static voltage in HV lines/equipment and capacitors before working on them.

Safety practice - first aid

Electric shock

We are aware that the prime reasons for severity of shock are the magnitude of current and duration of contact. In addition, the other factors contribute to the severity of shock are:

- age of person
- body resistance
- not wearing insulating footwear or wearing wet footwear
- Weather condition
- Wet or dry floor
- Mains voltage etc.

If assistance is close at hand, send for medical aid, then carry on with emergency treatment.

If you are alone, proceed with the treatment immediately.

Make sure the victim is not in contact with the supply.

Effects of electric shock

The effect of current at very low levels may only be an unpleasant tingling sensation, but this itself may be sufficient to cause some persons to lose their balance and fall.

At higher levels of current the person receiving a shock may be thrown off his feet and will experience severe pain and possibly minor burns at the point of contact.

At an excessive shock can also cause burning of the skin at the point of contact.

Treatment of electric shock

Prompt treatment is essential.

Check for the victim's natural breathing and consciousness. Take steps to apply respiratory resuscitation if the victim is unconscious and not breathing.

In the case of burns/injury in the back, follow Nelson's method

In case the mouth is closed tightly, use Schafer's or Holgen-Nelson method.

Treatment for electrical burns

A person receiving an electric shock may also sustain burns when the current passes through the body.

Do not waste time by rendering first aid to the victim until breathing has been restored and the patient can breathe normally unaided.

Burns are very painful. If a large area of the body is burnt, do not give treatment, except to exclude the air, eg. by covering with clean paper or a clean cloth, soaked in clean water. this relieves the pain.

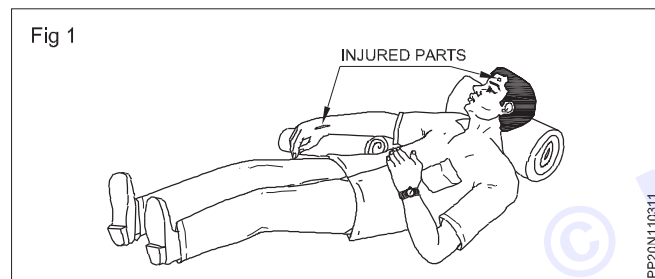
Severe bleeding

Any wound which is bleeding profusely, especially in the wrist, hand or fingers must be considered serious and must receive professional attention.

Immediate action

Always in cases of severe bleeding

- make the patient to lie down and rest
- if possible, raise the injured part above the level of the body (Fig 1)



- apply pressure to the wound

Safety practice - Safety signs

Objectives: At the end of this lesson you shall be able to

- state the responsibilities of employer and employees
- state the safety attitude and list the four basic categories of safety signs.

Responsibilities

Safety doesn't just happen - it has to be organized and achieved like the work-process of which it forms a part. The law states that both an employer and his employees have a responsibility in this behalf.

Employer's responsibilities

The effort a firm puts into planning and organizing work, training people, engaging skilled and competent workers, maintaining plant and equipment, and checking, inspecting and keeping records - all of this contributes to the safety in the workplace.

The employer will be responsible for the equipment provided, the working conditions, what the employees are asked to do, and the training given.

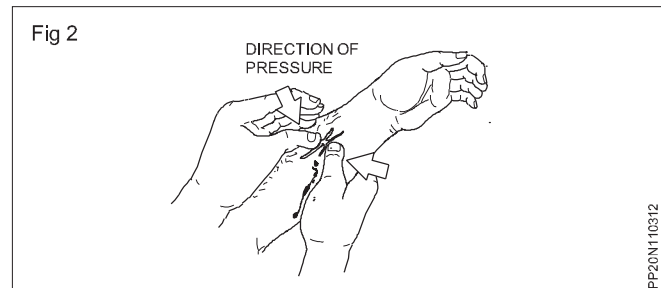
Employee's responsibilities

You will be responsible for the way you use the equipment, how you do your job, the use you make of your training, and your general attitude to safety.

- call for medical assistance

To control severe bleeding

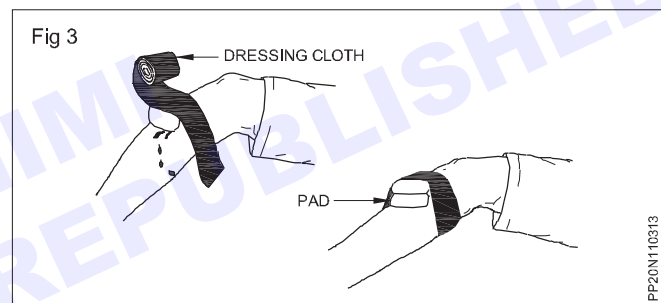
Squeeze together the sides of the wound. Apply pressure as long as it is necessary to stop the bleeding. When the bleeding has stopped, put a dressing over the wound and cover it with a pad of soft material. (Fig 2)



For an abdominal wound which may be caused by falling on a sharp tool, keep the patient bending over the wound to stop internal bleeding.

Large wound

Apply a clean pad and bandage firmly in place. If bleeding is very severe apply more than one dressing. (Fig 3)



A great deal is done by employers and other people to make your working life safer; but always remember you are responsible for your own actions and the effect they have on others. You must not take that responsibility lightly.

Rules and procedure at work

What you must do, by law, is often included in the various rules and procedures laid down by your employer. They may be written down, but more often than not, are just the way a firm does things - you will learn these from other workers as you do your job.

They may govern the issue and use of tools, protective clothing and equipment, reporting procedures, emergency drills, access to restricted areas, and many other matters. Such rules are essential; they contribute to the efficiency and safety of the job.

Safety signs

As you go about your work on a construction site you will see a variety of signs and notices. Some of these

will be familiar to you - a 'no smoking' sign for example; others you may not have seen before. It is up to you to learn what they mean - and to take notice of them. They warn of the possible danger, and must not be ignored. Safety signs fall into four separate categories. These can be recognized by their shape and color. Sometimes they may be just a symbol; other signs may include letters or figures and provide extra information such as the clearance height of an obstacle or the safe working load of a crane.

The four basic categories of signs are as follows:

- Prohibition signs (Fig 1 & Fig 5)
- Mandatory signs (Fig 2 & Fig 6)
- Warning signs (Fig 3 & Fig 7)
- Information signs (Fig 4)

Prohibition signs

Fig 1 	SHAPE	Circular
	COLOUR	Red border and cross bar. Black symbol on white background
	MEANING	Shows it must not be done.
	Example	No smoking

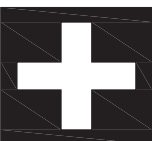
Mandatory signs

Fig 2 	SHAPE	Circular
	COLOUR	White symbol on blue background
	MEANING	Shows what must be done.
	Example	Wear hand protection

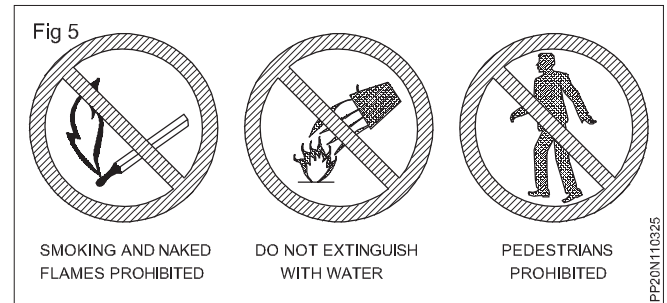
Warning signs

Fig 3 	SHAPE	Triangular
	COLOUR	Yellow back round with black border and symbol
	MEANING	Warns of hazards or danger
	Example	Caution risk of electric shock

Information signs

Fig 4 	SHAPE	Square or oblong
	COLOUR	Red and white
	MEANING	Indicates or gives information of safety provision.
	Example	First aid point

Prohibition signs



Mandatory signs



Warning signs



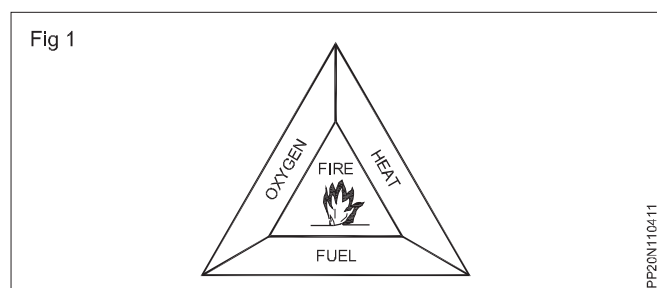
Classes of fire extinguishers

Objectives: At the end of this lesson you shall be able to

- state the effects of a fire break out and causes of fire in a workshop
- distinguish the different types of fire extinguishers
- state the classification of fires and basic ways for extinguishing the fire
- determine the correct type of fire extinguisher to be used based on the class of fire
- describe the general procedure to be adopted in the event of fire
- state the method of operation of fire extinguisher and extinguishing of fire.

Fire: Is it possible to prevent fire? Yes, fire can be prevented by eliminating anyone of the three factors that causes fire.

The following are the three factors that must be present in combination for a fire to continue to burn. (Fig 1)



Fuel: Any substance, liquid, solid or gas will burn, if there is oxygen and high enough temperatures.

Heat: Every fuel will begin to burn at a certain temperature. It varies and depends on the fuel. Solids and liquids give off vapor when heated, and it is this vapor which ignites.

Oxygen: Usually exists in sufficient quantity in air to keep a fire burning.

Extinguishing of fire: Isolating or removing any of these factors from the combination will extinguish the fire. There are three basic ways of achieving this.

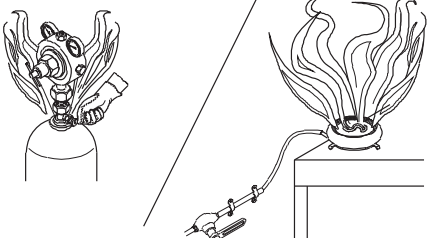
- **Starving** the fire of fuel removes this element.
- **Smothering** - ie. isolate the fire from the supply of oxygen by blanketing it with foam, sand etc.
- **Cooling** - use water to lower the temperature.

Removing any one of these factors will extinguish the fire.

Classification of fires: Fires are classified into four types in terms of the nature of fuel.

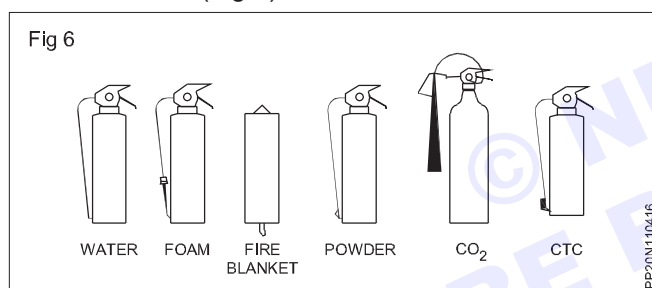
Different types of fires (Fig 2, Fig 3 Fig 4 & Fig 5) have to be dealt with in different ways and with different extinguishing agents.

Fire Classification and Fuel	Extinguishing Method
Fig 2 WOOD CLOTH PAPER	Most effective ie., cooling with water. Jets of water should be sprayed on the base of the fire and then gradually upwards.
Fig 3	Should be smothered :- The aim is to cover the entire surface of the burning liquid. This has the effect of cutting off the supply of oxygen to the fire Water should never be used on burning liquid. Foam, dry powder or CO₂ may be used on this type of fire.

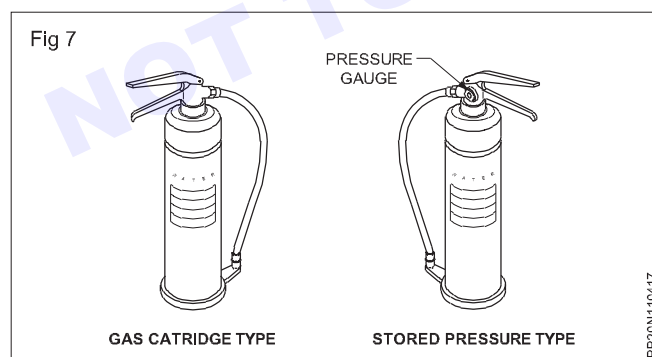
Fig 4 	Extreme caution is necessary in dealing with liquefied gases. There is a risk of explosion and sudden out-break of fire in the entire vicinity. If an appliance fed from a cylinder catches fire - shut off the supply of gas. The safest course is to raise an alarm and leave the fire to be dealt with by trained personnel. Dry powder extinguishers are used on this type of fire.
Fig 5 	Special powders have now been developed which are capable of controlling and/or extinguishing this type of fire. The standard range of fire extinguishing agents is inadequate or dangerous when dealing with metal fires. Fire on electrical equipment. Halon, Carbon dioxide, dry powder and vaporizing liquid (CTC) extinguishers can be used to deal with fires in electrical equipment. Foam or liquid (eg. water) extinguishers must not be used on electrical equipment under any circumstances.

Types of Fire Extinguisher

Many types of fire extinguishers are available with different extinguishing 'agents' to deal with different classes of fires. (Fig 6)



Water-filled extinguishers: There are two methods of operation. (Fig 7)



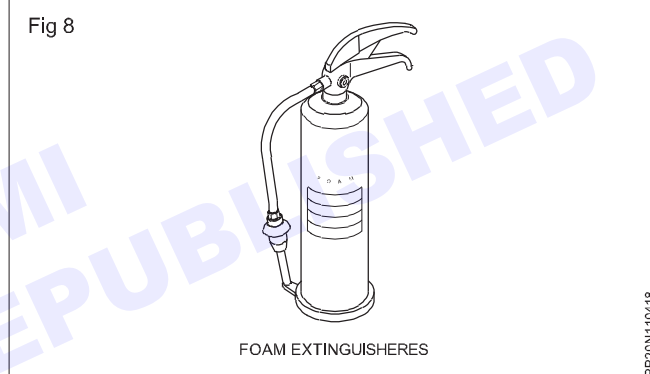
- Gas cartridge type
- Stored pressure type

With both methods of operation the discharge can be interrupted as required, conserving the contents and preventing unnecessary water damage.

Foam extinguishers (Fig 8): These may be of stored pressure or gas cartridge types.

Most suitable for

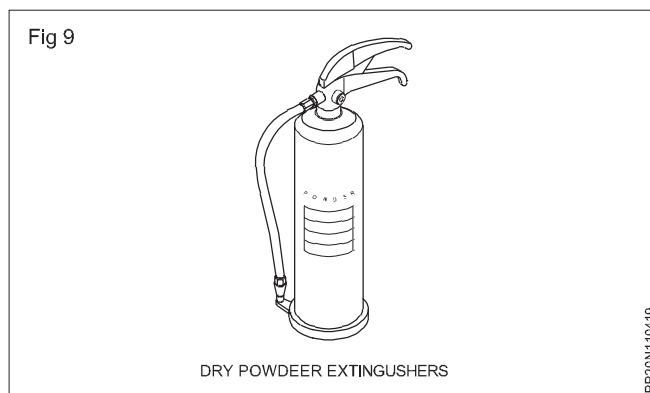
- Flammable liquid fires



- Running liquid fires

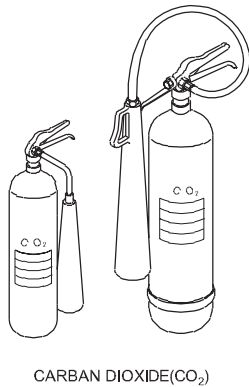
Must not be used on fires where electrical equipment is involved.

Dry powder extinguishers (Fig 9): Extinguishers fitted with dry powder may be of the gas cartridge or stored pressure type. Appearance and method of operation is the same as that of the water-filled one. The main distinguishing feature is the fork shaped nozzle. Powders have been developed to deal with class D fires.



Carbon dioxide (CO₂): This type is easily distinguished by the distinctively shaped discharge horn. (Fig 10)

Fig 10

CARBAN DIOXIDE(CO₂)

PP20N110/1A

Suitable for Class B fires. Best suited where contamination by deposits must be avoided. Not generally effective in open air.

Always check the operating instructions on the container before use. Available with different gadgets of operation such as - plunger, lever, trigger etc.

The general procedure in the event of a fire:

- Raise an alarm.
- Turn off all machinery and power (gas and electricity).
- Close the doors and windows, but do not lock or bolt them. This will limit the oxygen fed to the fire and prevent its spreading.
- Try to deal with the fire if you can do so safely. Do not risk getting trapped.
- Anybody not involved in fighting the fire should leave calmly using the emergency exits and go to the designated assembly point.
- Analyze and identify the type of fire. Refer Table1.

Table1

Class 'A'	Wood, paper, cloth, solid material
Class 'B'	Oil based fire (grease, gasoline, oil) liquefiable-gases
Class 'C'	Gas and liquefiable gases
Class 'D'	Metals and electrical equipment

Fire extinguishers are manufactured for use from the distance.

Caution

- While putting off fire, the fire may flare up
- Do not be panick belong as it put off promptly.
- If the fire doesn't respond well after you have used up the fire extinguisher move away yourself away from the fire point.
- Do not attempt to put out a fire where it is emitting toxic smoke leave it for the professionals.
- Remember that your life is more important than property. So don't place yourself or others at risk.

In order to remember the simple operation of the extinguisher. Remember P.A.S.S. This will help you to use the fire extinguisher.

P for Pull

A for Aim

S for Squeeze

S for Sweep

Introduction to occupational safety and health

Objectives: At the end of this lesson you shall be able to

- **define safety**
- **state the goal of occupational health and safety**
- **explain need of occupational health and safety**
- **state the occupational hygiene**
- **explain occupational hazards**
- **brief the occupational disease.**

Safety

Safety means freedom or protection from harm, danger, hazard, risk, accident, injury or damage.

Occupational health and safety

- Occupational health and safety is concerned with protecting the safety, health and welfare of people engaged in work or employment.
- The goal is to provide a safe work environment and to prevent hazards.
- It may also protect co-workers, family members, employers, customers, suppliers, nearby communities, and other members of the public who are affected by the workplace environment.
- It involves interactions among many related areas, including occupational medicine, occupational (or industrial) hygiene, public health, and safety engineering, chemistry, and health physics.

Need of occupational health and safety

- Health and safety of the employees is an important aspect of a company's smooth and successful functioning.
- It is a decisive factor in organizational effectiveness. It ensures an accident-free industrial environment
- Proper attention to the safety and welfare of the employees can yield valuable returns.
- Improving employee morale
- Reducing absenteeism
- Enhancing productivity
- Minimizing potential of work-related injuries and illnesses
- Increasing the quality of manufactured products and/ rendered services.

Occupational (Industrial) hygiene

- Occupational hygiene is anticipation, recognition, evaluation and control of work place hazards (or) environmental factors (or) stresses
- This is arising in (or) from the workplace.

- Which may cause sickness, impaired health and well being (or) significant discomfort and inefficiency among workers.

Anticipation (Identification): Methods of identification of possible hazards and their effects on health.

Recognition (Acceptance): Acceptance of ill-effects of the identified hazards

Evaluation (Measurement & Assessment): Measuring or calculating the hazard by Instruments, Air sampling and Analysis, comparison with standards and taking judgement whether measured or calculated hazard is more or less than the permissible standard.

Control of workplace hazards: Measures like Engineering and Administrative controls, medical examination use of Personal Protective Equipment (PPE) education, training and supervision.

Occupational hazards

"Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these"

Types of occupational health hazards

- Physical Hazards
- Chemical Hazards
- Biological Hazards
- Physiological Hazards
- Psychological Hazards
- Mechanical Hazards
- Electrical Hazards
- Ergonomic Hazards

1 Physical hazards

- Noise
- Heat and cold stress
- Vibration
- Radiation ((ionizing & Non-(ionizing)
- Illumination etc.,

2 Chemical hazards

- Inflammable
- Explosive
- Toxic
- Corrosive
- Radioactive

3 Biological hazards

- Bacteria
- Virus
- Fungi
- Plant pest
- Infection

4 Physiological

- Old age
- Sex
- Ill health
- Sickness
- Fatigue.

5 Psychological

- Wrong attitude
- Smoking
- Alcoholism
- Unskilled
- Poor discipline
- absentism
- disobedience

- aggressive behavior
- Accident proneness etc,
- Emotional disturbances
- violence
- bullying
- sexual harassment

6 Mechanical

- Unguarded machinery
- No fencing
- No safety device
- No control device etc.,

7 Electrical

- No ear thing
- Short circuit
- Current leakage
- Open wire
- No fuse or cut off device etc,

8 Ergonomic

- Poor manual handling technique
- Wrong layout of machinery
- Wrong design
- Poor housekeeping
- Awkward position
- Wrong tools etc,

Safety Slogan

A safety rule breaker, is an accident maker

Linear measuring tools (Steel rule)

Objectives: At the end of this lesson you shall be able to

- name the base unit of linear measurement as per the International System of units of measurement (SI)
- state the multiples of a metre and their values
- state the purpose of steel rule
- name the types of steel rule
- state the precautions to be followed while using a steel rule.

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is METRE.

Length - SI UNITS and MULTIPLES

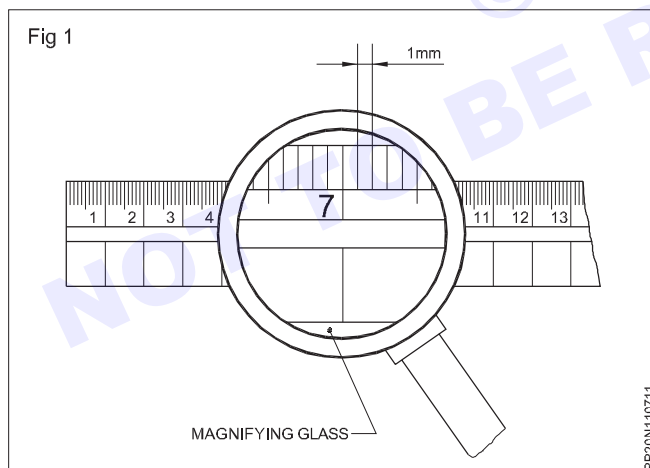
Base unit

The base unit of length as per the Systems International is metre. The table given below lists some multiples of a meter.

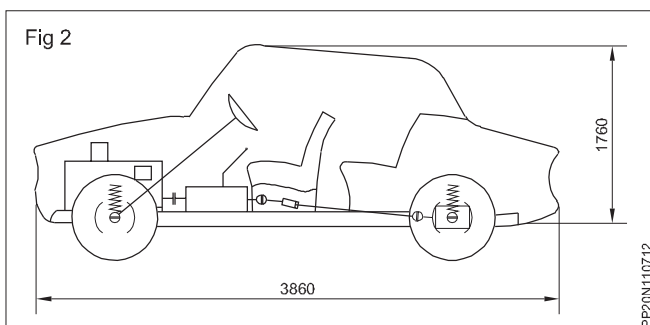
METRE(m)	
= 1000 mm	
CENTIMETRE (cm)	= 10 mm
MILLIMETRE (mm)	= 1000 μ
MICROMETRE (μ m)	= 0.001 mm

Measurement in engineering practice

Usually, in engineering practice, the preferred unit of length measurement is millimeter. (Fig 1)



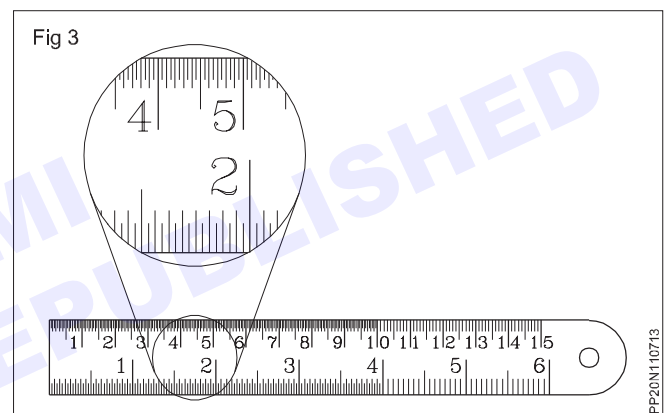
Both large and small dimensions are stated in millimeters. (Fig 2)



The British system of length measurement

An alternative system of length measurement is the British system. In this system, the base unit is the Imperial Standard Yard. Most countries, including Great Britain itself, have however in the last few years, switched over to SI units.

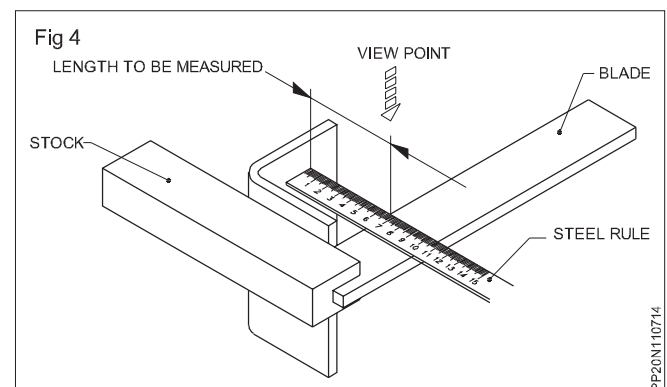
Engineer's steel rule (Fig 3) are used to measure the dimensions of work pieces.



Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is

0.5 mm and 1/64 inch.

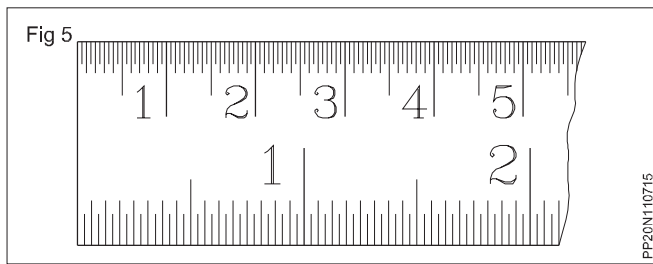
For accurate reading it is necessary to read vertically to avoid errors arising out of parallax. (Fig 4)



Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)

Other types of rule

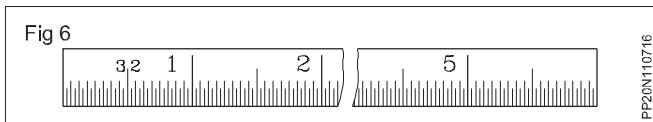
- narrow steel rules



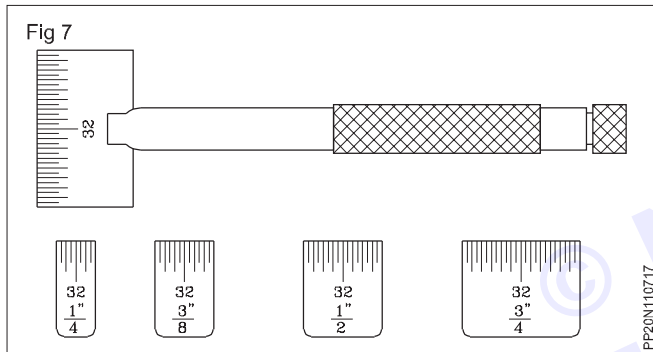
- short steel rules
- full flexible steel rule with tapered end.

Narrow steel rule

Narrow steel rule is used to measure the depth of key-ways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)



Short steel rule (Fig 7)

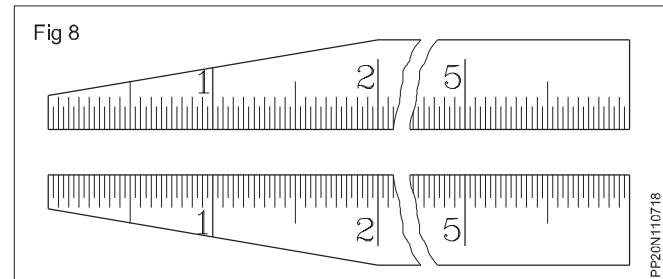


This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.

The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8", 1/2", 3/4" and 1" and each rule is graduated in 32nds on one side and 64ths on the reverse side.

Steel rule with tapered end

This rule is a favorite with all mechanics since its tapered end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)



For maintaining the accuracy of a steel rule, it is important to see that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

Angular measurement

Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

Measurements of fundamental, derived units

Measurement of length

Metric			British	
Micron	1 μ	= 0.001 mm	Thousandth of an inch	= 0.001"
Millimeter	1 mm	= 1000 μ	Inch	= 1"
Centimetre	1 cm	= 10 mm	Foot 1 ft	= 12"
Decimeter	1 dm	= 10 cm	Yard 1 yd	= 3 ft 1 furlong
Meter	1 m	= 10 dm	1 fur	= 220 yds
Decametre 1 dam		= 10 metre	1 mile	= 8 fur

Hand tools

Objectives: At the end of this lesson you shall be able to

- list the tools necessary for an PPO
- specify the tools and state the use of each tool
- explain the care and maintenance of PPO hand tools.

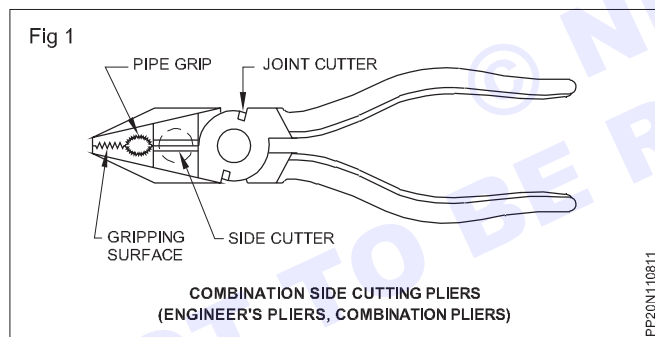
It is important that the electrician uses proper tools for his work. The accuracy of workmanship and speed of work depend upon the use of correct tools. If the tools are properly used, and maintained, the electrician will find the working efficiency increases and the skills becomes a work habit.

Their specifications and BIS number are given for your reference. Proper method of care and maintenance will result in prolonged tool life and improved working efficiency.

Pliers

They are specified with their overall dimensions of length in mm. The pliers used for electrical work will be of insulated grip.

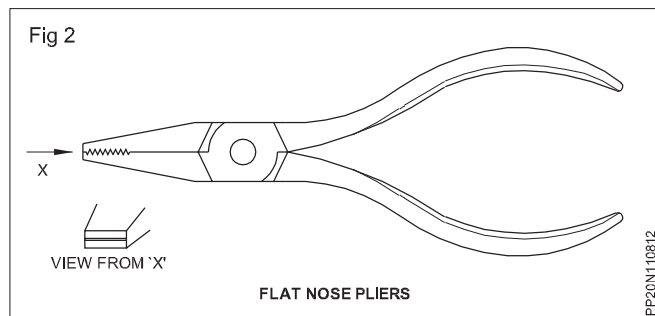
1 Combination pliers with pipe grip, side cutter and insulated handle. BIS 3650 (Fig 1)



Size 150 mm, 200 mm etc.

It is made of forged steel. It is used for cutting, twisting, pulling, holding and gripping small jobs in wiring assembly and repairing work. A non-insulated type is also available. Insulated pliers are used for work on live lines.

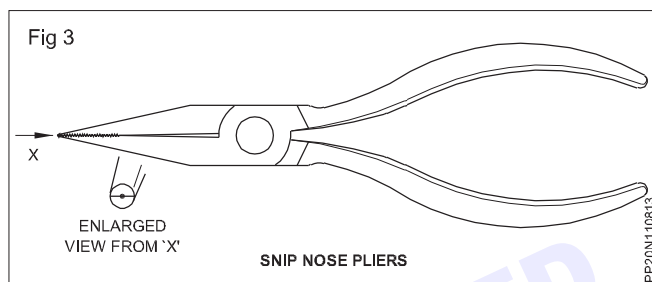
2 Flat nose pliers BIS 3552 (Fig 2)



Size 100 mm, 150 mm, 200 mm etc.

Flat nose pliers are used for holding flat objects like thin plates etc.

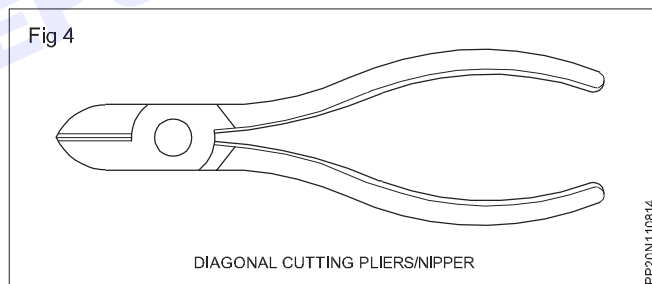
3 Long nose pliers or (snip nose pliers) with side cutter.BIS 5658 (Fig 3)



Size 100 mm, 150 mm etc.

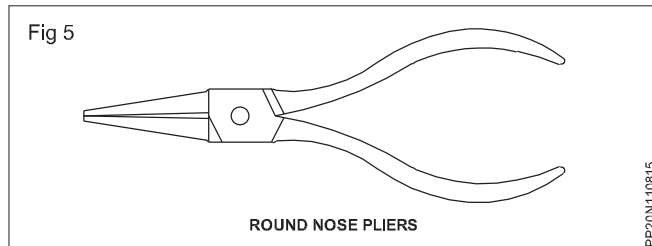
Long nose pliers are used for holding small objects in places where fingers cannot reach.

4 Side cutting pliers (Diagonal cutting pliers) BIS 4378 (Fig 4) Size 100 mm, 150 mm etc.



It is used for cutting copper and aluminum wires of smaller diameter (less than 4mm dia).

5 Round nose pliers BIS 3568 (Fig 5)



Size 100 mm, 150 mm etc.

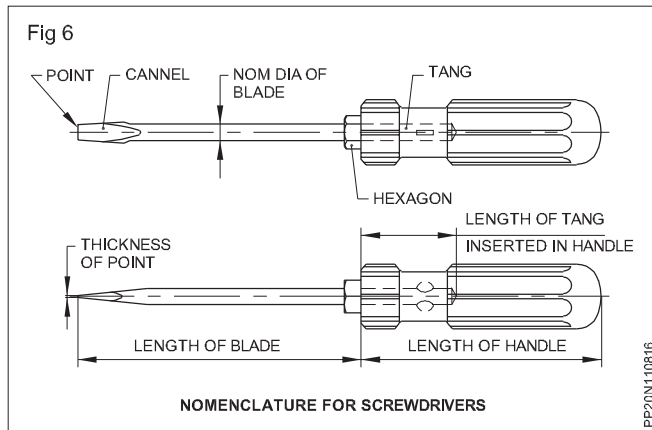
Wire hooks and loops could be made using the round nose pliers.

Care and maintenance of pliers

- Do not use pliers as hammers.
- Do not use pliers to cut large sized copper or aluminum wires and hard steel wires of any size.

- While using the pliers avoid damages to the insulation of hand grips.
- Lubricate hinged portions.

6 Screwdriver BIS 844 (Fig 6)



The screwdrivers used for electrical works generally have plastic handles and the stem is covered with insulating sleeves. The size of the screw driver is specified by its blade length in mm and nominal screwdriver's point size (thickness of tip of blade) and by the diameter of the stem.

eg. 75 mm x 0.4 mm x 2.5 mm
150 mm x 0.6 mm x 4 mm
200 mm x 0.8 mm x 5.5 mm etc.

The handle of screwdrivers is either made of wood or cellulose acetate.

Screwdrivers are used for tightening or loosening screws. The screwdriver tip should correctly fit the grooves of the screw to have maximum efficiency and to avoid damage to the screw heads.

As the length of the screw driver is proportional to the turning force, for small work choose a suitable small sized screwdriver and vice versa.

Star-head Screwdriver

It is used for driving star headed screws.

Care and maintenance

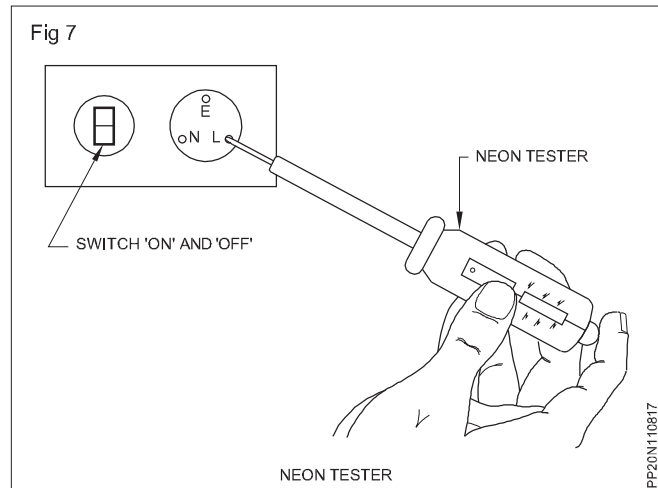
- Never use a screwdriver as a lever to apply force as this action will make the stem to bend and the use of the screw driver will be lost.
- Keep the tip in correct shape and in rare cases it could be grinded to shape.

7 Neon tester BIS 5579 - 1985 (Fig 7)

It is specified with its working voltage range 100 to 250 volts but rated to 500 V.

It consists of a glass tube filled with neon gas, and electrodes at the ends. To limit the current within 300 micro-amperes at the maximum voltage, a high value resistance is connected in series with one of the electrodes. It may have a tip like a probe or screwdriver at one end. The presence of supply is indicated by the

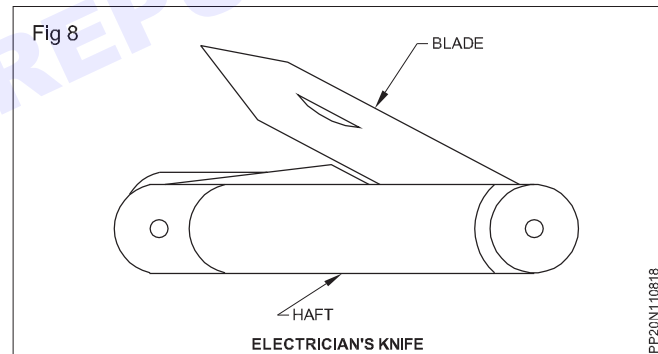
glow of the lamp when the tip is touched on the live supply and the brass contact in the other end of neon tester is touched by hand.



Care and maintenance

- Never use the neon tester for voltage higher than the specified range.
- While testing see the circuit is completed through the body. In case if you are using rubber soled shoes, the earthing of the body could be provided by touching the wall by one hand.
- Use the screwdriver tipped neon tester for light duty work only.

8 Electrician's knife (Double blade) (Fig 8)



The size of the knife is specified by its largest blade length eg. 50 mm, 75 mm.

It is used for skinning the insulation of cables and cleaning the wire surface. One of the blades which is sharp is used for skinning the cable and the rough edged blade is used for cleaning the surface of the wires.

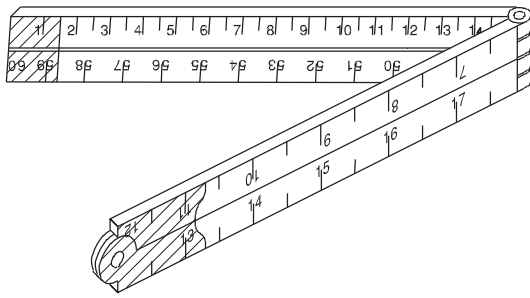
Care and maintenance

- Do not use the knife for cutting wires.
- Keep it free from rust.
- Keep one of the blades in a sharp condition.
- Fold the knife blade when not in use.

9 Four-fold box wood rule 600mm (Fig 9)

Used for measuring short lengths. To be kept in folded condition when not in use.

Fig 9

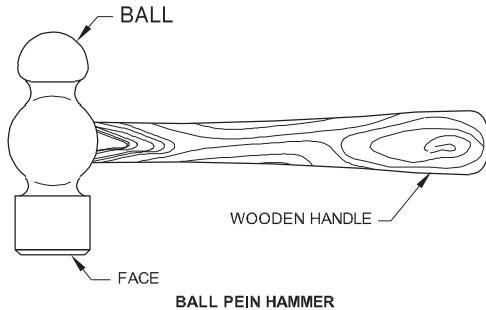


FOUR-FOLD BOX WOOD RULE

PP20N110819

10 Hammer ball pein (Fig 10)

Fig 10



BALL PEIN HAMMER

PP20N11081A

The size of the hammer is expressed in weight of the metal head. Eg. 125 gms, 250 gms etc.

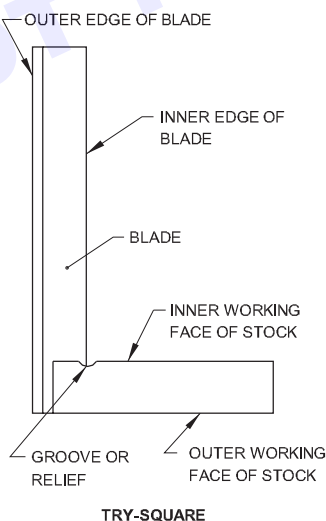
The hammer is made out of special steel and the striking face is tempered. Used for nailing, straightening, and bending work. The handle is made of hard wood.

Care and maintenance

- Do not use a hammer with a loose handle.
- The face of the hammer must be free from oil, grease and mushrooms.

11 Try-square (Engineer's square) (Fig 11) BIS 2103

Fig 11



TRY-SQUARE

PP20N11081B

This is specified by its blade length.

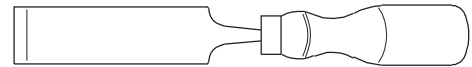
Eg. 50 mm x 35 mm
100 mm x 70 mm
150 mm x 100 mm etc.

There are two types; one is the beveled edge with stock and the other is the flat edge without stock. It is used to check whether the object is plane, perpendicular and at right angle. Two straight blades set at right angles to each other constitute the try-square. The steel blade is riveted to the stock. The stock is made of cast iron. The stock should be set against the edge of the job.

Do not use it as a hammer.

12 Firmer chisel (Fig 12)

Fig 12



FIRMER CHISEL

PP20N11081C

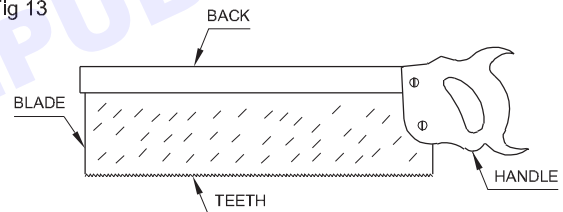
It has a wooden handle and a cast steel blade of 150 mm length. Its size is measured according to the width of the blade eg. 6 mm, 12 mm, 18 mm, 25 mm. It is used for chipping, scraping and grooving in wood.

Care and maintenance

- Do not use it for driving screws.
- Use mallet for chiseling.
- Grind on a water stone and sharpen on an oilstone.
- Do not use it in places where nails are driven.

13 Tenon-saw (Fig 13) BIS 5123, BIS 5130, BIS 5031

Fig 13



TENON-SAW

PP20N11081D

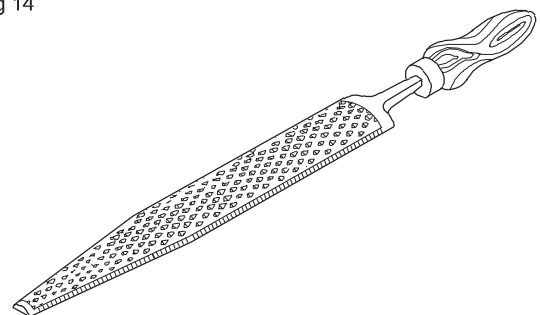
Generally the length of a tenon-saw will be 250 or 300 mm. and has 8 to 12 teeth per 25.4 mm and the blade width is 10 cm. It is used for cutting thin, wooden accessories like wooden batten, casing capping, boards and round blocks.

Care and maintenance

- Keep free from rust.
- Apply grease when not in use.

14 Wood rasp file (Fig 14) BIS 1931

Fig 14

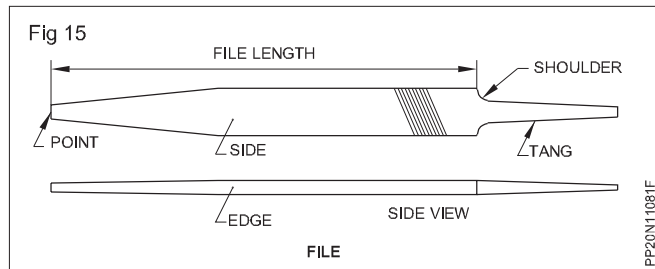


WOOD RASP FILE

PP20N11081E

It is used for filing wooden articles where finish is not important. Wood rasp files are of half round shape. They have sharp coarse single cut teeth.

15 Files (Fig 15) BIS 1931



These are specified by their nominal length.

Eg. 150 mm, 200 mm, 250 mm 300 mm etc.

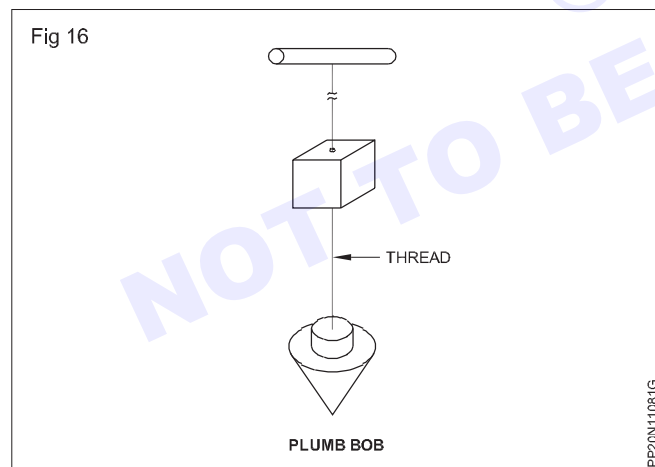
These files have different numbers of teeth designed to cut only in the forward stroke. They are available in different lengths and sections (Eg. flat, half round, round, square, triangular), grades like rough, bastard second cut and smooth and cuts like single and double cut.

These files are used to remove fine chips of material from metals. The body of the file is made of cast steel and hardened except the tang.

Care and maintenance

- Never use the file as a hammer.
- Do not use the file without the handle.
- Do not throw a file since the teeth get damaged.

16 Plumb bob (Fig 16)



It has a pointed tip with a center hole at the top for attaching a string as shown in Fig 16. It is used for marking vertical lines on the wall.

Care and maintenance

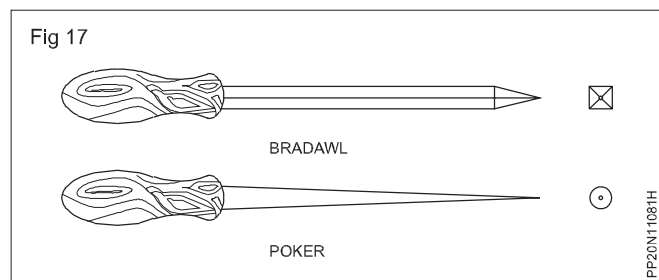
Do not drop to the ground.

17 Bradawl square pointed (or poker) (Fig 17)

BIS 10375 - 1982

It is specified by its length and diameter eg. 150 mm x 6 mm.

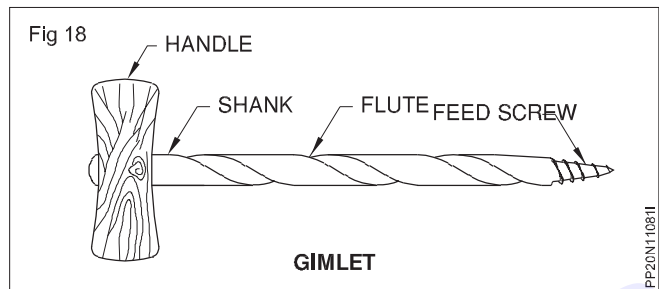
It is a long sharp tool used for making pilot holes on wooden articles to fix screws.



Care and maintenance

- Do not use it on metals for making holes.
- Keep it in good sharpened condition.

18 Gimlet (Fig 18)

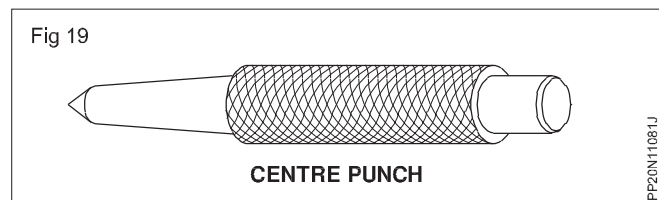


It is used for boring small holes on wooden articles. It has a wooden handle and a boring screwed edge. The size of it depends upon its diameter. Eg. 3 mm, 4 mm, 5 mm, 6 mm.

Care and maintenance

- Do not use it without the handle.
- Do not use it on nails.
- Keep it straight while making holes, otherwise the screwed portion can get damaged.

19 Centre punch (Fig 19) BIS 7177



The size is given by its length and diameter of the body.

Eg. 100 mm x 8 mm. The angle of the tip of the centre punch is 90°.

It is used for marking and punching pilot holes on metals. It is made of tool steel and the ends are hardened and tempered.

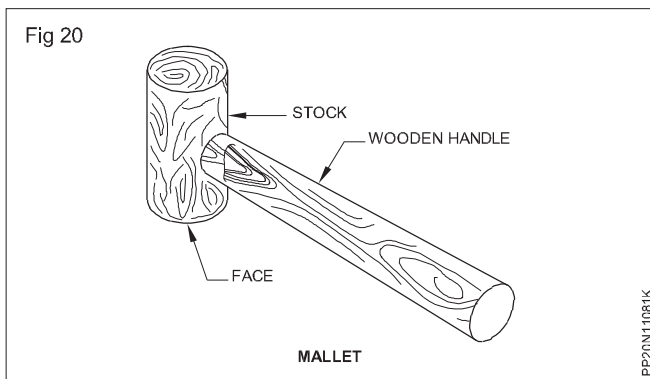
Care and maintenance

- Keep the tip sharp and at a proper angle.
- Avoid mushroom heads.

20 Mallet (Fig 20)

The mallet is specified by the diameter of the head or by the weight.

- eg. 50 mm x 150 mm
- 75 mm x 150 mm or 500gms, 1 Kg.

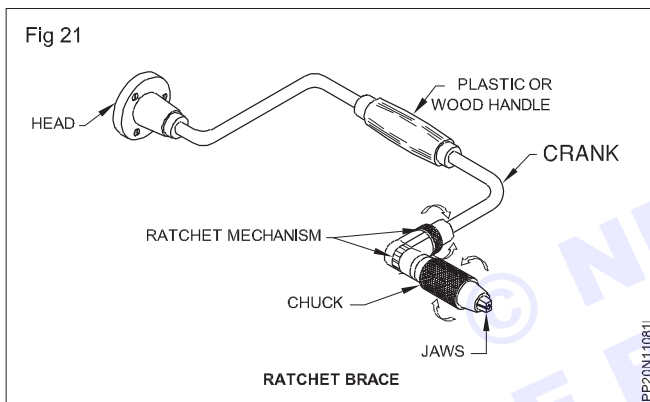


It is made out of hard wood or nylon. It is used for driving the firmer chisel, and for straightening and bending of thin metallic sheets. Also it is used in motor assembly work.

Care and maintenance

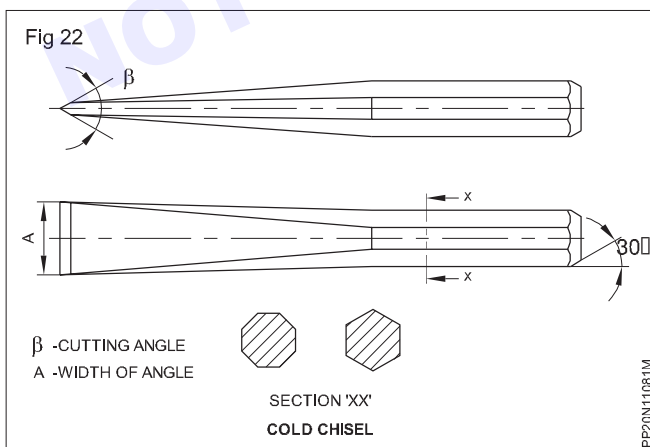
- Do not use it for fixing nails.
- Never use it on hard metal like steel and iron.

21 Ratchet brace (Fig 21) BIS 7042



The size of a ratchet brace is given by the size of drill bit it can accommodate ie. 0 - 6 mm, 0 - 12 mm. It is used to drill holes on wooden blocks.

22 Flat cold chisel (Fig 22) BIS 402



Its size is given by the nominal width and length.

- ie.
- 14 mm x 100 mm
 - 15 mm x 150 mm
 - 20 mm x 150 mm

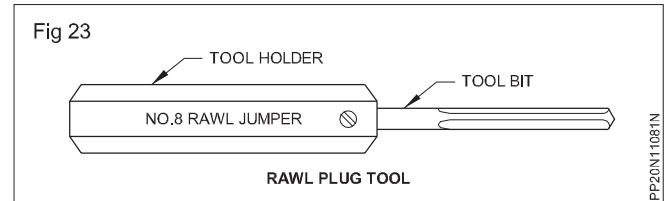
The body shape of a cold chisel may be round or hexagon.

The cold chisel is made out of high carbon steel. Its cutting edge angle varies from 35° to 45° . The cutting edge of the chisel is hardened and tempered. This chisel is used for making holes on wall etc.

Care and maintenance

- The edge of a chisel must be maintained as per the required angle.
- While grinding a chisel apply a coolant frequently so that its temper may not be lost.

23 Raw plug tool and bit (Fig 23)



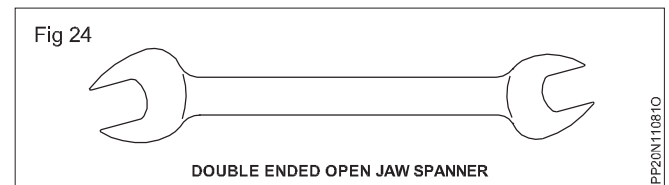
Its size depends upon the number. As the number increases, the thickness of the bit as well as the plug also increases. Eg. Nos.8, 10, 12, 14 etc.

A raw plug tool has two parts, namely the tool bit and tool holder. The tool bit is made of tool steel and the holder is made of mild steel. It is used for making holes in bricks, concrete wall and ceiling. Rawl plugs are inserted in them to fix accessories.

Care and maintenance

- Slightly rotate the holder after each hammering stroke.
- Hold the tool straight.
- Do not throw it on the ground.
- Keep its head free from mushrooms.

24 Spanner: double ended (Fig 24) BIS 2028



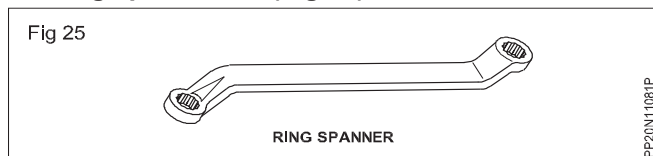
The size of a spanner is indicated so as to fit on the nuts. They are available in many sizes and shapes.

The sizes, indicated in double-ended spanners are

- 10-11 mm
- 12-13 mm
- 14-15 mm
- 16-17 mm
- 18-19 mm
- 20-22 mm.

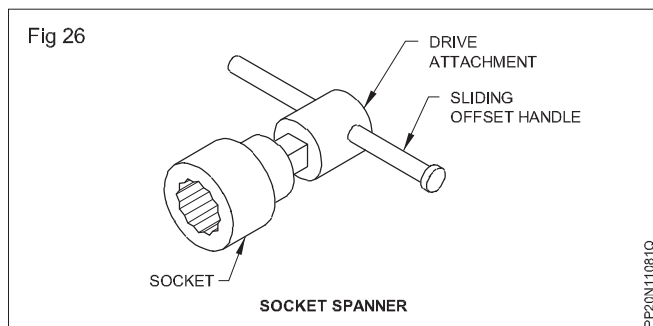
For loosening and tightening of nuts and bolts, spanner sets are used. It is made out of cast steel. They are available in many sizes and may have single or double ends.

25 Ring spanner set (Fig 25) BIS 2029



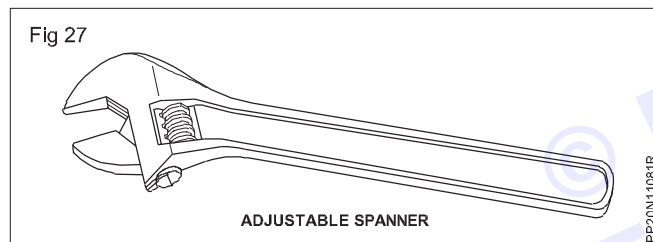
The ring spanner is used in places where the space is restricted and where high leverage is required.

26 Socket (box) spanner (Fig 26) BIS 7993, 7991, 6129



These spanners are useful at places where the nut or bolt is located in narrow space or at depth.

27 Single ended open jaw adjustable spanner (Fig 27) BIS 6149



It saves time and working. The movable jaw is made adjustable by operating a screw. It is known as a monkey wrench also. Available in 150,200,250mm etc.

Care and maintenance

- Use correct size spanner suitable to the size of nut and bolt.
- Do not use a spanner as a hammer.
- While using a spanner do not strike it with a hammer.
- Prevent the grease and oil traces on its jaws.

28 Measuring steel tape (Fig 28)

The size will be the maximum length it can measure. Eg. Blade 12 mm wide 2 metres long.

The measuring tape is made of thin steel blade, bearing dimensions on it.

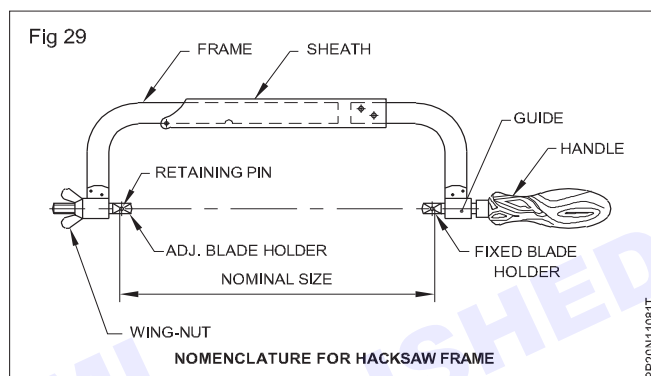
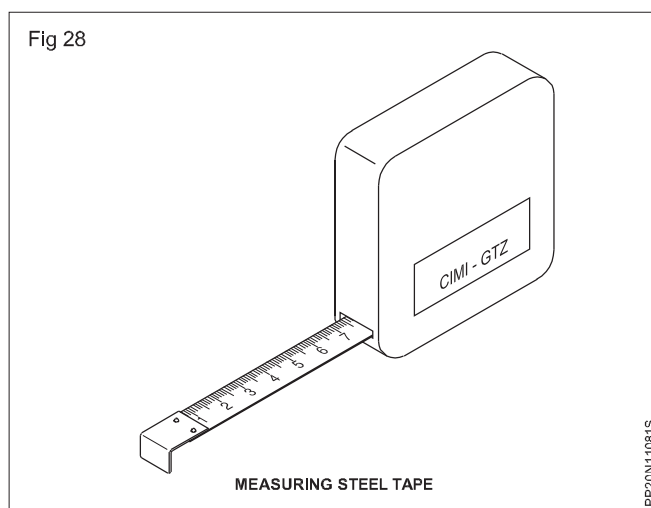
It is used for measuring the dimension of the wiring installation and general measurements.

Care and maintenance

Handle with great care as carelessness may spoil the graduation.

29 Hacksaw (Fig 29) BIS 5169-1986 for frames

BIS 2594 - 1977 for blades

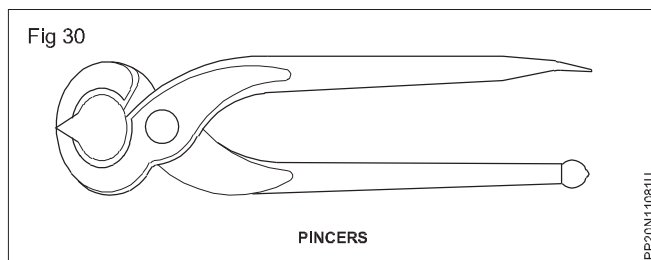


It is made out of sturdy nickel plated steel frame. The frame can be adjusted for 250 mm to 300 mm blades. It should be fixed on the frame with its teeth pointing away from the handle in order to do the cutting in forward stroke. It is mainly used for cutting metals.

Care and maintenance

- The blade should be properly tightened.
- Use a coolant while cutting.
- It should be straight during cutting.
- Lift the saw slightly on the return stroke.
- Do not attempt to saw too fast.

30 Pincers (Fig 30) BIS 4195



The size is given by its length. Eg. 100 mm, 150 mm, 200 mm.

It is used for extracting nails from the wood.

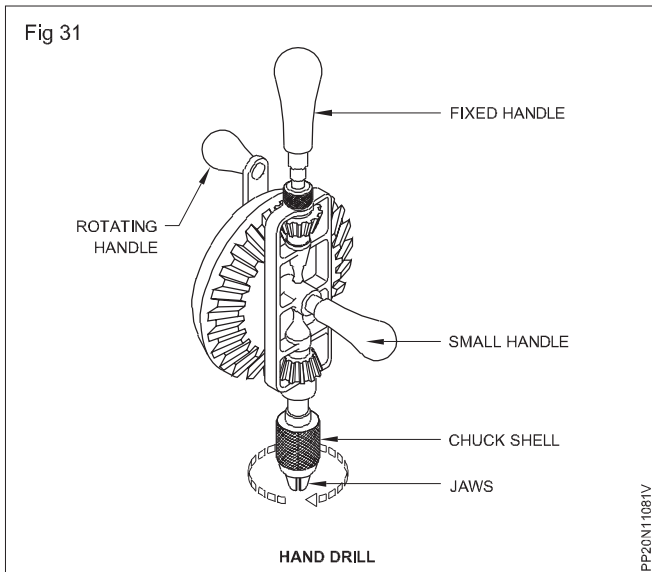
Care and maintenance

- Do not use it as a hammer.

31 Hand drill (Fig 31)

The size is given by the twist drill bits which can be fitted in. Eg. 6 mm, 0-12 mm capacity.

A hand drill machine is used for making holes in thin metal sheets or wooden articles.

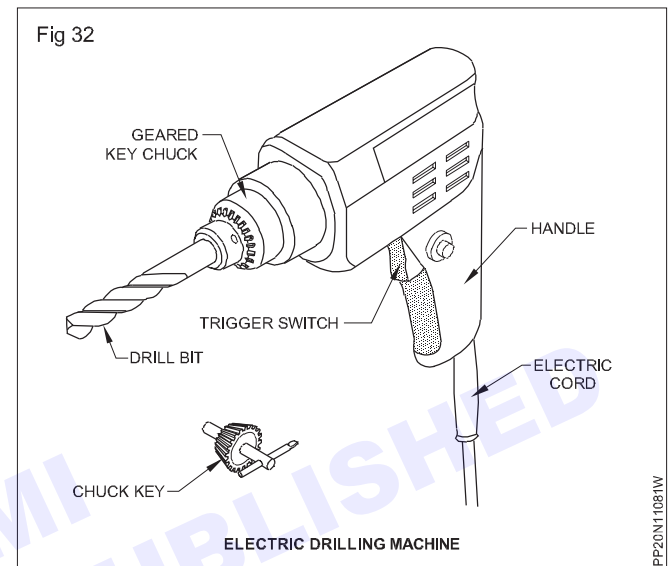


32 Portable Electric drilling machine (Fig 32)

When power is available, a power drilling machine is a more convenient and accurate tool for drilling holes on wooden and metal articles.

Care and maintenance

- Lubricate all the moving parts of the machine.
- Fix the drill bit firmly in the jaws.
- Before drilling, mark the job with a centre punch.
- For taking out the drill bit move the chuck in the reverse direction.
- Do not apply excess pressure on small bits.
- In the case of an electric drilling machine it must be properly earthed and the insulation should be sound.



Scribers

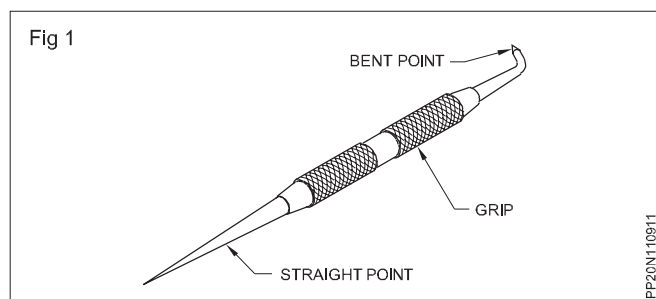
Objectives: At the end of this lesson you shall be able to

- state the features of scribers
- state the uses of scribers.

Scribers

In lay out work it is necessary to scribe lines to indicate the dimensions of the work piece to be filed or machined. The scribe is a tool used for this purpose. It is made of high carbon steel and is hardened. For drawing clear and sharp lines, the point should be ground and honed frequently for maintaining its sharpness.

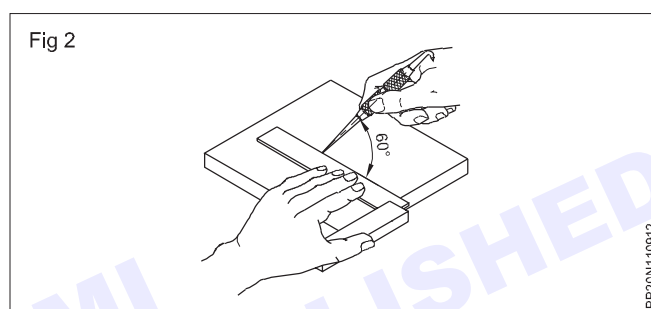
Scribers are available in different shapes and sizes. The most commonly used one is the plain scribe. (Fig 1)



While scribing lines, the scribe is used like a pencil so that the lines drawn are close to the straight edge. (Fig 2)

Scriber points are very sharp; therefore, do not put the plain scribe in your pocket.

Place a cork on the point when not in use to prevent accidents.



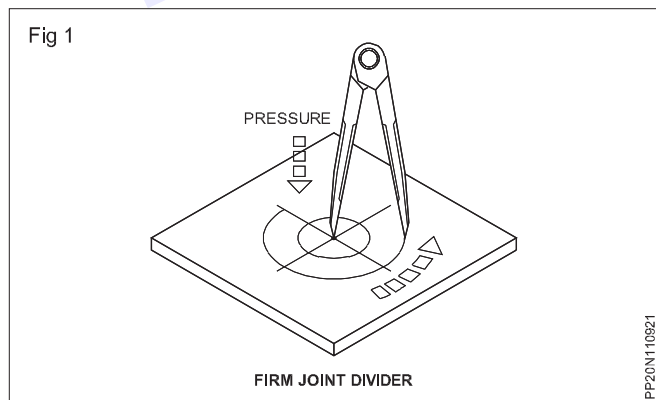
Dividers

Objectives: At the end of this lesson you shall be able to

- name the parts of a divider
- state the uses of dividers
- state the specifications of dividers
- state the important hints on divider points.

Dividers are used for scribing circles, arcs and for transferring and stepping off distances. (Fig 1,2 and 3)

Dividers are available with firm joints and spring joints. (Figs 1 & 4). The measurements are set on the dividers with a steel rule. (Fig 2)



The sizes of dividers range between 50 mm to 200 mm.

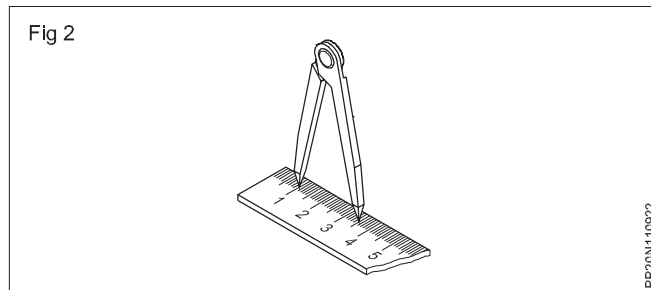
- 1 Mercury tools punching tools
- 2 Types of making punches
- 3 Types of calipers

4 Length measurements

5 Try square

6 Screw drive

7 Many and measuring tools

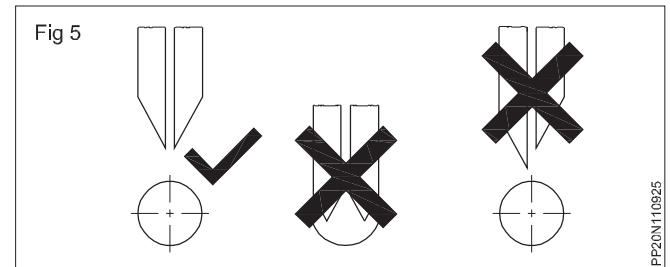
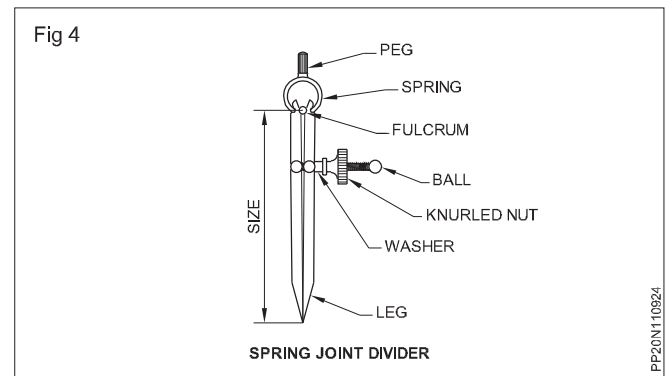
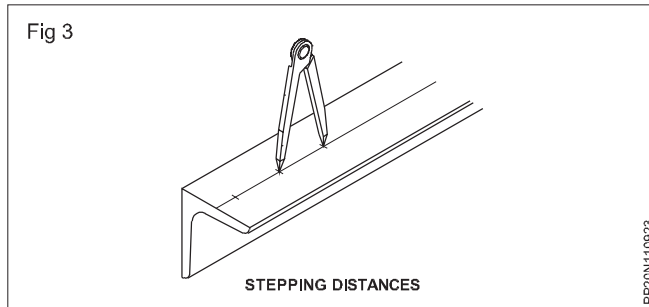


The distance from the point to the center of the fulcrum roller (pivot) is the size of the divider. (Fig 4)

For the correct location and seating of the divider point prick punch marks of 30° are used.

The two legs of the divider should always be of equal length. (Fig 5) Dividers are specified by the type of their joints and length.

The divider point should be kept sharp in order to produce fine lines. Frequent sharpening with an oilstone is better than sharpening by grinding. Sharpening by grinding will make the points soft.



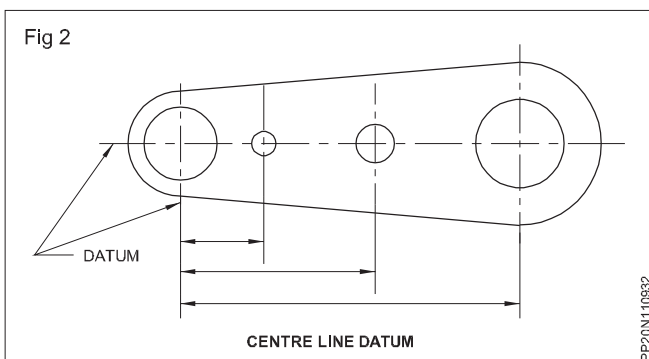
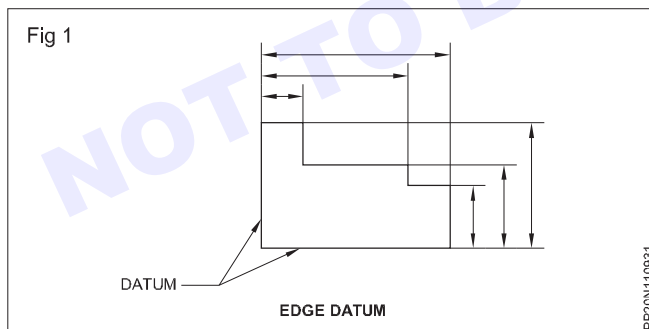
Datum

Objectives: At the end of this lesson you shall be able to

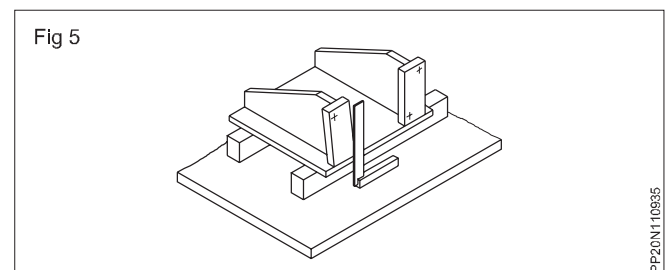
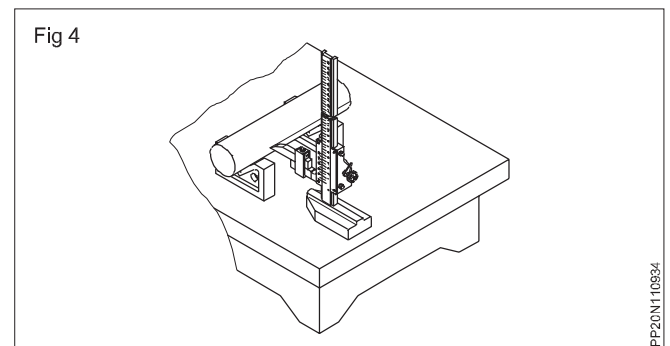
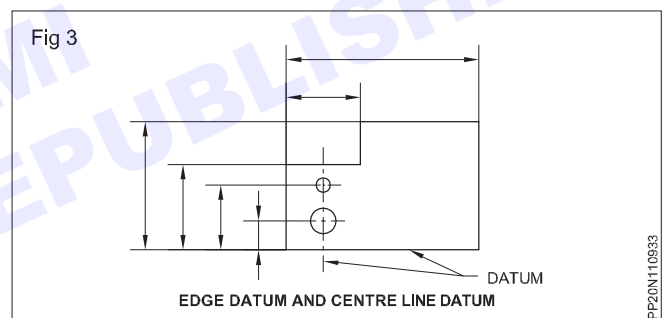
- state the need for datum while marking
- name the different datum references.

The height of a person is measured from the floor on which he stands, the floor then becomes the datum or the common basis for measurement.

A datum is a reference surface, line or point, and its purpose is to provide a common position from which measurements may be taken. The datum may be an edge or center line depending on the shape of the work. For positioning a point, two datum references are required. (Figs 1- 3)



Marking tables, surface plates, angle plates, 'V' blocks, and parallel blocks serve as a datum. (Figs 4 & 5)



The datum references are indicated in the drawing. The same datum references must be used for transferring dimensions to the work-piece.

Calipers

Objectives: At the end of this lesson you shall be able to

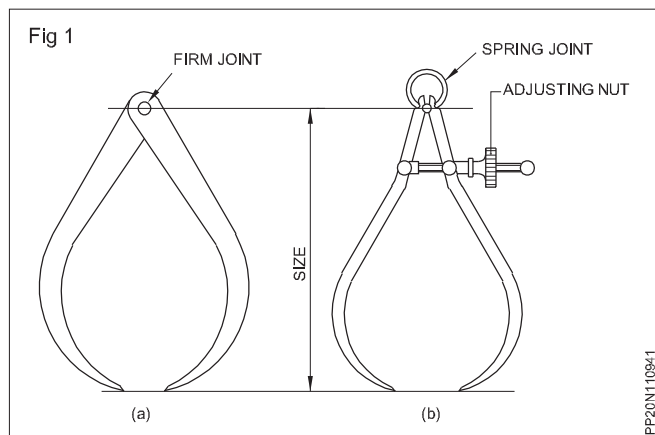
- name the commonly used calipers
- state the advantages of spring joint calipers.

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

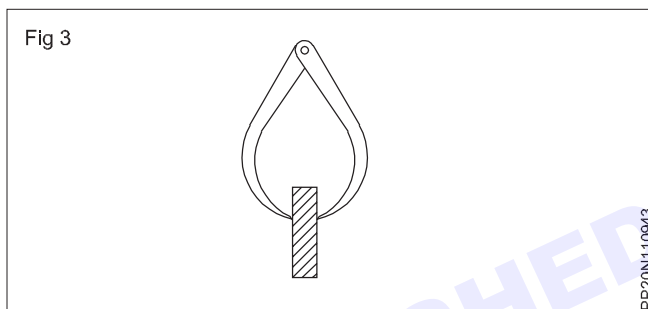
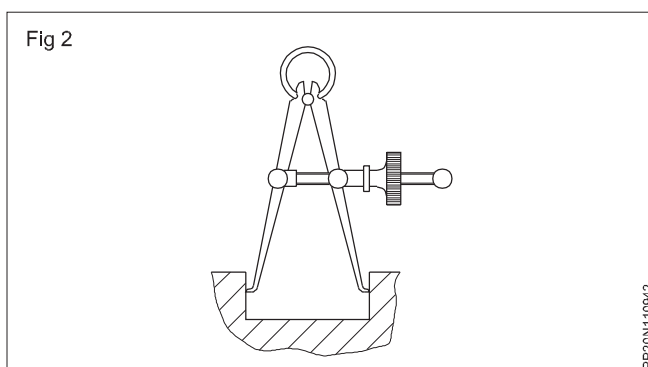
Joint

- Firm joint calipers (Fig 1a)
- Spring joint calipers (Fig 1b)



Legs

- Inside caliper for internal measurement. (Fig 2)
- Outside caliper for external measurement. (Fig 3)



Calipers are used along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using calipers with sensitive feel.

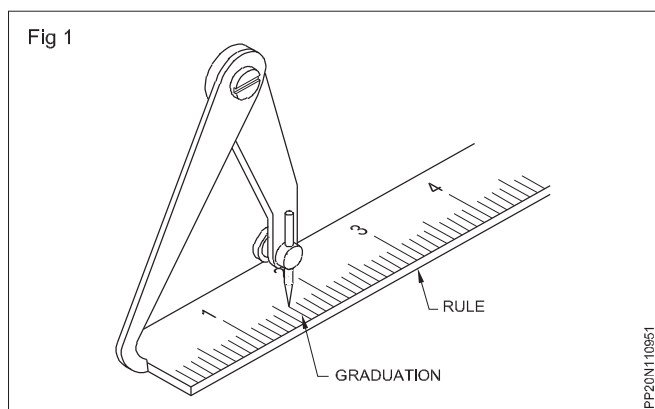
Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

Jenny calipers

Objectives: At the end of this lesson you shall be able to

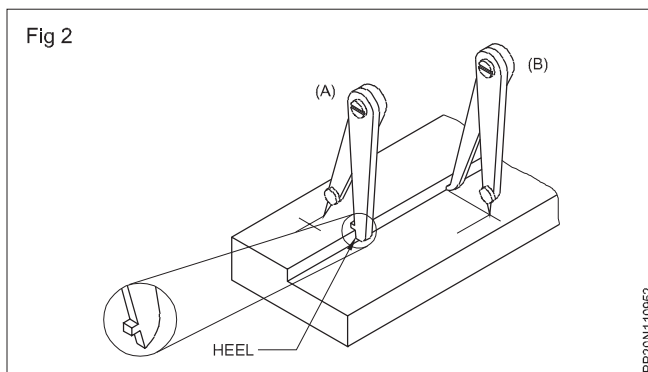
- state the uses of a jenny caliper
- state the two types of legs of a jenny caliper.

Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.



Jenny calipers are used

- For marking lines parallel to the inside and outside edges (Fig 2)

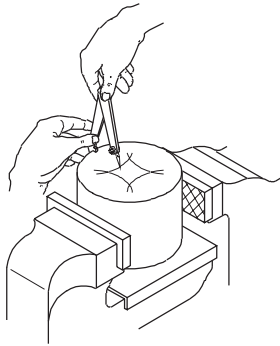


- For finding the centre of round bars. (Fig 3)

These calipers are available with the usual bent leg or with heel.

Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

Fig 3



PP20N110953

The other names for this caliper are:

- Hermaphrodite calipers
- Leg and point calipers
- Odd leg caliper

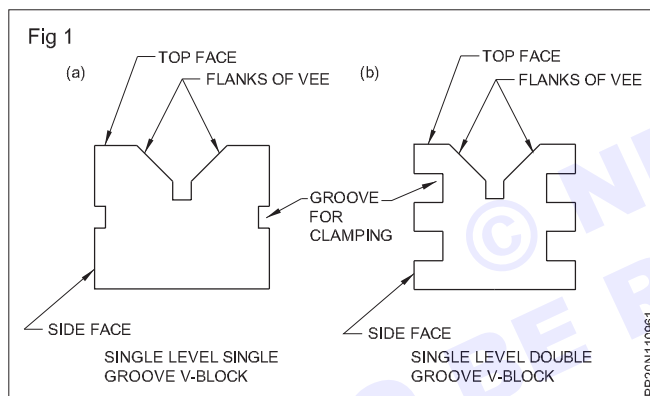
'V' Blocks

Objectives: At the end of this lesson you shall be able to

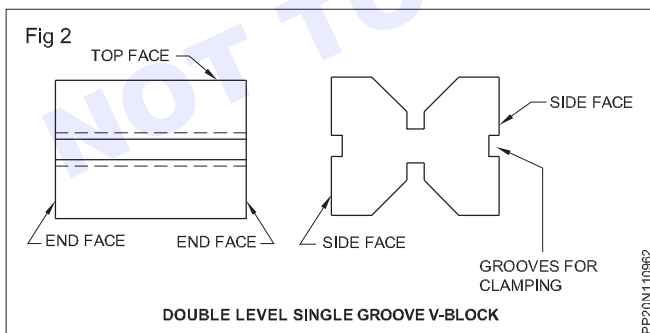
- state the constructional features of 'v' blocks
- name the types of 'v' blocks and state their uses
- specify 'v' blocks as per B.I.S standard.

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in (Figs 1 & 2).



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PP20N110962

The included angle of the VEE is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1a)

This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

Single level double groove 'V' Block (Fig 1b)

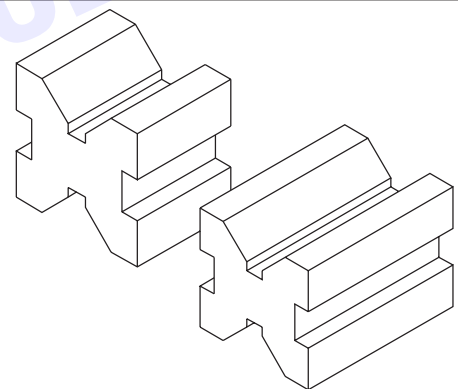
This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.

Double level single groove 'V' Block (Fig 2)

In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

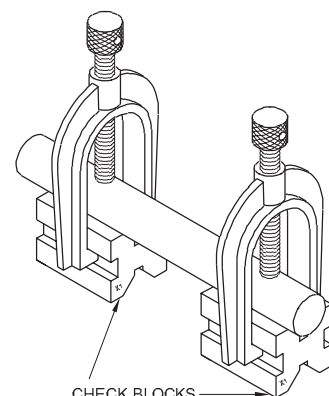
Matched pair 'V' Block (Figs 3 & 4)

Fig 3



PP20N110963

Fig 4



PP20N110964

These blocks are available in pairs which have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These sets of blocks are used for supporting long shafts parallel on machine tables or marking off tables.

Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

These are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

Clamping devices for 'V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks. (Fig 5)

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the work piece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.

In the case of matched pairs, it should be indicated by the letter M.

For 'V' Blocks with clamps it should be indicated as, 'WITH CLAMPS'.

Example

A 50 mm long (nominal size) 'V' Block capable of clamping work pieces between 5 to 40 mm in diameter and of Grade A will be designated as

Marking off and marking off table

Objectives: At the end of this lesson you shall be able to

- state why marking off is necessary
- state the function of witness marks
- state the features of marking tables
- write the uses of marking tables
- state the maintenance aspects concerning marking tables.

Marking off

Marking off or layout is carried out to indicate the locations of operation to be done, and provide guidance during rough machining or filing.

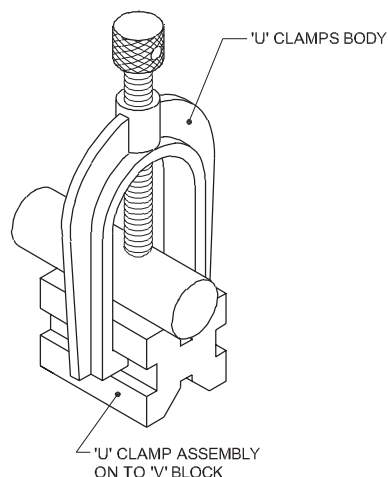
Witness marks

The line marked on metal surfaces is likely to be erased due to handling. To avoid this, permanent marks are made by placing punch marks at convenient mark intervals along the marked line. Punch marks act as a witness against inaccuracies in machining and hence, they are known as witness marks.

Marking off table (Figs 1 & 2)

A marking table (marking-off table) is used as a reference surface for marking on work pieces.

Fig 5



PP20N110965

'V' Block 50/5-40 A - I.S.2949.

In the case of a matched pair, it will be designated as

'V' Block M 50/5-40 A I.S.2949.

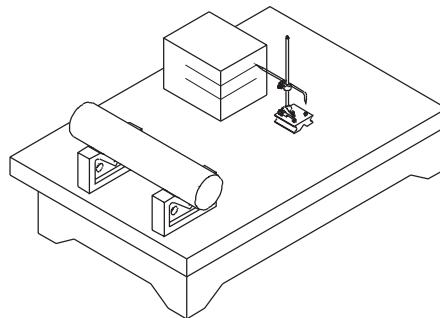
For 'V' Block supplied with clamps, the designation will be

'V' Block with clamp 50/5 40 A I.S. 2949.

Care and maintenance

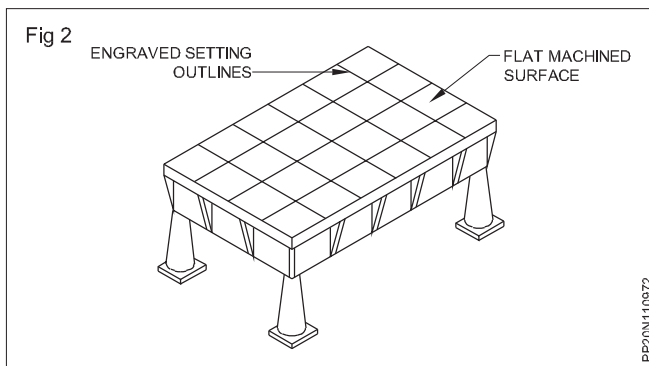
- Clean before and after use.
- Choose the correct size of 'V' block according to the job requirement.
- Apply oil after the use.

Fig 1



PP20N110971

Marking tables are of rigid construction with accurately finished top surfaces. The edges are also finished at right angles to the top surface.



Marking tables are made of cast iron or granite, and are available in various sizes. These tables are also used for setting measuring instruments, and for checking sizes, parallelism and angles.

Care and maintenance

A marking table is very precise equipment, and should be protected from damage and rust.

After use, the marking table should be cleaned with a soft cloth.

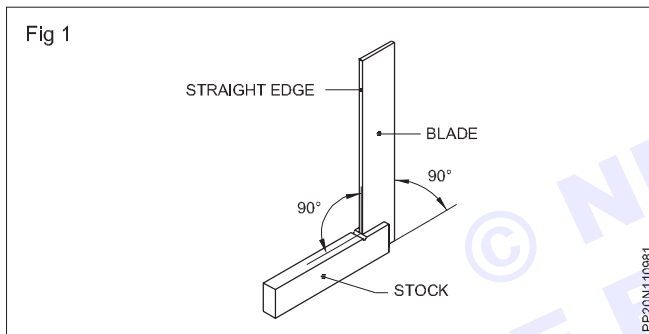
The Surface of the marking table, made of cast iron, should be protected by applying a thin layer of oil.

Try square

Objectives: At the end of this lesson you shall be able to

- name the parts of a try square
- state the uses of try square.

The try square (Fig 1) is an instrument which is used to check squareness (angles of 90°) of a surface.



The accuracy of measurement by a try square is about 0.002 mm per 10 mm length, which is accurate enough for most workshop purposes. The try square has a blade with parallel surfaces. The blade is fixed to the stock at 90° .

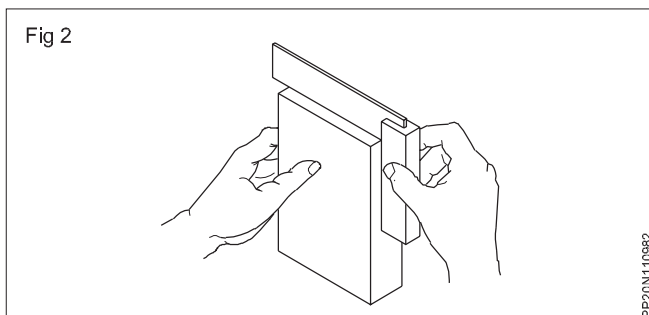
Try squares are made of hardened steel.

Try squares are specified according to the length of the blade i.e. 100 mm, 150 mm, 200 mm.

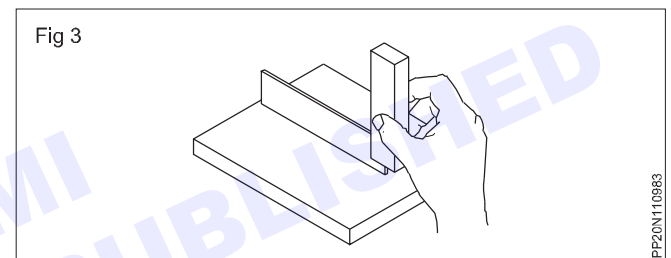
Uses

The try-square is used to:

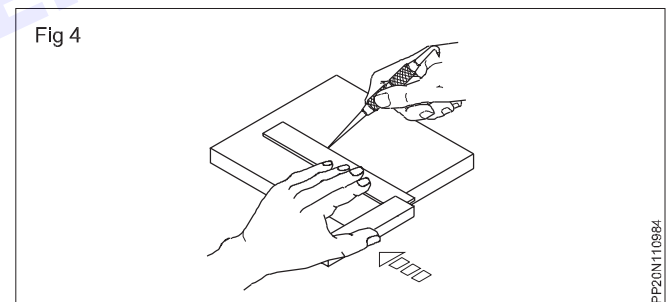
- check the squareness (Fig 2)



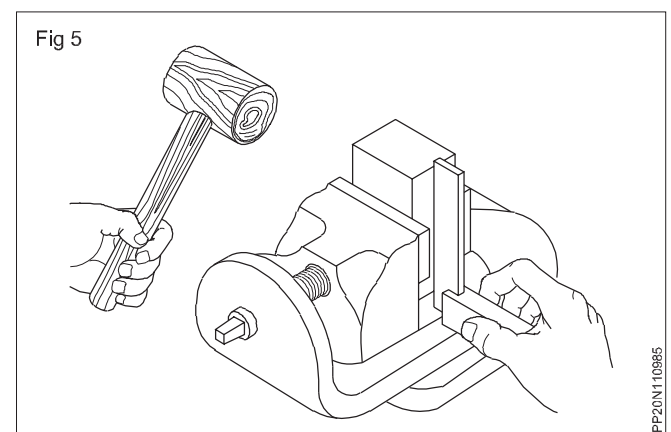
- check the flatness (Fig 3)



- mark lines at 90° to the edges of work pieces (Fig 4)



- set work pieces at right angles. (Fig 5)



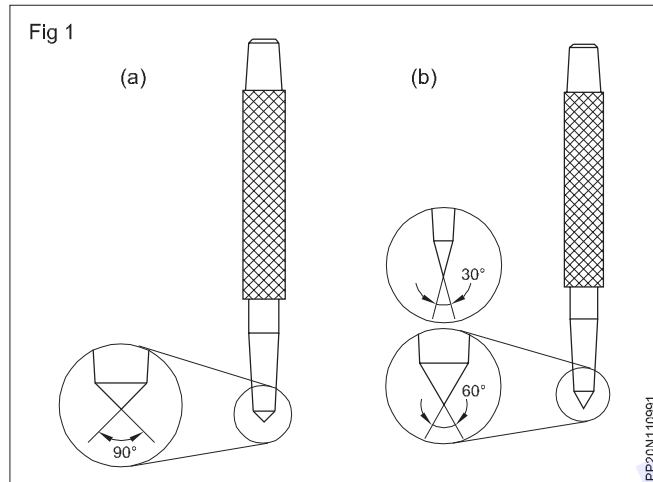
Types of marking punches

Objectives: At the end of this lesson you shall be able to

- name the different punches in marking
- state the features of each punch and its uses.

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are center punch and prick punch made of high carbon steel, hardened and ground.

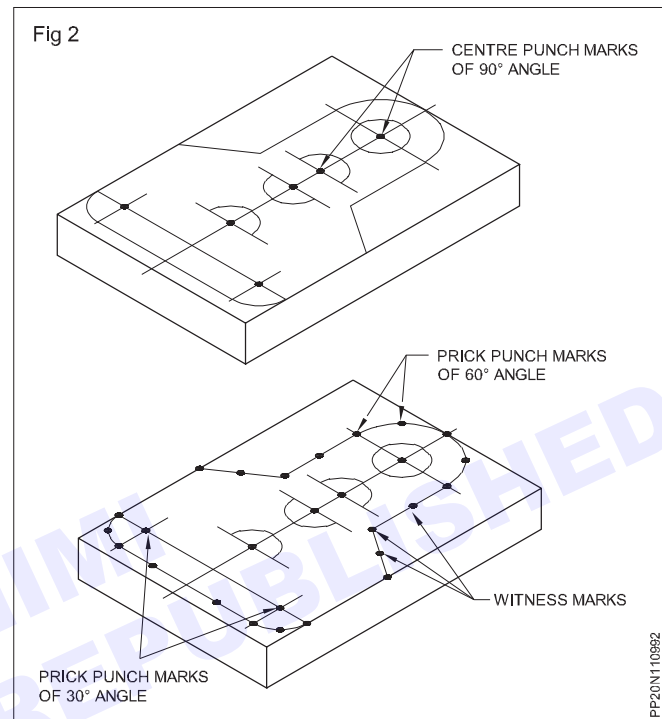
Center Punch: The angle of the point is 90° in a center punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a)



Prick Punch/Dot punch: The angle of the prick punch is 30° or 60° . (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider point will get a proper seating in the punch

mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

The witness marks should not be too close to one another.



Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to

- name the different types of hacksaw frames
- specify hacksaw blades
- name the different type of hacksaw blades
- describe the method of sawing.

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

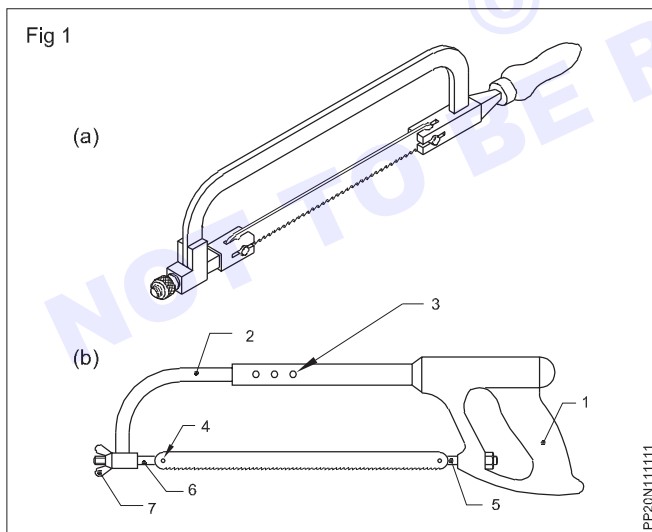
Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

Types of hacksaw frames

Solid frame (Fig 1a): Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type): Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

Adjustable frame (tubular type) (Fig 1b): This is the most commonly used type. It gives a better grip and control, while sawing.



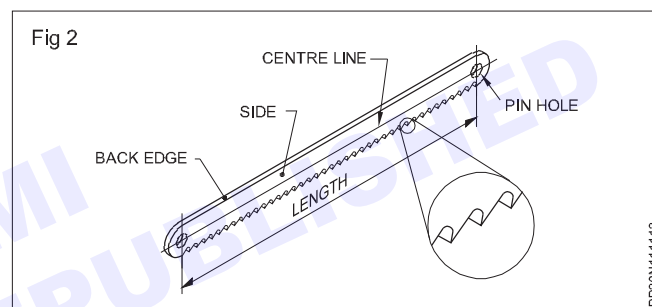
Parts of a hacksaw frame

- 1 Handle
- 2 Frame
- 3 Tubular frame with holes for length adjustment
- 4 Retaining pins
- 5 Fixed blade-holder
- 6 Adjustable blade-holder
- 7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

- 1 Back edge
- 2 Side
- 3 Centre line
- 4 Pin holes

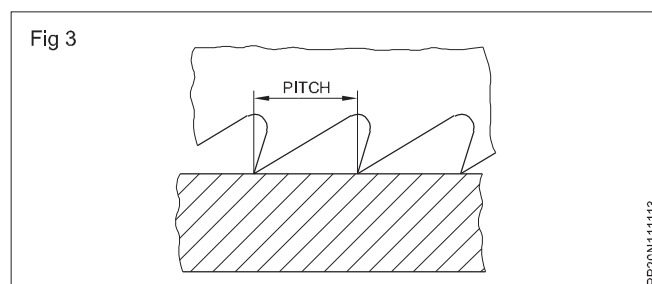


Type of hacksaw blades

All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3): The distance between adjacent teeth is known as the 'pitch' of the blade.



Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm

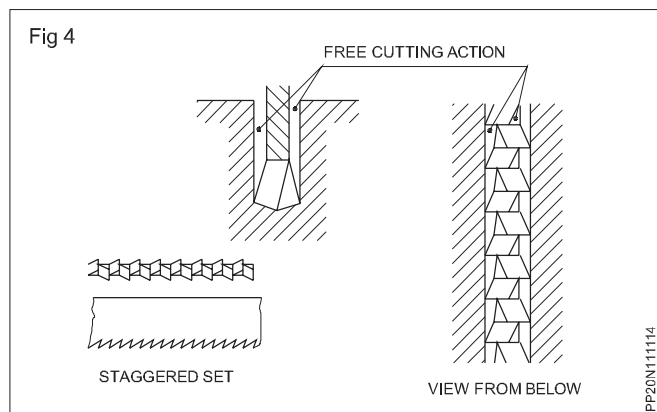
Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardized))

Example

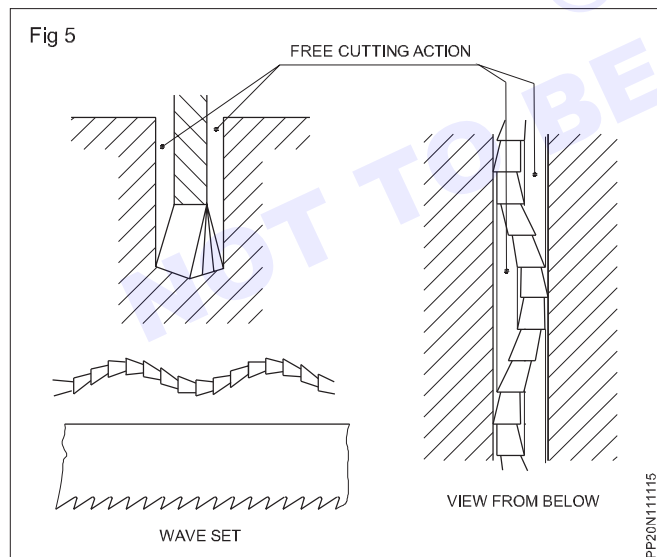
300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

Staggered set (Fig 4): Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.



Wave set (Fig 5): In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

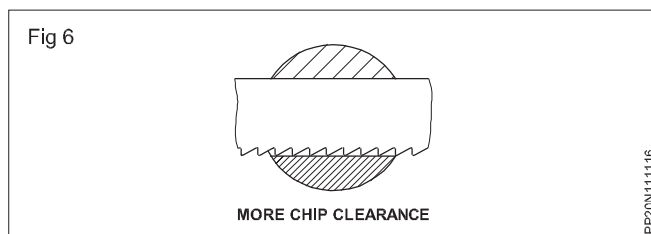


Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

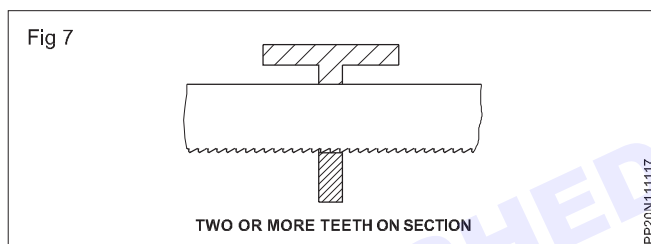
For the best results, the blade with the right pitch should be selected and fitted correctly.

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

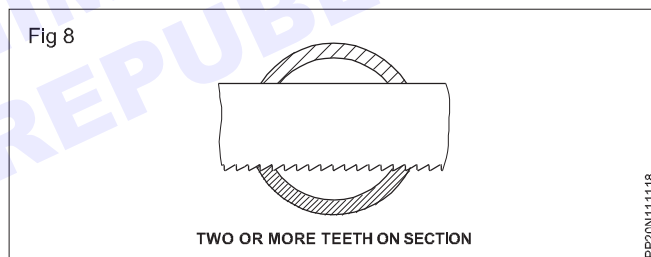
Pitch selection (Fig 6): For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.



For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that at least 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/sawing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Metal - cutting saws

Objectives: At the end of this lesson you shall be able to

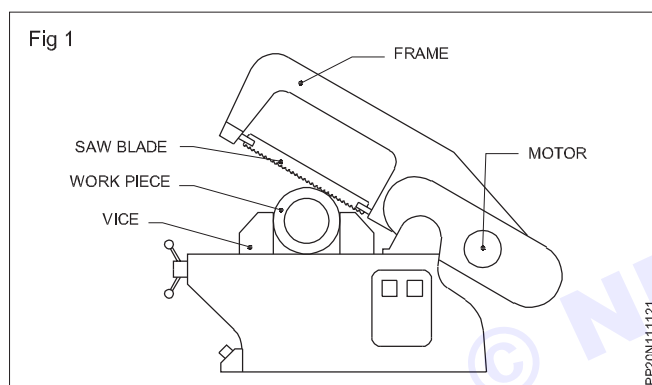
- name the common types of metal-cutting saws
- state the advantages of a horizontal band-saw
- state the features of different types of cutting saws
- state the specific use of a contour-saw
- state the precautions to be observed while machine sawing.

Metal-cutting saws of different types are used in industries. The most commonly used are the:

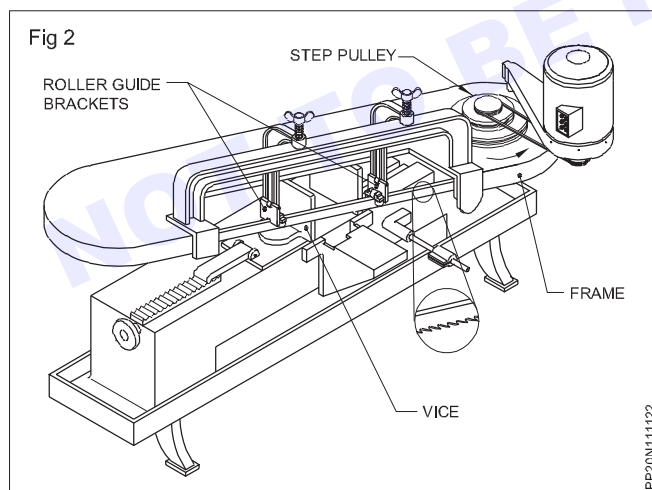
- power saw
- horizontal band-saw
- circular saw
- contour band-saw.

Power saw (Fig 1)

This is the most commonly used metal-cutting saw and discussed in related theory for Ex: 1.2.31.



Horizontal band-saw (Fig 2)



This has a saw frame on which a motor is fitted.

There are two pulley wheels on which an endless band saw passes.

Speed variation is obtained through the stepped pulleys on the motor.

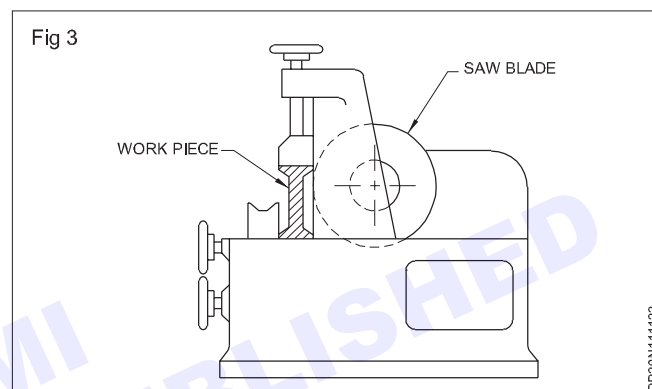
The roller-guide brackets provide the rigidity for the blade in the cutting area and also prevent wandering of the blade while cutting.

The blade tension is maintained by using the adjusting handle, provided for this purpose.

A vice is provided for holding the metal stocks. The vice is adjustable for angular cutting.

This machine has the advantage of continuous cutting ability, and is much faster than a power saw. It may be noted that a power saw cuts only in every alternate stroke.

Circular saw (Fig 3)



This type of cutting machine is used when cutting materials have a large cross-section. The circular saw has a continuous cutting action and is economical in production work where heavy section metals are used.

Contour saw (Fig 4)

In this, a metal band saw blade is used, and the contour saw has a continuous cutting motion. (Fig 5)

These machines are very much used for cutting metals to different profiles. (Fig 6)

Different speeds can be obtained while cutting, with the help of variable speed pulleys.

For repairing broken contour saw blades, these machines are fitted with a shear for trimming the blade ends, a butt-welding machine for joining the ends and the small grinder to finish the welded joint.

The table can be tilted to any angle for angular cutting.

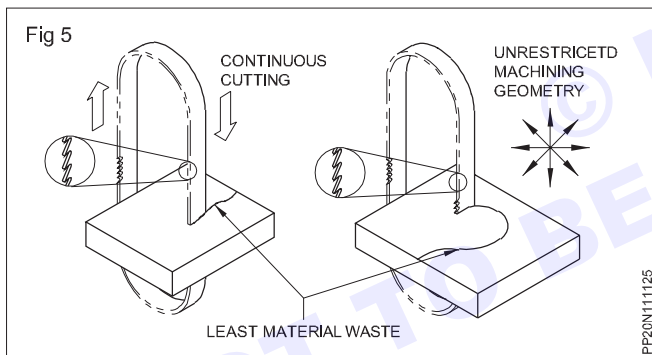
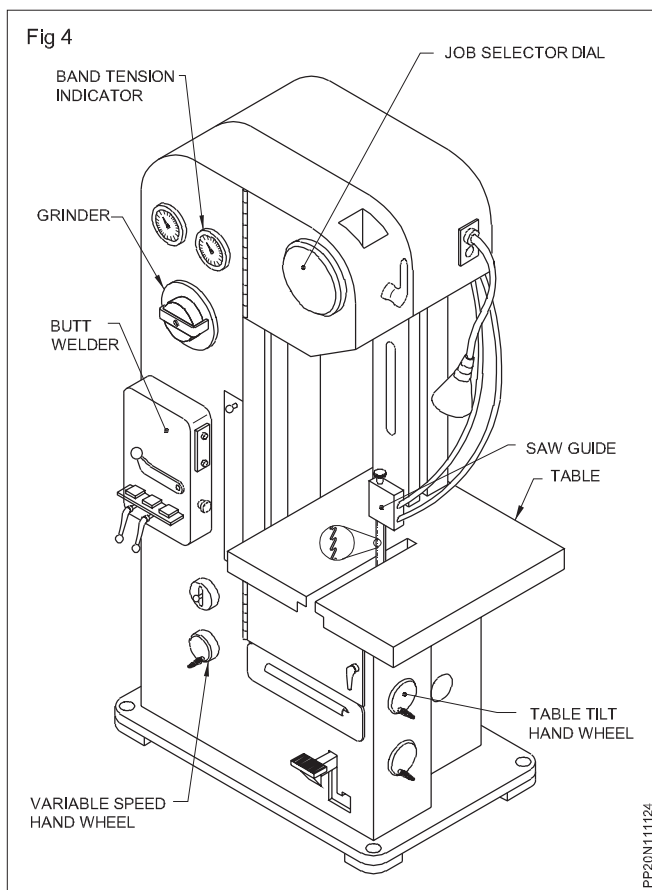
The blade passes through a guide which prevents the blades from wandering and keeps it rigidly.

These machines are widely used for tool-room work, and not as a machine for cutting raw material stock.

Precautions to be observed while machine sawing

In order to work safely and efficiently, certain precautions are to be observed.

While taking measurements of the work for setting, always stop the machine.

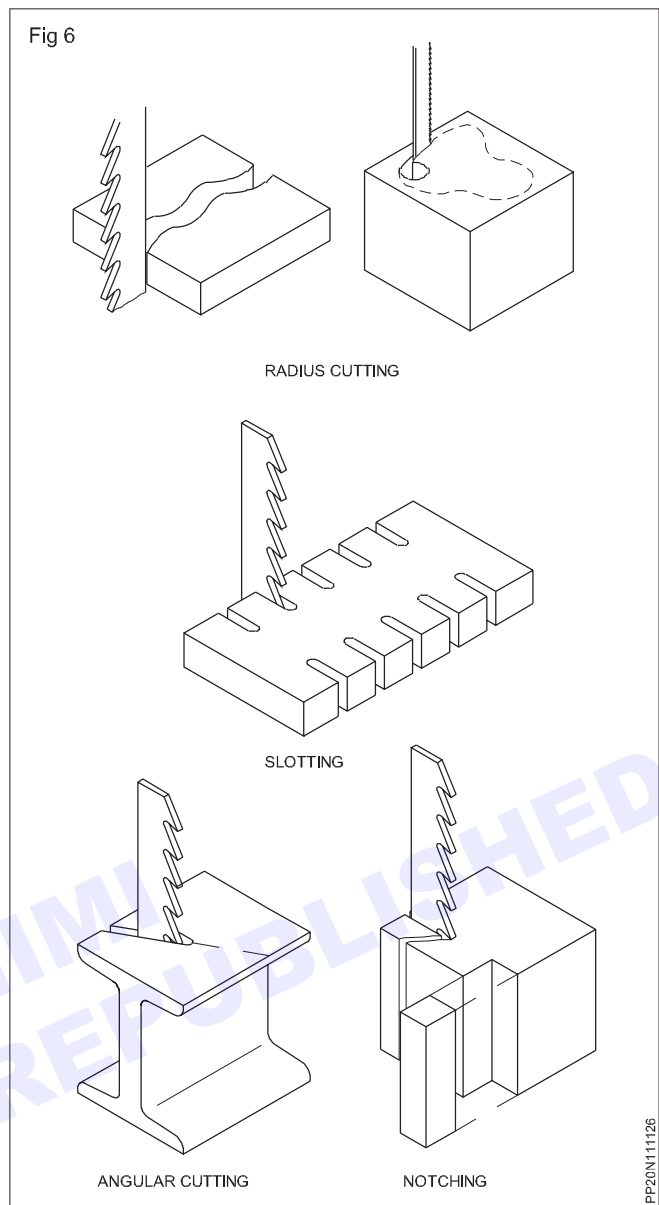


Projecting ends of the work should be well guarded, so that safety may be provided to others.

Ensure that the work does not protrude into the gangways.

When sawing thin pieces, hold the material flat in the vice to prevent the saw teeth from breaking.

Ensure a cutting fluid is used always.



Avoid giving excessive cutting pressure, because this can cause breakage to the blade, and cut work out of square.

When several pieces of the same length are to be cut, use a stop gauge.

When holding short work pieces in a vice, be sure to place a short piece of the same thickness in the opposite end. This will prevent the vice from twisting when it is tightened.

Lubricate the machines on the indicated points using oil can, oil gun or grease gun as specified by the machine manufacturer.

Elements of a file

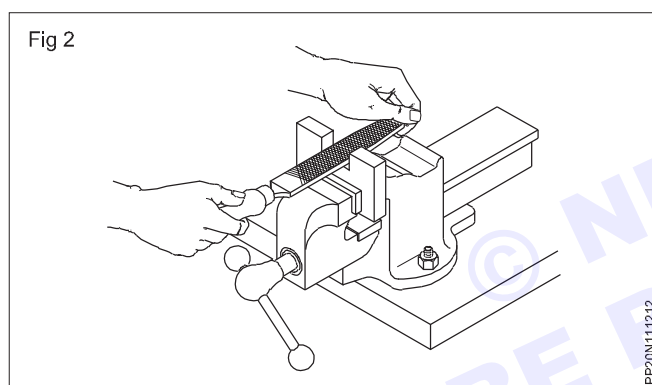
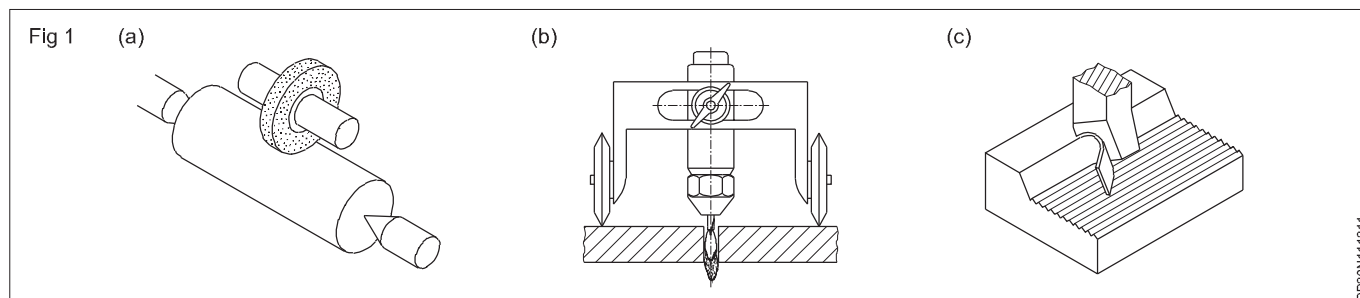
Objectives: At the end of this lesson you shall be able to

- name the parts of a file
- state the material of a file.

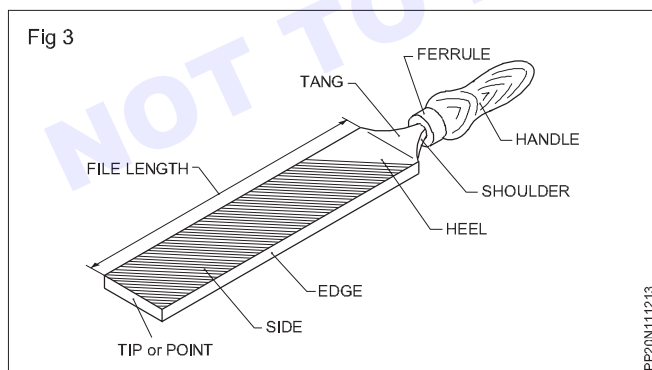
Methods of material cutting

The three methods of metal cutting are abrasion (Fig 1 a), fusion (Fig 1b) and incision (Fig 1c)

Filing is a method for removing excess material from a work piece by using a file which acts as a cutting tool. Fig 2 shows how to hold a file. Files are available in many shapes and sizes.



Parts of a file (Fig 3)



The parts of a file can be seen in figure 3, are

Tip or Point

the end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth

Shoulder

the curved part of the file separating tang from the body

Tang

The narrow and thin part of a file which fits into the handle

Handle

The part fitted to the tang for holding the file

Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

Cut of files

Objectives: At the end of this lesson you shall be able to

- name the different cuts of files
- state the uses of each type of cut.

The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts

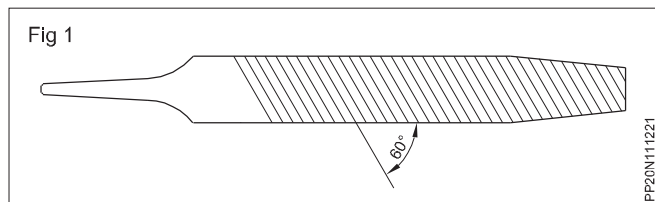
Basically there are four types.

Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

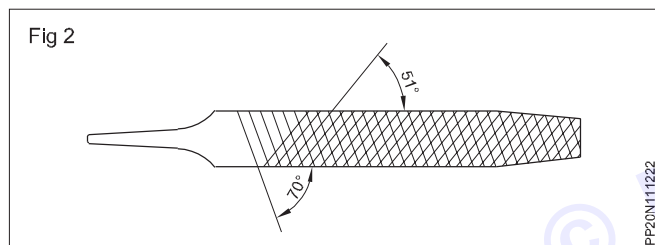
A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60° to the center line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminum, bronze and copper.

Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.



Double cut file (Fig 2)

A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70° . The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51° . This removes stock faster than the single cut file.



Rasp cut file (Fig 3)

The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials. These files are available only in half round shape.

File specifications and grades

Objectives: At the end of this lesson you shall be able to

- state how files are specified
- name the different grades of files
- state the application of each grade of file.

Files are manufactured in different types and grades to meet the various needs.

Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel.

File grades are determined by the spacing of the teeth.

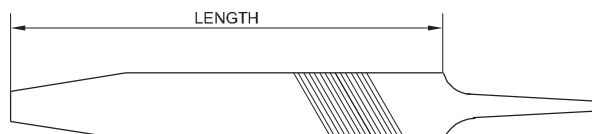
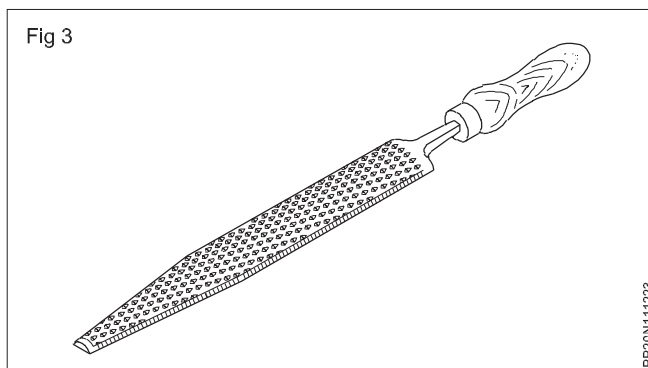


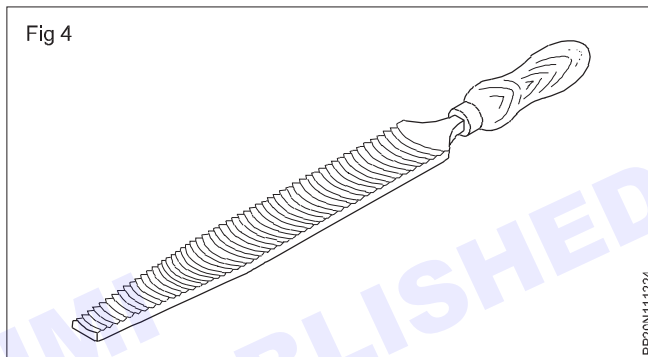
Fig 3



Curved cut file (Fig 4)

These files have deeper cutting action and are useful for filing soft materials like - aluminum, tin, copper, and plastic.

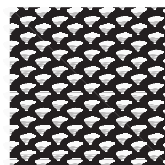
The curved cut files are available only in a flat shape.



The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.



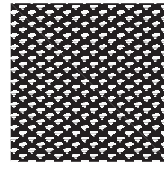
A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.



A **bastard file** is used in cases where there is a heavy reduction of material

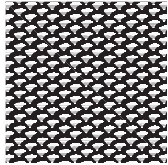


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.



A **dead smooth file** is used to bring the material to accurate size with a high degree of finish.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



A **smooth file** is used to remove small quantity of material and to give a good finish.

The most used grades of files are **bastard, second cut, smooth and dead smooth**. These are the grades recommended by the bureau of Indian standards (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

Table - 1

Grade of files (Number of cuts over the length of 10mm)					
Length of file	Rough	Bastard	Second cut	Smooth	Dead smooth
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Types of files

Objectives: At the end of this lesson you shall be able to

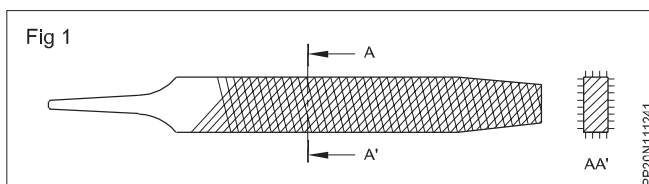
- identify the different shape of files (types)
- state the uses of flat files, Hand files square, round, half round, triangular and knife-edge files
- state the correct shape of files for filing different profiles.

For filing and finishing different profiles, files of different shapes are used

The shape of files is stated by its cross section.

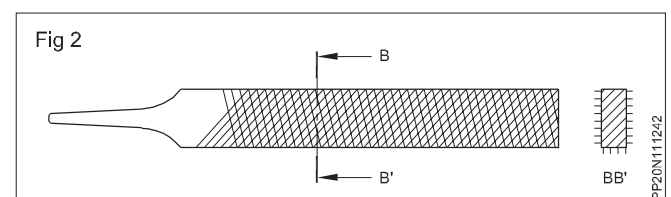
Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file and Knife-edge file.

Flat file (Fig 1)



These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filing and finishing external and internal surfaces.

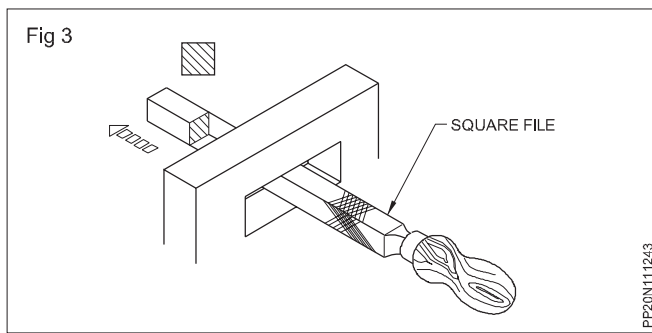
Hand file (Fig 2)



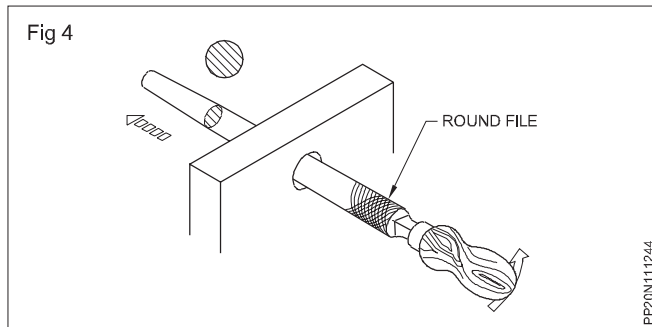
These files are similar to the flat files in their cross section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.

Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filling at right angles to a finished surface.

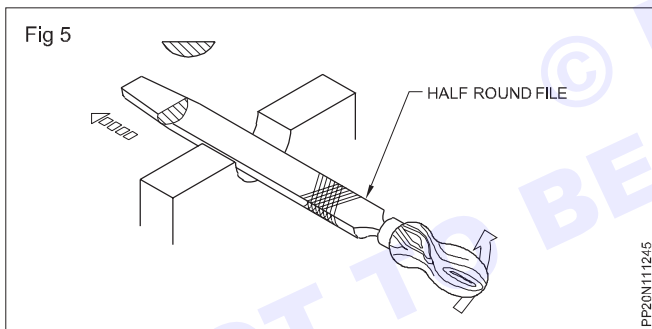
Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)



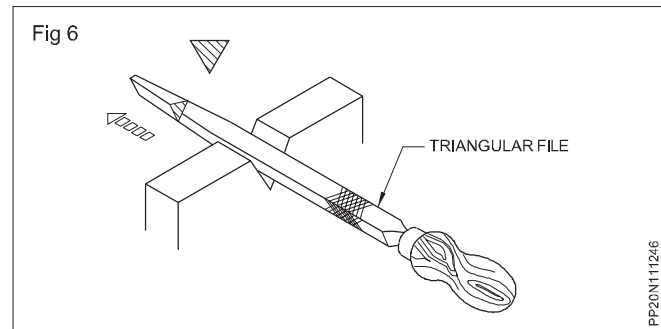
Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 4)



Half round file: A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. (Fig 5)

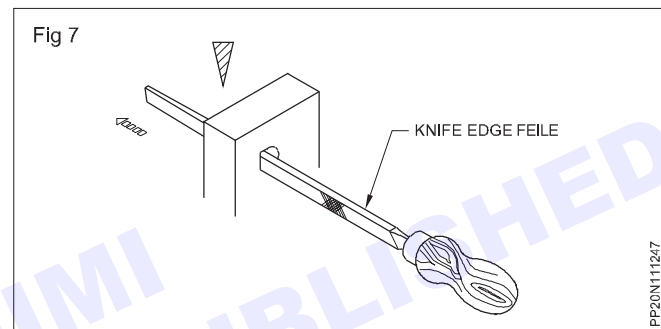


Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10° (Fig 6)



The above files have one third of their lengths tapered. They are available both single and double cuts.

Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60° . (Fig 7)



Square, round, half-round and triangular files are available in lengths of 100, 150, 200, 250, 300 and 400mm. These files are made in bastard, second cut and smooth grades.

Needle files

Objectives: At the end of this lesson you shall be able to

- name the different shapes of needle files
- designate needle files as per BIS.

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, barret and marking. (Fig 1)

Nomenclature of needle files. (Fig 2)

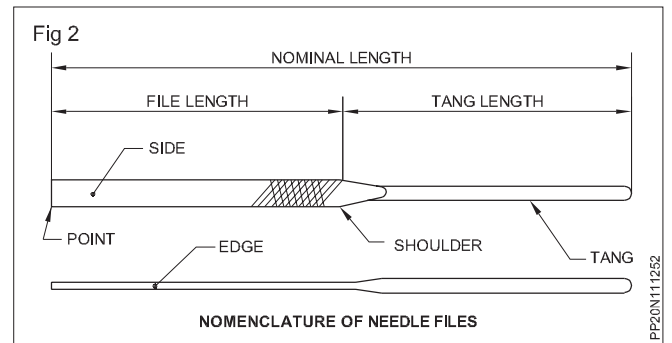
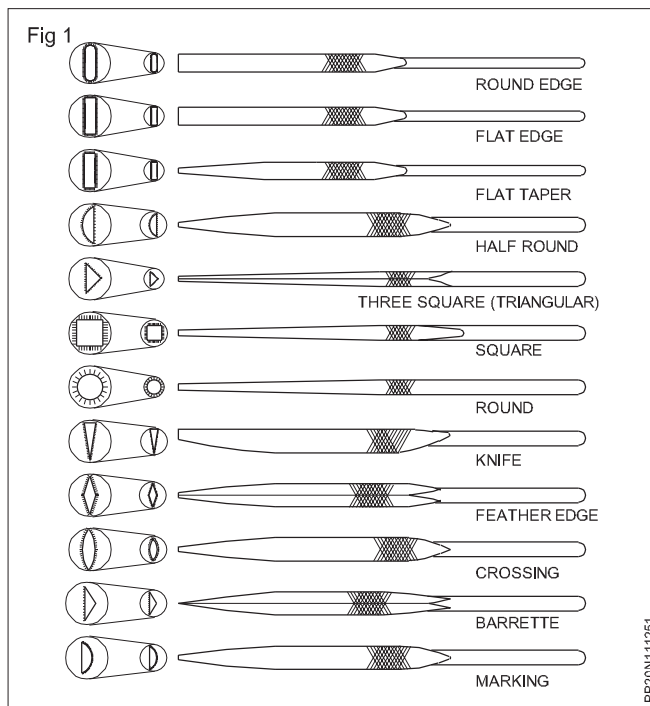
Length: These files are available in a nominal length of 120mm to 180mm.

Grades: The grades of cut may be identified by the cut number as follows

- bastard - Cut 0.
- smooth - Cut 2.

Designation of needle files: The needle files are designated by their names

- grade of cut
- nominal length
- BIS number



Example

A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152

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Drilling processes - drilling machines, types, use and care

Objectives: At the end of this lesson you shall be able to

- name the various types of drilling machines
- name the parts of the bench and pillar type drilling machines
- compare the features of the bench and pillar type drilling machines.

The principle types of drilling machines are

- the sensitive bench drilling machine
- the pillar drilling machine
- the column drilling machine
- the radial arm drilling machine (radial drilling machine).

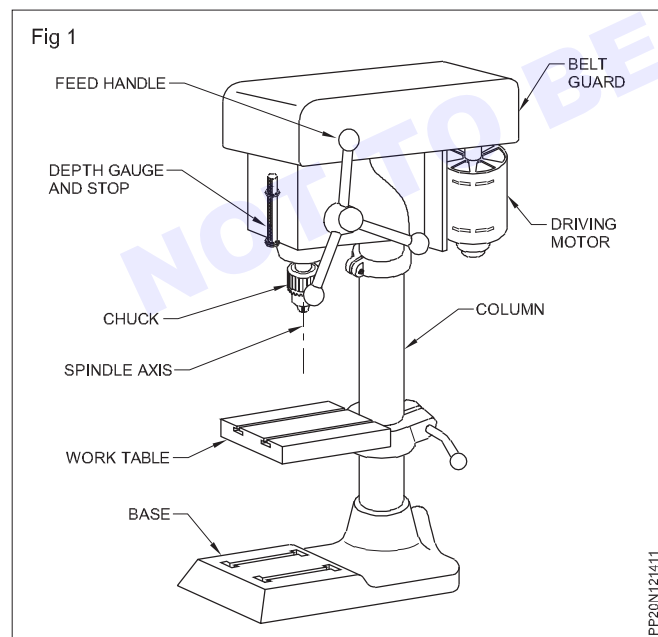
(You are not likely to use the column and radial type of drilling machines now. Therefore, only the sensitive and pillar type machines are explained here)

The sensitive bench drilling machine (Fig 1)

The simplest type of the sensitive drilling machine is shown in the figure with its various parts marked. This is used for light duty work.

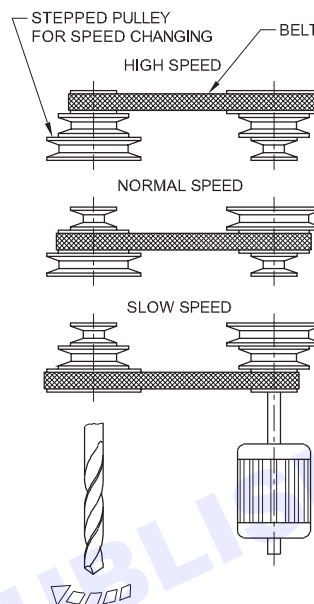
This machine is capable of drilling holes up to 12.5 mm diameter. The drills are fitted in the chuck or directly in the tapered hole of the machine spindle.

For normal drilling, the work-surface is kept horizontal. If the holes are to be drilled at an angle, the table can be tilted. (Tilting arrangement is shown in Fig 1)

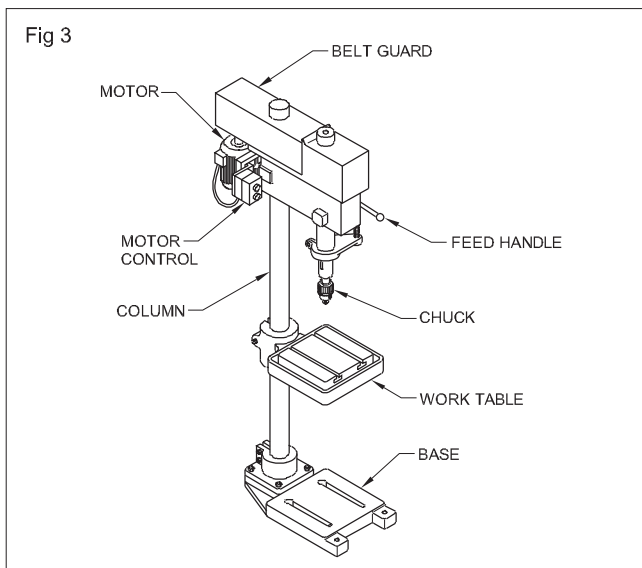


Different spindle speeds are achieved by changing the belt position in the stepped pulleys. (Fig 2)

Fig 2



The pillar drilling machine (Fig 3): This is an enlarged version of the sensitive bench drilling machine. These drilling machines are mounted on the floor and driven by more powerful electric motors.



They are also used for light duty work. Pillar drilling machines are available in different sizes. The larger machines are provided with a rack and pinion mechanism to raise the table for setting the work.

Drill - holding devices

Objectives: At the end of this lesson you shall be able to

- name the types of drill-holding devices
- state the features of drill chucks
- state the functions of drill sleeves
- state the function of drift.

For drilling holes on materials, the drills are to be held accurately and rigidly machines.

The common drill-holding devices are drill chucks and sleeves and sockets.

Drill Chuck

Straight shank drills are held in drill chucks. For fixing and removing drills, the chucks are provided either with a pinion and key or a knureld ring.

The drill chucks are held on the machine spindle by means of an arbor fitted on the drill chuck. (Fig 1)

Taper Sleeves and Sockets (Fig 1)

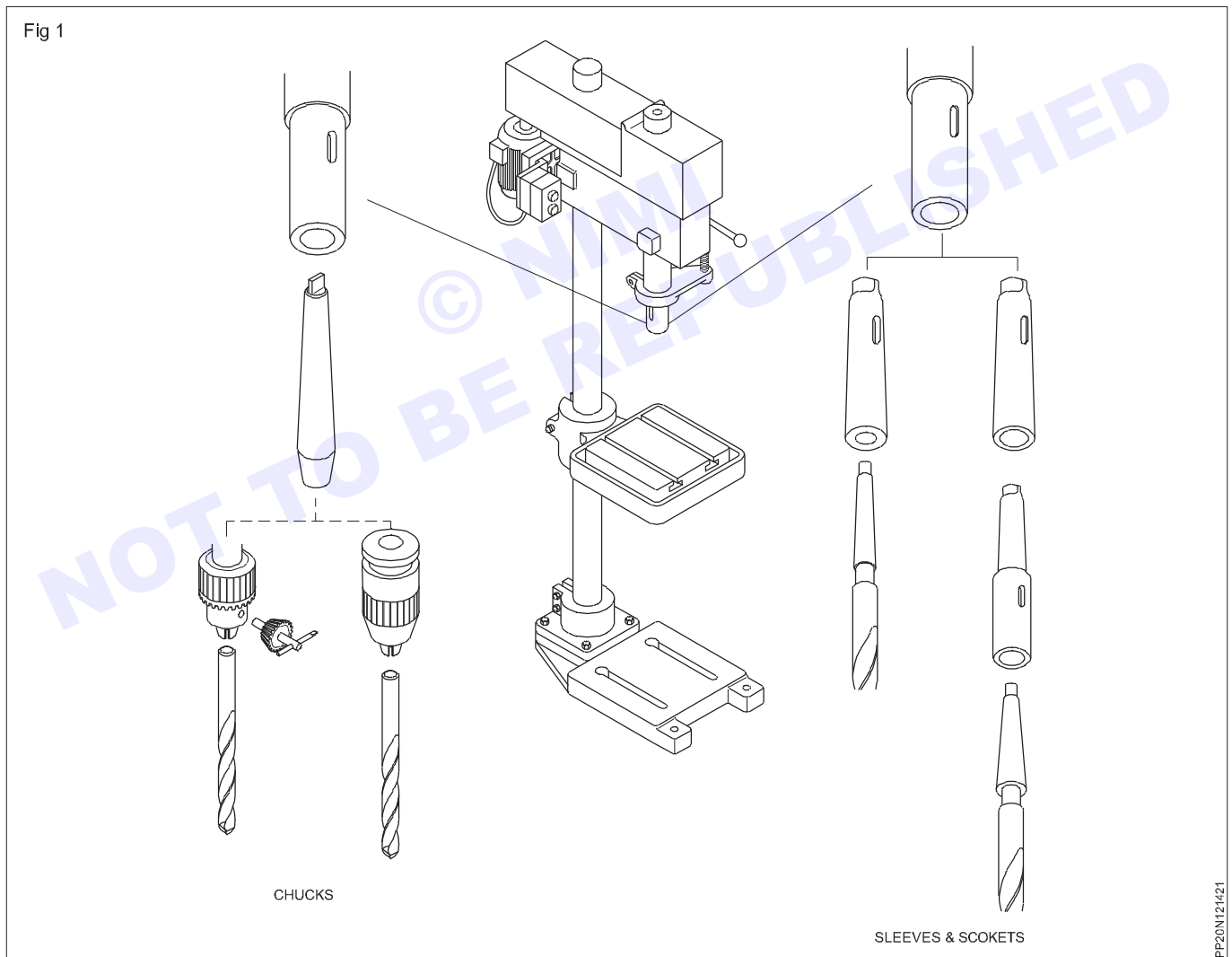
Taper shank drills have a mores taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedding action. Due to this reason mores tapers are called self-holding tapers.

Drills are provided with five different sizes of mores tapers, and are numbered from MT1 to MT5.

In order to make up the difference in sizes between the shanks of the drills and the type of machine spindles sleeves of different sizes are used. When the drill taper shank is bigger than machine spindle, taper sockets are used. (Fig 1)

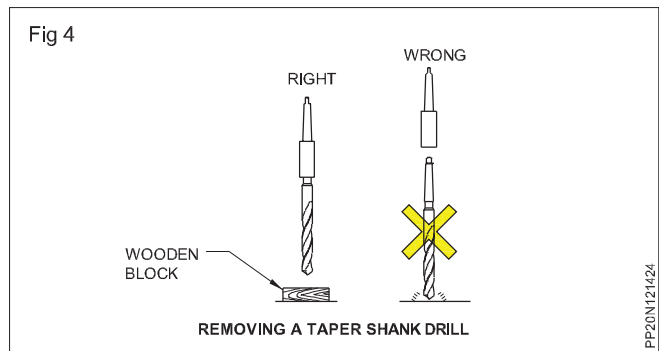
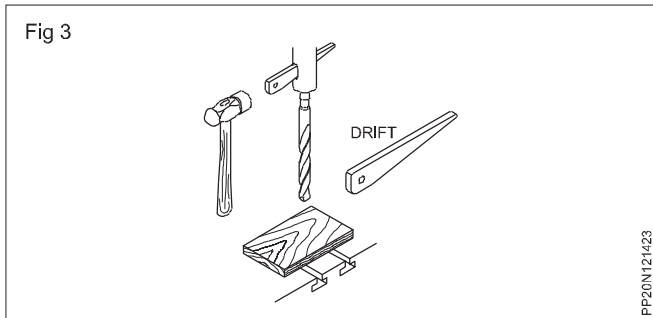
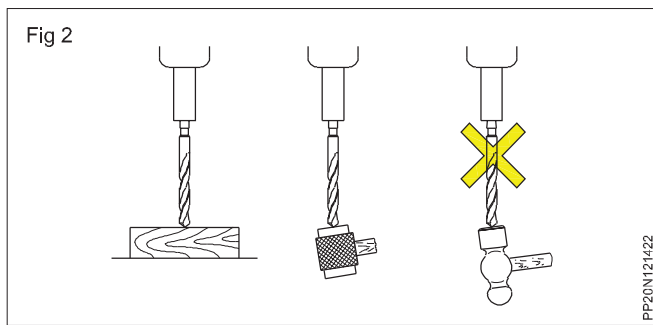
Fig 1



While fixing the drill in a socket or sleeve, the tang portion should align in the slot. (Fig 2) This will facilitate the removal of drill or sleeve from the machine spindle.

Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

While removing the drill from the sockets/ sleeves, don't allow it to fall on the table or jobs. (Fig 4)



Work - holding devices

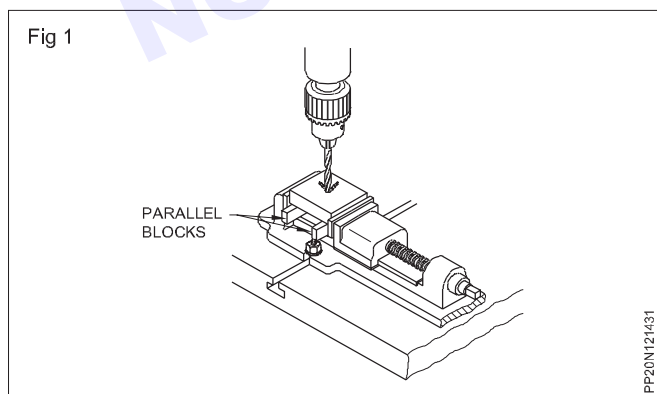
Objectives: At the end of this lesson you shall be able to

- state the purpose of work-holding devices
- name the devices used for holding work
- state the precautions to be observed while using work-holding devices.

Work pieces to be drilled should be properly held or clamped to prevent from rotating along with the drill. Improperly secured work is not only a danger to the operator but can also cause inaccurate work, and breakage to the drill. Various are used to ensure proper holding.

The machine vice

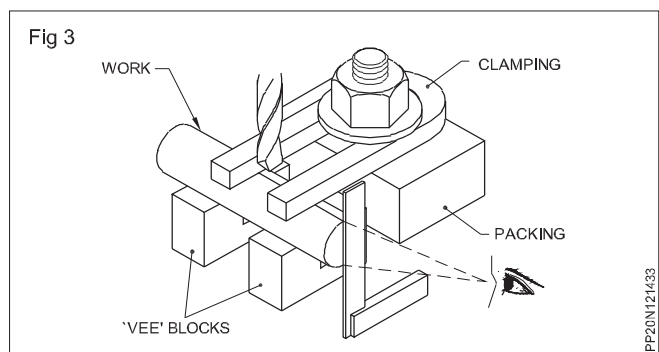
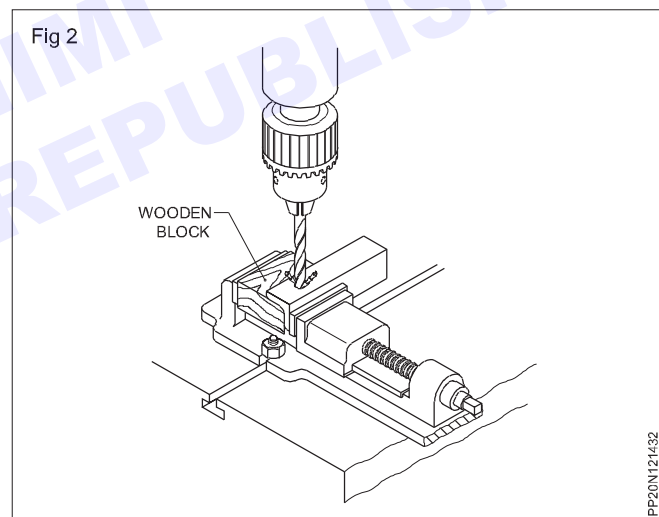
Most of the drilling work can be held in a machine vice. Ensure that the drill does not drill through the vice after it has passed through the work. For this purpose, the work can be lifted up and secured on parallel blocks providing a gap between the work and the bottom of the vice. (Fig 1)



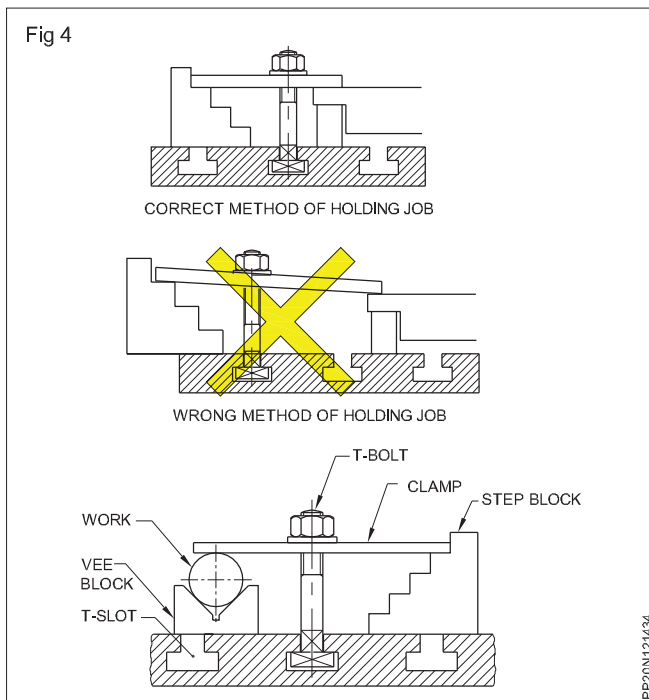
Work pieces which are not accurate may be supported by wooden pieces. (Fig 2)

Clamps and bolts

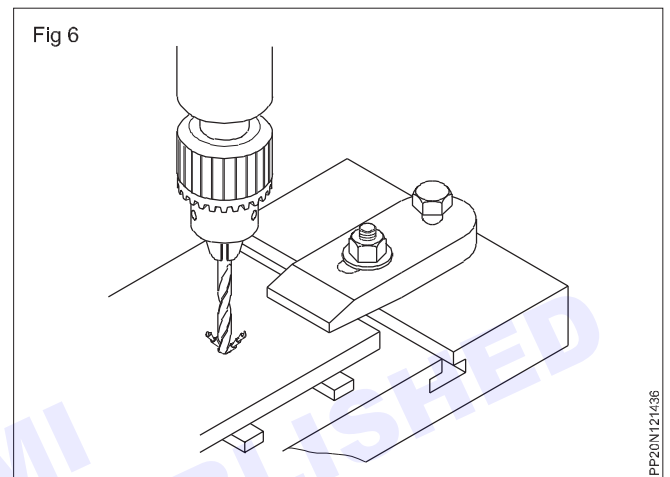
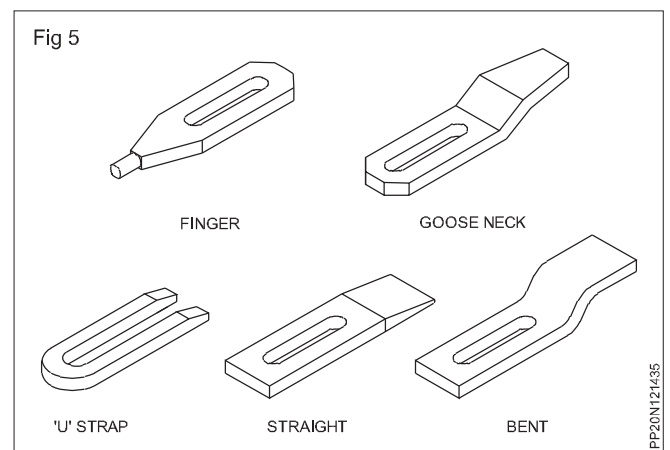
Drilling machine tables are provided with T-slots for fitting bolt heads. Using clamps and bolts, the work pieces can be held very rigidly. (Fig 3) While using this



method, the packing should be, as far as possible, of the same height as the work, and the bolt nearer to the work. (Fig 4)



There are many types of clamps and it is necessary to determine the clamping method according to the work. (Fig 5 & 6)



Cutting speed and RPM

Objectives: At the end of this lesson you shall be able to

- define cutting speed
- state the factors for determining the cutting speed
- differentiate between cutting speed and RPM
- determine RPM/spindle speed
- select RPM for drill sizes from tables.

For a drill to give a satisfactory performance, it must operate at the correct cutting speed and feed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the table. Based on the cutting speed recommended, the RPM, at which a drill has to be driven, is determined.

Materials being drilled for HSS	Cutting speed (m/min)
Aluminium	70 - 100
Brass	35 - 50
Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy,high tensile)	20 - 30
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Calculating RPM

$$n = \frac{v \times 1000}{d \times \pi} \text{ RPM} \quad v = \frac{n \times d \times \pi}{1000} \text{ m/min}$$

n - RPM

v - cutting speed in m/min.

d - diameter of the drill in mm

$\pi = 3.14$

Examples: Calculate the RPM for a high speed steel drill $\varnothing 24$ to cut mild steel.

The cutting speed for MS is taken as 30 m/min. from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ RPM}$$

It is always preferable to set the spindle speed to the nearest available lower range. The selected spindle speed is 300 RPM.

The RPM will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser RPM and smaller diameter drills will have higher RPM.

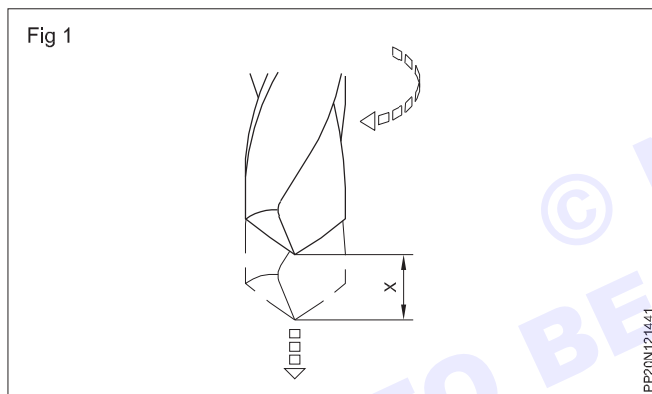
The recommended cutting speeds are achieved only by actual experiments.

Feed in drilling

Objectives: At the end of this lesson you shall be able to

- state what is meant by feed
- state the factors that contribute to an efficient feed rate.

Feed is the distance (X) a drill advances into the work in one complete rotation. (Fig 1)



Feed is expressed in hundredths of a millimeter.

Example - 0.040mm

The rate of feed is dependent upon a number of factors.

Finish required

Type of drill (drill material)

Material to be drilled

Factors like rigidity of the machine, holding of the work piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table for the feed rate given here is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

Drill diameter (mm) HSS	Rate of feed (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 - 12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.

Radial drilling machines

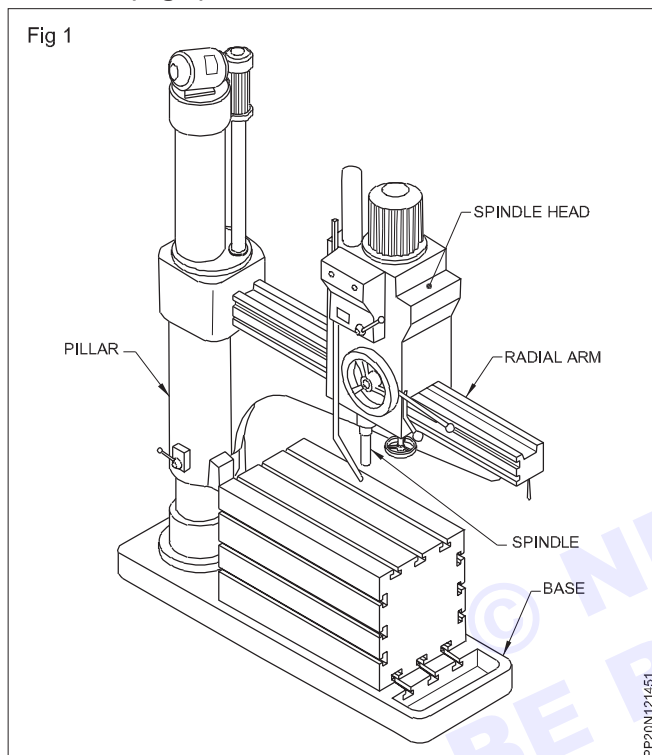
Objectives: At the end of this lesson you shall be able to

- state the uses of a radial drilling machine
- state the features of radial drilling machine.

Radial drilling machines are used to drill

- large diameter holes
- multiple holes in one setting of the work
- heavy and large work pieces.

Features (Fig 1)



The radial drilling machine has a radial arm on which the spindle head is mounted

The spindle head can be moved along the radial arm and can be locked in any position

The arm is supported by a pillar (column). It can be rotated about with the pillar as center. Therefore, the drill spindle can cover the entire working surface of the table. The arm can be lifted or lowered.

The motor mounted on the spindle head rotates the spindle.

The variable-speed gear box provides a large range of R.P.M.

The spindle can be rotated in both clockwise and anticlockwise directions.

Angular holes can be drilled on machines having tilting tables.

A coolant tank is mounted on the base.

Precautions

Ensure that the spindle-head and the arms are locked properly to avoid vibration.

The workpiece and the drill should be rigidly held.

Bring back the spindle head nearer to the pillar after use.

Switch off power when not in use.

Use the drill drift for removing the drills, chucks or sockets.

Use a minimum number of sockets and sleeves to make for the spindle bore size.

Clean and oil the machine after use.

Stop the machine to remove the swarf.

Use a brush to clean the chips and swarf.

Gang drilling machine and multiple spindle head drilling machine

Objectives: At the end of this lesson you shall be able to

- state the uses of a gang drilling machine
- state the construction of a gang drilling machine
- state the uses and construction of a multiple spindle head drilling m/c .

Gang drilling machine (Fig 1)

It consists of a large base supporting a long table. The top of the table is designed in such a way that several units may be mounted on it. Each spindle is driven by its individual directly connected motor.

The table has a groove around the outside for the return of the cutting lubricant, and may have 'T'-slots on its surface for ease in clamping the work to the table.

This type of machine is generally preferred when the work is to be moved from spindle to spindle for successive operations.

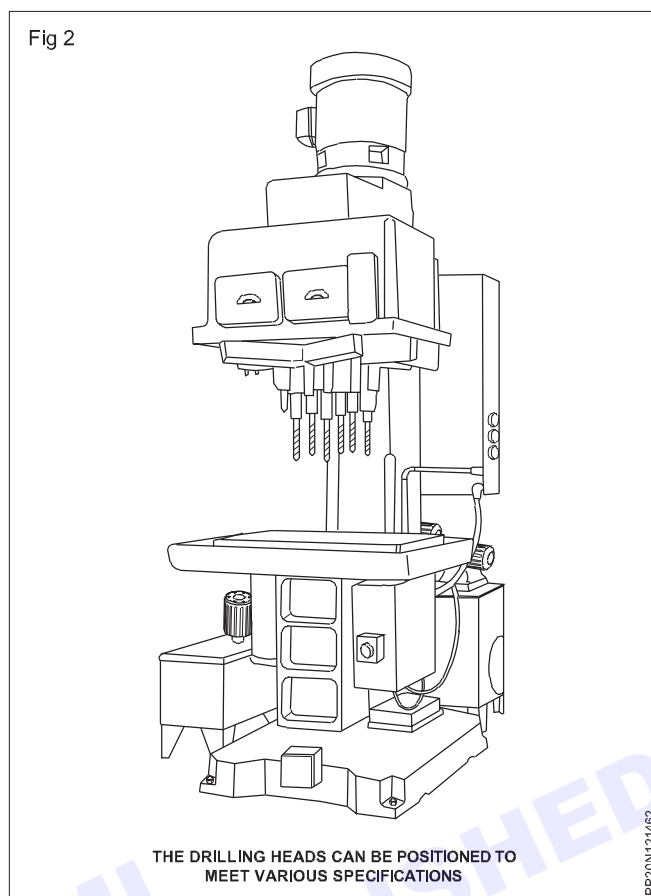
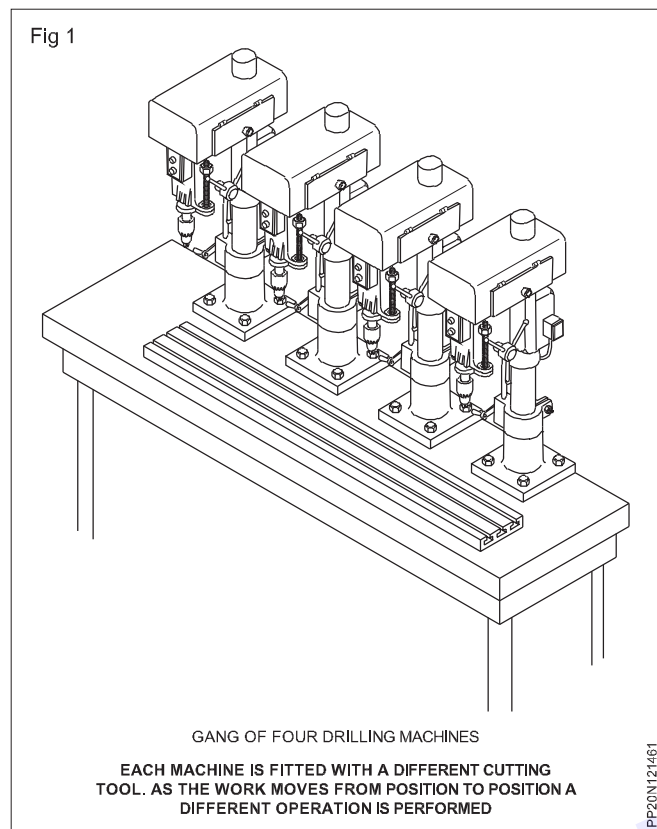
Multiple spindle head drilling machine (Fig 2)

The multiple spindle head drilling machine may have any number of spindles - from 4 to 48 or more, all driven from the one-spindle drive gear in one head.

The multiple spindle head drilling machine is specially designed for mass production operations such as drilling, reaming or tapping many holes at one time in a specific unit of work such as an automobile engine block.

There may be two or more drill heads on one machine, each with many spindles. This is necessary when holes

are drilled from more than one direction - for example, on the top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.



Hand taps and wrenches

Objectives: At the end of this lesson you shall be able to

- state the uses of threading hand taps
- state the features of hand taps
- distinguish between different taps in a set
- name the different types of tap wrenches
- state the uses of different types of wrenches.

Use of hand taps

Hand taps are used for internal threading of components.

Features (Fig 1)

They are made from high carbon steel or high speed steel, hardened and ground.

Threads are cut on the surface, and are accurately finished.

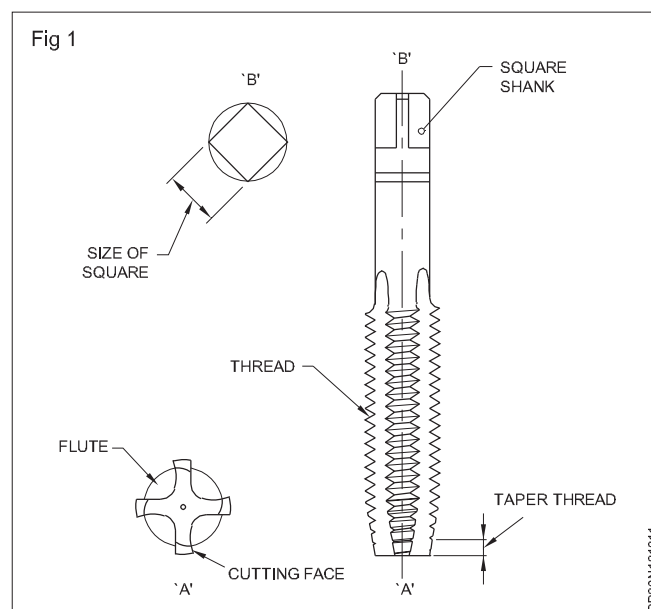
To form the cutting edges, the flutes are cut across the thread.

For holding and turning the taps while cutting threads, the ends of the shanks are squared.

The ends of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.

The size of the taps and the type of the thread are usually marked on the shank.

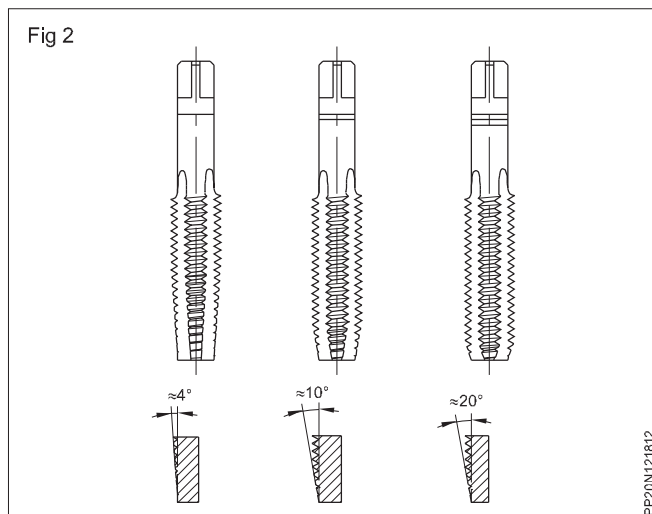
In certain cases, the pitch of the thread will also be marked.



Markings are also made to indicate the type of tap i.e. first, second or plug.

Types of Taps in a set

Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)



These are
first tap or taper tap
second tap or intermediate tap
plug or bottoming tap.

These taps are identical in all features except in the taper lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

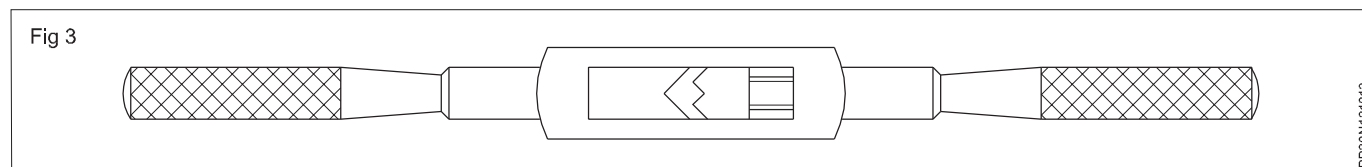
For identifying the type of taps quickly - the taps are either numbered as 1, 2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two rings and the bottoming tap has three rings. (Fig 2)

Tap Wrenches

Tap wrenches are used to align and drive the hand taps correctly into the hole to be threaded.

Tap wrenches are of different types.



Tap drill size

Objectives: At the end of this lesson you shall be able to

- state what is tap drill size
- choose the tap drill sizes of different threads from tables
- calculate the tap drill sizes for ISO metric and ISO inch.

What is a tap drill size?

Before a tap is used for cutting internal threads, a hole is to be drilled.

Double ended adjustable wrench, T-handle tap wrench, solid type tap wrench.

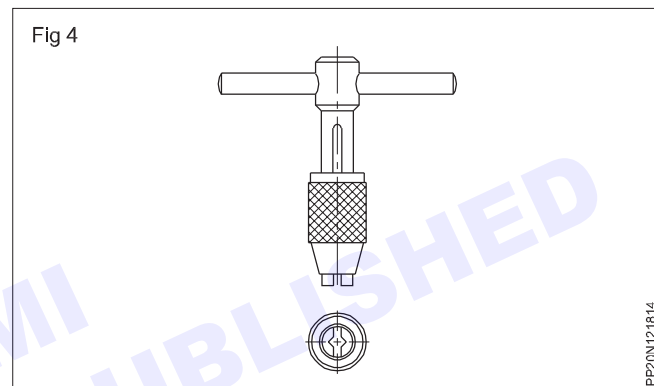
Double-ended Adjustable Tap Wrench or Bar Type Tap Wrench (Fig 3): This is the most commonly used type of tap wrench. It is available in various sizes. These tap wrenches are more suitable for large diameter taps, and can be used in open places where there is no obstruction to turn the tap. It is important to select the correct size of wrench.

T-Handle tap wrench (Fig 4)

These are small adjustable chucks with two jaws and a handle to turn the wrench.

This tap wrench is useful to work in restricted places, and is turned with one hand only.

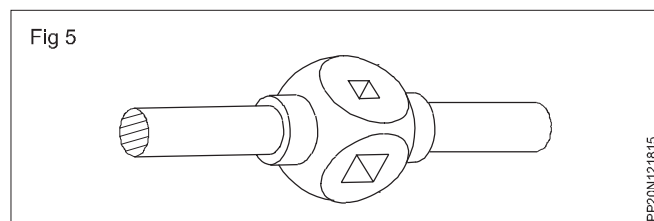
This wrench is not available for holding large diameter taps.



Solid type tap wrench (Fig 5)

These wrenches are not adjustable.

They can take only certain sizes of taps. This eliminates the use of wrong length of the tap wrenches, and thus prevents damage to the taps.



Tap drill sizes for different threads

ISO Metric Thread

Tapping drill size

for M10 x 1.5 thread

Minor diameter = Major diameter – 2 x depth

depth of thread = 0.6134 x pitch of a screw

2 depth of thread = 0.6134 x 2 x pitch

= 1.226 x 1.5 mm = 1.839 mm

Minor dia (D1) = 10 mm – 1.839 mm

= 8.161 mm or 8.2 mm

This tap drill will produce 100% thread because this is equal to the minor diameter of the thread. For most fastening purposes a 100% formed thread is not required.

A standard nut with 60% thread is strong enough to be tightened until the bolt breaks without stripping the thread. Further it also requires a greater force for turning the tap if a higher percentage formation of thread is required.

Considering this aspect, a more practical approach for determining the tap drill sizes is

Tap drill size = Major diameter – pitch

= 10 mm – 1.5 mm

= 8.5 mm.

Compare this with the table of tap drill sizes for ISO metric threads.

ISO Inch (Unified) threads Formula

Tap Drill size =

Major diameter – $\frac{1}{\text{Number of threads per inch}}$

For calculating the tap drill size for 5/8" UNC thread

Tap drill size = 5/8" – 1/11"

= 0.625" – 0.091"

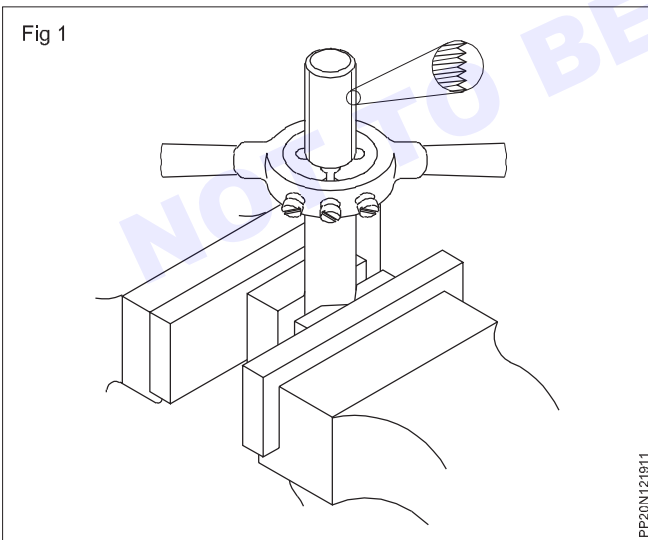
= 0.534"

Tools used in external threading die & die stock

Objectives: At the end of this lesson you shall be able to

- list the different types of dies
- state the features of each type of die
- state the uses of each type of die
- name the type of the stock for each type of die
- determine the diameter of blank size for external thread cutting.

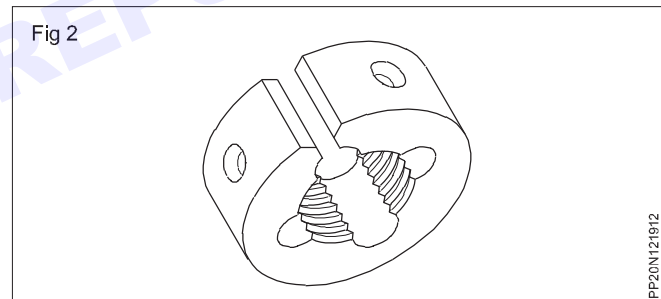
Threading dies are used to cut external threads on cylindrical work pieces. (Fig 1)



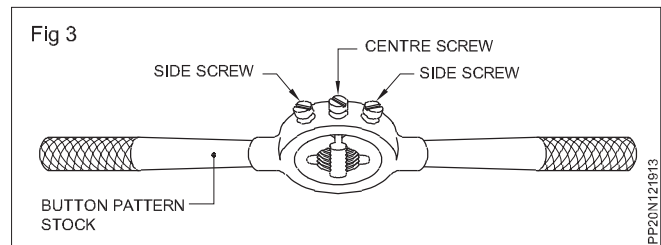
Types of dies: The following are the different types of dies.

- Circular split die (Button die)
- Half die
- Adjustable screw plate die.

Circular split die/button die (Fig 2): This has a slot cut to permit slight variation in size.



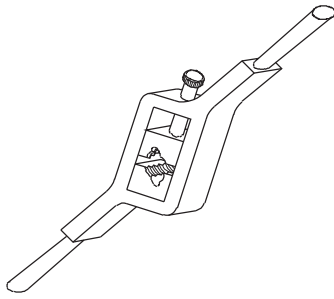
When held in the die stock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3) For adjusting the depth of cut, the centre screw is advanced and locked in the groove. This type of die is called the button die.



Half die (Fig 4): Half dies are stronger in construction.

Adjustments can be made easily to increase or decrease the depth of cut.

Fig 4



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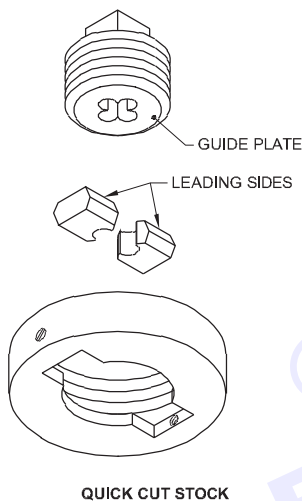
These dies are available in matching pairs and should be used together.

By adjusting the screw of the die, the die pieces can be brought close together or can be moved apart.

They need a special die-holder.

Adjustable screw plate die (Fig 5)

Fig 5



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This is another type of a two-piece die similar to the half die.

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

Vernier calipers

Objectives: At the end of this lesson you shall be able to

- name the parts of a vernier caliper
- describe the parts of a vernier caliper
- state the uses of a vernier caliper.

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

Parts of a vernier caliper

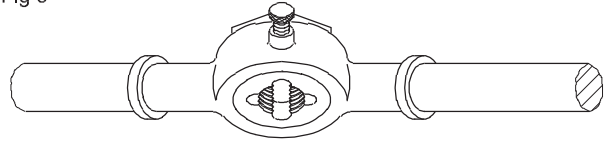
(Numbers as per Fig 1)

The die pieces can be adjusted, using the adjusting screws on the collar.

The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped. Both pieces should have the same serial numbers.

This type of die stock is called quick cut die stock. (Fig 6)

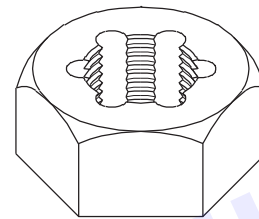
Fig 6



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Die nut (Solid die) (Fig 7): The die nut is used for chasing or reconditioning the damaged threads.

Fig 7



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Die nuts are not to be used for cutting new threads

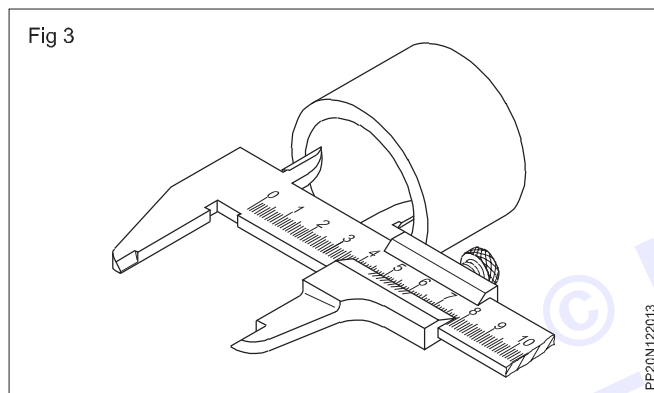
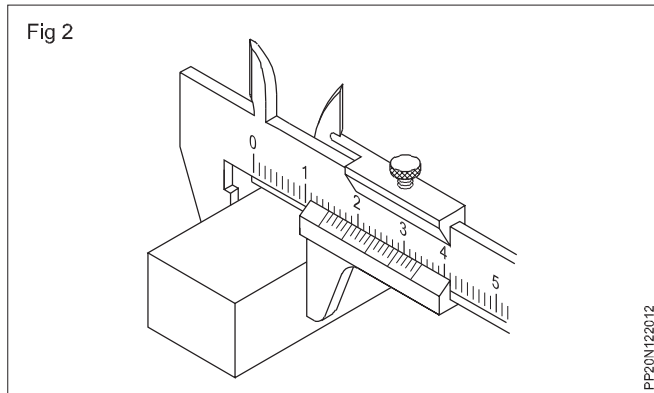
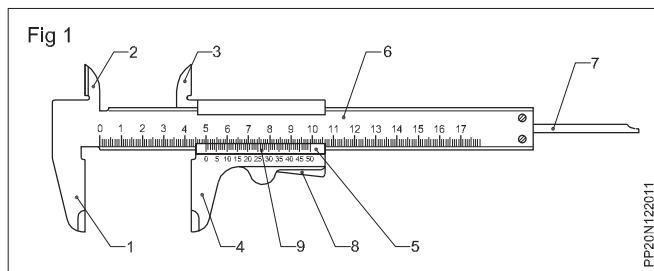
The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Determining the diameter of blank size for external thread cutting

Why should the blank size be less?

It has been observed from practice that the threaded diameters of steel blanks show a slight increase in diameter. Such increase in the diameter will make the assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced equal to $0.1 \times \text{pitch}$ of the thread before commencing the threading.



Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Graduations and reading of vernier calipers

Objectives: At the end of this lesson you shall be able to

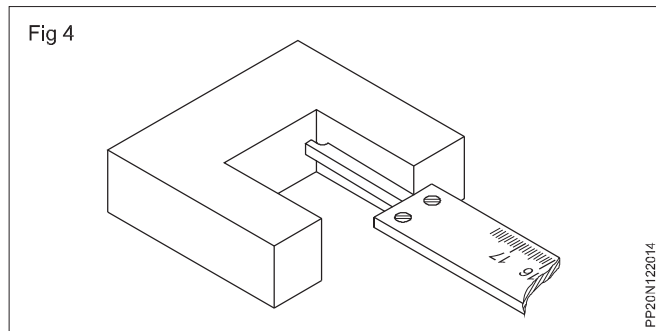
- determine the least count of a vernier caliper
- state how graduations are made on a vernier caliper with 0.02 mm least count
- read vernier caliper measurements.

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Depth bar (7) (Fig 4): The depth bar is attached to the vernier slide and is used for measurement of depth.



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm

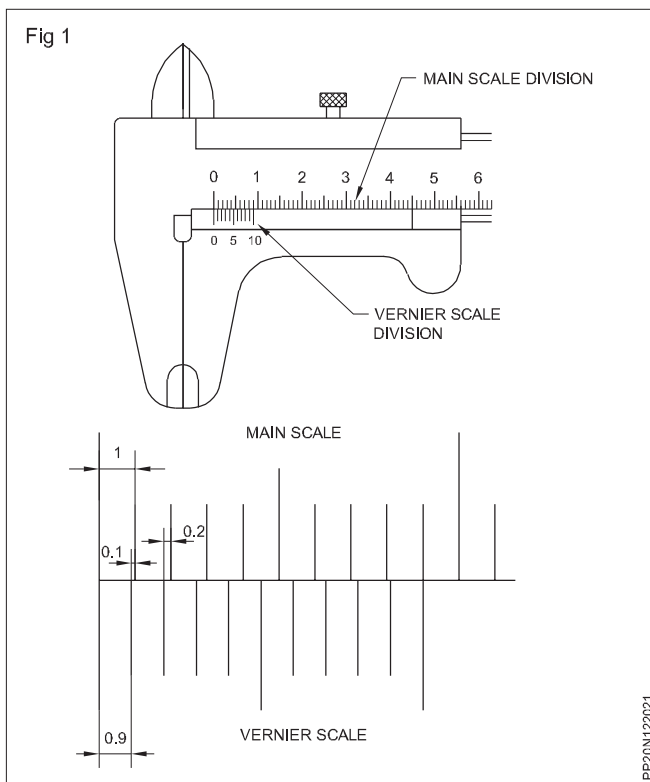
One vernier scale division (VSD) = $9/10$ mm

Least count = 1 MSD - 1 VSD

= 1 mm - $9/10$ mm

= 0.1 mm

The difference between one MSD and one VSD = 0.1 mm

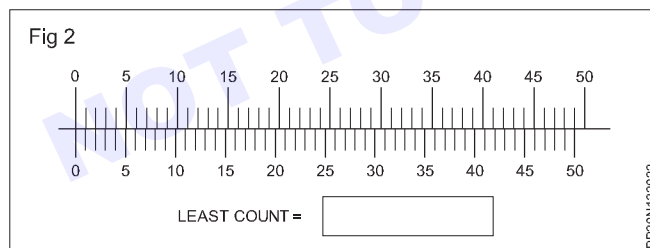


Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.



$$\begin{aligned}\text{Least count} &= 1 \text{ mm} - 49/50 \text{ mm} \\ &= 1/50 \text{ mm} \\ &= 0.02 \text{ mm.}\end{aligned}$$

Example for reading vernier caliper (Fig 3)

Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28th division, value = $28 \times 0.02 \text{ mm}$

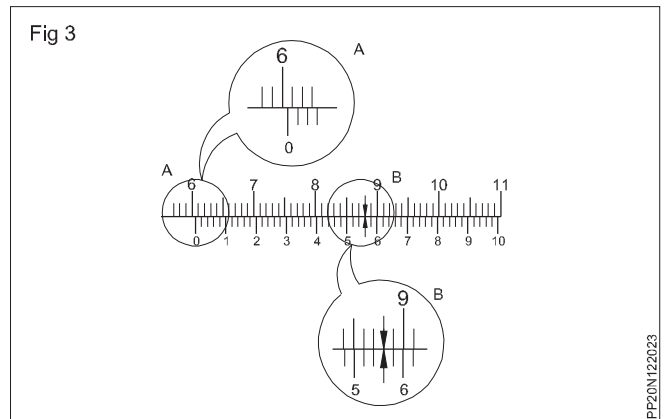
$$= 0.56 \text{ mm}$$

Reading

$$= 60 + 0.56$$

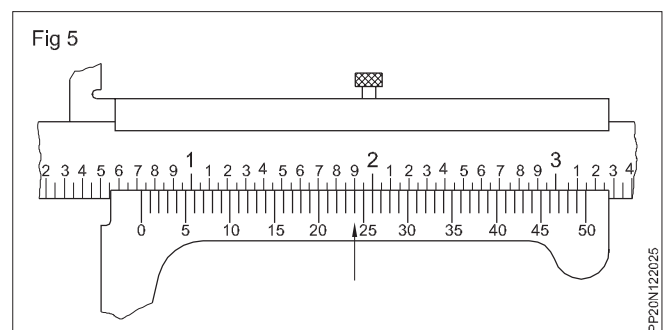
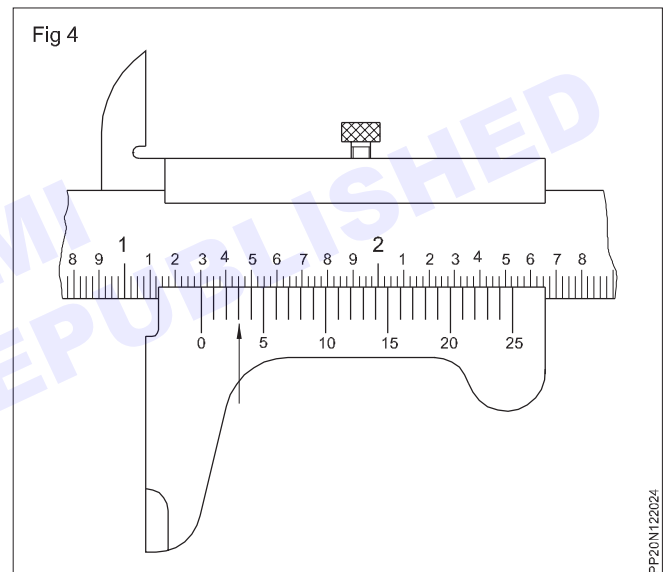
$$\text{Total Reading} = 60.56 \text{ mm}$$

Barrel subdivision 1/40 or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.



Assignment

- 1 Read the vernier caliper measurement as shown in Fig 4 and 5.



Answer inch.

Answer inch.

- 2 Read and record the measurements of an outside micrometer shown in the Fig 6 and 7.

Answer inch.

Answer inch.

Fig 6

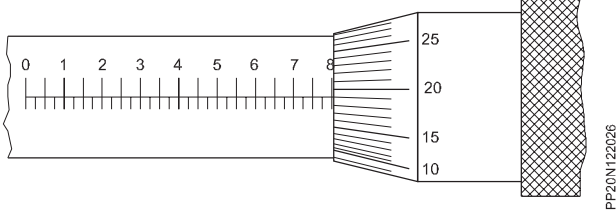
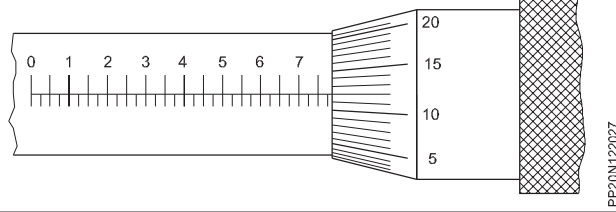


Fig 7



Micrometer

Objectives: At the end of this lesson you shall be able to

- name the parts of an outside micrometer
- state the functions of the main parts of an outside micrometer.

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

The parts of a micrometer are listed here.

Frame

The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

Thimble

On the bevelled surface of the thimble also, the graduation is marked. The spindle is attached to this.

Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded mechanism allows for the forward and backward movement of the spindle.

Anvil

The anvil is one of the measuring faces which is fitted on the micrometer frame. It is made of alloy steel and finished to a perfectly flat surface.

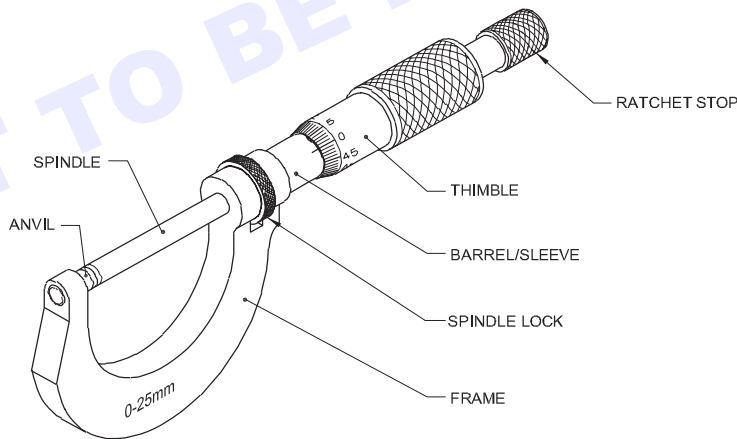
Spindle lock nut

The spindle lock nut is used to lock the spindle at a desired position.

Ratchet stop

The ratchet stop ensures a uniform pressure between the measuring surfaces.

Fig 1



Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to

- state the principle of a micrometer
- determine the least count of an outside micrometer.

Working principle

The micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw. The movement of the spindle to the distance of the pitch or its fractions can be accurately measured on the barrel and thimble.

Graduations (Fig 1)

In metric micrometers the pitch of the spindle thread is 0.5 mm.

Thereby, in one rotation of the thimble, the spindle advances by 0.5 mm.

On the barrel a 25 mm long datum line is marked. This line is further graduated to millimetres and half millimetres (i.e. 1 mm & 0.5 mm). The graduations are numbered as 0, 5, 10, 15, 20 & 25 mm.

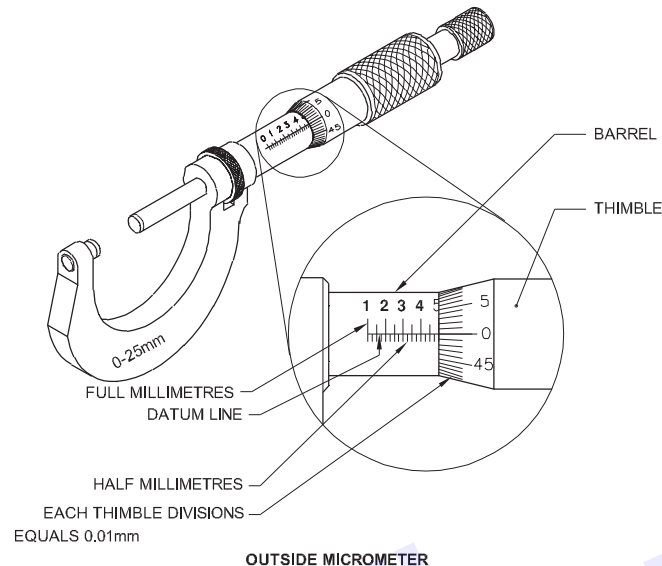
The circumference of the bevel edge of the thimble is graduated into 50 divisions and marked 0-5-10-15 45-50 in a clockwise direction.

The distance moved by the spindle during one rotation of the thimble is 0.5 mm.

$$\text{Movement of one division of the thimble} = 0.5 \times 1/50 \\ = 0.01 \text{ mm}$$

Accuracy or least count of a metric outside micrometer is 0.01 mm.

Fig 1



PP20N12221

Reading dimensions with outside micrometer

Objectives: At the end of this lesson you shall be able to

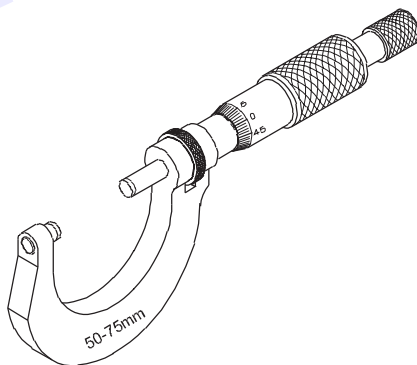
- select the required range of a micrometer
- read micrometer measurements.

Ranges of outside micrometer

Outside micrometers are available in ranges of 0 to 25 mm, 25 to 50 mm, 50 to 75 mm, 75 to 100 mm, 100 to 125 mm and 125 to 150 mm.

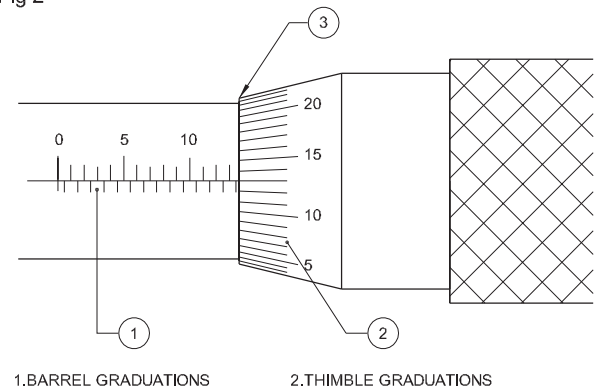
For all ranges of micrometers, the graduations marked on the barrel is only 0-25 mm. (Fig 1)

Fig 1



PP20N12231

Fig 2



PP20N12232

Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

$$13.00 \text{ mm (Main division reading on barrel)} \\ + 00.50 \text{ mm (Sub division reading on barrel)} \\ 13.50 \text{ mm (Main division + sub - division value)}$$

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)

Multiply this value with 0.01 mm (least count).

$$13 \times 0.01 \text{ mm} = 0.13 \text{ mm.}$$

Reading micrometer measurements

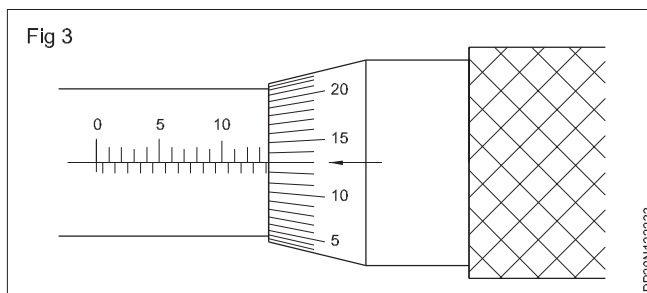
How to read a measurement with an outside micrometer? (Fig 2)

First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	63.63 mm

The micrometer reading is 63.63 mm.



Constructional features of outside micrometer

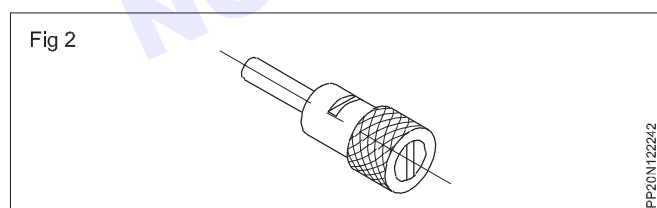
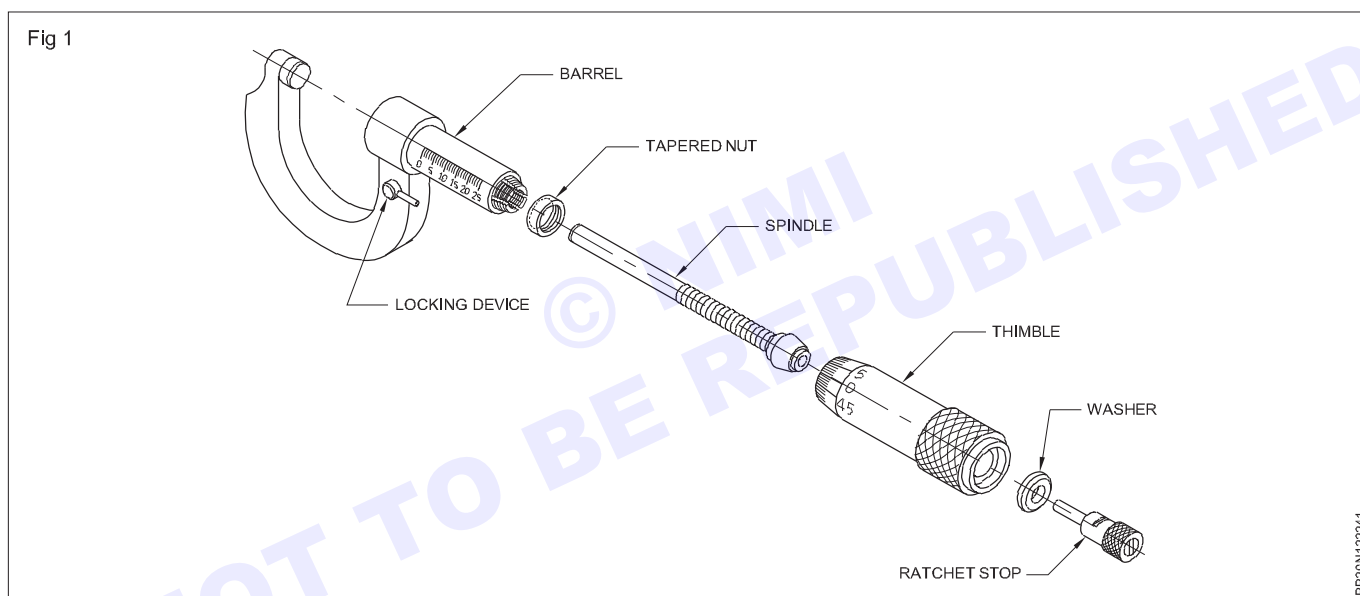
Objectives: At the end of this lesson you shall be able to

- name the internal parts of a micrometer
- state the functions of the various parts of a micrometer
- state the precautions to be observed while dismantling and assembling micrometers.

In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 1)

Ratchet stop (Fig 2)

This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.



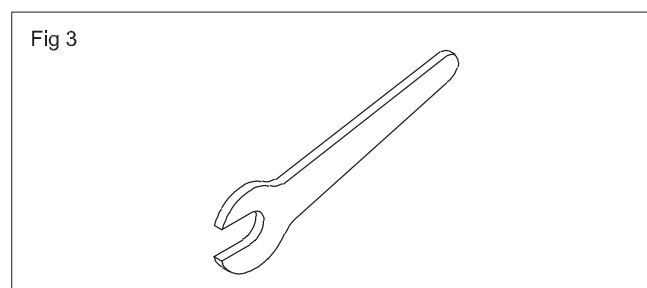
The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.

This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 3)

Thimble

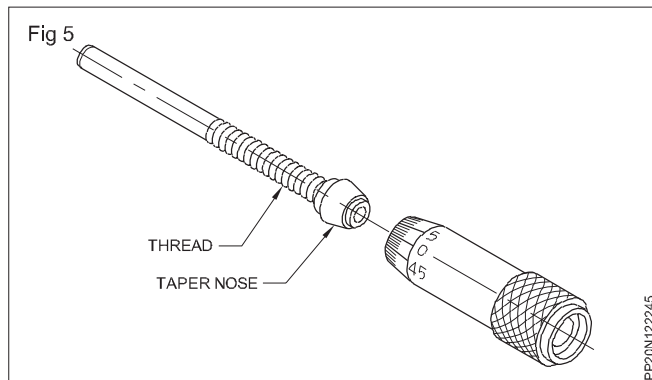
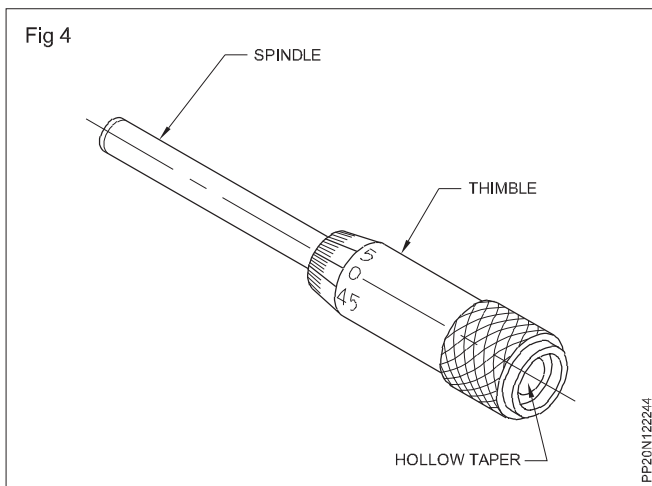
The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.



Spindle

One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 5)

The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

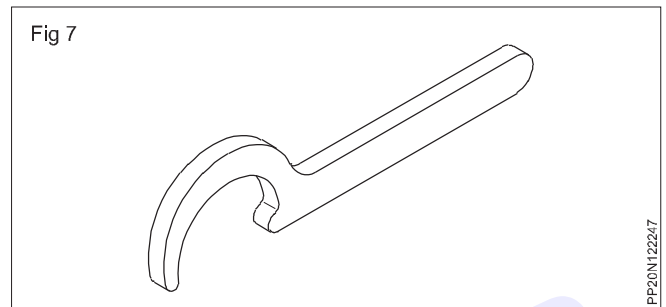
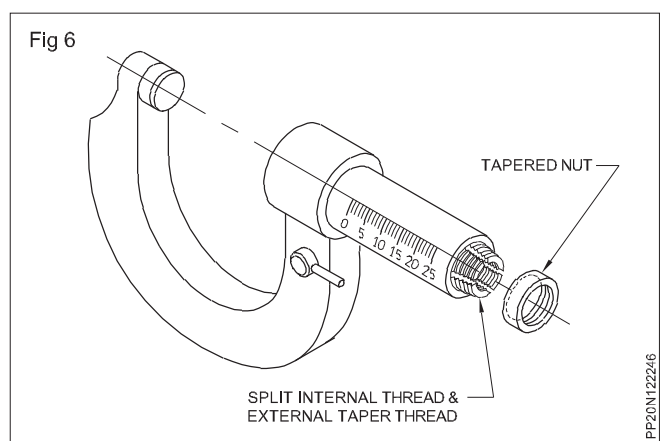


The spindle passes through a split internal thread (Fig 6) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

Tightening and loosening of this nut enables the split internal thread to close or open. This permits the wear adjustment in the mating threads.

A special spanner is provided for this purpose. (Fig 7)

The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.



Precautions while dismantling micrometers

Avoid touching the measuring faces with bare fingers as it might cause rusting.

Protect the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enamelled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Vernier height gauge

Objectives: At the end of this lesson you shall be able to

- name the parts of a vernier height gauge
- state the constructional features of a vernier height gauge
- state the functional features of a vernier height gauge
- state the various applications of the vernier height gauge in engineering.

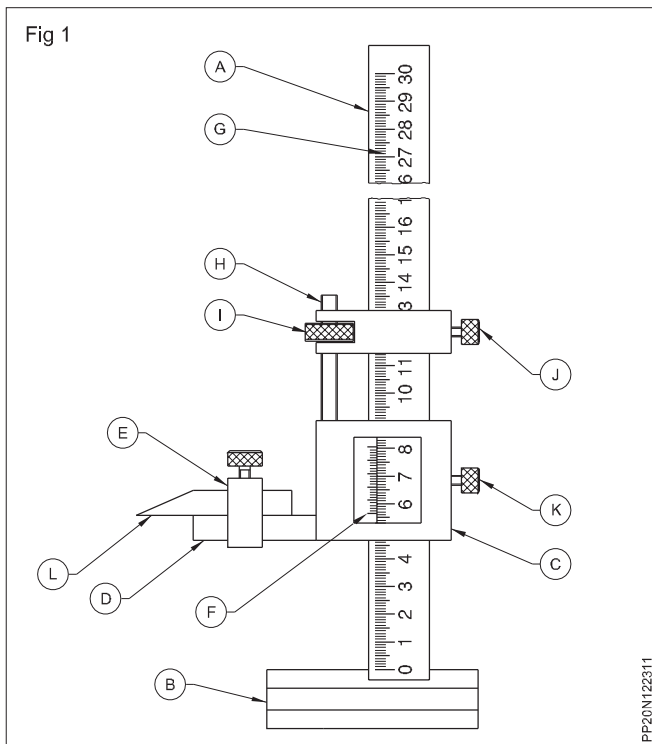
Parts of a vernier height gauge (Fig 1)

- A Beam
- B Base
- C Main slide
- D Jaw
- E Jaw clamp
- F Vernier scale
- G Main scale

- H Finer adjusting slide
- I Finer adjusting nut
- J&K Locking screws
- L Scriber blade

Constructional features of a vernier height gauge:

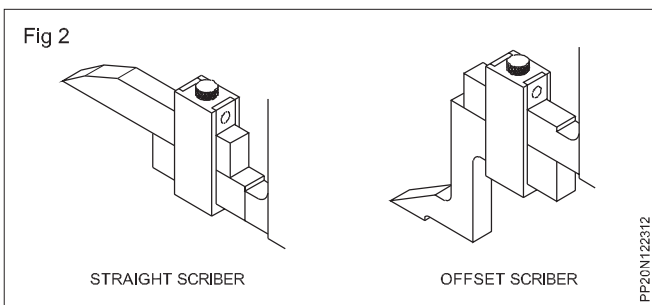
The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.



The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.

The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting

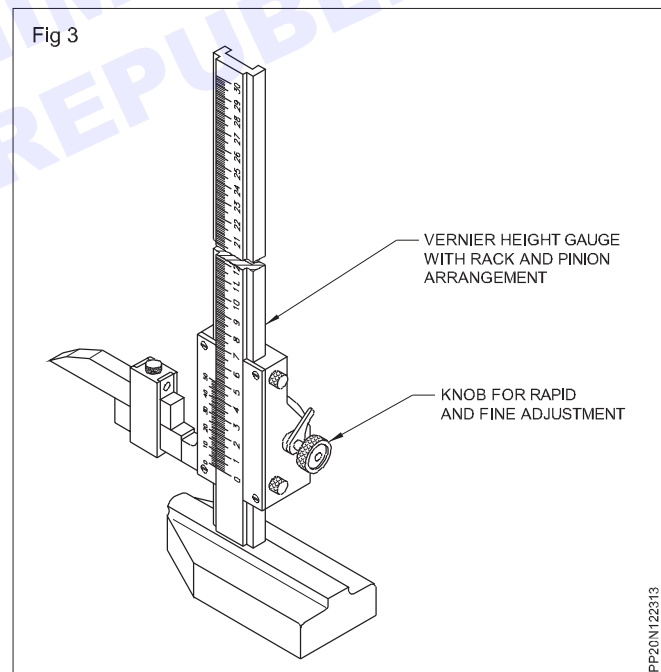
slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact mark able height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact mark able dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base. In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)

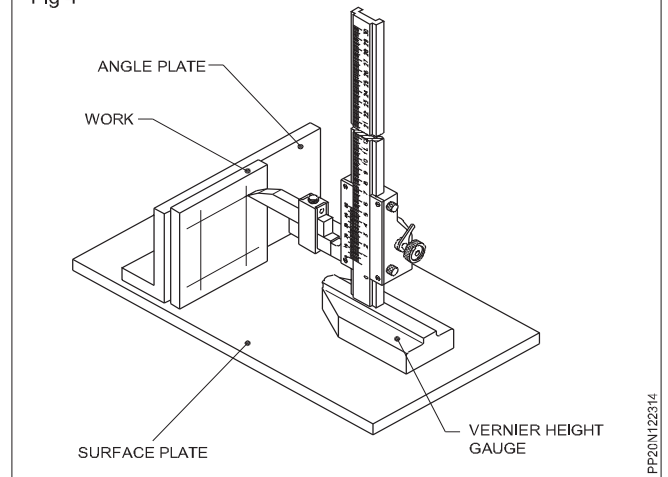
It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scribe.

Fig 4



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Vernier bevel protractor

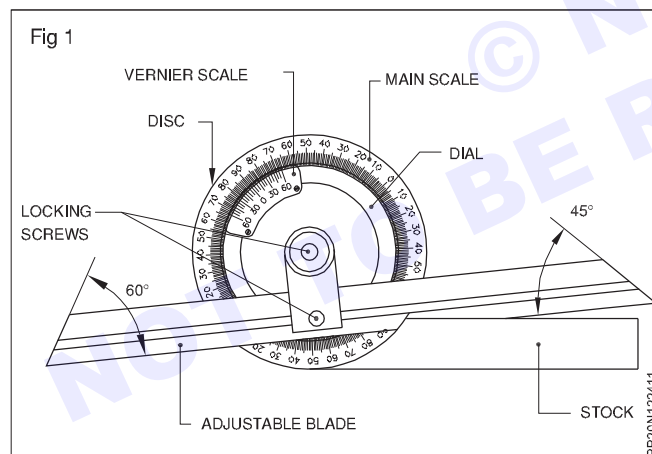
Objectives: At the end of this lesson you shall be able to

- name the parts of a vernier bevel protractor
- state the functions of each part
- list out the uses of a vernier bevel protractor.

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)



PP20N122411

Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the center of the blade to enable it to be longitudinally positioned whenever necessary.

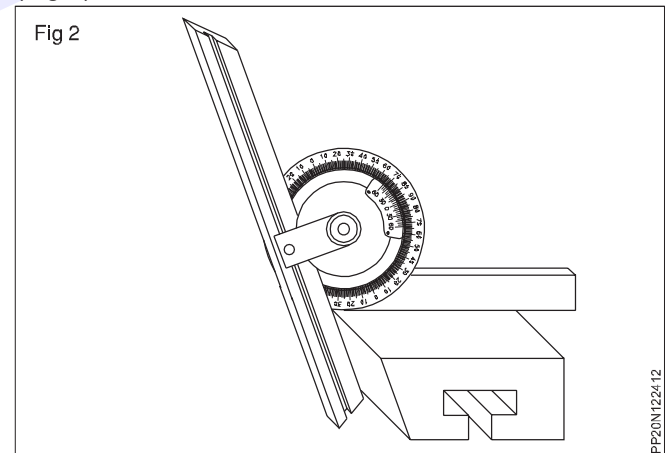
Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.

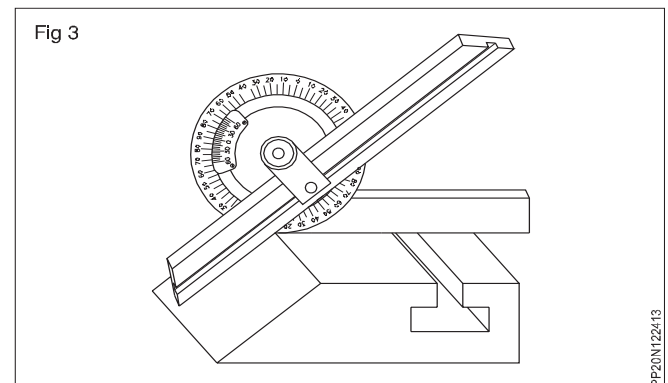
The vernier bevel protractor is used to measure acute angles than 90° (Fig 2) obtuse angles more than 90° (Fig 3).

Fig 2



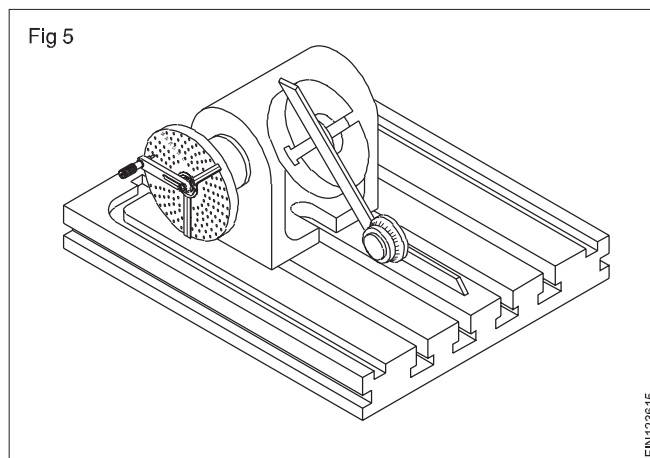
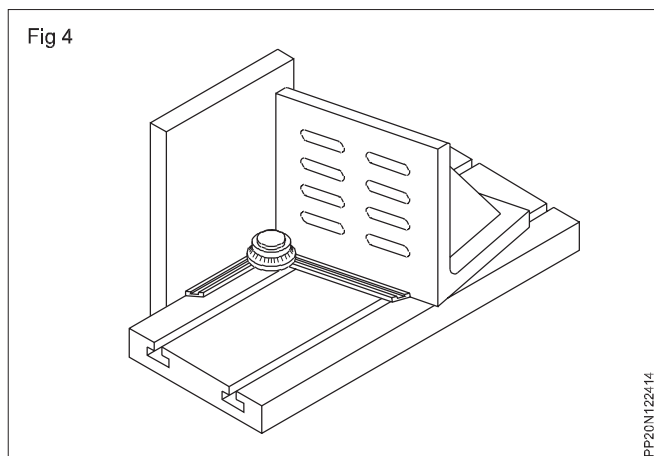
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Fig 3



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For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)

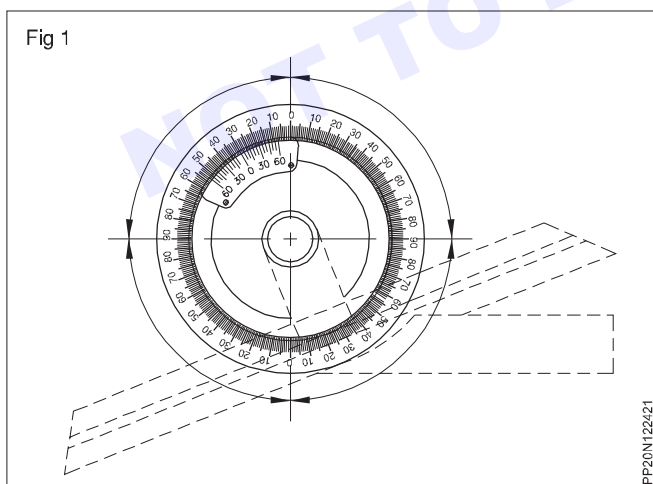


Graduations on universal bevel protractor

Objectives: At the end of this lesson you shall be able to

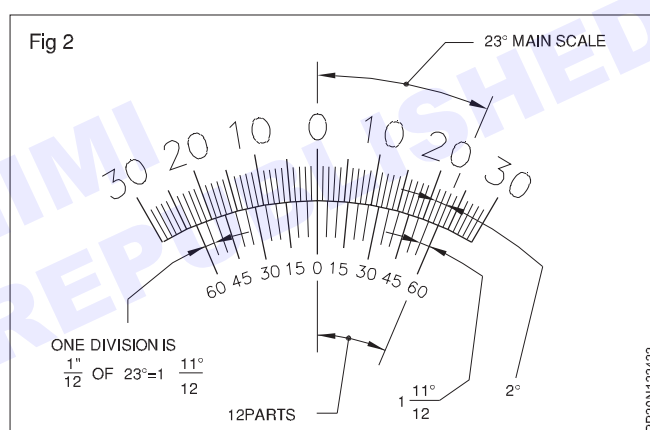
- state the main scale graduations on the disc
- state the vernier scale graduations on the dial
- determine the least count of the vernier bevel protractor.

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)



One vernier scale division VSD (Fig 2)

The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)



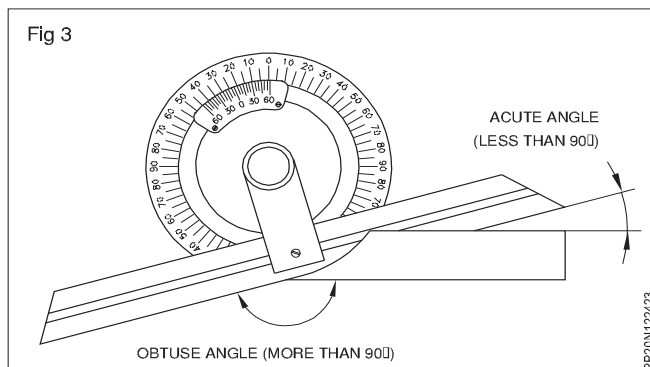
Hence the least count is

2 MSD - 1 VSD

i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^0}{12} = \frac{1^0}{12} \text{ or } 5'$$

For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

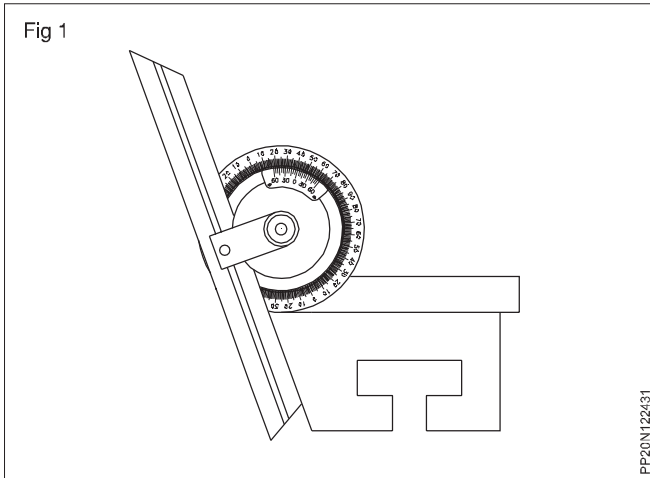


Reading of universal bevel protractor

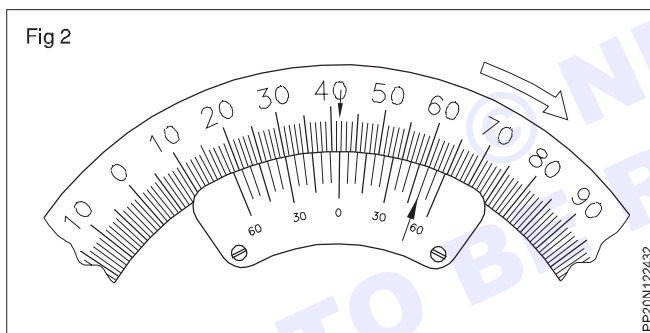
Objectives: At the end of this lesson you shall be able to

- read a vernier bevel protractor for acute angle setting
- read a vernier bevel protractor for obtuse angle setting.

For reading acute angle set up (Fig 1): First read the number of whole degrees between zero of the main scale and zero of the vernier scale.



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)



To take the vernier scale reading, multiply the coinciding divisions with the least count.

Example

$$10 \times 5' = 50'$$

Total up both the readings to get the measurements = $41^\circ 50'$.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

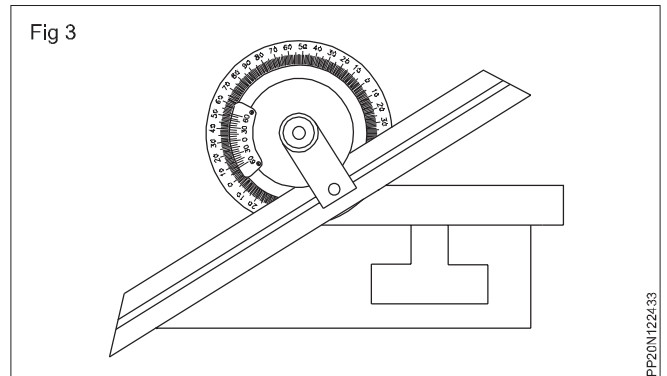
Locking device

Objectives: At the end of this lesson you shall be able to

- state the uses of bench vice
- specify the size of the bench vice
- name the parts of the bench vice
- state the uses of vice clamps
- mention the care and maintenance of vices.

Vices are used for holding the work pieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

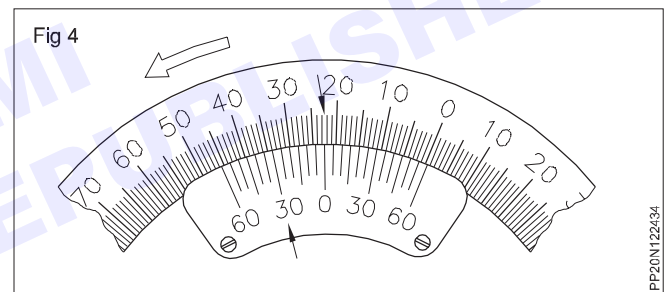
For obtuse angle set up (Fig 3)



The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

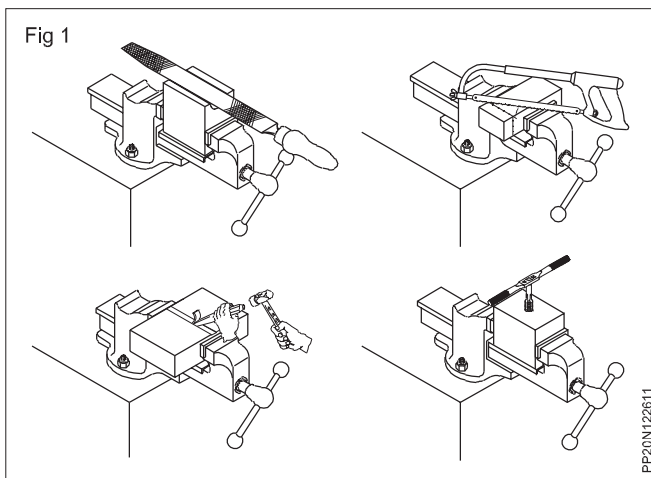
Reading $22^\circ 30'$

$$\text{Measurement } 180^\circ - 22^\circ 30' = 157^\circ 30'$$



Care and maintenance of vernier bevel protractor

- 1 Clean the vernier bevel protractor before use.
- 2 Loosen the locking screw of dial to move the blade according to the angle measurement.
- 3 While taking a measurement apply light pressure on vernier bevel protractor
- 4 Heavy pressure will force the two scales out of parallel and show the false reading.
- 5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.



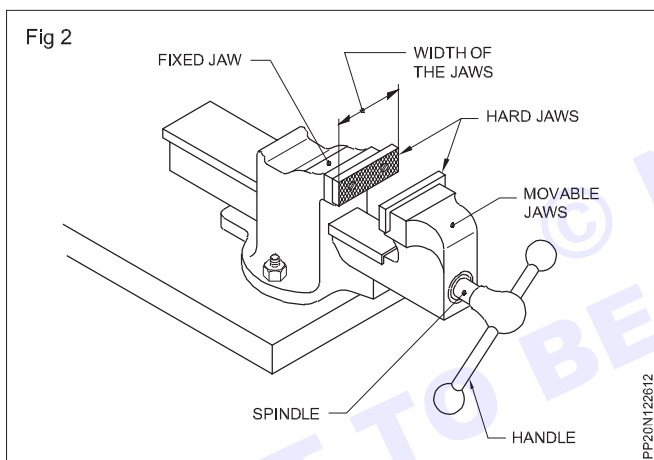
The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

The following are the parts of a vice.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.

The box-nut and the spring are the internal parts.



Types of vices

Objectives: At the end of this lesson you shall be able to

- state the different types of vices
- state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.

There are different types of vices used for holding work-pieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker's vice.

Quick releasing vice (Fig 1): A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.

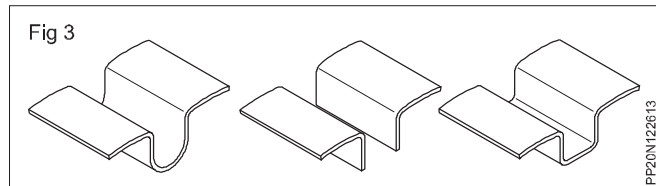
Pipe vice (Fig 2): A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.

Vice clamps or soft jaws (Fig 3)

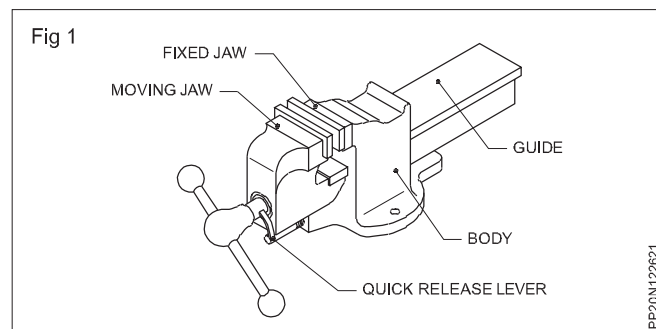
To hold a finished work use soft jaws (vice clamps) made of aluminum over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.



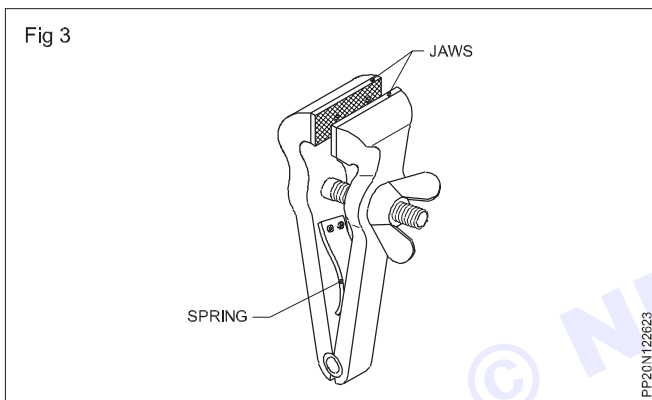
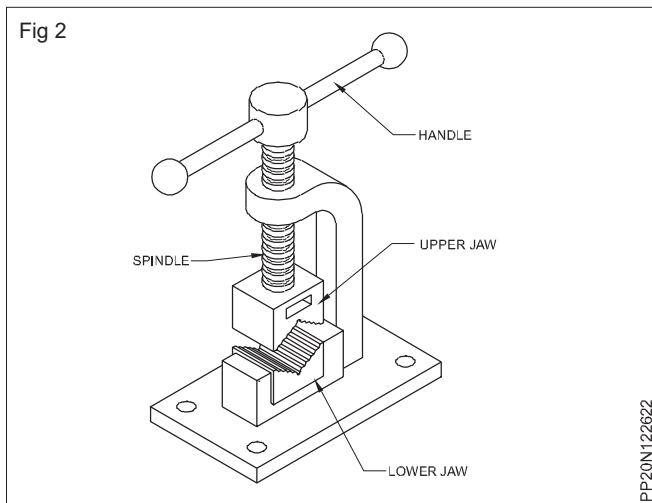
Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screw.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, bend or damaged otherwise the handle will become.

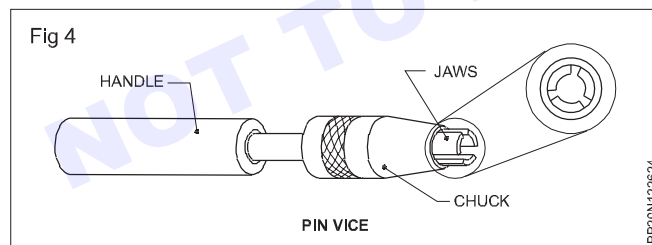


Hand vice (Fig 3): Hand vices are used for gripping screws, rivets, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width

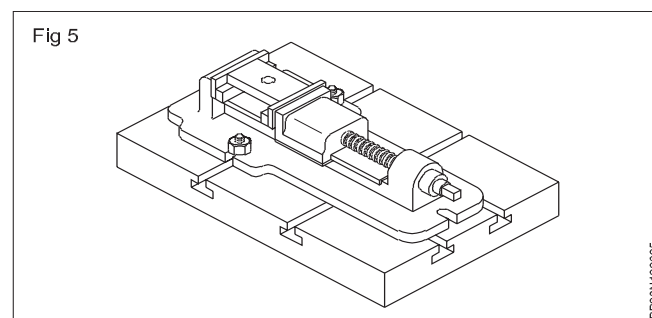
from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.



Pin vice (Fig 4): The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.



Toolmaker's vice (Fig 5): The toolmaker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.



Toolmaker's vice is accurately machined.

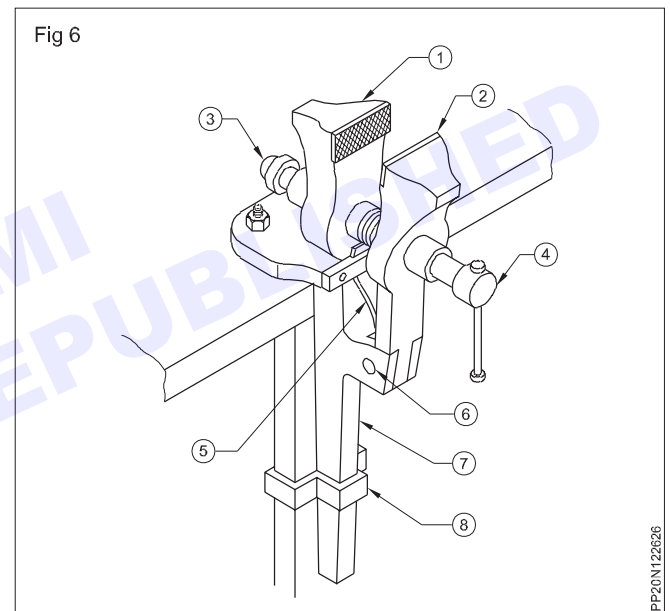
Leg vice

A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made of mild steel to avoid breakage while hammering.

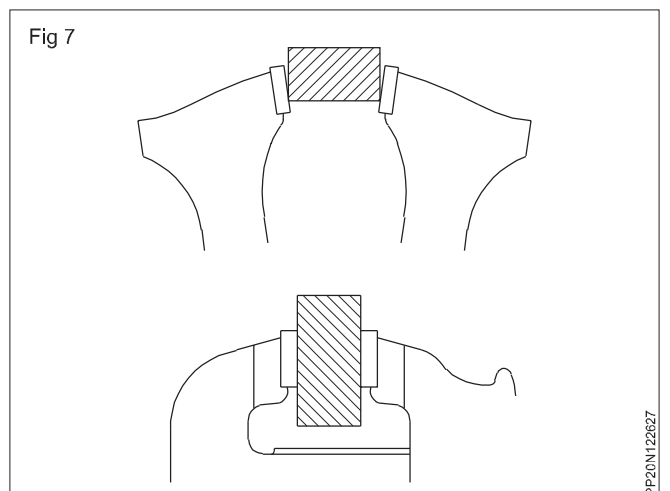
Main parts of a leg vice (Fig 6)

The following are the main parts of a leg vice.

- 1 Solid jaw
- 2 Movable jaw
- 3 Threaded jaw
- 4 Spindle
- 5 Spring
- 6 Pivot
- 7 Leg
- 8 Clamp



Since the hinged jaw moves in a radial path, the job held in this vice is not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.



Definition of electrical quantities and its units

Objectives: At the end of this lesson you shall be able to

- define electricity and atom
- explain about the atomic structure
- define the fundamental terms and definition of electricity
- state the type of supply, polarity and the effects of electric current
- state the conductors, insulators, wires - size measurement methods.

Introduction

Electricity is one of the today's most useful sources of energy. Electricity is of utmost necessity in the modern world of sophisticated equipment and machinery.

Electricity in motion is called electric current. Whereas the electricity that does not move is called static electricity.

Examples of static electricity

- Shock received from door knobs of a carpeted room.
- Attraction of tiny paper bits to the comb.

Structure of matter

Electricity is related to some of the most basic building blocks of matter that are atoms (electrons and protons). All matter is made of these electrical building blocks, and, therefore, all matter is said to be 'electrical'.

Atom

Matter is defined as anything that has mass and occupies space. A matter is made of tiny, invisible particles called molecules. A molecule is the smallest particle of a substance that has the properties of the substance. Each molecule can be divided into simpler parts by chemical means. The simplest parts of a molecule are called atoms.

Basically, an atom contains three types of sub-atomic particles that are of relevance to electricity. They are the electrons, protons and neutrons. The protons and neutrons are located in the Centre, or nucleus, of the atom, and the electrons travel around the nucleus in orbits.

Atomic structure

The Nucleus

The nucleus is the central part of the atom. It contains the protons and neutrons in equal numbers shown in (Fig 1).

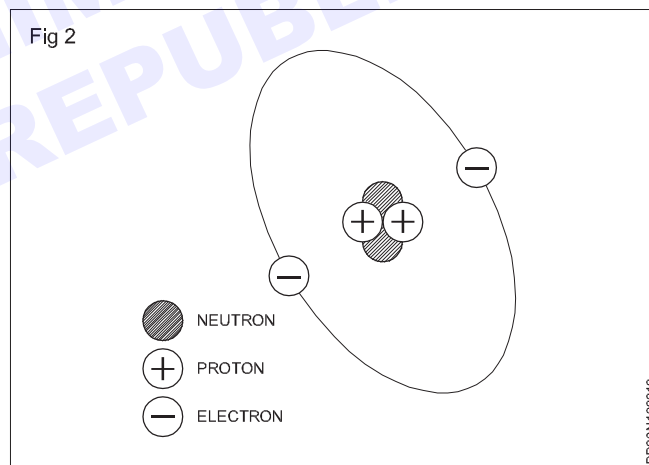
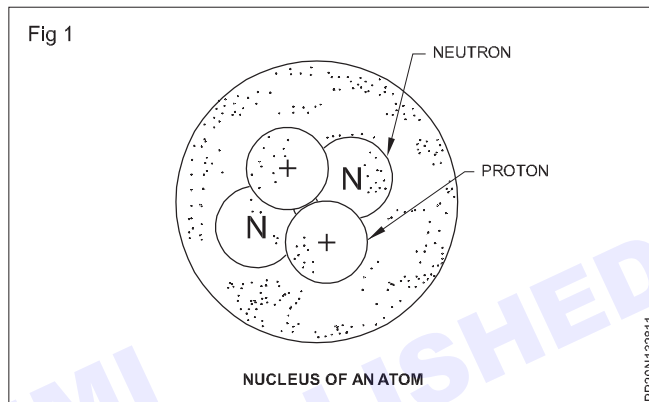
Protons

The proton has a positive electrical charge. (Fig 1) It is almost 1840 times heavier than the electron and it is the permanent part of the nucleus; protons do not take an active part in the flow or transfer of electrical energy.

Electron

It is a small particle revolving round the nucleus of an atom (as shown in Fig 2). It has a negative electric

charge. The electron is three times larger in diameter than the proton. In an atom the number of protons is equal to the number of electrons.



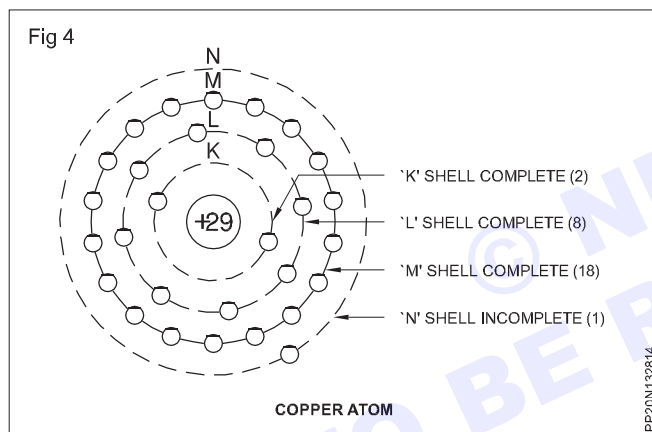
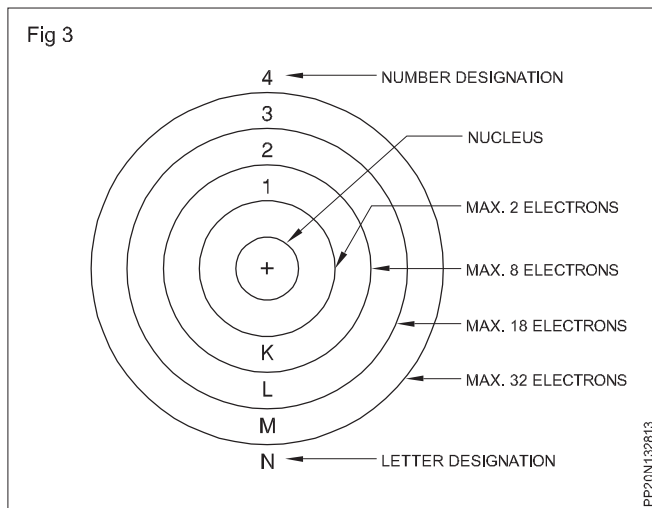
Neutron

A neutron is actually a particle by itself, and is electrically neutral. Since neutrons are electrically neutral, they are not too important to the electrical nature of atoms.

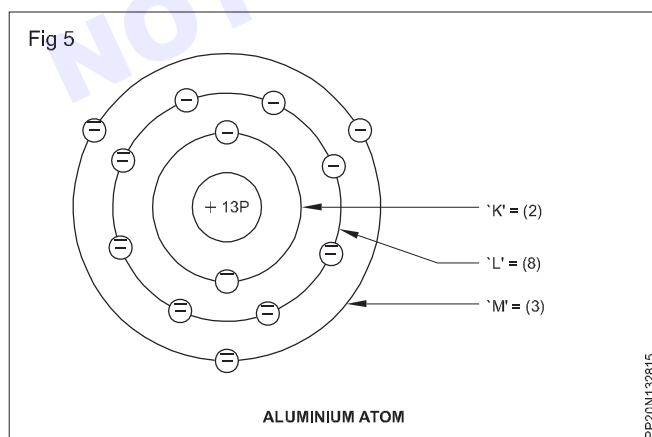
Energy shells

In an atom, electrons are arranged in shells around the nucleus. A shell is an orbiting layer or energy level of one or more electrons. The major shell layers are identified by numbers or by letters starting with 'K' nearest the nucleus and continuing alphabetically outwards. There is a maximum number of electrons that can be contained in each shell. Fig 3 illustrates the relationship between the energy shell level and the maximum number of electrons it can contain.

If the total number of electrons for a given atom is known, the placement of electrons in each shell can be easily determined. Each shell layer, beginning with the first, is filled with the maximum number of electrons in sequence. For example, a copper atom which has 29 electrons would have four shells with a number of electrons in each shell as shown in (Fig 4).



Similarly an aluminum atom which has 13 electrons has 3 shells as shown in (Fig 5).



Electron distribution

The chemical and electrical behavior of atoms depends on how completely the various shells and sub-shells are filled.

Atoms that are chemically active have one electron more or one less than a completely filled shell. Atoms that have the outer shell exactly filled are chemically inactive. They are called inert elements. All inert elements are gases and do not combine chemically with other elements.

Metals possess the following characteristics.

- They are good electric conductors.
- Electrons in the outer shell and sub-shells can move more easily from one atom to another.
- They carry charge through the material.

The outer shell of the atom is called the valence shell and its electrons are called valence electrons. Because of their greater distance from the nucleus, and because of the partial blocking of the electric field by electrons in the inner shells, the attracting force exerted by nucleus on the valence electrons is less. Therefore, valence electrons can be set free most easily. Whenever a valence electron is removed from its orbit it becomes a free electron. Electricity is commonly defined as the flow of these free electrons through a conductor. Though electrons flow from negative terminal to positive terminal, the conventional current flow is assumed as from positive to negative.

Conductors, insulators and semiconductors

Conductors

A conductor is a material that has many valence electrons permitting electrons to move through it easily. Generally, conductors have many valence shells of one, two or three electrons. Most metals are conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, are conductors, where as silver and gold are very good conductors

Insulators

An insulator is a material that has few, if any, free electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air, glass, rubber, plastic, paper, porcelain, PVC, , fiber, mica etc.

Semiconductors

A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductors have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

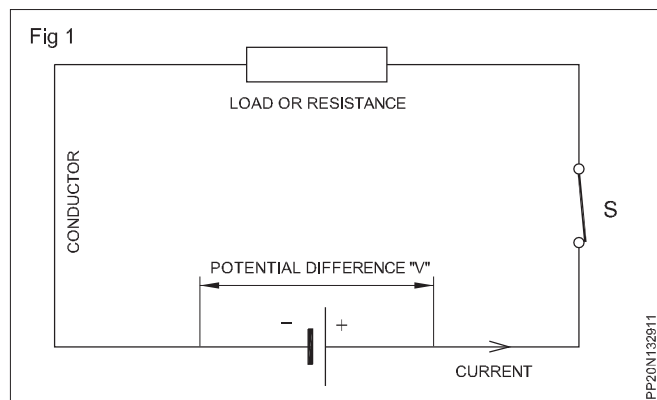
Ohm's law

Objectives: At the end of this lesson you shall be able to

- state Ohm's law
- apply Ohm's law in an electric circuit
- define electrical power and energy and calculate related problems.

Simple electric circuit

In the simple electric circuit shown in Fig 1, the current completes its path from the positive terminal of the battery via the switch and the load back to the negative terminal of the battery.



The circuit shown in Fig 1 is a closed circuit. In order to make a circuit to function normally the following three factors are essential.

- Electromotive force (EMF) to drive the electrons through the circuit.
- Current (I), the flow of electrons.
- Resistance (R) - the opposition to limit the flow of electrons.

Ohm's law

Ohm's law states that in any electrical closed circuit, the current (I) is directly proportional to the voltage (V), and it is inversely proportional to the resistance 'R' at constant temperature.

$$I \propto \frac{V}{R}$$

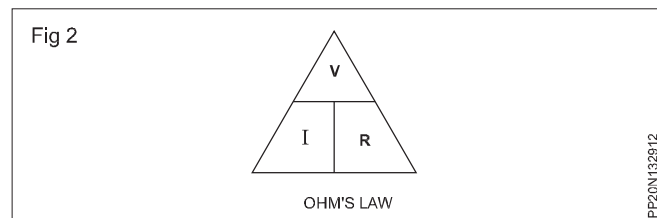
It means $I = V/R$

V = Voltage applied to the circuit in 'Volt'

I = Current flowing through the circuit in 'Amp'

R = Resistance of the circuit in Ohm (W)

The above relationship can be referred to in a triangle as shown in Fig 2. In this triangle whatever the value you want to find out, place the thumb on it then the position of the other factors will give you the required value.



For example for finding 'V' close the value V then, readable

$$I \propto \frac{V}{R}$$

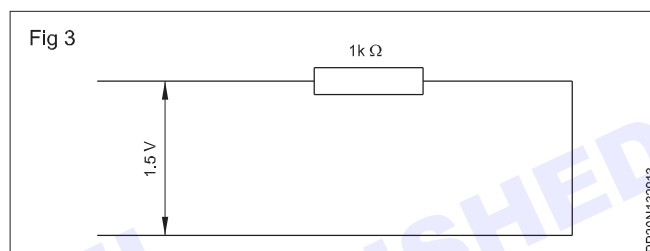
values are IR so, $V = IR$

$$R = V/I$$

$$I = V/R$$

Example 1

How much current (I) flows in the circuit shown in (Fig 3).



Given:

Voltage (V) = 1.5 Volts

Resistance (R) = 1 kOhm

= 1000 Ohms

$$I = \frac{V}{R}$$

Solution:

$$I = \frac{1.5 \text{ V}}{1000 \text{ Ohms}} = 0.0015 \text{ amp}$$

Electrical Power (P) & Energy (E) : The product of voltage (V) and current (I) is called electrical power. Electrical power (P) = Voltage x Current $P = V \times I$

The unit of Electrical power is 'Watt' It is denoted by the letter 'P' It is measured by Watt meter. The following formulae can also be derived from formula of power (P) as

$$\begin{aligned} P &= V \times I \\ &= IR \times I \\ P &= I^2 R \end{aligned}$$

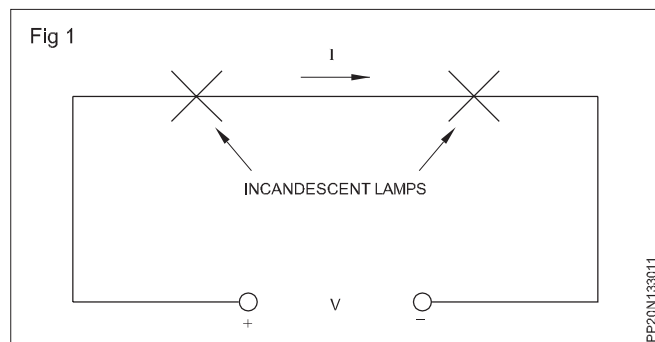
Types of circuits and its connection open and closed circuits

Objectives: At the end of this lesson you shall be able to

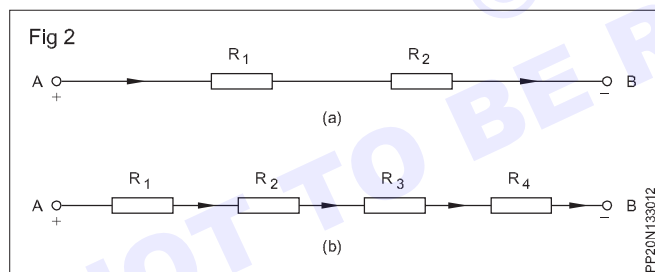
- state the characteristics of series circuit and determine the current and voltage across each resistors
- determine the total voltage sources in series circuit
- state the relation between EMF potential difference and terminal voltage.

The series circuit

If more than one resistors are connected one by one like a chain and if the current has only one path is called as series circuit. It is possible to connect two incandescent lamps in the way shown in Fig 1. This connection is called a series connection, in which the same current flows in the two lamps.



The lamps are replaced by resistors in Fig 2. Fig 2 (a) shows two resistors are connected in series between point A and point B. Fig 2(b) shows four resistors are in series. Of course, there can be any number of resistors in a series connection. Such connection provides only one path for the current to flow.



Current in series circuits

The current will be the same at any point of the series circuit. This can be verified by measuring the current in any two points of a given circuit as shown in Figs 3 a and 3b. The ammeters will show the same reading.

The current relationship in a series circuit is

$$I = IR_1 = IR_2 = IR_3 \text{ (Refer Fig 3a \& 3b)}$$

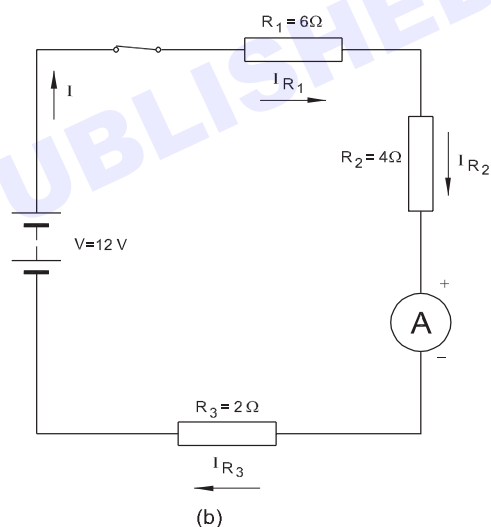
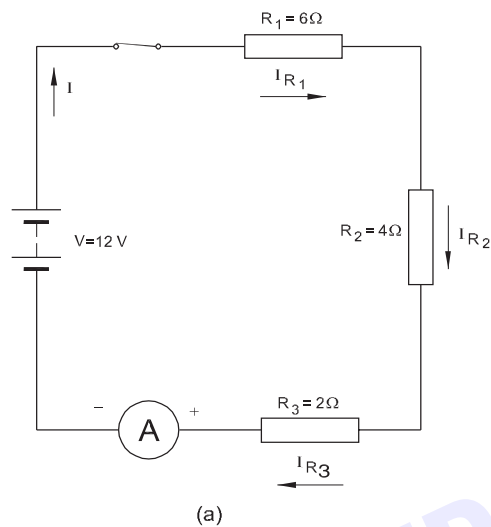
We can conclude that there is only one path for the current to flow in a series circuit. Hence, the current is the same throughout the circuit.

The total resistance in a series circuit is equal to the sum of the individual resistances around the series circuit. This statement can be written as

$$R = R_1 + R_2 + R_3 + \dots + R_n$$

where R is the total resistance

Fig 3



$R_1, R_2, R_3, \dots, R_n$ are the resistors connected in series.

When a circuit has more than one resistor of the same value in series, the total resistance is $R = r \times N$

where 'r' is the value of each resistor and N is the number of resistors in series.

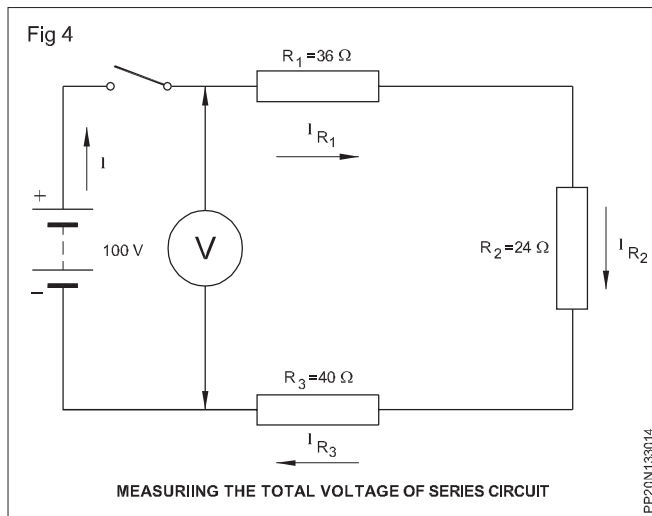
Voltage in series circuits

In DC circuit voltage divides up across the load resistors, depending upon the value of the resistor so that the sum of the individual load voltages equals the source voltage.

As the source voltage divides/drops across the series resistance depending upon the value of the resistances

$$V = VR_1 + VR_2 + VR_3 + \dots + VR_n$$

the total voltage of a series circuit must be measured across the voltage source, as shown in (Fig 4).



When Ohm's law is applied to the complete circuit having an applied voltage V , and total resistance R , we have the current in the circuit as

$$I = \frac{V}{R}$$

Application of Ohm's law to DC series circuits

Applying to Ohm's law to the series circuit, the relation between various currents could be stated as below

$$I = I_{R_1} = I_{R_2} = I_{R_3}$$

This could be stated as $\frac{V}{R} = \frac{V_{R_1}}{R_1} = \frac{V_{R_2}}{R_2} = \frac{V_{R_3}}{R_3}$

You can use any of the above formulae to calculate current in a series circuit.

$$V = VR_1 + VR_2 + VR_3$$

$$\text{i.e. } IR = R_1 I_{R_1} + R_2 I_{R_2} + R_3 I_{R_3}$$

$$\text{and Total resistance } R = R_1 + R_2 + R_3$$

DC parallel circuit

Objectives: At the end of this lesson you shall be able to

- explain a parallel circuit
- determine the voltages in a parallel circuit
- determine the current in a parallel circuit
- determine the total resistances in a parallel circuit
- state the application of a parallel circuit.

In an electrical circuit, if the current has more than one paths and equal voltage in each branch is called parallel circuit.

It is possible to connect three incandescent lamps as shown in Fig 1. This connection is called parallel connection in which, the same source voltage is applied across all the three lamps.

Voltage in parallel circuit

The lamps in Fig 1 are replaced by resistors in Fig 2. Again the voltage applied across the resistors is the same and also equal to the supply voltage.

We can conclude that the voltage across the parallel circuit is the same as the supply voltage.

Mathematically it could be expressed as $V = V_1 = V_2 = V_3$.

Use of series connection

- 1 Cells in torch light, car batteries, etc.
- 2 Cluster of mini-lamps used for decoration purposes.
- 3 Fuse in circuit.
- 4 Overload coil in motor starters.
- 5 Multiplier resistance of a voltmeter.

Definitions

Electromotive force (emf)

We have seen that the electromotive force (emf) of a cell is the open circuit voltage, and the potential difference (PD) is the voltage across the cell when it delivers a current. The potential difference is always less than the emf.

Potential difference

PD = emf – voltage drop in the cell

Potential difference can also be called by another term, the terminal voltage, as explained below.

Terminal voltage

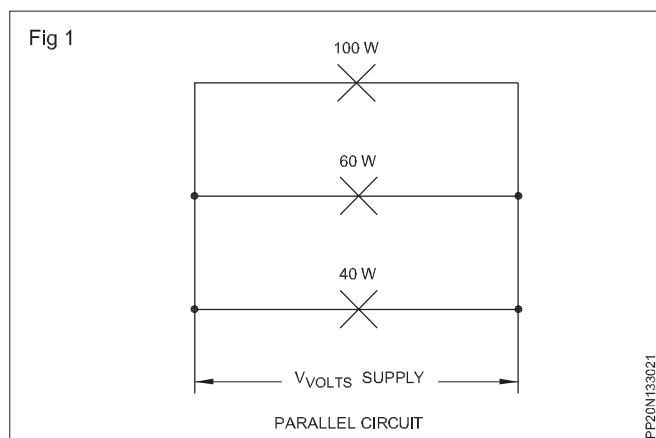
It is the voltage available at the terminal of the source of supply. Its symbol is V_T . Its unit is also the volt. It is given by the emf minus the voltage drop in the source of supply,

$$\text{i.e. } V_T = \text{emf} - IR$$

where I is the current and R the resistance of the source.

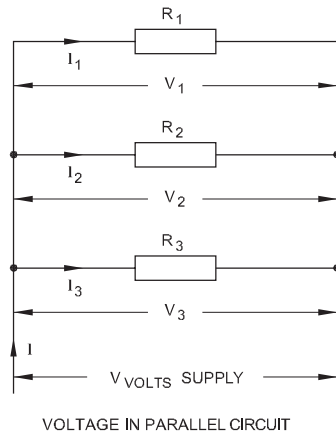
Voltage drop (IR drop)

The voltage lost by resistance in a circuit is called the Voltage drop or IR drop.



Current in parallel circuit: Again referring to Fig 2 and applying Ohm's law, the individual branch currents in the parallel circuit could be determined.

Fig 2



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Current in resistor $R_1 = I_1 = \frac{V_1}{R_1} = \frac{V}{R_1}$

Current in resistor $R_2 = I_2 = \frac{V_2}{R_2} = \frac{V}{R_2}$

Current in resistor $R_3 = I_3 = \frac{V_3}{R_3} = \frac{V}{R_3}$

as $V_1 = V_2 = V_3$.

Refer to Fig 2 in which the branch currents I_1 , I_2 and I_3 are shown to flow into resistance branches R_1 , R_2 and R_3 respectively.

$$V_1 = V_2 = V_3.$$

The total current I in the parallel circuit is the sum of the individual branch currents.

Mathematically it could be expressed as $I = I_1 + I_2 + I_3 + \dots I_n$.

Resistance in parallel circuit

In a parallel circuit, individual branch resistances offer opposition to the current flow though the voltage across the branches will be same.

Types of fuses

Objectives: At the end of this lesson you shall be able to

- explain the purpose of the fuse in a circuit
- classify the different types of fuses and their uses.

Purpose of fuses: A fuse is a safety device used for the purpose of protecting a circuit against excess current. In the event of excessive current, the fuse element melts and opens up the circuit thereby protecting it from damage.

Symbols: These are the graphical symbols used to illustrate an electrical fuse in electro-technical diagrams.

- General symbols of a fuse (Fig 1)

Placement of fuses: In electrical installations, the fuses are always connected into the live wires (Fig 2) and never into the neutral N.

Let the total resistance in the parallel circuit be R ohms.

By the application of Ohm's law

we can write

$$R = \frac{V}{I} \text{ ohms or } I = \frac{V}{R} \text{ amps}$$

where

R is the total resistance of the parallel circuit in ohms

V is the applied source voltage in volts, and

I is the total current in the parallel circuit in amperes.

We have also seen

$$I = I_1 + I_2 + I_3$$

$$\text{or } \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

As V is the same throughout the equation and dividing the above equation by V , we can write

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The above equation reveals that in a parallel circuit, the reciprocal of the total resistance is equal to the sum of the reciprocals of the individual branch resistances.

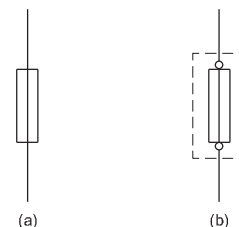
Applications of parallel circuits

The electric system used in homes consists of many parallel circuits.

An automobile electric system uses parallel circuits for lights, horn, motor, radio etc. Each of these devices operates independent of the others.

Individual television circuits are quite complex. However, the complex circuits are connected in parallel to the main power source. That is why the audio section of television receivers can still work when the video (picture) is in operative.

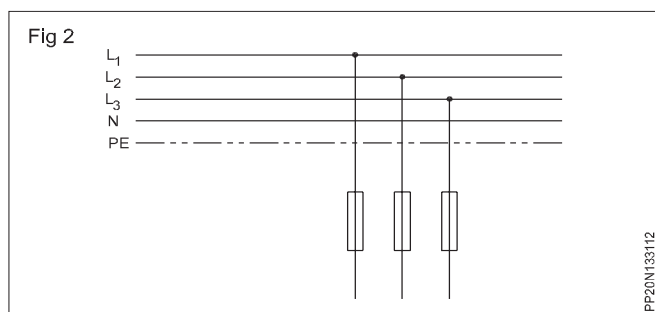
Fig 1



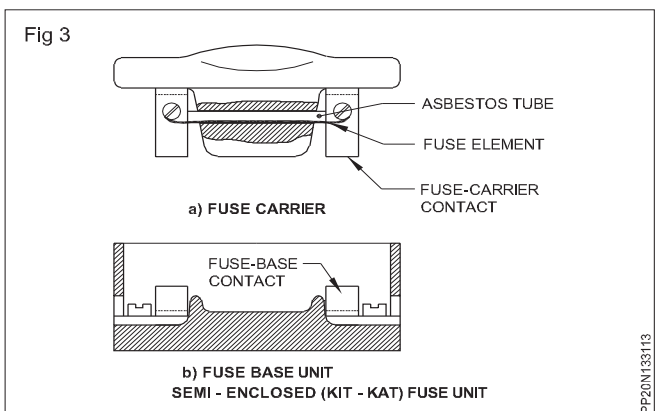
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Types of fuses used in domestic wiring

- Re-wirable type (up to 200A)
- Cartridge type (up to 1250A)



Rewritable type fuse (Fig 3): The fuse element in this type of fuse consists of a wire which may be replaced when necessary. These fuses are simple in construction and the initial cost as well as the renewal cost is very low.



The fuse elements used in this type are tinned copper wire, lead and tin alloy or aluminum wire (Table 1).

The fuse element will melt after approximately 2 minutes when carrying a current equal to twice the current rating.

Table 1

Current rating for	Approximate fusing current Amp	Tinned copper wire		Aluminium wire dia. in mm
		S.W.G	Diameter in mm	
1.5	3	40	.12192	--
2.5	4	39	.13208	--
3.0	5	38	.1524	195
4.0	6	37	.17272	--
5.0	8	35	.21336	--
5.5	9	34	.23368	--
6.0	10	33	.254	.307
7.0	11	32	.27432	--
8.0	12	31	.29464	--
8.5	13	30	.31496	--
9.5	15	--	--	.400
10.0	16	29	.34544	--
12.0	18q	28	.37592	--
13.5	25	--	--	.475
14.0	28	26	.4572	--
15.0	30	25	.508	.630

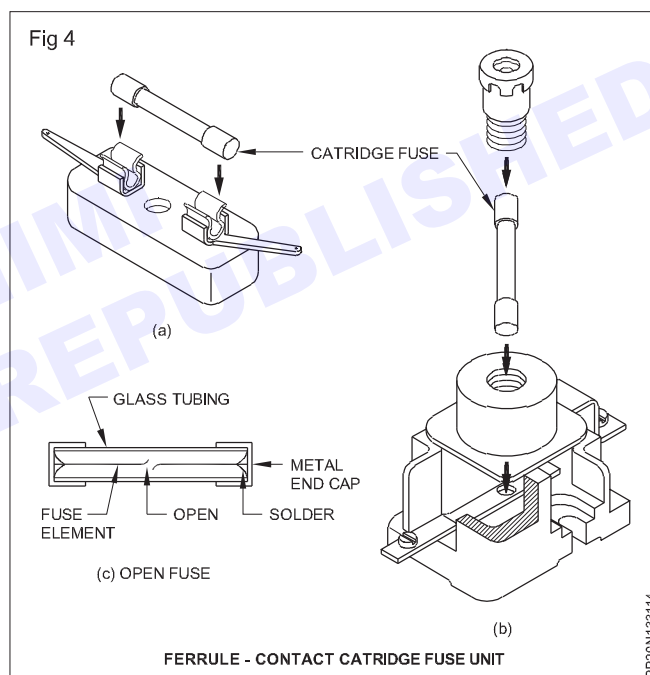
Disadvantages of rewritable type fuse

- Effected by the fluctuation of the ambient temperature.
- External flash or arc on blowing.
- Poor rupturing capacity (under short-circuit condition).
- Wrong rating possible by human error.

Rewritable-type fuses up to 16A rated current should not be used in locations where short circuit level exceeds 2 KA, (I.S. 2086-963).

Cartridge fuses: Cartridge fuses are developed to overcome the disadvantages of the rewritable fuses. As cartridge fuse elements are enclosed in an air tight chamber, deterioration does not take place. Further the rating of a cartridge fuse could be accurately determined from its marking. However, the cost of replacement of cartridge fuses is more than that of rewritable fuses.

- Ferrule-contact cartridge fuses (Fig 4).



Ferrule-contact cartridge fuses: This type, is used for protecting electrical and electronic circuits. These are available in 25, 50, 100, 200, 250, 500 mill amperes, and also in 1,2,5,6,10,16 & 32 amperes capacity.

Normally the current rating is written on one side of the cap, and while replacing, the same capacity fuse should be used. Its body is made of glass and the fuse wire is connected between two metallic caps.

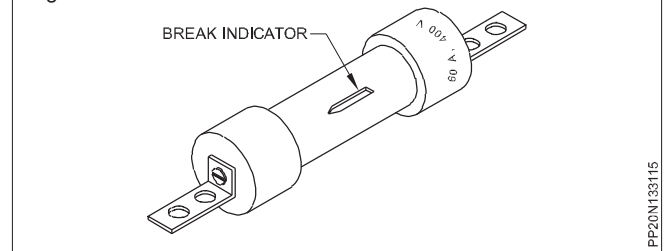
This fuse can be plugged into the fuse socket (Fig 4a) or it can be fitted into a fuse base with a screw, type fuse- holder (Fig 4b).

High rupturing capacity (HRC) fuses (Fig 5): They are cylindrical in shape and are made of a ceramic body filled in with a chemically treated filling powder or silica to quench the arcing quickly without any fire hazard.

Normally a silver alloy is used as the fusing element and when it melts due to the excessive current, it combines with the surrounded sand/powder, and forms small globules without making an arc, spark or gas. HRC fuses can open a short-circuited circuit within 0.013 second. It has an indicator to show the fuse has blown.

As HRC fuses are capable of opening circuits having very high faulty currents, these are preferred in high power circuits even though the replacement cost is high.

Fig 5



Earthing - types - terms

objectives: At the end of this lesson you shall be able to

- explain the reasons for system and equipment earthing
- define the terminology related to earthing
- state and explain the methods of preparing pipe earthing and plate earthing, according to B.I.S recommendations
- explain the procedure for reducing the resistance of earth electrodes to an acceptable value.

Earthing

Connecting the non-conductive metal body/parts of an electrical equipment and system to the earth through a low resistance conductor is called as earthing.

Earthing of an electrical installation can be brought under two major categories.

- System earthing
- Equipment earthing

System earthing: earthing associated with current-carrying conductors is normally essential to the security of the system, and is generally known as system earthing.

System earthing is done at generating stations and substations.

The purpose of system earthing is to:

- Maintain the ground at zero reference potential, thereby ensuring that the voltage on each live conductor is restricted to such a value with respect to the potential of the general mass of the earth as is consistent with the level of the insulation applied
- Protect the system when any fault occurs against which earthing is designed to give protection, by making the protective gear to operate and make the faulty portion of the plant harmless.

Equipment earthing: Earthing of non-current carrying metal work and conductor which is essential for the safety of human life, animals and property is generally known as equipment earthing.

Terminology

Trainees can be instructed to refer the international electro technical commission (IEC 60364-5-54) website for the standard safety rules related with earthing installation for the further details.

Dead: Dead' means at or about earth potential and disconnected from any live system.

Earth: A connection to the general mass of earth by means of an earth electrode. An object is said to be 'earthed' when it is electrically connected to an earth electrode; and a conductor is said to be 'solidly earthed' when it is electrically connected to an earth electrode.

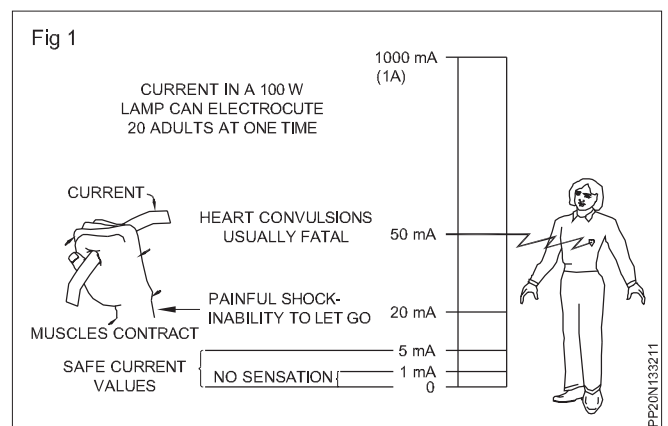
Earth-continuity conductor (ECC): The conductor which connect the non-conductive metal part/body of an electrical system/equipment to the earth electrode is called as earth contained conductor.

Earth electrode: A metal plate, pipe or other conductor electrically connected to the general mass of the earth.

Earth fault: Live portion of an electrical system getting accidentally connected to earth.

Leakage current: A current of relatively small value, which passes through the insulation of conductive parts/wire.

Fig 1 shows the magnitude of current and its effect



Reasons for earthing: The basic reason for earthing is to prevent or minimize the risk of shock to human beings and livestock. The reason for having a properly earthed metal part in an electrical installation is to provide a low resistance discharge path for earth leakage currents which would otherwise prove injurious or fatal to a person or animal touching the metal part

Table 1 shows the body resistance at specified areas of contact.

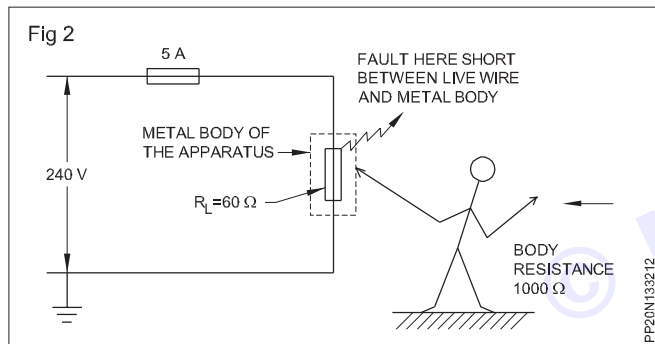
Table 1

Skin condition or area	Resistance value
Dry skin	100,000 to 600,000 ohms
Wet skin	1,000 ohms
Internal body-hand	400 to 600 ohms to foot
Ear to ear	about 100 ohms

CASE 1: Metal body of apparatus when it is not earthed

Let us consider a 240V AC circuit connected to an apparatus having a load resistance of 60 ohms. Assume that the defective insulation of cable makes the metal body live and the metal body is not earthed.

When a person, whose body resistance is 1000 ohms, comes in contact with the metal body of the apparatus which is at 240V, a leakage current may pass through the body of the person (Fig 2).



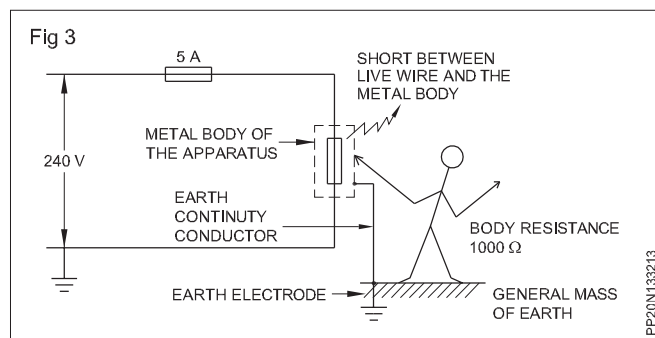
The value of current through the body = $\frac{V}{R_{\text{Body}}}$

$$= \frac{240}{1000} = 0.24 \text{ amps or 240 milliamperes.}$$

This current, as can be judged from Table 1, is highly dangerous, and might prove to be fatal. On the other hand, the 5 amps fuse in the circuit will not blow for this additional leakage current of 240 mill amperes. As such the metal body will have 240V supply and may electrocute any person touching it.

CASE 2: Metal body of apparatus when earthed

In case the metal body of the apparatus is earthed (Fig 3), the moment the metal body comes in contact with the live wire, a higher amount of leakage current will flow through the metal body to earth.



Assuming that the sum of the resistance of the main cable, metal body, earth continuity conductor and the general mass of earth is to the tune of 10 ohms

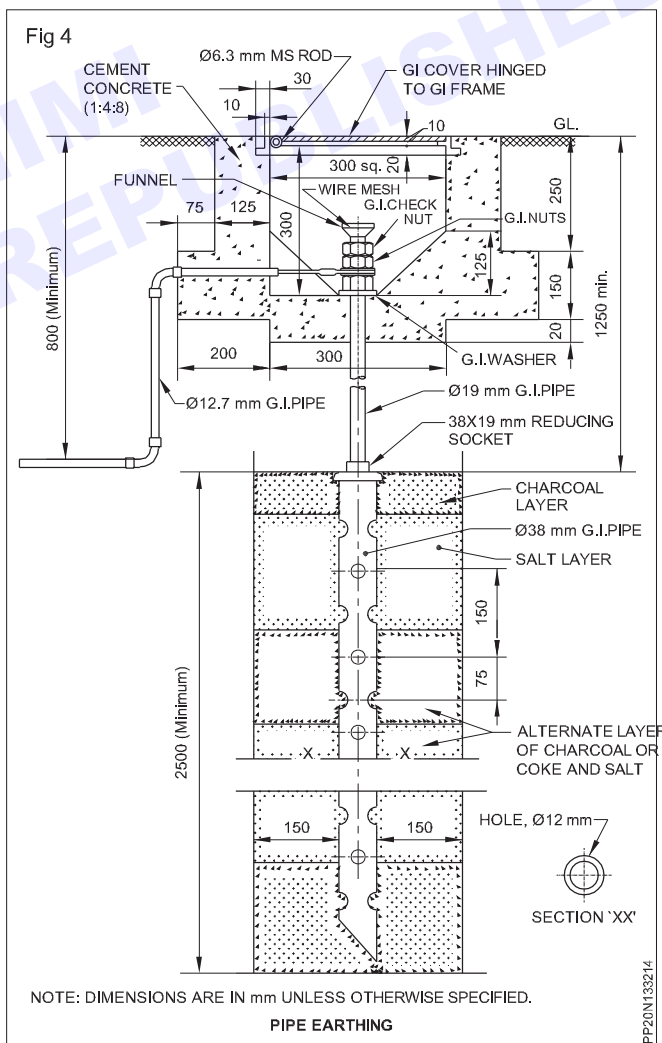
the leakage current = $\frac{V}{R_{\text{Total}}} = 240/10 = 24 \text{ amps.}$

This leakage current is 4.8 times higher than the fuse rating, and, hence, the fuse will blow and disconnect the supply from the mains. The person will not get a shock due to two reasons. Before the fuse operates, the metal body and earth are in the same zero potential, and across the person, there is no difference of potential. Within a short millie - seconds) time the fuse blows to open the defective circuit, provided the earth circuit resistance is sufficiently low.

By studying the above two cases, it is clear that a properly earthed metal body eliminates the shock hazards to persons and also avoids fire hazards in the system by blowing the fuse quickly in case of ground faults.

Types of earth electrodes

Rod and pipe electrodes (Fig 4): These electrodes shall be made of metal rod or pipe having a clean surface not covered by paint, enamel or other poorly conducting material.



Rod electrodes of steel or galvanized iron shall be at least 16 mm in diameter, and those of copper shall be at least 12.5 mm in diameter.

Pipe electrodes shall not be smaller than 38 mm internal diameter, if made of galvanized iron or steel, and 100 mm internal diameter if made of cast iron.

Electrodes shall, as far as practicable, be embedded in earth below the permanent moisture level.

The length of the rod and pipe electrodes shall not be less than 2.5 m.

Except where rock is encountered, pipes and rods shall be driven to a depth of at least 2.5 m. The length of the electrodes shall be at least 2.5 m, and the inclination not more than 30° from the vertical.

Plate electrodes (Fig 5): Plate electrodes, when made of galvanized iron or steel, shall not be less than 6.3 mm in thickness. Plate electrodes of copper shall be not less than 3.15 mm in thickness. Plate electrodes shall be of a size, at least 60 cm by 60 cm.

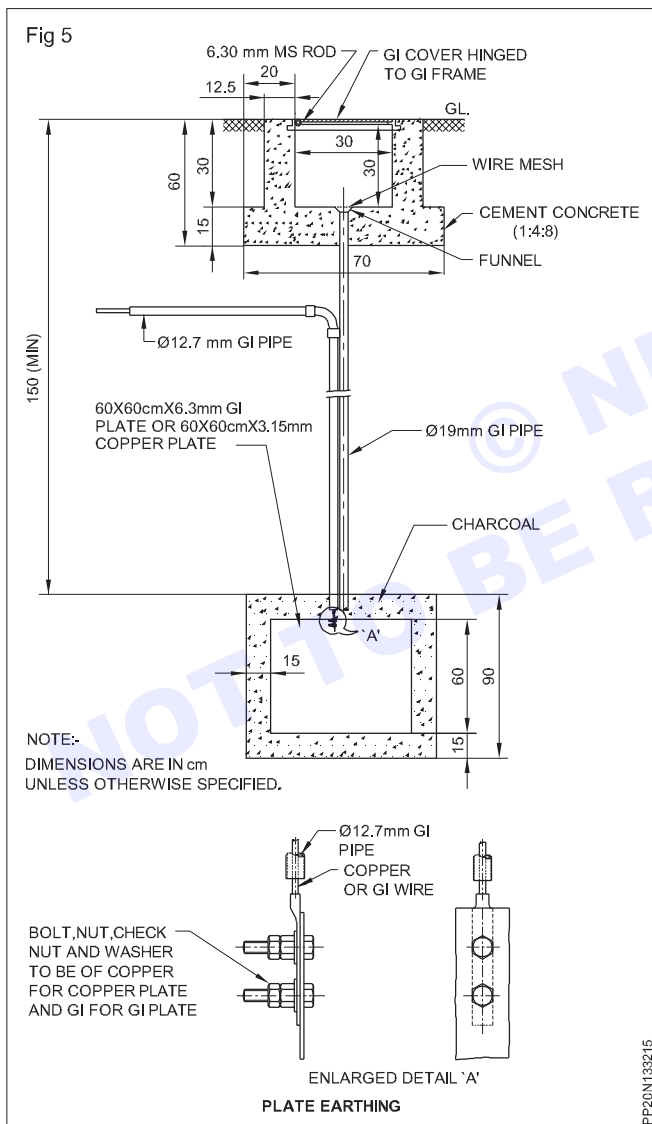


Plate electrodes shall be buried such that the top edge is at a depth not less than 1.5 m from the surface of the ground.

Where the resistance of one plate electrode is higher than the required value, two or more plates shall be used in parallel. In such a case, the two plates shall be separated from each other by not less than 8.0 m.

Plates shall preferably be set vertically.

Plate electrodes is recommended in generating stations and substations.

If necessary, plate electrodes shall have a galvanized iron water pipe buried vertically and adjacent to the electrode. One end of the pipe shall be at least 5 cm above the surface of the ground, and it need not be more than 10 cm. The internal diameter of the pipe shall be at least 5 cm and need not be more than 10 cm. The length of pipe, if under the earth's surface, shall be such that it should be able to reach the center of the plate. In no case, however, shall it be more than the depth of the bottom edge of the plate.

Methods of reducing the resistance of an earth electrode to an acceptable value

The earth electrode resistance is found higher in rocky or sandy areas where moisture is very low.

The following methods are suggested to bring down the earth electrode resistance to an acceptable value.

- 1 After installing the rod or pipe or plate in earth, the earth pit (the area surrounding the rod / pipe / plate) should be treated with layers of coke and common salt to get a lower value of earth resistance.
- 2 Pouring water in the earth pit at repeated intervals lowers the earth electrode resistance.
- 3 Connecting a number of earth electrodes in parallel reduces the earth electrode resistance.
- 4 Soldering the earth connections or using non-ferrous clamps lowers the earth electrode resistance.
- 5 Avoiding rust in the earth electrode connections lowers the earth electrode resistance.

Wire and cables

Objectives: At the end of this lesson you shall be able to

- define UG cable
- explain the construction of UG cables
- list and state the insulating materials used in cables
- list out and state the types of UG cables used for 3 phase service
- state the types of cable joints and laying methods
- explain the faults and testing procedures of cables.

Under Ground (UG) cables

“A cable so prepared that it can withstand pressure and can be installed below the ground level and normally two or more conductors are placed in an UG cable with separate insulation on each conductor”

Electric power can be transmitted (or) distributed either by over-head lines system or by underground cable system. The underground cable system have several advantage, such

Advantages

- Less chance to damage through storms or lightning.
- Low maintenance cost.
- Less chances of fault.
- Not affected by man- made problems like sabotage, strike etc.
- Voltage regulation in UG cables system is much better, because they have less inductive losses.
- Better general appearance of area compared to O.H lines.

Disadvantages

However, their major draw back / disadvantages are

- Initial cost of UG cable system is heavy.
- The cost of joints are more.
- Introduce insulation problems at high voltages compared with O.H lines.

For these reasons UG cables are employed where it is impracticable to use O.H lines like (i) thickly populated areas, where municipal authorities prohibit O.H lines for the reason of safety.

- Around plants
- In Substations,
- Where maintenance conditions do not permit the use of O.H construction.

The UG cable were used many years for distribution of electric power in congested urban areas to low and medium voltages. Then with improvement and development of design, the manufactures have made it possible to use at high voltage transmission of electric power for same moderate distances.

General construction of UG cables

An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover.

Necessity requirements for cables

In general, a cable must fulfill the following necessary requirements.

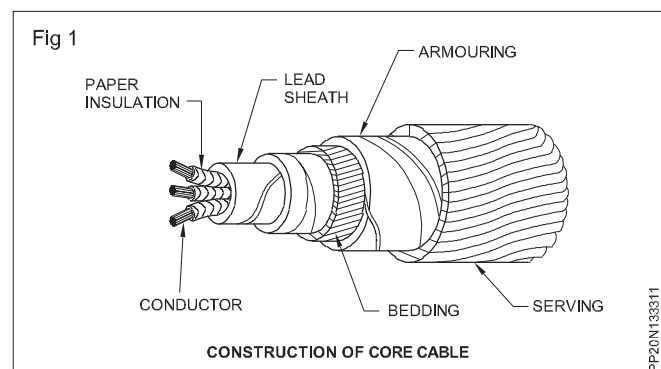
- The conductor used in cables should be tinned stranded copper or aluminum of high conductivity. (Strands of cable gives flexibility and carry more current).
- The size of the conductor should be selected, so that the cable carries the desired load current without overheating and limits the voltage drop to a permissible value.
- The cable must have proper thickness of insulation to ensure the safety and reliability for the designed voltage.

General construction of UG cables

- The cable must be provided with suitable mechanical protection so that it may withstand the rough use in laying it.
- The materials used in cables should be with complete chemical and physical stability throughout.

Construction of Cables

Fig 1 shows the general construction of a 3-core cable. The various parts are



- Cores or conductors:** A cable may have one or more than one core (conductor) depending upon the type of service for which it is intended. For instance, the 3-conductor cable shown in Fig 1 is used for 3-phase service. The conductors are made of tinned copper or aluminum and are usually stranded in order to provide flexibility to the cable and having high conductivity.
- Insulation:** Each core or conductor is provided with a suitable thickness of insulation, the thickness of layer depending upon the voltage to be withstood by the cable. The commonly used materials for insulation

are impregnated paper, varnished cambric or rubber mineral compound. Petroleum jelly is applied to the layers of the cambric to prevent damage.

- iii **Metallic sheath:** In order to protect the cable from moisture, gases or other damaging liquids (acids or alkalis) in the soil and atmosphere, a metallic sheath of lead or aluminum is provided over the insulation as shown in Fig 1. The metallic sheath is usually a lead or lead alloy.
- iv **Paper Belt:** Layer of impregnated paper tape is wound round the grouped insulated cores. The gap in the cores is filled with fibrous insulating material (jute etc.)
- v **Bedding:** Over the metallic sheath is applied a layer of bedding which consists of a fibrous material like jute or hessian tape. The purpose of bedding is to protect the metallic sheath against corrosion and from mechanical injury due to armoring.
- vi **Armoring:** Over the bedding, armoring is provided which consists of one or two layers of galvanized steel wire or steel tape. Its purpose is to protect the cable from mechanical injury while laying it and during the course of handling. Armoring may not be done in the case of some cables.
- vii **Serving:** In order to protect armoring from atmospheric conditions, a layer of fibrous material (like jute) similar to bedding is provided over the armoring. This is known as serving.

It may not be out of place to mention here that bedding, armoring and serving are only applied to the cables for the protection of conductor insulation and to protect the metallic sheath from mechanical injury.

Insulating materials for cables

The satisfactory operation of a cable depends to a great extent upon the characteristics of insulation used. Therefore, the proper choice of insulating material for cables is of considerable importance. In general, the insulating material used in cables should have the following properties:

- i High insulation resistance to avoid leakage current.
- ii High dielectric strength to avoid electrical breakdown of the cable.
- iii High mechanical strength to withstand the mechanical handling of cables.
- iv Non-hygroscopic i.e. it should not absorb moisture from air or soil. The moisture tends to decrease the insulation resistance and hastens the breakdown of the cable. In case the insulating material is hygroscopic, it must be enclosed in a waterproof covering like lead sheath.
- v Non-inflammable
- vi Low cost compared to O.H. system.
- vii Unaffected by acids and alkalis to avoid any chemical action.

The type of insulating material to be used depends upon the purpose for which the cable is required and the quality of insulation to be aimed at.

The principal insulating materials used in cables are

- i Rubber
- ii Vulcanized India rubber
- iii Impregnated paper
- iv Varnished cambric and
- v Polyvinyl chloride.

1 Rubber: Rubber may be obtained from milky sap of tropical trees or it may be produced from oil products. It has relative permittivity varying between 2 and 3, dielectric strength is about 30 KV/mm and resistivity of insulation is $10^{17} \Omega \text{ cm}$.

It suffers from some major drawbacks viz readily

- i absorbs moisture
- ii maximum safe temperature is low (about 38°C)
- iii soft and liable to damage due to rough handling and ages when exposed to light.

Therefore, pure rubber cannot be used as an insulating material.

2 Vulcanised Indian Rubber (V.I.R.) : It is prepared by mixing pure rubber with mineral matter such as zinc oxide, red lead etc. and 3 to 5% of sulphur. The compound so formed is rolled into thin sheets and cut into strips. The rubber compound is then applied to the conductor and is heated to a temperature of about 150°C . The whole process is called vulcanization and the product obtained is known as Vulcanized Indian Rubber.

Advantages: Vulcanised India rubber has greater mechanical strength, durability and water resistant property than pure rubber.

Disadvantages: Its main drawback is that Sulphur reacts quickly with copper. So, cables using VIR insulation must have tinned copper conductor. The VIR insulation is generally used for low and moderate voltage cables.

3 Impregnated paper: It consists of chemically pulped paper made from wood chippings and impregnated with some compound such as paraffinic or naphthenic material.

Advantages

- i Low cost
- ii Low capacitance
- iii High dielectric strength and
- iv High insulation resistance.

Disadvantages

- i The paper is hygroscopic and even if it is impregnated with suitable compound

- ii It absorbs moisture and thus lowers the insulation resistance of the cable.

For this reason, paper insulated cables are always provided with some protective covering and are never left unsealed. If it is required to be left unused on the site during laying, its ends are temporarily covered with wax or tar.

Since the paper-insulated cables have the tendency to absorb moisture, they are used where the cable route has a few joints. For instance, they can be profitably used for distribution at low voltages in congested areas where the joints are generally provided only at the terminal apparatus. However, for smaller installations, where the lengths are small and joints are required at a number of places, VIR Cables will be cheaper and durable than paper insulated cables.

4 Varnished cambric: It is a cotton cloth impregnated and coated with varnish. This type of insulation is also known as empire type. The cambric is lapped on to the conductor in the form of tape and its surface is coated with petroleum jelly compound to allow for the sliding of one turn over another as the cable is bent. As the varnished cambric is hygroscopic, therefore, such cables are always provided with metallic sheath. Its dielectric strength is about 4 KV/mm and permittivity is 2.5 to 3.8.

5 Polyvinyl chloride (PVC): This insulating material is a synthetic compound. It is obtained from the polymerization of acetylene and is in the form of white powder. For obtaining this material as a cable insulation, it is compounded with certain materials known as plasticizer which are liquids with high boiling point.

Advantages

- i It has high insulation resistance
- ii Good dielectric strength
- iii Mechanical toughness over a wide range of temperature.

This type of insulation is preferred over VIR in extreme environmental conditions such as in cement factory or chemical factory.

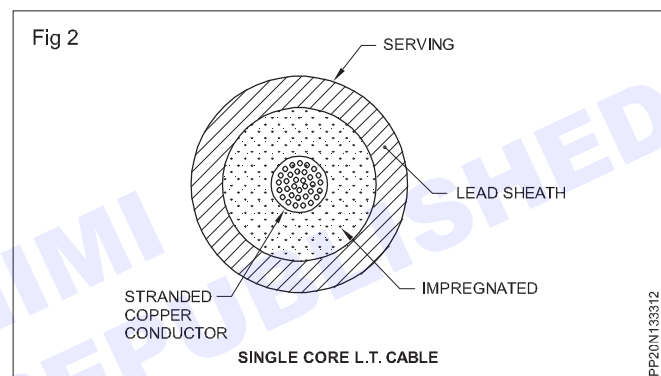
Classification of cables

Cables for underground service may be classified in two ways according to (i) the type of insulating material used in their manufacture (ii) the voltage for which they are manufactured. However, the later method of classification is generally preferred as

- i Low-tension (L.T) cables – upto 1100 V
- ii High-tension (H.T) cables – upto 11,000 V
- iii Super-tension (S.T) cables – from 22 KV to 33 KV
- iv Extra high-tension (E.H.T) cables – from 33 to 66 KV
- v Extra super voltage cables – beyond 132 KV

A cable may have one or more than one core depending upon the type of service for which it is intended. It may be (i) single-core (ii) two-core (iii) three-core (iv) four-core etc. For a 3-phase service, either 3-single core cables or three-core cable can be used depending upon the operating voltage and load demand.

Fig 2 shows the constructional details of a single-core low tension cable. The cable has ordinary construction because the stresses developed in the cable for low voltages (up to 6600 V) are generally small. It consists of one circular core of tinned stranded copper (or aluminum) insulated by layers of impregnated paper. The insulation is surrounded by a lead sheath which prevents the entry of moisture into inner parts. In order to protect the lead sheath from corrosion, an overall serving of compounded fibrous material (jute etc.) is provided. Single-core cables are not usually armored in order to avoid excessive sheath losses. The principal advantages of single-core cables are simple construction and availability of large copper section.



Cables for 3-Phase Service

In practice, underground cables are generally required to deliver 3-phase power. For the purpose, either three-core cables or three single core cables may be used. For voltages upto 66 KV, 3-core cable (i.e. multi-core construction) is preferred due to economic reasons. The following types of cables are generally used for 3-phase service.

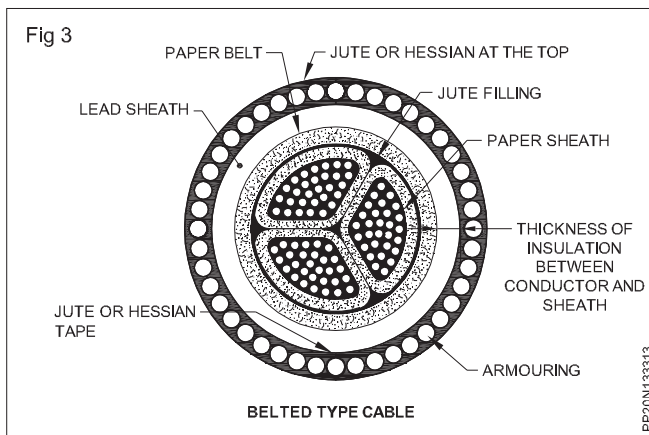
- 1 Belted cables – upto 11 KV
- 2 Screened cables – from 22 KV to 66 KV
- 3 Pressure cables – beyond 66 KV

1 Belted cables

These cables are used for voltages up to 11 KV but in extraordinary cases, their use may be extended up to 22 KV. Fig 3 shows the constructional details of a 3-core belted cables. The cores are insulated from each other by layers of impregnated paper.

Another layer of impregnated paper tape called paper belt is wound round the grouped insulated cores.

The gap between the insulated cores is filled with fibrous insulating material (jute etc.) The belt is covered with lead sheath to protect the cable against ingress of moisture and mechanical injury.

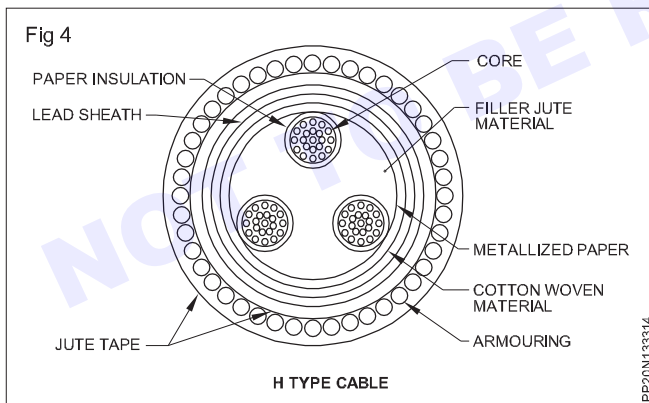


The belted type construction is suitable only for low and medium voltages as the electrostatic stresses developed in the cables for these voltages are more or less radial i.e. across the insulation. However, for high voltages (beyond 22 KV), the tangential stresses also become important.

2 Screened cable

These cables are meant for use upto 33 KV but in particular cases their use may be extended to operating voltages upto 66 KV. Two principal types of screened cables are H-type cable and S.L. type cables.

- i **H-type cables:** This type of cable was first designed by H. Horchstadter and hence the name. Fig 4 shows the constructional details of a typical 3-core, H-type cable. Each core is insulated by layers of impregnated paper. The insulation on each core is covered with a metallic screen which usually consists of a perforated aluminium foil.

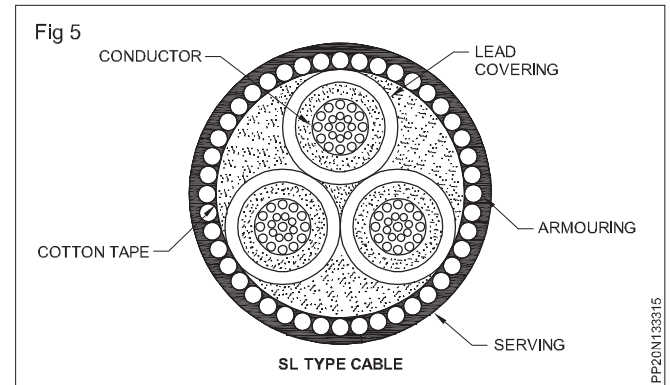


The cable has no insulating belt but lead sheath, bedding, armouring and serving follow as usual. As all the four screens (3 core screens and one conducting belt) and the lead sheath are at earth potential.

Advantages

- The possibility of air pockets or voids in the dielectric is eliminated
 - The metallic screen increase the heat dissipating power of the cable
- ii **S.L. type cables:** Fig 5 shows the constructional details of 3-core S.L (separate lead) type cable. It is basically H-type cable but the screen round each

core insulation is covered by its own lead sheath. There is no overall lead sheath but only armouring and serving are provided.



The S.L type cables have two main advantages over H-type cables.

- a The separate sheaths minimize the possibility of core-to-core breakdown.
- b Bending of cables become easy due to the elimination of overall lead sheath.

The disadvantage is that the three lead sheaths of S.L. cable are much thinner than the single sheath of H-cable

Limitations of solid type cables

All the cables of above constructions are referred to as solid type cables because solid insulation is used and no gas or oil circulates in the cable sheath. The voltage limit for solid type cables is 66 KV due to the following reasons:

- a As a solid cable carries the load, its conductor temperature increases and the cable compound (i.e. insulating compound over paper) expands. This action stretches the lead sheath which may be damaged.
- b When the load on the cable decreases, the conductor cools and a partial vacuum is formed within the cable sheath. If the pinholes are present in the lead sheath, moist air may be drawn into the cable. The moisture reduces the dielectric strength of insulation and may eventually cause the breakdown of the cable.
- c In practice, voids are always present in the insulation of a cable. Modern techniques of manufacturing have resulted in void free cables. However, under operating conditions, the voids are formed as a result of the differential expansion and contraction of the sheath and impregnated compound.

3 Pressure cables

For voltages beyond 66 KV, solid type cables are unreliable because there is a danger of breakdown of insulation due to the presence of voids. When the operating voltages are greater than 66 KV, pressure cables are used. In such cables, voids are eliminated by increasing the pressure of compound and for this reason they are called pressure cables. Two types of pressure cables viz oil filled cables and gas pressure cables are commonly used.

- i **Oil filled cables:** In such type of cables, channels of ducts are provided in the cable for oil circulation. The oil under pressure (it is the same oil used for impregnation) is kept constantly supplied to the channel by means of external reservoirs placed at suitable distances (say 500 m) along the route of the cable.

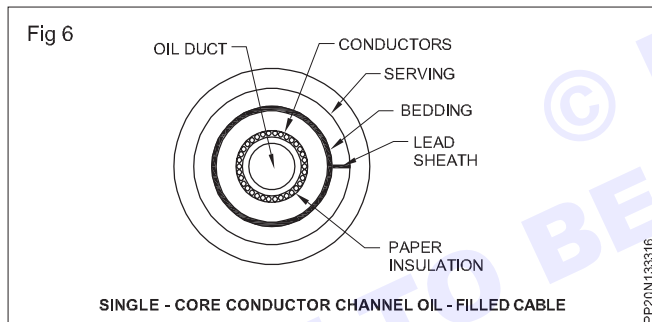
Oil under pressure compresses the layers of paper insulation and is forced into any voids that may have formed between the layers. Due to the elimination of voids, oil-filled cables can be used for higher voltages, the range being from 66 KV upto 230 KV.

Oil-filled cables are of three types viz.

- i Single-core conductor channel
- ii Single-core sheath channel and
- iii Three-core filler-space channels.

i Single-core Conductor channel

Fig 6 shows the constructional details of a single-core conductor channel, oil-filled cable. The oil channel is formed at the centre by stranding the conductor wire around a hallow cylindrical steel spiral tape. The oil under pressure is supplied to the channel by means of external reservoir. As the channel is made of spiral steel tape, it allows the oil to percolate between copper strands to the wrapped insulation.



The oil pressure compresses the layers of paper insulation and prevents the possibility of void formation. The disadvantage of this type of cable is that the channel is at the middle of the cable which is at full voltage w.r.t earth, so that a very complicated system of joints is necessary.

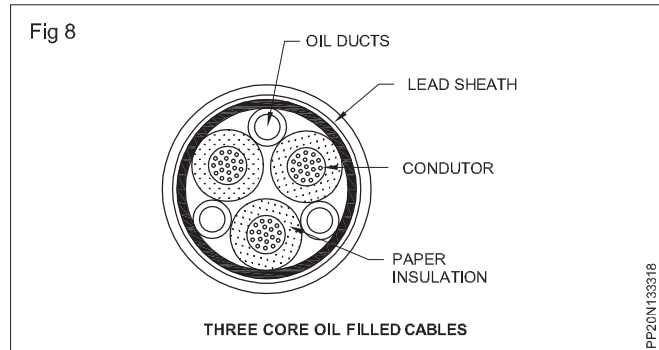
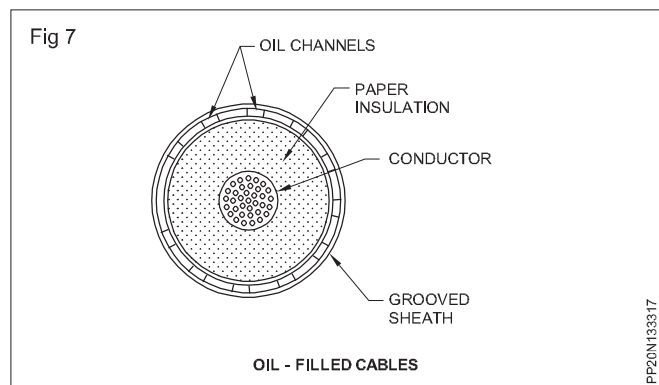
ii Single-core sheath channel (Fig 7)

In this type of cable, the conductor is solid similar to that of solid cable and is paper insulated. However, oil ducts are provided in the metallic sheath.

In the 3-core oil-filled cable shown in Fig 8, the oil ducts are located in the filler space. These channels are composed of perforated metal-ribbon tubing and are at earth potential.

Advantages

- a Formation of voids and ionization are avoided.
- b Allowable temperature range and dielectric strength are increased.

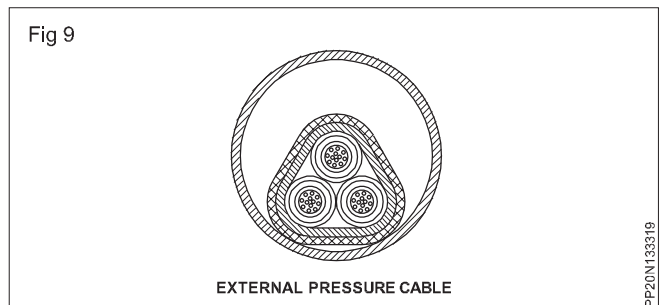


- c If there is leakage, the defect in the lead sheath is at once indicated and the possibility of earth faults is decreased.

Disadvantages

- a High initial cost and complicated system of laying
- ii Gas pressure cables. The voltage required to set up ionization inside a void increases as the pressure is increased. Therefore, if ordinary cable is subjected to a sufficiently high pressure, the ionization can be altogether eliminated. At the same time, the increased pressure produces radial compression which tends to close any voids. This is the underlying principle of gas pressure cables.

Fig 9 shows the section of external pressure cable designed by Hockstadter, Vogel and Bowden. The construction of the cable is similar to that of an ordinary solid type except that it is of triangular shape and thickness of lead sheath is 75% that of solid cable. The triangular section reduces the weight and gives low thermal resistance but the main reason for triangular shape is that the lead sheath acts as a pressure membrane. The sheath is protected by a thin metal tape. The cable is laid in a gas-tight steel pipe.



The pipe is filled with dry nitrogen gas at a pressure of 12 to 15 atmospheres. The gas pressure produces radial compression and closes the voids that may have formed between the layers of paper insulation.

Advantages

- Cables can carry more load current
- Operate at higher voltages than a normal cable.
- Maintenance cost is small and the nitrogen gas helps in quenching any flame.

Disadvantages

The overall cost is very high.

Further the cables are also classified according to their insulation system as under:

- | | |
|----------------------|---|
| PVC insulated cables | (Poly vinyl chloride) |
| MI cables | (Mineral insulation) |
| PILC cables | (Paper insulated lead covered) |
| XLPE cables | (Cross linked poly ethylene) |
| PILCDTA cables | (Paper insulated lead covered double tape armoured) |

The specification of underground cables

The cables shall carry the following information either labelled or stenciled on the reel or drum or container.

- Reference to the Indian Standard; for example Ref. IS 694-1977.
- Manufacturer's name, brand name or trademark.
- Type of cable and voltage grade.
- Number of cores.
- Nominal cross-sectional area of conductor.
- Cable code.
- Colour of cores (in case of single core cables)
- Length of cable on the reel, drum or coil
- Number of lengths on the reel, drum or coil (if more than one).
- Direction of rotation of drum (by means of arrow).
- Approximate gross weight.
- Country of manufacturing.
- Year of manufacture.

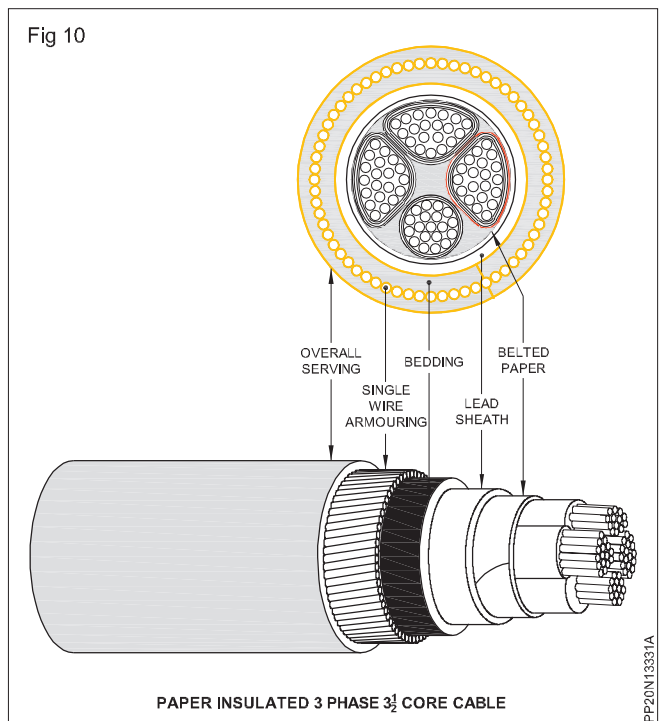
Fig 10 shows the paper insulated 3 phase 3 ½ core cable.

UG cables laying method

The reliability of the underground cable (UG) installation depends upon the proper laying and attachment of fittings (i.e) cable and boxes, joints, branch connectors etc.

Methods of laying of UG cables

The following are the methods of laying underground cables



- Laying direct in ground
- Laying in ducts
- Laying on racks in air
- Laying on racks inside a cable tunnel
- Laying along buildings or structures

The choice of any of the systems given above depends on

- The actual installation conditions
- Initial cost of laying
- Maintenance and repair charges
- Desired care in replacement of any cable or adding new cables for the future.

As far as possible the cable should be laid along the roads and streets. Power and communication cables should cross at right angles.

During the preliminary stages of laying the cable, consideration should be given to a proper location of the joints position so that when the cable is actually laid, the joints are made in the most suitable places.

As far as possible water logged locations, carriage ways, pavements, proximity to telephone cables, gas or water mains in accessible places, ducts pipes, racks etc shall be avoided for joint position.

Laying direct in ground: This method involves digging a trench in the ground and laying cable(s) on a bedding of minimum 75 mm riddled soil or sand at the bottom of the trench, and covering it with additional riddled soil or sand of minimum 75 mm and protecting it by means of tiles, bricks or slabs.

Depth: The desired minimum depth from ground surface to the top of cable is as follows:

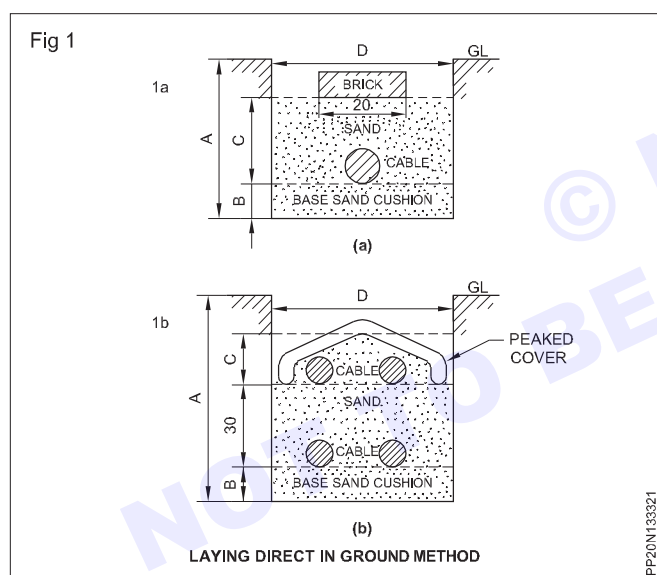
- a High voltage cables, 3.3 KV to 11 KV rating : 0.9 m.
- b High voltage cables, 22 KV, 33 KV rating : 1.05 m.
- c Low and medium voltage and control cables : 0.75 m.
- d Cables at road crossings : 1.00 m.
- e Cables at railway level crossings (measured from bottom of sleepers to the top of pipe) : 1.00 m.

Width: The width of a trench for laying a single cable should be minimum 35 cm. When more than one cable is laid in the same trench in horizontal formation, the width of the trench shall be so increased that the inter-axial spacing between two cables is 20 cm.

Clearance from the terminal cable to the sides of a trench should be 15 cm.

Cable is protected by sand or layer of brick as shown in Fig 1a. Bricks should be second class bricks of a size not less than 20 cm x 10 cm x 10 cm and laid for full length for one cable (bricks to be laid breadthwise).

When more than one cable is to be laid in the same trench, this protective covering shall extend at least 5 cm. over the sides of the end cables. An alternative to this covering can be earth ware or R.C.C. or fire-bricks of peaked covers section as shown in Fig 1 b.



It is good practice to leave about 3 meters of cable spare in a loop formation near poles and joints, so that in case joint fails, this additional cable comes to rescue. Cable should be laid 0.4 meter away from water and power mains.

For cable of rating

Ref.	up to 1.1 kV	Exceeding 1.1 kV
A	75	120
A1	$(75+n1 \times 30)$	$(120+n1 \times 30)$
B	8	8
C	17	17
D	35	35
D1	$(30+n2 \times 20)$	$(30n2 \times 20)$
E	15	15

$n1$ = Number of additional cables in vertical formation.

$n2$ = Number of additional cables in horizontal formation.

For road crossings cast iron, or 2nd class RCC pipes or M.S/G.I. Pipe of medium class having an appropriate diameter should be laid during construction of the road to avoid damage to the road later on. The top surface of the pipe should be at a minimum depth of 1m. Pipes provided for entry to a building shall slope upward to prevent entry of water into the building. After laying of the cable they should be sealed.

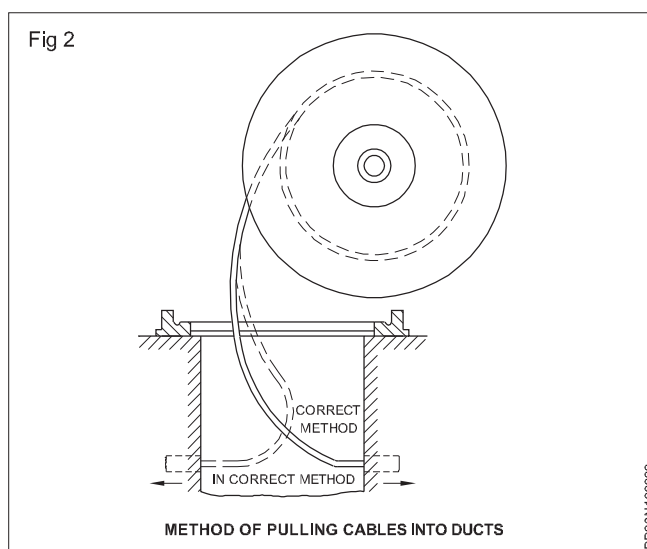
Advantages

- 1 It is a simple and less costly method.
- 2 It gives the best conditions for dissipating the heat generated in the cables.
- 3 It is a clean and safe method as the cable is invisible and free from external disturbances.

Disadvantages

- 1 The extension of load is possible only by a complete new excavation which may cost as much as the original work.
- 2 The alterations in the cable network cannot be made easily.
- 3 The maintenance cost is very high.
- 4 Localization of fault is difficult.
- 5 It cannot be used in congested areas where excavation is difficult.

Drawing the cables into duct pipes: When drawing the cables through ducts, lack of space in the drawing pits usually restricts the distance from the cable drum to the duct mouth. It is essential that the direction of curvature of the cables is not reversed as it enters the duct. If the cable drum is on the same side of the drawing pit, as shown in Fig 2, this condition is fulfilled.



B.I.S. Symbols

Objective: At the end of this lesson you shall be able to

- interpret the various BIS symbols used in electrical wiring diagrams.

In electro technical engineering the symbols are used in layouts and wiring circuits to represent the electrical parts or the function of the circuit.

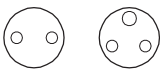
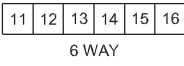
Since the drawing of the actual device is very laborious and would be drawn by each person differently,

standardized symbols are used. With the help of the symbols, an electric circuit can be represented easily and can be described precisely as well.

A few examples of standard symbols recommended by B.I.S. 2032 (different parts) used for wiring are given here.

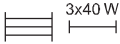
B.I.S. SYMBOLS FOR WIRING SCHEMES

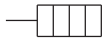
Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
1	One-way switch, single pole		
2	One-way switch, two poles		
3	One-way switch, three poles		
4	Multi-position switch single pole		
5	Two-way switch		
6	Intermediate switch		
7	Push-button or bell-push		

Sl.No.	Description	Symbols used in the circuit diagram	Symbols used in layout
8	Socket outlets, 6A		
9	Socket outlets, 16A		
10	Lamp or outlet for lamp		
11	Fuse		 MAIN & D.B FUSE BOARDS
12	Bell		
13	Buzzer		
14	Earth point		
15	Circuit breaker		
16	Terminal strip.		N.A
17	Link (closed)		N.A
18	Plug and socket (male and female)		N.A
19	Ceiling rose.		N.A
	N.A: Not applicable		

The B.I.S. Symbols used in the wiring is given here

ITEMS	SYMBOLS
I Wiring	
1 General wiring	
2 Wiring on the surface	
3 Wiring under the surface	
4 Wiring in conduit	
a Conduit on the surface	
b Conduit concealed	
The type of conduit may be indicated, if necessary.	
5 Wiring going upwards	
6 Wiring going downwards	
7 Wiring passing vertically through a room	
II Fuse-boards	
1 Lighting circuit fuse-boards	
a Main fuse-board without switches	
b Main fuse-board with switches	
c Distribution fuse-board without switches	
d Distribution fuse-board with switches	
2 Power circuit fuse-boards	
a Main fuse-board without switches	
b Main fuse-board with switches	
c Distribution fuse-board without switches	
d Distribution fuse-board with switches	
III Switches and switch outlets	
1 Single pole pull-switch	
2 Pendent switch	

ITEMS	SYMBOLS
IV Socket outlets	
1 Combined switch and socket outlet, 6A	
2 Combined switch and socket outlet, 16A	
3 Interlocking switch and socket outlet, 6A	
4 Interlocking switch and socket outlet 16A	
V Lamps	
1 Group of three 40 W lamps	
2 Lamp, mounted on a wall or light bracket	
3 Lamp, mounted on ceiling	
4 Counterweight lamp fixture	
5 Chain lamp fixture	
6 Pendent lamp fixture	
7 Lamp fixture with built-in switch	
8 Lamp fed from variable voltage supply	
9 Emergency lamp	
10 Panic lamp	
11 Bulk-head lamp	
12 Watertight light fitting	
13 Batten lamp-holder (Mounted on the wall)	
14 Projector	
15 Spotlight	
16 Floodlight	
17 Fluorescent lamp	
18 Group of three 40W fluorescent lamps	

ITEMS	SYMBOLS
Electrical appliances	
1 General If necessary, use designation to specify.	
2 Heater	
VII Bells, buzzers and sirens	
1 Siren	
2 Horn or hooter	
3 Indicator (at 'N' insert number of ways)	
VIII Fans	
1 Ceiling fan	
2 Bracket fan	

ITEMS	SYMBOLS
3 Exhaust fan	
4 Fan regulator	
IX Telecommunication apparatus	
1 Aerial	
2 Loudspeaker	
3 Radio receiving set	
4 Television receiving set	

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PPO - Identification of Plastics and Testing

Introduction of plastics

Objective: At the end of this lesson you shall be able to

- define the basic concepts of of polymerization, properties and applications of polymeric substance.

Introduction

Plastic as defined by American society for material testing is a material that contains as an essential ingredient substances of a large molecular weight.

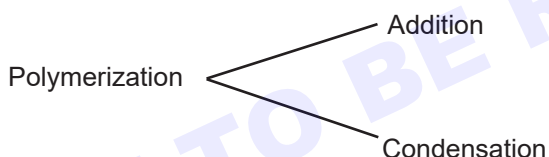
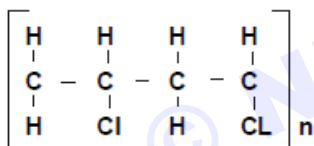
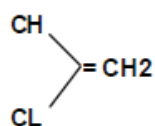
The word polymer is a combination of two words 'poly' and 'Mer'. 'Poly' means many whereas 'mer' means one or single. Polymer is organic substance but all polymers need not necessarily be plastics.

Polymerization:

A chemical reaction in which similar small molecules are linked together to form large molecule.

For example poly (Vinyl chloride) is produced by the double bonds of vinyl molecules opening up and linking up and linking together.

Ex:- P.V.C



Addition polymerisation

It is a chemical reaction in which monomers are linked together without elimination of water or other single molecules.

Ex: ethylene – addition polymerization- polyethylene.

Condensation polymerization

It is a chemical reaction in which monomers are linked together with the elimination of water or other simple molecules or by stepwise combination of these reaction polymer obtained is known as condensation polymer.

e.g. : phenolic resin, UF resin nylon 66 and poly carbonate.

Types of polymer

Natural polymer

The polymer which can be extracted from natural sources is known as natural polymer. The monomer of natural polymer is recovered from of natural sources like cotton, wood. Important natural polymers are cellulose Acetate, cellulose, rubbers, starch, sugar. The cellulose can be converted into cellulose acetate, cellulose nitrates etc.

Synthetic polymer

All polymers which are available from organic compounds are known as synthetic polymer, main organic compound which is used for synthetic polymer is coal or petroleum product (Naptha). The economical way of synthetic production is to use the petroleum product.

Amorphous polymer/plastics

May be defined as a polymer which has 50% or more of amorphous regions (Unrented regions). Because of this they have wide range of softening point.

Crystalline polymer/plastics

May be defined as a polymer which has 50% or more of crystalline regions (oriented region). Because of this they a sharp melting point.

Group of plastics

Objective: At the end of this lesson you shall be able to

- define the group of plastics and distinguish between them and also wil know the properties and major areas of application of thermoplastics .

Group of plastics

The plastics are divided into following two groups on the basis of their chemical characteristics.

- Thermo - plastics
- Thermosetting - plastics

Thermoplastic: These are plastic that soften repeatedly when heated and harden when cooled. They are soluble in specific solvents.

Examples – Nylon, acrylic, vinyl and cellulose acetate.

Thermosetting plastic

These are plastic that undergo chemical change during processing to become permanently insoluble and infusible.

Example: Phenolic, amino epoxy and polyester resins

Distinction between Thermoplastics & Thermoset plastics

Thermoplastics	Thermosets
a Can be recycled any number of time	a Cannot be recycled
b Will soften on heating and harden on cooling	b Once set is over set
c Undergoes physical change while processing	c Undergone irreversible chemical change while processing
d Mostly linear or branched chain polymers	d Cross linked polymers
e Can be processed by all conventional machine like injection moulding extrusion, blow moulding etc.	e Can be processed by compressed moulding / transfer moulding & specially designed injection moulding machine. Liquid resins can set a room temp. in casting application with the use of catalyst.

Applications

- a Household applications which includes handles, knobs, plugs and switches for electrical connections.
- b Electrical and electronic applications include insulators, components for switchgears, circuit breakers, relays and large portion of any module, circuit, assembly, is insulated protected and made by the plastics of this family.
- c Automobiles application includes body components, engine hood, buffers etc.
- d Chemical industries applications include process equipment's, tanks vots etc.
- e Industries & miscellaneous applications are in defense materials, aerospace, silos for food grain, air pollution control equipment's.

PE, PP, PVC, PMMA properties and uses of thermoplastic

Objective: At the end of this lesson you shall be able to

- define the properties and applications of low and high density polyethylene .

Introduction

There are three main types of conventional polyethylene:

- a Low density polyethylene (LDPE) with a density of 0.910 to 0.929 gm/cm³
- b Medium density polyethylene (MDPE) with density of 0.930 to 0.940 gm/cm³
- c High density polyethylene (HDPE) with density of 0.941 to 0.965 gm/cm³

LDPE is produced in autoclaves or tubular reactors at high pressures. MDPE and HDPE are produced by medium or low pressure processes. Although conventional LDPE is produced by a high pressure process, new technologies have been developed in recent years to produce LDPE by medium or low pressure processes similar to those used to manufacture MDPE and HDPE. The new species of LDPE has the same straight chain molecular structure as MDPE and HDPE and differs substantially in physical properties from conventional LDPE whole molecules contain innumerable long chain branches. Because of its straight chain molecular structure this new type of LDPE is called L-LDPE (linear LDPE). Its density, a major factor in the resins performances, is controlled by varying the amount of alpha olefins co- polymerized with ethylene. L- LDPE is generally superior to conventional LDPE with respect to tensile strength, glass and heat resistance. Physical properties of L-LDPE vary with the kind of alpha-olefins used as the co-monomer.

The properties of polyethylene are mainly determined by density, molecular weight and molecular weight distribution.

With increasing density (higher crystallinity) an increase also occurs in the following properties.

- Yield stress (tensile strength)
- Elastic modules (stiffness), hardness
- Solvent resistance.
- Impermeability to gases and vapors

On the other hand impact strength transparency and stress cracking resistance decrease with increasing density. An increase in molecular weight results in an increase in impact strength and notched impact strength, tensile strength at break and elongation at break. Within the same density range increase in molecular weight also results in stress cracking resistance.

The macromolecules of a thermoplastic possess chain lengths. This results in varying breadths different of molecular weight distribution. High density polyethylene with a narrow molecular weight distribution and a small low-molecular weight portion has higher impact strength, also at low temperatures, than a product with a wide molecular weight distribution within same ranges of melt index (MFI) and viscosity number. Products with a wide molecular weight distribution are in turn easier to process.

General Properties

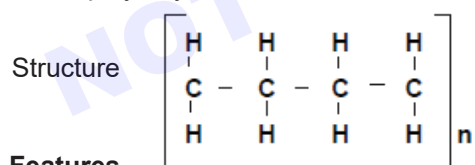
Because of the large number of polyethylene variations, it is difficult to be very specific about properties of polyethylene as they encompass a broad range. Keeping this in mind following are the distinguishing (properties) characteristics.

Polyethylene are amongst the lowest density plastics.

Impact behavior of polyethylene depends primarily on the crystallinity (density) and molecular weight (melt flow). The low density polyethylene are too flexible at room temperature to be broken by standard impact tests.

- Polyethylene's have very low water absorption.
- They exhibit poor weather ability unless they contain 2 to 2 ½ of properly dispersed carbon black. Under these conditions their weather ability is excellent.
- They have excellent electric properties with very low power factors which are virtually unaffected by frequencies and by temperature changes up to 60°C.
- Under no load conditions they have good heat stability. Even small loads, however, cause distortion and flow even at moderate temperature.
- They are essentially inert, unaffected by strong and weak acids and alkalis detergents, alcohols and ketones. They swell with chlorinated and aromatic hydrocarbons including gasoline and oils. They are susceptible to environmental conditions and is limited, by definition to those chemicals which do not attack polyethylene by swelling. These are usual long term phenomena and are dependent on the stress cracking agent temperature and stress.
- The material can be produced by extrusion, injection moulding blow moulding and rotational moulding.

Name polyethylene



Features

- Crystalline, versatile materials
- General purpose material used extensively
- Impact resistance from 40°C to 90°C
- Inert, non – toxic, moisture resistance
- Excellent resistance to chemicals
- Processed by all conventional processing methods
- Low temperature flexibility
- High thermal expansion
- Poor weathering resistance
- Subject to stress cracking
- Difficult to bond, flammable

Applications

- Films for all purpose
- Consumer durables like containers, buckets etc.
- Sports toys
- Tubes, pipes, for irrigation, potable water supply

PP

Introduction

Polypropylene is produced by polymerizing propylene. It is the fastest growing thermoplastic material. Both homopolymer and copolymers with ethylene are commercially available.

General properties

Polypropylene has the highest tensile strength of the olefins. It is high tensile modulus which can be further increased by reinforcements such as talc. Its notched impact strength is low for most grades. This does not correlate with service conditions where impact failure at room temperature is exceedingly rare. Unnotched impact tests give a much better correlation.

- It is very notch sensitive and care should be taken in part design to eliminate sharp corners. Copolymerizing with small amounts of polyethylene greatly improves the impact resistance.
- It has good low temperatures impact strength
- It has very good surface gloss.
- It has unusually good fatigue resistance. Hinges with about 0.4 mm thickness will flex almost indefinitely with very high tear strength. Because of its flexibility snap fits are practical.
- It has excellent abrasion resistance and very low co-efficient of friction, comparable to that of Nylon. However, lubricating nylon surfaces reduces the friction much more polypropylene. It is used for load bearing applications.
- Because of its high melting point, about 165°C and its high crystallinity it has excellent high temperature properties. It is usable up to 120°C and can be readily steam sterilized.
- It has poor weather ability which can be improved by UV stabilizers or carbon black.
- It has excellent chemical resistance of all olefins. It is resistance to dilute acids, concentrated acids (except oxidizing acids) alkalis, alcohols, detergents and water. It resists aromatic hydrocarbons, chlorinated hydrocarbons, greases and oils at room temperature but is attacked at about 60°C It does not exhibit environmental stress cracking of polyethylene. Its water absorption is very low with an equilibrium immersed water content of 0.03%.
- The homopolymer and copolymer can be compounded to be rated slow burning, self – extinguishing and nondripping.

- It is an excellent electrical insulator and has extremely low dielectric losses. Because of self-extinguishing properties of certain grades it has found wide use as support for electrical components with a density of 0.90.
- It is one of the lightest of all commercial polymers. It can be hot stamped, painted and printed as well.

Applications

Injection moulding

T.V. back covers, house wares, containers, hinged applications, closures, battery cases, tote boxes bolilet seats, washing machine agitators, pump parts , automobile bumpers fan canopies, regulator covers etc.

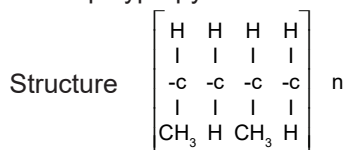
Extrusion

Sheets pipes. Films for packaging, monofilaments for and brush bristles etc.

Below moulding

Packaging containers.

Name polypropylene



Features

- Crystalline polymers with higher melting point compared with polyethylene
- Low density
- Processed by all thermoplastic methods
- Excellent chemical resistance
- Excellent fatigue resistance
- Good impact strength
- Degraded by UV. Flammable
- Attacked by chlorinated solvents and aromatics
- Difficult to bond

Applications

- Industries parts for fluid processing
- Household goods
- Automotive and electrical hardware
- Films – biaxial oriented
- Packaging, films , containers, strapping etc.

PVC

Introduction

Polyvinyl chloride (PVC) is obtained by polymerizing vinyl chloride. These reins are not suitable for direct processing like polystyrene etc. To confer the required processing and end-use stability it is necessary to add stabilizers to PVC. Lubrications are also required

to facilitate processing. Thus for unplasticised or rigid PVC stabilizers and lubricants are the only two basic ingredients.

Special features of PVC is its ability to accept plasticizers. Plasticizers can be added in various proportions, the softness and processing ease of the compound increase with increasing proportion of plasticizer. The PVC incorporates other additives also like flow promoters, fillers, extenders, colorants etc.

Products form PVC are usually made by

- a Injection
- b Blow moulding/injection blow moulding
- c Extrusion
- d Rotational
- e Thermoforming
- f Coating
- g Colendering
- h Compression moulding

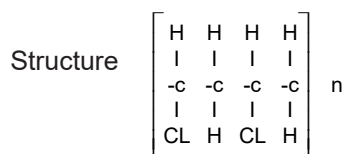
General properties

- It is chemically inert
- It is water, corrosion and weather resistant.
- It is light in weight
- It can be co-polymerized with variety of materials
- It is tough and dent resistant.
- It has good electrical resistance and thermal insulation properties.
- It is self- extinguishing.

Applications

- Principal products from rigid PVC includes pipe conduit, pipe fittings, rain water gutters etc.
- Flexible PVC is used for raincoats, baby pants, dolls, bottles, shoe soles, wire insulation, film, sheets, draperies, garden hose, gasket, closures, shower curtains, inflatable toys etc.

Name : polyvinyl chloride



Features

- Unmodified material is a rigid thermoplastic
- Flexibility is obtained by adding plasticizers.
- Also available in liquid suspension known as plastisol
- Processed by thermoplastic methods
- Self-extinguishing non-flammable
- Comparatively low cost

- Good dimensional stability
- Good resistance to weathering
- Attacked by several solvent types.
- Heat sensitive material. Hence care should be taken while processing. Evolves HCL gas on decomposition
- Higher density than many other plastics

Applications

- Pipes, tubes, & profiles
- Films, sheets
- Cables, wire insulation
- Bottles, household articles
- Fabric coatings
- Toys and sports goods

PMMA

Introduction

Acrylic is a polymethyl, methacrylate polymer (PMMA). It is hard, rigid, transparent engineering material with a number of outstanding properties. It is available in the form of moulding powder and sheet.

General properties

It has best transparency and optical properties of commercially available thermoplastic. It is colorless with a 92% light transmission. It has a refractive index of 1.49. It comes in a full range of transparent, translucent and opaque colors.

- It has excellent gloss and good 'feel'
- It has good dimensional stability
- It has good mechanical properties but on the low side for engineering materials.
- It is classified as slow burning, releasing little or no smoke.
- It has the best weather ability of all transparent plastics and probably of all plastics. It is exceptionally resistant to sunlight and outdoor exposure with a loss of 1 % in transmission over 5 years. It is highly resistant to ultraviolet radiation, particularly from fluorescent lighting.
- It is unaffected by human tissues (dentures and temporary fillings) and is usable with food.
- Resistant to dilute acids and alkalis, aliphatic petroleum oils, aliphatic hydrocarbons, dilute alcohols and detergents. It is not resistant to concentrated alkalis and oxidizing acids. Lower ketones, esters, aromatic and halogenated hydrocarbons. Thus solvent bonding of parts are possible.

Applications

Some of its major applications are lenses, outside lighting, indoor lighting beverage dispensers, housing

for vending machines, housing for gas and electric meters, decorative items. Its automotive applications include tail –lights, instrument panels, dials, signal lights, bath tubs, sinks, advertising displays, household articles etc.

PC (Polycarbonate)

Introduction

Polycarbonate is a condensation polymer of phenol and phosgene. It is one of the toughest, most dimensionally stable thermoplastic over a wide range of temperature.

General properties

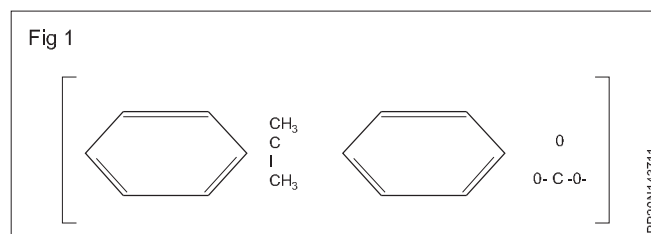
- It has water white transparency with 90% light color transmission. Its index of refraction 1.586. It is available in all colors.
- It has exceptionally high impact strength.
- It is one of the most dimensionally stable thermoplastic. It has high load bearing strength which further increases with glass reinforcement. This dimensional stability as with other properties is maintained over wide temperature range. It has uniform mould shrinkage of 0.06% in both direction which permits moulding with close tolerances.
- It is soluble in or attacked by chlorinated hydrocarbons, most aromatic solvents, esters and ketones.
- Properly stabilized it has good weather ability.
- It is physiologically inert.
- It has excellent electrical insulation over wide range of humidity and temperature condition.
- It is self-extinguishing
- It has very high service temperature range.

Applications

Some of the major uses of polycarbonates are in outdoor lighting, lenses, tool and appliance housings, bottle, air – craft interiors, trim bezel and lamp housing of automobiles, sunglasses, etc.

Name: Polycarbonate

Structure (Fig 1)



Features

- Toughness and rigidity up to 140°C
- Transparency
- Very good electrical insulation characteristics

- Self-extinguishing, high impact strength
- Physiological inertness
- Relatively expensive material among other plastics
- Special care required in processing
- Limited resistance to chemicals and ultraviolet light
- Notch sensitivity and susceptibility to crazing under strain

Applications

- Electrical/Electronic housings
- Covers for time switches, batteries, relays
- Photo projector housings.
- Films are used for engraving
- Very good glazing materials
- Optics- lamp housings, safety goggles etc.
- Cutlery items like cup, saucers, bowls, etc.

Properties and uses of thermoplastic material SAN, PC, NYLON, PET

Objective: At the end of this lesson you shall be able to

- comprehend and explain the styrene group of plastics, their general properties and applications .

STYRENE ACRYLONITRILE (SAN)

Styrene Acrylonitrile is a co-polymer of styrene and Acrylonitrile. Large number of general and special purpose grades are available.

General properties

- This co-polymer possesses most of the features considered desirable in crystal polystyrene and also exhibits improved resistance to chemical attack and stress cracking; high heat deflection and greater strength and toughness due to presence of acrylonitrile.
- It is a hard rigid and transparent thermoplastic offering good load bearing characteristic and dimensional stability.
- Products of SAN have good surface gloss and hardness.
- It is resistant to aqueous acids and alkalis, detergents and bleaches, gasoline and chlorinated hydrocarbons.
- However they may be swollen (not dissolved) by aromatic compounds. They are soluble in ketones.
- It possesses most of the easy processing characteristics found in general purpose polystyrene.

Applications: -

Telephone parts, filter bowls, terminal boxes, stationery juice battery box Battery caps, automotive juice blenders and mixer bowls, , cosmetic containers, pen and ball pen barrels, toys, camera parts etc.

Nylon

Introduction

Nylon is a generic term for polyimides. Nylon consists of a family of materials, the most common of which is 6/6, 6. 6/10 and 6/12.

General properties

- Nylon is a hygroscopic material. To be moulded satisfactorily nylon must have less than 0.3% moisture content.

- It has good toughness, high tensile strength and creep, particularly in the high temperature range. It can withstand repeated impacts.
- It has a combination of excellent abrasion resistance and exceptionally low co-efficient of friction. It can be used without lubrication.
- The resiliency of Nylons permits the load to be spread over large surface areas.
- Nylons are resistant to detergents, fuel, greases and oils including animal and vegetable oils. They are extremely resistant to aromatic and chlorinated hydrocarbons, ketone and ester solvents as well as alcohols. They are not affected by alkalis or dilute acids and are not resistant to strong acids, bleaching agents and hydrogen peroxide.
- They are soluble in phenol, which is used as a cement.
- Because of high crystallinity nylons have excellently high temperature resistance.
- Nylons are self-extinguishing.
- Electrical properties are not outstanding and are affected by water. It is generally used below 500V and 100HZ/Sec.
- Nylons can be machined and fabricated readily.
- They are translucent.
- Outdoor weathering characteristics are not outstanding but can be improved by carbon black and certain stabilisers.

Comparative properties of different types of nylons

Nylon 6/6 : It is most widely used. It has the highest tensile strength, flexural modulus and heat resistance. It absorbs less moisture than Nylon 6 and is about 25% stiffer. It has good weather ability when pigmented with carbon black.

Nylon 6 : It is similar to Nylon 6/6 in many respects though it has lower physical properties. It has lower melting point and hence can be processed at about 25°C lower temperature.

Nylon 6/10

It absorbs about one half as much water as nylon 6/6 and 1/3 as much as nylon 6. This greatly improves its electrical properties and stability. It is less crystalline and more flexible than the other two nylons. It is used primarily for its low moisture absorption and corresponding improvement in physical properties.

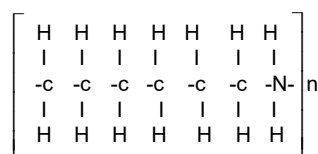
Nylon 6/12

It is gradually replacing Nylon 6/10. Retain its physical and electrical properties over a wide humidity range.

Applications

Gears, bearings cams, coil formers, housings, combs, battery cases, gaskets, wire connectors, zeppers. Monofilament applications include industrial sewing thread, brush bresttes, fishing nets etc. Packaging edible oils and food stuff.

Name polyamides (Nylons)



Features

- Crystalline thermoplastic material
- Tough and impact resistant
- Abrasion resistant
- Good solvent resistance
- Resistant to bases
- High moisture pick-up with related dimensional stability
- Requires UV stabilization
- High shrinkage in moulded sections
- Electrical & mechanical properties are greatly influenced by moisture content
- Generally, nylons are filled with glass fibers to enhance the performance/properties

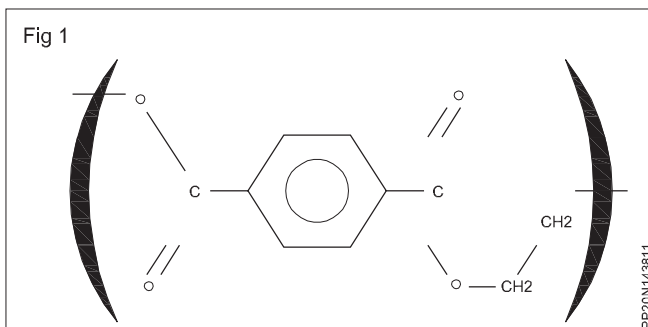
Applications

- Gears rollers, slides and cams
- Monofilament, fibers - ropes, mats etc.
- Tyre cord industry

- Engineering applications, especially with glass filled grades
- High barrier films, used in multi-layer systems.

Polyethylene Terephthalate (Fig 1)

Polyethylene terephthalate (commonly abbreviated PET, PETE, or the obsolete PETP or PET - P), is a thermoplastic polymer tesin of the polyester family Polyethylene terephthalate polyester (PETP) is the common thermoplastic polyester and is often called just "Polyester". (Fig 1)



Properties

- 1 Ability to exist either in amorphous or crystalline state.
- 2 High hardness and rigidity
- 3 Good strength
- 4 High dimensional stability
- 5 Very good slip and wear behavior
- 6 Has good gas barrier properties
- 7 Good chemical resistance except to alkalis
- 8 Strong and impact - resistant

Uses

- 1 Bottles and food containers
- 2 Fibres for clothing
- 3 Film for electrical insulation
- 4 Packaging
- 5 Amorphous molded bodies with high transparency.
- 6 Gastight bottles for carbonated beverages
- 7 Highly stressed technical molded parts such as bearings, gear teeth, cam wheels, connectors, bolts, screws, and washers.

Key Properties			
Chemical Resistance	Good		
Acids - Concentrated	Good		
Acids - dilute	Good		
Alcohols	Poor		

Alkalies	Poor		
Aromatic hydrocarbons	Fair		
Greases and Oils	Good		
Halogens	Good		
Ketones	Good		
Electrical Properties			
Dielectric Constant @ 1MHZ	3.0		
Dielectric Strength (Kv.mm-1)	17		
Dissipation factor @ 1kHz	0.002		
Surface resistivity (Ohm /sq)	1013		
Volume resistivity (Ohm.cm)	>1014		
Properties Polyethylene Terephthalate Fiber			
Property		Value	
Material		Medium	High Tenacity
Specific Modulus	cN /tex		700 - 800
Specific Tenacity	cN /tex	36	70 - 80
Density	g Cm ⁻³	1.39	1.39
Extension to break	%	36	13 - 16
Modulus	GPa		9 - 11
Shrinkage @ 100° C	%	4	1.5-6
Tenacity	GPa	0.5	0.9 - 1.1

Properties and uses of thermoset plastic material PF, UF,MF

Objective: At the end of this lesson you shall be able to

- state of the basic concepts of thermosets like PF, UF, MF, epoxides and polyester resin - their properties and applications .

Introduction

There are many phenolic moulding compounds depending upon resin system and filler composition

Single stage Resin (RESOL)

In production of single stage resin an alkaline catalyst is used. Sufficient formaldehyde is also introduced so that the resin can eventually crosslink and cure simply through the addition of heat without a curing agent. The process is controlled and stopped before complete crosslinking occurs so that the resin has enough "life" for the compounding and moulding operations. These resins are available in granule, powdered or liquid form

Two stage Resin (NOVOLAC)

This is produced by the controlled reaction of phenol and formaldehyde in presence of an acid catalyst. The amount of formaldehyde is maintained at a level insufficient to completely form a cured thermoset structure. To complete curing or cross-linking the chemical hexamethylenetetramine (hexa) is added. The crosslinking takes place with heat.

Compound

Phenolic moulding compounds are homogeneous mixtures of resins, various fillers, colouring agents, lubricants and modifiers. The resulting compounds are sold in the form of powder, granules or modules.

Compounds formulated with two stage resins have a greater moulding latitude better dimensional stability and better long term storage capabilities than with single stage resins. On the other hand compounds formulated with single stage resins are used where there is minimum ammonia requirement. They function well in electronic and appliance applications. Single stage compounds offer better resistance to cracking under conditions where one side and the other dry.

General properties

- Natural colour is dark brown.
- Excellent dimensional stability and rigidity.
- It is resistant to heat. Does not soften on heating but decomposes at high temperature.
- Retain properties at freezing temperature.
- Good dimensional stability on heating up to 150°C.

- Good resistance to alcohol, oils, grease and most common solvents and to weak acids and alkalies.
- Tend to darken on prolonged exposures.

Applications

These resins are used in the compounding of moulding materials, in bonding and laminating varnishes, laminates and overlays, foundry sands, water proof adhesives, insulation, bond for abrasive grains in grinding wheels, and brake linings, blocks and clutch faces.

Fillers for phenolic plastic

Sl.No.	Filler	Effect of fillers on plastic
i	Asbestos	Good resistance to high temperature Good dimensional stability. Low expansion Low moisture absorption.
ii	Carbon	Good electrical conductivity
iii	Cotton fibre and cloth	Good shock resistance
iv	Graphite	Good resistance to friction
v	Mica	Good electrical resistance, dimensional stability and low moisture absorption
vi	Paper, pulp form	Good impact resistance
vii	Wood flour	General purpose fillers
viii	Nylon fibre	Good impact resistance & dimensional stability
ix	Glass fibre	Dimensional stability, Excellent impact strength and electrical resistance High temperature resistance

Urea Formaldehyde

Introduction

Urea formaldehyde resin is made by reacting urea and formaldehyde in a resin kettle in a manner similar to that used for PF resin

General properties

- very greatly depending on fillers, laminating materials.
- Hard and rigid scratch resistant, strong and tough.
- Slight Shrinkage
- It has color range
- Thermosetting do not soften. Good stability to moderate temperature Burns with difficulties.
- Good resistance to most solvents and common chemicals.
- Unaffected by detergents, cleaning fluids (carbon tetrachloride) petrol, nail polish, alcohol, grease
Good insulation with resistance to arcing. Electrical properties do not deteriorate appreciably when moisture is absorbed.

Applications

a Resins and syrups

A range of material is produced for many purposes.

Uses: Foundry core production, surface coating, finishes for textile, papers, Adhesives, lamination.

b Moulding material

A wide range of moulding powder is produced in all shades including white translucent to opaque used for compression and transfer moulding

Uses: practical equipment (ie) plugs, switches etc., buttons, buckles, cosmetic jars, bottle taps, Knobs and handles, Cups, Saucers, plates, toys, clocks, radio cabinets Lighting fittings, kitchen equipments etc,

C Laminated material

Sheets and panels are made in a great variety of colours and patterns from UF

Use: Lighting fitting, building panels, signs.

Melamine Formaldehyde(MF)

Introduction: This is a condensation type thermosetting polymer produced by the reaction of formaldehyde with compounds containing the amino group. Amino resins usually are processed in the form of aqueous or alcoholic solution or spray dried powder. Where solubility is required the resin is of very low molecular weight. The resin solutions are clear and water white. Cure of Amino resins is by further condensation under influence of heat, catalyst or both.

Moulding compounds are for most part produced with alpha cellulose as the filler. However compounds are also formulated with various other fillers to provide special electrical and mechanical properties. The compound with desired pigments, lubricants and catalyst are ground in a ball-mill forming an intimately mixed, low bulk, fine powder.

Properties

The resins products are fast in speed of cure or conversion. Readily soluble in water on other commonly available solvents and compatible with a wide range of modifying agents. They are essentially colorless with a broad range of colourability, are light stable, have good hardness and mar resistance, have high heat deflection temperature, are resistant to solvents, oils and greases and have superior flame resistance, along with high electrical arc and track resistance.

Moulding compounds provide mouldings with good surface durability and high hardness. Parts are break and chip resistant, are self extinguishing, have good rigidity and load bearing strength, resistant to organic solvents, and have good track resistance. Moulded parts can be easily decorated.

Applications

Largest use moulding compound is in moulding of dinnerware. Use as housings for electric shavers and mixers, electronic equipment, soap dispensers, toilet seats, knobs and utensil handles.

The resins are used in industrial and decorative laminates, adhesives, protective coatings, textile treatment, paper manufacture. Their clarity permits products to be fabricated in virtually any color.

Epoxide resin

Introduction

They are long chain compounds which can be cross linked with various other chemicals to give thermosetting compounds.

Properties and uses of polyester resin SMC/DMC

Objective: At the end of this lesson you shall be able to

- explain the thermosetting group of plastic with particular reference to SMC and DMC and their properties and uses .

Introduction

Thermosets which are one of the groups of plastics have the basic character- is like-

- Sets permanently.
- Undergoes irreversible chemical change while processing.
- They are cross-linked polymers.
- They cannot be recycled.

Example's includes PF, UF, MF Epoxides polyester resins. Their properties are discussed under lesson 4.6 and SMC and DMC.

SMC (Sheet moulding compound)

SMC known as sheet moulding compounds are basically polyester base moulding formulation developed for certain specific industrial applications like I beams, fishing rods etc. There are processed on compression moulding machines with heated moulds.

The most important commercial epoxy resins are reaction products bis-phenol A and epichlorohydrin.

Commonly used curing agents for the resin are Alephatic amines, amides and polyphenols.

General properties

- Colour is generally yellow to brown
- Extremely tough Resistance to heat
- Low impact strength
- Ability to form strong adhesive bonds
- Good resistance to water
- Resistance to heat
- Good resistance to most common solvents and chemicals

Applications

- Epoxy resins are produced as syrup or solid resins
- Bonds for metal to metal
- Surfacing of concrete floor
- Manufacture of dies and jigs plastic processing mould
- Potting of electrical circuits like valves, transformers etc.
- Low pressure lamination.

SMC may be defined as a glass fibre reinforced thermosetting compound available in sheet forms usually rolled into coils inter-faced with plastic film to prevent auto-adhesion and air contact.

SMC is formed in a machine which consists of a series of rolls that are devised to bring the ingredients together and consolidate them into a sheet sandwiched between two layers of PE film.

Properties

- Higher mechanical and insulating properties.
- Most of the other properties of SMC and similar to DMC.

Application

The application of SMC is very wide and covers many uses where high strength is required. Typical application includes automotive parts as well as many electrical components, railway carriage components. It is a very good substitute for wood.

DMC (Dough Moulding Compound) or bulk moulding compound

Introduction

These materials are based on unsaturated polyester resins. The resins are blended with a fibers reinforcement (usually glass), fillers, pigments, styrene and a catalyst system. The mixture has a dough like consistency (hence the name) and in order to ease handling the composition is often supplied in a role like form

Properties

- The compounds may be specially formulated to maximize particular property e. flexural strength, resistance to heat, low co-efficient of thermal expansion, flame retardance.

- It is resistance to acids, alcohols, greases and oils.
- It can withstand exposure to high temperature (i.e. 160°C) for long periods.
- It is non-resistant to ketone and chlorinated hydrocarbons.

Applications

It is used where dimensional stability, high temperature and electrical resistance are required eg. moulded diesel engine head covers, drill housings machine guards, heavy duty contactors, circuit breakers and various telecom uses.

Identification of plastic commodity, engineering specialty

Objective: At the end of this lesson you shall be able to

- **identify material composition and properties .**

The identification of plastic commodities and engineering specialties is a crucial aspect of modern industrial processes. Plastics, being versatile and ubiquitous materials, find application in a myriad of products across various industries. Similarly, engineering specialties play a pivotal role in shaping the properties and applications of plastics in diverse fields.

Plastic Commodity Identification

Material Composition Analysis: Employing techniques such as spectroscopy, chromatography, and microscopy allows for the determination of the chemical composition of plastics. This aids in identifying the specific type of polymer used.

Physical Properties Assessment: Measuring properties like density, hardness, and thermal conductivity aids in differentiating between various plastic commodities. These characteristics are indicative of the material's suitability for specific applications.

Code Deciphering: The Resin Identification Code (RIC), denoted by symbols on plastic products, offers a quick reference for identifying the type of plastic. This coding system is vital for recycling and disposal purposes.

Engineering Specialties in Plastic Manufacturing

Polymer Engineering: This field focuses on the design and synthesis of polymers with tailored properties. Engineers work on optimizing the molecular structure and processing conditions to achieve desired mechanical, thermal, and chemical characteristics in the final product

Processing Technology: Engineers specialize in various plastic processing methods, such as injection molding, extrusion, and blow molding Each method imparts specific properties to the plastic, and specialists optimize these processes for efficiency and quality.

Additive Manufacturing (3D Printing): With the rise of 3D printing, engineers are exploring innovative ways to use plastics in additive manufacturing. This involves the precise layer-by- layer deposition of material to create complex and customized products

Composite Materials: Integrating plastics with reinforcing materials like fibers or nanoparticles enhances their mechanical strength and performance. Engineers in composite materials focus on optimizing these combinations for specific applications, such as aerospace or automotive components.

Recycling Engineering: As sustainability becomes a priority, engineers are developing advanced recycling processes for plastics. This involves designing systems to efficiently reclaim and reuse plastic materials, mitigating environmental impact.

Monomers in ABS polymer

Black ABS plastic pipes in use in a wet basement of a paper mill, Sault Ste. Marie, Ontario.

Acrylonitrile butadiene styrene (ABS) (chemical formula $(C_8H_8 C_4H_6 C_3H_3N)_n$) is a common thermoplastic used to make light, rigid, molded products such as piping (for example Plastic Pressure pipe systems), Musical instruments (Most notably recorders and plastic clarinets) golf club heads (Used for its good shock absorbance). Automotive body parts. Wheel covers, enclosures, protective head gear, buffer edging for furniture and joinery panels, airsoft BBS and toys, including Lego bricks (1). ABS plastic ground down to an average diameter of less than 1 micrometer is used as the colorant in some tattoo inks. Tattoo inks that use ABS are extremely vivid. This vividness is the most obvious indicator that the ink contains ABS, as tattoo inks rarely list their ingredients (2).

It is a copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35 % acrylonitrile, 5 to 30 % butadiene and 40 to 60 % styrene. The result is a long chains of poly (styrene - co - acrylonitrile). The nitrile groups from neighboring chains, being polar, attract each other and bind the chains together, making ABS stronger than pure polystyrene. The styrene gives the plastic a shiny, impervious surface. The butadiene, a rubbery substance, provides resilience even at low temperatures. ABS can be used between ? 25 and 60° C. The properties are created by rubber toughening, where fine particles of elastomer are distributed throughout the rigid matrix.

Production of 1 kg of ABS requires the equivalent of about 2 kg of oil for raw materials and energy. It can also be recycled. (3).

Properties

ABS is derived from acrylonitrile, butadiene, and styrene. Acrylonitrile is a synthetic monomer produced from propylene and ammonia; but audience is a petroleum hydrocarbon obtained from the C4 fraction of steam cracking; styrene monomer is made by dehydrogenation of ethyl benzene a hydrocarbon obtained in the reaction of ethylene and benzene. The advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber. The most important mechanical properties of ABS are resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. The impact resistance can be amplified by increasing the proportions of polybutadiene in relation to styrene and also acrylonitrile although this causes changes in other properties. Impact resistance does not fall off rapidly at lower temperatures. Stability under load is excellent with limited loads.

Even though ABS plastics are used largely for mechanical purposes, they also have good electrical properties that are fairly constant over a wide range of frequencies. These properties are little affected by temperature and atmospheric humidity in the acceptable operating range of temperatures. The final properties will be influenced to some extent by the conditions. Under which the material is processed to the final product; for example, moulding at a high temperature improves the gloss and heat resistance of the product whereas the highest impact resistance and strength are obtained by moulding at low temperature.

ABS polymers are resistant to aqueous acids, alkalis, concentrated hydrochloric and phosphoric acids, alcohols and animal, vegetable and mineral oils, but they are swollen by glacial acetic acid, carbon tetrachloride and aromatic hydrocarbons and are attacked by concentrated sulfuric and nitric acids. They are soluble in esters, ketones and ethylene dichloride.

The aging characteristics of the polymers are largely influenced by the polybutadiene content, and it is

normal to include antioxidants in the composition. On the other hand while the cost of producing ABS is roughly twice the cost of producing polystyrene, ABS is considered superior for its hardness, gloss toughness, and electrical insulation properties. However, it will be degraded (dissolve) (5) when exposed to acetone. ABS is flammable when it is exposed to high temperatures, such as wood fire. It will “boil”, then burst spectacularly into intense, hot flames.

Styrene - acrylonitrile resin

From Wikipedia, the free encyclopedia

(Redirected from Styrene - acrylonitrile)

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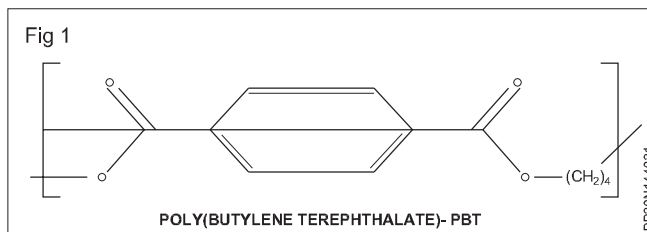
Styrene acrylonitrile resin is a copolymer plastic consisting of styrene and acrylonitrile. It is also known as SAN. It is widely used in place of polystyrene owing to its greater thermal resistance. The chains of the polymer show alternating repeat units of styrene and acrylonitrile, and it is a copolymer.

Properties

SAN is similar in use to polystyrene. Like polystyrene itself, it is optically transparent and brittle in mechanical behavior. The copolymer has a glass transition temperature greater than 100 C owing to the acrylonitrile units in the chain, so making the material resistant to boiling water. Uses include food containers, kitchenware, computer products, packaging material, battery cases and plastic optical fibers. It is structurally related to ABS plastic, where polybutadiene is copolymerized with SAN to give a much tougher material. The rubber chains form separate phases which are 10 - 20 micrometers in diameter. When the product is stressed, crazing from the particles helps to increase the strength of the polymer. The method of rubber toughening has been used to strengthen other polymers such as PMMA and nylon.

Polybutylene Terephthalate (PBT)

It is a thermoplastic crystalline polymer, and a type of polyester. PBT is resistant to solvents, shrinks very little during forming, is mechanically strong, heat - resistant up to 150° C (or 200 ° C with glass -fiber reinforcement) and can be treated with flame retardants to make it noncombustible. (Fig 1)



PBT is closely related to other thermoplastic polyesters. Compared to PET (Polyethylene Terephthalate), PBT has slightly lower strength and rigidity, slightly better impact resistance, and a slightly lower glass transition temperature. PBT and PET are sensitive to hot water

above 60C (140F). PBT and PET need UV protection if used outdoors, and most grades of these polyesters are flammable, although additives can be used to improve both UV and flammability properties.

Properties

- 1 Can be processed at low temperatures
- 2 Easily crystallize during cooling
- 3 Sensitive to water
- 4 Excellent dimensional stability
- 5 Good electrical insulating properties

Uses

- 1 Electrical and electronics applications
- 2 Automotive applications

Polyester resins

Polyester is a category of polymers which contain the ester functional group in their main chain. Although there are many types of polyester, the term "Polyester" as a specific material most commonly refers to polyethylene terephthalate (PET). Polyesters include naturally - occurring Chemicals, such as in the cutting of plant cuticles, as well as synthetics such as polycarbonate and polybutyrate. Natural polyesters and a few synthetic ones are biodegradable, but most synthetic polyesters are not.

Polyesters may be produced in numerous forms such as sheets and three - dimensional shapes. Polyesters as thermoplastics may change shape after the application of heat. While combustible at high temperatures, Polyesters tend to shrink away from flames and self - extinguish upon ignition. Polyester fibers have high tenacity and E - Modulus as well as low water absorption and minimal shrinkage in comparison with other industrial fibers.

Polyester resins are encountered as

- Laminating resins
- Moulding powders
- Fibers
- Films
- Surface coating resins
- Rubbers
- Plasticizers

Properties

- They have cross-linked structure so they are thermoset in nature.
- The base resin is usually clear water white syrups so wide colour range is possible.
- Correctly cured mouldings are odourless and tasteless.

- They have good chemical resistance and are unaffected by organic solvents and oils.
- They have excellent mechanical properties.
- They are rigid in nature
- They are flammable in nature but by compounding they can be converted into non flammable.
- They have good heat resistance
- They do not flow on heating.
- Relatively they are cheap than epoxy.
- Ester group provides site for hydrolytic degradation.
- Polar nature of the ester group limits their use as high frequency electrical insulator.
- Wide range of formulation can be done to meet a variety of requirements.
- Resist deterioration by sunlight, oxidation and fungus.
- Low tooling cost.

Applications

- FRP sandwich panel cores
- Dough (Bulk) Moulding compounds - DMC /BMC
- Sheet moulding compounds - SMC
- Cast sanitary ware
- Tenpin bowling ball cores
- Synthetic wood
- Buttons
- Marine Putties
- Plywood Patching
- Decorative castings
- Car body putty
- Civil engineering
- Adhesives

Epoxy Resins

Epoxy polyepoxide is a thermosetting epoxide polymer that cures (Polymerizes and crosslinks) when mixed with a catalyzing agent or hardener. Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol - A properties:

Properties

- They have crosslinked structure so that they are thermoset in nature.
- Correctly cured mouldings are odourless and tasteless
- They have good chemical resistance and are unaffected by organic solvents and oils.
- They have excellent mechanical properties
- They are rigid in nature

- The cured resin will not dissolve with our decomposition in solvent will be swollen by liquids of similar solubility parameter.
- The acidic hardeners form ester groups which will be less resistant to alkalis.
- Thermal properties of resin depend on degree of flexibility of hardener used.
- They have good heat resistance
- They are flammable in nature but by compounding they can be converted into non - flammable.
- They do not flow on heating.
- Exhibit high degree of adhesion when bonded to wide variety of surfaces as metal and wood due to polar nature and ability to wet various substrates.
- They have good corrosion resistance.

Applications

Surface coating applications

- Primer and paint for vehicle
- Chemical tank lining
- Inside coating of beer cans
- Marine coating
- Inside and outside coating of chemical pipes and drums.
- For meat and fish cans
- Thinner for aircraft and automobile applications.
- Powder coating.

Adhesives

- Adhesive for ply wood.
- Wood lamination.
- Metal to metal bonding.
- Floor surfacing compounds.
- Industrial wood and metal surface adhesives.

Foamed Plastics

There are four main types of plastic insulation:

- 1 Extruded polystyrene (XPS)
- 2 Extruded polyethylene (XPE)
- 3 Expanded polystyrene (EPS)
- 4 Polyurethane / Polyisocyanurate (PUR or PIR)

1 Extruded Polystyrene (XPS)

Extruded polystyrene (XPS) is made by mixing polystyrene pellets with various ingredients to liquefy them. A blowing agent is then injected into the mixture, to form gas bubbles. Next, the foaming liquid is forced through a shaping die. When cooled, it produces a closed - cell foam that is rigid and moisture resistant.

Characteristics

- Lightweight
- Very rigid
- Excellent water resistance
- Suitable for temperatures up to 75°C
- Typically available in 2.4 m x 1.2 m or 2.4 m x 0.6 m sheets.
- Can be cut to various component shapes and thicknesses.

Main uses

- Ground floor
- Flat roofs
- Heavy duty floor insulation
- Panels and other fabrication applications.

2 Extruded Polyethylene (XPE)

Extruded polyethylene (XPE) is made by mixing polyethylene pellets and other ingredients; a blowing agent is injected in liquid form causing a foaming reaction. A conical shaping die is used to shape and form the XPE, producing material that quickly cools into flexible, closed cell plastic foam.

Characteristics

- Light weight
- Excellent acoustic properties
- Excellent moisture resistance
- Good compression resistance
- Typically sold in roll form
- Available in cut component rolls.

Main uses

- Resilient layer in acoustic floors
- Flexible edge strip in screened floors
- Packaging

3 Expanded polystyrene (EPS)

Expanded polystyrene (EPS) is manufactured from small spherical beads of styrene which are pre - expanded with pentane. The beads then expand to over 40 times their original size when heated by steam. The expanded beads stick together under heat and pressure inside a mould and the finished product consists of approximately 98 % fresh air. Expanded polystyrene is also known as 'bead board'

Characteristics

- White / grey color
- Light weight
- Suitable for temperatures up to 75° C
- Mainly available in 2.4 m x 1.2 m Sheets.

Main uses

- General / domestic - floor thermal insulation
- Wall insulation.
- Packaging and fabrication.

4 Polyurethane (PUR) and polyisocyanurate (PIR)

Polyurethane (PUR) is produced by blowing a non CFC (Chlorofluorocarbon) gas (Usually Hydro carbon pentane) into urethane resin to produce a free foaming insulant (the gas used helps to improve the thermal performance of the product, but gradually escapes into the atmosphere over time). For this reason (and to stabilize the foam into boards), polyurethane and polyisocyanurate (PIR) boards are usually faced with aluminum foil. Polyisocyanurate is similar to polyurethane but usually contains long strand glass fibers the PIR foam core which is formulated to give off less dense smoke in a fire.

Characteristics

- Usually faced with aluminum foil or glass tissue
- Light weight
- Good insulation performance
- Mainly available in board form, but can also be spray applied on site in domestic projects.
- Suitable for temperatures to 75°C
- Combustible
- Potential loss of thermal performance if there is a reduction in the foil facing emissivity.

Main uses

- Flat roofs
- Pitched roofs
- Partial fill cavity wall insulation
- Domestic under - floor insulation
- Foamed composite panels.

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Different processing techniques

Objective: At the end of this lesson you shall be able to
• **explain the following techniques .**

- a The processability of LDPE, LLDPE & HDPE for producing various components/products utilizing the following processing techniques.
 - i Injection molding-for products like soap box, mug, comb, cup, trays etc.
 - ii Extrusion for products like blown film, pipe, sheet etc.
 - iii Blow moulding for products like bottles.
- b The processing aspects of PF and UF resin and moulding compound for producing various Industrial as well as household products utilising the following processing method.
 - i Compression molding for products like electrical components.

Processing

- i **Definition:** It can be defined as “Get the shape and set the shape”.

The process of converting the plastics raw materials into suitable finished products.

Processing of LDPE, LLDPE & HDPE, domes under the principle of “deformation” of polymer melt.

The processing techniques which operate on the above principle are:

- Injection Molding.
- Extrusion
- Blow Molding.

The process technique which operate on the above principle and used for processing of PF & UF moulding compounds is:

Processing of LDPE/LLDPE

a Injection Molding

- Brief description about the Machine
- Cycle time The total time required to produce one article which includes injection time, hold on time, cooling time, ejection time including dead time.

i Material and Component handling

- Predrying is not usually necessary unless hygroscopic (water absorbing tendency) additives are present. If necessary 3 hrs at 65°C is usually sufficient.
- Predrying is carried out either in oven or with hopper driver.

ii Melt temperature

- For LDPE/LLDPE 180°C to 230°C depending on specific grade.

iii Processing

- Easy process ability due to good flow ability at the process temperature and melt is stable against oxidation and
- To prevent material drooling it is usual to fit a valve in nozzle (e.g. spring loaded)
- To minimize material flowing back down the screw a valve also fitted to screw (e.g. Ring type non-return valve)

iv Shut down

- No need to purge with another material.

v Reprocessing

- 100% reground may be used. Ensure that the scrap is kept and dry.

vi Finishing

- Difficult to deflash because of the flexibility of the material Hand scalpers, cropping etc. may be used to remove the feed system.
- Better to design mould so that degating is achieved during mould opening.

Processing aspects of HDPE

a Injection Moulding

i Material and component handling

- Redrying is not normally necessary but if required it may be performed 85°C about 3 hrs with many black material (Based on carbon black) predrying may be required for this colour
- Some large components (e.g.) crates) may need to be held on cooling jigs after moulding to maintain sizes this is necessary as crates must fit together so that they can be stacked.

ii Cylinder equipment

- Similar to those used for LDPE.

iii Melt temperature

- For HDPE 205°C to 250°C.

iv Processing Parameters

- Refer skill information sheet

v Shutting down

- Purging with another material is not necessary.

vi Reprocessing

- The material is commonly retranslated and blended with virgin polymer (up to 20 to 30%)
- Material should be kept clean and dry.

vii Finishing

- HDPE flash removal is easier than PP.
- Sprues and runners are easily removed by cutting or cropping.
- It can be decorated by vacuum metallizing hot filing and printing (pretreatment of the surface is essential)

b`Extrusion

- Brief description of the single screw extruder process
- Understand the process of blown film extrusion, cast film and pipe production (Refer lesson 6.2)

i L/D Ratio

- The ratio between the length and the diameter of the screw. Screws used for polyethylene will usually have an L/D ratio of 20 to 24: 1.

ii Compression ratio

- The ratio of the volume of the first turn of the channel of the screw (at hopper end) to the volume of the last turn of the channel (at delivery end) of the screw is known as compression ratio.
- Usually polyethylene screw will have a compression ratio of 2.5 to 4.1.
- Materials and component handling: As per instruction given under unit 6.1 injection moulding (Theoretical information sheet)
- Processing Parameters Refer skill information sheet.

Classification of injection moulding machine

Objectives: At the end of this lesson you shall be able to

- explain co-injection structural foam
- define counter pressure structural foam
- explain expanding mold structural foam
- state gas assisted injection moulding and equipment.

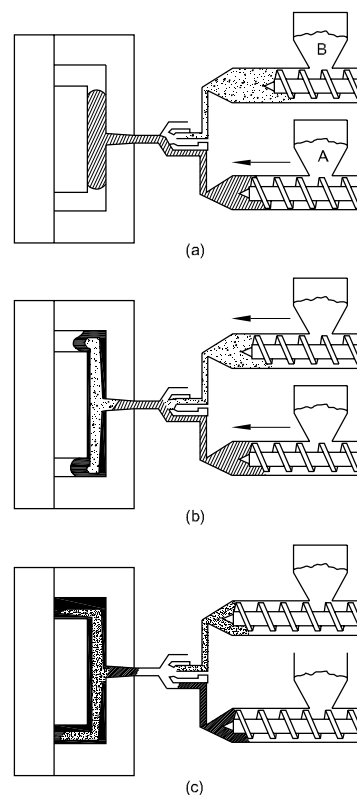
Co-injection structural foam

As the name implies, co-injection structural foam is the product of nearly simultaneous injection of two dissimilar but compatible materials. The goal is to produce a part with the foam core encapsulated within a solid skin. The heart of this technology lies in the molding equipment, which is a highly developed hybrid. There are three types of equipment for co-injection production. Purpose-built co-injection machines utilize two separate extruders, one that produces the skin component, which is a material without blowing agent, the other which provides the foam material with a chemical blowing agent. The blowing agent is heat activated but remains compressed under pressure. Reciprocating screws, which feed a special two-channel nozzle, provide injection pressure. The nozzle provides two concentric flow channels for the respective materials, which allows the skin to encapsulate the core. The hydraulic nozzle is controlled electronically to allow for the variable injection velocity of each flow channel. Hot runner manifolds can be designed with special co-injection features. Two barrels are usually involved with these systems. The latest equipment approach retrofits a special machine barrel with two material paths to allow separate materials.

In all of these equipment approaches, the same basic concept is followed. The first phase (Fig 1a) is injection of solid skin only. This is the formation of the leading edge and the entire outer skin. The second phase (Fig 1b) follows almost simultaneously with injection of solid skin and a short shot of foamed core. The solid-skin leading edge becomes smaller as it is stretched to the end of the flow. The final phase (Fig 1c) is shutoff of

the injection nozzle at a predetermined time when the mold cavity is less than completely full. The foamed core responds to the pressure drop by expanding to fill out the mold cavity. The leading edge of solid skin prevents the foam from breaking through; thus encapsulation occurs.

Fig 1



CO-INJECTION STRUCTURAL FOAM MOLDING STAGES

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The major advantage of the co-injection structural foam process is the surface finish, which is almost injection-like in appearance, when an injection-grade material is used for the skin component. The foamed core offers the advantages of low-pressure structural foam. It is noteworthy that no mixing of the materials occurs yet the core material is completely distributed. One of the unique features of the process is the capability of having different materials for skin and core. This can be of benefit when one material cannot provide all the properties required.

Counter pressure structural foam

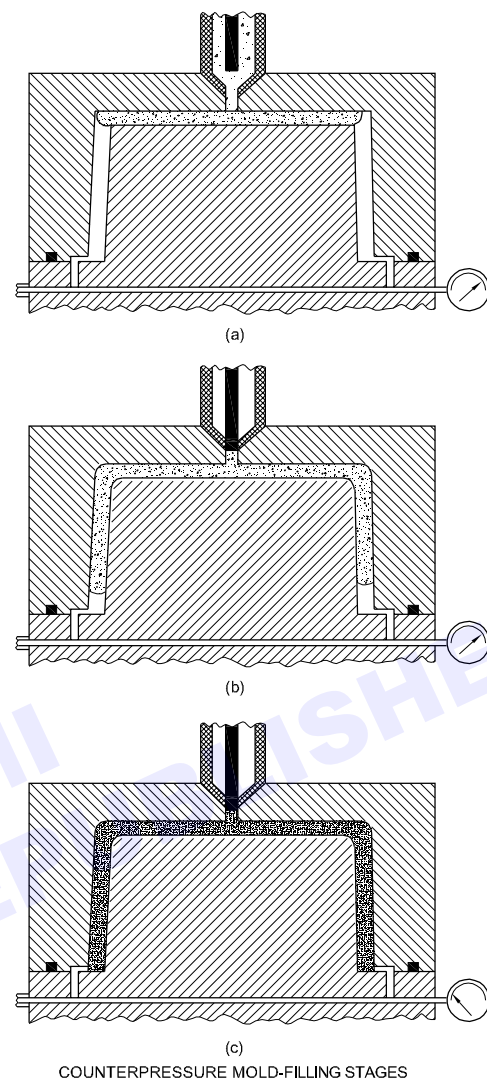
The next swirl-free molding technique is the use of counter pressure structural foam, a process previously called gas counter pressure. With the advent of gas-assisted injection molding there was too much gas in the terminology for these two very different processes. The concept behind counter pressure is to utilize a gas-pressurized mold, which through controlled venting allows the foam expansion stages of the cycle to occur after a smooth surface has been formed. The gas most commonly used nitrogen of at least 98% purity. The purpose is to improve the molded surface finish by preventing swirl formation. Counter pressure keeps the blowing agent compressed until solid skins are formed.

The process begins with a pressure-tight mold (Fig 2a), that is charged with gas counter pressure prior to the injection of plastic. To maintain pressure, the mold parting line, ejectors, moving slides, and nozzle seat must be sealed in some. The sealing techniques vary considerably, but the sealing concept is the same. When the proper in-mold counter pressure is obtained, a predetermined short shot, containing a dispersed and compressed blowing agent is injected into the mold (see (Fig 2b). During the injection sequence, controlled venting should occur to allow consistent counter pressure as the unfilled mold volume is being reduced. The counter pressure prevents the blowing agent from expanding, thus eliminating swirl, which is normally caused by the gas bubbles being trapped between the molded surface and the skin of the part. Again, many techniques are practiced, but the concept the same. The extent of the short shot is open to discussion. Good results are obtained with full-shot counter pressure, where the cavity is filled but not packed. A cavity pressure drop is caused by the volumetric shrinkage of the resin. The blow-agent, compressed up to this point, senses the pressure reduction and expands fill out the voids and to keep the walls packed against the mold cavity during the cooling stage.

At a predetermined time (Fig 2c), the counter pressure in the mold is eased through exhaust vents. This venting process causes a pressure drop inside the mold cavity, thereby allowing instantaneous expansion of the blowing agent, which is encapsulated by solid skin. Normal mold cooling and part ejection cycles follow. the sequence is repeated. The parts produced by gas counter pressure have 5 to 10% density reduction, compared to 15 to 20% for regular low-pressure structural foam. This is due to

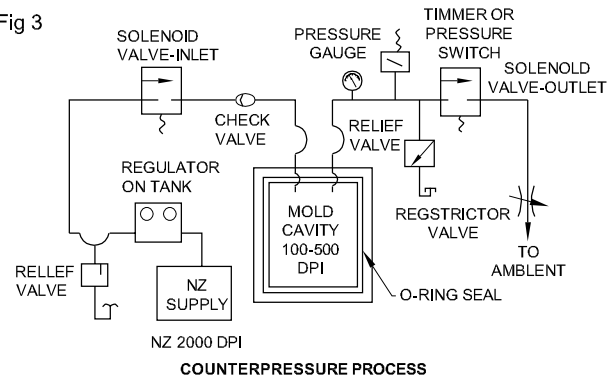
the formation of thicker skins. Gas counter pressure structural foam parts, while denser, do display more uniform cell structure throughout the part. This results in improved physical properties.

Fig 2



The gas counter pressure technique requires machines with greater clamp tonnage than that with low-pressure structural foam, due to the increased in-mold pressure caused by the gas counter pressure. The gas most commonly used for the counter pressure is nitrogen, but other inert gases may produce the desired results. The amount of additional clamp pressure required ranges from 25 to 100%, depending on the venting technique used during the injection of plastic into the mold (Fig 3).

Fig 3

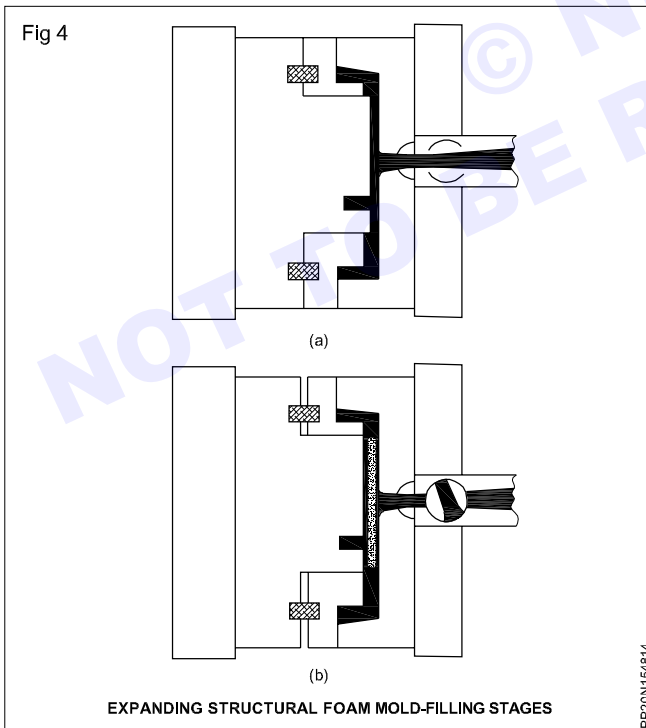


Expanding mold structural form

The mold design is one of the most important aspects of the process. (Fig 4a) shows the first step, injecting a premeasured shot of material and blowing agent into the mold under high pressure and with complete filling. The mold is packed under a high-pressure cushion, as in injection molding. The high in-mold pressure prevents blowing agent expansion, and thus no swirl is created.

Once the skins are established at a predetermined time, a specialized action in the mold progresses to a retracted position, increasing volume in the mold cavity and thus reducing pressures and allowing blowing agent expansion. (Fig 4b) illustrates the mold with the insert expanded and the blowing agent acting. Mold expansion controls where foaming occurs. The skins, which were formed prior to blowing agent expansion, are not subject to swirling. Higher levels of density reduction are feasible based on the increase in cavity volume. Areas with no mold expansion remain solid. This is a feasible process for parts that require large variations in wall thickness.

The disadvantages include design limitations because of tooling constraints caused by the expansion. There is a noticeable witness line on a part at the point of mold movement. The clamp tonnage of the molding machine will be like that of injection molding. The mold will be substantially higher, due to the moving action and the increased pressure requirements.

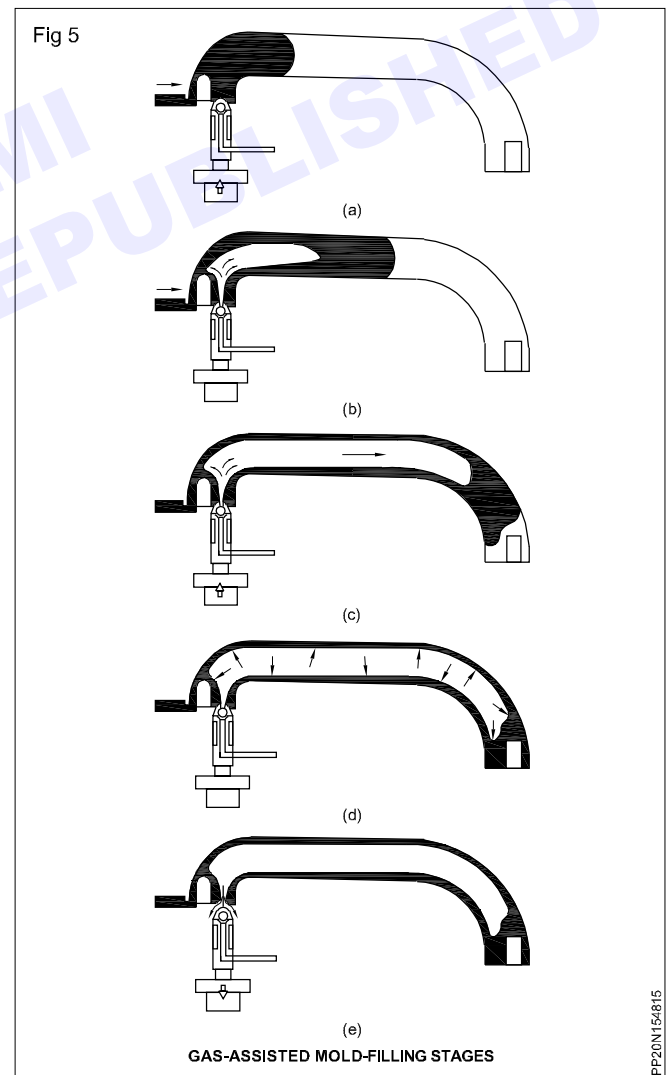


Gas - Assisted injection molding

Gas-assisted injection molding is a process in which gas (nitrogen) is injected together with molten plastic to produce a part that has at least some hollow sections.

The purpose is to assist with the normal injection molding problems of plastic flow and shrinkage. There are several categories of gas-assisted applications.

The process can best be described in the five steps of a short-shot molding. In (Fig 5a) the molten plastic is injected into a closed mold under high pressure. In (Fig 5b), the gas injection process is activated and the gas and molten plastic flow into the cavity together. In (Fig 5c), plastic injection stops while gas continues to flow into the cavity. The gas pushes the plastic in front of it to finish filling the cavity. It will move toward the areas of highest temperature and lowest pressure. In (Fig 5d), once the cavity is filled, the gas continues to push the plastic against the cool surfaces of the cavity. This action shortens the cooling cycle, discourages sink marks, and improves dimensional reproducibility. In (Fig 5e) the part has cooled sufficiently to retain its shape, the gas nozzle is retracted to vent the gas, and the part can be ejected. Of all the structural plastic processes, gas assist has the most to gain from a designer's vision of the molding process. The designer becomes the mold designer and the process engineer, with the engineer's ability to control the flow of both plastic and nitrogen.



Classification of plunger type injection moulding machine

Objectives: At the end of this lesson you shall be able to

- explain plunger type injection molding (Horizontal, vertical type)
- define typical injection units.

Plunger injection moulding : It is a type of injection moulding machine which uses a ram or plunger to displace the material from the barrel. They are much cheaper. The design of the plunger machine is ideally suited for moulding thermoplastic moulding compounds and bulk moulding compounds. In the plunger machine, the moulding compound is fed into the heating cylinder (barrel.) The plunger or ram forces the compound through the cylinder where it is heated by conduction of heat from the cylinder wall. As the material is forced forward, it passes over a spreader or torpedo within the barrel that causes mixing. The plunger forces the material through the nozzle and into the mold.

Machine: Plunger type vertical plastic injection moulding machine.

Details

- The machine has vertical injection by hydraulic cylinder and horizontal toggle clamping.
- Large platen area
- For positive locking, heavy duty accurate toggle arrangement.
- Automatic hydraulic granule feeder with adjustable stroke for correct material feeding.
- Oil indicator
- Heat Exchanger.

The ram fed injection moulding machine uses a hydraulically operated plunger to push the plastic through a heated region. The high viscosity melt is then spread into a thin layer by a "torpedo" to allow for better contact with the heated surfaces. The melt converges at a nozzle and is injected into the mold.

- 1 Set up a mold in the injection moulding machine, and check for proper alignment and clamp force. Caution: Be sure the safety device is in place to prevent mold closure before placing hands in the mold clamping area.
- 2 Select an appropriate material for the part to be molded.
- 3 Noting the effect of each process variable on product quality and cycle time, inject the material over a range of some of the following process variables: barrel temperature, residence time, injection pressure, cooling time, and injection speed. Determine the optimum settings for the process variables, and produce 5 parts in sequence.
- 4 Examine the parts for strength, distortion, shrinkage, and appearance.
- 5 Repeat the above with at least one other type of material and / or a different mold.

Injection Moulding of Thermoplastics

Injection moulding is the most important moulding method for thermoplastics. It is based on the ability of thermoplastic materials to be softened by heat and to harden when cooled. The process thus consists essentially of softening the material in a heated cylinder and injecting it under pressure into the mold cavity, where it hardens by cooling. Each step is carried out in a separate zone of the same apparatus in the cyclic operation.

A diagram of a typical injection - moulding machine is shown in Figure PP.6. Granular material (the plastic resin) falls from the hopper into the barrel when the plunger is withdrawn. The plunger then pushes the material into the heating zone, where it is heated and softened (Plasticized or plasticized). Rapid heating takes place due to spreading of the polymer into a thin film around a torpedo. The already molten polymer displaced by the new material is pushed forward through the nozzle, which is in intimate contact with the mold. The molten polymer flows through the sprue opening in the die, down the runner, past the gate, and into the mold cavity. The mold is held tightly closed by the clamping action of the press platen. The molten polymer is thus forced into all parts of the mold cavities, giving a perfect reproduction of the mold.

The material in the mold must be cooled under pressure below T_m or T_{ag} before the mold is opened and the molded part is ejected. The plunger is then withdrawn, a fresh charge of material drops down, the mold is closed under a locking force, and the entire cycle is repeated. Mold pressures of 8,000 ? 40,000 psi (562?2, 812 kg/cm²) and cycle times as low as 15 sec are achieved on some machines.

Note that the feed mechanism of the injection moulding machine is activated by the plunger stroke. The function of the torpedo in the heating zone is to spread the polymer melt into thin film in close contact with the heated cylinder walls. The fins, which keep the torpedo centered, also conduct heat from the cylinder walls to the torpedo, although in some machines the torpedo is heated separately.

Injection - molding machines are rated by their capacity to mold polystyrene in a single shot. Thus a 2 - oz machine can melt and push 2 oz of general - purpose polystyrene into a mold in one shot. This capacity is determined by a number of factors such as plunger diameter, plunger travel, and heating capacity.

Cross - section of a typical plunger injection - moulding machine. (Fig 1)

The main component of an injection - molding machine are (1) the injection unit which melts the moulding

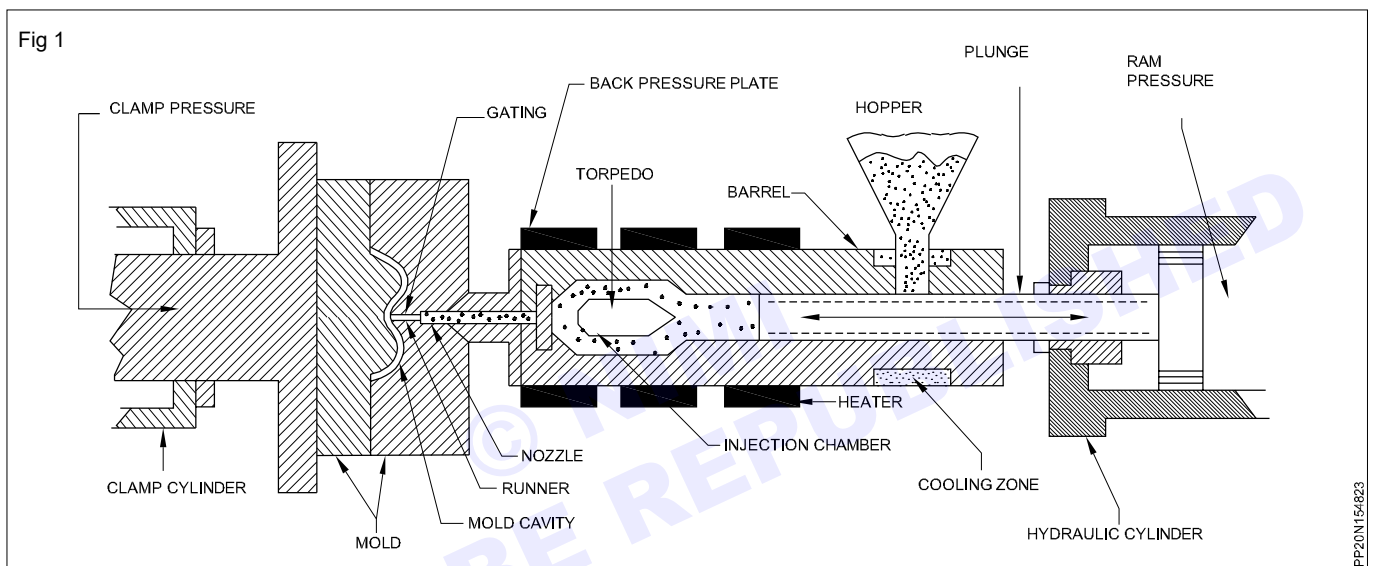
material and forces it into the mold. (2) The clamping unit which opens the mold and closes it under pressure. (3) The mold used and (4) The machine controls.

1 Types of injection units

Injection - molding machines are known by the type of injection unit used in them. the oldest type is the single stage plunger unit described above. As the plastic industry developed, another type of plunger machine appeared, known as a two - stage plunger. It has two plunger units set one on top of the other. The upper one, also known as a preplasticizer, plasticizes the moulding material and feeds it to the cylinder containing the second plunger, which operates mainly as a shooting plunger, and pushes the plasticized material through the nozzle into the mold. (Fig 1)

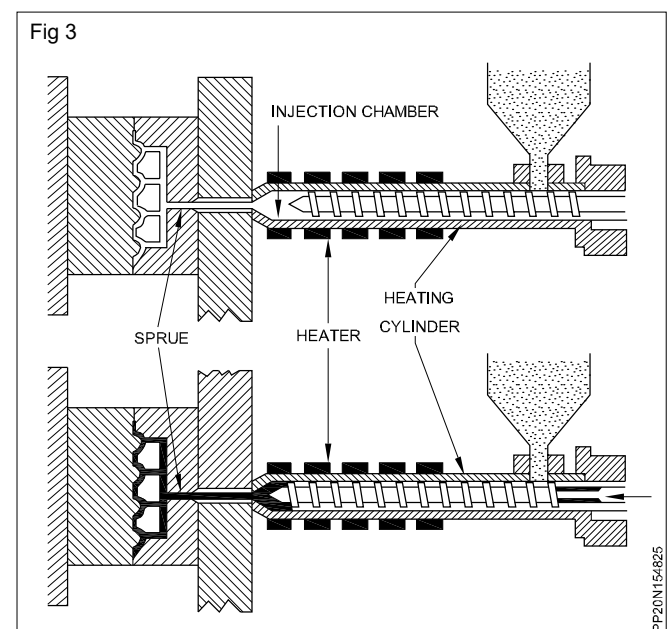
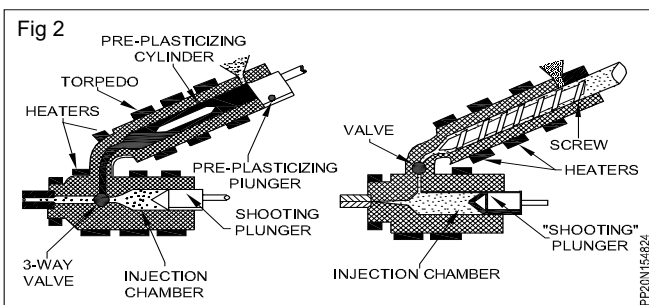
Schematic drawings of (a) a plunger - type preplasticizer and (b) a screw - type preplasticizer atop a plunger - type injection moulding machine.

Although the single - stage plunger units are inherently simple the limited heating rate has caused a decline in popularity they have been mostly supplanted by the reciprocating screw - type machines. In these machines the plunger and torpedo (or spreader) that are the key components of plunger - type machines are replaced by a rotating screw that moves back and forth like a plunger within the heating cylinder. As the screw rotates, the flights pick up the feed of granular material dropping from the hopper and force it along the heated wall of the barrel, there by increasing the rate of heat transfer and also generating considerable heat by its mechanical work. The screw more over, promotes mixing and homogenization of the plastic material.



As the molten plastic comes off the end of the screw, the screw moves back to permit the melt to accumulate. At the proper time the screw is pushed forward without rotation, acting just like a plunger and forcing the melt through the nozzle into the mold. The size of the charge per shot is regulated by the back travel of the screw. The heating and homogenization of the plastics material are controlled by the screw rotation speed and wall temperatures.

Cross - section of a typical screw - injection molding machine, machine, showing the screw (a) in the retracted position and (b) in the forward position. (Fig 3)



Hand injection moulding machine parts and function

Objectives: At the end of this lesson you shall be able to

- define the parts of the machine
- state the parts and functions rack and pinion, plunger, hopper, barrel, heater etc.

Rack and pinion: plunger top of which is working as rack, Hand wheel is connected with a pinion.

Injection pressure is applied through hand wheel and transferred to the plunger through rack and pinion

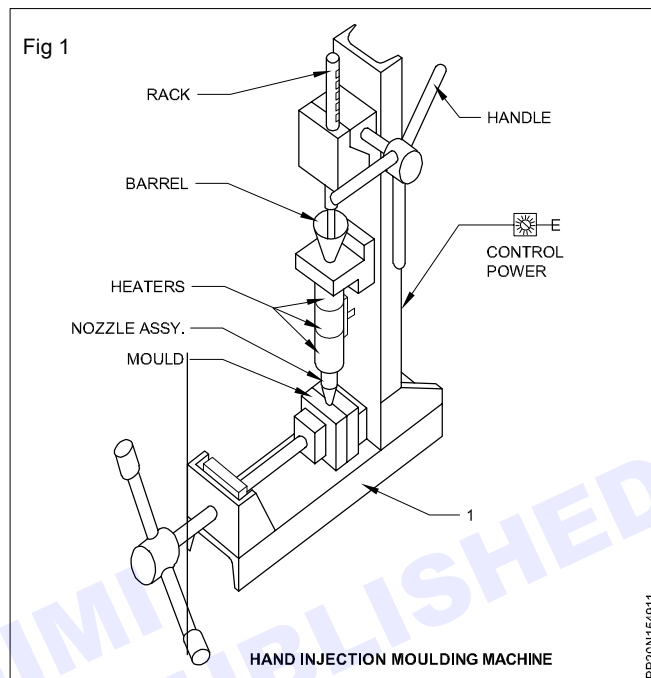
Hopper: Plastic granule is put in a tapered pot from where the feeding raw material into the barrel starts is Called hopper

Barrel: It is a hollow cylinder in which the plunger move up or down, where plastic granules are converted into melts. Barrel material should have resistance to Corrosion and wear.

Band Heater: Barrel is heated by the use of band heaters which are Independently controlled for different temperatures.

Torpedo: Torpedo is a stream lined metal block placed in the flow path of the molten plastic material in the heating cylinder injection molding machine. The function of the torpedo is to spread plastic material in to then layers, thus allowing the material into the intimate contact with the cylinder wall where the maximum temperature is available. (Fig 1)

Plunger: The functions of the plunger is to force the plastic material into the closed mould which is fed from the hopper into the cylinder.



Hand injection mould

Objectives: At the end of this lesson you shall be able to

- define injection moulding cycle
- explain trouble shooting in hand injection moulding machine.

Injection moulding cycle

The times associated with a conventional moulding cycle are shown in Figure 1, For 2 to 3 - mm thick parts, filling occurs in less than 5 s, packing requires one - third of the fill time (5), the holding time depends on the gate size , and cooling is longest part of the cycle. Thin - walled parts (i.e., wall thickness is less than 1 mm), however, filling in less than 1 s, typically have no packing or holding stage, and cool rapidly.

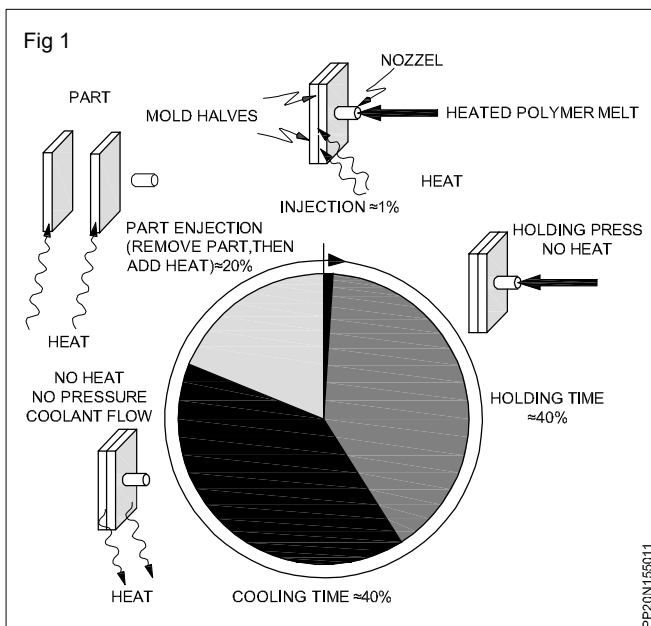
- Mould closing
- Injection
- Cooling includes dwelling
- Mould opening
- Ejection.

Fig 1 Moulding Cycle diagram

This repetition is called a cycle. The sum of the cycle times of each of these events is called the cycle time.

Example

1 Mold Closure : 03 secs



2 Inch Time: 10 seconds

3 Cooling time : 10 seconds (this time the material should be put)

4 Mold opening : 03 seconds
 5 Out of material : Taking 04 secs
 30 seconds.

A cycle takes place Take Time : 30 Seconds

In one hour Cycle taken = 120 cycle

Mold in a cavity So production number = 120 numbers

In two servitudes

Mold means manufacturing

Number = $120 \times 2 = 240$

Injection molding cycle

Mold closing -injection -mold opening -ejection

Trouble shooting in hand injection moulding

Faults	Remedies
Short molding	Increase injection pressure or melt temperature
Sink marks	Increase dwell time reduce melt temperature
voids	Increase injection pressure
Flash	reduce injection pressure
Poor finish	Increase melt temperature Increase injection speed polish mould surface.

Mould used in hand injection moulding and its terms

Objective: At the end of this lesson you shall be able to

- explain the terms used in injection moulding.

Hand Injection melting machines are used for small-scale plastic molding processes, and molds play a critical role in shaping the final product. Here's an overview of the molds used in hand injection molding machines and same related terms.

The injection mould is normally described a variety of Criteria including (1) number of cavities in the mold (2) material of construction (e.g) steel, stainless steel, hardened steel, beryllium copper, chrome plated aluminum and epoxy steel (3) parting line (e.g) regular, irregular, two plate mold, and three plate mold (4) method of manufacture (e.g) machining, hobbling casting, pressure casting, electroplating and spark erosion (5) runner system (e.g) hot runner and insulated runner (6) gating type (e.g) edge restricted (Pin point) submarine, sprue, ring, diaphragm, tab, flash, fan and multiple

Cavity : The cavity is the void or negative space within the mold where the plastic material is injected it determines the final shape and features of the molded product

Core : The core is the internal part of the mold that creates the internal features and contours of the molded product it complements the cavity to form the complete shape

Runner: The runner is the channel through which molten plastic flows from the injection unit to the cavity it is a crucial part of the mold design and affects the distribution of material within the mold

Gate: The gate is the point of entry for the molten plastic into the cavity. It connects the runner to the part being molded Proper gate design is essential for controlling the flow of plastic and minimizing defects

Guide Pins and Bushings

Guide pins and bushings help align the two halves of the mold and ensure accurate positioning. They contribute to the overall precision of the molding process.

Vent

Vents are small channels or gaps in the mold that allow air and gases to escape during the injection process. Proper venting is crucial to prevent air traps and ensure a complete fill of the mold.

Faults, causes and its remedies in hand injection molding process

Objective: At the end of this lesson you shall be able to

- describe the fault, causes and its remedies related to injection moulding.

In hand injection moulding processes, various fault can occur during the production of plastic parts Understanding the causes of these faults implementing appropriate remedies to essential achieving consistent and high quality results are potential remedies in hand injection mould

Faults

Short Shot

Cause insufficient material fills the cavity, resulting in an incomplete part

Remedy: Increase Injection pressure, extend injection time, or check for blocked gates and runners:

Flash

Cause Excess plastic escapes the mold, creating thin, excess material around the part

Remedy: Adjust clamping force, improve mold alignment, or reduce injection pressure.

Sink Marks

Cause Variations in part thickness leading to uneven cooling and contraction

Remedy: Increase injection pressure, optimize gate location, or modify part design to achieve uniform thickness

Weld Lines

Cause: Molten plastic meets and solidifies at different points, leaving visible lines on the part.

Remedy: Adjust injection speed, temperature, or gate locations to promote better material flow and fusion

Burning/Discoloration

Cause: Overheating of the plastic material during the injection process,

Remedy: Lower melt temperature, reduce injection speed, or improve cooling efficiency,

Basic knowledge of mould

Objective: At the end of this lesson you shall be able to

- describe the parts of mould and its functions.

Mould

Mould consists of two parts

1 Core

2 Cavity

1 Core: The solid part of the mould, which gives inside shape to the plastic moulding. It is the moving half of the mould.

2 Cavity: The hollow space in the mould where the plastic is formed to a shape, It is the fixed half of the mould.

The space between the core and cavity is filled with the plastic material and the component gets its shape. (Fig 1)

Moulded System

A typical Moulded system consists of the

- 1 Delivery system
- 2 Moulded part (s)

The Moulded system includes a delivery system and Moulded parts. (Fig 2)

Warpage

Cause: Non-uniform cooling or uneven wall thickness leading to distortion.

Remedy: Optimize cooling system, ensure uniform wall thickness, or use proper mold release agents

Jetting

Cause: High-speed Injection creates turbulent flow, resulting in a visible seam or mark.

Remedy: Reduce injection speed, increase mold temperature, or use flow enhancers.

Blow Holes/Porosity

Cause: Entrapped air or gas in the mold during the injection process

remedy: Enhance venting, optimize melt temperature, or increase injection pressure

Sticking

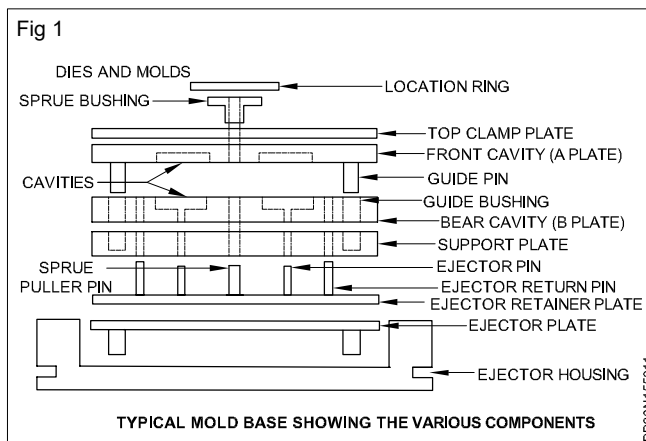
Cause: The part adheres to the mold, making ejection difficult.

Remedy: Apply mold release agents, optimize mold temperature, or adjust ejection settings.

Mold Corrosion

Cause Chemical reactions or environmental factors leading to mold degradation,

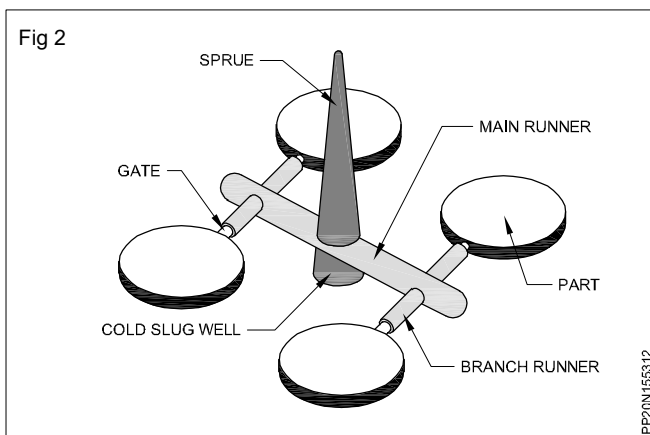
Remedy: Regularly clean and maintain molds, use corrosion-resistant materials, and control environmental conditions.



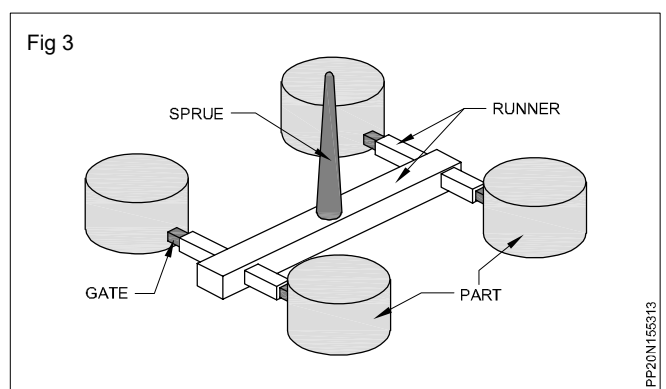
1 The delivery system

The delivery system, which provides passage for the molten plastic from the machine nozzle to the part cavity, generally includes:

- A sprue
- A main runner
- Branch runners
- Gates



Sprue: A Sprue is a channel through which to transfer molten plastic injected from the nozzle of the injector into the mould. It is a part of sprue bush, which is a separate part from the mould. (Fig 3)



Runner: A runner is a channel that guides molten plastic enters the cavity.

Gate: A gate is an entrance through which molten plastic enters the cavity.

The sprue, the runner, and the gate will be discarded after a part is complete.

Automatic injection moulding machine (Parts and function)

Objectives: At the end of this lesson you shall be able to

- describe various parts of the injection moulding machine & their functions
- describe the injection unit, clamping system, start up & shut down procedure, types of nozzle & hydraulic system.

Injection Moulding Machine

The basic concept of injection moulding is the ability of thermoplastic material to be softened by heating, formed to a shape under pressure in a mould and then hardened by cooling.

Requirements of Injection Moulding Machine

- 1 It should be able to plasticize (Melt) the polymer.
- 2 It should be able to inject the plasticized material at the required speed so that cavity is filled with polymer melt.
- 3 The mould should be clamped under specific force so that the mould cannot be open under the influence of melt pressure under the cavity.
- 4 There should be enough strokes for the movement of mould halves so that there is enough space for the ejection of mould parts.

Mechanisms

The injection moulding machines have specific mechanisms to perform all the above operations. They are:

- 1 Mould movement (Open / Close) clamping mechanism
- 2 Plasticizing and injection mechanism
- 3 Injection unit going back from the mould.

These mechanisms are operated by oil hydraulic system which can be programmed by either electrical controls i.e. contractor logic controls or by microprocessor controls.

Parts of injection Moulding Machine

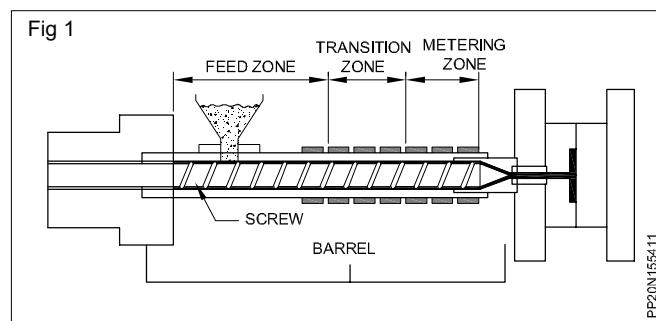
- 1 Injection Unit
 - 2 Clamp unit
 - 3 Safety gate
 - 4 Machine base
 - 5 Control system
 - 6 Electric motor & Hydraulic pump and valves
- 1 Injection Unit: It is the main part of the injection moulding machine. It consists of
- a Hopper
 - b Barrel
 - C Hydro motor
 - d Plasticizing unit
 - e Injection head
 - f Nozzle
- a Hopper:** Thermoplastic material is supplied to moulders in the form of small pellets. The material is feed inside the hopper. The pellets from the hopper due to the gravity enter through the hopper throat into the barrel and screw assembly.
- b Barrel:** The cylindrical part of the machine where the plastic material is plasticized (Melted) is called as barrel. It surrounds the screw of the injection - moulding machine. The heaters are placed around the barrel.

Two Types of heating System

- a Resistance heating
- b Induction heating
- c **Hydro motor:** Used for the movement of the screw inside the cylinder.
- d Plasticizing unit.

Screws may be reciprocating and non reciprocating screws. Non reciprocating screws move in only one direction only.

Reciprocating Screw: The reciprocating screw is used to compress, melt and convey the material. It consists of a round bar of hard steel in which is cut a helical channel (screw thread). It rotates inside the barrel taking the plastic material from the hopper towards the nozzle. It can move both forward and backward to allow enough plastic material to enter in to the mould. (Fig 1).



It consists of 3 Zones

- Feed zone
- Compression Zone
- Metering Zone

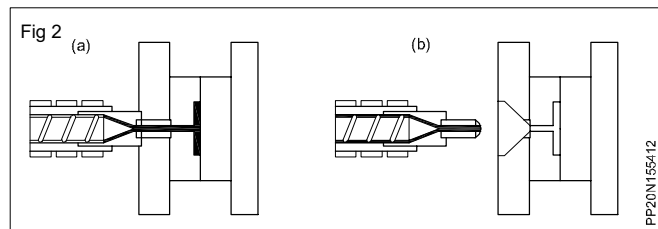
While the outside diameter of the screw remains constant, the depth of the flights on the reciprocating screw decreases from the feed zone to the beginning of the metering zone. These flights compress the material against the inside diameter of the barrel, which creates viscous (shear) heat. This shear heat is mainly responsible for melting the material. The heater bands outside the barrel help maintain the material in the molten state.

Plasticizing rate: It is the maximum rate at which polymer is plasticized.

e Injection head: It contains the nozzle.

f Nozzle: It is the small opening at the end of the screw through which the plastic material enters the mold. It is fitted at the injection head. It provides a passage for the plastic melt from the plasticizing unit to the mold. It is provided with a heater and there is a Mo couple that senses the temperature for temperature controller.

The Shape of the bore (hole) of the nozzle should be such that there should be no sharp corners in the melt passage. The change of diameter from injection head to nozzle bore should be smooth. (Fig 2)



Types of Nozzle

Open nozzle / standard nozzle

Shutoff nozzle / sealing nozzle

Reverse taper nozzle

2 Clamping unit: It is the portion of an injection – molding machine in which the mold is mounted. It provides both the motion and force to open and close the mold and to hold the mold closed with force during injection. It consists of:

- 1 Mounting platen / plate
- 2 Stationary platen / plate

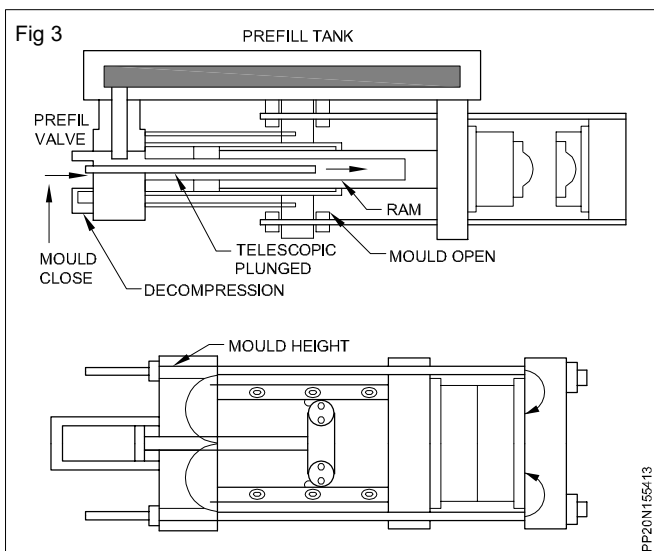
Stationary Platen / Plate: It is the fixed member of the clamping unit on which the stationary section of the mold (Cavity) is bolted.

Mounting Platen / Plate: It is the movable member of the clamping unit on which the movable section of the mold (core) is bolted.

- i Straight hydraulic clamp
- ii Linkage or toggle clamp
- iii Hydro mechanical clamp

i Straight Hydraulic Clamp (Fig 3)

This design uses hydraulic fluid and pressure to open and close the clamp and to develop the force required to hold the mold in closed condition during the injection of plastic.



The basic concept is to direct the hydraulic fluid to the telescopic plunger tube to move the clamp ram forward. Oil fills the main area by flowing from the tank through the prefill to the valve ram space. As the ram moves

forward, a slight vacuum is developed in the main area, pulling the fluid from the tank into this chamber. Once the clamp is closed pre – fill valve is closed, trapping the valve in the main cylinder area. High – pressure fluid is put into this area, compressing this volume of this oil and thus raising the pressure in this area. The maximum pressure is controlled by a pressure control valve, which closely controls the clamp tonnage.

To open the clamp, hydraulic fluid is directed to the pull back side of the cylinder while the pre – fill valve is open, with the fluid from the main cylinder being returned to the tank.

One of the major advantage of the straight hydraulic clamp is its very precise control of clamp tonnage. It has long term reliability, excellent control of low pressure mold protection and avoids over stressing

ii Linkage or Toggle Clamp: This concept uses the mechanical advantage of a linkage to develop the force required to hold the mold closed during the plastic injection portion of the cycle. A small hydraulic cylinder is used to closer the clamp. This cylinder travels at a constant speed with the slow down for mold close built into the linkage.

The main advantage is that less hydraulic fluid id required to open and close the clamp. The mechanical advantages extremely high, so even a small closing cylinder can develop high tonnage.

iii Hydro mechanical Clamp

This design uses a mechanical means for high speed close and open. A short stroke cylinder is used to develop tonnage identical to the straight hydraulic design.

The hydro mechanical design normally has a high – speed clamp close and open device in which is usually a hydraulic cylinder is used as an actuator. The closing and opening mode occurs with relatively low force. Once the clamp is closed, a blocking action takes place allowing a large diameter hydraulic cylinder to build tonnage similar to the straight hydraulic design. When the clamp is to be opened, the blocking member is removed and the clamp opens rapidly. The blocking action is normally a mechanical device and the clamping action is done by hydraulics, hence it is named as hydromechanics.

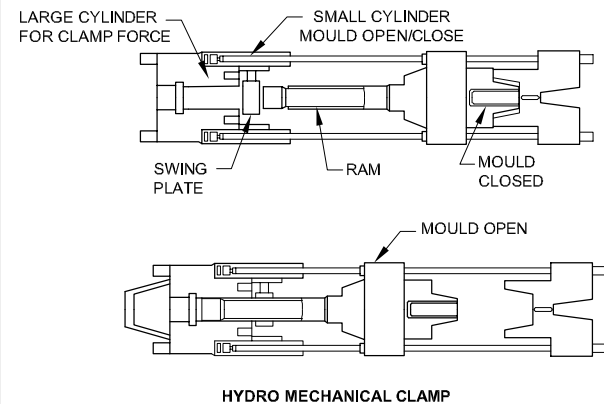
This concept is said to offer both the advantage of High speed mold open and close and also precise control of clamp tonnage. (Fig 4)

3 Safety Gate: It safeguards the person from the injection mold.

4 Control system

The control system provides consistency and repeatability in machine operation. It monitors and controls the processing parameters, including the temperature, pressure, injection speed, screw speed and position, and hydraulic position. The process control has a direct impact on the final part quality and the economics of the process. Process control systems can range from a simple relay on / off control to an

Fig 4



extremely sophisticated microprocessor based, closed – loop control.

5 Hydraulic System

Reservoir

The reservoirs of tanks provide hydraulic oil to the system for use in powering the machine. The size of the reservoir must be large enough to store oil for supply.

Hydraulic pump

The hydraulic clamp sucks oil from the reservoir and delivers the oil at the rated flow rate to the hydraulic system. The pump provides flow rate of oil and restriction to flow of oil in the system generates pressure. The pump is capable of delivery of constant flow rate up to a specified pressure. The system is allowed to limit operation below this specified pressure for the pump.

The most common pump used is fixed displacement type pump. It provides constant output at various pressures. Variable volume and pressure compensated pumps are being used for conserving energy.

- **Directional valves:** It is used to direct the hydraulic oil from the pump to various parts of the machine.
- **Check Valve:** It allows flow in one direction only.
- **Relief valve:** It will not allow the pressure to exceed the set value in the machine.
- **Pressure Reducer:** It is used to maintain pressure, when the pressure increases. Cooling channels (circuits)

Cooling channels are passageways located within the body of a mold, through which a cooling medium (typically water, steam, or oil) circulates. Their function is the regulation of temperature on the mold surface. Cooling channels can also be combined with other temperature control devices, like bafflers, bubblers, and thermal pins or heat pipes.

Ejection: Ejection system is used to remove the component from the mold after the molding process. There are different types of ejection systems available. The designer should select the type of the ejection and the location of the ejector.

Types of ejection

- a Pin ejection
- b blade ejection
- c sleeve ejection
- d stripper ring ejection
- e stripper plate ejection
- f air ejection

Pin ejection

This is the most common type of ejection. It is very easy to use in a mold. The working diameter of the ejector pin must fit correctly in the mold plates. The greater the ejection force the less will the distortion occurring in the component.

It is used from very slender parts such as ribs and projections. It is in rectangular shape and is machined from a steel rod and fitted in not a ejector pin.

Sleeve ejection

It is used for circular moldings, circular bosses etc., the core pin is fits into the sleeve is attached to the back plate.

Screw type injection moulding machine

Objective: At the end of this lesson you shall be able to

- explain in detail about screw type injection moulding machine.

Screw type injection moulding machine

In screw type injection unit a raw material from the hopper falls on the screw. As the screw rotates material through the helical groove comes to the heated cylinder and granular cold raw material is converted into a homogenous melt of required viscosity. Plasticized material through the groove is accumulated in front of

Stripper ring ejection

It is used mainly for circular boss or types of moldings and is generally restricted for use on molds with one or two impressions only. When there are multi impressions the stripper plate design is more economic.

The Internal bore of the stripper ring is a sliding fit on the major diameter of the core. The inner diameter of the ring avoid the possibility of the ring scoring the side of the core during operation.

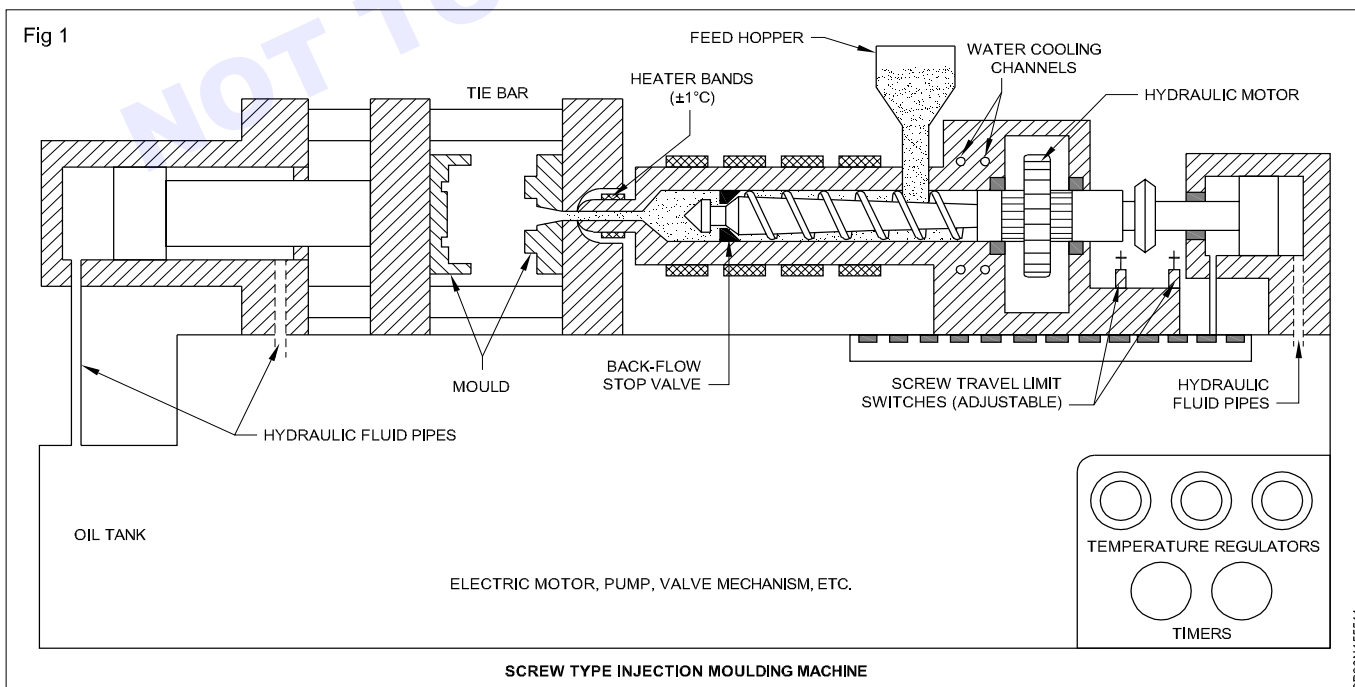
Stripper plate ejection

It is generally used where ejector pins cannot be used and from large components. They are used on single or multi cavity molds. An angle of approx. 5° is machined in the stripper plate and on the core as shown in fig in order to match them on the assembly to prevent the leakage of the material during flowing.

Air ejection

The ejector force is provided by compressed air. The effective force is dependent upon the pressure of the compressed air on which it acts. The compressed air can be under either manual or machine control.

the screw and this accumulated melt pushes the screw back (i.e. towards the right hand side of the operator) then screw functions as ram with the help of a hydraulic cylinder and accumulated plasticated material is pressed into the closed mould through the machine nozzle (this pressing of plasticated material through the orifice of nozzle into the closed mould is known as injection.



The screw type injection unit is comprising the following:

- Feed hopper
- Barrel
- Screw
- Rotating mechanism
- Hydraulic cylinder for pushing The screw
- Carriage.

Feed hopper

Plastic granule is put in a tapered pot from where the feeding of raw material in to the Cylinder starts is called hopper, In order to prevent lump formation at the hopper throat is generally cooled by circulating water.

Barrel

It is a hollow cylinder in which the screw rotates where plastic granules are converted into melts. Barrel material should have resistance to corrosion and wear. Barrel is heated by the use of band heaters which are independently controlled for different temperatures.

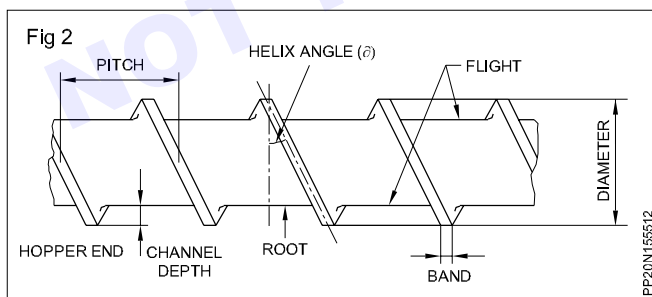
Recommended material is Nitriding steel Nitrided thickness of layer should be between 0.2 mm to 2 mm hardness of barrel internal surface is about 70 HRC

Screw

It is a solid shaft on which helical groove is cut. This is like a propeller. The main function of the screw is to take the cold plastic material (granular) from the hopper, compact, helps to plasticate the plastic material and finally push out the plasticated material from the top of the screw The screw is also functioning as plunger and inject the plasticated material into the closed mould.

Screw geometry

The figure (below) shows the detailed geometry of the screw: (Fig 2)



- **Depth:** The perpendicular distance from the top surface of the screw to root surface of the screw.
- **Flight:** The empty space enclosed by the one complete thread in a screw is flight.
- **Helix angle:** The angle between the screw thread and the transverse plane of the screw. It is generally 17.7°C
- **Lead:** It is the horizontal distance travelled by the material in one complete revolution of the screw.
- **Land:** It is the surface of radial extremity of a thread of the screw (usually 0.1 of diameter).

- **Pitch:** It is the horizontal distance between two consecutive points of a thread.

Material of the screw should be softer than that of barrel, because it is easy and economical to replace the screw than the barrel.

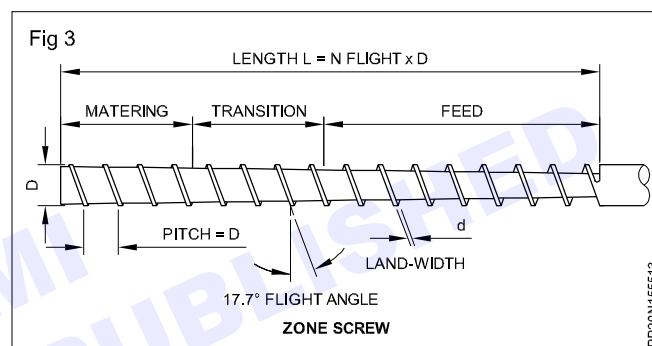
Screw material contains C = 0.4, Cr = 0.8, NO 0.15 which is flame hardened to RC 50-53.

Clearance between barrel and screw is kept around 0.002 mm of diameter of the screw.

Zones of Screws

The thermoplastic screw has been divided in three zones. They are as follows: Fig 3 indicates the details al the screw.

- Feed zone
- Transition or Compression zone
- Metering zone.



- **Feed zone:** This zone receives the plastic material (Granules) from hopper and conveys to next zone. The depth of helical groove is greatest in this zone. This zone covers 50% (approx.) of the effective length of the screw. This zone is having temperature lower than the compression and metering zone. While material moves forward it is compacted and gradually heated.
- **Transition zone or compression zone:** The depth of the groove is gradually decreased in this zone. The length of this zone is about 25% of the screw length. As the solid granules are converted to molten condition so it is called transition zone. In fact the term compression zone is more suitable name because the main function of this zone is to remove the air from the plastic material which enters through the hopper along with Plastic material. This removal of air is achieved by compressive force which is depending on the compression ratio of the screw.

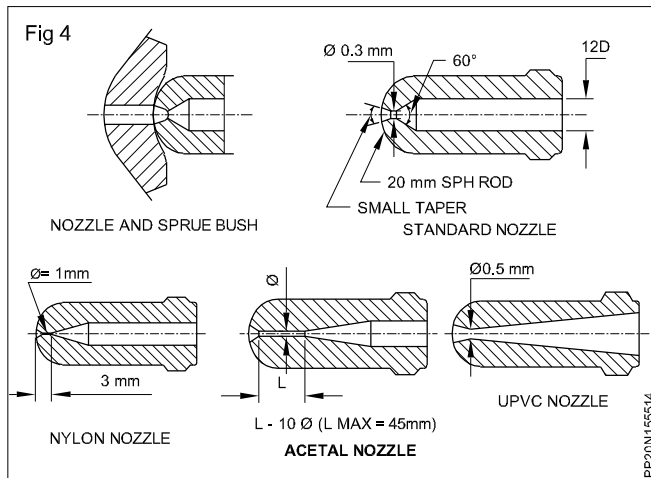
$$\text{Compression ratio} = \frac{\text{Groove depth of first in feed zone}}{\text{Groove depth of flight in last melting zone}}$$

Compression ratio for general purpose screw is maintained from 2.0 to 3.0 to suit most of the thermoplastics.

- **Metering zone:** The purpose of this zone is to take the fully plasticized material from transition zone and push the same out of the screw at a metered quantity.

This zone acts as positive displacement pump. The depth of groove in this zone is minimum compared to other two zones. This zone covers about 25% of the total length. In this zone melted material is mixed & homo- genes.

Machine nozzle: Every machine is provided with standard nozzles depending upon the capacity of the machine. The nozzle radius should be smaller than sprue bush radius to ensure proper alignment. Nozzle is a tube like device which functions as a leakproof connection between cylinder of the machine to mould with minimum pressure. Fig 4 gives a details of nozzle.



Fixed platen

A fixed platen is provided in all injection moulding machine for holding the fixed half of the mould. The platen will have the numbers of threaded holes at different locations which enables to hold the different sizes of mould.

Movable platen

Movable platen is provided in all injection moulding machine to which the movable half of the mould is fixed. The movable platen moves forward for closing the mould and retarts backwards for opening the mould and for ejection of the component into the half of hydraulic or toggle mechanism.

Length of the screw to depending on the dia of screws: The most common ratio is:

$L = 16 \text{ to } 20D$.

L = length of screw

D = dia of screw

Plunger type injection machine

Objective: At the end of this lesson you shall be able to

- explain plunger type injection machine in detail.

Plunger Type

In plunger type injection machine, the raw materials into the feed hopper. A measured quantity of raw material is fed into the cylinder then plastic material is heated and plastic (softened), Thu plasticated material is injected

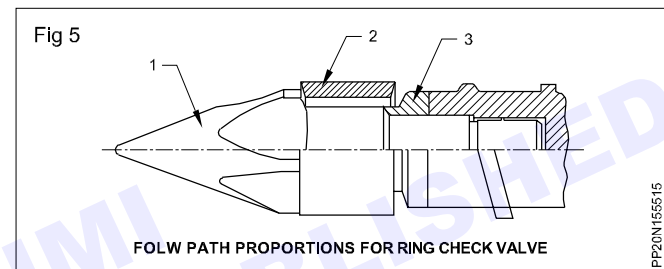
Screw tips: When injection pressure is applied the accumulated material is forced from the barrel into the mould through feed system i.e. sprue, runner and gate. If an extrusion screw is used as the plunger, then, as the screw is forced forward by the application of pressure, material will be forced backwards along with the screw flight. This will reduce the amount of material required per shot for filling and mould packing.

To prevent such leakage flow, the tip of the screw is usually fitted with back flow valve (Non-return valve).

Two types of backflow valve are explained in this chapter which are commonly used in the injection moulding machine of thermoplastic material.

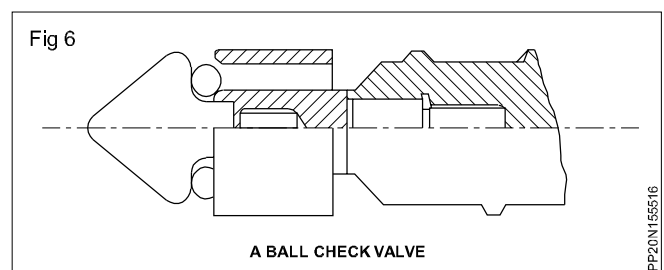
a Ring check valves This valve consists of 3 parts 1,2,3 as shown in figure below. (Fig 5)

- 1 Nose or tip.
- 2 Ring
- 3 Ring seat.



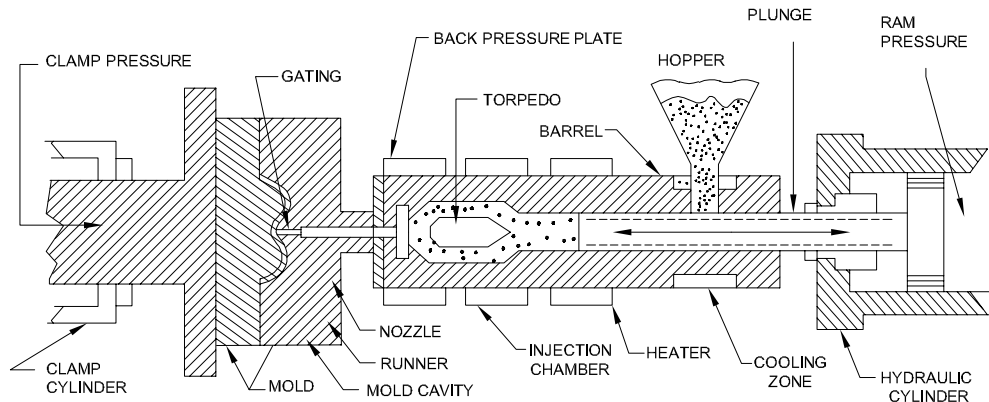
The taper surfaces of ring (Part-2) and the Part No.3 which provide the dimension 'b' should be polished so that while injection takes place plasticised material is not able to flow back to the groove of the screw.

b Ball check valves The alternative to ring check valve is a ball check valve in which a ball is used to close the melt flow path during injection. The figure below shows the construction of ball check valve. (Fig 6)



into the closed mould through the machine nozzle. Plasticisation is done by the application of heat through band heaters put around the cylinder. (The temperature is controlled in such a way that it increases gradually train hopper to nozzle side). Fig 1 shows the details of machine.

Fig 1



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Torpedod

Torpedo is a streamlined metal block placed in the flow path of the molten plastic material in the heating cylinder injection moulding machine. The function of the torpedo is to spread plastic material into thin layers, thus allowing the material into the intimate contact with the cylinder wall where the maximum temperature is available.

Plunger: In plunger type machine the functions of the plunger is to force the plastic material into the closed mould which is fed from the hopper into the cylinder. The Fig 1 shows the actual operation of the plunger.

Hydraulic system for Injection

In plunger injection moulding machine the plasticised material is injected into the mould by plunger and after the injection is over the plus is brought back for the material to be re-fed for the next shot. forward and backward actions of plunger is performed by the hydraulic system.

Cross - section of a typical plunger injection - moulding machine.

The main component of an injection - moulding machine are (1) the injection unit which melts the moulding material and forces it into the mold (2) The clamping unit which opens the mold and closes it under pressure (3) The mold used and (4) The machine controls.

Different type of clamping system

Objective: At the end of this lesson you shall be able to

- explain different types of clamping system Straight hydraulic clamp, linkage or toggle clamp, hydro mechanical clamp.

Clamping Unit

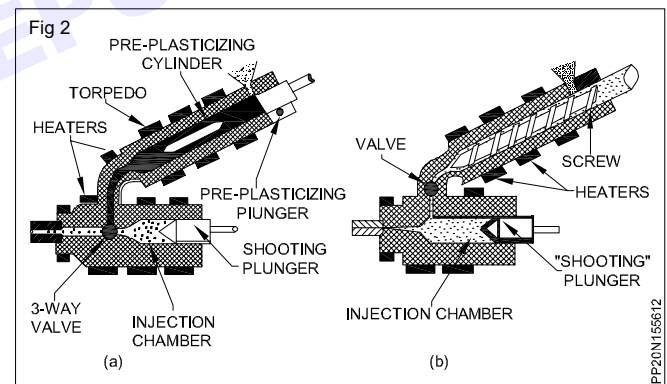
It is the portion of an injection - moulding machine in which the mould is mounted. It provides both the motion and force to open and close the mould and to hold the mould closed with force during injection. It consists of

- 1 Mounting platen / plate
- 2 Stationery platen / Plate

Types of injection units (Fig 2)

Injection - moulding machines are known by the type of injection unit used in them. The oldest type is the single stage plunger unit described above. As the plastic industry developed, another type of plunger machine appeared, known as a two - stage plunger. It has two plunger units set one on top of the other. The upper one, also known as a preplasticizer, plasticizes the moulding material and feeds it to the cylinder containing the second plunger, which operates mainly as a shooting plunger, and pushes the plasticized material through the nozzle into the mold.

Schematic drawings of (a) a plunger - type preplasticizer and (b) a screw - type preplasticizer atop a plunger - type injection moulding machine.



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Stationery platen / plate: It is the fixed member of the clamping unit on which the stationary section of the mould (Cavity) is bolted.

Mounting platen / Plate: It is the movable member of the clamping unit on which the movable section of the mould (core) is bolted.

There are three different types of clamping designs:

- i Straight hydraulic clamp
- ii Linkage or toggle clamp
- iii Hydro mechanical clamp

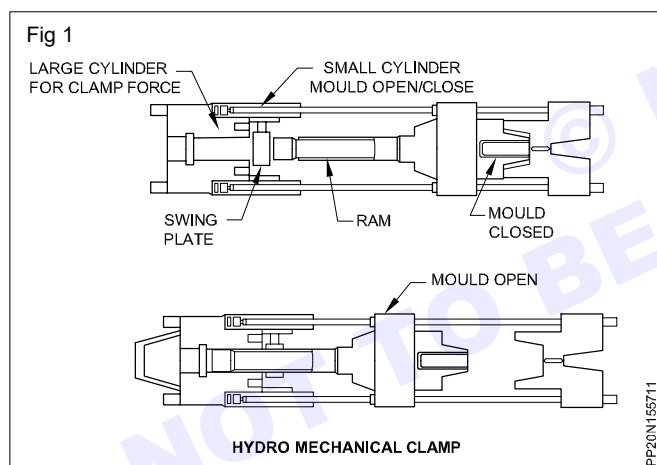
i Straight Hydraulic Clamp

This design uses hydraulic fluid and pressure to open and close the clamp and to develop the force required to hold the mould in closed condition during the injection of plastic.

The basic concept is to direct the hydraulic fluid to the telescopic plunger tube to move the clamp ram forward. Oil fills the main area by flowing from the tank through the prefill to the valve ram space. As the ram moves forward, a slight vacuum is developed in the main area, pulling the fluid from the tank into this chamber. Once the clamp is closed pre - fill valve is closed, trapping the valve in the main cylinder area. High - pressure fluid is put into this area, compressing this volume of this oil and thus raising the pressure in this area. The maximum pressure is controlled by a pressure control valve, which closely controls the clamp tonnage.

To open the clamp, hydraulic fluid is directed to the pull back side of the cylinder while the pre - fill valve is open, with the fluid from the main cylinder being returned to the tank.

One of the major advantages of the straight hydraulic clamp is its very precise control of clamp tonnage. It has long term reliability, excellent control of low pressure mould protection and avoids over stressing. (Fig 1)



ii Linkage or Toggle Clamp

This concept uses the mechanical advantage of a linkage to develop the force required to hold the mould closed during the plastic injection portion of the cycle. A small hydraulic cylinder is used to closer the clamp. This cylinder travels at a constant speed with the slow down for mould close built into the linkage.

The main advantage is that less hydraulic fluid is required to open and close the clamp. The mechanical advantage is extremely high, so even a small closing cylinder can develop high tonnage.

Toggle type clamping

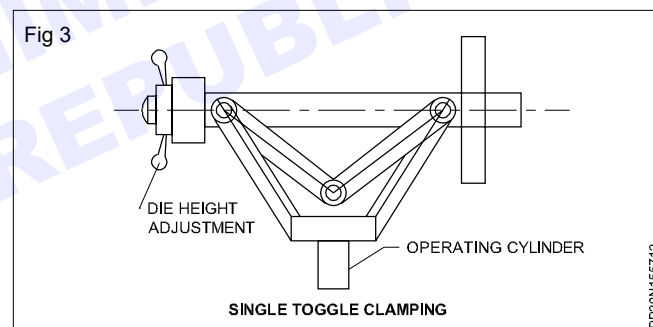
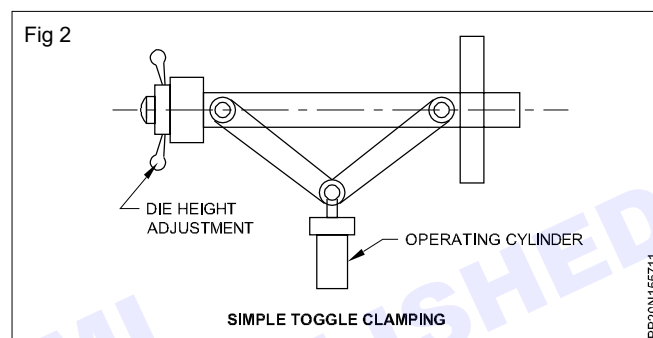
This is a clamping system consisting of a system of levers. The levers moved by means of a hydraulic cylinder. This system consists of both mechanic and hydraulic, so it is also called hydro mechanical clamping.

For better understanding and to have clear concept of the mechanism References.

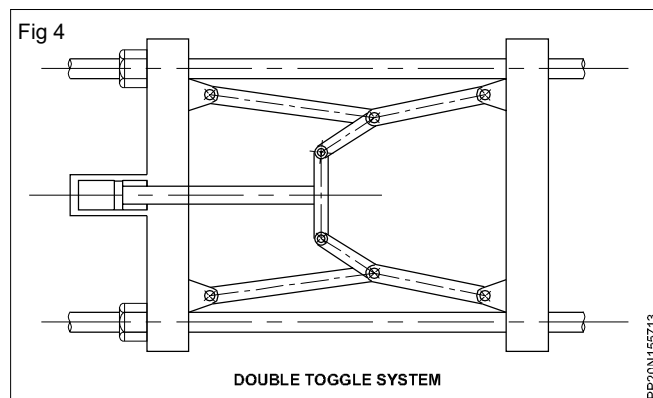
The toggle consists of the two levers, and one small hydraulic rammed cylinder One end of each lever is connected with platen (one lever is connected with fixed platen and other one with movable platen) other end of the lever is connected with ram (both the lever is connected with ram).

When the toggle is bent the mould is in the fully open position, the position of the hydraulic ram is at the bottom position. When the toggle (levers) straighten the mould is close.

Single and double toggles : Fig 2 and Fig 3 shows the single and double toggle mechanism. Single toggle is basically an unbalanced system as the force is applied from one side only.

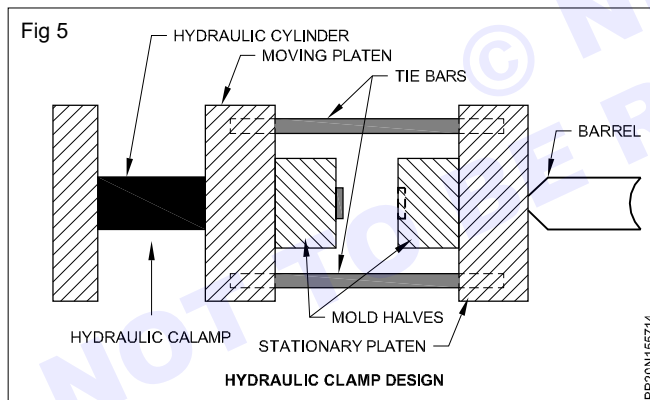


In double toggle system there are two single toggles provided. In this case as the toggle starts straightening the twisting force exerted in one toggle in one direction is balanced by an equal and opposite force acting in the opposite direction there by unbalancing problem in case of single toggle is avoided. (Fig 4)



Hydraulic Clamp System

A hydraulic clamp operates using hydraulic fluid and pressure sure to close, hold, and open the clamp. This system consists of a large main cylinder which is located at the rear of the machine. There are three platens: cylinder, movable, and stationary. The central cylinder and two transverse cylinders, moving at a higher speed than the central cylinder, control the motion of the mold tool without mechanical linkages or connections. The clamp also utilizes a larger clamp cylinder that is used to build the required clamp tonnage for the injection molding machine. The basic concept of the hydraulic clamp is to direct hydraulic fluid used to move the clamp forward. Hydraulic oil is fed from a storage tank, which fills the main area at the large cylinder. The oil is fed by gravity if the oil storage reservoir is located overhead, and is fed by suction if the reservoir is located below the clamp cylinder. As the cylinder moves forward, the oil flows from the reservoir to the area behind the cylinder. Once the clamp is closed, the prefill valve is closed, trapping the oil behind the cylinder. High-pressure fluid is used in this area, and the volume of oil in this area is compressed, increasing the pressure in this area to a level used for holding the mold closed during injection and cooling of the molten material. Upon opening of the mold, the hydraulic fluid is directed away from behind the cylinder and is returned to the storage reservoir after the prefill valve opens. Fig 5 shows a hydraulic clamping system.



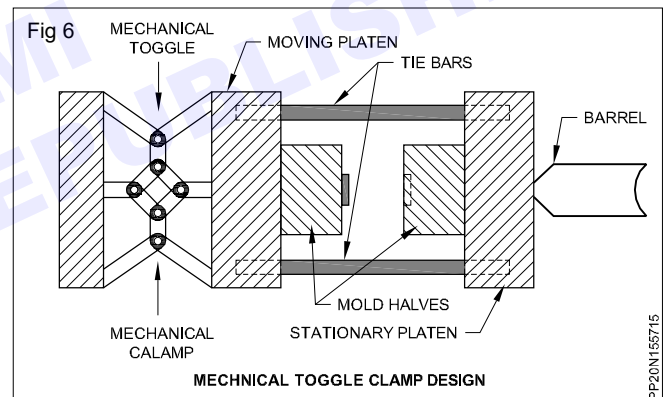
Mechanical Clamp System

The mechanical clamp system has been used for many years in injection molding and was its most common use until development of the hydraulic clamp. The concept of a mechanical clamping system utilizes a mechanical linkage, referred to as a toggle, which develops the clamping force needed to hold the mold closed during the injecting and cooling portion of the injection molding cycle.

A mechanical clamp consists of three platens, four tie bars, and a toggle system activated by a hydraulic cylinder. Two types of mechanical toggle are used: the single-toggle lever and the double-toggle lever. The single-toggle lever is used for machines built for lower clamping forces (25 to 50) tons but has been used with machines built for as much as 200 tons of force. The

double-toggle lever is used for clamping forces as high as 1000 tons. In the single toggle lever system, a small hydraulic cylinder is used with the single-toggle lever for closing the clamp. The cylinder travels at a constant speed with a slowdown built in as the two mold halves close. This system allows for only short opening strokes. For the double-toggle lever system, a center hydraulic driving system is used, and larger opening strokes are realized, depending on the length of the driving system.

In a mechanical toggle system, the hydraulic cylinder causes the toggle to stretch or collapse the toggle mechanism similar to the way that the human elbow extends or contracts the human arm. The mold is fully closed once the toggle has stretched and is locked in place. To assure that the toggle is not overstretched or not stretched enough, after the mold is installed between the platens, the clamp is moved forward until the mold actually "snaps" the mold halves to a closed position. This is adjusted at the rear of the machine using the die height adjustment. If the toggle is overstretched, the mold may open slightly, causing material to flash excessively between the mold halves. To prevent overstretching, machines with toggle systems are equipped with a limit switch that will switch off the hydraulic valves operating the linkages. Fig 6 shows a mechanical toggle clamping system.



Electric Clamp System: Developed in the late 1980s, the electric clamping system operates similar to the mechanical clamping system, but in this case, no main hydraulic cylinders move the toggle. An electrically driven motor is used to move the toggle forward and backward to position using a ball screw mechanism. The electric clamping system provides an energy-efficient mechanism to accomplish all machine functions and is totally mechanical. Velocity and pressure are adjusted independently. Injection rates are high and provide a rapid response to profile changes. Energy savings have been realized at 60 to 70% of hydraulic clamping system.

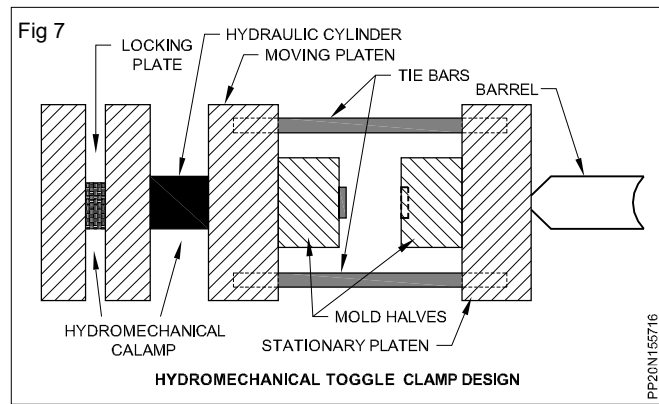
Hydro mechanical clamp

This design uses a mechanical means for high speed close and open. A short stroke cylinder is used to develop tonnage identical to the straight hydraulic design.

The hydro mechanical design normally has a high-speed clamp close and open device in which is usually a hydraulic cylinder is used as an actuator. The closing and

opening mode occurs with relatively low force. Once the clamp is closed, a blocking action takes place allowing a large diameter hydraulic cylinder to build tonnage similar to the straight hydraulic design. When the clamp is to be opened, the blocking action is normally a mechanical device and the clamping action is done by hydraulics, hence it is named as hydromechanics.

This concept is said to offer both the advantage of high speed mold open and close and also precise control of clamp tonnage. (Fig 7)



Auto injection moulding machine mould its parts and functions

Objective: At the end of this lesson you shall be able to

- describe auto injection molding machine mold its parts and functions.

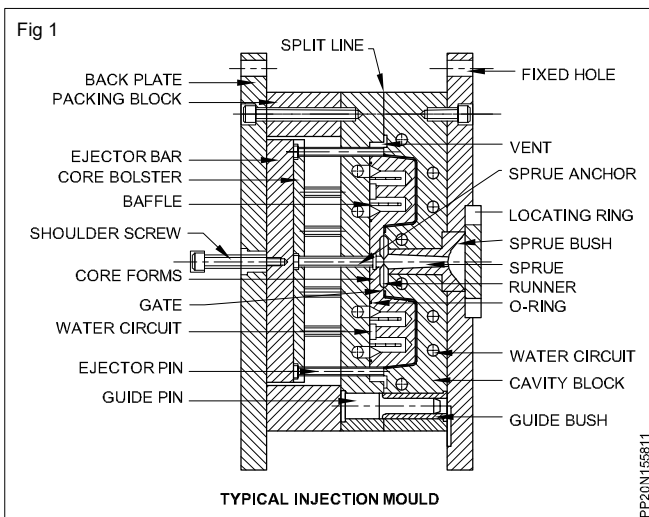
Injection mould

Injection mould in an assembly of parts of containing within it can impression into which plastic material is injected and cooled.

Mould System

The mold system consists of tie bars, stationary and moving platens, as well as molding plates (bases) that house the cavity sprue and runner systems ejector Pins and cooling channels as shown in figure the mold is essentials a heat exchanger in which the molten thermoplastic solidifies to the desire shape and dimensional details defined by the cavity. An mold system is an assembly of platens and molding plates typically made of tool steel. The mold system shapes the plastics inside the mold cavity (or matrix of cavity) and eject the molded parts (s) the stationary platen is attached to the barrel side of the machine and is connected to the moving platen by the tie bars. One cavity plate is generally mounted on the stationary platen and hearses the injection nozzle. The core plate moves with the moving platen guided by the tie bars. Occasionally the caving plated is mounted to the moving platen and the core plate and a hydraulic knock-out (ejector) system in mounted to the stationary platen.

Typical Injection Mould (Fig 1)



Parts of Mold the mold consists of the following parts (Fig 2)

- 1 **Core:** The solid part of the mold
- 2 **Cavity :** The hollow space in the mold
- 3 **Cavity Plate:** It is used to house the cavity.
- 4 **Core plate:** It is used to house the core.
- 5 **Core backing plate:** It is used to support the core plate.
- 6 **Ejector plate:** To transmit the force applied for ejection to eject the component.
- 7 **Ejector back plate:** It is connected to the ejector plate by screws. It helps that the ejector pin does not move away from its position.
- 8 **Ejector Retainer:** It is used to retain ejection pins.
- 9 **Locating ring:** To ensure that alignment of sprue and the machine mold. The mold must be central to the machine. This can be achieved by the ring.
- 10 **Sprue bush:** It is the part of the mold. Connecting between the machine nozzle and the mold base. It provides a path through which material can travel on its way to the impression.
- 11 **Guide pillar and guide bush:** It is used for the alignment of core and the cavity of the mold.
- 12 **Ejector Pin:** It is a rod or pin or sleeve that pushes the component out of the cavity with a force.

Mould parts and its Materials

S. No	Mould parts	Materials
1	Cavity plate	Tool steel
2	Core plate	Tool steel
3	Core backing plate	Mild steel
4	Ejector back plate	Mild steel

5	Ejector retainer	Mild steel
6	Core	Tool steel
7	Cavity	Tool steel
8	Locating ring	Mild steel
9	Sprue bush	Mild steel
10	Guide pillar	Case hrd & grd steel

11	Guide bush	Case hrd & grd steel
12	Ejector pin	Carbon steel
13	Push back pin or return pin	Carbon steel
14	Ejector stop pads	Carbon steel
15	Ejector housing	Mild steel

Types of mould two and three plate mould, hot runner mould

Objective: At the end of this lesson you shall be able to

- the types of injection molds, its constructional features, etc.

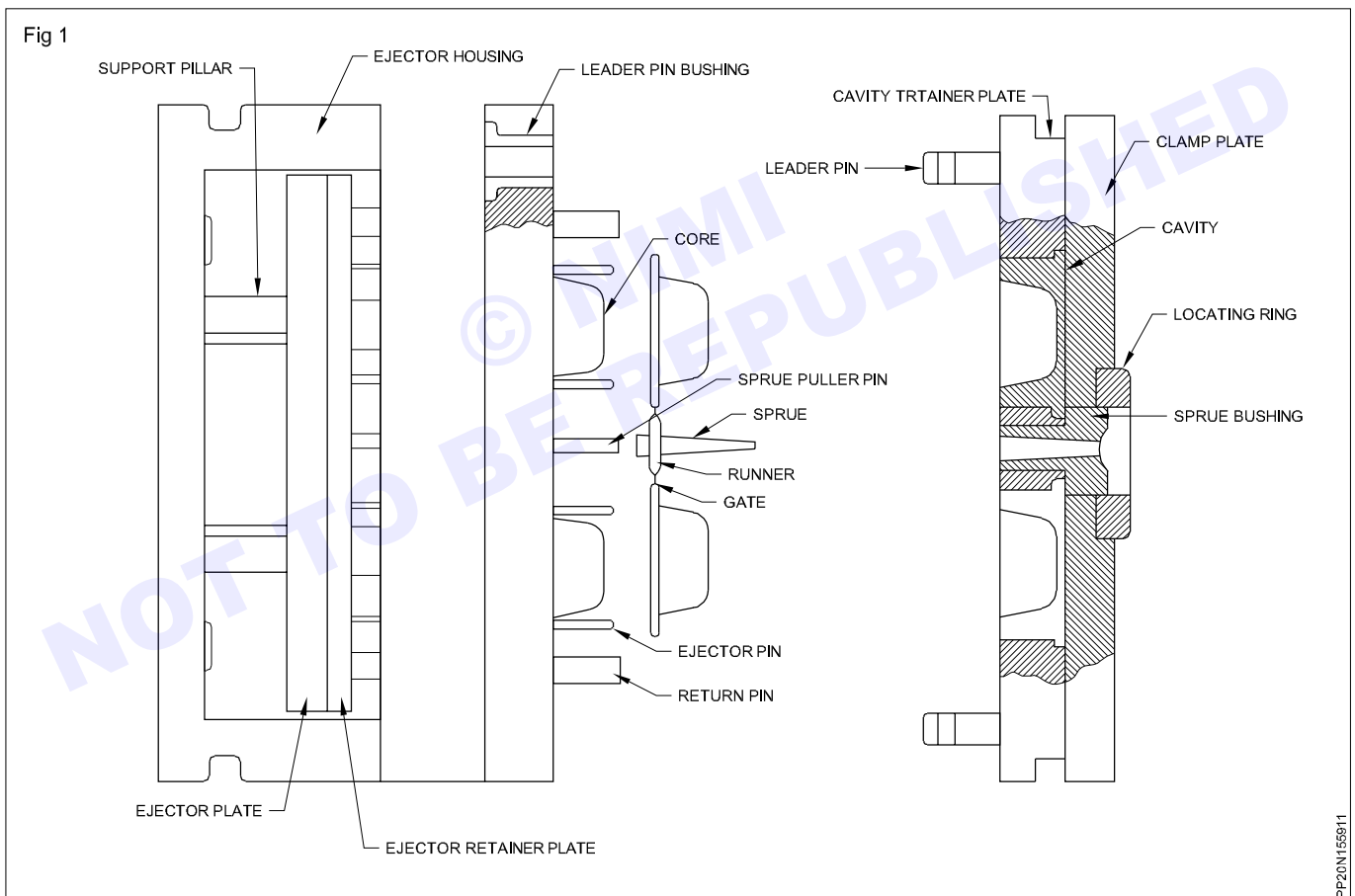
Injection molds

Main types (Fig 1)

i Two plate mould

ii Three plate mould

iii The simplest is the two plate mould with a fixed and movable platten.



The three plate mould has a third plate, which is called the floating or center plate. The center plate carries the gate and some of the runner system. When the mould is opened, the center plate is separated from the other two plates in order to allow the moldings to be ejected on one side and the sprue and runners on the other side. A three plate mould is shown in Fig. 2 given below. The three plate mould requires a larger opening stroke, the availability of necessary stroke must be checked.

The overall dimensions of the mould construction must suit the injection machine to be used.

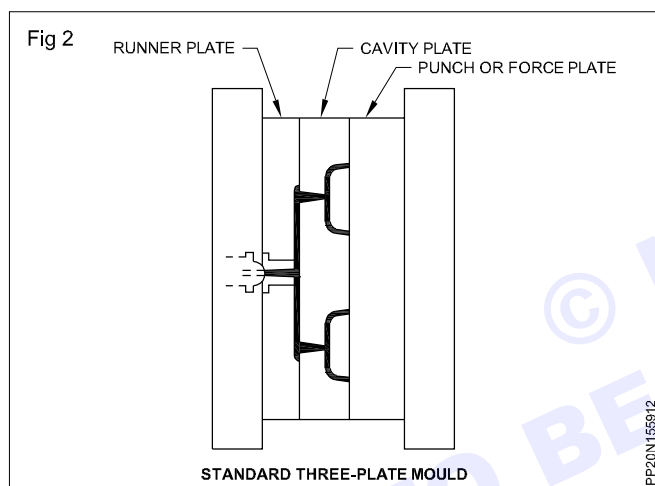
Hot Runner Systems

Cold runner systems have a runner that is ejected from the tool after the part is cooled. However, hot runner systems, referred to by some as runner less systems, do not have a runner that is ejected with the part. As mentioned earlier hot runner systems differ from cold

runner systems by extending the barrel of the injection moulding machine and acting as an extension of the machine nozzle. A hot runner system maintains a major portion of the molten polymer material at approximately the same temperature and viscosity as the polymer in the barrel. There are two general types of hot runner systems, insulated and conventional.

An insulated hot runner system allows the molten polymer to flow into the runner and then cool to form an insulating skin of solid, cooled material along the walls of the runner. This insulating layer decreases the diameter of the runner and helps maintain the temperature of the molten polymer as it awaits injection into the mold cavity.

The insulated runner is designed so that while the runner volume does not exceed the cavity volume, the entire molten polymer in the runners is injected into the mold during each shot. This full consumption of molten material is necessary to prevent excess built up of the insulating skin and to minimize any drop in melt temperature.



A conventional hot runner system allows increased control over melt temperatures and other processing conditions, as well as increased freedom in mold design, especially in molding large multicavity tools. Hot runner systems retain some of the advantages of the insulated runner system over the cold runner system, and eliminate some of the disadvantages. For example, startup procedures are easier than with insulated runner systems. However, increased costs are present with hot runner systems, due to more complex mold design,

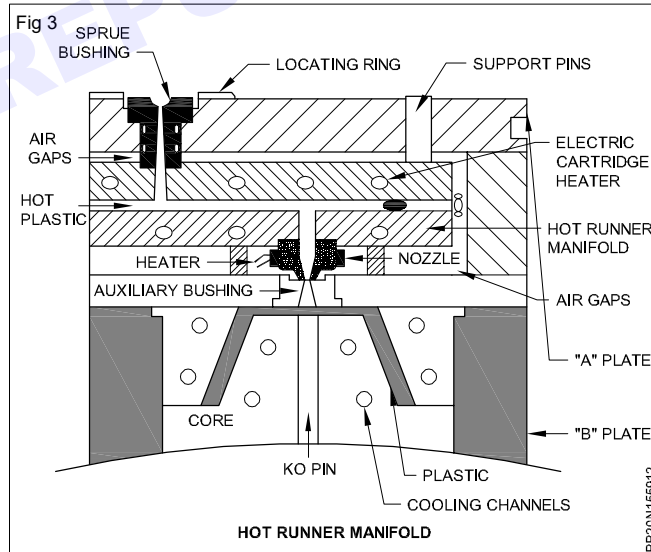
manufacturing, and operation. This is due to the need to install a heated manifold located inside the tool in the path of the molten polymer flow, balanced heating needed by these manifolds, and minimized molten polymer hang-up areas.

The heated manifold acts as an extension of the barrel of the injection molding machine by maintaining a totally molten material from the nozzle to the gate. To accomplish this, the manifold includes heating elements and controls for keeping the melt at the desired temperature. Installation and control of the heating elements are difficult. Insulating the rest of the mold from the heat of the manifold is also difficult. The challenge is to keep the heat of the manifold away from the cyclic cooling of the cavity without affecting the overall cycle time.

Using heated manifolds causes another concern with thermal expansion of mold components, such as movable slides and inserts. This is a major consideration to ensure the maintenance of proper alignment between the manifold and the cavity gates. Currently, there are many suppliers of hot runner systems, and the main considerations in selecting a hot runner system are cost and design limitations.

Hot Runner Mold

In a three - plate mold, the runner system must be reground and the material is reused. It is possible to eliminate the runner system entirely by keeping the material fluid. This is done by not runner mold. (Fig 3)



Processing defects, causes and remedies

Objectives: At the end of this lesson you shall be able to

- explain the various molding defects the various molding / processing defects that may be encountered in processing of materials like LDPE, HDPE, PP, PVC etc. utilizing injection moulding their causes and remedies.

Common injection molding defects, causes and remedies

Defect	Causes	Remedies
i Short shot	a Less feed b Insufficient injection pressure c Less melt temperature d Narrow gate and runner system e Less injection speed	a Increase feed b Increase injection pressure c Increase melt temperature d Widen the gate and runner e Increase injection speed
ii Parts flashing	a Excessive feed b High injection pressure c High melt temperature d Improper mould alignment e Foreign matter left on the mould	a Reduce feed b Reduce injection pressure c Reduce melt temperature d Check for mould alignment e Check for any foreign matter left on the mould
iii Sink marks	a Insufficient pressure on parts b Insufficient material packed in the cavity c Poor part design	a Increase injection and hold on pressure b Increase material packing c Try to avoid thick sections adjacent to thin section
iv Voids	a Insufficient plastic in the cavity b Less injection pressure c Inadequate drying of hygroscopic materials	a Ensure sufficient material packed in the cavity b Increase injection pressure c Ensure adequate predrying
v Poor welds	a Insufficient temperature & pressure at the weld location b Insufficient mould venting c Less mould temperature	a Increase melt temperature and pressure b Provide venting c Increase mould temperature
vi Brittleness	a Degradation of material b Contamination	a Reduce melt temperature b Check for material contamination
vii Silver streaks	a Moisture in the plastic material b High melt temperature c Contamination	a Pre dry material b Reduce melt temperature c Check for contamination
viii War page	a Insufficient cooling b Excess material packed in the cavity c Improper ejector system	a Increase cooling time b Reduce injection pressure and hold on pressure c Ensure proper ejection system

Processing trouble shooting of injection moulding machine

Objectives: At the end of this lesson you shall be able to

- define the trouble shooting of various plastic materials
- explain the various molding / processing trouble shooting that may be encountered during injection molding of PC , PP /PE, materials and their problem, cause and solution.

Injection troubleshooting guide: polycarbonate

Problem	Cause	Solution
Black specks	Machine not purged properly Excessive fines in material	Follow guideline for purging material and, if necessary, manually clean out check rings, barrel, and screw Use equipment such as a deduster to separate fines from pellets Also, check material handling system for any sharp corners in delivery lines.
Burn marks	Nozzle temperature too high Injection speed too fast Injection time too long Insufficient venting in mold Gate size too small Barrel heater malfunctioning	Reduce nozzle temperature. Reduce injection speed. Reduce injection time Check vent sizes and vent according to material supplier recommendations. Also, check for clogged or obstructed vents. Increase gate size without sacrificing part degating Check and calibrate heaters or replace malfunctioning heaters
Discoloration	Machine not purged properly Melt temperature too high Nozzle temperature too high Overall cycle time too long Material contaminated Insufficient venting in mold Machine size too large for the part causing a long residence time of the material in the barrel; barrel-to-shot ratio too low	Follow guideline for purging material and, if necessary, manually clean out check rings, barrel, and screw. Reduce melt temperature. Reduce nozzle temperature. Reduce cycle time Remove any contamination, review material handling procedures, or contact material supplier. Check vent sizes and vent according to material supplier recommendations. Also, check for clogged or obstructed vents. Move mold to a machine with a shorter barrel and higher barrel-to-shot ratio.
Jetting	Injection speed too fast Melt temperature too low Mold temperature too low Gate size too small, restricting flow and producing high pressures for material entering the cavity Gate located in an area where the material injects into a large space, such as a thick wall or deep area	Reduce injection speed. Increase melt temperature. Increase mold temperature. Enlarge gate size. Relocate gate to direct flow path into a shallow wall or tab.

Problem	Cause	Solution
Part brittleness	Resin not dried sufficiently Material contaminated Regrind levels too high Melt temperature too high Barrel heater malfunctioning	Review recommendations by material supplier for drying and check drying equipment operation and dryer hose conditions and connections. If using regrind, check for larger pellet size. Remove any contamination, review material handling procedures, or contact material supplier. Reduce regrind levels. Reduce melt temperature. Check and calibrate heaters or replace malfunctioning heaters.
Sinks and voids Sinks Voids Sinks Voids Sinks Voids	Injection pressure too low Injection hold time too short Injection speed too slow Injection speed too fast Mold temperature too low Mold temperature too high Melt temperature too low Melt temperature too high Gate size and/or runner size too small, freezing off before part is completely filled	Increase injection pressure. Increase injection hold time. Increase injection speed. Reduce injection speed. Increase mold temperature. Reduce mold temperature. Increase melt temperature. Reduce melt temperature. Enlarge gate size.
Sticking in cavity	Injection pressure too high Injection hold time too long Injection time too long Mold-closed time too short Mold temperature too high Melt temperatures too high Insufficient part draft used in part design Undercuts found in mold	Reduce injection pressure. Reduce injection hold time. Reduce injection time. Increase mold-closed time. Reduce mold temperature. Reduce melt temperature. Increase draft angles on part to facilitate part ejection. Machine and polish out undercuts.
Sticking on mold core	Injection pressure too high Injection hold time too long Injection time too long Mold-closed time too long Melt temperature too low Melt temperatures too high Insufficient part draft used in part design Undercuts found in mold	Reduce injection pressure. Reduce injection hold time. Reduce injection time. Increase mold-closed time. Reduce mold closed time. Reduce melt temperature. Increase draft angles on part to facilitate part ejection. Machine and polish out undercuts.
Splay marks, silver streaks. and splash marks	Resin not dried sufficiently Material contaminated Melt temperatures too high Melt temperatures too high Overall cycle time too long Injection speed too fast Mold temperature too low Gate size too small, restricting flow and producing high shear for material entering the cavity	Review recommendations by material supplier for drying and check drying equipment operation and dryer hose conditions and connections If using regrind, check for larger pellet size. Remove any contamination, review material handling procedures, or contact material supplier. Reduce melt temperature Reduce melt temperature.

Problem	Cause	Solution
	Back pressure too low Decompression (“suck back”) set too high, pulling trapped air into melt stream	Reduce injection speed Increase mold temperature. Enlarge gate size Increase back pressure. Reduce decompression
Warping, part distortion	Cooling rate of both mold halves not consistent with each other Parts warping after part ejection Injection hold time too short Mold closed time too short Parts too hot after ejection	Balance out cooling rate of both mold halves. General rule of thumb Keep both mold halves within $\pm 10^{\circ}\text{F}$ of each other. Check handling of part after ejection: Increase injection hold time Increase mold-closed time Quench part in cool bath, but be aware of possibly creating molded-in stresses in part .
Weld lines or knit lines	Injection pressure too low Injection speed too slow Injection hold time too short Mold temperature too low Melt temperature too low Vents in weld line area clogged with foreign matter Insufficient venting in mold	Increase injection pressure. Increase injection speed. Increase injection hold time. Increase mold temperature Increase melt temperature. Clean out all vents Check vent sizes and vent according to material supplier recommendations in the area of the joining melt fronts. Relocate gates to move weld lines.

Injection troubleshooting guide: PP/PE (polypropylene/polyethylene)

Problem	Cause	Solution
Brittle parts	Degradation of material High level of molded-in stresses in part Material contaminated	Decrease barrel temperatures starting with middle zones. Residence time in barrel too long: Measure barrel-to-shot ratio. Increase barrel temperatures starting with middle zones. Reduce injection speed. Remove sharp corners and transitions in parts and radius corners. Reduce injection packing and hold times. Remove any contamination, review material handling procedures, or contact material supplier. Check compatibility of color concentrate with base resin.
Excessive shrinkage	Cooling time too short Injection pressure too low Mold temperature too high Melt temperature too high Gates and runner size too small Excessive wall thickness variation	Increase cooling time. Increase injection pressure. Reduce mold temperature. Reduce melt temperature. Enlarge gates and runners. Design part with consistent nominal wall thickness.

Problem	Cause	Solution
Flashing of parts	Injection pressures too high Clamping pressures too low Melt temperature too high Barrel heater malfunctioning Back pressure too high Obstruction on mold surface preventing mold from closing completely	Reduce injection pressure. Increase clamp pressure. Reduce melt temperature. Check and calibrate heaters or replace malfunctioning heaters. Reduce back pressure. Check compatibility of color concentrate with base resin.
Flow marks	Melt temperature too low Injection speed too slow Mold temperature too low Poor surface finish on mold Flow marks located in areas that compromise part integrity	Increase melt temperature. Increase injection speed. Increase mold temperature. Polish cavity and core surfaces. Relocate flow marks away from areas where strength is critical.
Gas burn marks (dieseling)	Injection speed too high. Melt temperature too high Insufficient venting in mold	Reduce injection speed. Reduce melt temperature Check vent sizes and vent according to material supplier recommendations in the area of the joining melt fronts.
Gloss Too low Gloss	Injection speed too slow Melt temperature too low Mold temperature too low Injection pressure too low Poor surface finish on mold Injection speed too high	Increase injection speed. Increase melt temperature. Increase mold temperature. Increase injection pressure Polish cavity and core surfaces. Reduce injection speed.
Too high	Melt temperature too high Mold temperature too high Injection pressure too high Mold surface highly polished Mold not properly balanced Machine undersized for part Check ring worn out	Reduce melt temperature. Reduce mold temperature: Reduce injection pressure. Add texture to surface. Check a series of short shots to check flow pattern of part or run 2D or 3D mold filling analysis. Check barrel-to-shot ratio as we volumetric requirements of machine and heating capacity machine. Inspect check rings for cracks worn valve seats.
Nozzle drool	Melt temperature too high Hot runner manifold and/or barrel drop temperatures too high Overall cycle time too short Decompression ("suck back") shut off	Reduce melt temperature. Check and calibrate heaters or malfunctioning heaters. Increase cycle time. Utilize decompression.
Part sticking in cavity	Injection pressure too high Overall cycle time too short Surface imperfections on mold Insufficient draft angles in part Gates located near projections, such as ribs, bosses, and holes	Reduce injection pressure Reduce overall cycle time. Polish cavity and core surfaces. Utilize high lubricity mold coatings or finishes. Increase draft angles on part. Relocate gates away from projections.

Problem	Cause	Solution
Part sticking on core	Injection pressure too high Overall cycle time too short Surface imperfections on mold Insufficient draft angles in part Undercuts on part preventing part ejection Insufficient number of ejector pins Incompatible color concentrate	Reduce injection pressure. Reduce overall cycle time. Polish cavity and core surfaces. Utilize high lubricity mold coatings or finishes. Draw machine cores (machine in direction of flow). Increase draft angles on part. Remove undercuts on part. Modify or improve ejector pin setup or system.
Poor color dispersion	Incompatible color concentrate Melt temperature too low Back pressure too low Poor mixing in barrel	Change to a compatible color concentrate Increase melt temperature. Increase back pressure. Replace standard machine screw with an improved mixing screw such as a barrier-type screw. Use static mixer or mixing nozzle.
Poor weld lines/ knit lines	Melt temperature too low Mold temperature too low Injection time too short Weld lines located in areas that compromise part integrity Air trapped at joining melt fronts	Increase melt temperature. Increase mold temperature. Increase injection time. Relocate weld lines away from areas where strength is critical. Add vents at melt junction, overflow channels, or use porous metal inserts.
Rough Part Surface	Melt temperature too low Mold temperature too low Insufficient venting in mold Poor surface finish on mold	Increase melt temperature. Increase mold temperature. Check vent sizes and vent according to material supplier recommendations in the area of the joining melt fronts. Polish cavity and core surfaces.
Short shots	Insufficient screw feed setting. Reducing short size Injection time too short Melt temperature too low Mold temperature too low Gates and runner size too small Nozzle and gates blocked due to foreign matter Insufficient venting in mould Melt flow rate of material too low Mold not properly balanced	Increase screw feed settings to increase shot size. Increase melt temperature Increase mold temperature Enlarge gates and runners. Remove foreign matter from gates and nozzle. Check vent sizes and vent according to material supplier recommendations in the area of the joining melt fronts. Switch to a higher melt flow rate material. Check a series of short shots to check flow pattern of part or run 2D or 3D mold – filling analysis.
Sink marks	Injection pressure too low Injection time too short Injection speed too fast Gates size too small Gates located in thin section of part, causing flow path to go from thin section	Decrease injection pressure. Lengthen injection time. Decrease injection speed. Enlarge gates. Relocate gates in thick section of part.

Problem	Cause	Solution
	Nominal wall too thick Wall too thick at projections (ribs, bosses, gussets)	Core out part to reduce wall thickness or thin part and use ribs. Reduce wall thickness at projections.
Splay marks	Wall too thick at projections (ribs, bosses, gussets) Resin not dried sufficiently Material contaminated Moisture accumulating on mold. Flow path disrupted due to burr, sharp corner Injection speed too high Melt temperature too high Back pressure too high Injection pressure too low Mold not properly balanced	Review recommendations by material supplier for drying, and check drying equipment operation and dryer hose conditions and connections. If using regrind, check for larger pellet size. Remove any contamination, review material handling procedures or contact material supplier. Set mold temperatures above dew point. Polish out burrs and radius sharp corners. Reduce injection speed. Reduce melt temperature. Reduce back pressure. Increase injection pressure. Check a series of short shots to check flow pattern of part or run 2D or 3D moldfilling analysis.
Voids	Moisture in material Material contaminated Insufficient venting in mold Gates located in thin section of part causing flow path to go from thin to thick section Injection speed too high	Dry material, if needed, Remove any contamination, review material handling procedures, or contact material supplier Check vent size and vent according to material supplier recommendations in the area of the joining melt fronts. Relocate gates in thick section of part Reduce injection speed.

Introduction to microprocessor control and programmable logic controllers (PLCs)

Objectives: At the end of this lesson you shall be able to

- explain about microprocessor control system
- explain the importance of programmer logic controller.

Microprocessor Control (Fig 1)

Microprocessor control is a technology that involves the use of a microprocessor as the central processing unit (CPU) in a control system. A microprocessor is a compact integrated circuit that contains the functions of a computer's central processing unit, including arithmetic and logic operations, control unit, and memory. In the context of control systems, microprocessors are employed to manage and regulate various processes, making them more efficient and automated.

The key features of microprocessor control include real-time processing, flexibility, and the ability to execute complex control algorithms. Microprocessors are commonly used in a wide range of applications, such as industrial automation, home appliances, automotive systems, and more. They play a crucial role in enhancing the precision, speed, and reliability of control processes.

Programmable Logic Controllers (PLCs)

Programmable Logic Controllers, or PLCs, are specialized digital computers designed for industrial control applications. These devices are used to automate electromechanical processes, such as manufacturing processes, machinery operation, and various industrial tasks. PLCs are equipped with a microprocessor and are programmable, allowing engineers and technicians to create customized control logic to suit specific industrial requirements.

PLCs are characterized by their ruggedness, reliability, and the ability to withstand harsh industrial environments. They typically consist of input and output modules, a central processing unit (CPU), memory, and communication interfaces. The programming of PLCs is done using ladder logic or other programming languages specifically tailored for control applications.

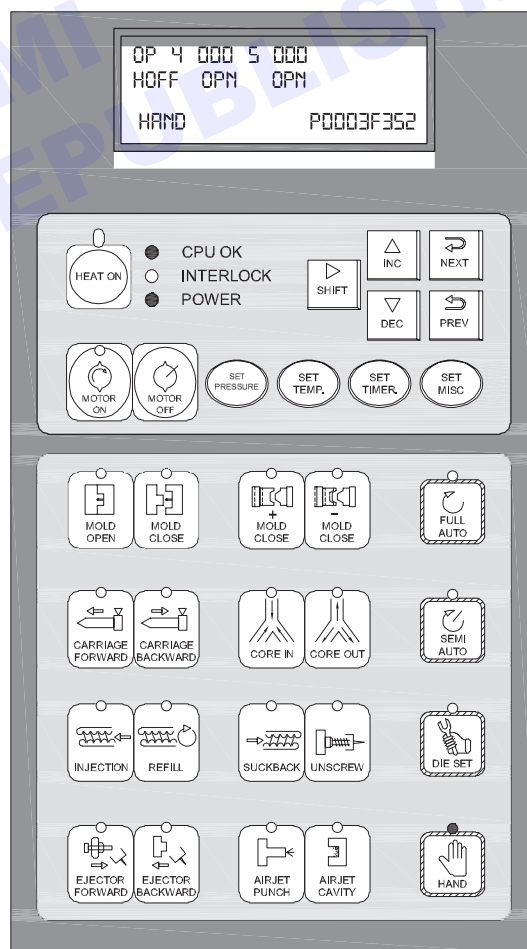
Distinguishing Features and Applications

While both microprocessor control and PLCs involve the use of microprocessors in control systems, they have distinct characteristics and applications.

Microprocessor control is a broader concept that encompasses the use of microprocessors in various electronic systems, including but not limited to industrial control. Microprocessors are versatile and can be found in computers, consumer electronics, and other applications where control and processing capabilities are required.

On the other hand, PLCs are specialized devices designed exclusively for industrial automation and control. PLCs excel in applications where reliability, durability, and real-time control are critical, making them well-suited for manufacturing, process control, and other industrial settings.

Fig 1



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Advantages of microprocessor control and PLC

Objective: At the end of this lesson you shall be able to

- describe the advantages of microprocessor control and PLC.
-

Advantages of Microprocessor Control

Versatility: Microprocessors are highly versatile and can be used in a wide range of applications, from consumer electronics to industrial control systems. Their flexibility allows them to adapt to different tasks and environments.

Processing Power: Microprocessors provide significant processing power, enabling the execution of complex algorithms and calculations. This capability is essential for handling intricate control tasks in real-time, such as in automotive control systems, robotics, and smart devices.

Integration with Other Technologies: Microprocessors can be easily integrated with other technologies, such as sensors, actuators, and communication interfaces. This facilitates the creation of interconnected systems and enables seamless communication between different components.

Customization: Microprocessor-based systems allow for customization of control algorithms to meet specific requirements. Engineers can design and implement tailored solutions to address the unique needs of a particular application.

Upgradability: Microprocessor-based systems are often upgradeable through software updates, allowing for improvements in functionality, performance, and security without the need for hardware changes. This makes them adaptable to evolving technological standards.

Advantages of Programmable Logic Controllers (PLCs)

Dedicated for Industrial Automation: PLCs are specifically designed for industrial automation and

control applications. Their rugged construction and resistance to harsh industrial environments make them well-suited for tasks such as manufacturing processes and machinery control.

Reliability and Durability: PLCs are built to withstand tough industrial conditions, including temperature variations, humidity, and electromagnetic interference. This makes them highly reliable in environments where other electronic devices might struggle to operate consistently.

Real-Time Processing: PLCs are optimized for real-time processing, ensuring that control tasks are executed with precision and minimal delay. This is crucial in industrial applications where timing is often critical for maintaining operational efficiency and safety.

Easy Programming and Troubleshooting: PLCs are programmed using languages like ladder logic, which is intuitive and easy to understand for control engineers. The graphical representation of control logic simplifies both programming and troubleshooting, reducing downtime in industrial processes.

Scalability:

PLC systems are easily scalable, allowing for the addition or modification of control elements without significant changes to the overall system. This scalability is valuable in industries where production processes may evolve or expand over time.

Centralized Control:

PLCs enable centralized control of various components in a system. This centralized control facilitates efficient monitoring, maintenance, and modification of industrial processes.

Electrical injection moulding machine

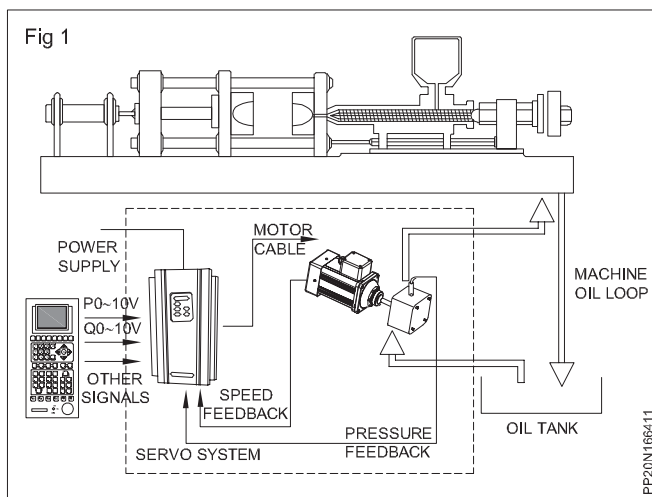
Objective: At the end of this lesson you shall be able to

- explain briefly about electrical injection moulding machine.
-

An electrical injection moulding machine is a type of industrial machinery used in the manufacturing process of plastic parts through the injection molding process. Injection molding is a widely used technique in the production of plastic components, and an electrical injection molding machine incorporates advanced electrical and electronic control systems for enhanced precision, efficiency, and reliability in the molding process.

Here are key features and aspects of electrical injection moulding machines

Electric Drive System (Fig 1): Unlike traditional hydraulic injection moulding machines that use hydraulic systems for various functions, electrical injection molding machines employ electric drive systems. These systems consist of high-performance electric servo motors for the movements of the injection unit, clamping unit, and other machine components.



Electric drive systems offer precise control over the molding process, allowing for accurate and repeatable positioning of the mold and injection unit.

Energy Efficiency

Electrical injection molding machines are known for their energy efficiency compared to hydraulic counterparts. The electric drive systems are designed to use power only when needed, reducing overall energy consumption during the molding cycle.

The ability to decouple the movements of different machine components contributes to energy savings, as the electric motors can operate at optimal speeds for each specific function.

High Precision and Speed

Electric servo motors provide high precision and speed in the control of the injection and clamping processes. This precision is crucial for achieving tight tolerances and consistent quality in the molded products.

The quick response time of electric drive systems enables faster cycle times, increasing the overall production efficiency of the injection molding process.

Reduced Maintenance

Electric injection molding machines often require less maintenance compared to hydraulic machines. The absence of hydraulic oil and associated components simplifies maintenance procedures and reduces the risk of oil-related issues.

The electric drive systems are generally more durable and have longer service intervals, contributing to increased uptime and productivity.

Improved Control and Monitoring

Electrical injection molding machines feature advanced control systems that allow for precise monitoring and adjustment of various parameters during the molding process.

Integrated sensors and feedback systems provide real-time data on temperature, pressure, and other critical variables, enabling operators to optimize settings for different molds and materials.

Cleaner and Quieter Operation

The absence of hydraulic oil in the electric drive systems results in a cleaner working environment. There is no risk of oil leaks or contamination of molded parts.

Electric machines also operate more quietly compared to their hydraulic counterparts, contributing to a more comfortable working environment.

Adaptability and Programmability

Electrical injection molding machines are often highly adaptable and programmable. The control systems allow for easy adjustment of parameters, making it possible to accommodate different molds, materials, and production requirements.

Basic principles and features of thermoset injection moulding process

Objective: At the end of this lesson you shall be able to

- describe basic principles and features of thermoset injection moulding process.

1 Thermosetting Plastics (Fig 1)

Chemical Structure:

Thermosetting plastics, unlike thermoplastics, undergo irreversible chemical reactions during curing. This curing process involves the formation of a three-dimensional network, making the material rigid and heat-resistant.

No Melting Point:

Thermosets do not have a distinct melting point since they undergo a chemical transformation when exposed to heat, turning them into a solid and infusible state.

2 Injection Molding Process

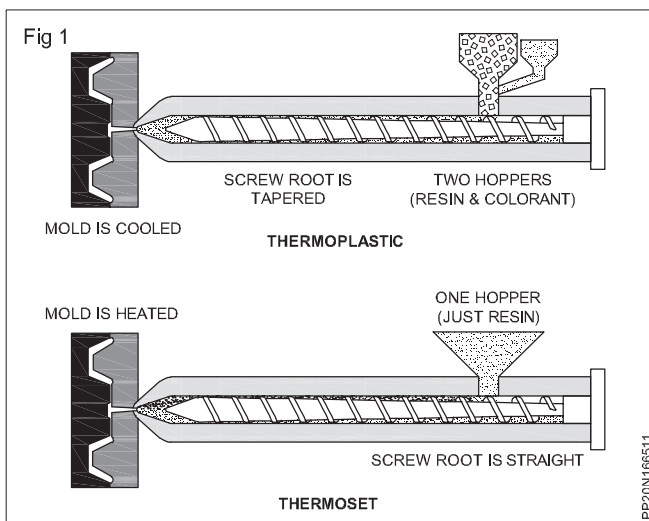
Material Preparation: Thermosetting plastic, usually in the form of granules or pellets, is preheated to a

specific temperature to facilitate the molding process. This temperature is below the point of initiation of the curing reaction.

Injection: The heated thermosetting material is injected into a mold cavity under high pressure. This mold is designed to shape the final product.

Curing (or Cross-Linking): After injection, the mold is heated to a higher temperature to initiate the curing reaction. Cross-linking occurs, creating a strong and durable network within the plastic material.

Cooling: Once the curing process is complete, the mold is cooled, and the finished part is ejected. The cooling step ensures the final product retains its shape and integrity. (Fig 1)



3 Key Features of Thermoset Injection Moulding

Irreversibility: The curing reaction in thermosetting plastics is irreversible, resulting in a final product that cannot be re-melted or reprocessed. This characteristic makes thermosets ideal for applications where dimensional stability and heat resistance are critical.

High Temperature Resistance: Thermoset materials can withstand higher temperatures compared to many thermoplastics. This feature makes them suitable for applications in which exposure to heat is a concern.

Dimensional Stability: Once cured, thermoset materials exhibit excellent dimensional stability. This property ensures that the molded parts maintain their shape and size under varying conditions.

Comparison between conventional injection moulding machine and PLC & microprocessor injection moulding machine

Objective: At the end of this lesson you shall be able to

- compare between conventional moulding m/c and PLC & microprocessor injection moulding machine.

Control System: Conventional Machine. Relies on mechanical controls and manual adjustments for various parameters such as injection speed, pressure, and temperature.

PLC & Microprocessor Machine: Utilizes advanced programmable logic controllers (PLCs) and microprocessors for precise and automated control of the injection molding process. This allows for real-time adjustments, better repeatability, and ease of programming.

Precision and Accuracy: Conventional Machine, Limited precision due to manual control, leading to variations in product quality.

PLC & Microprocessor Machine Offers high precision and accuracy in controlling injection speed, pressure, and other critical parameters. This results in consistent and repeatable part quality.

Energy Efficiency

Conventional Machine: Typically consumes more energy as it may lack energy-saving features.

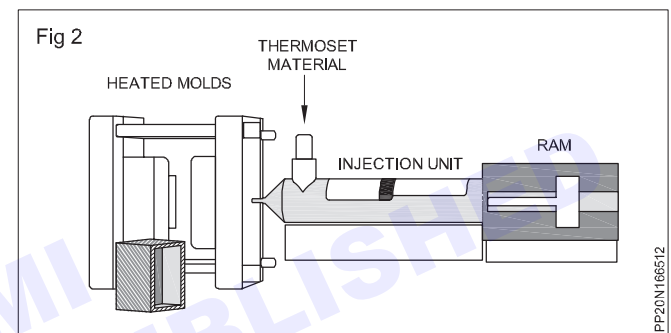
Chemical Resistance: Thermosetting plastics often display resistance to a wide range of chemicals, enhancing their suitability for applications in corrosive environments.

High Strength and Rigidity: The cross-linking structure formed during curing imparts high strength and rigidity to thermoset products, making them suitable for structural components in various industries.

4 Tooling Considerations

Heat Resistance: Due to the elevated temperatures involved in the curing process, molds used in thermoset injection molding must be made from materials that can withstand these high temperatures without deformation or degradation.

Venting: Proper venting is crucial to allow the escape of gases produced during the curing process, ensuring the final product is void-free and of high quality. (Fig 2)



PLC & Microprocessor Machine Generally more energy-efficient due to the use of advanced electric drive systems and the ability to optimize energy usage through programmable control.

Ease of Operation

Conventional Machine: Requires skilled operators with in-depth knowledge of the machine's mechanical controls.

PLC & Microprocessor Machine: User-friendly interface and intuitive programming make it easier for operators to set up and monitor the injection molding process. Automation reduces the reliance on manual adjustments.

Cycle Time

Conventional Machine: Longer cycle times due to manual adjustments and limited automation.

PLC & Microprocessor Machine: Shorter cycle times facilitated by the precise and rapid control of the injection

and clamping processes. This contributes to increased overall production efficiency

Maintenance

Conventional Machine: May require more frequent maintenance, and repairs can be complex.

PLC & Microprocessor Machine: Generally requires less maintenance due to the absence of hydraulic systems and the use of durable electric drive components. Diagnostic tools in PLCs assist in identifying and addressing issues efficiently

Adaptability

Conventional Machine: Limited adaptability to different molds and materials without manual adjustments

PLC & Microprocessor Machine: Highly adaptable, with the ability to store and recall multiple mold setups. Quick and easy adjustments for different materials and production requirements contribute to greater flexibility.

Monitoring and Data Collection

Conventional Machine: Limited monitoring capabilities, relying on manual observation.

PLC & Microprocessor Machine: Provides real-time monitoring and data collection through sensors and feedback systems. Operators can access comprehensive data on parameters like temperature, pressure, and cycle times, aiding in quality control and process optimization.

Noise Level

Conventional Machine: Can be noisy due to hydraulic systems and mechanical components.

PLC & Microprocessor Machine: Operates more quietly, contributing to a more comfortable working environment.

Cost

Conventional Machine: Initial cost may be lower, but operating costs and variability in product quality can impact long-term costs.

PLC & Microprocessor Machine: Higher initial investment, but the potential for energy savings, reduced scrap, and improved efficiency can lead to lower overall operating costs over time.

Importance of preventive maintenance

Objective: At the end of this lesson you shall be able to

- **schedule wise preventive maintenance of injection moulding machine.**

Injection moulding machine Maintenance

The Maintenance of injection molding machine consists of the following

- 1 Basic Machine Maintenance & safety concerns
- 2 Fluid and platen maintenance
- 3 Screw and barrel maintenance
- 4 Preventative maintenance & logging.

1 Basic Machine Maintenance and safety

- 1 All personnel that will use the machine tools must either take a class in Machine Tool operation or, through their prior experience, be able to prove their proficiency to the shop instructor.
- 2 The area directly surrounding the Machine Tools must be marked off (Yellow floor tape or paint).
- 3 All personnel in the shop area must wear eye protection at all times.
- 4 Hearing protection (ear plugs) should be readily available to shop users.
- 5 A first aid kit must be placed in the shop, and a lab member should be assigned to keep it well stocked.
- 6 An oil spill kit should be purchased and placed in an accessible spot with an assigned lab responsible for its contents.
- 7 A fire extinguisher must be readily available
- 8 Basic safety rules must be followed at all times.

Among these are

- a Long hair must be tied back at all times
- b No sandals or opened toed shoes are permitted in the work area.
- c If lifting heavy objects you are required to wear steel toe safety shoes
- d Any oil spilled on the floor must be immediately cleaned up
- e Loose fitting clothing must be tucked in or tied up
- f Neckties must be removed
- g Bracelets and other loose jewelry must be removed prior to using the shop
- h No horseplay around the machines is permitted, machine tools can be dangerous.
- 9 No person should work alone, in certain situations people may establish a buddy system where people located in other of the building are responsible for checking to see that the shop user is safe at all times. A possible implementation might involve the purchase a good set of two – way radios. The “buddy” does not get a response, he / she would then immediately go to the shop area to check on the shop user. As part of this system, a sign - in sheet could be placed in the shop that the users would fill in to indicate when they entered and left the area, and name and location of their buddy.

- 10 The shop area must be kept clean. It is impossible to maintain a safe work environment, stock and last weeks coffee are lying about the equipment. A lab member should be put in charge of the shops cleanliness.
- 11 Practice common sense. If your gut tells you not to setup a part in a certain way in a machine, don't do it. Most shop accidents are a result of lack of knowledge, not carelessness.

Fire & Emergencies

- Know what to do and where to go in an emergency
- Have a plan for emergencies
- Appoint emergency response personnel to oversee emergency evacuations
- Know the location of emergency exits
- Have fire extinguishers checked regularly
- Practice emergency evacuations
- Always keep fire exits clear
- Obey no smoking signs.

House keeping

Good housekeeping – it involves good planning and control. It also includes the same disciplines needed to manage OH & S effectively and to run a business well.

- Keep passageways clear
- Store goods and equipment where they belong
- In particular, pay attention to
- Power cables
- Amenities
- Emergency exit lights
- Lighting
- Cluttered areas
- Dust
- Rubbish
- Granules
- Spills

Safety Concerns

- Temperature
- Electricity
- High speed
- High pressure
- Pinch points
- Unclean work area
- Fumes
- Noise

Safety equipment

- Safety glasses
- Respirator
- Clothing
- Footwear
- Hearing Protection
- Head Protection

Slips & Trips

Poor Housekeeping can hurt people !

Some general principles can help to get housekeeping in order.

A clean, orderly and well organized workplace:

- Reduces the risk of injury
- Is better to work in
- Avoids waste
- Impresses visitors (Looks well managed)
- Saves time, is more productive

Maintenance

Maintenance of the machine tools is key to safe operation Each week a lab member should be elected to lubricate the equipment. Cutting tools, such as drill bits, end mills, and lathe turning tools should be inspected and sharpened as required on a weekly basis. A sheet should be placed in the shop so the shop users record which drills, tool bits, end mills etc. are either broken or in need of sharpening or repair.

Milling machines should have the alignment checked on a monthly basis. The machinery must be cleaned after each usage. Dirty machine tools tend to need repair and alignment more frequently than clean ones. It is the responsibility of the shop user to clean up after him / her. Chips and debris must be swept up and properly disposed. One must clean the machine tools so they are in the same condition as when one began to work. All hand and measuring tools must be returned to their proper storage. If your lab has a belt driven milling machine the belt should be inspected for wear every month.

Measuring tools should be kept in good working order. They should be stored in clean space, away from the chips and oil of the cutting environment. Measuring tools should have their "Zero" checked prior to each use. If you do not know how to "Zero" a micrometer or dial caliper, ask Stan.

A machine shop is, by nature, a dangerous place. All machinery has the potential to cause you harm if it is used incorrectly or not inspected periodically. Please remember that it is always a bad idea to run dangerous equipment if you are over tired or not feeling well. Never operate the equipment if you are under the influence of alcohol or cold medication that makes you drowsy. Focus is very important.

Accidents in the shop happen very quickly and most always there isn't any warning before a problem occurs. The shop guidelines listed above. If put into use, will allow one to work safely and independently in a small machine shop. It is a good idea to have Stan come in and align / inspect your equipment annually. Remember, above all else it is important to work safely!

Fluid and platen Maintenance

Dirt is responsible for majority of malfunctions of the machine. Dirt is formed in a Hydraulic system either at the time fabrication of the components or during the manufacture of the machine. Dirt may be in the form of metal chips, particles of components etc.

The planets should be free from rust and corrosion. They should be free of water, dust, dirt, etc.,

Screw and Barrel Maintenance:

Barrels

The heating cylinders of injection molding machines have their internal bore finished by either nitriding or adding another metallic liner. Cylinders for nitriding are made of special steel with a high aluminum content and chromium and molybdenum.

The surface requires additional finishing, and the final depth of the hardness may be considerably less. The hardness of the lining decreases with depth; thus, wear further reduces the surface hardness and is self – accelerating.

Screws

Most screws are made from 4140 steel and then flame hardened and chrome plated. They can also carburized and nitride, and a hard surface obtained by spraying on a layer of metal. Worn screws can be rebuilt several times, providing that there is not excessive wear.

Major causes for screw / barrel breakdown include:

- Fatigue failure, primarily caused by thermal shock conditions, aggravated by improper starting and stopping procedures.
- Corrosion from the thermoplastics used.
- Damaging materials (trash) fed into the hopper and then the barrel.
- Prolonged use of high injection pressure. (The use of two – stage injection profiles will substantially reduce this type of failure.)

Preventive Mantence: With faster operating speeds and higher pressures accelerated degradation of the hydraulic fluid occurs. The smaller fluid reservoirs cause contaminant concentrations to increase. Fluid contamination can cause 70 to 90% of machine failures.

Maintenance the proper oil level and oil quality can be as important as maintaining the rest of the machine. The more sensitive and sophisticated machine with microprocessor control are easily subject to hydraulic fluid contamination.

S.No	Faults	Possible Problems
1	Wrong location of gate	weld lines, flow line, melt jetting, air entrapment, voids, warping, stress concentrations, sink marks etc.
2	Gates / runners too narrow	Short short, overheating plastic, premature melt freezing, voids, etc.
3	Runners too large	Increased cycle time, plastic waste, pressure loss, etc.
4	Unbalanced cavity layout in multiple cavity layout	Unbalanced cavity pressure buildup, mold distortion, dimensional variation due to poor shrinkage control, stresses, flash etc.
5	Non uniform cooling nor properly applied	Increased cycle time, distortion during ejection, high after shrinkage, stresses or warpage, poor part release, etc.
6	Poor or no venting	Use higher injection pressure, plastic burns or streaks, short shot, etc.
7	Poor ejection system or bad location of ejector	Poor mold release, part distortion or damage, changes or upsets in molding cycle, etc.
8	Insufficient sprue to nozzle contact	Melt leakage occurs, mold wear, higher injection pressure required, poor cycle repeatability, etc.
9	Sprue tool long	Pressure loss develops, longer molding cycle, requires increase in heat requirement, premature freezing of sprue, etc.
10	Draft molded part too small	Poor mold release, part distortion, dimensional variation, etc

Microprocessor controlled machines require accuracy, part quality and cycles. A sluggish response caused by poor oil quality affects everything from fill rate

repeatability to cushion size, to pressure switching, to platen movement.

The operator must watch the mold cooling water temperature either by means of instruments such as thermocouples or pyrometers or manually occasionally touching the water line surfaces.

Repair Techniques

Cylinders in need of repair may be disassembled and inspected for surface imperfections where material hang up is occurring. Something of the surface should correct the problem. Any small cracks can be welded and finished. Wear caused by the sliding of the non – return valve has not been found to be a major problem. Worn barrels can be rebred and the screw size increased to the necessary dimensions. The barrel is best cleaned with a wire brush attached to a long broom handle. Screws are relatively easy to disassemble and clean.

Corrosion

If there is to be a prolonged shutdown period, purging should occur. Considerable wear often occurs when molding glass and mineral filled thermoplastics in screw machines. It was thought that the wear came from erosion at the feed end of the screw, however, evidence has shown that wear occurs more in the return valve section at the front of the screw.

Start – Up / Shut – down procedures

When a machine has a cold start – up, it is important to allow enough time for the heating cylinder to completely reach molding temperature. Many molders allow an additional period of approximately 20 minutes past the pyrometer indication of molding heat. This will substantially reduce the stress in the barrel and screw when starting. Purging at start – up should be done at low pressure. When the machine is shut – down, it should be purged until no more material comes out, and the screw left in the forward position.

Working with Machines

Some general principles for operating or maintaining machines

- Follow standard operating procedures (SOPs) etc.
- Lock out / tag out machines when repairing and maintaining them
- Wear correct personal protective equipment (PPE)
- Do not wear loose clothing
- Always the back long hair
- Ensure guards are in place

Incidents at plastics Machinery

- Safety devices (guard and inter locks etc.) not fitted.
- The safety devices have been over ridden , removed or broken.
- The safety device have not been properly reactivated after setting or maintenance, ie die change

Hazards of injection molding Machines

- Exposed nip points on all equipment need to be identified & controlled. The key is to identify the hazards & install workable controls.
- Robotics must be fully enclosed to prevent access, with complete interlocking for maintenance.
- The purging process creates exposure to fumes.

Keep the shop clean: Cleanliness in the molding shop is a very important in the maintenance job. Contamination of the resin by dust, dirt or metal parts will make production of good pieces impossible. It may also damage the screw, die and other parts of the machine.

Keep spare parts in stock

It is always necessary to keep spare parts like there Mo couples, heater, fuses, etc. The operator must be prepared for emergencies occurring. Catastrophic failure occurs when a lards particle enters a pump or valve. The result may well be complete seizure of the pump or motor. Intermittent failure follows wear, corrosion and cavitation's erosion. They cause increased internal leakage in the system components.

Hazard	Where	Risk	Controls
Hot surfaces or splashed plastic	Between nozzle and fixed platen during purging	Burns	Not parts of injection unit must be insulated or guarded.
Nip Points	Between die and platens Moving platens via the top of mold moving platens Traps at core and ejectors Movement of the damping mechanism robotics	Crush	Ensure guarding complies with AS 4024 Safeguarding of machinery
Fumes poor air quality	Purging process and heated materials	Chemical related illness	Portable fixed extraction unit Suitable respiratory protection

Introduction of hydraulic system

Objectives: At the end of this lesson you shall be able to

- define hydraulic system
- define Pascal's law
- state the Bernoulli's principle.

Any working or control system that uses liquid as the transmitting fluid is known as hydraulic system.

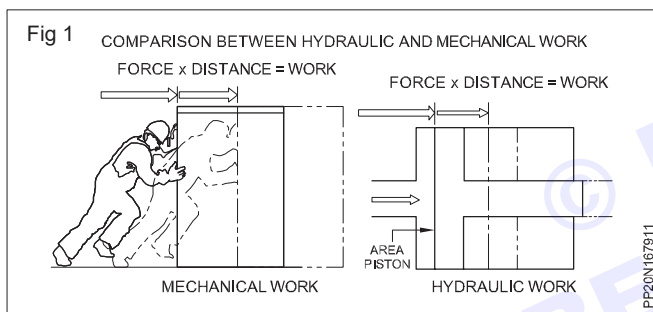
The word hydraulic is derived from Greek words “hydra” meaning water and “aulic” meaning pipe.

Some common examples of hydraulic system include automobile braking, power steering, elevators, earth moving equipment's, jacks, presses, riveting machines, tool feeding mechanisms etc. The liquid used in hydraulics is generally viscous petroleum oils.

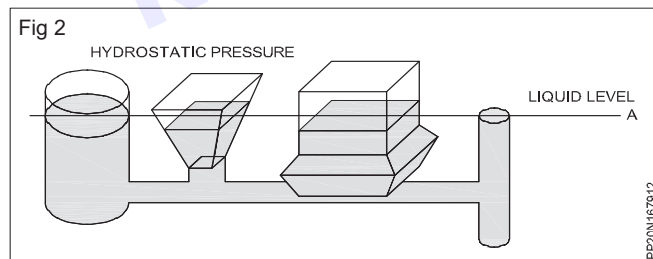
The following paragraphs gives basic physical properties and laws that govern liquids, relevant to hydraulic systems.

“Work” is defined as the product of force and the distance in which the object has moved in the direction of force.

Fig 1 shows the comparison between the work done in a mechanical and hydraulic system.



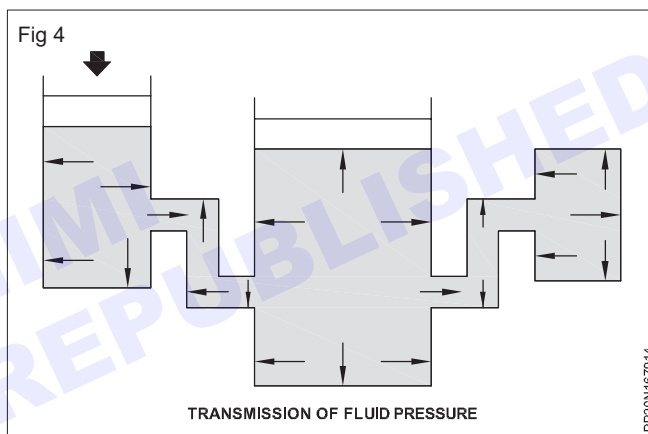
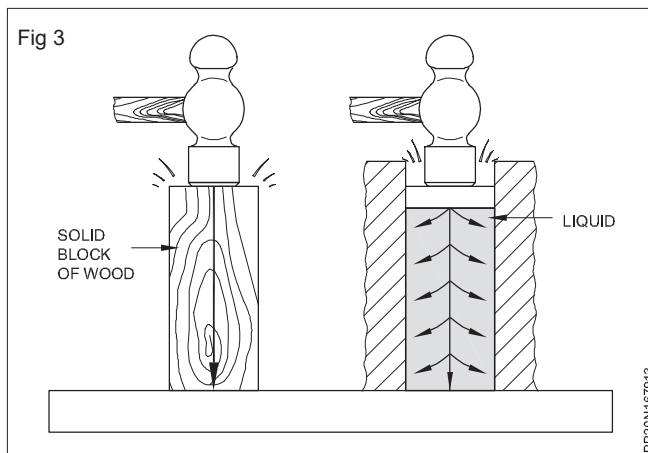
The Fig 2 shows that different shaped and sized containers inter-connected by a pipe, the level of the liquid remains same. This is because of the internal pressure of the liquid. At any point the liquid attains certain pressure proportional to the height of the liquid above.



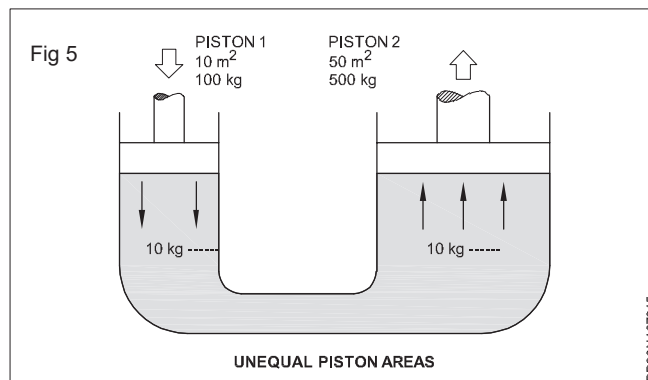
Therefore the higher pressure in any of the container will force the liquid to flow to the next container until the pressure on both the sides are equalized.

Through the line 'A' the pressure in all the open containers remain the same, since height of liquid columns are same.

Pascal's Law: It states that the pressure exerted on a liquid is transmitted equally in all the directions. Fig 3 clearly explains this law followed by Fig 4.

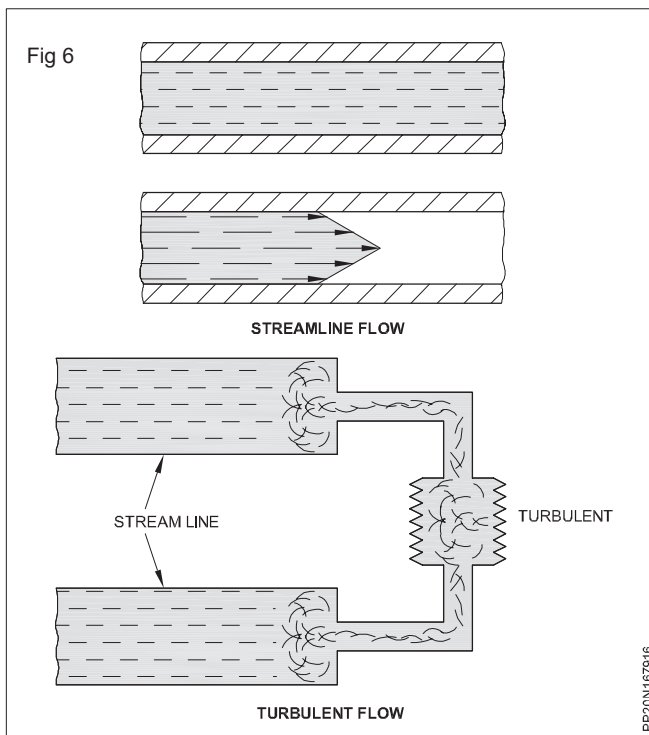


Thus if small amount of pressure is exerted on a smaller piston as shown in Fig 5, the higher force can be attained at the larger piston, since the pressure is equally applied on larger area.



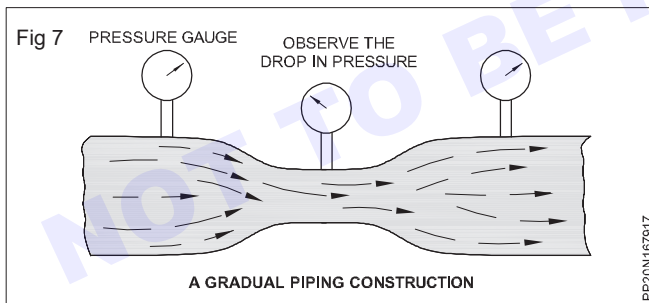
Cavitation

The inter-locked air bubbles and pockets in the hydraulic pipe lines and components is called cavitation. In cavitation the static pressure falls below vapor pressure. The vapor formation condenses resulting in pressure jerks and noise, and heating-up the oil resulting in a turbulent flow. Therefore resulting flow of oil should be a stream line or laminar in the pipe lines (Fig 6).



Bernoulli's principle: Kinetic energy is the energy present in oil by virtue of its motion. Potential energy is due to the pressure. The total energy is the sum of these two energies.

The Bernoulli's principle states that the total energy of fluid always remains constant. During the course of flow of liquid, the flow increases and pressure decreases when a restriction is encountered. If the flow decreases, liquid pressure increases Fig 7. Depicts this principle clearly.



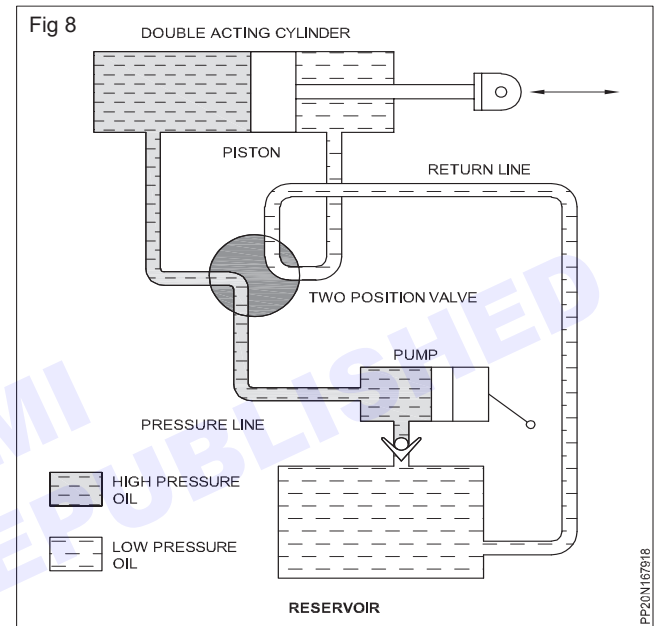
Effect of heat: Since the liquids (oil) full in containers cannot expand or be compressed on heat, it exerts pressure on the container thus developing unwanted stresses.

Heat also thins out the oil. The low viscous oil may leak through seals and packings. Heat also causes the deterioration of oil. Hence a suitable cooling system must be provided.

The basic hydraulic system consists of the following elements

- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A control valve to direct the flow of fluid
- An actuating unit, such as a cylinder
- A suitable hydraulic fluid
- Piping or tubing to circulate the fluid through the system.

But the following components make up actual hydraulic power system (Fig 8) for a safe and greater range of work.



- A reservoir to store the hydraulic fluid
- A pump to provide fluid pressure to the system
- A filter to remove dust, chips and other foreign particles from the fluid
- A pressure-regulating valve, which keeps the fluid pressure in the main part of the system at the proper level
- An accumulator, which acts as a cushion and prevents large variations in fluid pressure that occurring in the system
- Check valves, which permit fluid flow only in the desired directions.
- A hand pump for operating the system manually if necessary.

Hydraulic cylinders (linear actuators)

Objectives: At the end of this lesson you shall be able to

- state the basic principle of hydraulic cylinder
- explain the construction of hydraulic cylinders
- state the sealing arrangement in a hydraulic cylinder
- name the parts of the hydraulic cylinder
- specify the hydraulic cylinder
- state the application of hydraulic cylinders
- calculate speed and force of a cylinder.

Linear actuator

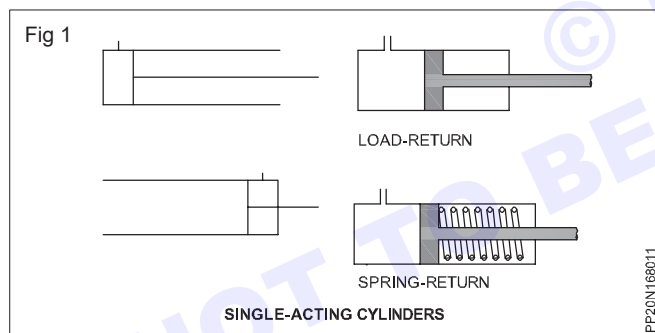
A hydraulic linear actuator is basically a cylinder, used to convert the hydraulic pressure and flow into a linear mechanical motion or force. Cylinder can be coupled with different types of mechanical linkages to produce enhanced or restricted movements in the combination of linear and rotary motions. Likewise with the arrangements, force can be multiplied or reduced.

In a cylinder, the hydro-static pressure energy of the oil is converted into mechanical motion.

Working principle

Single acting cylinder

The Fig 1 shows the cross-section of a single acting cylinder. Pressurized oil from the pump enter the pressure port. The pressure of oil exerts onto the piston and piston is moved (also against the force of spring tension), to other side.

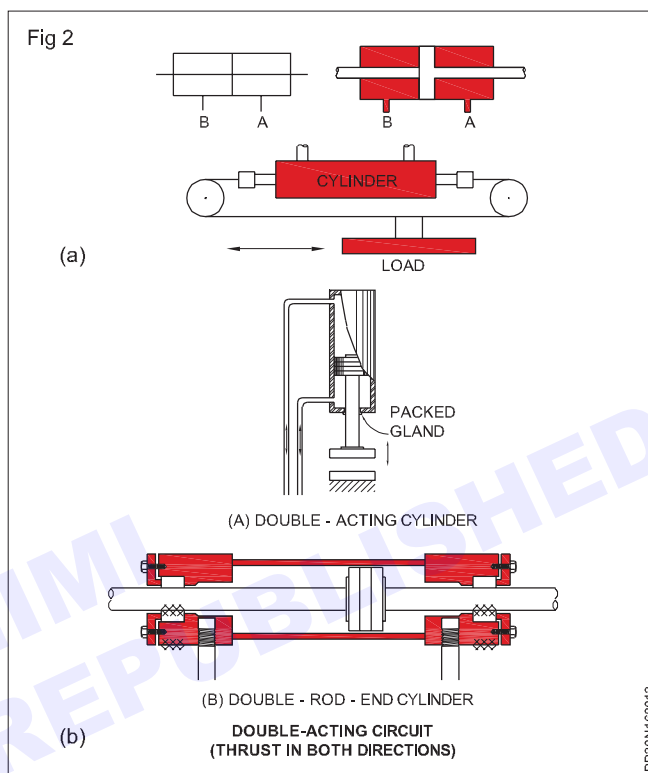


Useful work or movement can be attained from the free end of the piston-rod. After expansion of the oil, the spring tension overcomes the oil pressure. Now the spring pushes the piston to the left hand side. The oil is expelled through the same port.

Double acting cylinder

In a double acting cylinder Fig 2 Oil is supplied to both the sides of piston through ports A and B. When oil is supplied to port B, piston moves slowly. This is due to lesser area on the port side B, because force is proportional to the area. When the piston starts moving from left to right side, by the supply of oil pressure through port A, pressure less oil present on the right side is expelled through port 'B' and vice versa.

To have an equal force on both the strokes, piston rod is provided on the left side of the piston also. (Fig 2a and 2b)



Construction of a double acting cylinder (Fig 3a)

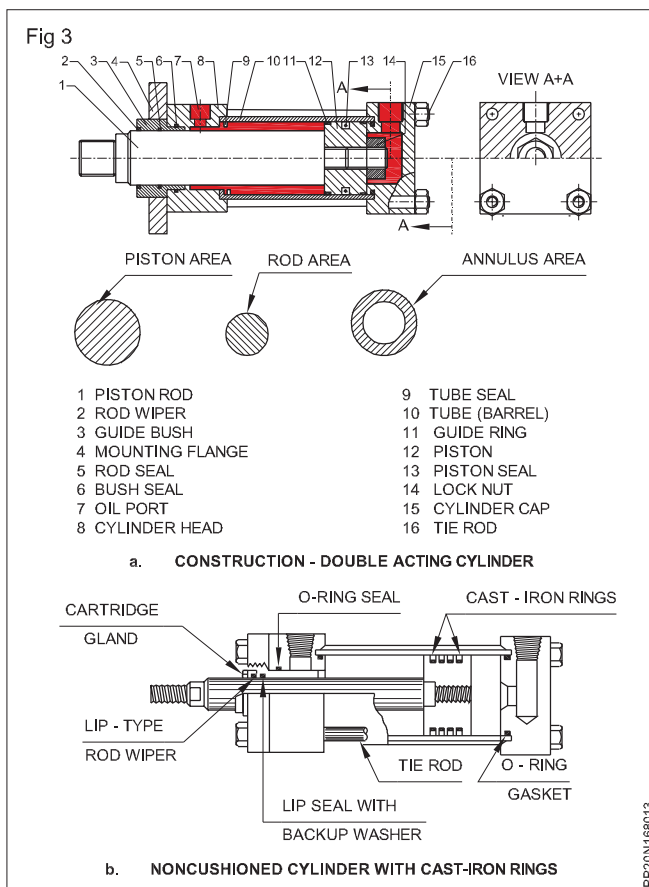
The general construction of a double acting cylinder is shown in Fig 3a. Piston rod is made of a chrome plated and piston is made of cast steel. Cylinder head is honed inside and has rod bearing support and a port. Cylinder cap blocks the end of the cylinder and firmly attached to head by means of tie-rods and nuts.

Static seals keeps the cylinder air-tight. Viper seals prevent the dust or other foreign particles from entering inside. The rod-bearing is usually replaceable by means of fasteners.

Piston seal prevents the oil from either-side of the piston, piston rings are made of high quality alloy steel/cast iron. (Fig 3b) For high pressures, cup packed seals are used.

These seals generally made of composition of rubber. For some high temperature applications, teflon seals are also used. Ports are threaded to connect the pipe ends/connectors.

Leakage in between cylinder and head is prevented by O-rings made up of rubber as shown in the Fig 3b. Better view of sealing arrangement can be seen in Figs 3b.



End cushioning

High pressure oil at the ends of the stroke will make the piston to impact on the ends of cylinder. To avoid this, end cushioning is generally provided. Springs find common application. But when the spring is compressed beyond its full home length, it is prone to damage. Hence cushioning is done by restricting the oil outlet as shown in the Fig. 4a. This arrangement is provided in the end portion of cylinder heads.

As shown in Fig. 4b the other side of the piston is provided with a plunger or cushioning piston. In the cylinder head, the check valve connects the passage from outlet to the cylinder. Another passage is connected by a restricted orifice 'O'.

This orifice can be adjusted by a screw (Fig 4)

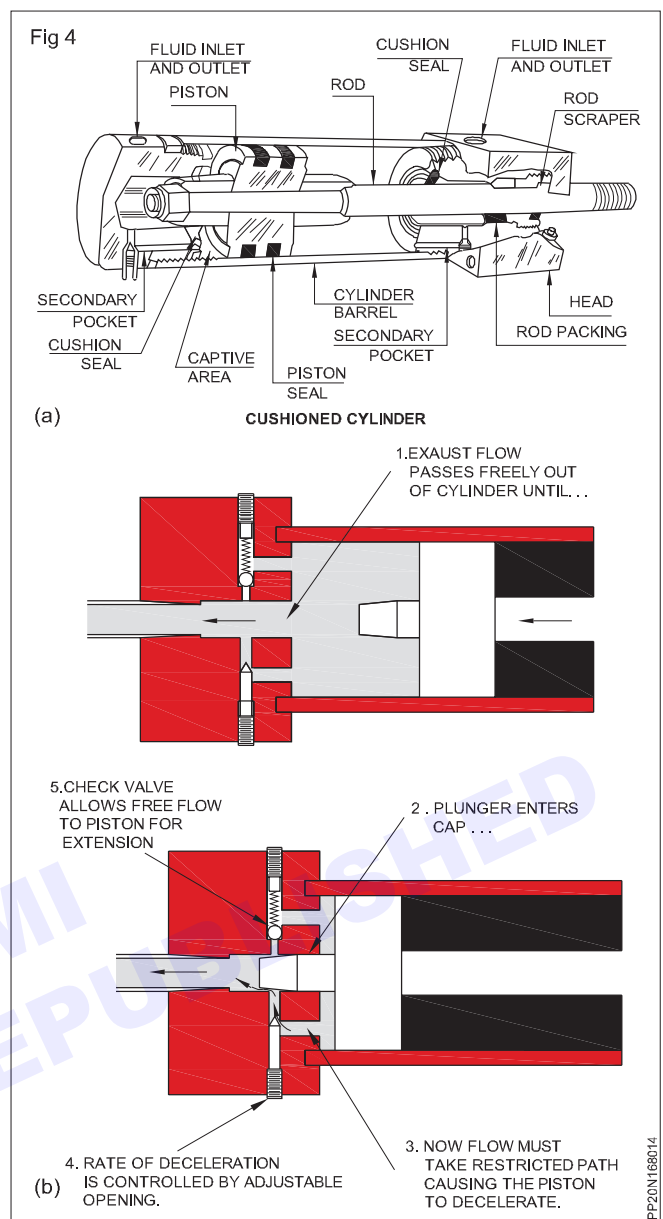
As the piston travel to the left-hand side, the plunger or cushioning piston enters outlet port 'E'. Now oil can escape through limited passages C and O only. But the check-valve blocks the oil passage by means of a ball. Now the oil can pass through the passage 'O' only. Thus travel of the piston is slowed down at the ends.

Pressure and speed of piston

Pressure exerted by the piston = Pressure (Kg/cm²) x Area of cross section of piston (cm²)

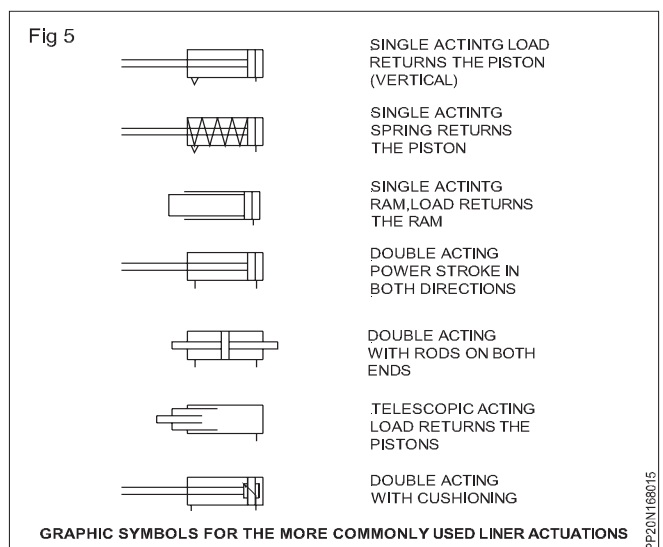
$$\text{Speed of the piston (cm/min)} = \frac{1000 \times \text{LPM}}{\text{Area of piston (cm}^2\text{)}}$$

Where LPM = Litres Per Minute.



Symbol

The symbols for hydraulic cylinders resembles the symbols of pneumatic cylinders. The symbols for commonly used cylinders are given in Fig 5.



Classification of cylinders

Two basic types of cylinders are

- Single acting cylinders
- Double acting cylinders

Single acting cylinders are further classified into

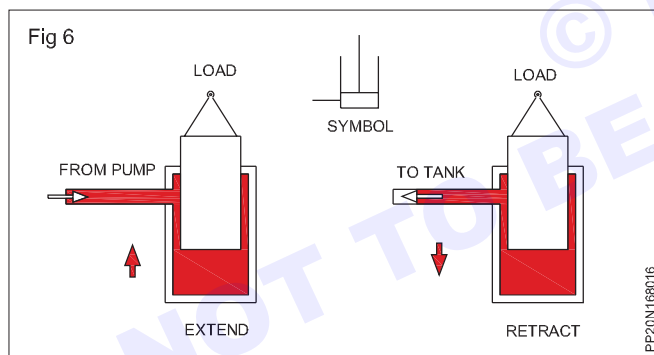
- Plunge type
- Piston type
- Ram type
- Telescopic type.

Double acting cylinders can be further classified into

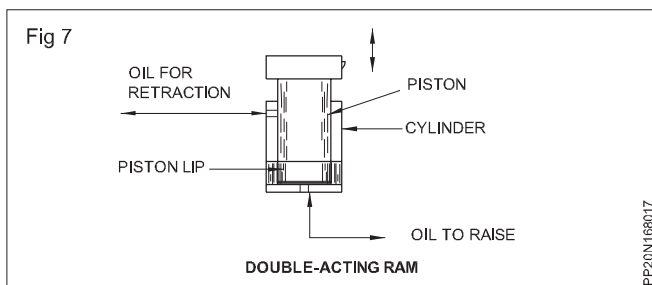
- Single piston rod type
- Double sided piston rod
- D.A. cylinder with end cushioning
- Telescopic type
- Pressure intensifier
- Tandem cylinder.

Ram

It is the simplest linear actuator as shown in Fig 6. It has only one chamber for oil. They are usually mounted vertical and ram descends down by its self weight. Rams are practically suitable for long strokes and used in elevators jacks and automobile.

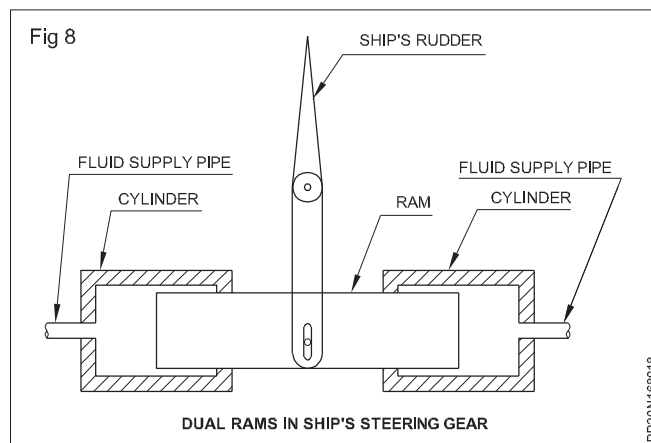


Since the diameter of the Ram is throughout and there is no piston rod, if the Ram has to descend down at a faster rate than gravity, oil has to be supplied to the top as in the case of a double acting cylinder. (Fig 7)



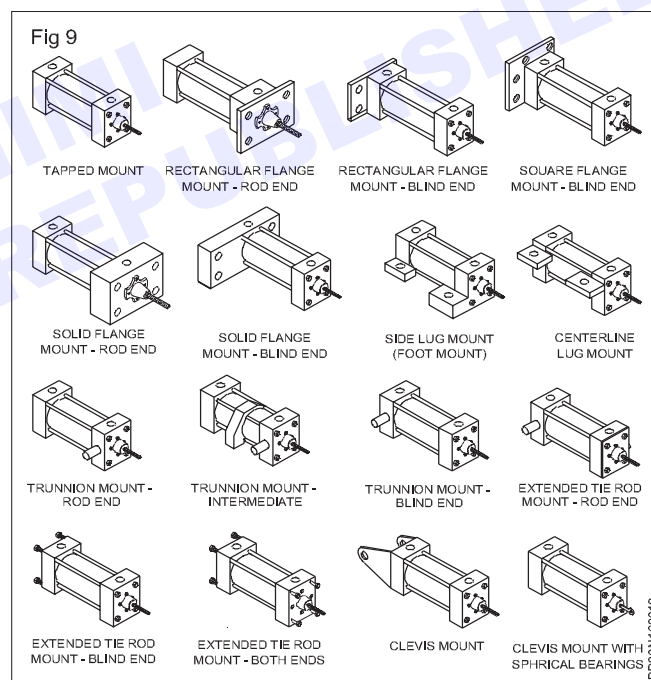
However, the diameter of the Ram can be reduced only to a little extent to have piston rod.

The application of a double sided or dual Ram in turning the rudder of a ship is shown in Fig 8.



Mountings of cylinders

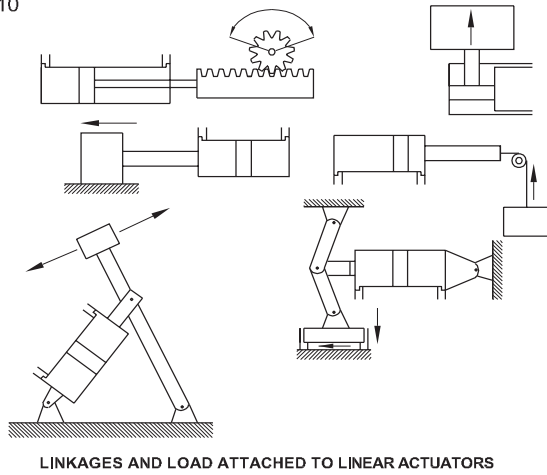
Cylinders are mounted on different points to have a desirable movement space limitations, severity of load, direction of actuation etc. Fig 9 shows the possible methods of mounting a hydraulic cylinder.



Actuation by linkages

Fig 10 shows the various methods of handling load, clamping, oscillation, lift, tilt and other kinds of applications of a cylinder along with mechanical linkages.

Fig 10



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Hydromotors (Rotary actuators)

Objectives: At the end of this lesson you shall be able to

- state the principle of working of hydromotor
- state various types of hydromotor
- state the specification of hydromotor
- calculate the efficiency of hydromotor
- name the parts of the hydromotor.

Hydromotor

This is a rotary actuator used in hydraulics, also called as hydraulic motors. This is very useful when a rotary motion is required. (The rotary action is achieved by this hydro motors) Similar to linear actuators, this also can be controlled in terms of displacement, direction of rotation, pressure or torque requirement. Nearly all elements used in linear circuits are used in rotary circuits also.

Cylinders provide linear motion where as hydro motors provide rotary motion.

Various types of hydromotors

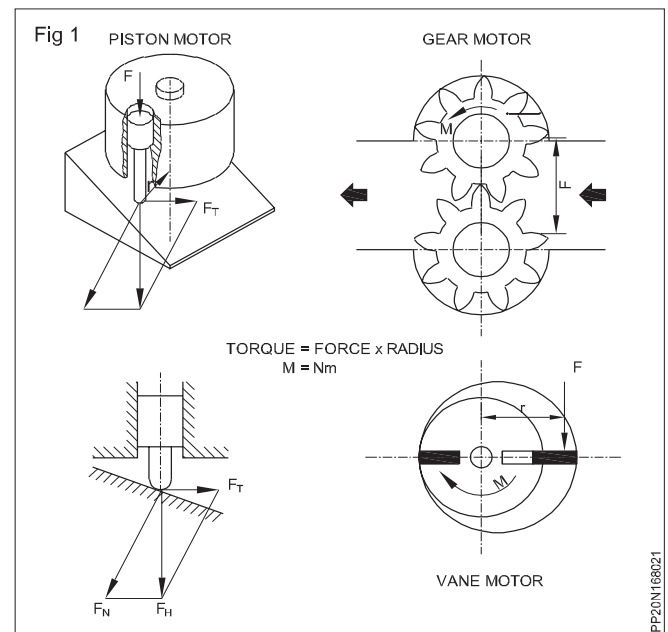
Hydromotors are classified according to their internal design. Hydromotors are of three types namely:

- Gear type
- Vane type
- Piston type.

All these types have the common principle of working. These almost resemble a hydraulic pump in construction.

Operation of hydraulic motor is opposite to that of hydraulic pump.

The principle of working is shown with a simple line sketch in Fig 1



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Direction control valve

Objectives: At the end of this lesson you shall be able to

- explain function of various direction control valves and non return valve
- interpreted direction control valve function in a hydraulic circuit
- define meaning of by - pass circuit.

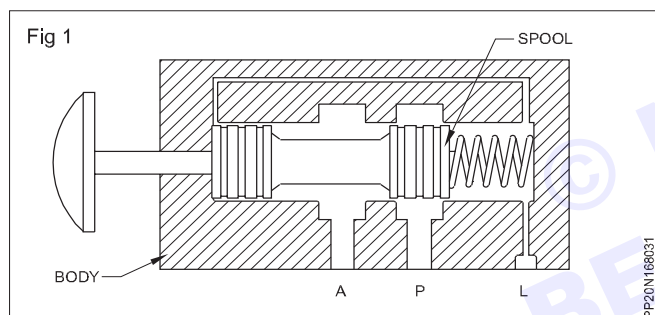
Direction control valve are components which change, open or close flow path in hydraulics system. They are used to control the direction of motion of hydraulic actuator as well as responsible to stop the motion of actuator.

Direction control valves are classified as following according to the number of ports and positions:-

- 2/2- Way valve
- 3/2- Way valve
- 4/2-Way valve
- 4/3-Way valve

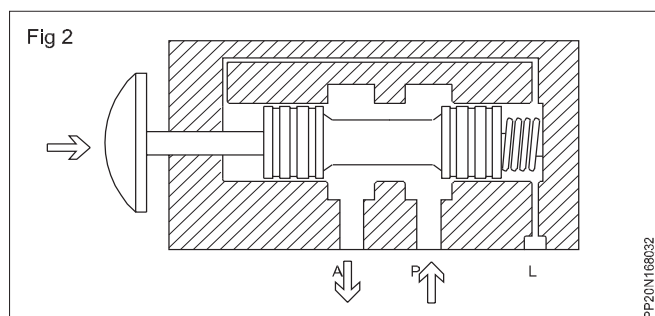
2/2 Way valve

The 2/2-way valve has a working port A, a supply port P and a leakage- oil port L. In the case of the valve shown here, of slide design, flow from P to A is closed in the normal position. (Fig 1)



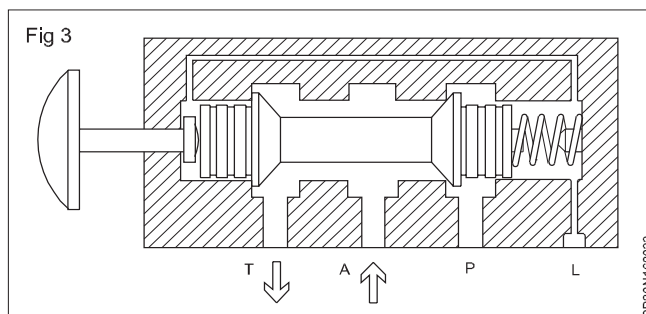
A relief line leading to the leakage - oil port is provided to prevent a build -up of pressure in the spring and piston chambers.

The 2/2-way valve is actuated and the passage from P to A is open. 2/2 -way valves are also available which are normally open from P to A. (Fig 2)

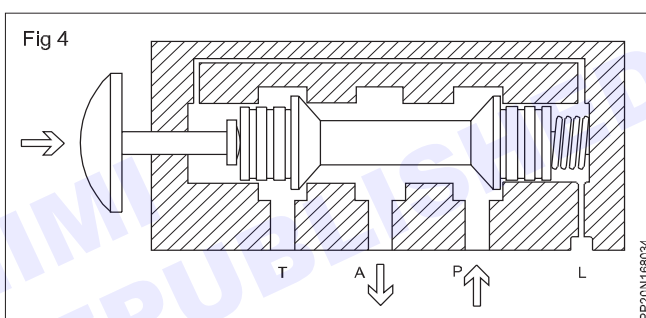


3/2-Way valve

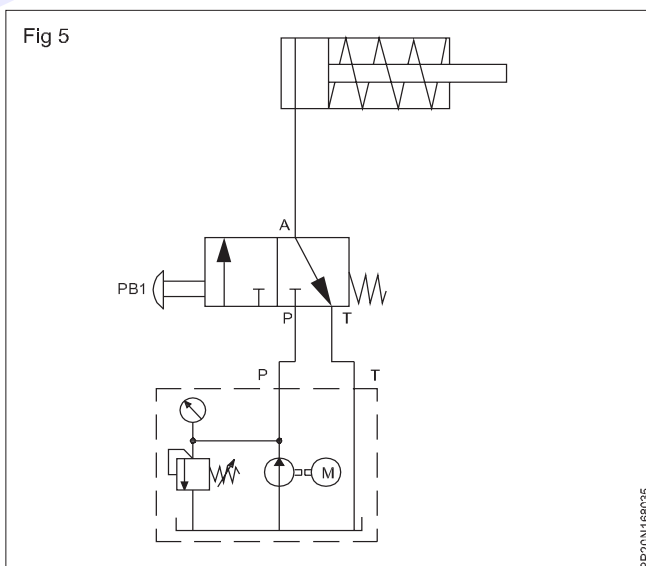
The 3/2-way valve has working port A, a supply port P and a tank port T. Volumetric flow can be routed from the supply port to the working port or from the working port to the tank port. The third port in each case is closed. In the normal position shown, P is closed and flow released from A to T. (Fig 3)



The 3/2-Way valve is actuated; flow is released from P to A, the outlet T is closed. 3/2-Way valves which are normally open from P to A and T closed are also available. (Fig 4)

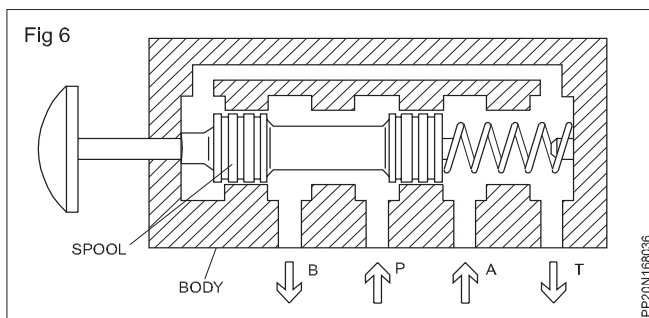


Example of 3/2 way circuit with single acting cylinder. (Fig 5)

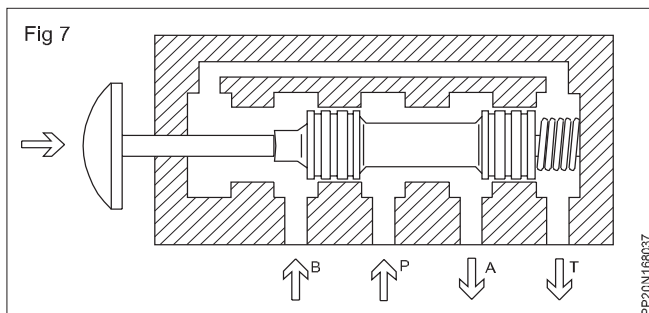


4/2 Way valve, two pistons

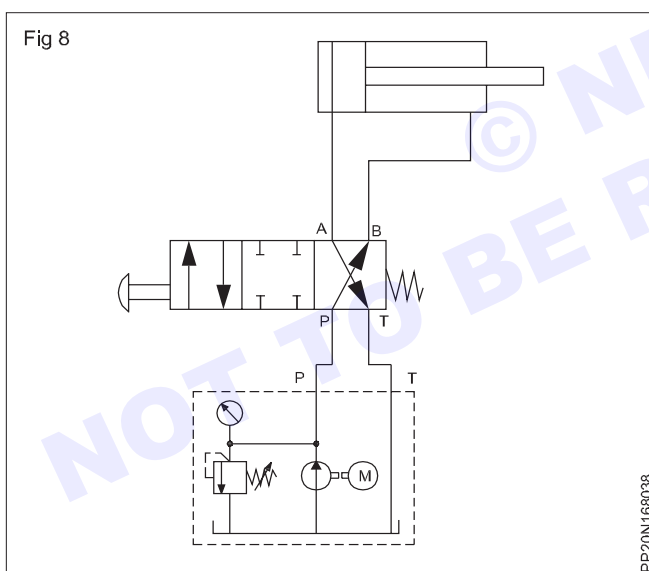
The 4/2-Way valve has two working ports A and B, a supply port P and a tank port T. The supply port is always connected to one of the working ports, while the second working port is routed to the tank. In the normal position, there is flow P to B and from A to T. (Fig 6)



The 4/2-Way valve is actuated, and there is flow from P to A and from B to T. 4/2-way valves are also available which are normally open from P to A and from B to T. (Fig 7)



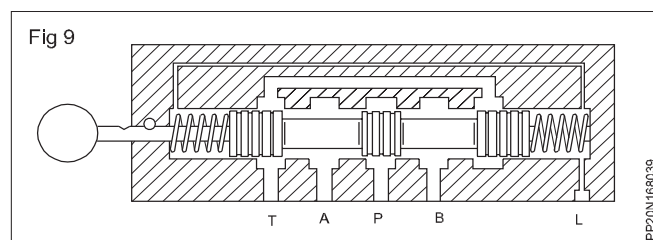
Example of 4/2 way circuit with double acting cylinder. (Fig 8)



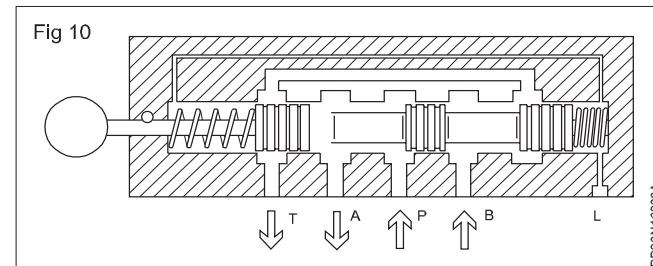
4/3- Way valve

From the logic point of view, 4/3-way valves are 4/2-way valves with an additional mid-position. There are various versions of this mid-position (in the mid-position in the example shown, the supply port P is directly connected to the tank T, see next illustration). In the switching position shown, there is flow from p to B and from A to T.

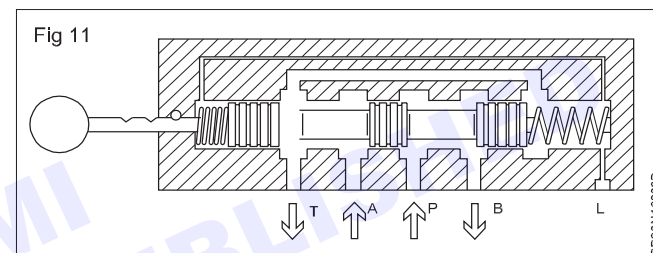
The 4/3-way valve is in its mid-position; there is flow from P to T, while A and B are closed. Since the output from the pump flows to the tank, this switching position is called pump bypass or also pump recirculation. In the case of pump bypass, the pump needs to operate only against the resistance of the valve, which has a favorable effect on the power balance. (Fig 9)



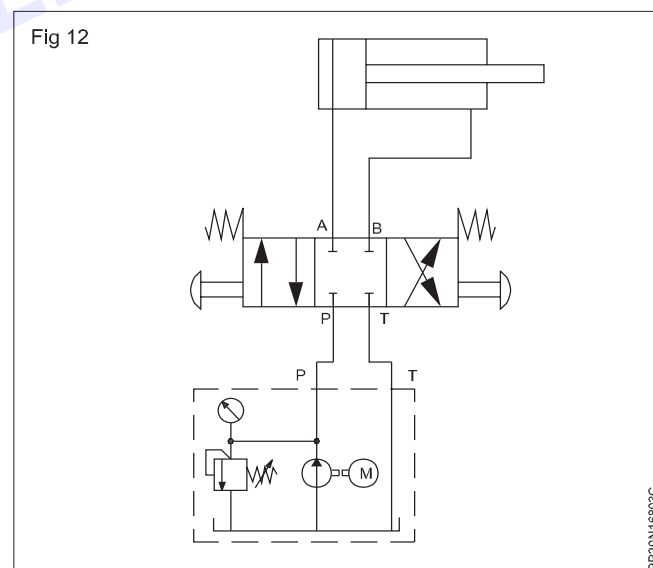
The valve is in its left-hand switching position; there is flow from P to A and from B to T. (Fig 10)



And the valve is in its right hand switching position there is flow from P to B and A to T. (Fig 11)



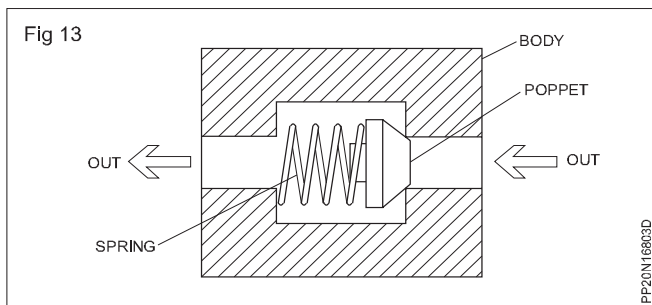
Example of 4/3 way circuit with double acting cylinder. (Fig 12)



Non-return valve

Non-return valves block flow in one direction and allow free flow in the other. In the direction of flow shown, the sealing element is pressed against a seat by a spring and the hydraulic fluid. (Fig 13)

A spring loaded Non-return valve is shown in Fig 13. If oil pressure is more on left side of NRV, poppet of valve will not open as well as it will not allow the flow of oil.



And when oil pressure is more on right side of valve then poppet of valve will move for opening and oil will flow through the valve. (Fig 14)

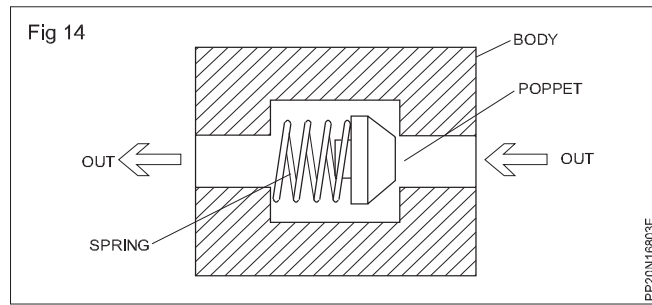
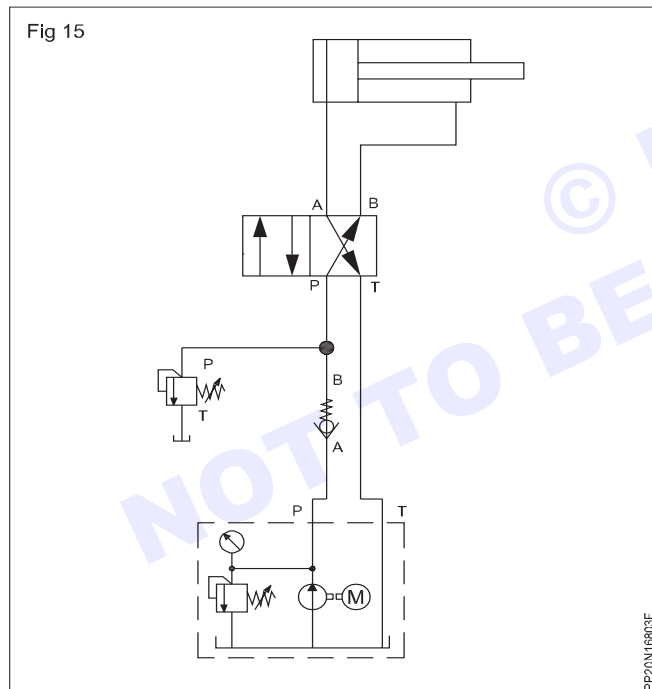


Fig 15 shows the application of non-return valve for pump protection. (Fig 15)



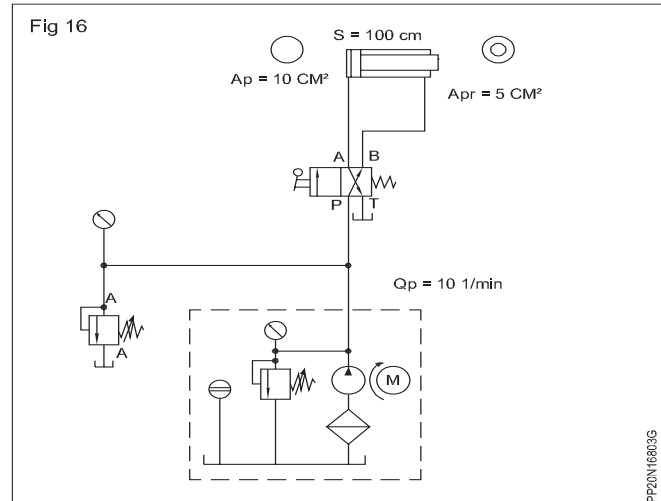
By- pass circuit

By-pass circuit is used to advance a cylinder rapidly than it could with pump flow alone. To achieve this, oil from the rod end of a cylinder is added to the pump flow to the blind end, increasing the rate of advance. Common applications of by-pass circuit are found in shearing and punching machines.

In general, differential cylinder is used in hydraulics machines. In this cylinder the area ratio of the full piston surface to the annular piston surface is 2:1, since as the result the piston rod area is only half the size of the piston area, the return stroke is twice as fast as the advance stroke.

In most of machines less advance speed is required, but in some machines high speed is required in forward stroke of piston like in shearing and punching machines.

For example the piston area A_p of the differential cylinder equal 10cm^2 , the annular piston surface $A_{PR} = 2\text{ cm}^2$. The mp delivers $Q_p = 101/\text{min}$. So that speed of piston in advance and return stroke is given below: (Fig 16)



Note: Regeneration circuits apply only to single rod cylinders in the extended direction.

Advance and Return speed

As we know from previous topics

$$V = Q/A$$

$$Q_{\text{pump}} = 101/\text{min} = 10,000\text{ cm}^3 / \text{min}$$

Advance speed

$$V_{\text{adv}} = 10,000\text{ cm}^3 / 10\text{ cm}^2\text{ min}$$

$$V_{\text{adv}} = 10,00\text{ cm/ min}$$

$$V_{\text{adv}} = 10\text{m /min}$$

Return speed

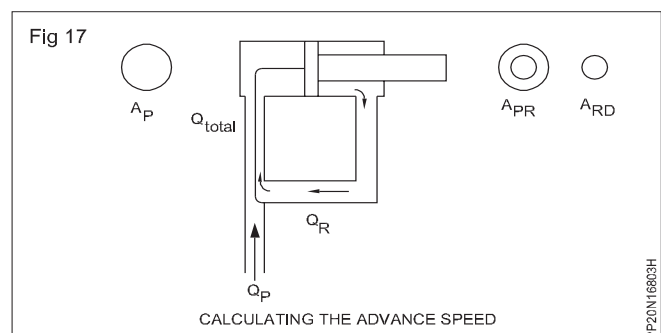
$$V_{\text{ret}} = 10,000\text{ cm}^3 / 2\text{ cm}^2\text{ min}$$

$$V_{\text{ret}} = 5000\text{ cm / min}$$

$$V_{\text{ret}} = 50\text{cm / min}$$

From this result it can be seen that the area ratio has a direct effect on speed and time.

For getting more forward speed in differential cylinder we can utilize the oil of rod side of cylinder into piston side, such (Fig 17) a circuit is known as regeneration circuit or bypass circuit.



Q_p = pump delivery

Q_R = return delivery from piston rod area

Q_{total} = Pump delivery + return delivery

It means oil which is going inside the piston end of cylinder is more than pump flow and more flow means more speed of actuator.

When the rod ends port is directly connected to the piston end port than during forward stroke of piston, rod end oil is recirculated and added on piston end of cylinder.

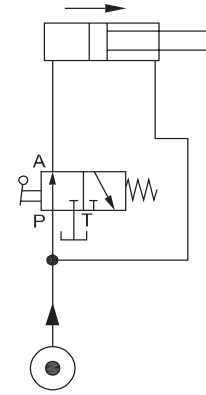
Below circuit is the example of a regeneration circuit along with 3/2 way valve. In normal condition (without actuation) oil is only going on the rod side of cylinder and from the piston end of cylinder oil is coming back into tank so that the piston remain in retracted position. (Fig 18)

In actuated condition of valve, A port and B port are connected to P port, means pump flow is added with flow of rod side.

$$Q_{total} = \text{Pump delivery} + \text{return delivery}$$

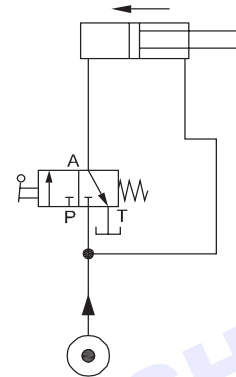
More flow is going inside the cylinder in actuated condition so that speed becomes very high (Fig 19)

Fig 18



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Fig 19



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Symbols for hydraulic components

Objectives: At the end of this lesson you shall be able to

- read and interpret the circuit symbol
- state the uses of symbol in hydraulic components.

In a hydraulic circuit symbols are used to represent individual component to impart representation of hydraulics system in diagrams. A symbol identifies a component and its function. These symbols are as per ISO 1219 standards.

Pump and motor

Hydraulic pump and motor are represented by means of a circle. Triangle within the circle represent the direction of flow and position of triangle differentiates between the symbol of pump or motor.

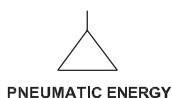
If triangle is filled darkened means it is meant for hydraulics fluid but if triangle is not filled means it is for gaseous pressure media or Pneumatic energy. (Figs 1 & 2)

Fig 1



PP20N168111

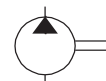
Fig 2



PP20N168112

Symbols of pump and motor (Figs 3 to 9)

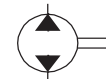
Fig 3



UNIDIRECTIONAL FIXED DISPLACEMENT PUMP

PP20N168113

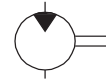
Fig 4



BIDIRECTIONAL FIXED DISPLACEMENT PUMP

PP20N168114

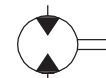
Fig 5



UNIDIRECTIONAL HYDRAULIC MOTOR

PP20N168115

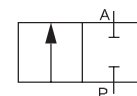
Fig 6



BIDIRECTIONAL HYDRAULIC MOTOR

PP20N168116

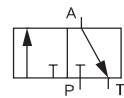
Fig 7



2/2-WAY VALVE

PP20N168117

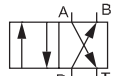
Fig 8



3/2-WAY VALVE

PP20N168118

Fig 9



4/2-WAY VALVE

PP20N168119

Direction control valve

Direction control valves are represented by several connected squares.

- The number of squares indicates the number of switching positions.
- Arrows in the squares indicate the direction of flow.
- Lines indicate how the ports are interconnected in the different switching position.

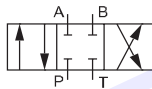
Port designation

P	Pressure port
T	Tank port
A	Service port (output port)
B	Service port (output port)
L	Leakage port

Symbols of Direction control valve (Figs 10 to 11)

Port should always be represented in the neutral position of valve.

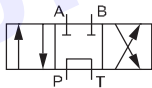
Fig 10



4/3-WAY CLOSE CENTRE VALVE

PP20N16811A

Fig 11



4/3-WAY OPEN CENTRE VALVE

PP20N16811B

The neutral position is a position which automatically come in valve due to spring force when no any command is available in valve, it is also the initial position unless otherwise actuated.

Actuating mechanism of Valve

The switching position of direction control valve can be changed by various actuation methods.

Different mechanisms of actuation of valve are shown in Fig 12 to Fig 19.

Mechanical actuation

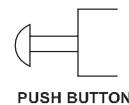
Fig 12



GENERAL MANUAL OPERATED

PP20N16811C

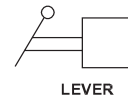
Fig 13



PUSH BUTTON

PP20N16811D

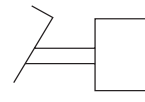
Fig 14



LEVER

PP20N16811E

Fig 15

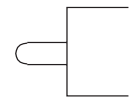


PEDAL

PP20N16811F

Manual actuation

Fig 16



PUSH PIN

PP20N16811G

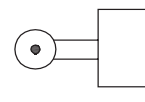
Fig 17



SPRING

PP20N16811H

Fig 18

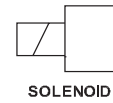


ROLLER

PP20N16811I

Electrical actuation

Fig 19



SOLENOID

PP20N16811J

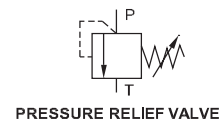
Pressure control valve

Pressure control valve are represented by a single squares. Arrow within the square indicate the direction of fluid flow.

The position of arrow within the square indicates whether the valve is normally open or normally closed.

Symbols of pressure control valve(Fig 20 to Fig 22)

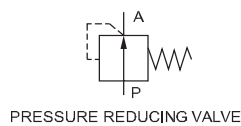
Fig 20



PRESSURE RELIEF VALVE

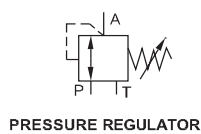
PP20N16811K

Fig 21



PP20N1681L

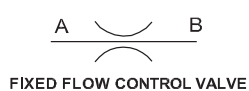
Fig 22



PP20N1681M

Flow control valve(Fig 23 to Fig 25)

Fig 23



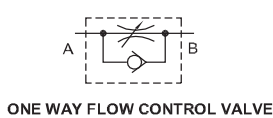
PP20N1681N

Fig 24



PP20N1681O

Fig 25



PP20N1681P

Non-return valves

The symbol of non-return valve is a ball which is pressed against a sealing seat. (Fig 26 to Fig 28)

Fig 26



PP20N1681Q

Fig 27



PP20N1681R

Fig 28

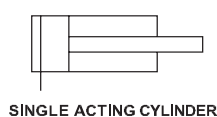


PP20N1681S

Cylinder

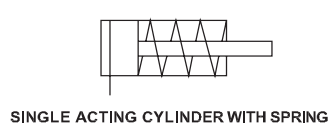
Single acting cylinders have one port and double acting cylinder have two ports.(Fig 29 to Fig 31)

Fig 29



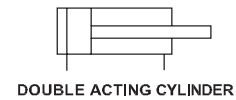
PP20N1681T

Fig 30



PP20N1681U

Fig 31



PP20N1681V

Measuring devices

Measuring devices are shown in the Fig 32 to Fig 36

Fig 32



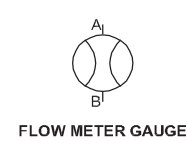
PP20N1681W

Fig 33



PP20N1681X

Fig 34



PP20N1681Y

Fig 35



PP20N1681Z

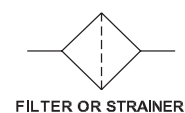
Fig 36



PP20N1681A1

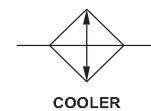
Other symbols(Fig 37 to Fig 39)

Fig 37



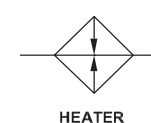
PP20N1681A2

Fig 38



PP20N1681A3

Fig 39



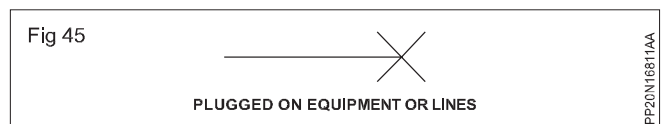
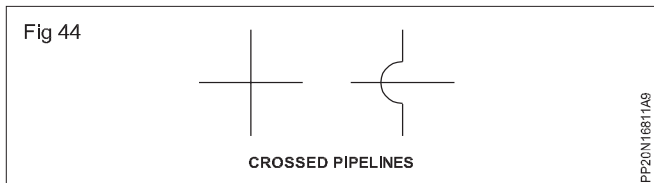
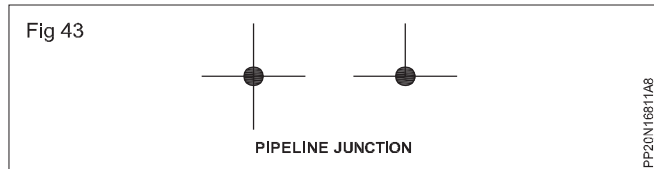
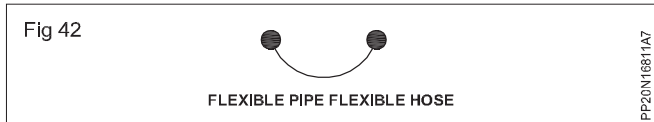
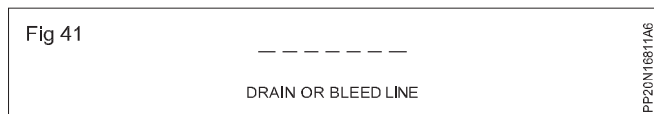
PP20N1681A4

Symbols using Line (Fig 40 to Fig 46)

Fig 40



PP20N1681A5

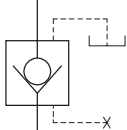
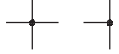


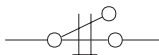
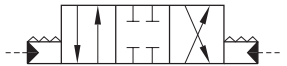
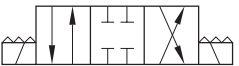
Hydraulic oil Functions and properties

The primary function of a hydraulic fluid is to convey power. In use, however, there are other important functions of hydraulic fluid such as protection of the hydraulic machine components. The table below lists the major functions of a hydraulic fluid and the properties of a fluid that affect its ability to perform that function:

Function	Property
Medium for power transfer and control	Non compressible (high bulk modulus) Fast air release Low foaming tendency Low volatility
Medium for heat transfer	Good thermal capacity and conductivity
Sealing Medium	Adequate viscosity and viscosity index hear stability
Lubricant	Viscosity for film maintenance Low temperature fluidity Thermal and oxidative stability Hydrolytic stability / water tolerance Cleanliness and filterability Demulsibility Antiwear characteristics Corrosion control
Pump efficiency	Proper viscosity to minimize internal leakage High viscosity index

SI.No	Symbols	Hydraulic & Electrical elements
1		Electric motor
2		Hydraulic pump (Fixed displacement)
3		Hydraulic pump (Variable displacement)
4		Double acting cylinder
5		Single acting cylinder

6		Filter
7		Cooler
8		Pressure Gauge
9		Shut off Valve
10		Pipe below fluid level
11		Pipe above fluid level
12		Non return valve
13		Flexible pipe
14		Drain line
15		Pilot line
16		Enclosure (One unit)
17		Restriction
18		Pilot operated check valve
19		Throttle - Valve
20		Pipe line junction
21		Pipe line cross over

22		Air bleed
23		Normally open contact
24		Normally closed contact
25		Limit switch open contact
26		Limit switch open contact
27		Push button open contact
28		Push button open contact
29		Rotary switch
30		Relay coil
31		Time delay relay
32		Indicating lamp
33		Solenoid
34		Fuse
35		D.C Valve Hydraulically operated
36		D.C Valve solenoid operated

37		D.C Valve Electric Hydraulic Operated
38		Contact manometer
39		Relief valve direct operated
40		Relief valve pilot operated
41		Brake valve
42		Pressure red valve direct operated
43		Pressure red valve pilot operated
44		Cartridge valve
45		Bie metal relay
46		Voltmeter
47		Ammeter
48		Thermocouple
49		Motor
50		Thermal relay contact
51		Transformer

Processing technique used for thermoset material

Objectives: At the end of this lesson you shall be able to

- preforming method of cold pressing a molding components into a pill or preform
- pre heating.

Know comparison molding process

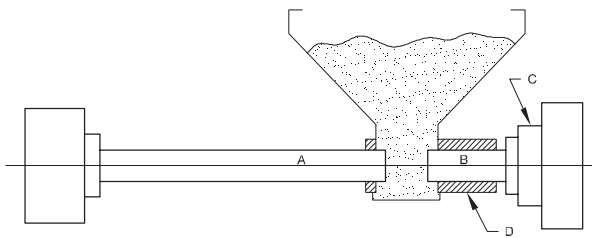
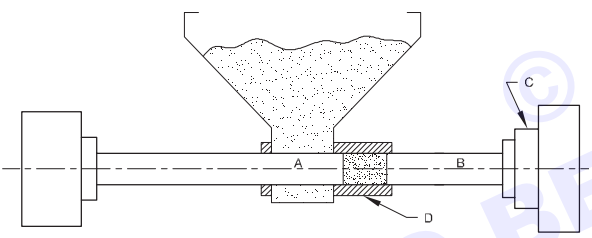
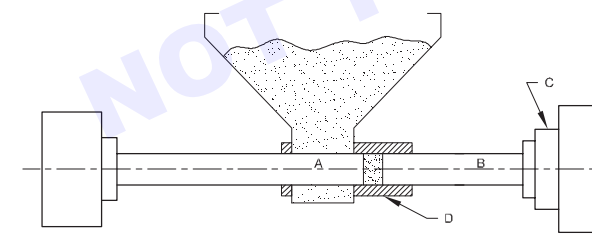
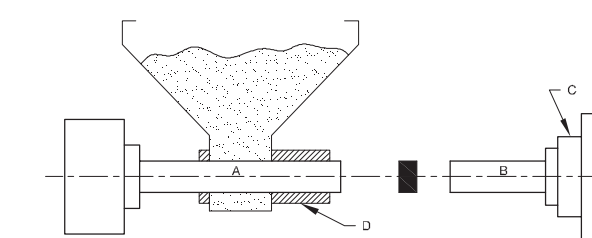
Preforming

Preforming is a method of 'cold' processing a molding compound into a pill or preform. It has a specific shape and precise weight. The perform provides as easy way

to handle the mold charge both for preheating and for charging the mold.

The preforms can be round, square or rectangular with the shapes they preferred, because they can easy to be placed in the preheated oven.

Pellettiser

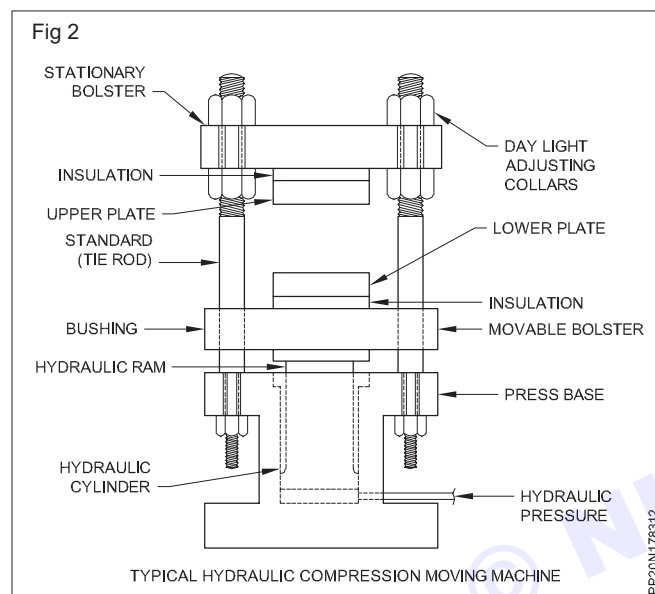
	In feed position the moulding powder ripples form the hopper between stationary plunger (a) the movable plunger (b).
	By a shifting of the hopper a certain amount of moulding material is brought into a cylindrical mould which is connected to the hopper.
	The moveable plunger is moved by a hydraulic ram c against the stationary plunger and the tablet is formed.
	Hopper and cavity are moved on by the stationary plunger. The moveable plunger is drawn back. The tablet falls out.

Pre heating

Pre heating is often used to reduce the molding cycle. It can aid in providing even heat throughout the material and can cause a more rapid rise in heat than occurs in the mold.

Preheating may be accomplished by a warm surface plate infrared lamps, a hot air oven a screw / barrel pre heater. But the best and quickest method is high frequency heating. Pre heating is usually carried out at 66 C – 150 followed by quick transfer to a mold cavity.

The actual heat depends on the material the heater capacity and the speed of transfer. (Fig 2 & 3)



- To reduce curing time
- To reduce cycle time
- To increase dimensional stability
- To increase strength
- To reduce in thermal stresses

Introducing about compression moulding process

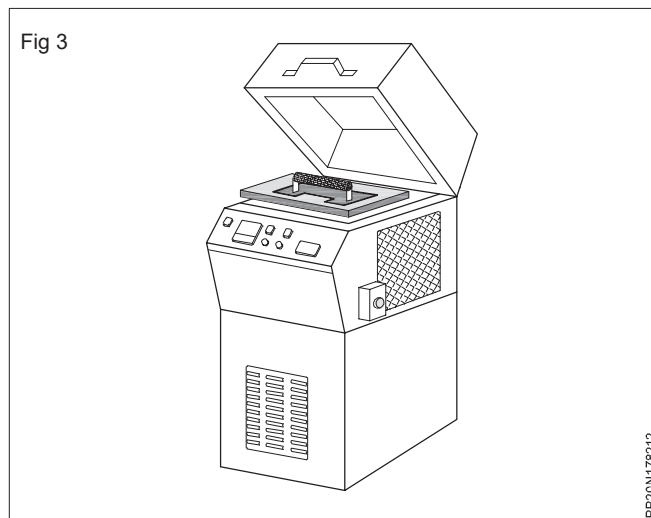
Objectives: At the end of this lesson you shall be able to

- state and explain the functions of various parts components of a compression moulding machine (press)
- define moulding machinery.

Introduction: Compression moulding is the oldest method of mass production in the plastic industry. It is used for mass production of intricate and accurate parts at relatively low cost. Thermosetting resin-compounded material is used very much in the compression moulding technique. The press machine must be sturdily designed and constructed to perform the process with the minimum of maintenance. It must also be accurate to align the tool. Four pillars are usually incorporated to give rigidity and to act as guides for the moving press head.

The compression moulding method requires a mould which is heated between 123°C and 160°C. Moulding material is placed between the two halves of the mould

Fig 3



- To improve surface finish
- To reduce molding pressure
- To improve flow.

1 Compression Moulding Process

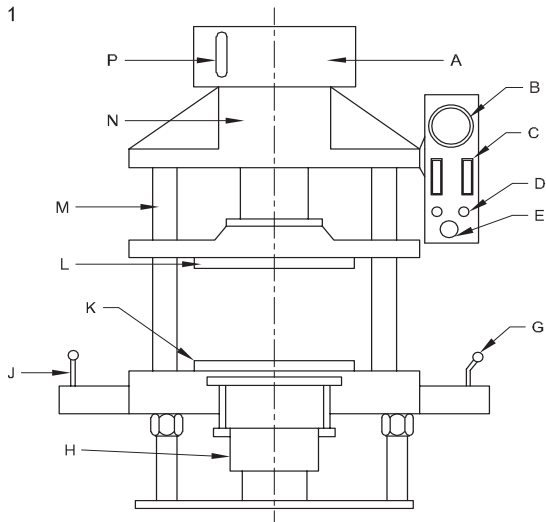
The principle of the compression molding process can be outlined follows.

- A prepared quantity of molding compound is placed inside the mold. Usually by hand the mold placed in the press.
- The mold is held between the heated platens of hydraulic press.
- The press closes with sufficient pressure to prevent or minimize the flash at the mold parting line.
- The compound softens and flows to shape, the chemical curing reaction takes place as the internal mold temperature becomes high enough.
- The press is opened and the molding is removed from the mold.
- The mold is reloaded with a fresh charge material before closing the press to commence another cycle.

which are then closed together by mechanical or hydraulic means. A pressure of 200 to 600 Kg/cm² is applied and under the action of both heat and pressure, the moulding material becomes plasticised, fills the mould, to the shape of the mould cavity and is allowed to cure.

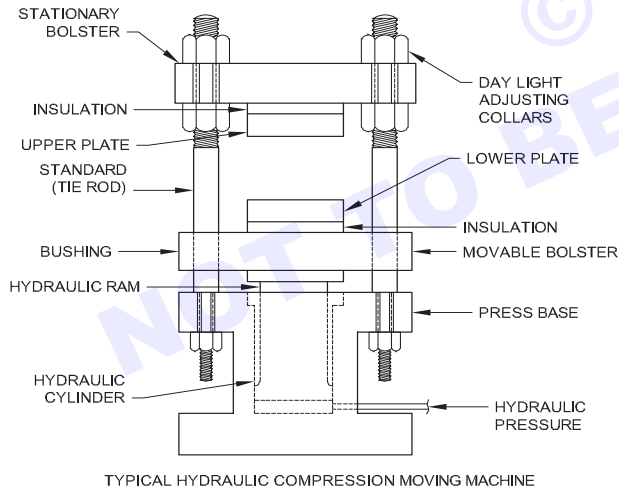
Compression moulding machinery: The compression moulding presses are available either as simplest hand-operated toggle lever press (See Fig 1) or conventional hydraulically operated press with an independent hydraulically controlled ejection system. Two main types of press are available as follows

Fig 1



Down stroking Press: The most widely used type in the down stroking press (See Fig 2) where the platen making use of an overhead hydraulic cylinder, uses the downward stroke of the ram to move the platen and this exert moulding pressure into the stationary section or bottom platen Down stroke press is generally used for bigger and deeper components. The up stroking press is similar in operation except that the hydraulic cylinder is mounted beneath the bottom platen and moves its platen towards lived top Upstroke press is used generally for smaller components but not suitable for large parts.

Fig 2



TYPICAL HYDRAULIC COMPRESSION MOVING MACHINE

Hydraulically operated semi-automatic Press: Semi-automatic machine means where all the operation will be done automatically by the initiation of press buttons except loading of proform, unloading of moulding and cleaning of moulds etc.

In this type of press (See Fig 2) it is necessary to employ any operator to feed power or preformed pellets, to individual cavities into moulds which are firmly clamped to the press platens. Then the operator will initiate the moulding cycle by operating press buttons and remove the cured moulding at the end of the cycle. It is necessary to clean out any residued flash from the mould and charge the cavities with powder or preform (tablet) and initiate a new moulding cycle by pressing the press buttons. During the moulding cycle all subsidiary sequences such as slow-closing procedure, dwelling, breathing of the mould to allow escape the gases, timing of total cure and initiation of press opening etc. are fully automatic functions controlled by the presetting of timers, limit switches, hydraulic valves etc.

Modern pre-heating systems are of radio frequency or high frequency which is the fastest method of pre-heating (see Fig 4). In this method preforms are usually placed in a non-metallic paper or plastic tray which is positioned between two flat plate electrodes in the pre-heater. By action of the radio frequency current (27 80 megahertz) the preforms can be brought to a temperature of about 100°C 120°C in 5 and 10 seconds time. In this way, the preforms are heated from the inside out, so that maximum removal of volatiles takes place.

Specification of compression press: Generally compression press is rated according to the No. of tonnes of clamp: pressure it can exert by means of hydraulic or hydro mechanical pressure.

Press capacity in tones (F) = (P) Hydraulic line pressure(Kg/cm³) x (A) ram area m (cm²)

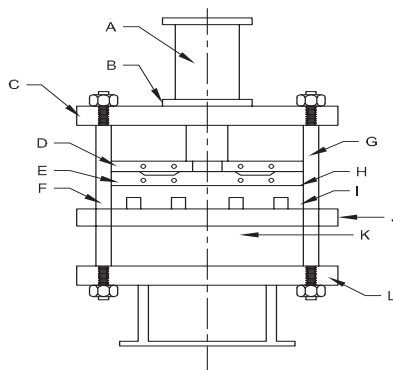
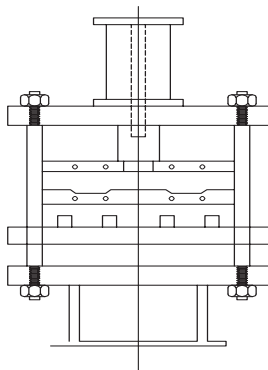
The required compression force or load can be calculated from the total projected area of the mould cavities multiplied by the required minimum pressure for a particular material.

Compression Pressure (tonnes) Moulding pressure kg/cm² x Projected area (cm³).

$$\text{So, Moulding Pressure(kg/cm}^2\text{)} = \frac{\text{Press pressure (tonnes)}}{\text{Projected area (cm}^2\text{)}}$$

Technical specifications of press: The technical specification of press is designed by the following parameters (Fig 3)

Fig 3



- A - TRANSFER CYLINDER
- B - PLUNGER
- C - TOP PLATEN
- D - PLUNGER RETAINER
- E - POT
- F - COLUMN
- G - CAVITY RETAINER
- H - MOLDED PART
- I - SPACER
- J - BOTTOM PLATEN
- K - CLAMPING PLUNGER
- L - CROSS HEAD

- Press tonnage in tons
- Piston stroke (Travel) in mm.
- Daylight of the press (maximum) in mm
- Daylight of the press (minimum) in mm.
- Platen size in length (mm) x width (mm).
- Clamp speed opening/closing in cms/min. or mm/sec.

Automatic Compression Molding: In fully automatic compression molding, the molding compound is metered and fed from a hopper or preform dispenser into one or more cups on a movable frame. The frame is then positioned automatically under a heating source, often an infrared heating lamp, to preheat the molding compound before dropping the charges into each cavity. Following the preheating, the frame transports the pre-heated charges directly over the bottom mold half, opens the bottom of the frame under the cup, and allows the preheated plastic to drop from each cup into its respective cavity. The frame then returns to its position below the hopper in preparation for the next cycle. The molding cycle proceeds through press close, breathe if necessary, material cure, and ejection, following which a "comb" or robot will enter the space between the open mold halves, remove the molded part or parts, and transport the parts to a container or conveyor belt. The next cycle is then initiated automatically.

4 Materials used in compression moulding: The materials that are used in the compression molding technique are the thermosetting resins.

The following are the main thermosetting categories

- Phenol – formaldehyde resins
- Urea – formaldehyde resins
- Melamine – formaldehyde resins
- Epoxy resins
- Silicones
- Di – ally phthalate and other allyols
- Unsaturated polyester.

5 Types of compression molds

There are three basic compression mold designs are available, they are

There are three basic compression mold designs are available, they are

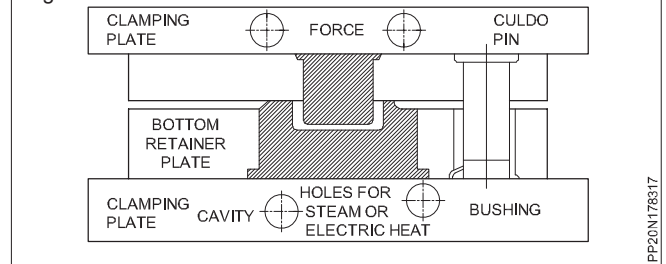
- Open flash type (Horizontal (lash type)
- Positive type (Vertical flash type)
- Semi positive type (Horizontal and vertical flash)

I Open flash type (Fig 4)

Open flash type is the simplest of all the thermos set molds and is still widely used in the production of simple shapes such as

- Dinner ware
- Ash trays

Fig 4



3 Closures

4 Knobs etc

In this type, the upper mold is allowed to enter the cavity in the lower half with a loose fitting and form a land to restrict the molding powder. The powder flows in the cavity due to applied pressure and temperature.

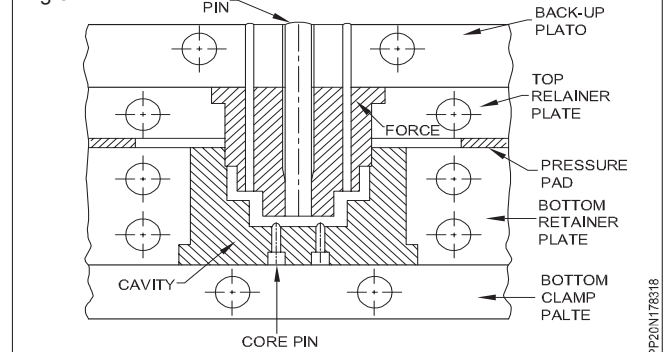
The cavity and core should be built with good steel through hardened to resist the compression load on the cut off lands of the cavity. Both unit are highly polished and hard chrome plated for easy mold release and superior surface finish.

This type of mold is very suitable for the production of article where

- Variation in wall thickness
- Eccentricity is permissible
- The material is not fully fabric
- The displacement of the mold cavity sufficiently large to contain required material in mold.
- The corner is square on the outer edge of the molding.

Positive type: (Fully positive type) (vertical flash type): The core in the upper mold half is allowed to enter the cavity in the lower half with a tight fit between the two components, providing direct and positive pressure on the compound in the mold cavity. (Fig 5)

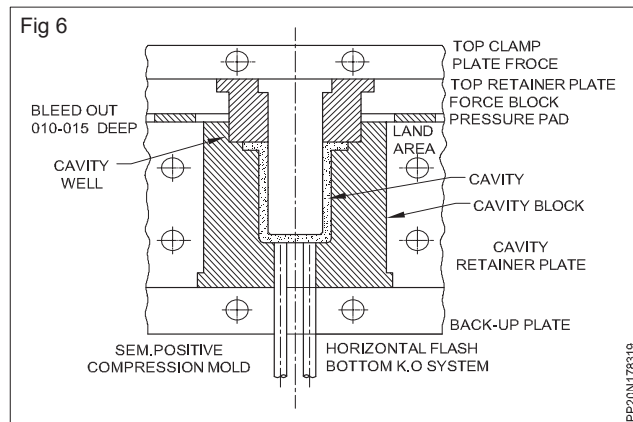
Fig 5



The mold charge should be excess of the part weight and the excess compound will be allowed to escape in a vertical direction as vertical flash. This vertical flash can be easily removed by manually pressing the upper face of the part, against an abrasive surface. So it will not affect the aesthetic appearance of the product.

iii semi positive type: This type takes an advantages of both positive and semi positive type. It resembles mold except that the positive mold except that the force actually “ lands” within the cavity wall.

It produces a horizontal as well as vertical flash. The effect of landing the force provides a better control of the flash thickness as well as the part dimensions that are determined from the parting line of the mold. (Fig 6)



The semi positive molds are designed for the following purposes.

- 1 To provide a powder cavity for bulky plastic material
- 2 To provide a powder cavity of bulky component in any material
- 3 To provide a way for flash escaping.

1 Compression moulding

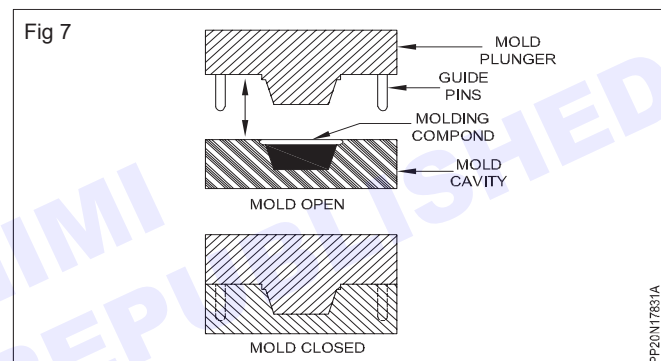
In the compression molding process the plastic material is placed in the mold cavity by the operator. When mold is closed, plastic material is compressed to mold shape and held in this from until it hardness.

The molds used for compression molding consist of a cavity and a force (or) plunger guide pins maintain the proper alignment between the cavity and force. The molding compound (or) plastic material is generally loaded in 0 the mold cavity. The mold plunger compress the compound.

When the mold is closed the mold cavity forms one surface of the molded part and the mold plunger forms and other surface of the molded part while it hardness between the plunger and cavity.

Provision for heating is often included in the mold design some presses are quipped with heating platens which transfer the heat to the molds.

Knockout (or) ejector pins are often used to push the piece away from the cavity (or) plunger. (Fig 7)



Hand compression moulding machine parts and function

Objective: At the end of this lesson you shall be able to

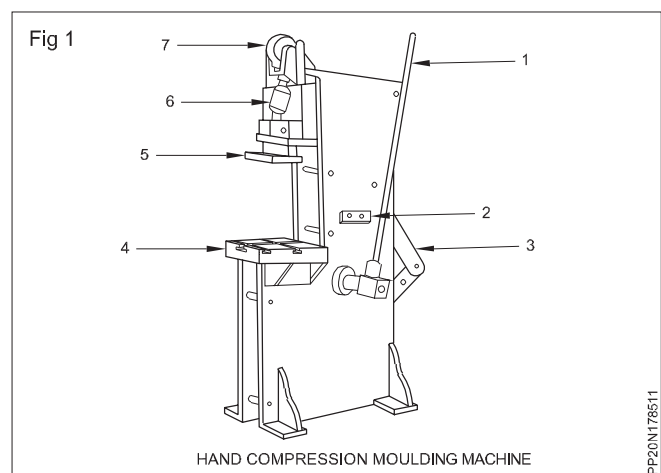
- define the parts of the machine and function.

Hand compression moulding machine

- 1 Handle for closing and opening mould
- 2 Temperature regulator
- 3 Toggle locking (closing the mould with pressure)
- 4 Fixed platen (Clamp the cavity mould)
- 5 Movable platen (clamp the core mould)
- 6 Height adjustment component (day light purpose)
- 7 Lever (clamping force)

Hand toggle lever press

This has easy operated and maintenance free machine. Using this machine small components can be produced and also many electrical component (e.g) switch, ceiling rose etc, produced. In this machine situated toggle locking mechanism, top platen height adjustment component, temperature regulator (Fig 1)

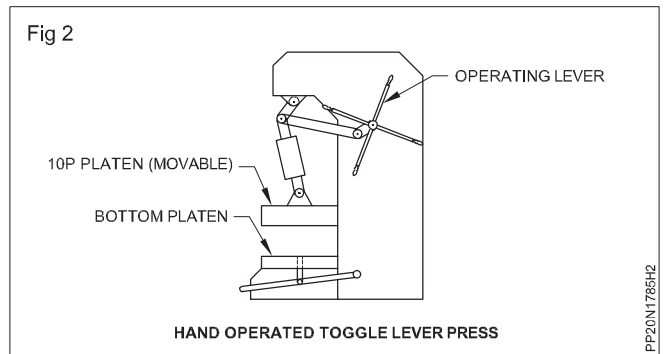


Working principle

When toggle lever is pressed downwards top movable platen moves downward and close the moulded components when the lever is released top platen moves upward and open the mould, takes the component from the machine.

Toggle clamping (Fig 2)

This machine consists of a rotating lever instead of a toggle lever. When the handle is rotated anticlockwise, the top platen moves downward and is seated with the bottom platen between the mould components. The handle is rotated clockwise, the top platen moves upward and the mould opens. The toggle platen in a horizontal position represents the mould closing position, and in a 'V' position, the mould is in the open position.

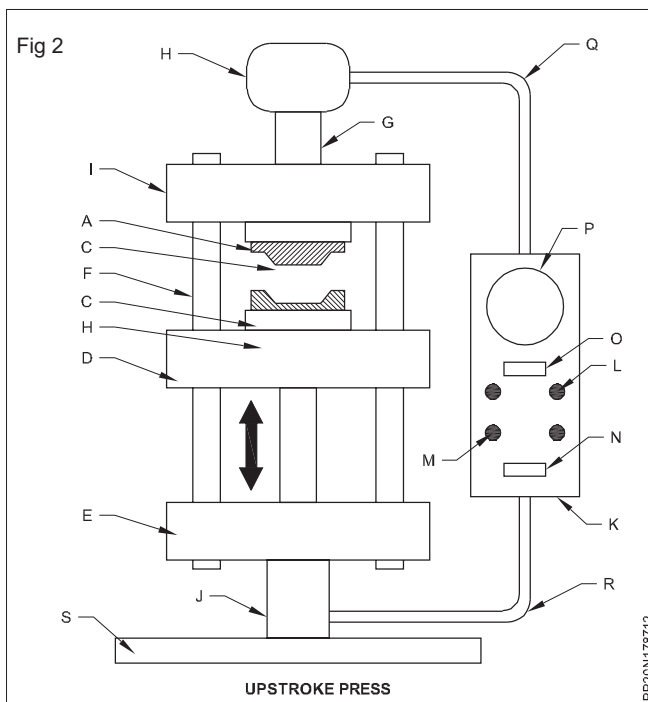


Defects, causes and remedies

Objective: At the end of this lesson you shall be able to

- detect the production of Compression mould
- detect the defects
- find the causes, remedies.

Defects	Causes	Remedies
1 Air bubbles	1 Less cure time 2 Less breathing time 3 High mould temperature	1 Increase cure time 2 Increase breathing time 3 Power mould temperature
2 Dull surface	1 High or low mould temperature 2 Dull mould surface 3 Rapid mould closing	1 Adjust mould temperature 2 Polish or chromeplate mould 3 Close mould more slowly
3 Mould sticking	1 Low mould temperature 2 May be due to presence of moisture 3 Uncleared mould surface	1 Rise mould temperature 2 Pre-heat to eliminate moisture 3 Clear mould surface
4 Porosity	1 Less pressure 2 High mould temperature 3 Unpreheated material used	1 Increase pressure 2 Low mould temperature 3 Preheat material
5 Brittleness	1 Less wall thickness 2 Malfunctioning of knockout pin 3 Brittle material	1 Increase wall thickness 2 Check knockout pins 3 Use more flexible material



Down stroke and up - stroke Parts name

- A - Mould platen
- B - Mould platen
- C - Mould
- D - Top platen
- E - Bottom platen
- J - Hydraulic ram
- S - Bottom portion
- F - Guide pillar
- I - Fixed plate
- H - Hydraulic reservoir
- Q - Hydraulic pipe
- G - Reservoir pipe
- P - Pressure gauge
- O, N - Indicator lamp
- L, M - Operating switches
- K - Panel board
- R - Supply pipe

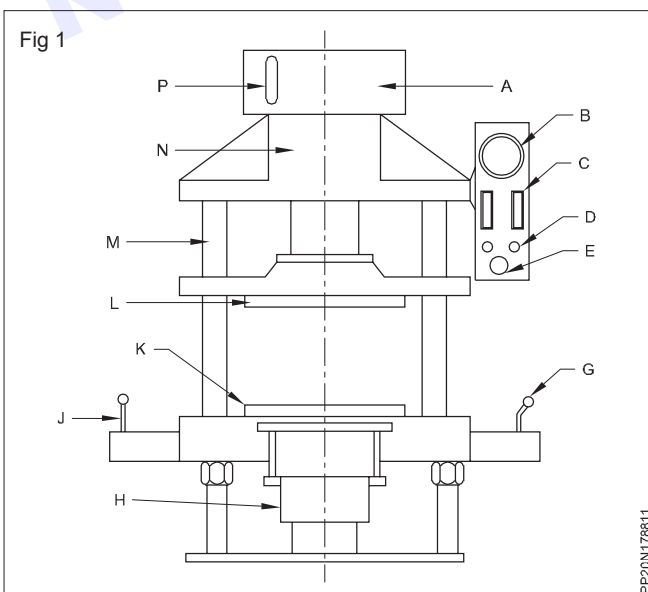
Semi - auto compression moulding machine parts and function

Objective: At the end of this lesson you shall be able to

- explain about the parts and function of the machine.

Down stroking press

The most widely used type is the down stroking press (Fig 1) Where the top platen making use of an overhead hydraulic cylinder, uses the downward stroke of the ram to move the platen and thus exert molding pressure into the stationery section or bottom platen. Down stroke press is generally used for bigger is generally used for bigger and deeper components. The up stroking press is similar in operation except that the hydraulic cylinder is mounted beneath the bottom platen and moves its platen towards fixed top. Upstroke press is used generally for smaller components but not suitable for large parts.



Parts

- A Hydraulic reservoir
The top platen making of an overhead hydraulic cylinder
- B Pressure indicator
It shows main ram pressure
- C Temperature indicator
To shows the top and bottom platen temperature and controls
- D Push buttons
To Start and stop the running machine
- E Stop button
Emergency stop button.
- F Moving head
- G Control lever
Main ram control
- H Hydraulic ram
For operating ejection mechanism
- J Ejection lever
To control ejection.
- K Bottom platen
Heated platen carried on a fixed head
- L Top platen
Heated platen carried on a moving head
- M Pillar
machine pillar
- N Main ram
- P Oil level indicator

Heating system used for mould

Objective: At the end of this lesson you shall be able to

- describe the uses of heating system in compression moulding.

Heating system used for mould

The heating system used for molds is a crucial component in various manufacturing processes, especially in industries like plastic injection molding and die casting. The heating system is responsible for maintaining the required temperature of the mold to ensure proper material flow, solidification, and demolding. Here are common types of heating systems used for molds

Types of Heating Systems for Molds

Hot Runner Systems: Description: Hot runner systems are an advanced and widely used method for heating molds. They consist of a series of heated channels or nozzles that directly inject molten material into the mold cavity.

Advantages

Eliminates the need for runners and sprues, reducing material wastage.

Enables precise control over temperature, improving part quality.

Ideal for complex and intricate mold designs

Electric Heating

Description: Electric heating involves the use of electric heaters or heating elements installed with the mold. These heaters generate heat, which is transferred to the mold surface.

Advantages

Precise temperature control.

Quick and efficient heating.

Suitable for various mold sizes and shapes.

Steam Heating

Description: Steam heating utilizes steam as a heating medium to maintain mold temperature. Steam is circulated through channels or jackets in the mold.

Advantages

Uniform heating across the mold surface

Energy-efficient

Suitable for large molds.

Oil Heating

Description: Oil heating systems involve circulating heated oil through the mold's channels or jackets. The oil transfers heat to the mold surface.

Advantages

Excellent heat transfer properties.

Stable and uniform temperature distribution

Suitable for high temperature applications

Water Cooling and Electric Heating Combo:

Description: Some molds use a combination of water cooling and electric heating elements. Water is used for cooling, while electric heaters maintain the desired temperature.

Advantages

Precise temperature control.

Balanced heating and cooling

Considerations for Mold Heating Systems

Temperature Control

Precise temperature control is essential for achieving consistent part quality. Modern heating systems often incorporate advanced temperature control mechanisms.

Energy Efficiency

Energy-efficient heating systems are desirable to minimize operational costs. Efficient insulation and control systems contribute to energy savings

Uniform Heating

Uniform heating across the mold surface helps prevent inconsistencies in material flow and solidification, leading to high-quality finished products.

Different types of compression mould

Objective: At the end of this lesson you shall be able to

- explain different types of compression mould.

Different types of compression mould

Compression molding is a manufacturing process that involves molding a material, typically a composite or polymer, by applying heat and pressure. There are various types of compression molds designed to accommodate different materials and shapes. Here are some common types of compression molds:

Open-Ring Moulds

Description: Open-ring molds are simple molds that consist of two flat plates, one stationary and one movable, with a cavity in between. The material is placed in the cavity, and pressure is applied to compress and shape the material.

Applications: Suitable for simple shapes and low-volume production.

Closed-Ring Moulds

Description: Closed-ring molds, also known as closed-loop molds, are similar to open-ring molds but with a circular or closed shape. They provide more control over material distribution and are often used for more intricate parts.

Applications: Commonly used in the production of complex composite parts.

Trunnion Moulds

Description: Trunnion molds have a unique design with a central pivot or trunnion that allows the mold to rotate. This rotation facilitates uniform material distribution and is especially useful for large and complex parts.

Applications: Ideal for molding large, asymmetrical components.

Transfer Moulds

Description: Transfer molds have a mechanism for transferring the material from a loading chamber to the mold cavity. This type of mold is efficient for handling multiple cavities simultaneously.

Applications: Suitable for high-volume production of small to medium-sized parts.

Matched Metal Moulds

Description: Matched metal molds, also known as matched die molds, consist of two or more matching metal plates that close together to form the mold cavity. This design allows for precise control of part dimensions.

Applications: Commonly used in the production of high-precision parts.

Composite Moulds

Description: Composite molds are designed for molding composite materials, which typically consist of a resin matrix and reinforcing fibers. These molds are built to withstand the unique challenges posed by composite molding processes.

Applications: Widely used in the aerospace, automotive, and sporting goods industries.

Polymer Moulds

Description: Polymer molds are made from polymer materials and are suitable for molding thermoplastics or elastomers. They are known for their cost-effectiveness and ease of fabrication.

Applications: Used in various industries for molding plastic components.

Compression mould design

Compression and transfer molding processes are mainly used for the manufacturer of thermosetting plastics products such as electrical switches, cooker handles, miniature circuit breakers, ceiling roses, switch gears.

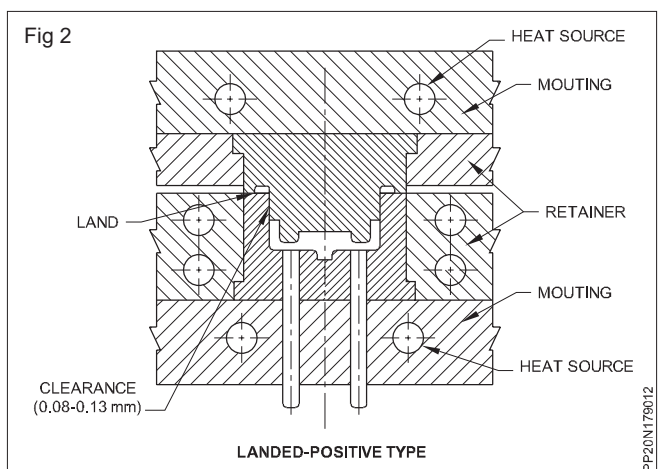
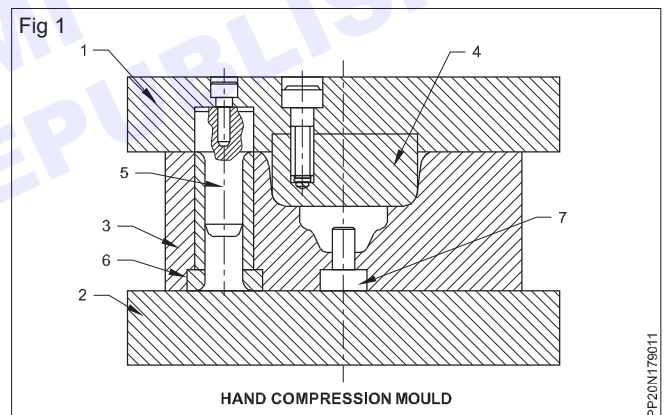
Switch boxes and also various consumer oriented products. To some extent this process is also used for thermoplastics components which are otherwise not possible to produce by other conventional processing methods due to processing limitations. Example includes PTFE liners, Gears & Washers, UHMWPE products etc. Several technological advancements have taken place in this area which are mainly aimed at improving the quality of the product and enhancing the production rate.

Robotics and process automation with microprocessor based control systems have revolutionized the entire compression & transfer molding line and specially designed thermoset injection molding process.

In quality of products largely depends upon the machine and the mold. In this context, the requirement for precision mold cannot be less emphasized.

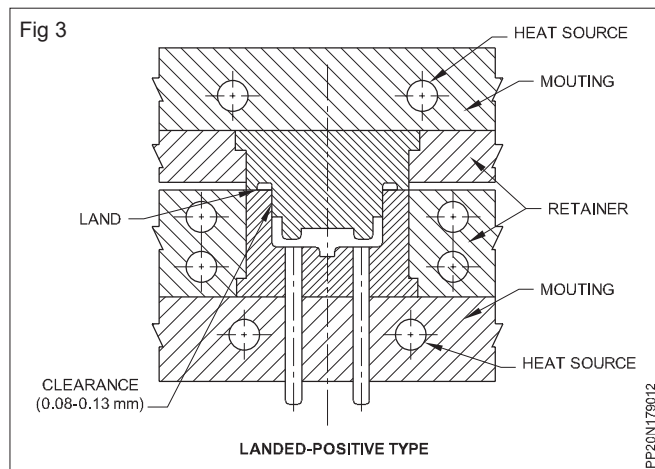
Compression Mould design

In general, compression and transfer molds are made of high carbon and high chromium or tool die steel. The core & cavity should be heat treated to the required hardness for maintaining the dimensional accuracy of product and also the life of the mold. There are different types of compression molds in use. The Figs. 1, 2, 3, 4, 5 & 6 illustrate the various types of compression molds.

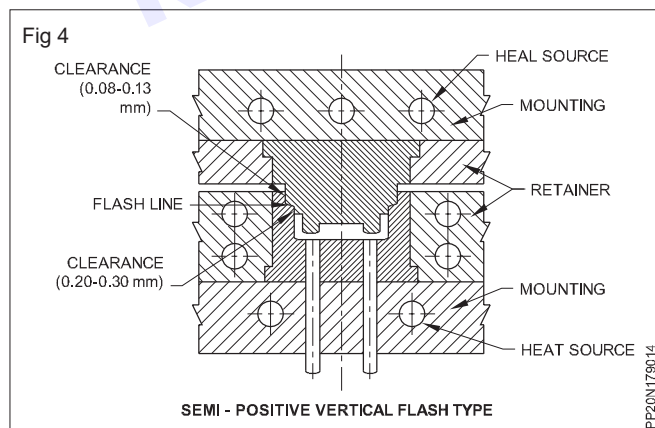


- 1 Top force ret, plate
- 2 Bottom force plate
- 3 Bottom force

- 4 Top force
- 5 Guide pillar
- 6 Guide bush
- 7 Bottom force insert
- 8 Smaller in size and weight not more than 12 kg for easy handling.
- 9 Production is limited to small parts, short runs or prototype work.

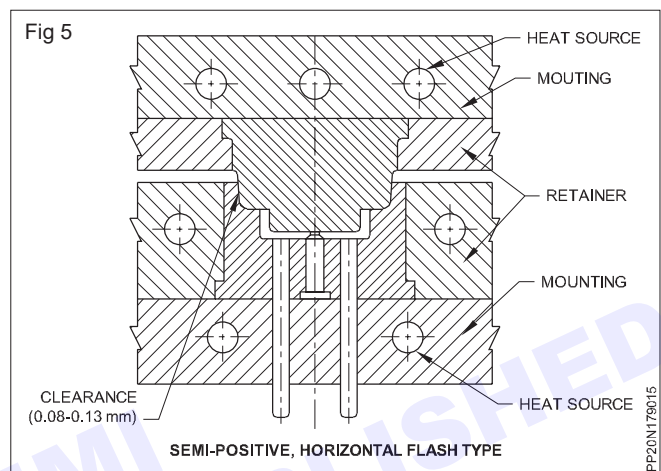


- 10 Overall height of the molding is controlled by land areas on mating surfaces of the top force and cavity.
- 11 Maximum density of the molding may be maintained by clearance between the side wall of the top force and the cavity.
- 12 Used as a single cavity mold on a rotary press and molding pressure is controlled at each station.
- 13 Flash must be removed in the land area otherwise it will result in damage or breakage of the lands.
- 14 It is advisable to provide additional pressure pads outside the cavity.
- 15 Used for high bulk materials and large deep draw parts when maximum density is required.



- 16 It is a single cavity mold and uses an accurately weighed charge of material.
- 17 All the applied pressure is exerted on the material.

- 18 Flash between the top and bottom force can be produced in the direction of pressure.
- 19 Flash thickness varies according to the clearance between the loading chamber and top force.
It controls maximum density and critical dimensions as related to cavity and top force.
- 20 Easy removal of flash on large parts and leaves no flash line scar on the side of the parts.
- 21 It is less costly and more popular.
- 22 It is recommended for close tolerance parts and assures minimum flash finish.

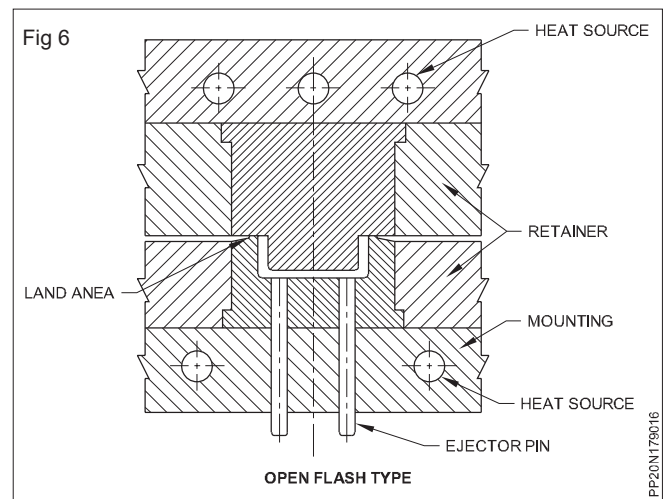


Classification of compression moulds by number of cavities

Compression molds can be further classified by the number of piece parts produced in each cycle. Single cavity molds producing one piece are generally used in molding large cavities. Multiple cavity molds come in several types. Identical cavity molds contain a separate cavity, top force and loading well for each piece part. The number of cavities varies depending on the size of the piece part, size locking force & pressure of the press, ease of loading and ejection of the piece parts. Often two or more cavities molding differently shaped piece parts are mounted in the same mold base.

Another type of multiple cavity mold, called the sub-cavity mold, or gang mold, contains a common well or loading chamber and common top force and a number of identical parts are molded. The sub-cavity mold is used for molding small parts where loading of individual cavities would be impractical. Enough powder or material is placed in the common well to produce all the pieces, care must be taken so that the top force does not touch the bottom on the land surface of the loading well. Again an external land provided to keep the top force 0.05mm to 0.13mm from the inner land surface. This clearance between the land surface and the top force forms a thin fin or flash between the cavities, which breaks off easily. The land area between the cavities should be kept at a minimum. If the land area between cavities is too large, much of the molding pressure is wasted on molding and not enough pressure is exerted on the piece parts,

resulting in shorts molding and parts of low density. It is recommended that the molding area be approximately three times greater than the land area. This type of mold is recommended when molding rather small and shallow parts using the more free flowing thermosetting materials.



Defects, causes, remedies of processing

Objective: At the end of this lesson you shall be able to

- list common defects, causes and remedies in compression moulds.

Common defects, causes and remedies in compression mouldings

Defects	Causes	Remedies
i Cracking after moulding	a Less wall thickness b Malfunctioning of knock-out pin c Brittle material	a Increase wall thickness b Check knock-out pins c Use more flexible material
ii Blisters	a Less cure time b Less breathing time c High mould temperature	a Increase cure time b Increase breathing time c Lower mould temperature
iii Bull surface	a High or low mould temperature b Dull mould surface c Rapid mould closing	a Adjust mould temperature b Polish mould of chrome plate c Close mould more slowly
iv Mould sticking	a Low mould temperature b May be due to presence of moisture c Uncleared mould surface	a Rise mould temperature b Pre-heat to eliminate moisture c Clear mould surface
v Orange peel	a Unpre-heated material used b Softer material might have been used c High mould temperature	a Use preheated material b Use stiffer material c Low mould temperature
vi Porosity	a Less pressure b High mould temperature c Unpre-heated material used	a Increase pressure b Low mould temperature c Pre-heat material

Trouble shooting of compression moulding machine

Objective: At the end of this lesson you shall be able to

- explain the various holding / processing defects that may be encountered in processing of materials pf,mf, uf etc.

Trouble shooting for compression molded thermosets

Defects	Remedies
1 Cracking after moulding	- Increase well thickness around inserts - Check knock out pins - Correct size of shrink fixtures - Use more flexible material
2 Pimping	- Breath mold - Use higher finer material - Use softer material - H.F. Preheat - Lower mold temperature
3 Thick flash	- Reduce mold temperature - Increase high pressure - Reduce mold charge
4 Dull surface	- Adjust mold temp - Polish mold - Chrome plate - Close mold more slowly
5 Mould stroking	- Raise mold temperature - Preheat to eliminate moisture - Clean mold - Polish mold
6 Porosity	- Increase pressure - Lower mold temperature - Preheat material

Introduction about transfer moulding process and comparison of compression moulding and transfer moulding

Objectives: At the end of this lesson you shall be able to

- describe about transfer moulding
- compare compression transfer moulding.

Transfer moulding

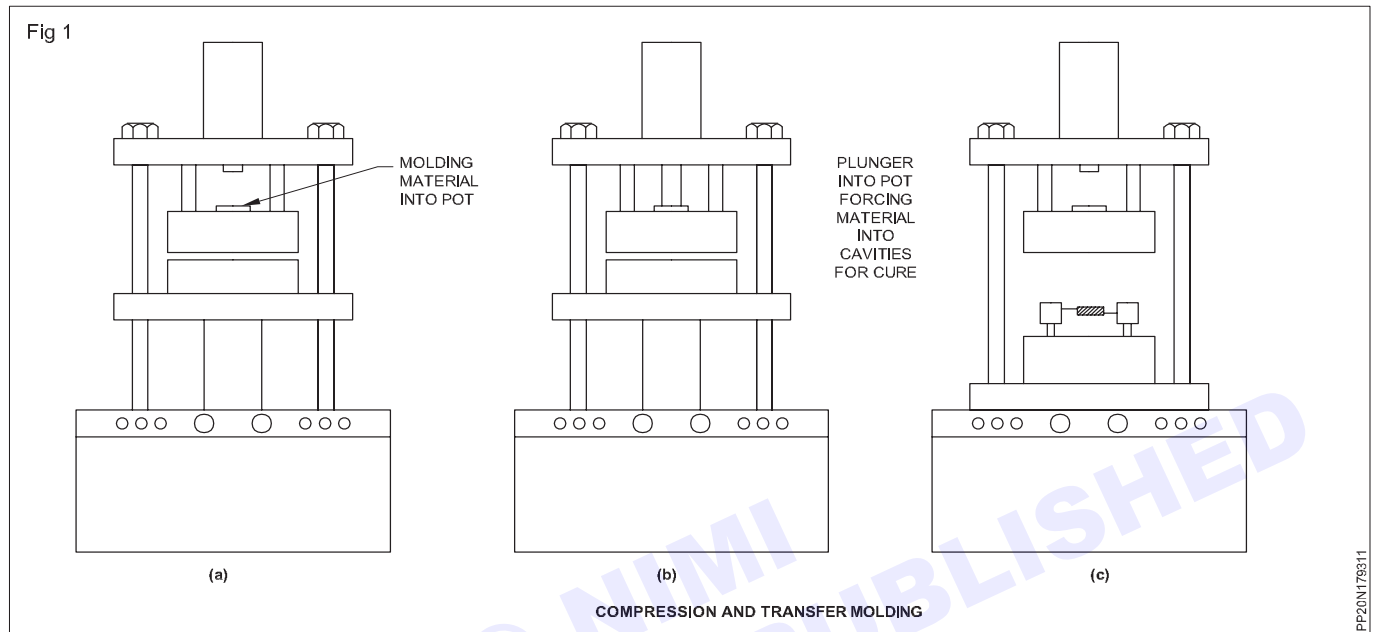
In 1928, Louis Shaw, founder of Shaw Insulator Company of New Jersey, secured a patent on a method for molding thermosets, whereby following press close (with cavities empty), a measured quantity of molding compound is placed in a chamber in the upper mold half (called the transfer pot), then forced by a transfer plunger to flow from the pot, into a runner system,

through which the material is caused to flow, under continued pressure from the transfer plunger, into the cavity or cavities until the cavities are full, at which time the plunger stops further advance but hold a pressure (often 2000 to 5000 lb/in², depending on the molding compound) on the material as it cures. On completion of cure, the controls signal the press to open the transfer plunger to travel into the pot another in. to ensure that the (cured residual plastic) is pushed downward out of

the pot, following which transfer plunger is retracted from the pot to await the next cycle. The press continues to open the mold and effect ejection of the molded parts as in compression molding (Figures 1 to 4). Molded parts are removed manually or atomically, and the press and mold are ready for the next cycle.

Advantages of transfer molding over compression molding are several. One advantage is that part dimensions, in direction of mold closing and opening,

can be held to closer tolerances because the mold is firmly closed, metal to metal, before the plastic flows into the cavity. Flash at the mold-parting surface is minimal, if any. Another advantage of transfer molding over compression molding is that the mould cavities are exposed to plastic that is already somewhat fluid, enabling longer cavity life. In compression molding, dry granular plastic contacts the mold cavity surface and in time, the hard chrome plating on cavity surfaces will abrade, requiring more frequent mold maintenance.



ii Transfer Molding

Transfer molding is a development of compression molding. In this a reservoir or pot where the molding compound is loaded in the mold and is transferred via runners to the cavities.

Transfer molding offers the mold user for certain advantages. Some typical applications where this process is useful are as follows.

- 1 For parts requiring side draw core pins, which must be readily withdrawn before discharging part from the mold.
- 2 For applications where inserts must be molded into intricate parts.
- 3 For complicated parts where tolerances are very close to their dimension
- 4 Finishing costs are reduced because of less mold flash on the transfer – molded parts.

1 Description of process: This type of molding requires the transfer of material under pressure from a “pot” or “well” through runners and gates into cavities retained in a closed heated mold. Usually the charge has been heated before placing it in the pot. Due to pre heating less pressure is required for transfer and in addition it reduces the mold cycle time.

Molding cycle

- 1 Material is placed in the transfer pot and heated.
- 2 It is forced through an orifice into the closed mold.
- 3 The mold opens; the cull and sprue are removed as one unit.
- 4 The part is lifted out of the cavity by ejector pins and ejected.

3 Material used in transfer molding (Fig 3)

PF and MF molding compounds are the materials most usually used in transfer molding. General results with these are excellent.

UF materials have been transfer molded quite successfully in some cases, principally for small articles.

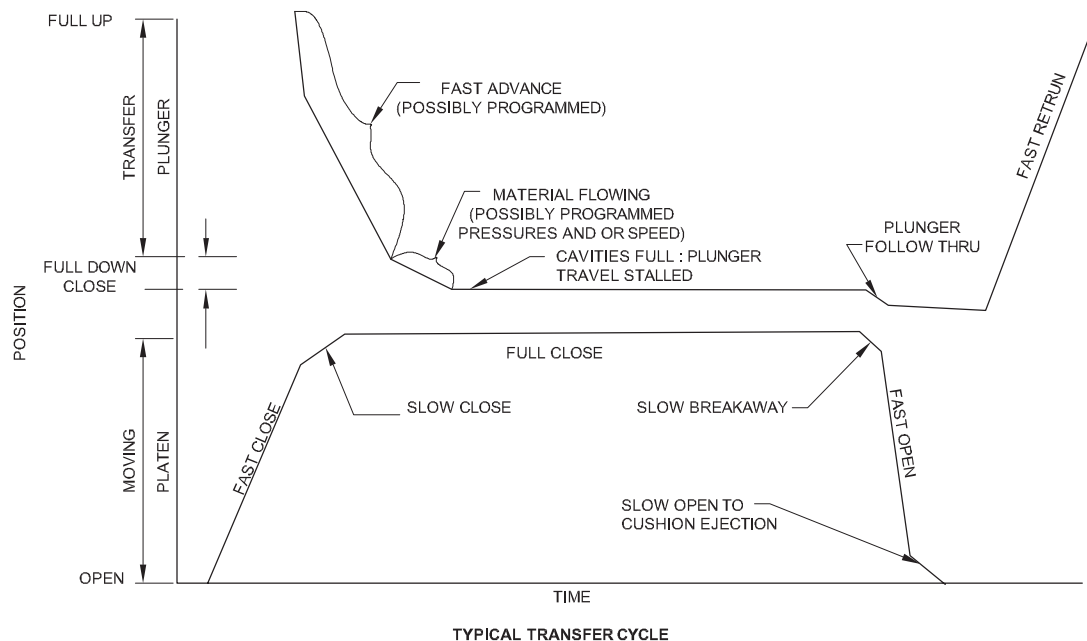
- 1 PF – 0.1 – 0.9% (With filler)
- 2 PF – 1 – 1.2% (without filler)
- 3 MF – 0.6 – 1.5 %
- 4 UF – 0.6 – 1.4 %

4 Type of transfer mold (Fig 4)

Transfer mold can be divided into two types

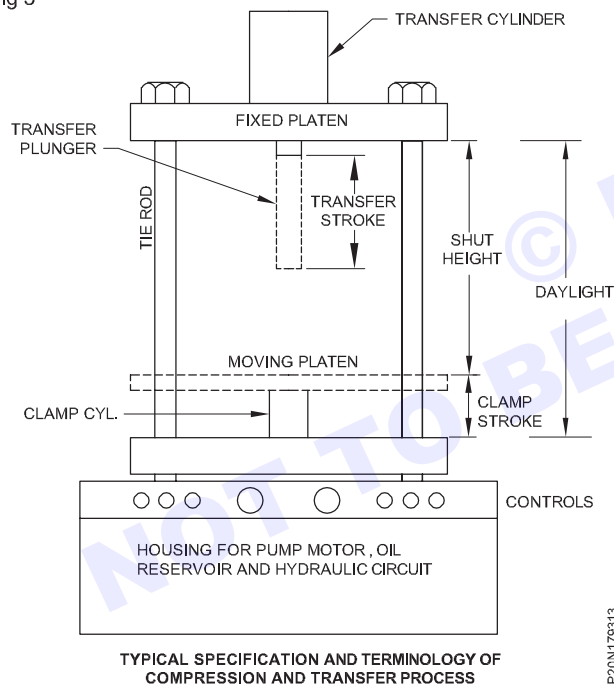
- Pot type
- Plunger type (or) Auxiliary ram type

Fig 2



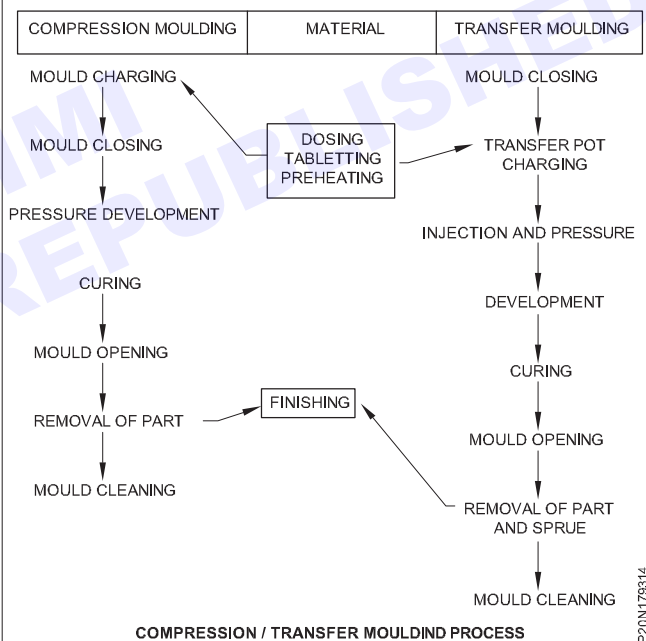
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Fig 3



PP20N179313

Fig 4



PP20N179314

i Pot type transfer molding (Fig 5)

This mold design provides a pot into which the heated compound or unheated is placed and the press flows.

The material is held in the transfer chamber (pot) has preform (or) powder form this material in the pot is kept under heat through plasticize for some to get good melt flow.

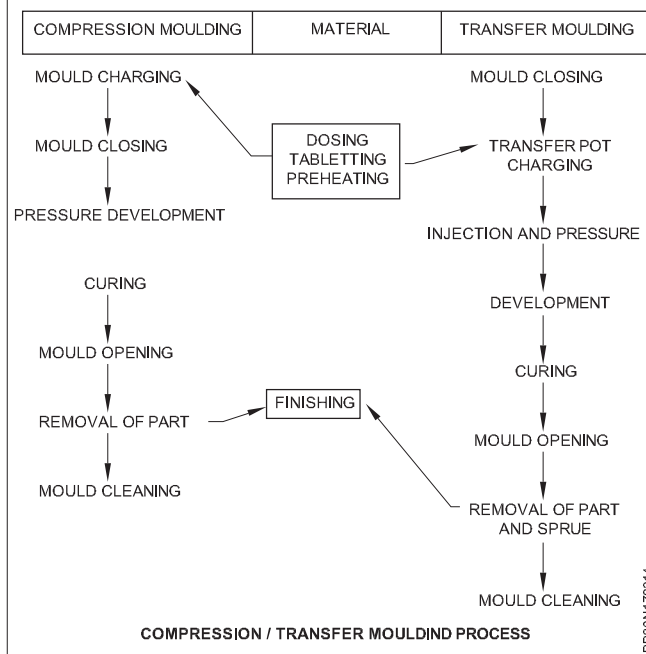
As the mold is closed, the material, which is plasticized, is pushed into the mold through feed system and fills the impressions. During the time the compound will be compressed into a (or) cull. The cull will absorb the entire applied pressure and punch travel will be slug

stopped until the heat has plasticized the compound to the point flow.

The cull pickup is provided in the punch as an undercut. This is used to take off the cull, during the mold opening and ejection stage. So that it facilitates smooth melt flow for the next cycle. The cull, the sprue or runner from the pot is removed as one unit.

The method is usually faster than compression molding, since cure time particularly for thick sections often is shorted because the hot material is injected into the closed cavity under high pressure. This results in molded parts with good dimensional control and uniform density.

Fig 5



ii Plunger type transfer molding (Auxiliary ram transfer)

The plunger type molding is similar to pot transfer molding except that an auxiliary ram is used ! to exert pressure on the material through runner into the cavities of the closed mold. A two – plate mold is used. Most of this type molding is semi automatically operated with self – contained presses.

In this type by the arrangement of the plunger it can be further divided in to three

- Top plunger
- Bottom Plunger
- Side plunger (or) horizontal plunger

Top plunger type transfer moulding (Fig 6)

In top plunger type transfer, molding press contains a main clamping cylinder to open and close the mold. An independently controlled double acting auxiliary cylinder to operate plunger. The molding compound is fed with the mold in a closed position.

Basic steps of this process are similar to those of the pot or transfer molding method. When the plunger is with drawn and the mold opened the molded pair may be removed from the cavity. With the runners and cull still attached as a unit.

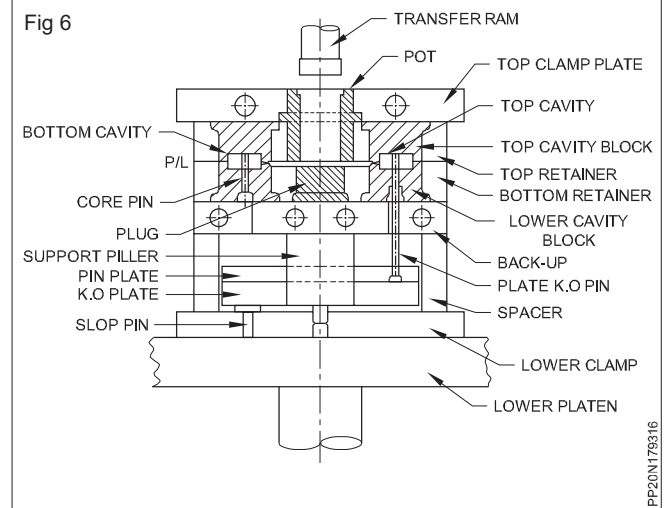
The over – all molding cycle in plunger molding is normally shorter than the pot transfer molding. Since removal of the sprue, runners or cull does not require a separate operation.

The transfer ram acting from the clamping attachment will force tie material. Due to

High – applied pressure, the material flow from the loading chamber into a runner and gate system and feeding the individual cavities of the mold.

The lower main clamping ram shows to keep the mold tightly closed during the entire molding cycle, and also provides sufficient pressure to open the mold after the cure time.

Fig 6



2 Bottom plunger type mould: A bottom plunger is basically the same as a top plunger except that the plunger cylinder assembly is mounted below the mold clamping platen. This design permits good cycle time, minimum plunger transfer stroke and top ejection of the parts from the mold.

With the piston withdrawn and the tool open the powder is loaded into the chamber. The mold is closed and the piston applies the pressure. Due to high – applied pressure, temperature the material flows into the runner, gate and impressions.

After the curing period the mold is opened and the position made 10 protrude above the bottom half of the mold and automatically eject the products and any excess materials in the chamber. The whole may be removed and the Piston returned to its lowest position for second cycle.

3 Side plunger (or) Horizontal plunger type

The horizontal plunger assembly is mounted parallel to the press platen. The main ram of the press supplies vertical clamping pressure to clamp the mold. The auxiliary cylinder actuates the transfer ram which is positioned horizontally buy the external hydraulic mounting.

A powder material is charged in the side plunger chamber and injected to the impressions through runners and gates. After curing the products are ejected by the ejection system separately.

This type of a design is not normally used ‘ since it requires special equipment’s for operation.

4 Advantages of transfer moulding

In transfer molding the thermos set material is subjected to heat and pressure then forced into a closed mold cavity. The pressure and heat is maintained inside cavity until curing taken place. The special features of transfer mold are follows.

- 1 In transfer molding, the material is plastic / cd in a separate heal chamber.
- 2 The plasticized material enters into the mold cavity at a speed high enough to fill the impression.
- 3 Due to high – pressurized material, the complicated shapes can also be molded.
- 4 Since the fluidized plastic powder is forced by the plunger form the loading chamber to the closed mold cavity, good heating mixture can be achieved.
- 5 The high – pressure flow material in fluidized condition can flow easily around the core pins, inserts, and projections. So that bending or off – setting of pins during processing is avoided.
- 6 Due to the uniform curing around the component, good electrical insulation can be achieved.
- 7 The external force is applied to flow the powder so that transfer mold is greater speed of molding by reduced curing time.
- 8 In transfer molding, the short filled molding is reduced.

- 9 The outer surface of the molding is good.
- 10 It is very suitable for insert type molding . Since the inserts can be placed very easily without any disturbance by molding.
- 11 Since the pressurized material is plastic / Cd in a separate chamber it possible to get equally plasticized melt or all the impressions.

5 Disadvantages of transfer molding

- 1 In transfer molding greater amount of material is required compare with compression molding because of the sprue and runner system is wasted for every shot.
- 2 The only plastic powder, which has high plastic content, and good how characteristics can be used for transfer molding .
- 3 The construction of transfer mold is difficult and costlier than compression mold.
- 4 Hydraulic power requirements are highly expensive to actuate the transfer mold.
- 5 The scrap material cannot be reground as in injection molding because thermos set material is used.

Comparison between compression molding and transfer moulding

S. No	Compression molding	Transfer molding
1	Materials are into the mold when mold is in open conditions.	Materials are into the mold when mold is in closed conditions
2	Insert molding is difficult to process	Insert molding is easy to process
3	Pressure pads are used	No pressure pads are used
4	No complicated product are produced	Highly complicated product are produced
5	No cull is present	Cull, sprue runner gate are present
6	Low pressure precess	High pressure process
7	No plunger activation	Plunger activation
8	Difficulty for multi cavities molds	Multi cavities mold are mold
9	More flash	Very less flash
10	Secondary operation is required	No secondary operation is required

Trouble shooting of compression moulding machine

Objectives: At the end of this lesson you shall be able to

- know the causes and prevention of compression moulding machine Malfunctions.

Defect	Cause	Rectify
Machine break down	Electrical fault	Electrical mains supply and starter supply should be checked
Motor starting problem	Starter fault	Starter supply should be checked
Motor not running at required speed	1 Motor defect 2 Low voltage	Check the motor leads and check the voltage.
Motor loading trip	Over load	Check for starter over load
The mould will over heat	There mocouple is not fitted properly theremocouple circuit cut	Thermocouple must be properly fitted Thermocouple must be adjusted
Failure to open the mould	Curing timer defect	The curing timer should be adjusted.
Making noise while the pump is running	1 Clogged filter 2 Low oil level	The filter should be removed and cleaned The correct amount of oil should be filled
Oil over heating	The amount of water going to the cooler is low	The cooler should be removed and cleaned.

Introduction - FRP (Fiber Reinforced Plastic) and advantages of (FRP)

Objective: At the end of this lesson you shall be able to

- explain the various types of reinforced plastic their important properties and uses.
-

Introduction

At present the significant role which the reinforced plastics is playing is to replace many metals.

Resin is a major component for the reinforcement of plastic. Reinforcement includes glass, carbon, graphite, alumina fibers, asbestos, woven and non-woven textile. Fillers are often particles such as powders, pellets, spheres and needles, granular.

Polyesters reinforced plastic

Polyesters are low in cost and easy to mould. They have good mechanical, chemical and electrical properties. Some types are fire resistant.

Uses - Aircrafts parts, building panels, electrical components, motor components, decorative, protective surface, furniture

Epoxy reinforced plastics

It gives mechanical strength dimensionally stability, corrosion resistance, good electrical properties, low water absorption.

Uses - Ducting, aircraft rocket parts.

Phenol reinforced plastics

It also gives high mechanical strength, high temperature resistance, good thermal insulation, electrical properties & good chemical resistance.

Uses - Interior aircraft parts, finishing rods and honey combs, missile parts.

Melamine reinforced plastics

It has excellent color range good abrasion resistance, good electrical properties,

good resistance to alkali, flame resistant.

Uses - Rayon paper, wall tiles, laminates.

Silicon reinforced plastics:-

It gives highest electrical properties, heat stable.

Uses - Electrical resistance, hot-induct, missile structure, rocket nozzle, missile motor housing.

Reinforced Thermoplastic**Introduction**

Most commonly known as fiber reinforced thermoplastic (FRTTP). Major materials, reinforced are the engineering plastic such as nylon, acetols, polycarbonate PBT, PET etc.

General properties

It depends on base polymer and on the type and concentration of the fibrous fillers. Glass fiber is very popular and is used over the range 15 to 50%. (Glass content by weight), 20 to 40% being most common as below 20% there may be little reinforcement. Whereas above 40% processing is difficult, because of the effect of processing, the final fiber length is of the order of 0.5 ml. and the effect on strength is not as great as it is for thermoset. This means the final mouldings may be stiffer than the unreinforced material.

Material is stiffer than the base polymer and has lower co-efficient and lower thermal expansion. It has high distortion temp. and higher density. FRTTP are available as pre-compounded materials and in master batch form.

The creep resistance of FRTTP is better than that of the parent polymer. Low temperature impact resistance is sometimes better than that of parent plastic.

FRTTPs are usually based on expensive plastic and good house keeping is therefore essential if cost is to be kept down. Impact strength at low temperature is usually improved by fiber addition.

Applications

Major areas are equipment and appliances (1) Hair dryer casing, power tool casing etc. (2) Automobile bumpers, under bonnet parts. (3) Electrical coil frame for release transformer housing etc.

Miscellaneous Bearings, gears etc.

Material used in FRP and process used for FRP

Objective: At the end of this lesson you shall be able to

- explain different forms of glass fiber and grades and types of polyester resin used.
-

Definitions**1 Laminate**

- When two or more sheets of materials are superimposed and joined by an adhesive or by fusion the combination is called a "Laminate".

- Otherwise defined as materials made by bonding two or more sheets of reinforcing fibers using suitable binding resin.

2 Gelcoat

- They are high viscous polyester resins used for producing resin rich surface.

3 Preparing materials

- Preimpregnated materials sold to the purchaser in an uncured form.

4 Catalyst

- Is a chemical compound/substance which initiates the curing reaction. (e.g. MEKP).

5 Accelerator

- Is a chemical substance which accelerates the rate of curing reaction. (e.g. Cobalt Naphthanate).

6 Release agent

- The agent used to release the component from the mould. (e.g. WAX, PVOH).

Main constituents of Reinforced plastics

1 Resin

- Mainly unsaturated polyester resin and expoxids.

2 Reinforcing material - Fibre glass.

- Fiber glass - Chemically known as borosilicate's.
- Glass fibers are treated with silane coupling agent for better bonding with resin system

3 'A' Type

- High line borosilicate's
- Higher moisture absorption
- High alkali content (10-15%)

4 'E' Type

- High lime borosilicate's
- Low moisture absorbtion &, alkali content
- Widely used as reinforcing material.

5 'S' (High strength) Type

- Used in aero space or pressure vessel application to meet more exacting tensile or deflection requirements.

6 'M' (High modulus) glass

- Approximately 10 times more expensive than 'E' glass.

Different forms of glass fiber reinforcements

1 Revings

- Continuous rope like bundle of strands without any twist.

2 Chopped strands

- Fibers ranging from 3 to 5 mm.

3 Chopped strand mat

- Strands of length 12 to 50 mm are bonded together in a random fashion to form a mat. Glass mat provides lower cost reinforcement than woven fabric.

4 Surfacing mat

- Is a fine Tissue like glass mat.
- Used for top layers of corrugated and flat sheets and lamp shades.
- The use of surface mat tends to conceal coarser mat fibres underneath and extends weather resistance by preventing stiffer fibers from blooming.

Other materials

Apart from polyester resin and fiber glass other materials required for fabrication of a laminate are.

1 Catalyst

- For room temperature, curing MEKP is used and for elevated temperature, curing Benzoyl peroxide is used.

2 Accelerator

- Speeds up rate of curing.
- Cobalt Naphtha Nate is used.

3 Inner fillers

- Reduce cost. (e.g. Clay, sand, saw dust & calcium carbonate – CaCO_3)

4 Releasing agent

- For mould release purpose
- Wax, PVOH etc.

Method of Fabrication

Methods of fabrication should be determined by

- 1 The No. of components needed.
- 2 Their dimensions
- 3 The properties required
- 4 The cost of manufacture

Processes

1 Open mould process

- Hand lay up process
- Spray up techniques
- Filament winding
- Vacuum bag moulding
- Pressure bag moulding
- Centrifugal casting
- Pultrusion
- Auto clave moulding

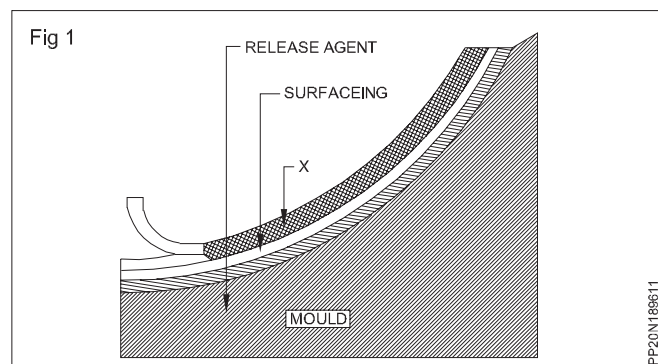
Hand lay up process

Objective: At the end of this lesson you shall be able to

- describe hand lay up process.

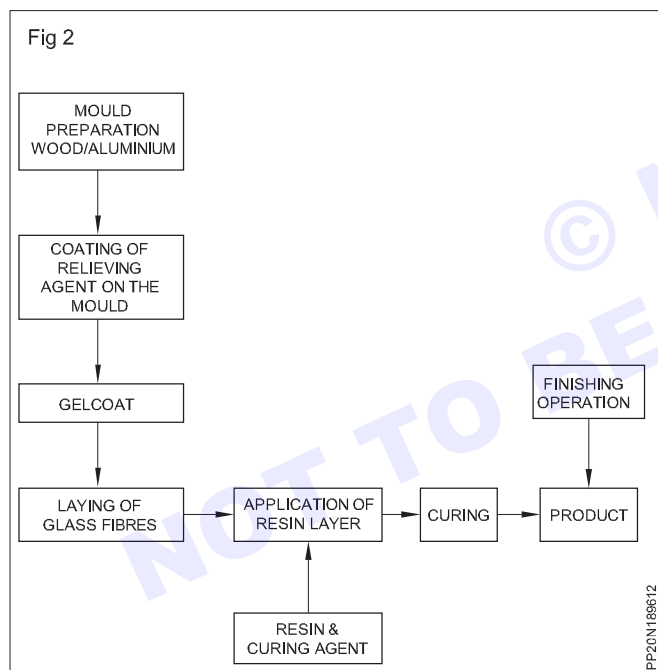
Easy and simple process

- Detailed procedure is given in the skill information sheet (Fig 1)



Fiber reinforced plastics process (Hand lay up)

Many useful industrial / Domestic products are being made by hand lay up process (Fig 2 & 3)



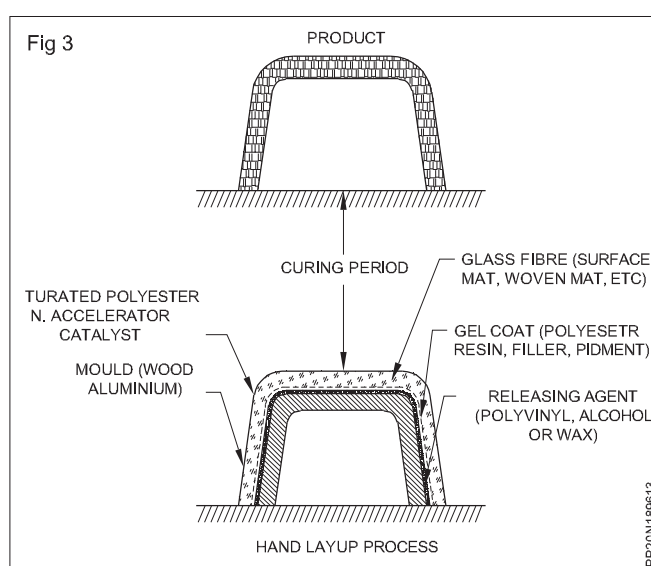
- Simple process
- No elaborate processing machinery required
- Freedom of design

Some of the products made by the above technique

- Helmets
- Chairs
- Bathroom tube
- Wash basins
- Mirror frames

Advantages

- Cheap and simple process



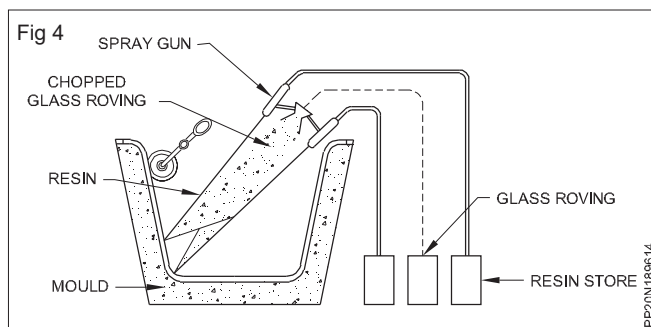
- Low cost mould
- Suitable to produce large parts like boats, chairs etc.

Disadvantages

- Low production rate
- More resin may be required
- Voids may occur
- Little control can be exercised over wall thickness
- Single side finish because of open mould process

Spray up techniques (Fig 4)

- Is actually a wet lay up open mould process using polyester resin, glass fiber and room temperature catalysts. The difference is in the method of depositing glass fibers and liquid resin compares with the use of mat in the case of hand lay up process.



Advantages

- Easy to perform
- Homogeneous wetting of resin and fibre glass possible.
- Parts with complicated shape can be made.
- Less resin may be used hence better mechanical properties than hand lay up process.

Disadvantages

- Single side

- Chances for voids
- Little control over wall thickness.

Vacuum bag moulding

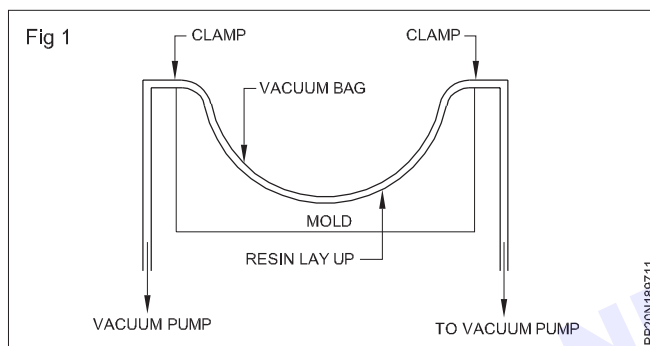
Objective: At the end of this lesson you shall be able to

- describe vacuum bag moulding.

Vacuum Bag moulding (Fig 1)

The application of vacuum to an FRP parts serves to improve quality by removing air within the lay up before and during curing. When used with condensation type resins, vacuum draws off gases by products, reducing the danger of delamination.

The vacuum ensures that each layer or loose fiber is pressed lightly into place/ As the air is evacuated from within the seated assembly, atmospheric pressure exerts an external force evenly over the laminate.



Advantages

- One piece tooling can be used, either male or female.
- Virtually no limit to the size of the part that can be bagged.
- Void free laminates are possible.
- Prepress can be used.
- Product not rich in resin content hence better mechanical properties.

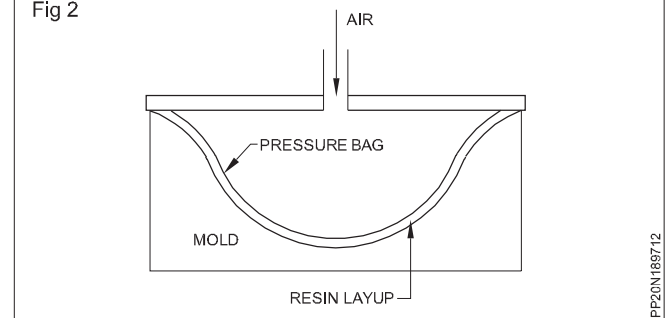
Disadvantages

- Single side finish.
- Complicated shapes and sharp corners are difficult to form.
- A minor leak in the bag during cure results in poor quality or rejected part.

Pressure bag moulding

- Preimpregnated sheets of required thickness and size are kept. Over an wooden/aluminum mould which is already coated with a layer of a mould releasing agent. (Fig 2)
- The prepare lay up is covered with PE, PTEF/ cellophane bag and tightly clamped.
- Pressure is applied (As shown in Fig) to consolidate the resin content in the lay up.

Fig 2



Advantages

- Extra consolidation of lay up and decrease in resin content hence better mechanical properties than hand lay up.
- Voids are totally eliminated.

Disadvantages

- Single side finish
- Costlier process

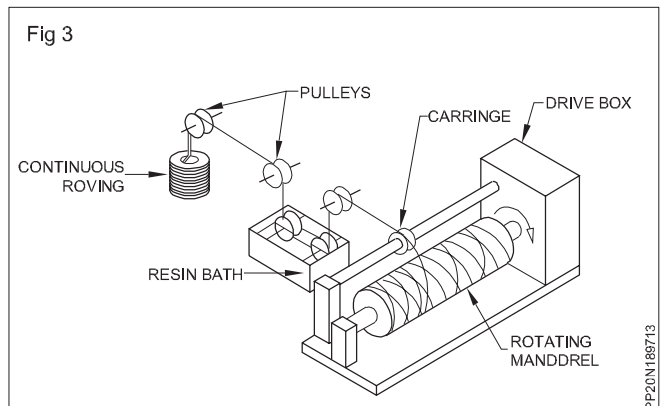
Auto clamp moulding

Autoclaves are steel pressure vessels ranging from 20ft. or more in dia and 40ft. in length. Hand lay up's enclosed in special rubber bags after evacuation of air, steam or heated air pressure to 125 psi, exerts both heat and pressure to cure the part

Filament winding (Fig 3)

- In this process, which is useful for making cylindrical sections, the preimpregnated roving's are wound round tightly on a mandrel to required thickness and size.
- The part is cured in an oven or atmosphere depending on the type of catalyst employed.

Fig 3



Hot press moulding

Objective: At the end of this lesson you shall be able to

- briefly explain hot press moulding.

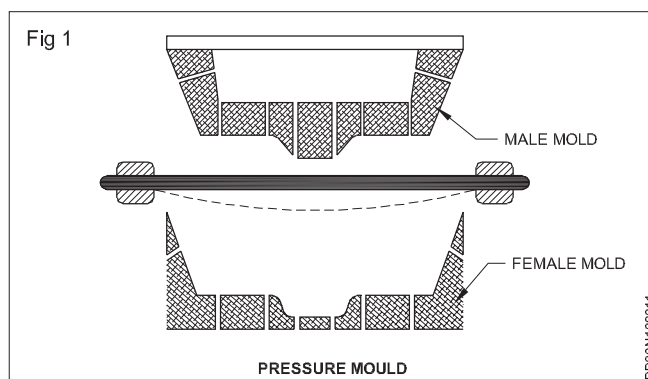
The ultimate in production rate of FRP is realised by use of compression presses and matched metal mould.

Preform moulding (Fig 1)

To ensure that fibers are located correctly within a moulded part, a dry preform that conforms closely to final moulded shape must first be made in compression moulding.

Bulk moulding

This process utilises Bulk Moulding Compound (BMC / DMC). BMC is processed usually in this process which is called also as match-die moulding.



Fault, cause, remedies of FRP

Objective: At the end of this lesson you shall be able to

- list the fault, causes and remedies of FRP.

Fault, causes, remedies of FRP

Faults in Fiber Reinforced Plastic (FRP) manufacturing processes can arise from various factors, including material issues, processing conditions, and equipment malfunctions. Identifying the causes of these faults and implementing appropriate remedies is crucial for maintaining the quality and integrity of FRP products. Here are some common faults, their causes, and potential remedies in FRP manufacturing.

Faults

Delamination

Cause: Poor adhesion between layers of fiberglass and resin.

Remedy: Ensure proper surface preparation, use compatible resin, and optimize curing conditions.

Air Bubbles or Voids

Cause: Entrapped air during the layup or curing process.

Remedy: Vacuum or pressure-assisted molding, proper roller consolidation during layup, and controlled curing conditions.

Fiber Misalignment

Cause: Improper fiber orientation during layup.

Remedy: Use skilled labor for layup, implement proper tooling, and utilize alignment guides or templates.

Cracks or Fractures

Cause: Excessive stress, impact, or uneven distribution of resin.

Remedy: Reinforce critical areas, improve mold design, and optimize resin-to-fiber ratio.

Surface Imperfections (Pinholes, Pitting)

Cause: Incomplete wetting of the fibers, air entrapment, or contamination.

Remedy: Ensure thorough mixing of resin, control environmental conditions, and apply suitable release agents.

Warping or Distortion

Cause: Uneven cooling or curing, insufficient support during curing.

Remedy: Optimize curing conditions, use appropriate support structures, and consider post-cure procedures.

Resin Starvation

Cause: Insufficient resin flow during layup

Remedy: Modify layup techniques, ensure adequate resin viscosity, and use appropriate tooling

Color Variations

Cause: Inconsistent pigment dispersion, improper curing conditions.

Remedy: Use quality pigments, ensure thorough mixing, and maintain consistent curing conditions

Inadequate Adhesion to Core Materials

Cause: Poor bonding between FRP and core materials.

Remedy: Use compatible adhesives, ensure proper surface preparation, and optimize curing conditions.

Health hazards associated with processing and fabrication of FRP

Objective: At the end of this lesson you shall be able to

- list the fault, cause and remedies of FRP.
-

While Fiber Reinforced Plastic (FRP) processing and fabrication offer various advantages, it is important to be aware of potential health hazards associated with these activities. Workers involved in the manufacturing of FRP products may be exposed to certain risks. Here are some health hazards commonly associated with the processing and fabrication of FRP.

Resin Exposure

Hazard: Many FRP processes involve the use of liquid resins, which may contain hazardous substances such as styrene. Prolonged exposure to these substances can cause skin irritation, eye irritation, and respiratory issues.

Preventive Measures: Implement proper personal protective equipment (PPE), including gloves, eye protection, and respiratory masks. Ensure adequate ventilation in the working area.

Fiberglass Dust and Particles

Hazard: Cutting, sanding, or grinding fiberglass materials can generate fine dust and airborne particles. Inhalation of these particles can lead to respiratory problems and irritation of the eyes and skin.

Preventive Measures: Use dust extraction systems, wear appropriate respiratory protection, and provide workers with protective clothing.

Catalyst and Additives

Hazard: Some FRP processes involve the use of catalysts and additives, which may be hazardous if not handled properly. Skin contact or inhalation of these substances can cause irritation and sensitization.

Preventive Measures: Follow proper handling procedures, use PPE, and provide training on the safe use of catalysts and additives.

Noise Exposure

Hazard: Power tools and machinery used in FRP fabrication can generate high levels of noise, leading to hearing damage over time.

Preventive Measures: Implement engineering controls, such as noise barriers or enclosures, and provide workers with hearing protection devices.

Volatile Organic Compounds (VOCs)

Hazard: VOCs emitted during the curing and processing of resins can contribute to air pollution and pose health risks, including respiratory irritation and headaches.

Preventive Measures: Ensure proper ventilation, use low-VOC or VOC-free resins when possible, and conduct work in well-ventilated areas.

Manual Handling and Ergonomics

Hazard: The manual handling of heavy or awkwardly shaped FRP components can lead to musculoskeletal disorders and injuries.

Preventive Measures: Provide proper training on lifting techniques, use lifting aids when necessary, and design workstations to promote ergonomic practices.

Heat and Thermal Exposure

Hazard: Some FRP processes involve the application of heat during curing. Workers may be exposed to high temperatures, posing a risk of burns.

Preventive Measures: Provide heat-resistant PPE, implement engineering controls to minimize heat exposure, and train workers on safe handling procedures.

Blow moulding

Objectives: At the end of this lesson you shall be able to

- define extrusion blow moulding machine & its functions
- explain the blow moulding techniques.

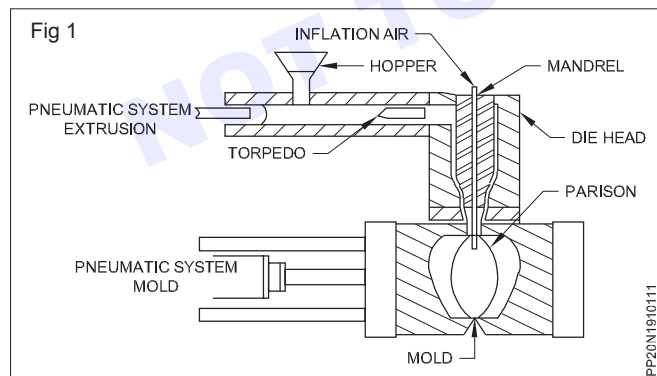
Blow Moulding - basic principle (Fig 1)

Blow molding is a primary processing method used for the molding of plastic bottles and other containers from thermoplastic material. Blow molding is a technique employed for manufacturing products, which are essentially hollow. The air is acting as an internal core to produce a product.

In blow molding a heated plastic tube called the parson is inflated in a mold to form a hollow part. In more detail, process steps are

- Parson is formed between mold halves
- Mold closes around the parson
- Sealing one end of the parson
- Closing the parson around a mandrel at the other end
- Parson is inflated by air blown through hollow mandrel or needle in side of parson
- Cooling and solidification of the part
- Mold opening and part ejection

During this process the resin raw material is melted in the machine barrel, forced over a spreader and through the die head into the mold. The mold halves are held on platens which ride on tie rods or tie bars.



In plunger type machines all the heat for melting the plastic is supplied by external heaters. In screw type machines the shear heating of the resin between the screw flights provides a large contribution to heating and barrel heaters are used to produce complete melting and for controlling the final temperature of the melt, as in most injection molding machines. The spreader or torpedo is used to produce uniform flow around machine component peripheries and to produce desired flow – induced molecular structure.

The simplest ways of producing the parson are to reheat a previously formed tube or to fold a plastic sheet and heat seal the edge. In using a preformed plastic tube to form the parson the tube was probably produced in an extrusion process. The parson extrusion process can be included into the blow molding machine so that parson extrusion and blow molding occur sequentially on one machine. This extrusion blow molding process is one of the two widely used types of blow molding. The other is injection blow molding.

Details of processing

- 1 Production of parson
- 2 Mold closing
- 3 Blowing
- 4 Cooling
- 5 Mold opening
- 6 Ejection

Parson wall thickness control

1 Die assembly and wall thickness

The die can have a circular or ring shaped hole through which the parson is extruded. The size of the hole determines the diameter of the parson. The die gap determines the wall thickness.

The area around the die gap is very critical. Any imperfections in the land area will show up in the product. The mandrel (pin) and the die (bushing) can be separately removed from the die assembly. This permits the fitting of other die – pin combinations without removing the complete assembly from the machine.

Types of mandrel and die bushings

There are two types of mandrel and die bushings used.

These are

- 1 Convergent type
- 2 Divergent type

The selection of the head tooling is made by the size of the parson necessary. Convergent tooling is the easiest to control and is used wherever possible. Divergent tooling is used when the parson heads to be larger (for e.g.: industrial containers).

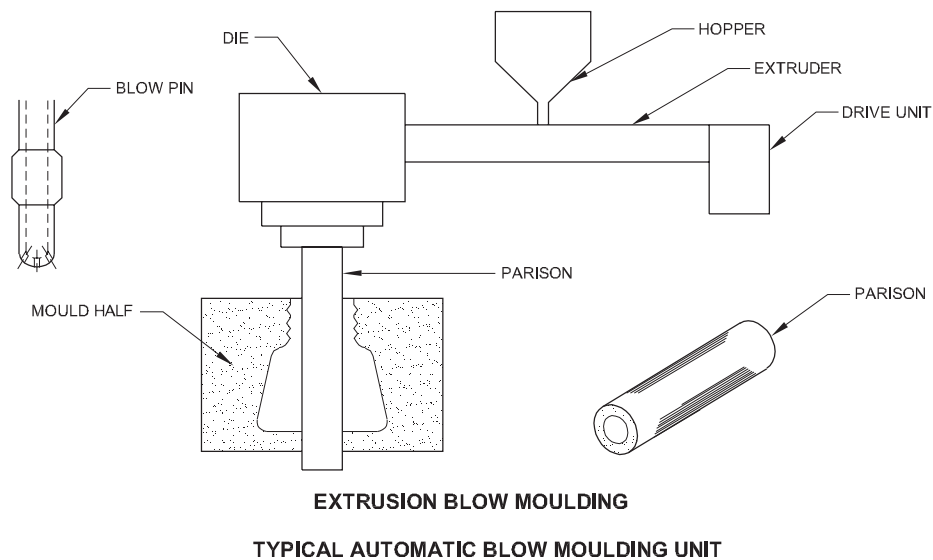
Extrusion blow moulding (Fig 2)

In the EBM process, molten thermoplastic material from an extruder passes down wards through a die and

is formed like a tube. This tube is clamped between the two mold halves and locking the bottom end. A blow

pin is inserted at the top to fill the parison with air and expand it inside the mold.

Fig 2



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Types of EBM

The EBM can be divided into the following

- A Continuous parison blow molding
- B Intermittent parison blow molding
- A Continuous parison blow molding

This process is normally associated with the manufacture of small containers such as bottles used for shampoos, oil cans, washing up liquids etc. In this type the parison is produced on a continuous basis.

Stage 1: Extrusion

The hopper contains plastics materials, which are fed into the extruder they are heated until plasticized and

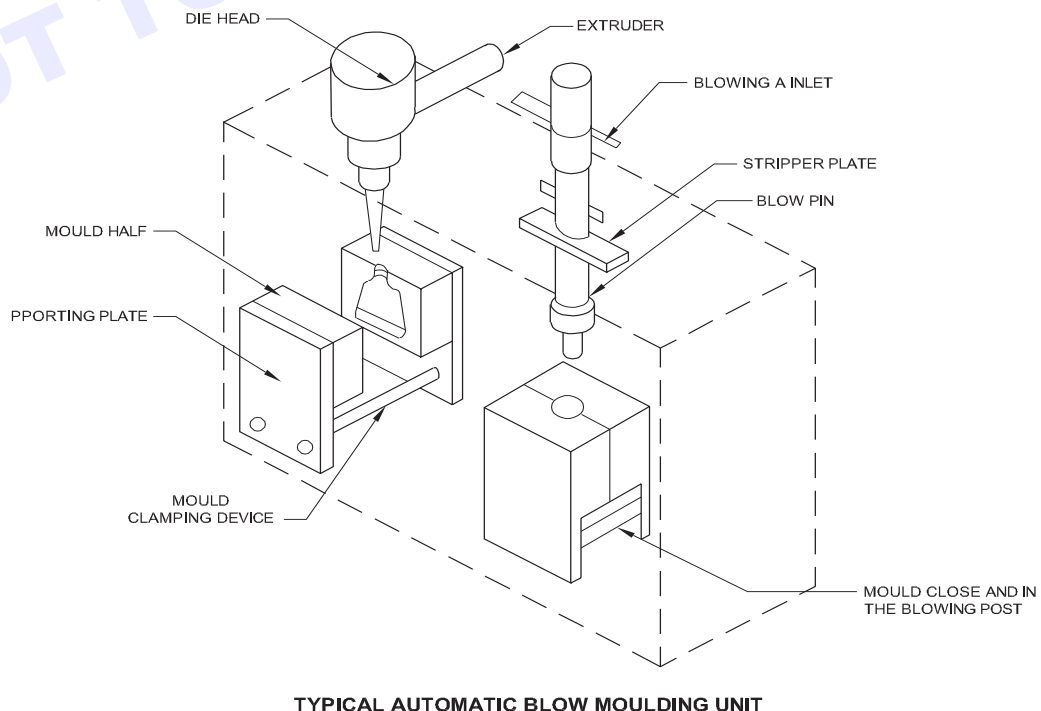
then pushed by the extruder, to the die. This melt is further extruded through a ring shaped opening in the die to form a tube or parison. The extruder runs all the time and the parison is extruded on a continuous basis.

Stage 2: Closing / Clamping

When the parison reaches the required length, the mold tool closes leaving behind a small amount of waste below the mold. This is known as 'Tail flash' or 'Bottom flash'. A knife then cuts the parison and the mold tool is moved from under the die, from the die head to the blow pin station

Stage 3: Blowing (Fig 3): The blow pin moves down and as it enters the mold tool, it automatically shapes the neck of the container and forms the threads. This

Fig 3



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is called 'calibration'. Compressed air enters by the blow pin and inflates the soft parison forcing it to take up the shape of the mold. The blow pin also cuts away the waste material on top and bottom. This is known as 'Neck flash'. The total time taken for this to happen is known as the 'Blowing Time'.

Stage 4: Cooling

By being kept in contact with the surface of the mold, the soft plastic cools and solidifies and retains its 'blown' shape. This can be done by the circulation of cold water. It is called cooling time of the mold.

Stage 5: Opening

The blowing air is turned off and air pressure inside the blown article is allowed to exhaust to atmosphere. Once the pressure has equalized, the mold tool opens and the blow pin retracts.

State 6: Ejection

During the retraction of blow pin operation, as it does so, the molding is ejected out. While all this has been happening, the parison continued to be extruded it has not stopped. Hence it is called in the name continuous parison extrusion.

The mold tool moves back from the blow pin station to the die head which brings us, back to the stage 1. Thus the cycle is completed.

Types of continuous extrusion molding

- 1 Rising method
- 2 Twin station system (shuttle method)
- 3 Rotary systems

1 Rising method

With the rising method, the parison is continuously extruded above the mold. When it reaches the proper length, the open mold rises quickly to clamp the parison. It returns downward to the blow station, which is located at the bottom of the mold. Till this time the parison continues to extrude. After the part is blown and cooled, the mold opens part is removed, and the process repeats.

2 Twin stations systems or shuttle method

This is a single die head and one or two molds which reciprocate between the two stations of the die. One station is used to catch the parison while the other used to blow it. In operation the mold – I, Under the die receives parison from die head. Then it moves to the other station called blowing station – I. In this stage blowing takes place and component is ejected. Till that time the parison extrudes downward and after reaching required length the mold – II receives parison. Then mold – II moves to blowing station – II for further operation. The mold – I return back to parison station to receive the parison.

3 Rotary systems: Hence, the molds are stationed on a rotary table. The rotary wheels are used 3 -20 clamping stations or more. A parison is pinched in

the mold. Then the parts are molded and cooled. The cooled part is removed. All these operations are done simultaneously as the wheel rotates continuously. This method provides high production rates.

B Intermittent parison blow molding or shot blow molding

In this process the parison is produced intermittently in a series of individual short length. This process is used for larger thicker walled parts particularly for large containers and for industrial applications. Because it is not easy to produce such a long, thick parison within a limited extruding time (the parison will freeze if extends this time.) So it is normally associated with the manufacture of larger items such as fuel tanks, barrels and technical moldings.

Types of intermittent blow Molding

- A Accumulator type blow molding
- B Reciprocating type blow molding
- C Accumulator type blow molding

In this type an accumulator head is provided for intermittent parison molding. In the case of a large blow molded container. The extruder may not be able to produce a parison quick enough. For this purpose a temporary storage (accumulator) is provided for better process.

Process

In operation, an accumulator head is attached to the end of extruders are designed to collect and eject a measured amount of plastic. The melt from the extruder is filled in the storage space above the die turned as the 'Accumulator Chamber'. When the chamber has been charged with sufficient melt, hydraulically operated piston is forced down into the accumulated chamber. Thus it pushes the melt out through the die opening to form a parison. The length of the parison will depend on the amount of plastic, melt pushed out of the accumulator chamber. This is known as a 'shot'. The extruder continues to melt the material and as the piston moves back to its starting position, the accumulator head is once again filled with plastic melt which is ready for the next shot. The connecting channels between the extruder and accumulator, as well as the accumulator itself are designed to prevent restrictions to the flow of melt and material hang up. This enables avoiding thermal degradation of heat sensitive materials.

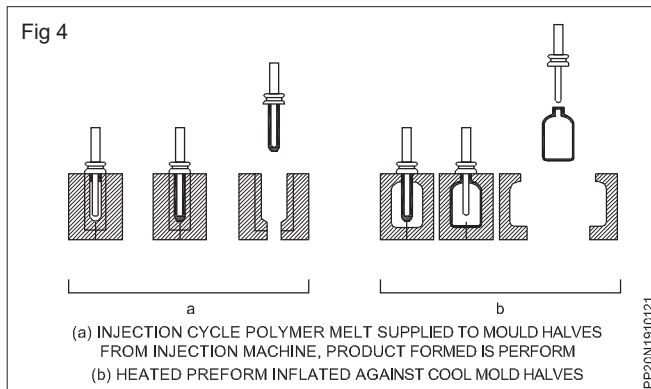
To ensure that the least residence time is developed during processing, the design of the accumulator ensures that the first melt into the accumulator is the first to go out when the 'ram' moves. The goal is to have the chamber totally emptied on each stroke. Plastics that are not heat sensitive permit some relaxation in their heat history.

B Reciprocating screw type

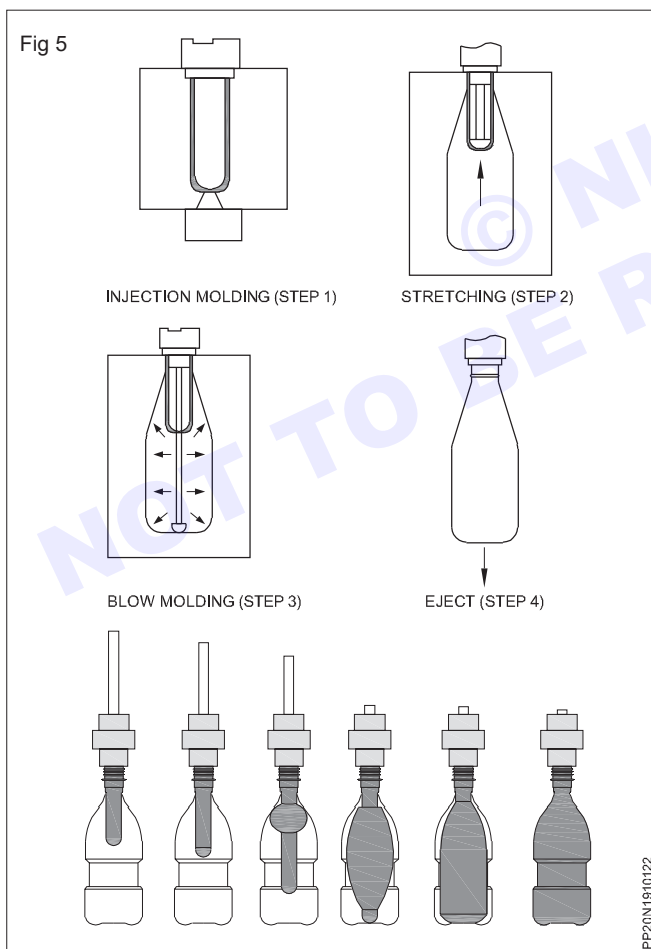
The reciprocating screw unit acts much like the injection molding machine screw. Plastics is conveyed and melted by the screw rotation. As melt accumulates at

the front of the barrel, the screw is pushed backward due to the backpressure. Once if a sufficient quantity of melt is in the barrel, the screw stops rotating and pushes forward (ram or plunger action) forcing the melt through a die to form a parison. This parison is further used for blowing, cooling and ejection.

Injection blow molding is a scrap free process used for the manufacturer's of plastic bottles. Containers etc. IBM has three stages.



Stages of injection blow molding process (Fig 5)



Stage – 1 Making preform: The screw injects hot melt through the nozzle into one or more preform shaped (test tube shaped) cavities. An exact amount of polymer is injected around the core pins.

Stage – 2: Heating preform: Instead of cooling a mold a hot liquid is supplied by hoses through mold – heating channels around the preform cavity. These channels have been redesigned to provide the correct heat control on the melt within the mold cavity.

Stage – 3: Shifting preform from injection mold to blow mold: The two – part mold opens & the core pins carry the hot plastic preform to the second stage, the blow molding station. There it is placed between blow mold halves.

Stage 4: Blowing preform: In the blow mold, controlled chilled water circulates through redesigned mold channels around the mold cavity (Usually 4 -10 C) & solidifies the hot plastic.

Stage – 6: Ejection: The two – part blow mold open & the core pin carry the complete blown container to the third stage, which ejects the part. Ejection can also be done by using a stripper plate, air, a combination of stripper plate and air robots.

Stretch blow molding

Stretch blow molding is done to impart strength in the blow – molded container.

SBM processes have been introduced to enhance the level of crystallization in a molded container.

Types of stretch blow molding

The stretch blow molding can be broadly divided into

- 1 Extruded stretch blow molding
- 2 Injection stretch blow molding

Injection Blow Molding Vs Extrusion blow molding

1 Extrusion stretch blow molding

This process requires two molds

- 1 Perform mold
- 2 Stretch mold

The perform mold is smaller than the stretch mold. The parison is clamped in the preform mold & blown to shape in the usual way. The neck tail flash is removed at this point. Before the preform solidifies in a hot condition, the blowing air is shut off. Cooling is not given in the blow mold. In some cases reheating of the preform can also be done to bring it to the orientation temp of the material.

The perform mold opens and whilst the still hot perform remains on the blow pin. Then it places between stretch blow mold and closed.

The blow pin (air activated telescopic mandrel) extends, pushing and stretching to the bottom of the mold tool. Then it allows compressed air to enter and blow the preform to shape.

The bottle is then cooled very rapidly in the mold. The blowing air is shut off and the stretch blow mold opened. The blow pin raised and the article removed.

S.No	IBM	EBM
1	Used for smaller parts.	Used for larger parts.
2	Best process for GPPS and PP and most resins can be and are used.	Best process for PVC and many resins can be used provided adequate melt strength is available.
3	Scrap free, no flash to recycle, no pinch off scars, no post mold trimming.	Resins can be used provided adequate melt strengths available.
4	Injection molded neck provides more accurate neck finish dimensions.	Neck flash Tail flashes are to be trimmed.
5	Accurate for repeatable part weight & thickness control.	Not so accurate.
6	Excellent surface finish or texture.	Limited wall thickeners control or resin distribution.
7	IBM best produces wide mouth containers.	Better surface finish.
8	Higher tooling (mold costs) costs. Short run or long run production.	Low cost tooling of tern made of aluminum ; ideal for
9	Weight of the bottle does not vary significantly.	Adjustable weight control, ideal for prototyping.
10	Provides the best surface finish	Good surface finish.
11	Low rate and production	High rates of production possible.
12	No trimming is needed	Trimming can be accomplished.

2 Injection stretch blow molding

In this process the preform is made by injection molding and it stretch blow molded.

Production of preform

It is similar to extrusion stretch blow molding but the only difference is that the preform is injection molded. The 1st stage is to produce an injection molded preform that is totally amorphous. This will involve high melt temp of 270 – 280 C, low injection pressure & low mold temperature (between 4 C & 20 C)

Heating and stretching

The extracted preforms are then fed to a reheating device where they are raised to about 30 C above the T_g (i.e) to almost 100 C. The reheated preforms are then immediately inserted into the blowing cavity where an air activated telescopic mandrel stretches the preform longitudinally.

Cooling and ejection

The compressed air expands the preform to the shape of the mold cavity. Thus the polymer is stretched biaxial, resulting in an increase in crystallinity. The mold allows to cool for a required time. The solidified components are ejected.

Stretch Blow molding processing characteristics

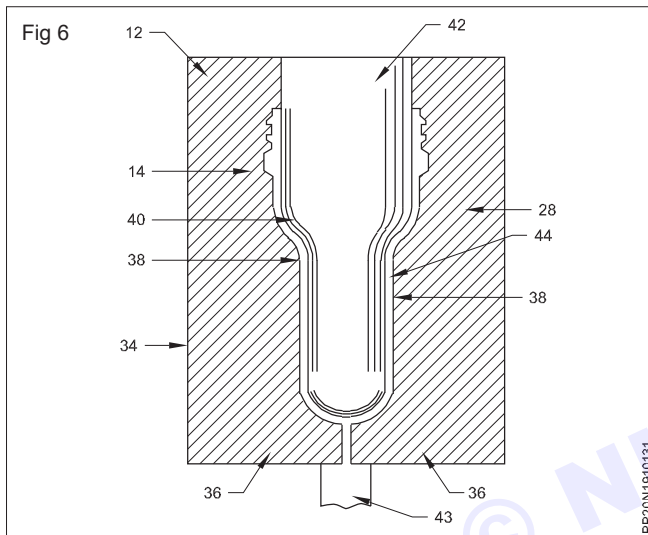
Plastic	Melt temp °C	Stretch orientation temp °C	Max stretch ratio
PET	250	88 - 116	16
PVC	199	99 - 116	7
PAN 8	210	104 - 127	9
PP 168	121 - 136	6	

Advantage of SBM

- Lighter moldings of comparable rigidity.
- Moldings have higher transparency & gloss.
- Moldings have reduced permeability
- Moldings show greater precision
- When made by injection stretch blow techniques are free weld seams and bottom beads. Increased bursting strength.
- The technique allows the use of thin walled components with no decrease in strength.
- Reduces material costs.

- Allows wall thickness to be more accurately controlled.

Multi layer blow moulding: A multi – layer plastic preform (14) and a method for making the preform with an inner layer (28) that is extrusion blow molded from a resin having an intrinsic viscosity greater than 0.90, and an outer layer (44) that is injection molded around the inner layer from a resin having an intrinsic viscosity that is at least 0.10 less than the intrinsic viscosity of the inner layer. The inner layer (28) is no greater than 20% (preferably no greater than 15%) by weight of the total weight of the preform and the outer layer (44) is at least 80% (Preferably at least 85%) by weight of the total weight of the preform. (Fig 6)



A conductive multilayer blow molding composed of at least two constituent layers of thermoplastic resins, characterized in that at least one of the constituent layers is a layer

- 1 Made of a polyphenylene sulfide resin or a thermoplastic resin composition mainly comprising a polyphenylene sulfide and at least one of them is a layer.
- 2 Made of a thermoplastic resin other than the polyphenylene sulfide resin or a thermoplastic resin composition mainly comprising a thermoplastic resin other than the polyphenylene sulfide resin.
- 3 And at least one of the constituent layers including the above layers (i) and (ii) is made of a conductive thermoplastic resin composition comprising of conductive filler and / or a conductive polymer and a thermoplastic resin as the essential components.

This invention provides a blow molding process for manufacturing multilayer hollow articles having sections different from one another in respect to the kind of resins, different from one another in respect to the kind of resins, number of layers, and thickness of layers along the circumference in the horizontal section of an article with the narrowest of the sections in any one of the resin layers extending in a specified width along the longitudinal wall of an article and being capable of satisfying the sectional performance requirements, an

apparatus, and said hollow articles. It also provides a process for manufacturing multilayer hollow articles with the wall thickness ratio of resin layers in each section varying along the longitudinal wall of an article, an apparatus, and said hollow articles. Hollow articles molded by the process and apparatus of this invention are particularly useful for automotive bumpers, the seats and backs of chairs, and boiler – room doors.

Dip moulding (Fig 7)

Dip molding is the process where a heated form or pattern is dipped into a heated or ambient temperature material. The pattern is normally dipped into molding material multiple times to build successive layers until the desired part thickness is obtained. After the material has cooled or solidified, the molded part is removed from the form or pattern.

Dip molding is a very capable process as intricate and undercut geometries are possible, however design requiring trapped volumes or other features resulting in air pockets should be avoided. Dip molding materials are normally polymer compounds referred to as plastisol. Plastisol is a polymer vinyl compound which is in a liquid state at ambient temperatures. When plastisol is heated to a known temperature, the plastisol material fuses into a durable plastic – rubber like material. After the application of heat energy, the plastisol does not return to the liquid state. Plastisol polymer compounds can be formulated to a wide range of hardness, matte to glossy finish, color, chemical and solvent resistance, or with specific dielectric or other electrical characteristics. Many plastisol compounds are used in applications meeting FDA non toxic standards.

Typical Dip moulding applications

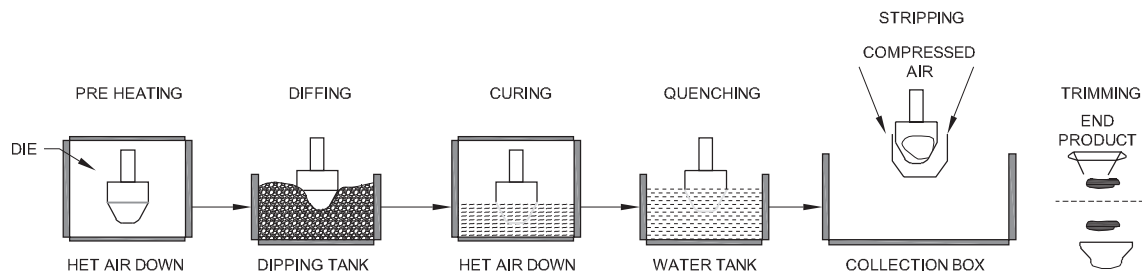
- Surgical gloves
- Hand tool handles
- Caps
- Covers
- Grips
- Plugs

Dip moulding trace its roots to the ancient art of candle making. It is fair to say that the current capabilities in the plastic dip molding industry have increased exponentially. In fact, so many dynamic improvements have been made that dip molded parts are now competing with injection molded parts on design and not just cost.

How dip moulding works

Dip molding is a plastic manufacturing process where by heated metal molds are immersed or “dipped “ in a tank of liquid plastisol. The heat from the mold attracts the cool plastisol and the part is formed around the mold. The molds are extracted from the liquid and run through a baking process to cure the plastisol. From there, the parts are cooled and stripped from the molds in preparation for shipment or secondary operations.

Fig 7



PP20N1910132

So what is so new about dip moulding?: While the basic process has remained the same there have been two major technical advances over the past decade that have expanded the popularity of dip molding as an option for design engineers.

Multi – dipping capabilities were ushered into mainstream products when “dual – walled” beverage can coolers were designed to combine a durable and slick inside liner with an insulating. Cushioned foam exterior. Since then the double and triple dipping process has been utilized for numerous design projects when two or three different materials characteristics are needed for a single product for example, tool companies have designed hand grips with hard inside liners that fit tightly and provide durability while covering the outside layer with more consumer friendly materials that are more comfortable and have a better feel. An added bonus is the ability to make these in different colors and give the product an upscale look.

Material development in the plastisol industry has also evolved significantly in the past decade. Historically, dip molded plastics had been limited to being smooth and shiny in feel and appearance. Advances in the formulation, dipping, and curing processes have led to numerous new materials including both closed and open called foams, textured and matte finish formulations, and materials that simulate the look and feel of suede or expensive rubber compounds.

Limitations of dip molding

The dip molding process is an extremely flexible process in that one set of tooling can make parts with different wall thicknesses and lengths. However, with the exception of internal dimensions, tolerances are often much higher than on injection molded parts. Further, the internal molding process limits exterior design possibilities and control.

Tooling

Dip molded tooling typically consists of numerous metal molds that are affixed to channels or plates. Typically, the more molds one can dip at a time, the lower the piece cost will be. This, however, is limited to the size of the machine on which the parts will be run and machine sizes vary greatly in the industry.

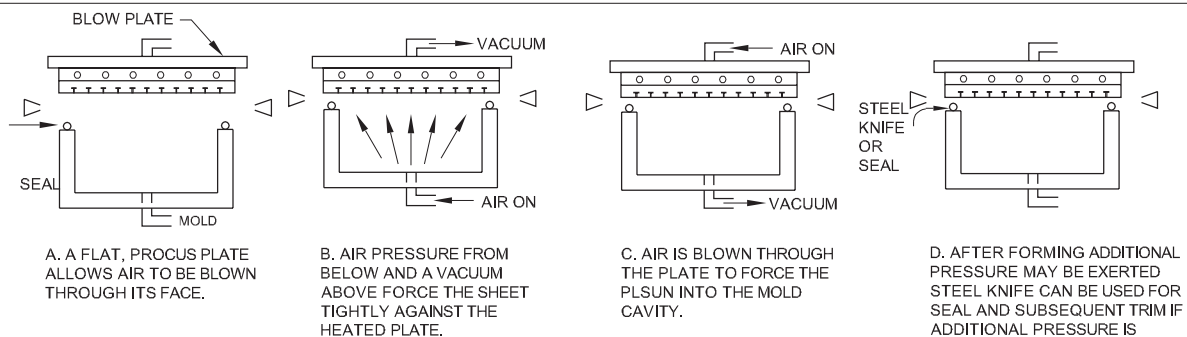
As a general rule, dip molded tooling is less expensive and faster to make than injection molding tooling and this is one advantage that the industry likes to exploit. This is especially true in the case of prototypes where single molds can be used to make actual products in days.

Hot press molding

A matched metal tool is placed between the platens of a hydraulic press and heated to between 130 C and 170 C. The pre – preg or reinforcement material is placed the tool which has a cavity in the shape of the component required. The tool is rapidly closed and the cure is completed within 2 -3 minutes. The tool is opened and the component removed. In order to aid removal of the component from the tool, release agents are either incorporated into the resin mix or applied to the surface of the tool. (Fig 8)

This method uses the various compounds including SMC (sheet Molding compound), DMC (Dough molding compound) and BMC (Bulk molding compound). The compounds use polyester resin, filler, catalyst, pigment and other additives. The fiber pre – forms are typically a sprayed chopped fiber and binder or thermally deformed chopped strand mat containing a thermoplastic binder. This method does allow for a high production rate and is preferred by the automotive industry.

Fig 8



TRAPPED-SHEET CONTACT-HEAT PRESSURE FORMING

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Blow Moulding Troubleshooting

Problems	Possible causes	Suggested Solutions
Rough crystalline surface	1 Overheating of copolymer	1 a. Lower extruder temperature and increase barrel cooling if possible. Try to reduce melt temperature below 400°F (204°C) b. Slow down extruder
Great number of large gels	1 Overheating of copolymer in blow moulder or grinder	1 The suggested solution is the same as above 2 Reduce heat build up in grinder.
Contamination from highly incompatible resins and other sources	1 Resin will not purge out some polymers easily 2 Contamination by foreign material 3 Contamination by decomposed particles.	1 The best plan is to head and thoroughly clean 2 Inspect bags, hopper loader and grinder if used. Take indicated steps to eliminate foreign material. 3 a. Clean die and extruder of any degraded material. b. cool extruder before shut down.
Pock marks, bubbles or streaks in part	1 Moisture	1 Dry resin at 140°F (60°C) for approximately one hour.
Cloudy or hazy part	1 Contamination 2 melt temperature too high or too low 3 Mould temperature too cool	1 Same as contamination problem above. 2 Correct melt temperature to 360-390°F (182- 199°C) 3 Adjust mould temperatures to approximately 75°F (24°C)
Part dull in appearance	1 Parison necking down 2 Larger part periphery at top	1 a. Program parison. b. Increase extrusion rate. c. Lower melt temperature. 2 Invert mould, if possible.
Poor wall thickness circumferentially	1 Non-symmetrical part shape	1 a. Shape die to increase parison thick thin area. b. Preblow parison. c. Use larger parison diameter.
Parison rupture or part “blowout”	1 Too large a blow up ratio 2 Mould separation 3 Pinch-off too sharp	1. Use larger die tooling. 2. Increase clamp pressure or decrease blow pressure 3. Provide wider pinch-off land.

Die lines	1 Dirty or damaged die	1 a Clean die land surfaces b Nicks or scratches in die or mandrel may need to be removed. c Check for foreign material. d Streamline flow to eliminate holdup in die
Parson "doughnut" formation	1. Mandrel not up to temperature 2. Mandrel too high 3. Die face dirty	1 Allow mandrel to reach equilibrium with rest of system 2. Lower mandrel slightly. 3. Clean die
Parson length variations	1. Cooling to extruder feed zone not turned on 2. Insufficient back pressure 3. Extruder operating erratically 4. Extruder slipping	1. Turn on air/water cooling to feed section. 2. Increase back pressure. 3. Repair extruder. 4. Repair extruder.
Low part weight	1. Wall thickness of parson too thin	1. a. Increase annular opening to make wall thicker b. Make parison faster.
Part weight too heavy	1 Wall thickness of parson too heavy	1 Decrease annular opening to make wall thinner.
Part not fully inflated	1 Blow air pressure inadequate	1. a. Increase annular opening to make wall thicker b. Make parison faster.
Blow needle not puncturing parison	1 Insertion rate too slow 2 Needle stroke too short 3 Needler is blunt	1. a. Increase blow air pressure. b. Check for blocked air lines. 1. Increase pressure to needle cylinder. 2. a. Lengthen stroke if possible. b. Install cylinder with longer stroke. 3. Sharpen needle to ensure good puncture.
Parison collapses inside mould	1 Blow air incorrectly timed	1. Start blow air earlier in cycle.
Thinning or stretching at parting line	1 Low blow pressure 2 Air entrapment	1. Increase blow pressure. 2. Improve mould venting.
Poor weld at pinch-off closing	1 Mould temperature too high 2 Mould closing speed too fast 3 Pinch-off land too sharp	1. Reduce mould temperature to 75°F (24°C). 2. Increase mould "cushion" or decrease mould speed. 3. a. Widen pinch land. b. Dam up pinch-off relief to thicken pinch weld
Warping	1 Insufficient cooling 2 Non-uniform cooling due to air entrapment 3 Cooling differential in thick and thin areas.	1. a. Provide good water flow in moulded channel b. Increase cooling time. 2. Increase good venting. 3. Improve wall distribution.

Common causes and remedies

Objective: At the end of this lesson you shall be able to

- **determined the product defects**
- **determined the causes**
- **rectify the remedies.**

Intermittent (Accumulator) method: In this method, the extruder runs continuously. A chamber, called an accumulator, gathers and retains (accumulates) a substantial volume of well plasticized melt that is delivered by the extruder as the previous part is being blown and cooled. Once the required amount of hot plastic has accumulated and the mold is ready, a plunger or ram forces the melt out through the die head to form the parison (Fig 1, 2)

The intermittent or accumulator method is widely used to make large industrial parts, ranging from municipal waste containers to leaf blower housings (Fig 3,4) A benefit of the intermittent or accumulator method is that it allows the delivery rate of hot plastic from the die head to be independent of the delivery rate of the extruder. The extrusion of resin into the accumulator chamber is relatively slow compared to the extrusion rate of the parison by the ram. Accumulator capacity determines the

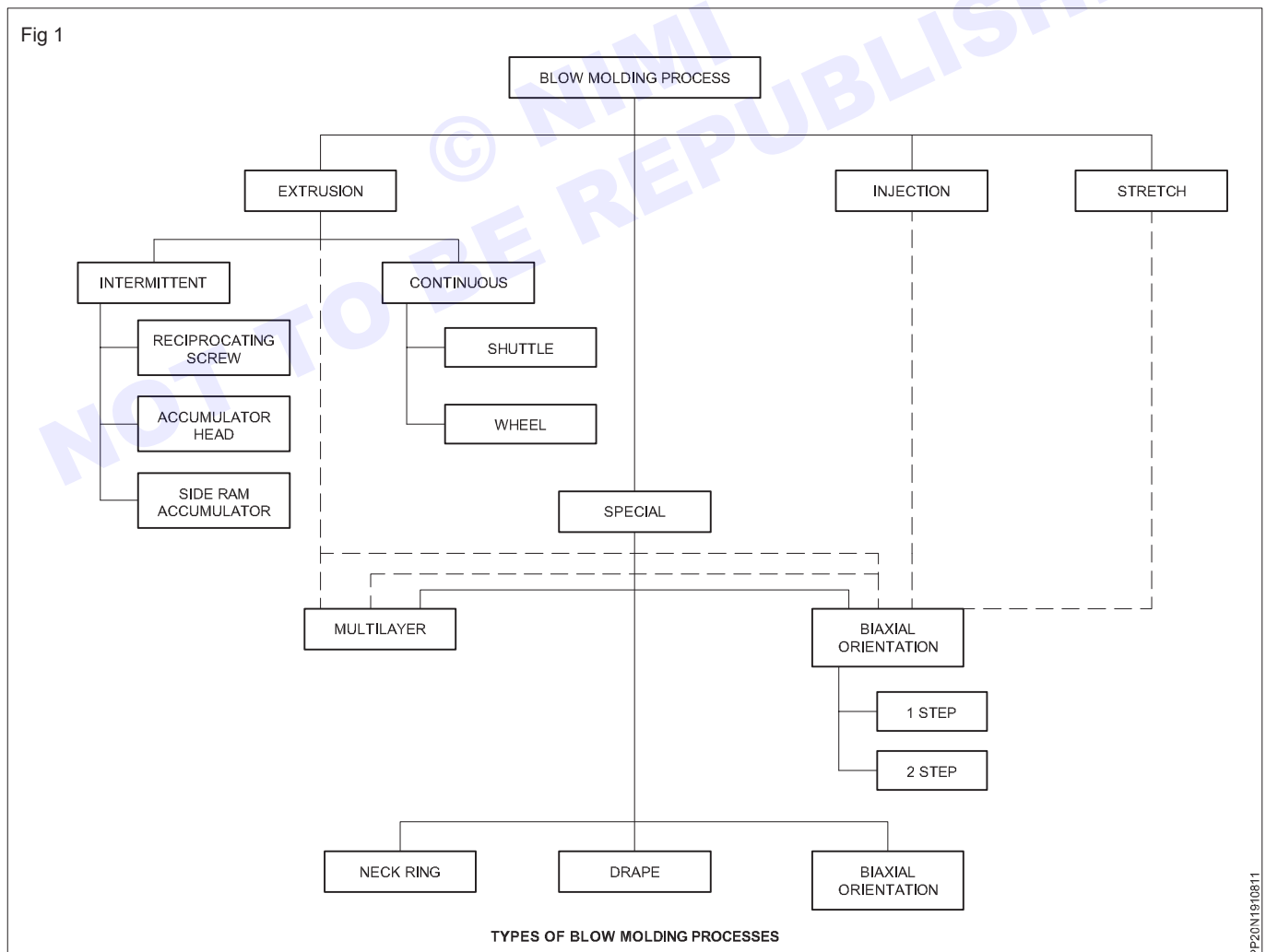
maximum size of large blown parts. A large accumulator may hold enough plastic melt to make a parison for a 150 – 1b (68 – kg) part.

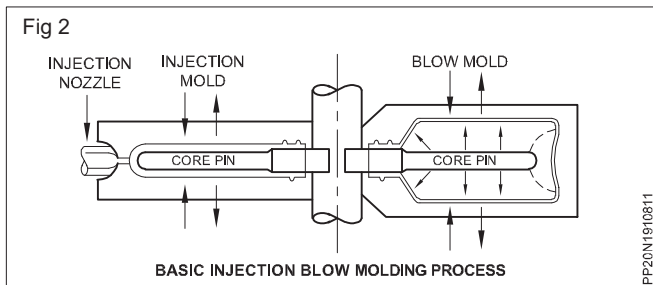
The advantages of an accumulator are: It holds a large volume of melt for large items requiring very long (up to several minutes) molding and cooling cycles.

Injection blow molding

Injection blow molding is used to produce a molded parison called a preform. Injection blow molding is usually preferred over extrusion blow molding for making small parts that require high production volumes and closer control of dimensions. The injection blow molding process occurs in two steps: 1 (Injection molding a preform onto a support pin or core, which provides neck threads that are already formed to their required dimensions and (2) blowing the preform still on the support (core) pin to its final shape in a separate mold.

Fig 1

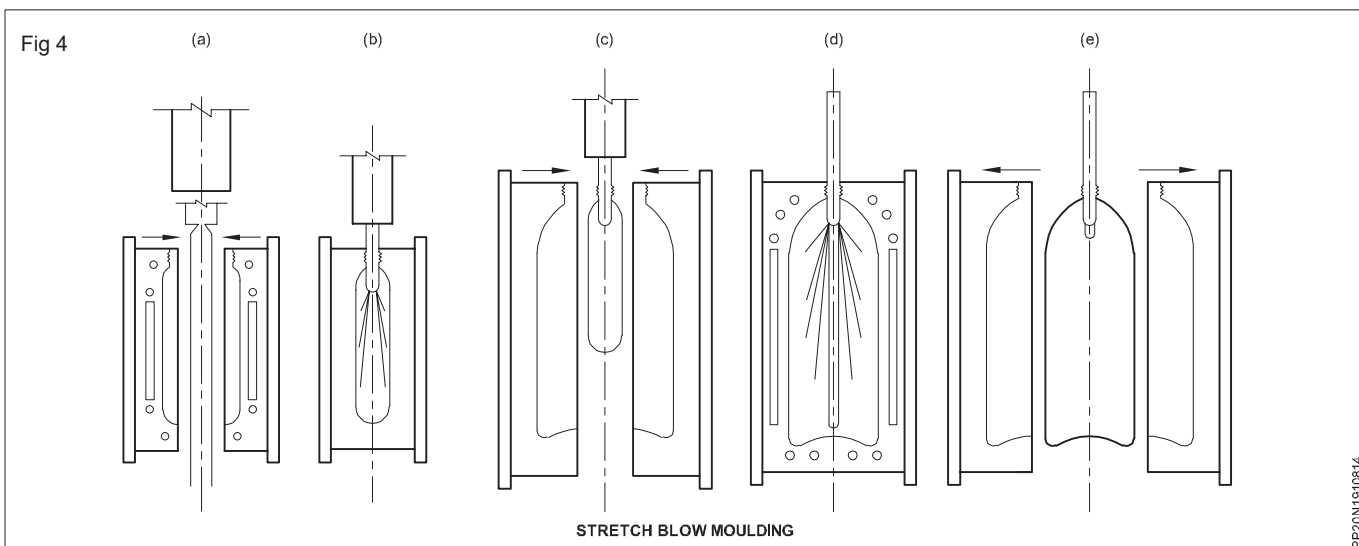
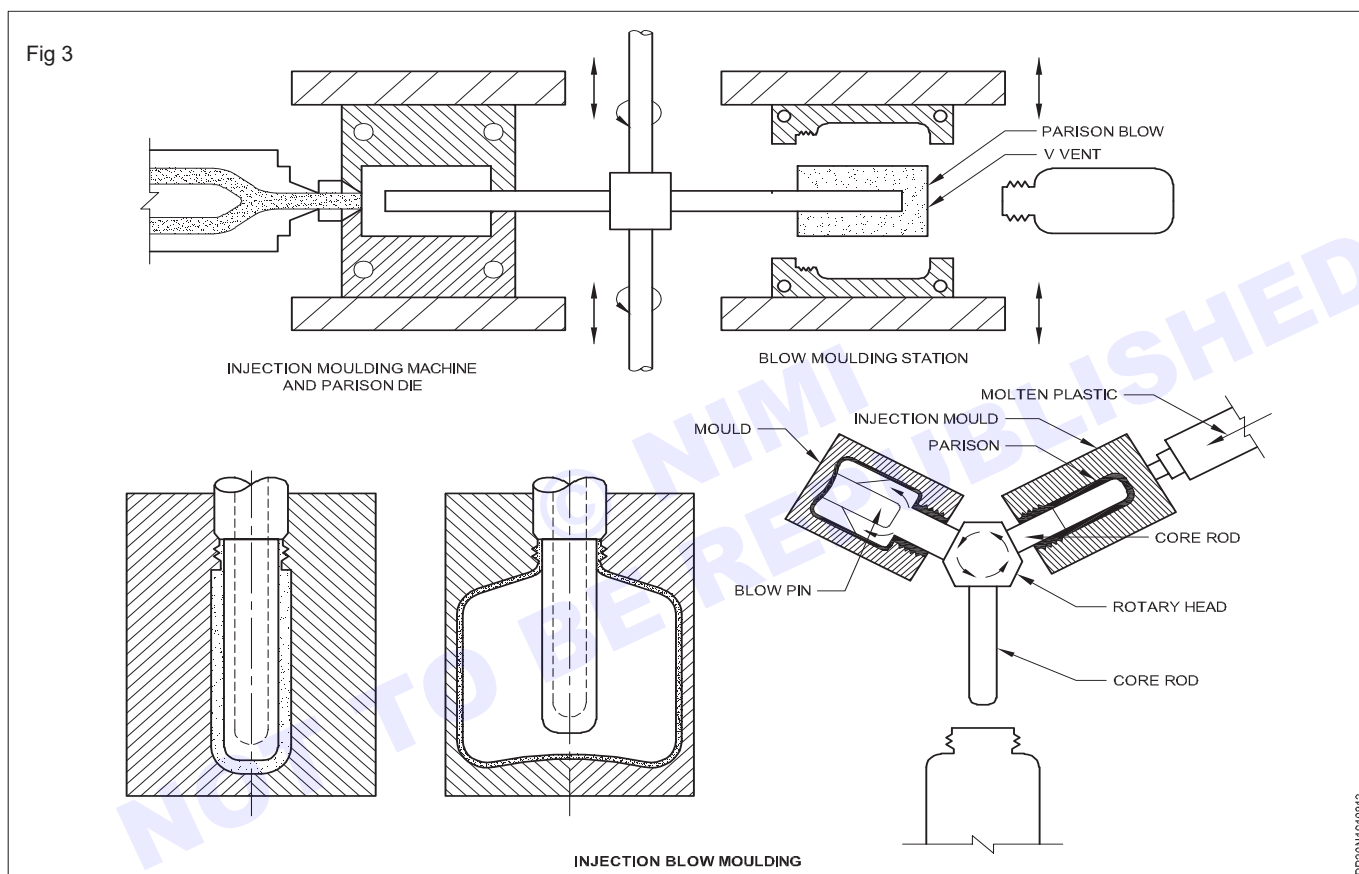




Stretch blow molding: Stretch blow molding is a modification of either blow molding. (referred to earlier as injection stretch blow molding (ISBM) or extrusion blow molding. It involves conditioning (heating) a molded

and cooled preform to a specific temperature, closing it in the blowing mold, then very quickly stretching it in two directions, length and diameter. This biaxially orients the polymer molecules. Often, a rod is used to stretch the hot preform in the axial direction. with air pressure then used to stretch in in the radial direction. Doing this improves impact strength, transparency, surface gloss, gas barrier, and stiffness properties. The four plastics commonly used are polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET) and polyacrylonitrile (PAN), with the most common application for stitch blow molding being the soda bottles made of clear or tinted PET An injection stretch blow molding machine is shown in (Figs 3 & 4)

Blow Moulding Troubleshooting



Introduction about pneumatics

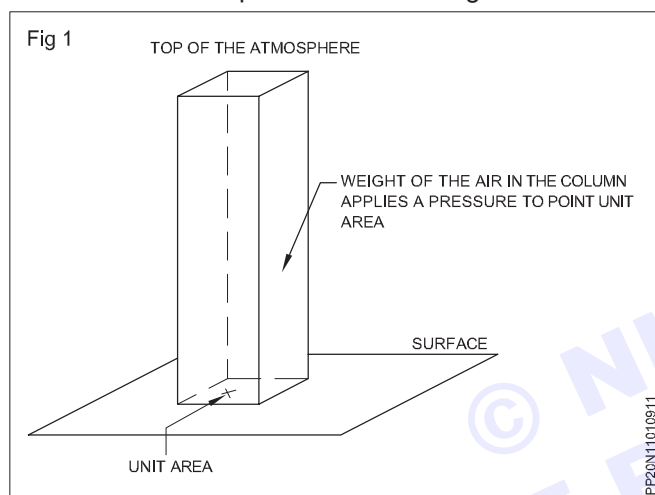
Objectives: At the end of this lesson you shall be able to

- define pneumatics
- state the application of Pneumatics
- list the advantages and limitation of pneumatics.

Overview of Pneumatic

original word PNEUMA is taken from Greek language which means breathing.

Pneumatic system gets compressed air as an energy input then converts it into a suitable work and after that exhaust back to the atmosphere. This process of intake and exhaust is compared with breathing.



Definition: It is the science under which you study properties and application of air.

Common terms used in pneumatics

Pressure

Pressure is defined as the load acting upon unit area. (Fig1)

$$\text{Pressure} = \text{Force} / \text{Area}$$

In pneumatic system three terms related to pressure are commonly used.

Atmospheric Pressure

It is pressure caused by weight of column of atmospheric air acting on the surface

Gauge Pressure

It is pressure value read through an instrument called Pressure Gauge. It indicates pressure value above the atmospheric pressure.

Absolute Pressure

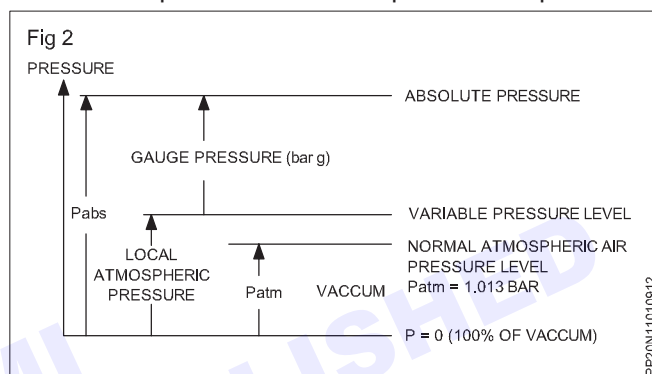
It is the pressure value measured with respect to perfect vacuum.

$$\text{Absolute pressure} = \text{Atmospheric pressure} + \text{gauge pressure}$$

$$\text{Abs Pr} = \text{Atm Pr} + \text{Gg Pr}$$

Fig 2 shows the relation between Absolute pressure, Gauge pressure and Atmospheric pressure.

Units of Pressure: Pressure is measured in Pascal (Pa) in SI unit. 1 pascal = 1 newton per meter square. one



Pascal is the pressure exerted by a force of magnitude one newton perpendicularly upon an area of one square meter...

Example: Pressure = Bar = 1 Kg/Cm² (approx.)

Bar is a metric unit of pressure equal to 100,000 pa (Pascal) standard atmospheric pressure at sea level is 1013.25 mille bar or 101.35 kilo Pascal

$$1 \text{ Bar} = 1 \text{ Kg} / \text{Cm}^2$$

Force

Force is the product of pressure and cross section area upon which force is acting.

$$\text{Force} = \text{Pressure} \times \text{Area} \quad (F = P \times A)$$

Unit of Force: Force is measured in Newton in SI unit

$$1 \text{ newton} = 1 \text{ kg m} / \text{s}^2$$

Flow rate

Flow rate is the volume of air flowing per unit time.

Units of Flow Rate: Flow rate is measured in lpm (Liter/ Minute) or M³/ Hour.

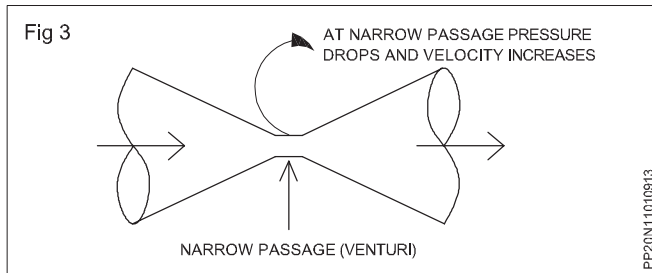
Example: Flow Rate = 10 Liter/ Minute

Or Flow Rate = 50 M³/ Hour

Properties of Air

- Atmospheric air posses certain properties as follows:
- Air is a mixture of gasses. (Nitrogen - 78%, Oxygen- 21%, Other gases, Water vapor- 1% by Volume)

- It contains dust particles and water vapor.
- Air is compressible means it's volume can be reduced.
- Air does not burn itself.
- Volume of air increases with increase in temperature.
- Moisture or water vapor carrying capacity increases with increase in temperature of air or volume of air.
- Pressure of air increases with reduction of volume.
- Air temperature increases with increase in pressure.
- When air passes through narrow passage pressure drops velocity increases. (Fig 3)



Applications: Pneumatic is widely used in many industrial automation applications where fast movements of lesser loads are required.

Pneumatics is used to move load with less efforts, general applications are:

- Push - Pull
- Lift - Drop
- Clamp - Unclamp
- Tilt

Boyle's Law

Robert Boyle (1627-1691), an English scientist, was among the first to experiment with the pressure volume relationship of gas at constant temperature.

Statement: If a given mass of a gas is compressed or expanded at a constant temperature, then the absolute pressure is inversely proportional to the volume.

Pneumatic valves

Objectives: At the end of this lesson you shall be able to

- state the directional control valve
- list the classification or directional control valve
- state the sealing action in valves
- explain the different types of directional control valve.

Valves are the devices used to control, regulate commence, terminate or change direction of flow and pressure of fluid used in the system.

Valves in pneumatics are grouped according to their function. They are

- Directional control valves
- Non-return valves

Pressure $\propto \frac{1}{\text{Volume}}$ when temperature = constant
or $pV = \text{constant}, p_1 v_1 = p_2 V_2$

Advantages of Pneumatics

Pneumatics is popular in industrial applications as Low Cost Automation because of following advantages

- Air is available at free of cost.
- Air is available in unlimited quantity every where.
- Air can compressed, pressurised and can be transported through pipes.
- Air can be exhausted to the environment without any harmful effects.
- Action is fast.
- Speed control is possible.
- System is overload safe.
- Air does not ignite.
- Simple in design and construction.
- Long life and low maintenance
- Components are simple in design and hence cheaper.

Limitations

- Pneumatic system has certain limitations as follows:
- Pneumatic system is economical up to a limit of 3000 kgf force.
- Pneumatics needed fine quality equipment to remove dust and moisture. (Air filters & DE moisture)
- Air exhaust is noisy
- Uniform speed is not possible.
- Special lubrication technique is required to avoid friction between internal components.
- In case of leakage pneumatic system becomes costly.
- Compressing air beyond 7 bar is costlier.

- Pressure control valves
- Flow control valves.

These valves will be discussed in the following lessons.

Directional control valve

Directional control valves are used to control the (1) direction of flow of the fluid, (2) commencement and termination of the flow of fluid. Direction control valve

finds its place in the circuit immediately before the cylinder/air motor.

Classification of directional control valve

Directional control valves can be classified according to the following features by virtue of construction and function

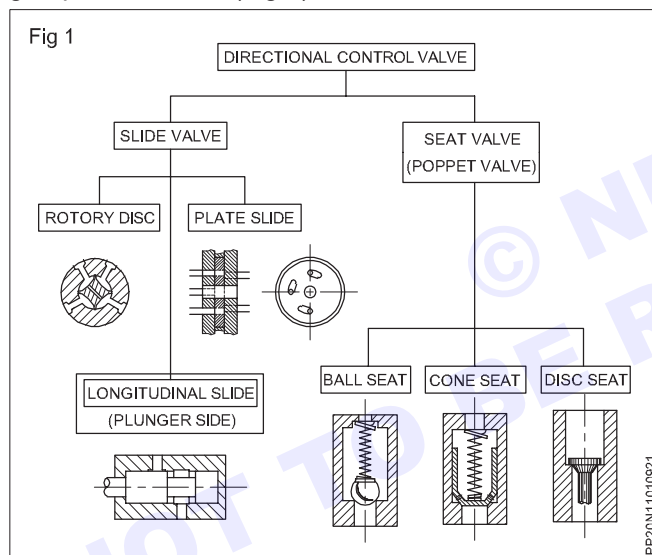
- According to the internal design
- According to the number of ports and position
- According to the valve actuating mechanism.

According to the internal design

The design of the valve even though not affecting the function, plays an important role in terms of

- Life of valve
- Actuating force
- Means of actuation
- Means of connection.

Directional control valves are classified in two major group as shown in (Fig 1)



Slide valves

Slide valves are called so, because the opening and closing takes place by sliding of one of its member. Further in slide valve we have

- Rotary disc valve
- Longitudinal slide or spool valve
- Plate slide valve

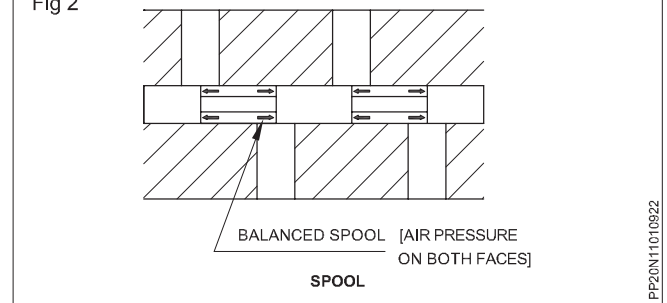
Slide valves are used extensively in pneumatics because of its advantages like.

- Balanced spool (Fig 2)
- Less force required to actuate

However they have their disadvantages also

- A fine finish and accuracy are required for sliding parts
- Sensitive towards dirt in the air

Fig 2



- Length of actuation is more
- Wear and tear is more
- Life is less.

Seat valves

Seat valves are also called as poppet valves. The valve is opened or closed by the lift of seating element.

These valves are further grouped as

- Ball seat valve
- Cone or taper seat valve
- Disc seat valve.

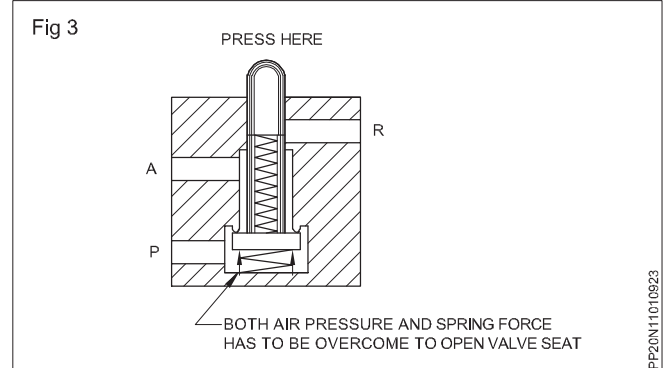
Seat valve are superior in terms of the following

- Wear and tear is minimum
- Actuating length or lift is very less
- Provides leak proof arrangement
- Long life
- Insensitive to dust/dirt

However these valve also have a few disadvantages

- Force, required to operate is more
- Balancing of force not adequate. (Fig 3)

Fig 3



Valve classification according to the number of ports and position

A directional control valve has a number of ports through which air enters and exits.

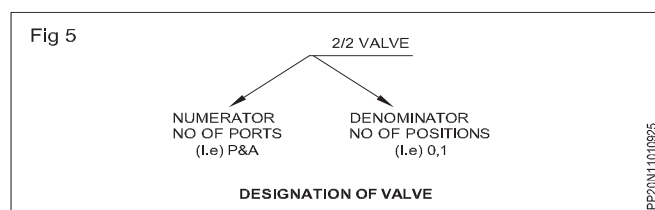
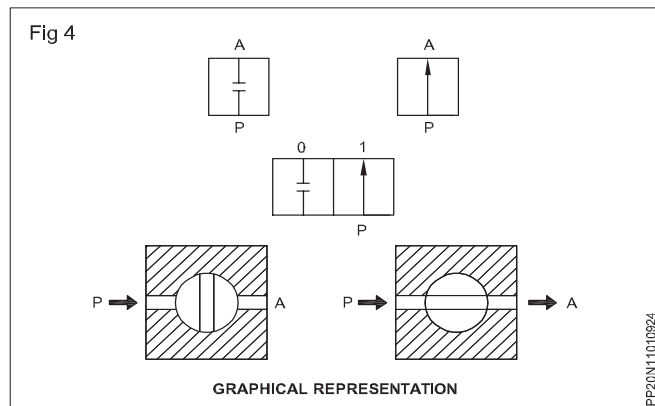
It also takes various position according to flow path of air.

The valve shown has inlet(P) and outlet(A) position (Fig 4)

It also has two positions.

Initial position - No flow. Final position - Full flow. This is graphically represented as one square for each operating position.

Inside this square the path of flow of air is indicated by arrow marks. The valve shown in the Figs 4 & 5 is designated a 2/2 valve.



The ports are named as follows

P - Pressure port

This is to indicate the entry of the compressed air from the compressor into the valve. (which is represented by a square)

A,B,C - working parts

These ports supply air to the cylinder and receive air from cylinder.

R,S,T = Exhaust parts

These are the ports from where used air is exhausted.

X, Y, Z - Control or signal ports.

These ports are used as signal input and signal outputs.

The positions of valves are named as 0, 1 and 2 or 1, 2 according to the type of actuation.

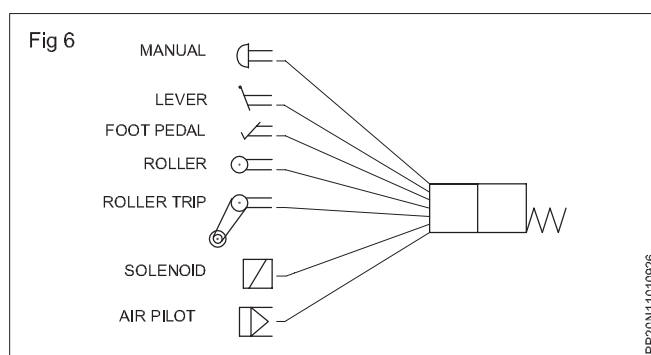
Valve classification according to the type of actuation

The valves have more than one marking position. For the position to change, an external force is required. The method of actuating the valve plays a very significant role to suit the purpose for which the valve is employed. This also determines the level of automation of the circuit. The actuation is grouped into 2 major groups as

- Spring return valve
- Detent valve

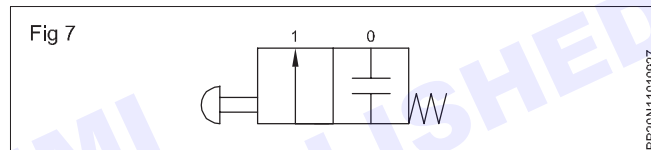
Spring return

In this mechanism the valve always assumes a particular position because of the spring. When operated it changes its position. Actuation of other end may be of the following types. (Fig 6)



- Manual type
- Lever type
- Pedal type
- Roller type
- Roller trip type
- Solenoid
- Pilot operated

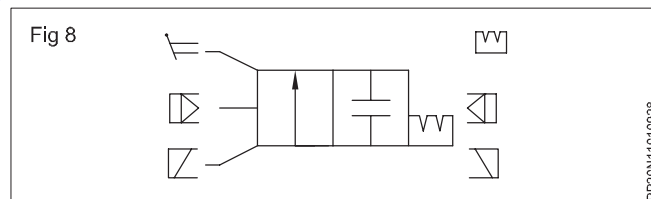
Initial position of a spring return valve is always named as '0' and other position as 1. (Fig 7)



Detent valve

In this mechanism the change of position of the valve is retained (by latch), unless it is actuated, again. This type of valve is called a detent valve.

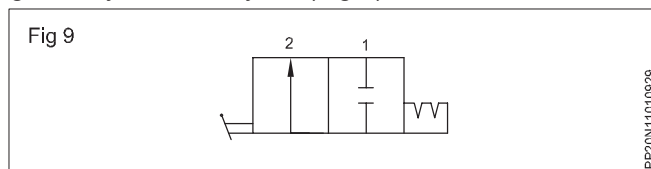
Under this category we have (Fig 8)



- Lever operated
- Impulse operated
- Solenoid operated

The return is also effected by any of the above mechanism.

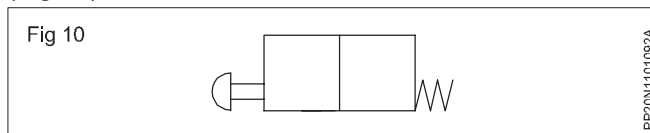
The positions of these detent valves are indicated as 1 and 2 since it does not have a normal position, that is generally denoted by '0'. (Fig 9)



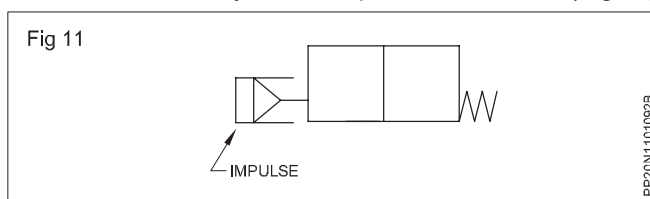
According to the proximity of actuation mechanism from control again actuations can be

- Direct or
- Remote

Direct actuations are hand lever, pedal, roller etc. (Fig 10)



Remote control is by air, air impulse solenoid et (Fig 11)



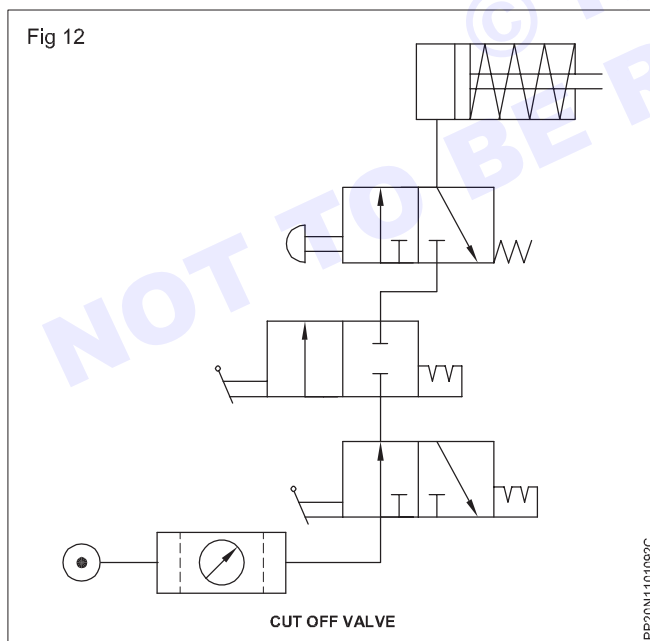
Various types of directional control valve

Here we discuss various types of valves according to their function. The type of actuation and constructions are not considered.

2/2 directional control valve

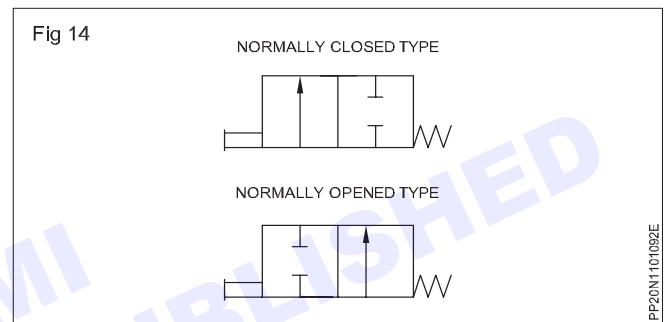
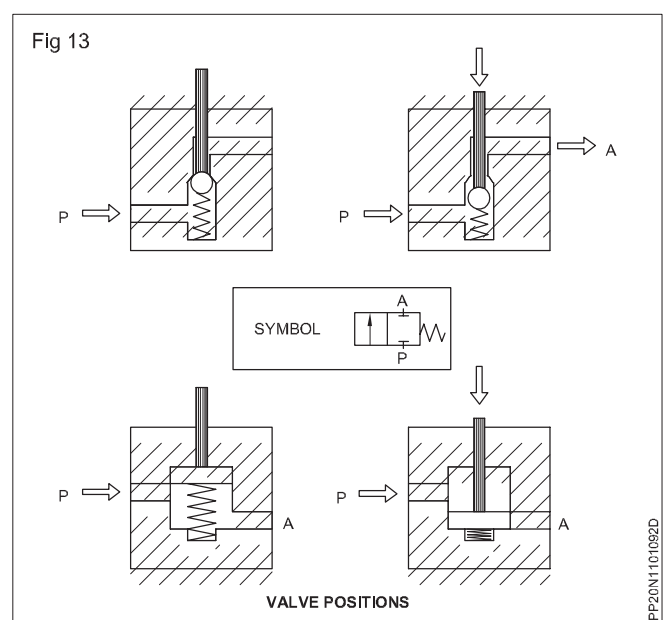
This has 2 ports and 2 positions

This valve normally is used for termination and commencement of air flow. This valve ideally serves as a cut-off valve in circuit. For emergency situations a cut-off valve shown in the circuit diagram, (Fig 12) can stop the cylinder movement, suddenly by cut-off the air supply. The various 2/2 valves according to the internal design are shown in (Fig13) in both normal and operated conditions. These valves can be normally closed type or opened type. (Fig 14)



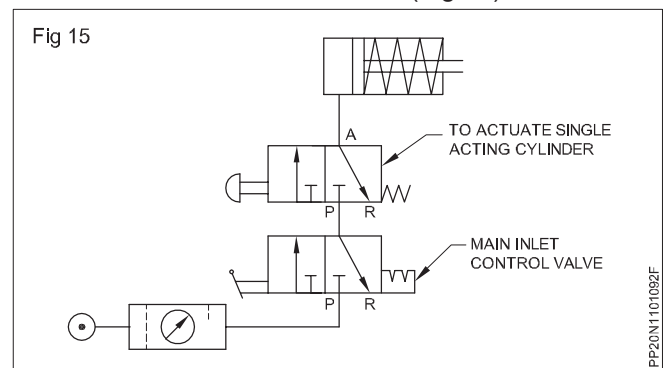
3/2 directional control valve

The main advantage of the 3/2 valve is that it gives vent for the used air through the exhaust port. It has 3 ports P, A and R. This facilitates to generate a signal and also to cancel the signal in the valve as shown in the Fig 15 initial position P is blocked, A is connected to R. In the actuated position P gets connected to A, R gets blocked.



A 3/2 valve is ideally suited for an application of inlet valve, and also for actuating a single acting cylinder (Fig 15).

This valve is also very ideal for remote control of main direction control valves as impulse and pilot type. The construction of various 3/2 valves in normal and actuated conditions are shown in (Fig 15).



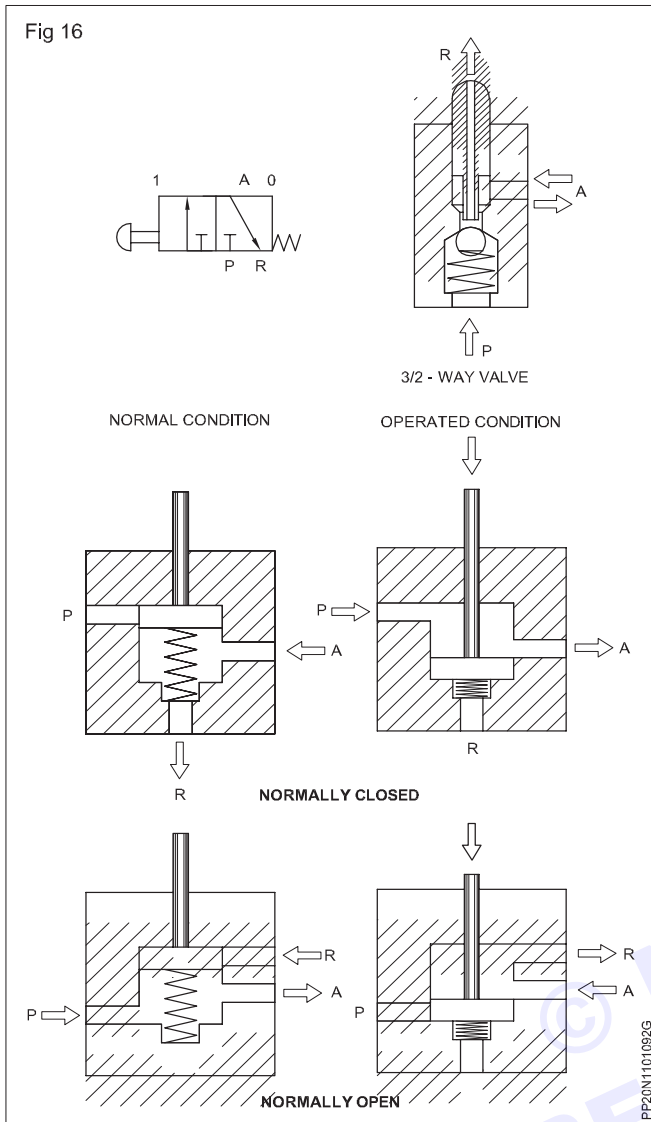
3/2 valves are available as both normally opened type or closed type, which can be selected according to the requirement of the circuit. (Fig 16)

4/2 directional valve

The main application of a 4/2 valve is in actuation of a double acting cylinder. This valve has 4 ports namely

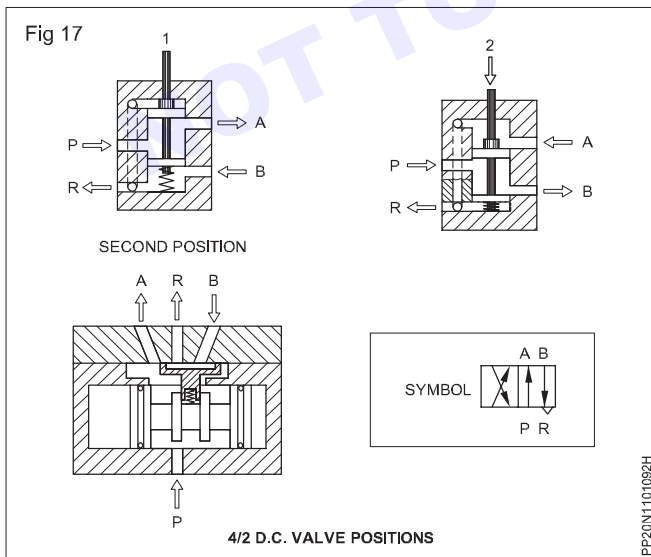
- P - Pressure port
- A & B - Working port
- R - Exhaust port

Fig 16



In normal position (Fig 17) P is connected to A and B is connected to R and vice-versa in the other position.

Fig 17



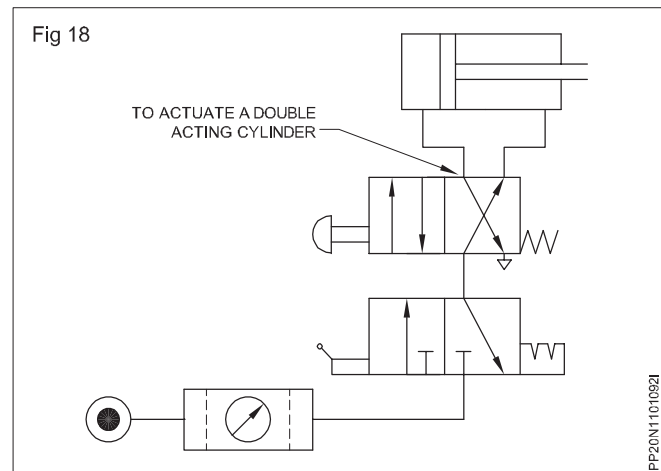
The application of a 4/2 valve to actuate of double acting cylinder is shown in Fig 18.

5/2 directional control valve

A 5/2 directional control valve functions similar to that of a 4/2 valve, to actuate a double acting cylinder. 5/2

valve has the advantage of having separate exhaust paths for forward and retraction motion, thereby the motion can be controlled independently. 5/2 valve also has advantage in its simple manufacturing process. 5/2 valve has 5 ports

Fig 18



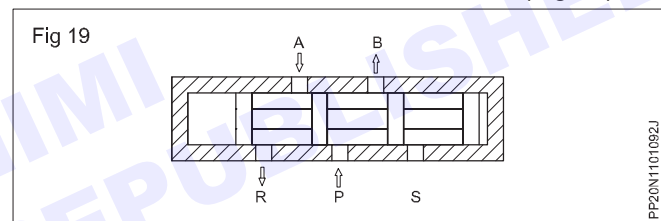
P - Pressure port

A & B - Working ports

R & S - Exhaust ports.

The construction of a 5/2 valve is shown in (Fig 19)

Fig 19



Sealing action in valves

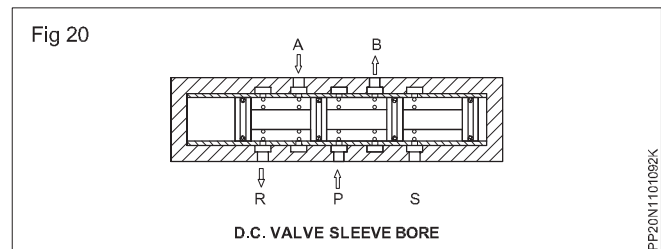
The body of the valve and the seat or the spool should have minimum leakage between them. This is a very important criteria in the design of valves.

The sealing is done by the following methods.

In spool valves

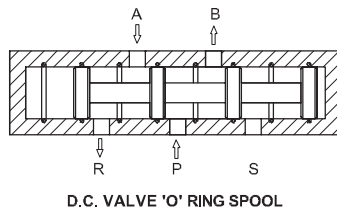
- The bore of the body and spool are matched by super finishing to have a minimum working clearance (Fig 19) and a metal to metal sealing.
- A separate sleeve (Fig 20) is inserted into the body of the valve. The sleeve ID and the spool have a close tolerance, with (Fig 21) 'O' rings on the spool creating a leak proof working.

Fig 20



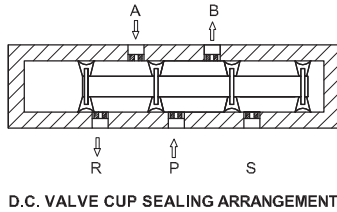
- 'O' ring mounted on the bore of the body (Fig 21) also helps in sealing.
- Cup seats mounted on the spool also helps in having a leak proof (Fig 22) spool movement.

Fig 21



PP20N1101092L

Fig 22

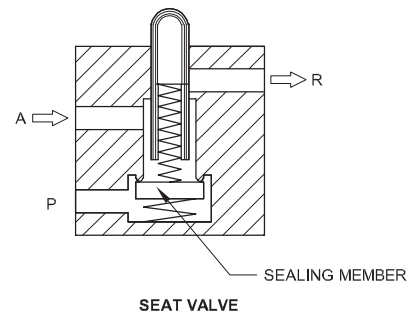


PP20N1101092M

Sealing in seat valve

In seat valves the seat or the disc is usually made of non-metallic substance like rubber, nylon etc., so as to have perfect sealing of the ports. These valves have better sealing compared to slide valves. Hence seat valves are more reliable. (Fig 23)

Fig 23



PP20N1101092N

Pneumatic symbols of components

Objectives: At the end of this lesson you shall be able to

- identify components using ISO 1219 symbol
- interpreted symbol of direction control valve symbol.

Symbol: It is a representation of pneumatic component. Commonly pneumatic symbols are drawn as per ISO 1219 standards.

Symbol does not indicate size of the Component.

It does not indicate orientation or arrangement of inner components.

Symbols use common geometrical shapes which categorize the type of component. The shapes used in general are:

Square: It represents a valve.

Circle: It represents compressor, pneumatic motor and gauge.

Line: it represents piping.

Dimond: It represents filter, dryer, lubricator.

Cylinder: It represents receiver.

Rectangle: It represents cylinders.

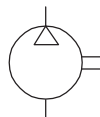
Dotted box: It represents an assembly of various components.

Triangle: It represents pneumatic energy i.e. service air.

Symbol with circle

Unidirectional (Fig 1)

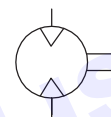
Fig 1



PP20N1101111

Pneumatic motor (Fig 2) bidirectional

Fig 2

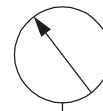


PP20N1101112

Pressure Gauge (Fig 3)

Symbol with diamond shape

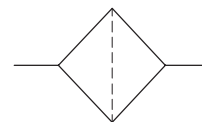
Fig 3



PP20N1101113

Filter (Fig 4)

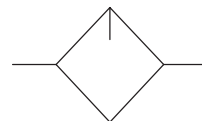
Fig 4



PP20N1101114

Lubricator (Fig 5)

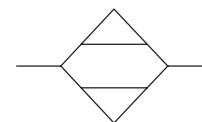
Fig 5



PP20N1101115

Dryer (Fig 6)

Fig 6



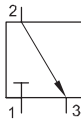
PP20N1101116

Symbol with square

As explained earlier, square means valve. Look at Fig 7 given below.

In this figure, three extended lines 1, 2, & 3 are shown which show that the port means where you connect

Fig 7

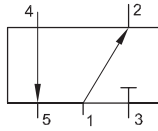


PP20N1101117

pipes. Arrow inside the square shows the path of air flow inside the valve. The figure shows port 1 is closed but port 2 & 3 are connected internally.

In figure 8 there are 5 ports namely 1,2,3,4 & 5 where you can connect pipes. The figure shows that ports 1 & 2 are connected such a way that flow direction is from 1 to 2, similarly ports 4 & 5 are connected in such a way that flow direction is 4 to 5. But port 3 is closed.

Fig 8



PP20N1101118

The port numbering has certain meaning as follows:

Input port: Port where incoming compressed air is connected. It is always "1" and also represented by port "p".

Output port: From where air comes out of the valve is always even number "2" and "4". Output ports are also represented by port "A" & "B".

Exhaust port: From where air is vented to the atmosphere is always odd number "3" and "5". Output ports are also represented by port "R" & "S".

Types of Valves

There are three types of valves used in pneumatic system.

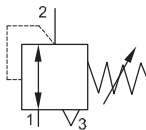
Pressure Valve: Used to control pressure there by force in the pneumatics. It is always represented by single square.

Direction control valve: Used to control the direction of movement of load connected to piston rod; like forward or reverse, clockwise or counter clockwise. It is always represented by combination of minimum two squares.

Flow control valve: Used to control speed of load, in this case square is not used.

Pressure Regulator: Symbol of pressure regulator is shown in (Fig 9)

Fig 9



PP20N1101119

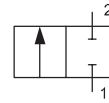
Direction control valves: Look at the symbol shown in Fig 10

In this symbol there are two squares drawn side by side. A square indicates position, thus right square indicate one position and left square other position.

Position refers to status. In the right position port 1&2 are closed, but in the left position both ports are connected.

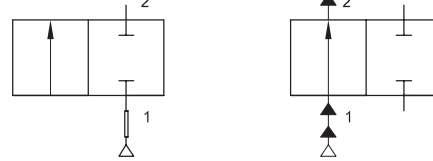
Let us compare the two positions as shown in (Fig 11).

Fig 10



PP20N110111A

Fig 11

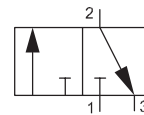


PP20N110111B

In this valve there are 2 ports and 2 positions, hence called two port two position valve or simply 2/2 way valve.

3/2 Way valve: By name it is clear this valve is having 3 ports and 2 position. Symbol is shown (Fig 12)

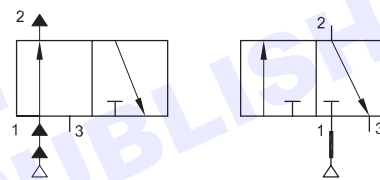
Fig 12



PP20N110111C

Compare the two positions as shown in (Fig 13)

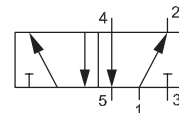
Fig 13



PP20N110111D

5/2 Way valve: By name it is clear this valve is having 5 ports and 2 position. Symbol is shown in (Fig 14)

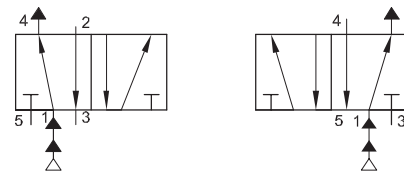
Fig 14



PP20N110111E

Compare the two positions as shown in (Fig 15)

Fig 15



PP20N110111F

Actuation Type

It is a device which indicates how to operate the valve. There are several types available but our scope is limited to following types.

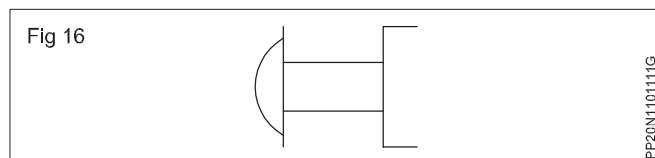
- Manual Type
- Mechanical Type
- Pilot Type
- Solenoid Type

Manual Type

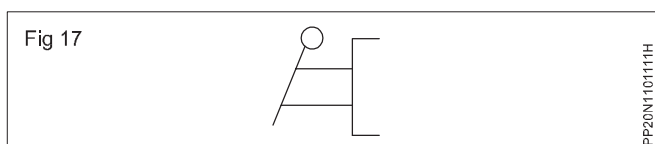
This mechanism is operated by a person, like

- Push Button
- Lever
- Foot pedal

Push Button: It is a button type device when pressed by operator valve actuates (Fig 16)

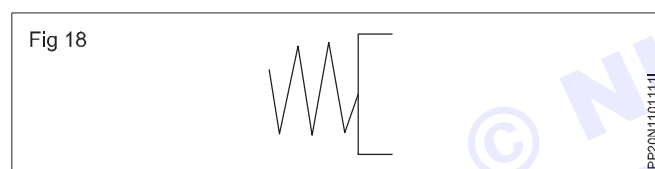


Lever: It is a handle type device when pressed by operator valve actuates (Fig 17)

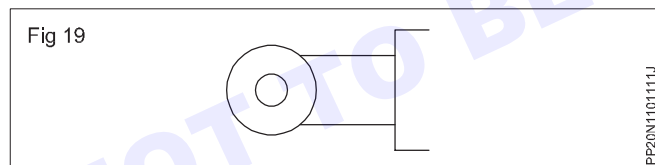


Mechanical Type: Valve is operated by some mechanical force.

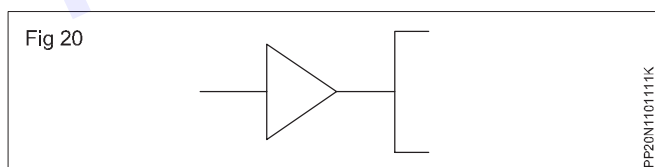
Spring: Common compression spring which actuates valve on de-compression (Fig 18)



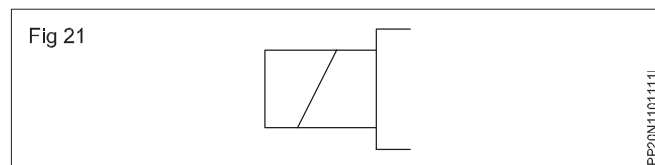
Roller: It is like a lever with small wheel type device when pressed by some object valve actuates (Fig 19)



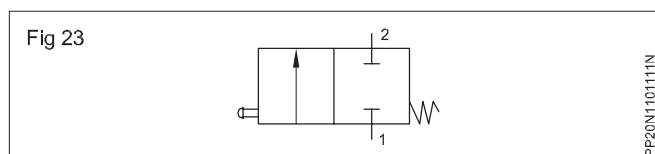
Pilot: It is air operated type (Fig 20)



Solenoid: IT is electrical operated type (Fig 21)



Symbol



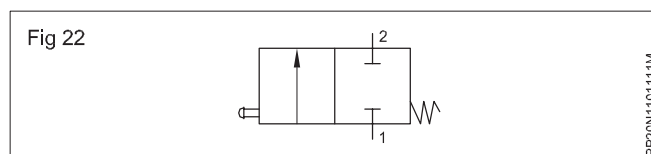
Identifying the direction control valve

To identify direction control valve follow the procedure given below.

- Identify number of ports.
- Identify number of positions.
- Identify actuation mechanism.
- Observe air flow path in the symbol, in each position.

Observe the symbol given in (Fig 22)

In the (Fig 22)



- No of ports: Two (1 & 2)
- No of positions: Two; (2 Squares)
- Actuation methods: Push Button (at left side), spring (at right side)

Write this information in the format given:

-----Port----- Position-----operated-----return

So you get:

2 port 2 position push button operated spring return Direction control valve. Whenever you observe spring in the symbol it means "Normal" position exists. Normal position refers to predominant unactuated condition.

In the symbol shown in Fig 22, right side position is achieved due to spring when there is no force applied on push button, means right side position is the normal position.

It is important to note that whether input port (1 or p) is open or closed in normal position.

If input port is closed, we say normally closed valve.

If input is connected to output port (2,4 or A, B then we say normally open valve:

In the symbol shown above, in normal position input port is closed therefore valve is normally closed valve.

We can rewrite complete designation of the valve as follows:

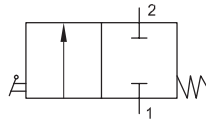
2 port 2 position push button operated spring return normally closed Direction Control Valve.

Lets try to identify valves given in the next pages. (Fig 23 to Fig 59)

Designation

2 port 2 position push button operated spring return normally closed Direction Control Valve.

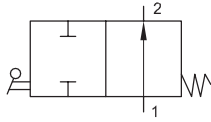
Fig 24



PP20N110111O

2 port 2 position lever operated spring return normally closed Direction Control Valve.

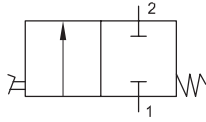
Fig 25



PP20N110111P

2 port 2 position lever operated spring return normally open Direction Control Valve.

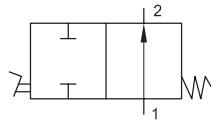
Fig 26



PP20N110111Q

2 port 2 position foot pedal operated spring return normally closed Direction Control Valve.

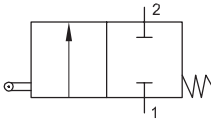
Fig 27



PP20N110111R

2 port 2 position foot pedal operated spring return normally open Direction Control Valve.

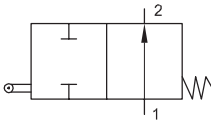
Fig 28



PP20N110111S

2 port 2 position roller operated spring return normally closed Direction Control Valve.

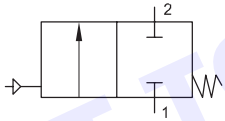
Fig 29



PP20N110111T

2 port 2 position roller operated spring return normally open Direction Control Valve.

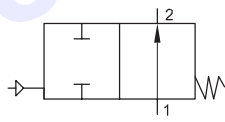
Fig 30



PP20N110111U

2 port 2 position pilot operated spring return normally close Direction Control Valve.

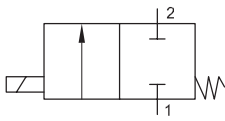
Fig 31



PP20N110111V

2 port 2 position pilot operated spring return normally closed Direction control Valve.

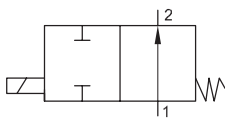
Fig 32



PP20N110111W

2 port 2 position Solenoid operated spring return normally closed Direction Control Valve.

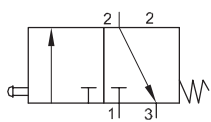
Fig 33



PP20N110111X

2 port 2 position Solenoid operated spring return normally open Direction Control Valve.

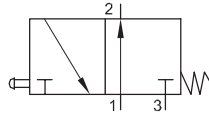
Fig 34



PP20N110111Y

3 port 2 position push button operated spring return normally closed Direction Control Valve.

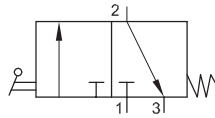
Fig 35



PP20N110111Z

3 port 2 position push button operated spring return normally open Direction Control Valve.

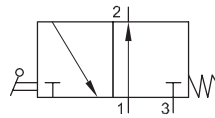
Fig 36



PP20N110111A1

3 port 2 position lever operated spring return normally closed Direction Control Valve.

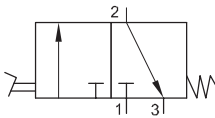
Fig 37



PP20N110111A2

3 port 2 position lever operated spring return normally open Direction Control Valve.

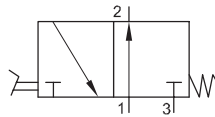
Fig 38



PP20N110111A3

3 port 2 position foot pedal operated spring return normally close Direction Control Valve.

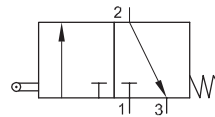
Fig 39



PP20N110111A4

3 port 2 position foot pedal operated spring return normally open Direction Control Valve.

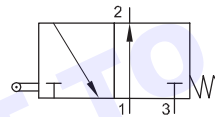
Fig 40



PP20N110111A5

3 port 2 position roller operated spring return normally close Direction Control Valve.

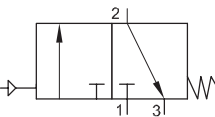
Fig 41



PP20N110111A6

3 port 2 position roller operated spring return normally open Direction control Valve.

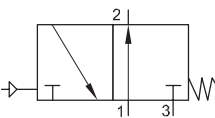
Fig 42



PP20N110111A7

3 port 2 position pilot operated spring return normally close Direction Control Valve.

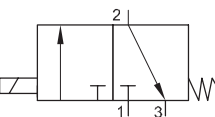
Fig 43



PP20N110111A8

3 port 2 position pilot operated spring return normally open Direction Control Valve.

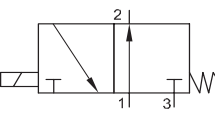
Fig 44



PP20N110111A9

3 port 2 position solenoid operated spring return normally close Direction Control Valve.

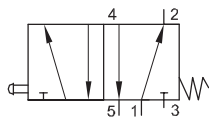
Fig 45



PP20N110111AA

3 port 2 position solenoid operated spring return normally open Direction Control Valve.

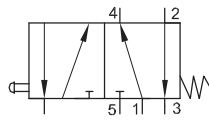
Fig 46



PP20N11011AB

5 port 2 position push button operated spring return Direction Control Valve, normally 1 is connected to 2.

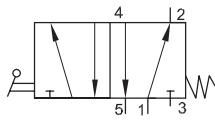
Fig 47



PP20N11011AC

5 port 2 position push button operated spring return Direction Control Valve, normally 1 is connected to 4.

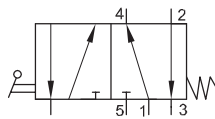
Fig 48



PP20N11011AD

5 port 2 position lever operated spring return Direction Control Valve, normally 1 is connected to 2.

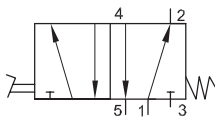
Fig 49



PP20N11011AE

5 port 2 position lever operated spring return Direction Control Valve normally 1 is connected to 4.

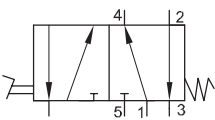
Fig 50



PP20N11011AF

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 2.

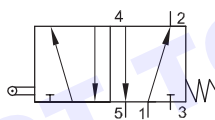
Fig 51



PP20N11011AG

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 4.

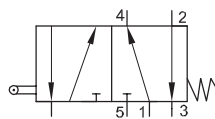
Fig 52



PP20N11011AH

5 port 2 position roller operated spring return Direction Control Valve normally 1 is connected to 2.

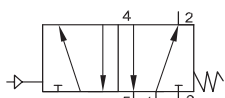
Fig 53



PP20N11011AI

5 port 2 position roller operated spring return Direction Control Valve normally 1 is connected to 4.

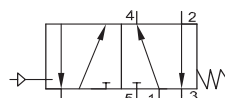
Fig 54



PP20N11011AJ

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 2.

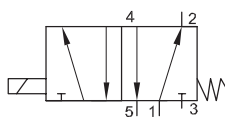
Fig 55



PP20N11011AK

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 4.

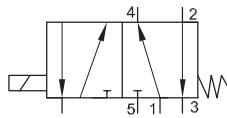
Fig 56



PP20N11011AL

5 port 2 position solenoid operated spring return Direction Control Valve, normally 1 is connected to 2.

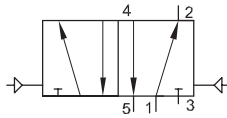
Fig 57



PP20N110111AM

5 port 2 position Solenoid operated spring return Direction Control Valve, normally 1 is connected to 4

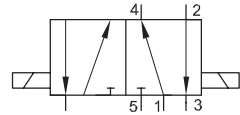
Fig 58



PP20N110111AN

5 port 2 position double pilot operated Direction Control Valve.

Fig 59



PP20N110111AO

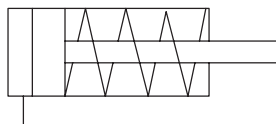
5 port 2 position double solenoid operated Direction Control Valve.

Symbol with Rectangle

In general rectangle is used to represent linear actuator like single acting cylinder and double acting cylinder.

Single acting cylinder (Fig 60)

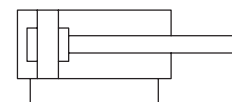
Fig 60



PP20N110111AP

Double acting cylinder (Fig 61)

Fig 61



PP20N110111AQ

Symbol with cylinder

In general cylindrical shape is used to represent air receiver or air storing device (Fig 62).

Fig 62



PP20N110111AR

Symbol with triangle

In general triangular shape is used to represent air source (Fig 63).

Fig 63



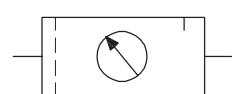
PP20N110111AS

Symbol with dotted box

Symbol shown in dotted box represents assembly of components like FRL, Time delay valve.

FRL: It is an assembly of Filter, regulator and lubricator. (Fig 64).

Fig 64

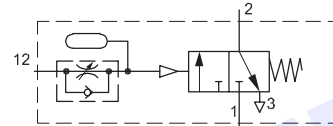


PP20N110111AT

Time delay valve

It is an assembly of flow control valve, 3/2 way valve and an air receiver (Fig 65.)

Fig 65



PP20N110111AU

Other Symbols

Non return valve (Fig 66)

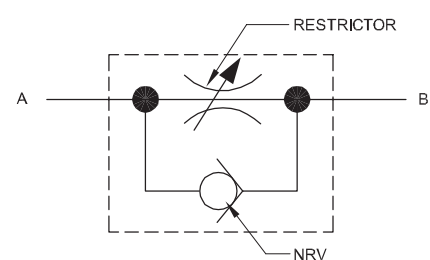
Fig 66



PP20N110111AV

Flow control valve (Fig 67)

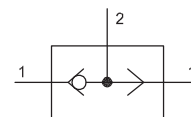
Fig 67



PP20N110111AW

Shuttle valve (Fig 68)

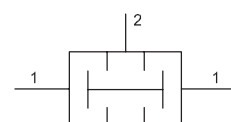
Fig 68



PP20N110111AX

AND valve (Twin pressure valve) (Fig 69).

Fig 69



PP20N110111AY

PPO - Extrusion Blow Film Process

Auto blow moulding machine parts and functions

Objective: At the end of this lesson you shall be able to

- define and state about the machine parts and functions.

Hopper: hopper is a tapered sheer metal enclosure where raw material (plastic) is put. Material from hopper drop into the screw by the action of gravity. (Fig 1)

Parson adjusting bolt: tightened the bolt to adjust the parison wall thickness.

Locking cylinder: used to close the mould, open the mould

Safety guard: close the safety guard allow to continue the process periodically

Guard rod: safety guard process, at once machine start to operate.

Motor mounting plate: motor fixed on this plate

Water cooling: feeding granules safety purpose

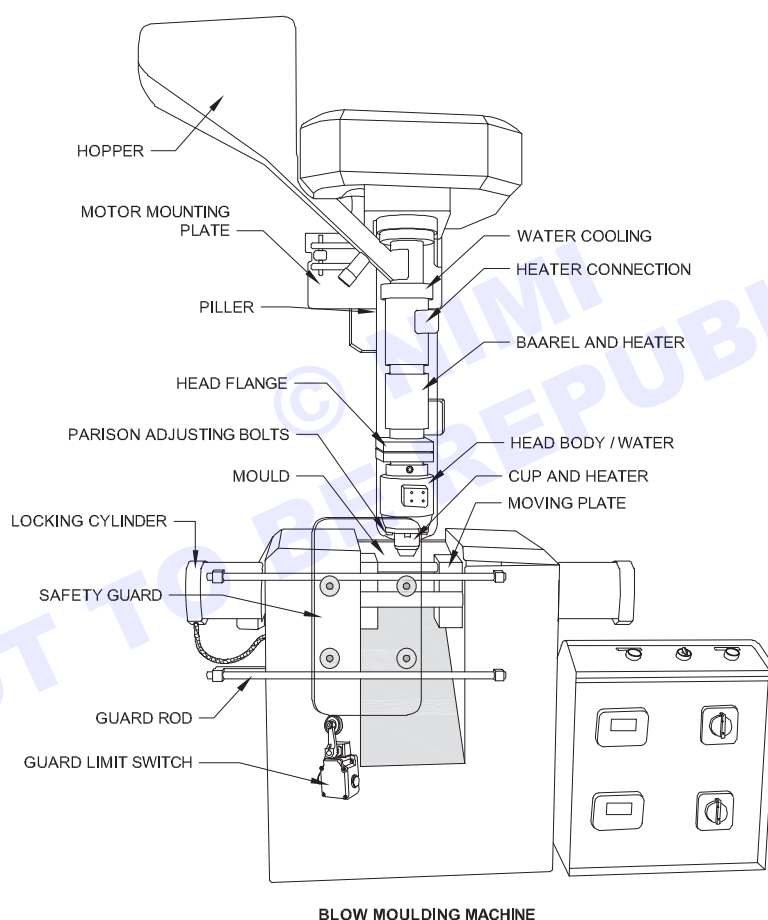
Heater connection: current supply to band heaters

Pillar: support for motor and hopper

Barrel heater: heater gives temperatures to plasticised plastic material inside of the barrel and screw.

Mould: mould is fixed on the moving plate.

Fig 1



PP20N1111211

Cycle of auto blow moulding process

Objective: At the end of this lesson you shall be able to

- list the stages of the blow moulding process.

There are many ways to make blow moulded plastic parts, but they all have the following stages in common

- Plasticizing (melting) the resin.
- Production of the parison (extrusion) or perform (injection)
- Inflation of the parison or perform followed by cooling in the mould.
- Injection of the parison or perform followed by cooling in the mould.
- Injection of the part from the mould.
- Trimming or finishing the part (the trim steps is frequently) performed while the other steps are cycling.

Faults, causes remedies of blow molding

Objective: At the end of this lesson you shall be able to

- state faults, causes remedies of blow molding.

S.No	Faults	Causes	Remedies
1	Bend parson	Improper die centering	Die should be centered properly
2	Longitudinal flow lines	a Dirty die and die head b Edge of the die damaged	a Clean die and die head b Check for the burrs on edge of the die
3	Dull internal surface	a Less melt temperature b Unpolished rough mandrel	a Increase melt temperature b Polish mandrel
4	Dull external surface	a Less melt temperature b Less die temperature b Rough die	a Increase melt temperature b Increase die temperature c Polish mandrel
5	Poor gloss	a Parson temperature too low b Resin MFI too low	a Raise stock temperature b Use higher MFI resin
6	Holes in Product	May be due to material contamination	Check for material contamination

Preventive maintenance of blow moulding machine

Objectives: At the end of this lesson you shall be able to

- know about the machine maintenance.

Personal protective equipment

Personal protective equipment commonly referred to as "PPE" is equipment worn to minimize exposure to hazards that cause serious work piece injuries and illness. These injuries and illness may result from contact with physical, electrical, mechanical or other work place hazards.

Personal protective equipment may include items such as gloves, safety glasses and shoes, ear plugs, hard hats, respirators or coveralls, vests and full body suits.

PPE and their uses and hazards

Hazards	PPE to be used
Falling objects striking against objects spatter	Helmets
Hot spatter	Leather leg guards
Dust particles vapors, gases	Nose mask
Heat burn due to direct contact electric shock	Hand gloves
Flying dust particles	Goggles
High noise level	Ear plug Ear muff
Hot particles	Leather aprons

Extrusion process

Objectives: At the end of this lesson you shall be able to

- describe the processing in extruder
- list types of extruders and their operations
- list the application of extruders.

Equipment & Machinery

An extruder is used for continuous melting, blending, forming and solidifying the plastics into a desired shape. The cross section of the profile formed will be constant. Varying cross-sectional profiles cannot be machined using an extruder.

Construction of an extruder (Fig 1)

An extruder has the following parts

- 1 Barrel
- 2 Screw
- 3 Hopper
- 4 Motor & Gear Drive
- 5 Thrust Bearing
- 6 Heating & Cooling
- 7 Breaker Plate
- 8 Extruder Die.

1 Extruder Barrel

Barrel is made of high-grade steel and surfaces are hardened. The barrel is heated by heater bands. Some materials emit gases during extrusion, therefore on some barrels a 'vent' is provided to allow these gases to escape to the atmosphere.

Another important dimension is the length to diameter ratio (L/D). Usual values are 20/1, 24/1 and 30/1 which means for one-mil meter dia of extruder barrel, lengths will be 20, 24 or 30 mil meters.

2 The Screw

The screw is considered to be the heart of the machine. It rotates and has a close fit inside the barrel of the extruder. It is made of high-grade alloy steel. The surfaces are hardened and chrome plated to resist corrosion and wear.

It is to find from the screw figure that the channel is deeper in the feed zone than the compression or metering zone. Most screw has three distinct sections, the feed section, the transition or compression and the metering sections.

3 The Hopper

The plastic material is loaded in to the hopper directly from the bags. The material must be dry and free flowing. Many hoppers have an electrically driven feed device. A magnetic grill in the base of the hopper helps to protect the screw from damage by metallic particles.

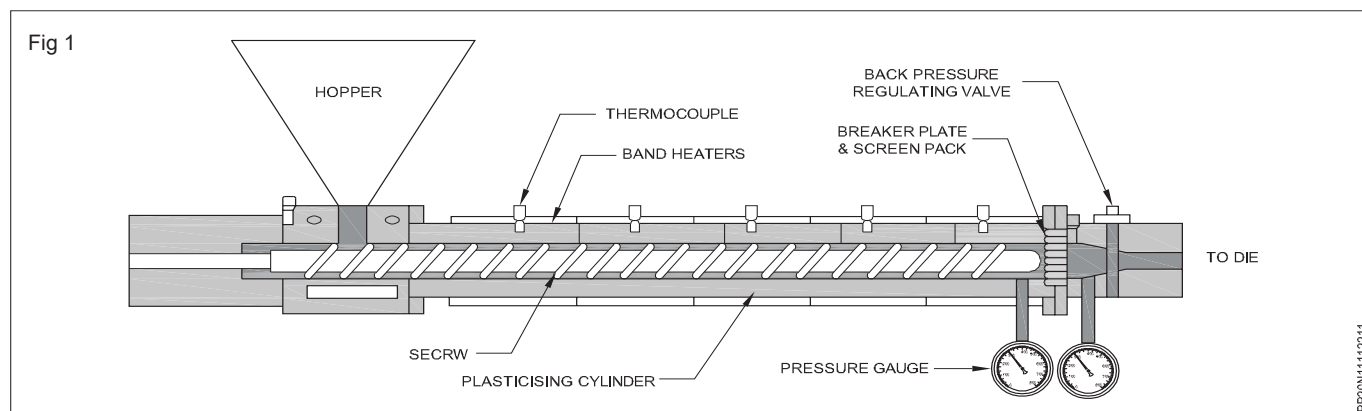
Occasionally the powder or granules will stick to or bridge of the hopper. The hopper throat is cooled by circulating water to avoid bridging or lamping. The hopper must be kept closed by a lid during operation to avoid entering of dust and moisture etc. many hoppers have circulating hot air system or remove moisture from the plastic before feeding.

4 Motors and Gear Reducer

The power to turn on the screw comes from an electric motor through a gear reducer. Modern extruders are fitted with sleeplessly variable speed drives such as a.c commutator or thyristor controlled D.C Motors, to allow precise selection of the screw speed.

The rate at which molten plastic is pumped out of the extruder depends upon how fast the screw is rotated. There is almost a direct relationship between the pumping rate and the screw speed. The drive should operate at a very steady speed to get constant flow of material. Common screw speeds range from 20 to 200 r.p.m. (Rotation per minute)

A gear reducer is used between the motor and the screw. Further reduction in speed comes from the pulleys and belts connecting the motor and gear reducer. Common variable speed unit provides 20 to 1 change of speed.



5 Thrust Bearing

The shank end of the screw fits into a driving mechanism, which is supported in a thrust bearing. To pump molten plastic through a die it is necessary to develop pressure in the melt.

The pressure in the melt also acts on the screw, pushing against the thrust bearing. In many extrusion operations, pressures of 2000 pounds per square inch (PSI) are developed in the melt and thrust bearing are designed to withstand that pressure.

6 Heating and Cooling System

The outside of the extruder barrel is equipped with heating and cooling systems to maintain the barrel at a desired temperature. The electrical resistance heaters are fit around the barrel for which a service of heaters is required.

Heater generally divided into 3 to 5 zones along the length of the barrel with each zone having a separate thermocouple and control instrument.

Thermocouples do the job of a thermometer and measure temperature electrically. By turning a knob of the controller, the operator selects the operating temperature for the controller, the operator selects the operating temperature for the control zone.

Many modern extruders are equipped with a barrel cooling system. Cooling is required when the resin is over heated due to mechanical mixing of the resin by the screw. Cooling systems use either air or water.

7 Breaker Plate

A screen pack and supporting breaker assembly fitted between the barrel and the die adapter performs an important work to change spiral flow to laminar flow and also creates back pressure.

8 Extruder Die

The important part of the extruder is the die, which determines the shape of the extrudate. While the die may be quite complex in design and construction, it is simply a shaped hole through which the stream of plastic melt is pushed out.

It is usually made of hardened steel polished chromium plated and is vulnerable to damage. The molten plastic is flexible and rubbery. Plastic material in a molten state is also very sticky. This means that they flow slowly and therefore requires high pressures. So that die must be very strong and rigid.

Classification of an Extruder

Based on the screws, the extruders are mainly classified into

- Single screw extruder
- Multiple screw extruder (Twin screw)

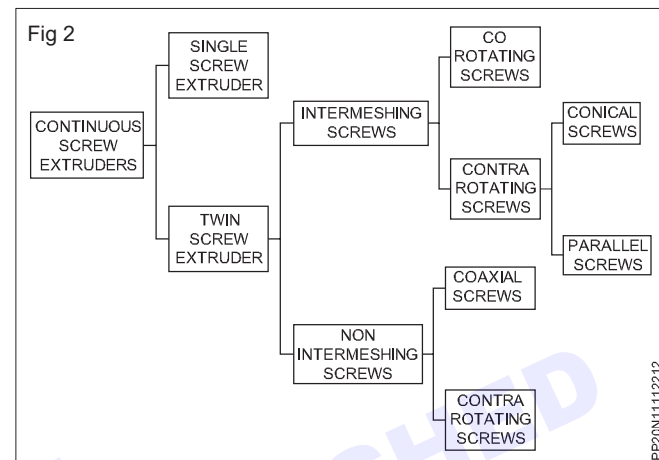
Single Screw Extruder

The single screw machine dominates the extrusion field. It is conventionally used in a types of The main

application of types of extrusion process this type of screw is making different type of products and also for compounding.

Twin Screw Extruder (Fig 2)

Instead of a single screw, it is possible to use two or four screw extruders. They are often used where improved dispersion and mixing are required like in compounding of additives. There has been a steady increase in the use of extruders which use twin screws rotating in a barrel. This permits a wide range of output rates, mixing efficiency, heat generation, etc.



A twin screw extruder can be classified further as follows

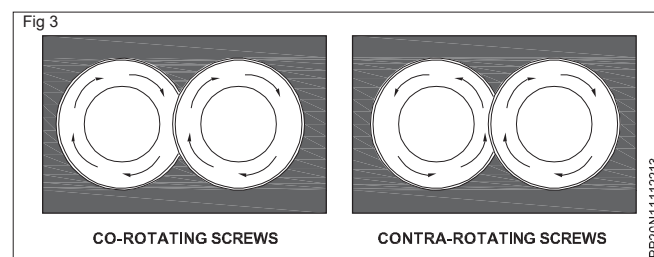
1 Intermeshing screws

In these extruders the two screws intermesh with each other. There is a contact between both the screws. These are divided into two types; Co rotating and contra rotating screws; based on the direction of rotation.

Co-rotating screws rotate in the same direction whereas contra-rotating screws rotate in opposite directions. Contra- rotating screws can be parallel or conical.

ii Non intermeshing screws

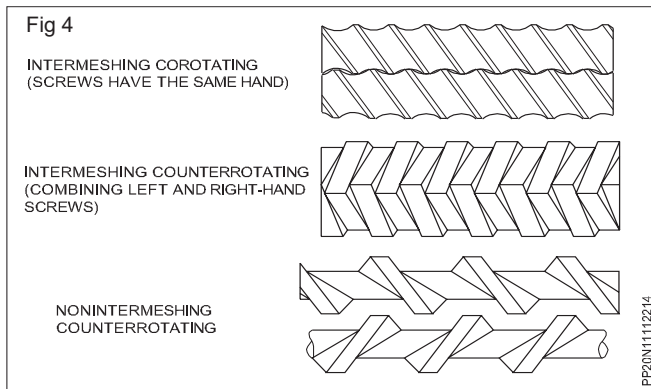
In these extruders the two screws do not intermesh with each other. There is no contact between both the screws. These are divided into two types; Coaxial and contra rotating screws. (Fig 3)



Applications

1 Production of Pipe (Fig 4)

A pipe Extrusion line is shown in fig. The pipe is extruded horizontally. The main plastics used for pipe are polyethylene and PVC. A pipe extrusion line consists of the following uses



Operation of pipe line

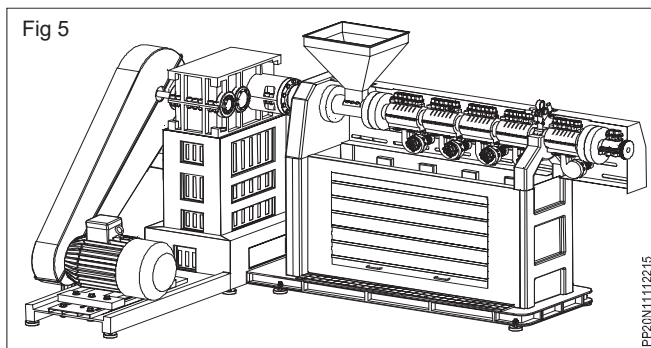
In this process, the melt is forced from the extruder through the breaker plates and out through the opening in the die must be circular or ring shaped, this is achieved by positioning a mandrel in the die opening. The soft pipe immediately after leaving the die is sized or calibrated on the outside diameter, using either pressure sizing or vacuum sizing. Then the pipe comes to the cooling section where it passes through water bath and if necessary water will be sprayed from the top. In this section the finished pipe solidifies to maintain its continuous shape and size. It passes through a rubber padded haul-off unit which will be driven with a synchronized speed. Finally the pipe is cut to the required length either by using circular saw cutter or is wound up in case of flexible tube.

Construction of pipe extruder

The following are the basic parts of construction of pipe extruder

- 1 Extruder with a pipe die
- 2 Sizing unit
- 3 Cooling unit
- 4 Haul off or take-off unit
- 5 Cutter (Saw cutter)

1 Extruder with a pipe die: Generally a single screw extruder is used and an inline pipe die is fitted on the extruder head by using an adapter plate. A suitable diagram of a pipe die is shown in (Fig 5)



2 Sizing Unit

Sizing of the pipe can be done by using the following

- a Vacuum Sizing
- b Extended mandrel method
- c Sizing sleeves
- d Plate sizing

a Vacuum Sizing

It is widely used technique for pipes. This method is based on bringing a mollen tube inside of a vacuum tank. The Vacuum is applied outside of the pipe through the vacuum tank. The air in the tube causes it to expand as a result of the vacuum on the outside of the pipe. Cooling of the pipe by water in the tank can resist expanding further by the vacuum

b Extended mandrel method

The extended mandrel is attached with the center of die During extrusion, the inner diameter of the pipe is controlled over the mandrel. Cooling is given simultaneously to retain the inner diameter of the pipe.

sheet (or) Flat film extrusion line

There are no major differences between the extrusion of fat and sheet The main components of a sheet line are the extruder, the roll stock, the cooling section, the edge trimmer and sheet remover.

c Sizing sleeves

Sizing sleeves are nothing but circular ring, which have arranged in series or in some case a single big ring. When the pipe from the die immediately enters into the sleeve then the outer die of the Pipe is maintained Cooling water supply retains its outer dia.

d Plate Sizing

It is used commonly for smaller diameter flexible tubes and pipes. The plates are positioned at the outlet of die. The outer diameter of the pipe is controlled by the arrangement of series of plates.

3 Haul-Off Unit

It is used to pull the extruded pipe with a uniform or synchronized speed matching with the extruder speed. Haul-off belts are lined with rubber pads to have soft and firm grip of the pipe without damaging the shape of the pipe. It is driven by a separate motor whose speed can be adjusted as per the requirement. It pulls the extruded pipe through the sizing and cooling units and feed it to the cutter.

4 Cutter Unit

The cutter unit is provided to cut the solidified pipe after required length is achieved. It moves with the speed of pipe during cutting so that it maintains the wall thickness by without disturbing the pipe.

5 Production of Blown Film

Material used or upward blown films are LDPE, LLDPE, HOPE, HMHOPE, PVC, PET, Nylon etc. Material used for downward blown films is PP, for producing better clarity

This process is used to make thin films like carry bags. The extruded materials flow through a tubular die (or) an annular die. The resin heated inside the barrel and conveyed to the die which may either be bottom feed (or) side feed.

Components of Blown film production line

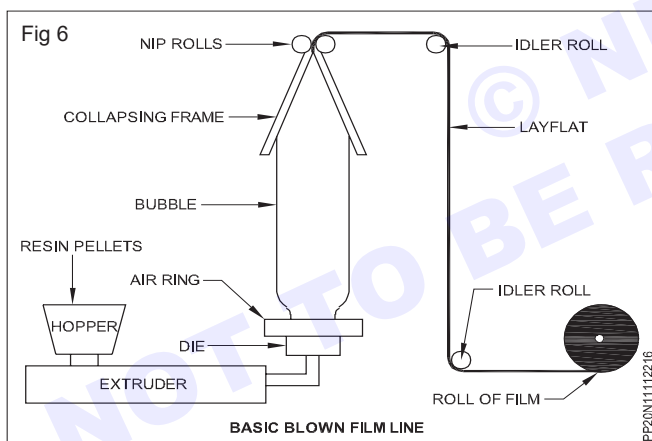
- i Blown film Die
- ii Blown pin
- iii Nip Rollers and Collapsing Frame
- iv Winder

i Blown film Die

The molten materials flows around the mandrel inside the die and is formed into a tube. The die opening normally varying between 4mm and 6.5mm and is adjusted to uniformity soon after the start up. For well balance properties in the film, the die diameter should perfectly be three to six times the screw diameter.

ii Blow Pin

The tube is usually extruded vertically upward and air is introduced slowly through the center of the mandrel from the backside of the die. The air flows and pushes the tube outward, which is called as bubble. The air flowing inflates the tube to the desired bubble size. This is done by the blow pin introduced in the die. (Fig 6)



iii Nip Rollers and Collapsing Frame: The entrapped air is maintained in the bubble by die at one end and nip rolls at the other end. The bubble is forced into a flat sheet by collapsing guides and moved into nip rolls. The nip rolls pinch material together, so that the maintained. The nip rolls also pull on the plastic act as a bubble is puller system. After the nip rollers the film travels down over some more rollers and entrance the take off equipment.

iv Winder : The winder rotates with uniform speed to wind up film. The calibration systems also used to maintain the thickness of the film. In order to ensure a wrinkle free film and uniform wind up of the rolls, it is important that the films produced should be of uniform thickness. The extruder output, die adjustment, internal air pressure, nip roll speed and cooling air velocity are the major factors that affect the thickness and uniformity of the film.

Advantages blown film

- 1 One advantage of the blown film process is that it can produce not only tubular Products (bags) but also flat film, simply by slitting open the tube.
- 2 The advantages of blown film extrusion produce film with a more uniform strength in both the horizontal and vertical (Biaxial orientation) directions.
- 3 In blown film extrusion by balancing blow up ratios against take off rate, it is possible to achieve physical properties which are very nearly equal in both directions and this gives a film of maximum toughness.
- 4 Another advantage of blown film is in bag making, where the only seal is necessary across the bottom of the bag. As in flat film either one or two longitudinal seals are also necessary. No edge trim is required as in flat film.

The main disadvantage is the lower clarity of the blown film but this can be improved by more efficient cooling.

Roll stock

The roll stock contains three rolls that are often referred to as polishing rolls. They are used to exert pressure on the sheet and to impart the surface conditions to the plastic sheet if a smooth roll is used. of the nip rolls to the plastic sheet if a smooth roll is used or any angle between vertical and horizontal. In some roll stocks, the angle is also adjustable.

The rolls are normally cored so that the temp of the rolls can be controlled. This is usually done with circulating hot oil. It should be possible to adjust the temp of each roll separately.

Cooling section

The cooling section consists of a number of rolls positioned in a frame with chilled water input facility. At the end of the cooling section is the pull rolls or nip rolls, These are rubber rolls that pull the sheet from the roll stock to maintain certain tension in the sheet. (Fig 7)

Edge trimmer and sheet remover

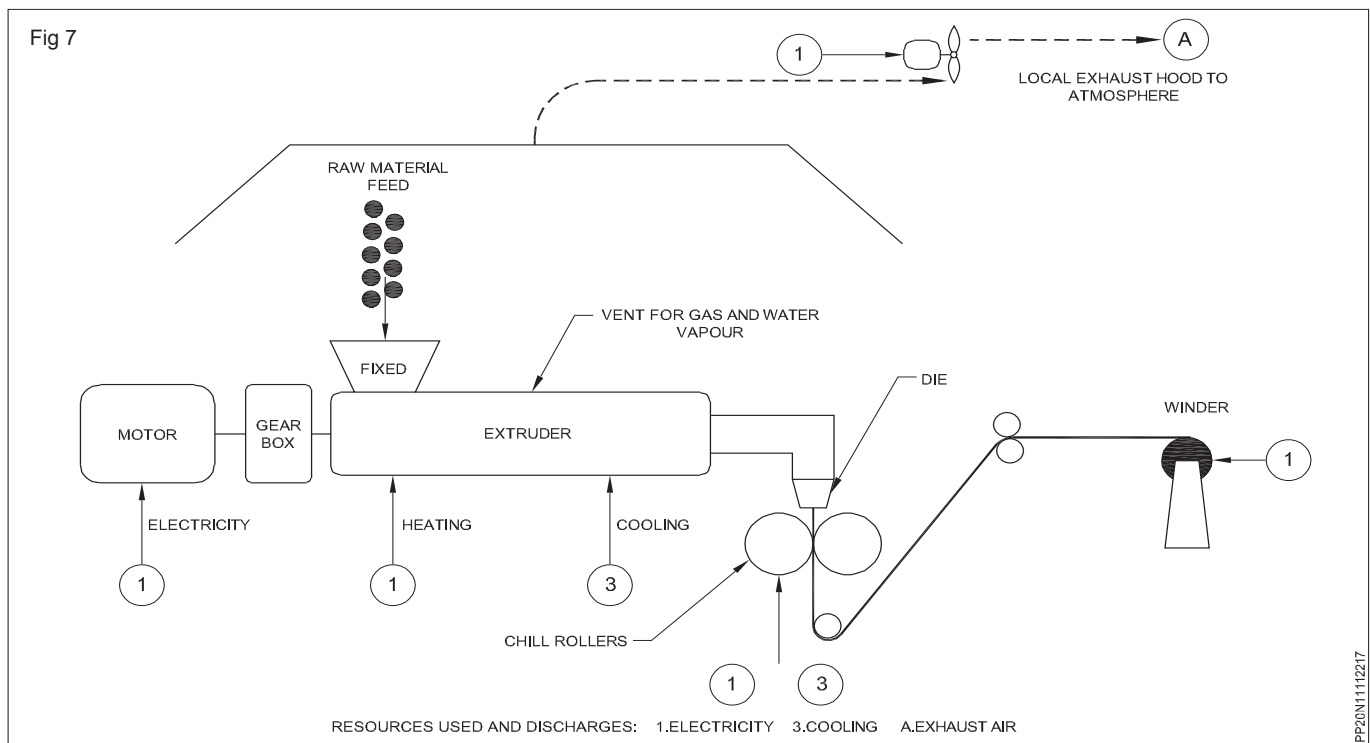
After the nip rolls, the sheet is led to the edge trimmer.

If a textured surface is needed, a textured surface is used on the roll. The roll texture is the negative of the texture required on the sheet. It is possible to produce a sheet with one texture surface and the other smooth by using a smooth and textured roll next to each other.

Fig shows the plastic sheet going up along the centre roll and making a wrap around the Centre roll and top roll. this is called "up stock" operation. The sheet can also run in the "down stock" mode, if the material makes a wrap around the Centre roll and bottom roll. The rolls do not have to be in the vertical position; they can be in a horizontal position.

where unbalanced wall thickness of the sheet (Normally at the edge only) is removed. Then it moves to the cutter unit for preset cutting. It is then removed by sheet removal stock.

Fig 7



Casting

Thin films are often cast on chill roll rather than extruded into a roll stock. The main components of a cast film line are the extruders, the film die, the chill roll unit, thickness gauging system, surface treatment unit and the winder.

Chill rolls Unit

The film is extruded downward onto the chill roll. The initial contact between the film and the chill roll is established by the use of an air knife. The air knife produces a thin stream of high velocity air across the width of the chill roll, the air stream pushes the film against the roll surface as shown in fig.

Thickness gauging unit

From the chill roll unit the film is led to a thickness-gauging unit where the thickness of the sheet is measured across the width of the film. Most thickness gauges for film and sheet have a scanning measuring head that transverse across the film back and forth to measure the thickness both along the length and across the width of the film.

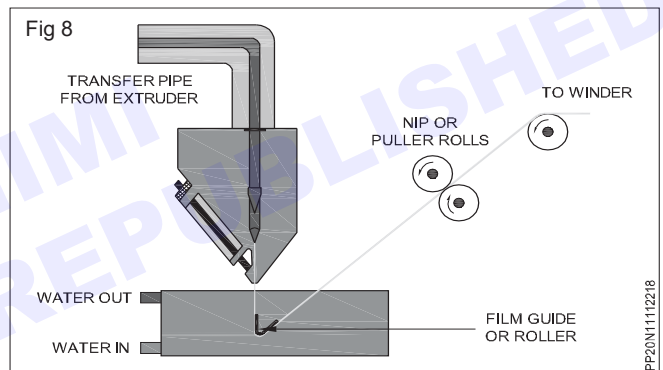
Surface treatment unit (Fig 8)

After the thickness-gauging unit, the film passes through as surface treatment unit. Such a unit is incorporated if surface treatment of the film is required. This is normally done to improve adhesion for instance for a subsequent printing or laminating operation.

The most important adhesion promoters are

- Flame treatment
- Corona discharge treatment
- Ozone treatment
- Primers

Fig 8



Winder Unit

From the treatment unit, the film is used to the winder unit, just as with sheet extrusion, many different types of winders are also available.

Co-extrusion

Co-extrusion is a commonly used technique for processing Two or more different plastics passing through a single extrusion die.

There are two major co-extrusion techniques are available

- 1 Feed block system
- 2 Multi manifold systems

1 Feed block system

In the feed block system the different plastics are combined in the feedback module. It enters into a regular extrusion die with a single inlet manifold and outlet.

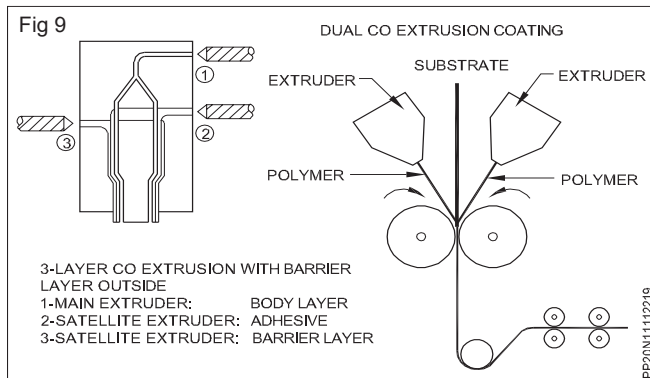
The advantage of feed block system is that it is simple, inexpensive and allows many layers to the combines. The main draw backs is that the flow properties of the

different plastics have to be quite close to avoid interface that can be combined through feed block co-extrusion.

2 Multi manifold system (Fig 9)

In the multi system each plastic has its own entrance and manifold in the co-extrusion die. The different melt streams are combined just before they exit the die. So that minimum interface distortion can occur. In this system even a plastics with widely different flow properties can be combined.

As a result, there is a wide choice of material that can be combined through this extrusion technique “the disadvantage is that the design of the die is more complicated and therefore more expensive.



6 Wire & Cable Covering

The demand for covered wire and cable in the various communication industries is very large and steadily increasing. So this extrusion process is a very important one. Fig illustrates the general layout of a wire coating extrusion line.

Coating is preformed by extruding plastic. This may be accomplished by feeding the wire directly through a hole in the Centre of the crosshead die.

Hot melt is extrudate over a pretreated wire to improve adhesion and reduce shrinkage stresses. Before the wire enters the die, preheating is done by an electric

current, radiant heater and so on. Thick wired or wires or cables can be heated a gas flame or hot gas, in order to achieve uniformity, all peripheral equipment is carefully controlled and manifold from the input drum to the output drum.

Cooling of the thermoplastic-coated wire usually occurs as soon as it leaves the die through water cooling and it winds up continuously in the winder.

7 Coating and lamination (Fig 10)

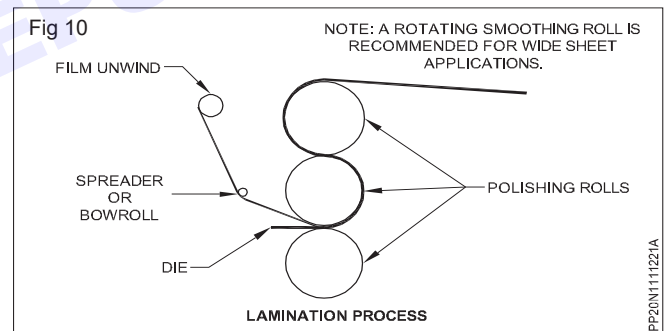
Laminating is the process of bringing two or more materials together and bonding them. There are many variations on the methods for bonding the materials.

The most common is with the use of PSA (pressure sensitive adhesive) as a bonding agent. The adhesive can be applied as ‘transfer tape’ which is adhesive pre-coated onto a release liner (with or without a carrier) or coated directly onto one of the surfaces.

Heat activation is often used to melt the surfaces or thermoplastic adhesive that was previously costed and get the materials to bond under the pressure of the lamination rollers Heat is the method of choice for selective lamination such as sealing bags.

Some materials such as filter papers respond to ‘knitting’ which involves passing the layers between rollers with a raised pattern that forces the fibers together and makes a Bond.

Troubleshooting Common Extruder Problems and Solutions General Considerations.



Trouble Shooting

Problem	Causes	Solution
Surging	Resin bridging in hopper In - correct melt temp Improper screw design. Improper metering length	Eliminate bridging Correct melt temp Check design increases or decreases rear temp. Increases screen pack use proper screw design.
Gels (Contaminants) that look like small specks or bubbles	Melt temp too high Not enough progression in screw. Melt temp is too high.	Lower melt temp. Use new screw. Check resin Quality Check melt temp.

Melt fracture (Rough surface finish also called "Shark Skin")	Melt temp too low. Die gaps too narrow aids.	Increase melt temp & heat die lips Increase die gaps use processing
Bad color	Color concentrate in compatible with resin	Ensures melt index of concentrate base Material is close to melt Index of resin.
Bubbles	Wet material	Dry material thoroughly
Overheating	Overheating Shallow metering section. Improper screw design.	Decrease temp check thermocouple Use proper compression ratio screw. Use lower compression screw.
Die lines	Restriction to flow Barrel temp too low Scratched die.	Check die for restriction Increase temp Refinish die surface
Flow lines	Contamination of polymer Over head material	Clean head and die. Check for dead spots in head temp to prevent freezing. Decrease temp use correct screw
Wrinkles	Poor mixing, contamination, Improper temp profile. Dirty collapsing frame.	Design clean system adjusts profile. Clean frame.
Folds	Too much web tension. Improperly designed air ring. Gauge variations, insufficient cooling. Misalignment between nip rolls and die. Excessive stretching between nip & roller.	Adjust tension. Use new air ring, see gauge variations. Use refrigerated air, increase flow of air reduce output check alignment.
Blocking	Nip assembly drive is not constant. Inadequate cooling.	Reduce winding speed Adjust or replace die. Use better cooling method
Port lines	Excessive winding tension Excessive pressure on the nip rolls. Bad resin. Melt temp too low	Adjust pin tension Adjust pressure check resin Increases melt temp
Splitting	Die too cold or too hot in relation by melt temp. Excessive orientation in m/c direction	Adjust die temp. Increases melt temp

Die lines	Die lines degraded resin Poor resin choice Nick on die lip dirty.	Reduce melt temp Ensure resin is suitable. Change dies clean die.
Gauge variation (m/c direction)	Die inadequate purging. Surging	Increase purging time between resin changes. Check tamp
Gauge variation (Transverse direction)	In - consistent take up speed	Check hopper for bridging check take up speeds.
Printing problems	Non uniform die gap In sufficient treatment. Additives interfering with ink.	Adjust gap Centre air ring on gap. Use properly heated film Use resins with no interfering additives. Frantic treatment reduces 600 RPM for water based inks.
Poor gauge uniformly	Melt flow is not suitable	Use gear pump to stabilize flow.
Viscosity not stable	Viscosity not stable	Use static mixture
Streaks	Contaminated system	Clean chopper, check screw & die.
Total discoloration	Excessive regrind	Check amount of regrind used.
Discontinuous lines	Too much moisture	Increase resin drying use hot re-grinds.
Poor output	Poor output	Ensure die and screw are designed for desired output.
ID blisters	Insufficient vacuum Excessive moisture	Increase vacuum maintain normal % of moisture in the compound. Reduce temp stop water access.
ID burn streaks	Mandrel heat too high Stock temp is too high	Check mandrel, heat reduce, Temp slowly
ID grooves	Mandrel is coated with material	Clean mandrel.
ID way surface	Screw clearance set improperly Puller driving slipping	Adjust clearance, Adjust replace puller drive.
OD burn streaks	Material hung up on die. Temp is too high.	Clean die, reduce temp slowly.
OD uneven circumference	Too much air pressure on puller.	Reduce air pressure check air pressure and all the connection.
CD discolor used	Stabilized level is too low	Check stabilizers level.
OD pock marks	Air bubbles adhering to pipe in floatation tank.	Install wiper in tank.
	Improper adjustment of spray rings that surrounded water tank.	Read just spray rings.
OD over sized	Air supply too high, insufficient water supply.	Adjust air supply increases water supply.
		Allow pipe to cool before measuring.
Wall too thick	Misadjusted die busing	Adjust die busing to achieve uniform
	Wrong die setup	Thickness, use correct setup.

Blown film extrusion

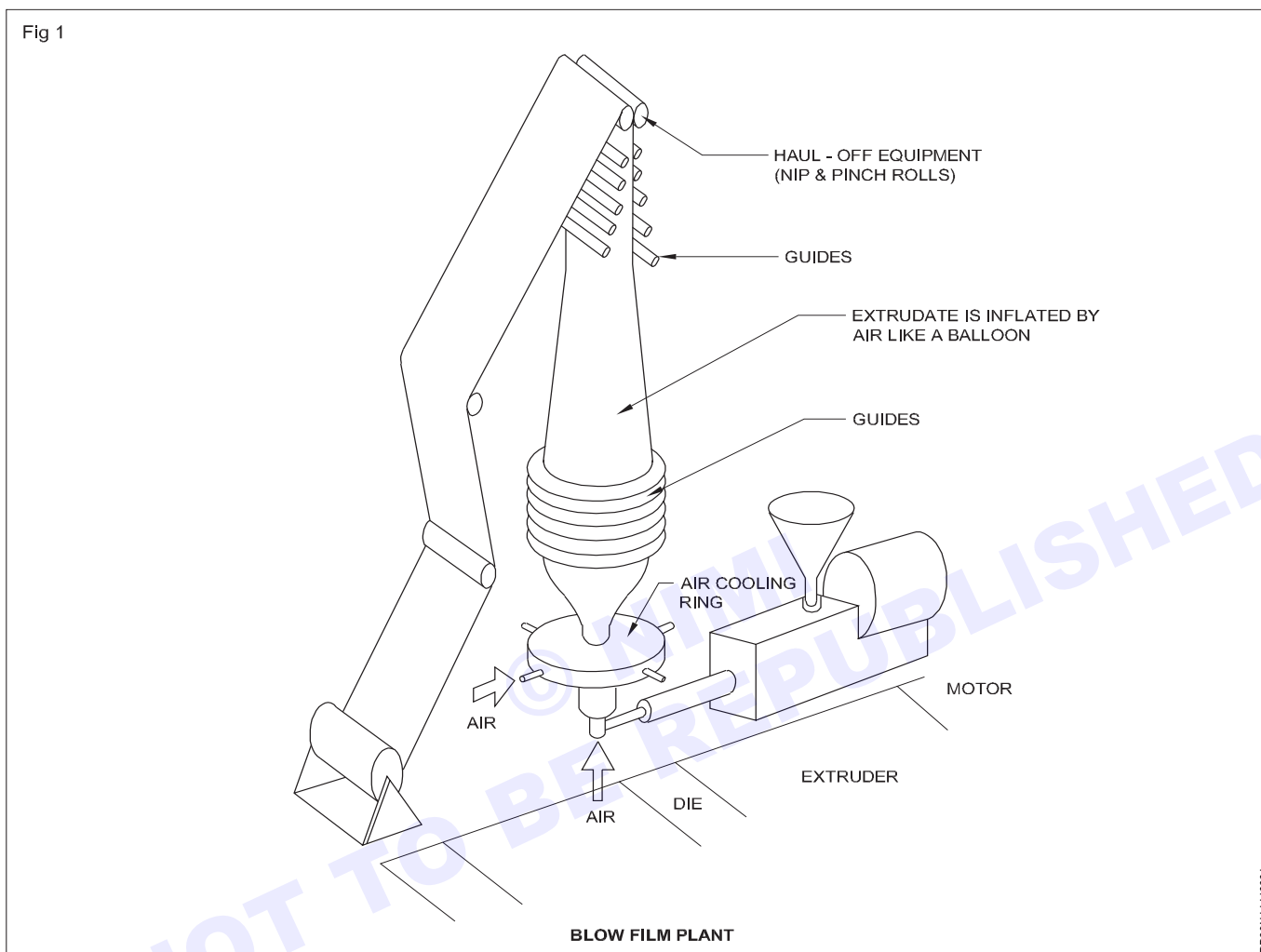
Objective: At the end of this lesson you shall be able to

- explain blown film extrusion set up and working principle.

Blown film extrusion

An extrusion tubular blown film line is shown fig. Film is extruded as a continuous tube whilst still soft is blown

up like a balloon, then cooled, collapsed and would into a roll as a double layer flat film. It is commonly operated in upward direction. (Fig 1)



Blown film plant

Components for the production of thin film for plastic bags or sheeting may look this.

The film leaves the die in the shape of a tube and whilst still soft is blown up like a balloon and then cooled. This too is a continuous process.

The blown film die take melt from the extruder and comes out through a circular opening as a thin tube. If the tube is sealed off and air is passed through the die into the soft tube, which will blow the tube into a bubble. Movement of the bubble is limited by guide rolls. The tube is collapsed in a controlled manner by a frame before the double layer film reaches the nip rolls which prevent air from escaping from the tube and pulled with a uniform speed. The collapsed tube usually is returned to floor level where it is wound on a winder.

Lay-flat width

The size of tubular film is usually described by its lay-flat width. This is the width of a roll of double-thickness film. A tube having diameter 'D' gives a lay-flat width of $\pi \cdot D/2$ or $1.57D$.

Air ring

An important piece of equipment is the air ring which is used for forced and controlled cooling of the molten tube. This forced air cooling allows the film to freeze faster and thus more feet per minute of film can be made.

Blow-up

The diameter of the bubble is larger than that of the die opening. This is called blow-up and the amount of blow-up is calculated as the blow-up ratio. It is the diameter of the bubble divided by the diameter of the die. The blow-up ratio is commonly in the range of 1.5 to 2.5.

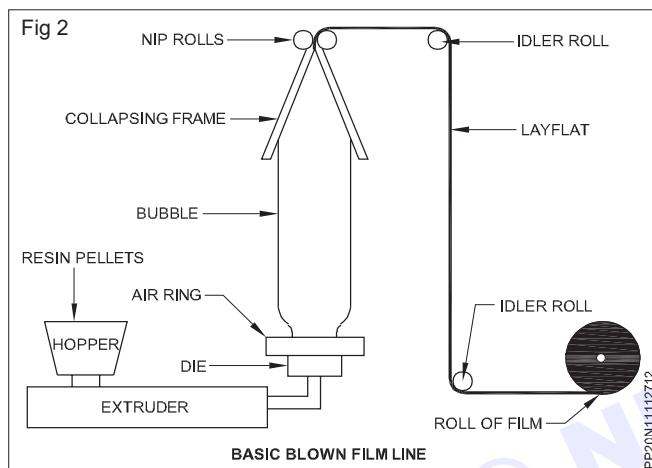
discharger) which changes (oxidises) the chemical nature of the surface of the film so that it will accept the ink.

Important faults, causes and remedies in extrusion

2 Production of blown film

Material used for upward blown films are LDPE, LLDPE, HDPE, HMHDPE, PVC, PET, Nylon etc. Material used for downward blown films is PP, for producing better clarity.

This process is used to make thin films like carry bags. The extruded materials flow through a tubular die (or) an annular die. The resin heated inside the barrel and conveyed to the die which may either be bottom feed (or) side feed. (Fig 2)



Components of blown film production line

- i B 1 Own film die
- ii Blown pin
- iii Nip rollers and collapsing frame
- iv Winder

i Blown film die

The molten materials flows around the mandrel inside the die and is formed into a tube. The die opening normally varying between 4mm and 6.5 mm and is adjusted to uniformity soon after the start up. For well balance properties in the film, the die diameter should perfectly be three to six times the screw diameter.

ii Blow pin

The tube is usually extruded vertically upward and air is introduced slowly through the center of the mandrel from the backside of the die. The air flows and pushes the tube outward. Which is called as bubble. The air flowing inflates the tube to the desired bubble size. This is done by the blow pin introduced in the die.

iii Nip rollers and collapsing frame

The entrapped air is maintained in the bubble by die at one end and nip rolls at the other end. The bubble is forced into a flat sheet by collapsing guides and moved into nip rolls. The nip rolls pinch material together. So that the bubble is maintained. The nip rolls also pull on the plastic act as puller system. After the nip rollers the film travels down over some more rollers and entrance the take off equipment.

iv Winder

The winder rotates with uniform speed to wind up film. The calibration systems also used to maintain the thickness of the film. In order to ensure a wrinkle free film and uniform wind up of the rolls, It is important that the films produced should be of uniform thickness. The extruder output, die adjustment, internal pressure, nip roll speed and cooling air velocity are the major factors that affect the thickness and uniformity of the film.

Advantages blown film

- 1 One advantage of the blown film process is that it can produce not only tubular products (bags) but also flat film, simply by slitting open the tube.
- 2 The advantages of blown film extrusion produce film with a more uniform strength in both the horizontal and vertical (Biaxial orientation) directions.
- 3 In blown film extrusion by balancing blow up ratios against take off rate, it is possible to achieve physical properties which are very nearly equal in both directions and this gives a film of maximum toughness.
- 4 Another advantage of blown film is in bag making, where the only seal is necessary across the bottom of the bag. As in flat film either one or two longitudinal seals are also necessary. No edge trim is required as in flat film.

The main disadvantage is the lower clarity of the blown film but this can be improved by more efficient cooling.

Product	Faults	Cause	Remedies
1 Film	1 Discolored 2 Varying thickness 3 Wrinkles	Over heating Heavy spot on the finishing roll. Asymmetrical Bubble Bubble instability	Check condition & colour of feed reduce the temperature Adjust die opening Try to stabilize the bubble
2 Pipe	1 Uneven thickness 2 Rough surface 3 Porosity 4 Continuous line 5 Oval shape	Die is not centered properly Temperature low Moisture content Damaged die Sizing unit not perfect	Adjust the die Increase the temperatures Avoid moistures by predrying Replace the die Rectify it
3 Profile	1 Depression 2 Dull or matt finish 3 Discontinuous lines across the extrusion	Moisture in material Die temp too low Irregular flow through die	Pre-dry the material Increase the die temperature Adjust the die opening

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PVC compounding and its chemical ingredients

Objectives: At the end of this lesson you shall be able to

- define the basic chemistry aspects of PVC, its properties and application.

Introduction

Polyvinyl chloride (PVC) is obtained by polymerising vinyl chloride. These resins are not suitable for direct processing like polystyrene etc. To confer the required processing and end-use stability, it is necessary to add stabilizers to PVC. Lubricants are also required to facilitate processing. Thus for unplasticised or rigid PVC stabilizers and lubricants are only two basic ingredients.

Special feature of PVC is its ability to accept plasticizers. Plasticizers can be added in various proportions, the softness and processing ease of the compound increases with proportion of plasticizer. The PVC incorporates other additives also like flow promoters, fillers, extenders, colorants etc.

Products from PVC are usually made by

- Injection
- Blow Moulding / Injection Blow Moulding
- Extrusion
- Rotational
- Thermoforming
- Coating
- Colendering
- Compression Moulding

General properties

- It is chemically inert
- It is water corrosion and weather resistant
- It is light in weight
- It can be co-polymerised with variety of materials
- It is tough and dent resistant
- It has good electrical resistance and thermal insulation properties
- It is self-extinguishing.

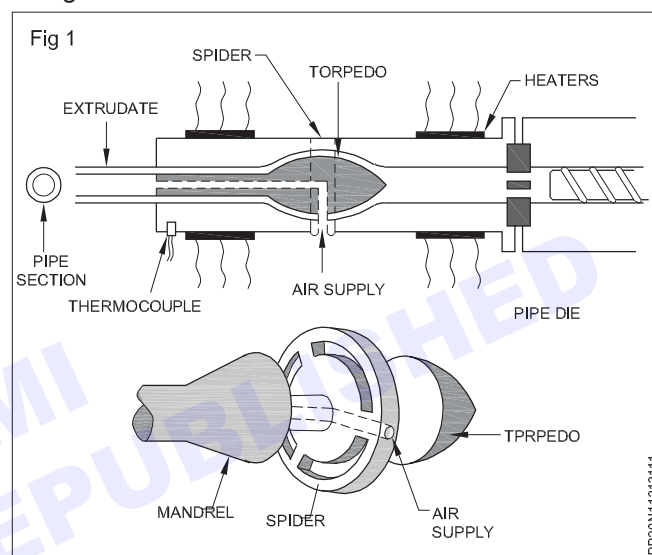
Application

- Principle products from rigid PVC includes pipe conduit, pipe fittings, rainwater gutters etc.
- Flexible PVC is used for raincoats, baby pants, dolls, bottles, shoe soles, wire insulation, film, sheets, draperies, garden hose, gaskets, closures, shower curtains, inflatable toys etc.

Pipe plant extrusion its limits and function

Extruder with a pipe die

Generally a single screw extruder is used and an inline pipe die is fitted on the extruder head by using an adapter plate. A suitable diagram of a pipe die is shown in Fig 1.



Sizing Unit

Sizing of the pipe can be done by using the following

- Sizing plates
- Vacuum sizing
- pressure sizing
- Combination of pressure & Vacuum.

Plate sizing

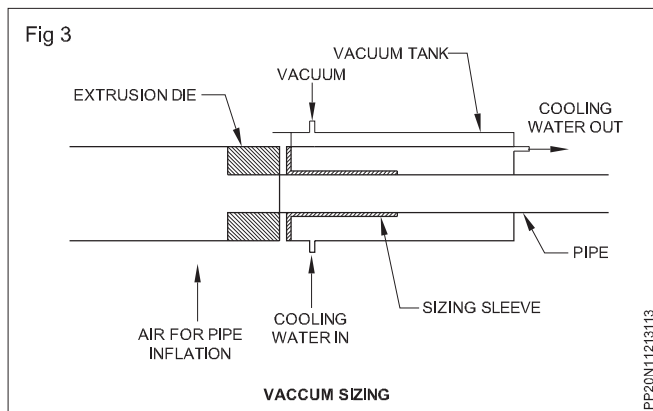
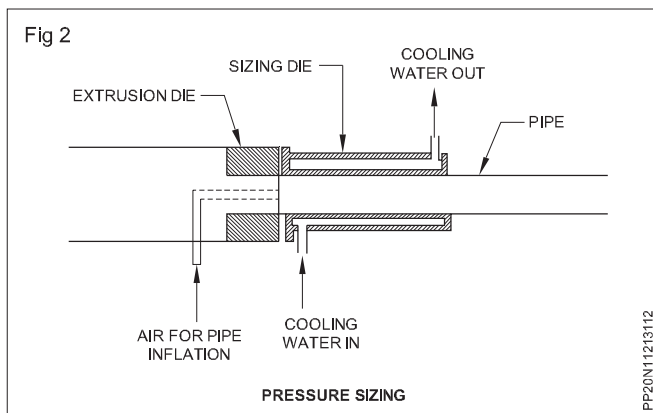
It is used commonly for smaller diameter flexible tubes and pipes.

Pressure sizing

In pressure sizing the compressed air is supplied through one leg of the spider and the mandrel, which allows the extruded pipe to be inflated against the walls of the sizing die. The pressure is maintained either by folding over the free end of the pipe or a floating plug is attached to the inner mandrel of the die Fig 2.

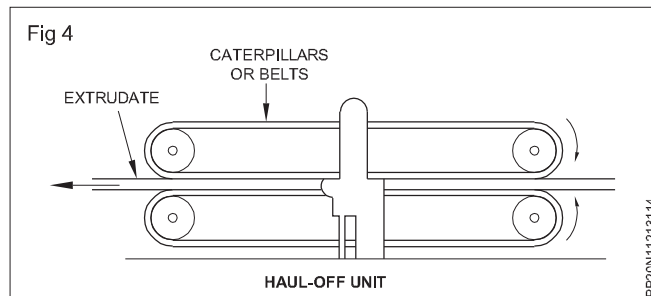
Vacuum sizing

It is widely used technique for pipes. The method is based on bringing a molten tube the inside of which is open to air into a vacuum tank. The air in the tube causes it to expand as a result of the vacuum on the outside of the pipe. Cooling of the pipe by water in the tank can resist expanding further by the vacuum. (See vacuum sizer in Fig 3)



Haul-off unit

It is used to pull the extruded pipe with an uniform or synchronized speed matching with the extruder speed. Haul-off belts are lined with rubber pads to have soft and firm grip of the pipe without damaging the shape of the pipe. It is driven by a separate motor whose speed can be adjusted as per the requirement. It pulls the extrudated pipe through the sizing and cooling units and feed it to the cutter (See Haul-off unit in Fig 4)



Important faults, causes & remedies in extrusion

Products	Faults	Causes	Remedies
Film	Discoloured	Over heating	Check condition & color of feed reduce the temperature
	Varying thickness	Heavy spot on the finishing roll /Asymmetrical bubble	Adjust die opening
	Wrinkles	Bubble instability	Try to stabilize the bubble
Pipe	Uneven thickness	Die is not centered properly	Adjust the die
	Rough Surface	Temperature low	Increase the temperature
	Porosity	Moisture content	Avoid moisture by predrying
	Continuous line	Damaged die	Replace the die
	Oval shape	Sizing unit not perfect	Rectify it
Profile	Depression	Moisture in material	Pre-dry the material
	Dull or matt finish	Die temp too low	Increase the die temperature
	Discontinuous lines across the extrusion	Irregular flow through die	Adjust the die opening

Re - processing of plastic

Objective: At the end of this lesson you shall be able to

- state explain scrap grinder parts & function.

Sequence of operations to be followed in grinding

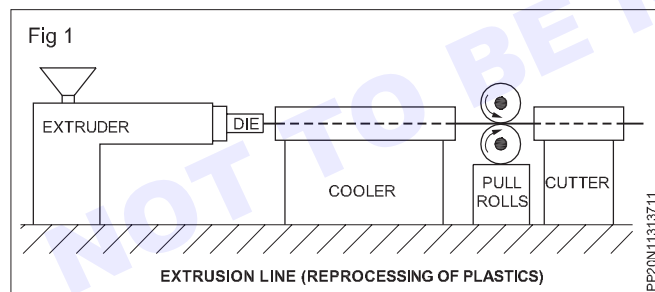
- Separate the scrap / waste material as far as possible
- Cut it to small size using hack-saw.
- Wash / Clean and dry the scrap in drier.
- Grind the waste using scrap-grinder.

Extrusion line

Reprocessing of plastic

In this process the various equipment commonly used are i.e. grinder, blender, extruder and palletization line. First of all, the scrap and waste material is ground in a grinder and these reground material is fed into a dry blender drum for pigmentation or direct into the feed hopper of the extruder. The extruder is fit with a strand die with opening of 4 - 6 mm diameter and total of 10 – 20 holes.

The melt is extruded through the strand die and after cooling in a water trough a pulling unit, which is a pair of motor driven, rubber covered rolls. It is the cater-pillar (take-off / haul-off) which pulls the water cooled strand. The strands are cut into pellets in the lengths of about 3 – 5mm. An extrusion reprocessing line is shown in Fig 1.



Scrap grinder parts and function

- 1 **Rotating cutter:** In this cutter three blades are fixed and rotate to cut plastic scrap.
- 2 **Static blades:** Two static blades are fixed it support to cut scrap.
- 3 **Drive motor:** Switch on to drive motor connected, pulley belt to rotate the three blade wheel for cutting scrap.
- 4 **Perforated grid:** Filter the ground scrap.

Dies

The term dies are generally used to a device, which forms a part of any extrusion unit through which the molten material is forced out so as to take its shape. This package deals with only the follow dies

- 1 Cast film die
- 2 Blown film die
- 3 Pipe die
- 4 Blow moulding die

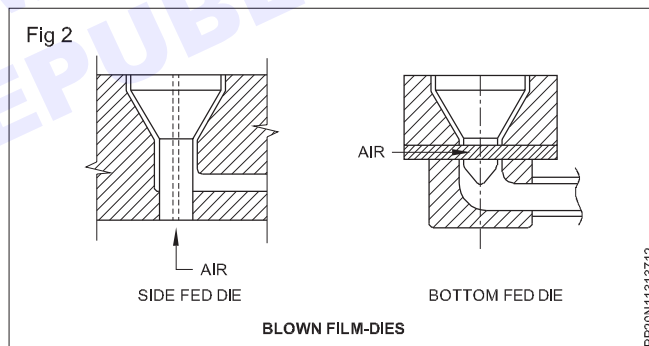
Blown film dies

Basically two different types of dies are used

- a Side fed die
- b Centre fed die or bottom fed die (Fig 2)

When the melt from the extruder enters the die side way, the die is called a side fed die. For inflating the bubble, air is blown through a hole inside the torpedo.

In a center fed die, the melt from the extruder centers the die from the center and so, the die is called a centerfed or bottom-fed die. Air for inflating the bubble is fed through a hole drilled through the spider and the torpedo.



Pipe die

A typical pipe die used for producing, PVC Pipe

The pipe die requires a central mandrel or core to support and shape the inside of the pipe wall. This core must be made as a spider with supporting arms to hold the core in place concentrically. The plastic flows around these arms and welds together again before leaving the die. The core is water cooled for PVC pipe to avoid degradation.

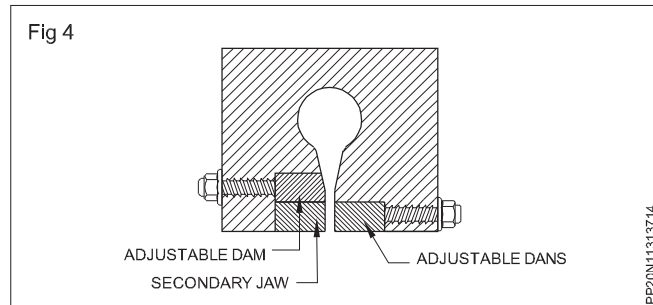
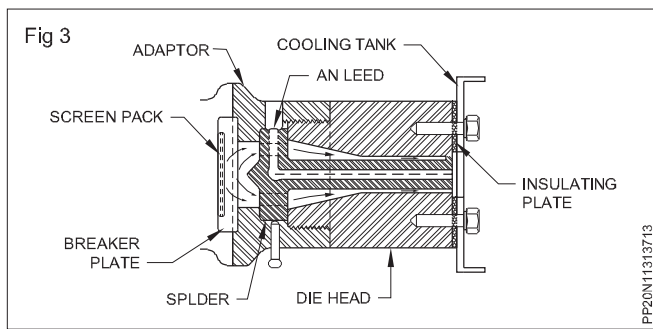
Sheet/film die

For producing film/sheet using cast film technique mainly two different types of dies are used.

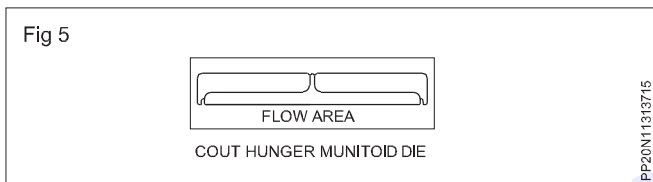
- a "Coat hanger type" die (Fig 3)

- b "T" type die (Fig 4)

Production of pipe: A pipe extrusion line is shown in fig. The pipe is extruded horizontally. The pipe is extruded horizontally. The main plastics used for pipe



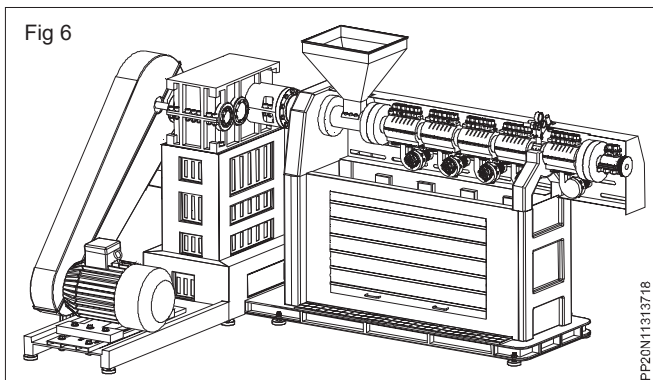
are polyethylene and PVC. A pipe extrusion line consists of the following uses. (Fig 5)



Operation of pipe line (Fig 6)

In this process, the melt is forced from the extruder through the breaker plates and out through the opening in the die must be circular or ring shaped. This is achieved by positioning a mandrel in the die opening. The soft pipe immediately after leaving the die is sized or calibrated on the outside diameter, using either pressure sizing or vacuum sizing. Then the pipe comes to the cooling section where it passes through water bath and if necessary water will be sprayed from the top. In this section the finished pipe solidifies to maintain its continuous shape and size.

It passes through a rubber padded haul – off unit which will be driven with a synchronized speed. Finally the pipe is cut to the required length either by using circular saw cutter or is wound up in case of flexible tube.

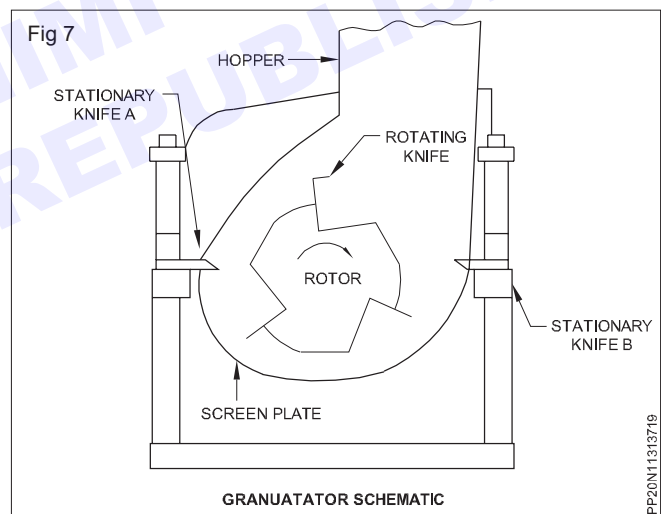


Reprocessing of plastics – Granulator

Reprocessing is a technique of breaking down plastic products in to scrap material which can be reused in the manufacturing process to obtain new components. The ratio of the scrap material added is inversely proportional to the quality of the product. However, reprocessing is used to cut down the cost of the product.

A plastic granulator is a machine used to break plastic products down so they can be recycled. Recent surveys report that discarded bottles, bags, packaging, and other plastic products represent as much as 40% of the solid waste tossed out by residents in communities across the nation. Unfortunately, plastic is not biodegradable. Therefore, it does not break down naturally to become part of the earth. This means recycling is the only option for reducing the amount of plastic in landfills.

A plastic granulator operates much like a large shredder. It turns full sized bottles, jugs, and other plastic products into flakes, or granules. The material produced by the plastic granulator is later sold to molders and manufacturers of plastic products as recycled raw material. The recycled raw material can be used to make new plastic items. A side from aluminum and glass, plastic is the only material capable of being reprocessed into new items that are of the same quality as the original. (Fig 7)



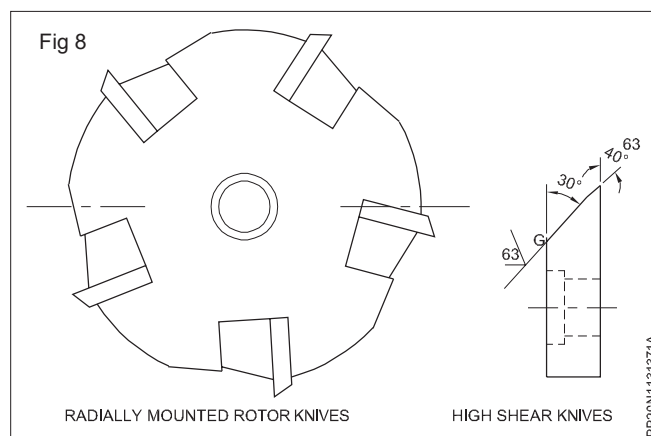
A plastic granulator is comprised of a large electric motor that turns a rotor. Cutting blades are attached to the rotor and encased within a closed chamber. These blades and chambers are available in numerous shapes and sizes. When used plastic material is placed inside the chamber, the rotating blades shred it into granules.

A screen is also located inside the chamber. It serves as a shifter, ensuring the plastic is small enough to be resold. If the plastic pieces are larger than 125 to 375 inches (0.318 to 0.953 centimeters), they are reprocessed until they are small enough.

A plastic granulator is rated by pounds per hour, which refers to how much it can shred within an hour. For industrial recyclers, the chamber of the plastic granulator needs to be large. It is, however, possible to purchase a plastic granulator for home or small

business use. It is important to note that these machines can be a dangerous, no matter how small. Therefore , it is important to follow the precautions provided by the manufacturer.

In order to properly maintain a plastic granulator, the user must keep it clean. Otherwise, it will not produce the desired small granules of plastic. The blades of the plastic granulator must be oiled periodically. In addition, the inside of the chamber needs to be wiped clean, including the screen. In fact, it is best to remove and clean the screen after every large job the machine completes. (Fig 8)

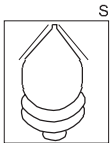
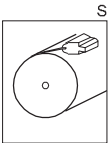
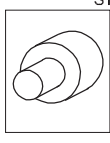
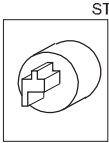
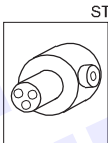
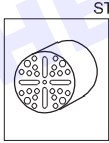


Different plastics and its use

Material type	Description	Typical uses
Acetals	Natural to opaque white and very tough	Gears and bearings: taps and aerosol valves
Acrylics	Transparent and as strong as wood	Lenses: car light housing and reflectors
A.B.S.	Natural opaque and very tough	Telephone handsets and vacuum cleaner housings.
Cellulose Acetate	Transparent and tough –ranges from flexible to rigid	Spectacle frames and screwdriver handles
Nylons	Almost opaque or white and very tough	Bushes and bearings for many products: curtain runners and combs
Polycarbonate	Transparent: very tough and resilient	Street lamp covers and safety helmets
polythenes a) Low Density	Natural waxy appearance: tough and flexible	Kitchen ware and many sealing lids and closures
b) High Density	Natural waxy appearance: tough and stiff	Chair seats and milk crates
Polypropylenes	Natural waxy appearance: tough and stiff	Beer crates and spade handles
Polysyrenes a) General purpose	Transparent and brittle	Cosmetics packaging and ballpoint pen barrels
b) High impact	Natural translucent and tough	Food containers: cotton reels; toys – model construction kits
P.V.C (a) Rigid	Transparent to opaque: tough	Outdoor applications: Such as gutters, drainpipes and fittings
(b) Plasticised	Transparent to opaque: tough and flexible	Shoe soles
S.A.N	Transparent and brittle	Table and picnic ware

Hazard	Where	Risk	Controls
When gaining access to blades for cleaning or clearing a blockage.	Blade: Powered Motion	Amputation / Cuts/ Lacerations	Lock out / tag out procedures (or maintenance)
When a blockage is removed	Blade: Un powered movement	Cuts / Lacerations	Specific procedure for jamming / blockages and changing blades.
Sharp edges of blades.	Blade: Stationary	Cuts / Lacerations	Documented maintenance procedure, including PPE

Haard	Where	Risk	Controls
Entanglement or jarrlng when feeding materials	Feed material	Amputation / Cuts/	Ensure guarding compiles with AS 4024 - Safeguarding of machinery.
No guards on feed rolls	Feed rolls	Amputation / Cuts / Lacerations	
Falling into hopper or trapped	Hopper	Amputation / Cuts / Lacerations	
No restraint on ejected materials	Ejected Material	HITS by flying object.	
Guard can loosen and fall of	Motor cooling fan	Amputation / Cuts / lacerations	
Not securely fenced	Transmission Machinery	Amputation / Cuts / Lacerations	

 Blown film plants Sacks bags shrink films HM-film Carrier bags Packaging film Construction films Agricultural films	 Chill roll film casting plants Packaging films Coating films Adhesive films Thermoforming Films Weaving tapes Typewriter ribbons Multilayer films Strapping tapes	 Sheet lines for single and multilayer sheet Vacuum-formed Articles Building components Containers Decorative sheets Semi-finished Products Foamed and highly filled sheets	 Pipe plants Pressure pipes Sewerage water Pipes Hydraulic pipes Hoses Medical tubes and catheters drainage pipes Irrigation pipes Insulating pipes
 Section extrusion plants Building profiles Window profiles Skirting's and edgings Furniture profiles Cable ducts Motorcar sealing Strips Double layer Hollow sheets	 Melt spinning plants Fibers for technical textiles and garments Filaments Weaving tapes Monofilaments Wire replacement Filaments Multifilament's Ropes Non-wovens	 Coating plants Cables Conductors Wires Steel pipes	 Pelletizing plants Granules Recycling KEY S = Single screw ST = Either single or twin screw

Trouble shooting and preventive maintenance of extrusion machine

Objectives: At the end of this lesson you shall be able to

- regularly clean and oil various parts of the machine
- identify oiling holes and greasing nipples according to manufacturer's chart
- identify units susceptible to severe service condition
- carry out routine maintenance of different valves, heaters, motors and other electrical parts and components.

Sequence of Operation

Cleaning and oiling of machine

- Clean the machine with dust free cotton waste
- Clean the oil can / grease gun before oil or grease is put into it.
- Oil the all sliding surfaces with a thin film of oil.

Identification of parts to be lubricated

- Select the oil and grease as recommended.
- Clean the spots with the help of dust free cotton waste.
- Put oil and grease in excess quantity and then wipe out.

(The lubricating spots can be identified by referring to manufacturer's manual)

Identification of units susceptible to severe service

• Cooling water system

Check the inlet and outlet valves of the water through and see that, they are opening and closing properly by actually allowing water to fill the through.

Similarly check the inlet and outlet valve of Extruder.

• Gear box

The gear boxes provided both at Hauling unit and Extruder unit are to be checked regularly, to see the oil level.

If the oil is found gone-down below the minimum level, then fresh oil as recommended, has to be added. The bearing of the gear boxes are also required to be greased periodically.

Electrical control panel

- Check the electrical terminals to see that all the connecting nuts are tight.
- Check the band-heaters over the cylinder to see that the surfaces are in well-contact with the cylinder.
- Check the temperature controllers, thermos couples and ensure their proper functioning.

As the machine is responsible for more than one product, the undergoes continuous operation with less time of rest period. As such regular preventive maintenance is highly essential.

The service units of the machines are mainly

- Water pipe line

- Screw of barrel
- Cross head
- Electrical fittings

Preventive maintenance

The preventive maintenance can be carried out as mentioned below

Electrical components

Warning: All electrical maintenance work should be undertaken with the machine isolated

Relay contact should be cleaned with carbon Tetra chloride or a special fluid. Badly pitted contacts may required dressing with fine emery cloth.

Air break starter contacts may be filled and afterwards. Polished with emery cloth but avoid excessive removal of metal. Eveline or contact lubricant may be applied to contacts to reduce further pitting.

Check all connection on circuit for tightness. Replace frayed insulation on Heaters.

Check pyrometer controls and blower operation. Tighten and/or replace, loose or damaged toggle switches, push buttons etc.

Oil change

The oil lever in the main reduction gear box and oil sump for thrust bearing should be checked regularly. During the running period of the machine the lubrication of thrust bearings should be adhered to. Oil changes must carried out with the same type of oil originally used. The oil filter should be cleaned thoroughly with every oil change.

Oil sump for thrust bearings

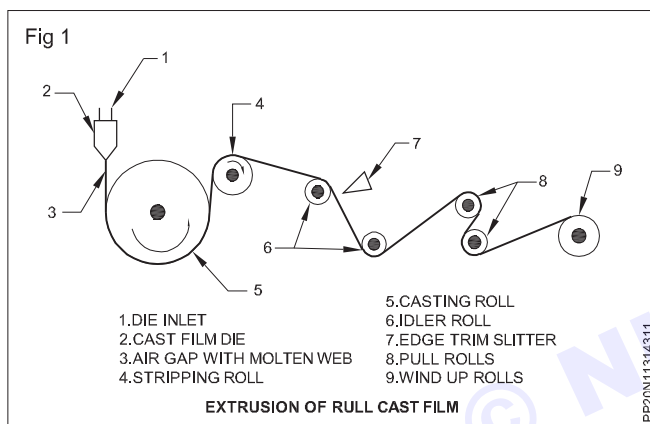
- | | |
|--------|--|
| Grade | - As recommended by manufacturer. |
| Change | - First change after 1500 operating hours and further oil change every 5000 hours. |

Main Gear box

- | | |
|--------|--|
| Grade | - Bharat petroleum (Amocam) 680 OR, Indian oil (Servo mesh) SP 320 for Ambient temp. 26°C–40°C as per recommendation of manufacturer. |
| Change | - first change after 500 hours running or 2 month whichever is earlier. Subsequent change should be made every 2000 hours or 6 months whichever is earlier. Oil should be drained off and gear case thoroughly flushed with light flushing oil. Operating temperature of 80°C to 90°C is harmless. |

The motor is mounted on Base plate and torque arm is provided to obtain the desired belt tension.

Extrusion of cast film (Fig 1): The principle of the cast film/that film process is illustrated in Fig. The extruded melt through a flat-die or slit die as a thin web is cooled on a polished chilled metal roll. This kind of film is called as chill roll film or cast film. The polished roll whose temperature is controlled by circulation of water. The roll is made from steel and has a mirror like surface. The roll designed for efficient and controlled cooling by circulation of water through it. The roll is cold compared to the temperature of the melt. An air knife is used which pushes the web against the roll and helps prevent air entrapment. The stripping roll strip-off the contact of the film from the chilled roll. This roll is also chrome plated and water cooled. The edge of the film always has a thick edge. It is removed by a trimmer. The trimmer often is a simple device that holds a razor blade.



The cooling of the film is done by rolling it over cooling rolls and a pulling roll device which pulls the film with an uniform speed and tension. Finally, the finished and cooled film is wound up on to a winder roll.

Calendering

The process of forming thermoplastic sheeting or film by passing the material through a series of heated rollers. The gap between the last pair of heated rollers determines the thickness of the sheet subsequent cold rollers cool the sheet.

The plastic compound is usually premixed and plasticated on separate equipment, then fed continuously into the nip on the first pair of calender rolls.

The product from this process is used for wall coverings, fabrics, shower curtains pool lines, laminated sheets for vacuum moulding.

Flexible & rigid PVC compounds are used as raw material for calendering ABS & polyethylene are calendered for various applications.

The calendering process consists essentially of rolling out a mass of fluxed plastic between pair of large rolls to from a homogeneou & accurately sized sheet. Most plastic calendars have four rolls arranged in an inverted 'L' configuration with three rolls in a vertical stack and the fourth roll horizontally to the side of the top roll of the stack.

Calendar plastic sheet is produced on widths up to about 80" and in the range of 0.002" to 0.050" in thickness.

3 Sheet (or) flat film extrusion line

There are no major differences between the extrusion of flat film and sheet. The main components of a sheet line are the extruder. The roll stock, the cooling section, the edge trimmer and sheet remover.

i Roll stock (Fig 2)

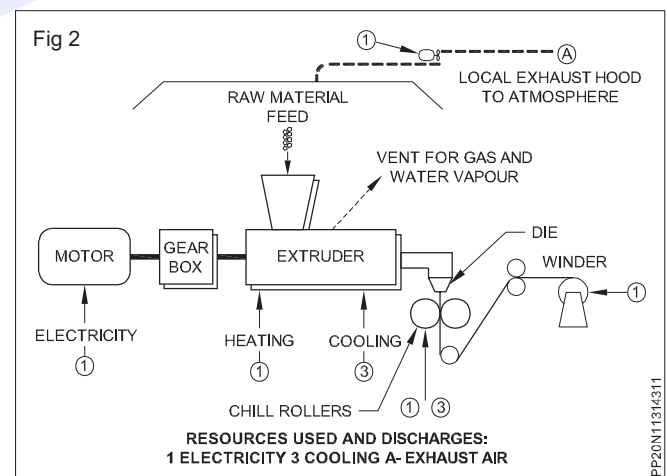
The roll stock contains three rolls that are often referred to as polishing rolls. They are used to exert pressure on the sheet and to impart the surface conditions of the nip rolls to the plastic sheet if a smooth roll is used.

If a textured surface is needed, a textured surface is used on the roll. The roll texture is the negative of the texture required on the sheet. It is possible to produce a sheet with one textured surface and the other smooth by using a smooth and textured roll next to each other.

Fig shows the plastic sheet going up along the center roll and making as wrap around the center roll and making as wrap around the center roll and top roll. This is called "up stock " mode, if the material makes as warp around the center roll and bottom roll. The rolls do not have to be in the vertical position; they can be in a horizontal position.

Or any angle between vertical and horizontal. In some roll stocks, the angle is also adjustable.

The rolls are normally cored so that the temp of the rolls can be controlled. This is usually done with circulating hot oil. It should be possible to adjust the temp of each roll separately.



ii Cooling section

The cooling section consists of a number of rolls positioned in a frame with chilled water input facility. At the end of the cooling sections is the pull rolls or nip rolls. These rubber rolls that pull the sheet from the roll stock to maintain certain tension in the sheet.

iii Edge trimmer and sheet remover

After the nip rolls, the sheet is led to the edge trimmer, where unbalanced wall thickness of the sheet (Normally at the edge only) is removed. Then it moves to the cutter unit for preset cutting. It is then removed by sheet removal stock.

iv Casting

Thin films are often cast on chill roll rather than extruded into a roll stock. The main components of a cast film line are the extruders, the film die, the chill roll unit, thickness gauging system, surface treatment unit and the winder.

v Chill rolls unit

The film is extruded downward on to the chill roll. The initial contact between the film and the chill roll is established by the use of an air knife. The air knife

produces a thin stream of high velocity air across the width of the chill roll, the air stream pushes the film against the roll surface as shown in fig.

vi Thickness gauging unit

From the chill roll unit the film is led to a thickness – gauging unit where the thickness of the sheet is measured across the width of the film. Most thickness gauges for film and sheet have a scanning measuring head that transverse across the film back and forth to measure the thickness both along the length and across the width of the film.

Identification code number for different plastics and its uses

Objectives: At the end of this lesson you shall be able to

- know the identification code and its uses.

Identification code	Type of flexible polymer	Characteristics	Common packaging applications
	Polyethylene teraphthalate (3043242) PET	Clarity for strength heat, gas and	Soft drinks, water, mixed greens, decorative bottles peanut, butter, jam jars.
	High densits polyethylene HPPE	Stiffness, strength, ductility , moisture, resistance, gas permeability	Water pipes, five gallon buckets milk, juice, water bottles, grocery bags, some shampoo bottles.
	Polyvinyl chloride PVC	Easy mixability packaging strength, hardness	The solvents required to flex the pressed plastic aretoxic and are threrfore not used for baking. Rigid tubing, records, electrical cables, insulation uses.
	Low density polyethylene (LDPE)	Ease of processing strength, hardness flexibility, moisture barrier.	Bags for frozan food, squeezable honey, mustard bottles, flexible container lids, cling wraps.
	Polypropylene	Strength, hardness heat, chemicals, grease and oil resistant, versatile applications, moisture proof	Reusable kitchen ware single use microvave containers, cups and plates.
	Polystylene	Versability, clarity, case of design.	Egg carton, peanut bags, disposable plates, containers.
	Other plastics often Polycarbonate or ABS	Dependent on polymers or combinations of polymers.	Wine bottle, baby milk bottles, black lenses, glasses, vehicle head lamps, riot shields tools, etc.,

What are the different plastic recycling codes (disposal examples)

Reuse and recycle plastics. We have heard and what does it mean if there is a inside the three arrows on plastic products ? Plastics have their own identification codes or numbers, meaning that not all plastics can be recycled in the same way or at all. They tell you what types of plastic they are and how to recycle them.

How are plastics identified ?

Resin identification codes

Identify plastics by RIC

They are usually listed under or on the side of the plastic product.

What is plastic resin code?

Resin codes were developed by the society of the plastics industry (SPI) in 1988. It helps to standardize the materials used in various plastic products. Plastic products labeled with a PIN identification code can be more easily identified and recycled or disposed of accordingly.

A detailed overview of plastics commonly accepted by garbage recycling programs and those that are not plastics commonly accepted by curbside recycling programs.

Plastics not commonly accepted by curbside recycling programs	Plastics not commonly accepted by curbside recycling programs
#1 – Polyethylene terephthalate PET	#1 – Polyvinyl chloride PVC
#2 – High density polyethylen HOPE	#2 – Low density poly Ethylene LOPE
#3 - Polystyrene PS	#3 - Polystyrene PS
	#4 - Others

Plastics not commonly accepted by curbside recycling programs

- 1 Polyethylene terephthalate PET
- 2 High density polyethylene HOPE
- 3 Polypropylene PP

Check with your commercial hauler to see if plastic is accepted in your area before disposing of any material. Disposal options for each plastic code vary by state and facility.

What are the different plastic codes ?

Recycling prin symbols are represented by three a triangular formation. Seven resin codes to identify plastic products. 1 - 7 each number is a different type of plastic and how / where to dispose of it indicates that Plastic No 1 – PETE (Polyethyl terephthalate)

Polyethylene terephthalate can be abbreviated as PET or PETE.

PET is one of the most commonly used plastics in consumer food products.

PET plastics are for single use

Plastic No. 1 has a low risk of leakage and is considered safe.



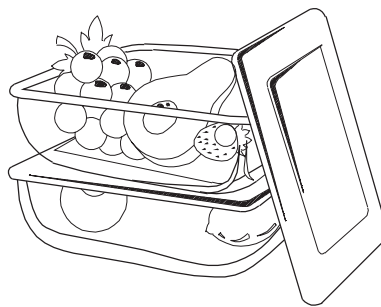
Clear PET can withstand temperature's from 20 ° F - 120° F glass – like transparency and preparation.

It is a popular food packaging material due to its ability to retain freshness.

Oven ready / CPET is temperature resistant from 32 F – 400 F making it capable of withstanding a wide range of temperatures. Product examples make the product ideal for freezer to oven applications

- Cold drink cup
- Soft drink bottles
- Water songs
- Clear hinged containers
- Containers of peanut butter.

Fig 1



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Containers

- Bottles of salt dressing
- Oven ready cooking plates

End of life management

Number 1. PETE plastics are recyclable and accepted by most curbside recycling programs. They should be washed and dried before collection.

After recycling, PET is turned into flakes. It is used to spin carpet fiber fiberfill or bags.

Plastic No. 2 – HDPE high density polyethylene

High density polyethylene is commonly known as HDPE.



HDPE is highly durable and corrosion resistant to last longer.

High density polyethylene is safe to reuse.

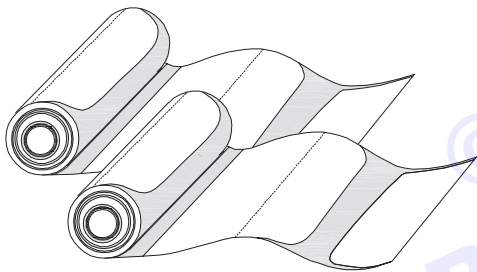
Plastic No. 2 has low risk of leakage and is considered safe.

HDPE must withstand temperatures of 40° F – 226°F.

Product Examples

- Milk jugs
- Juice bottles
- Clean bottles
- Trash can liners
- Butter and yogurt containers

Fig 2



End of life Management

No 2 HDPE plastics

Are recyclable and may be accepted by some curbside recycling programs depending on the product accept.

They should be rinsed and dried before collection.

After recycling, plastic number 2 Plastic fences, picnic tables and recycled into lawn chairs.

Plastic No. 3 – PVC (Polyvinyl chloride)

Polyvinyl chloride is commonly referred to as vinyl or PVC.



PVC is light weight and versatile PVC is single use. Polyvinyl chloride is the product of chloride

Breaks down into dangerous chemicals like

PVC compound can withstand temperatures of 0° F & 150 ° F

Product examples

Fig 3



Window still bottles soap bottles

Food service film wrap

Cooking oil bottles

Clear food packaging

End of life Management:

Number 3, PVC plastics are not generally accepted by curbside recycling programs but are accepted at some recycling drop – off centers.

PVC can be recycled into products such as traffic cones, plastic No 4 (Low density polyethylene)



Low density polyethylene is abbreviated as LDPE. Low density polyethylene is safe to reuse

It is very flexible durable and lightweight. It is a common plastic used in food film and squeezable bottles.

LDPE is considered safe and is not known to make any chemicals.

LDPE 58° F – 185° F temperature resistant.

Fig 4



Product Examples

Squeezable bottles

Bread bags

Frozen food bags

End of life Management

Number 4, LDPE plastics are generally not accepted by curbside recycling programs but may be accepted at some recycling drop off centers.

After recycling LTPE can be reprocessed into landfill liners, composite lumber and pipes.

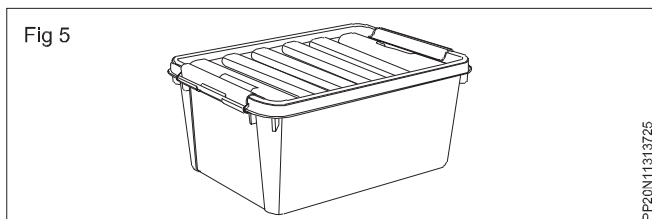
Plastic No 5 – PP (Polypropylene)



Polypropylene, or PP durable and lightweight polypropylene is safe to reuse.

Polypropylene has a high melting point, making it a popular choice for hot liquids.

PP can withstand up to temperatures from 0° F – 250°F.



Product Examples

Take out the containers

Nuts / bowls

Cattery

Bottles of syrup

Ketchup bottles

End – of – life management No. 5 PP

Plastics are increasingly accepted by curbside recycling programs. They should be washed and dried before collection. After recycling , plastic is number 5 recycled into bins, bike racks, ice scrapers and brooms.

Plastic No 6 PS (Polystyrene)



Polystyrene is lightweight. Versatile and cheaper

Polystyrene plastics once will only be used



These chemicals, including plastics, styrene and benzene can transfer to food and beverages if not used properly. Polystyrene in microwave or polystyrene can withstand temperatures of 20° F – 18°F slowing down is not safe

Product Examples

- Disposable nuts

- Wealth files
- Meat platters
- Egg cartons
- Carry out containers with straw

Fig 6



End of life Management

Although polystyrene can be recycled, No 6 Plastics are generally not accepted by curbside recycling programs but may be accepted at some recycling dropoff centers.

Polystyrene is difficult to recycle. Because it is lightweight but does not break easily recyclability is calculated by weight and because polystyrene is highly recycled, but with very little weight, it is not profitable for recycling companies to accept it. Recycling polystyrene uses more energy and costs more than the benefits gained from recycling.

Polystyrene can be manufactured as expanded polystyrene foam (EPS). It is commonly known as Styrofoam.

Plastic No 7 other Aquatic

Fig 7



Nylon, Fiberglass, other No 7 Plastics are grouped into 10 groups of various plastics that differ in back and chemical makeup other including agar polycarbonate Tylon fiberglass biodegradable plastics political

Product Examples

Five gallon water bottle

BSA biodegradable cups

Bulk food containers

End of life Management

No. 3 Plastics differ from price youth plan. This makes it difficult to adopt rapid recycling programs 7 can be composted some items can be made some are considered trash for more information on your number 7 plastic product, please contact the manufacturer. Contact your local merchants to see if they currently accept your # 7 plastic item

Actual tolerances may vary by manufacturer, product and or product

Introduction thermos forming process

Objectives: At the end of this lesson you shall be able to

- describe the thermoforming process
- list various types of thermoforming process
- explain troubleshooting of thermoforming.

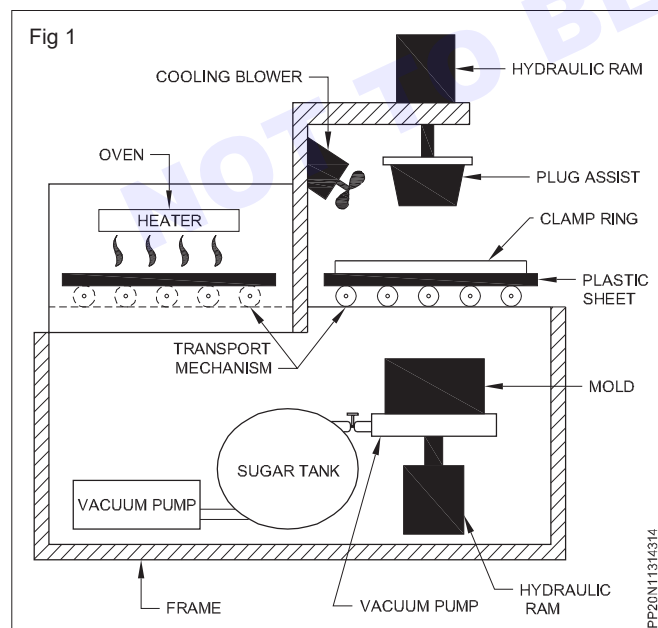
Thermoforming is a process in which a flat thermoplastic sheet is heated and deformed into the desired shape. The process is widely used in packaging of consumer products and to fabricate large items such as bathtubs. Contoured skylights, and internal door liners for refrigerators.

Thermoforming consists of two main steps: Heating and forming. Heating is usually accomplished by radiant electric heaters. Located on one or both sides of the starting plastic sheet at a distance of roughly 125 mm (5 in.) Duration of the heating cycle needed to sufficiently soften the sheet depends on the polymer, its thickness and color. The methods by which the forming step is accomplished can be classified into three basic categories:

- Vacuum thermoforming.
- Pressure thermoforming, and
- Mechanical thermoforming.

In the packaging industry, most thermoforming operations are performed on thin films.

A thermoforming machine is as shown below (Fig 1)



Vacuum Thermoforming

The earliest method was vacuum thermoforming (called simply vacuum forming when it was developed in the 1950s), in which negative pressure is used to draw a preheated sheet into a mold cavity. The process is

explained below in its most basic form. The holes for drawing the vacuum in the mold are on the order of 0.8 mm (0.031 in.) in diameter, so their effect on the plastic surface minor.

Vacuum thermoforming: (1) a flat plastic sheet is softened by heating; (2) The softened sheet is placed over a concave mold cavity, (3) A vacuum draws the sheet into the cavity and (4) The plastic hardens on contact with the cold mold surface and the part is removed and subsequently trimmed from the web. (Fig 2)

Pressure thermoforming

An alternative to vacuum forming involves positive pressure to force the heated plastic into the mold cavity. This is called pressure thermoforming or blow forming. Its advantage over vacuum forming is that higher pressures can be developed because the latter is limited to a theoretical maximum of 1 atm. Blow – forming pressures of 3 to 4 atm are common. The process sequence is similar to the previous, the difference being that the sheet is pressurized from above into the mold cavity. Vent holes are provided in the mold to exhaust the trapped air. The forming portion of the sequence (steps 2 and 3) is illustrated below.

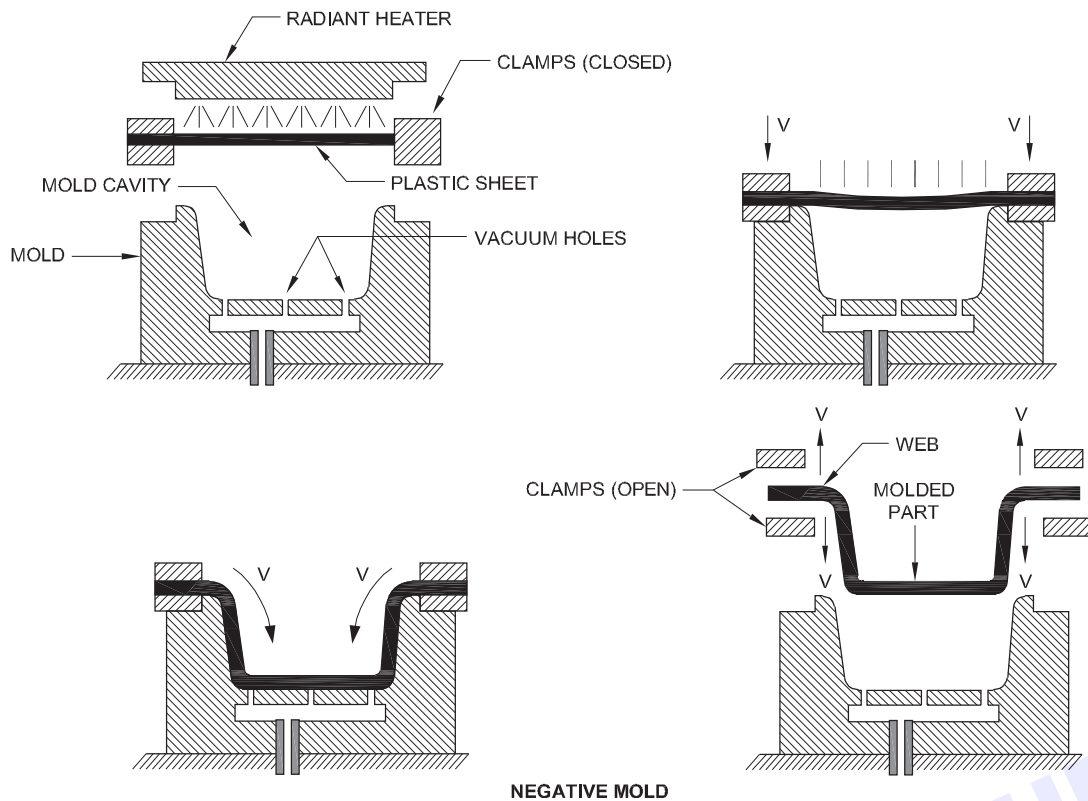
Pressure thermoforming, The sequence is similar to previous figure, the difference being; (2) sheet is placed over a mold cavity; and (3) Positive pressure forces the sheet into the cavity. (Fig 3)

At this point it is useful to distinguish between negative and positive molds. The molds shown above are negative molds because they have concave cavities. A positive mold has a convex shape. Both types are used in thermoforming. In the case of the positive mold, the heated sheet is draped over the convex form and negative or positive pressure is used to force the plastic against the mold surface. The positive mold is shown in below for the case of vacuum forming.

Use of a positive mold in vacuum thermoforming: (1) The heated plastic sheet is positioned above the convex mold and (2) The clamp is lowered into position draping the sheet over the mold as a vacuum forces the sheet against the mold surface. (Fig 4)

The difference between positive and negative molds may seem unimportant, since the part shapes are virtually identical, as shown in the diagrams. However, if the part is drawn into the negative mold, then its exterior surface will have the exact surface contour of the mold cavity. The inside surface will be an approximation of

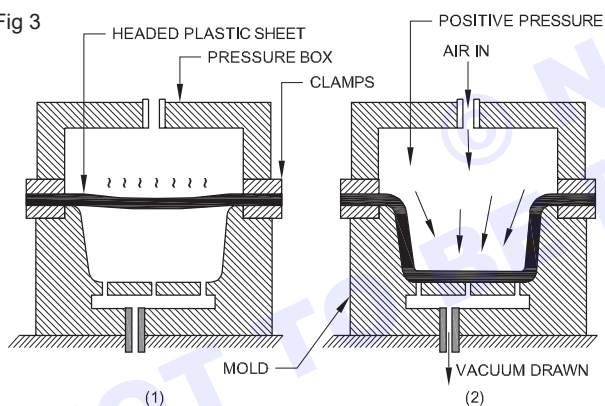
Fig 2



NEGATIVE MOLD

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Fig 3

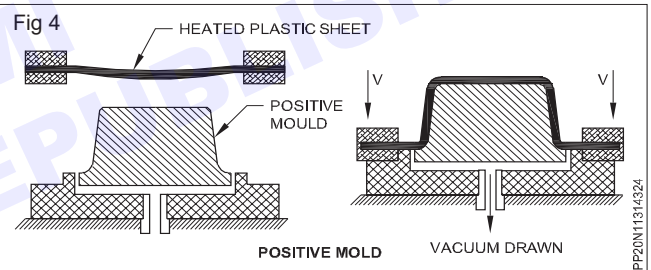


(1)

(2)

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Fig 4



PP20N11314324

the contour and will possess a finish corresponding to that of the starting sheet. By contrast, if the sheet is draped over a positive mold, then its interior surface will be identical to that of the convex mold; and its outside surface will follow approximately. Depending on the requirements of the product, this distinction might be important.

Another difference is in the thinning of the plastic sheet, one of the problems in thermoforming. Unless the contour of the mold is very shallow, there will be significant thinning of the sheet as it is stretched to conform to the mold contour. Positive and negative molds produce a different pattern of thinning in a given part. Consider our tub shaped part as an example. In the positive mold, as the sheet is draped over the convex form, the portion making contact with the top surface (Corresponding to the base of the tub) solidifies quickly and experiences virtually no stretching. This results in a thick base but with significant thinning in the walls of

the tub. By contrast, a negative mold results in a more even distribution of stretching and thinning in the sheet before contact is made with the cold surface.

A way to improve the thinning distribution with a positive Mold is to prestretch the sheet before draping it over the convex form. As shown in figure below, the heated plastic sheet is stretched uniformly by vacuum pressure into a spherical shape prior to drawing it over the mold.

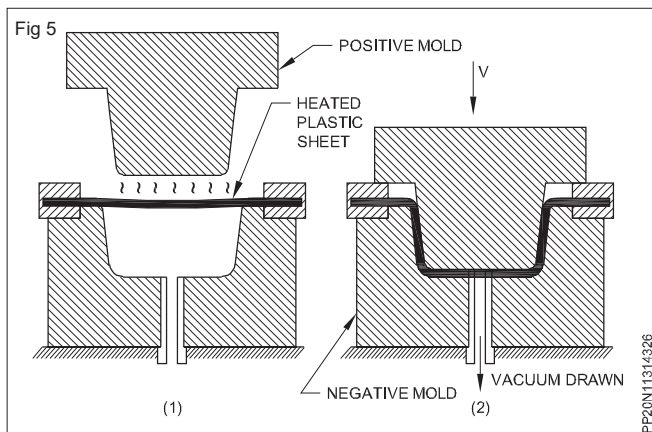
Pre – stretching sheet in (1) Prior to draping and vacuuming it, over a positive mold.

The first step depicted in frame (1) of the figure above can be utilized alone as a method to produce globe – shaped parts such as skylight windows and transparent domes. In the process, closely controlled air pressure is applied to inflate the soft sheet. The pressure is maintained until the blown shape has solidified.

Mechanical Thermoforming

The third method, called mechanical thermoforming, uses matching positive and negative molds that are brought together against the heated plastic sheet, forcing it to assume their shape. In the pure mechanical forming method, air pressure (Positive or negative) is not used at all. (Fig 5)

The process is illustrated below. Its advantages are better dimensional control and the opportunity for surface detailing on both sides of the part. The disadvantage is that two mold halves are required; The molds for the other two methods are therefore less costly.



Applications: Thermoforming is a secondary shaping process, the primary process the being that which produces the sheet or film. Only thermoplastics can be thermoformed, since extruded sheets of thermosetting or elastomeric polymers have already been cross-linked and cannot be softened by reheating. Common thermoforming plastics are polystyrene, cellulose acetate and cellulose acetate butyrate. ABS PVC, acrylic (Polymathic methacrylate), Polyethylene, and polypropylene.

Mass production thermoforming operations are performed in the packaging industry. The starting sheet or film is rapidly fed through heating chamber and then mechanically formed into the desired shape. The operations are often designed to produce multiple parts with each stroke of the press using molds with multiple punches and cavities. In some cases, the extrusion machine that produces the sheet or film is located directly up stream from the thermoforming process, thereby eliminating the need to reheat the plastic. And for best efficiency, the filling process to put the consumable food item into the container is placed immediately downstream from thermoforming.

Thin film packaging items that are mass produces by thermoforming include blister packs and skin packs. They offer an attractive way to display certain commodity products such as cosmetics, toiletries, small tools, and fasteners (nails, screws, etc.). Thermoforming applications include large parts that can be produced from thicker sheet stock. Examples include covers for business machines, boat hulls, shower stalls, diffusers for lights, advertising plays and, signs, bathtubs, and certain toys.

Some other types of thermoforming used are

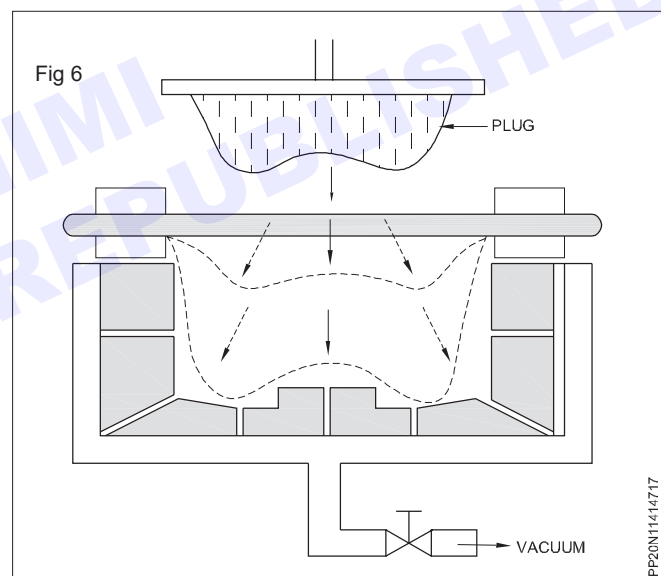
Plug – Assist Forming

- In this system, a plug is used to force the material into the mold.
- Generally the plug will not pushed the material completely into the mold, then a vacuum is applied to draw materials against the cavity walls.

- Instead a Vacuum, air pressure could be used to force the parts against the walls.
- Better wall thickness uniformity than obtained from vacuum and pressure forming.
- Plugs can be made of metal, wood or thermoset materials
- The plug should be 10% to 20% smaller in length and width than the female cavity.

Reverse draw forming

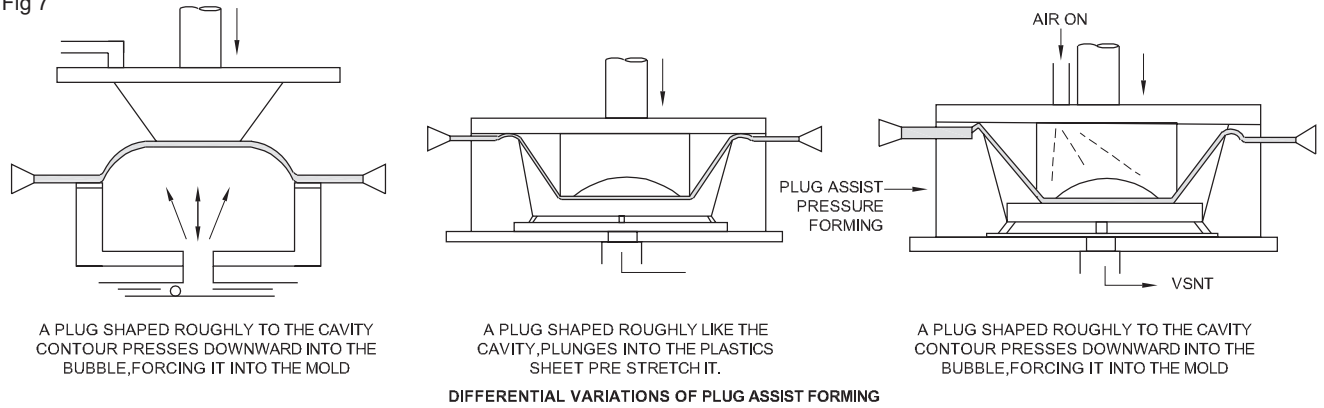
- Is used when very deep draws are needed
- In this technique, the material is heated to the sag point, and then blown away from the mold.
- The purpose of blowing is to thin the material in the center of the sheet.
- The size of the bubble is controlled by an electric eye. When the bubble reaches the correct size, the pressure is topped and the plug press the material to the mold.
- The vacuum is activated through the mold to draw the plastic against the mold wall. (Fig 6)



Free forming (Fig 7, 8)

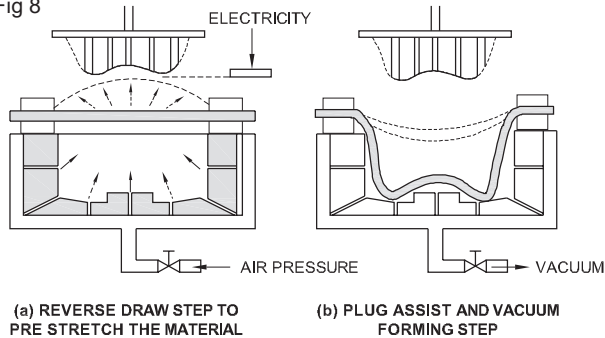
- The forming is done without a mold, especially those where a very high optical quality is required.
- Touching the mold can result in under sir able changes in the surface quality of the part.
- Complexity of shapes of parts is limited
- Often used for canopies
- The part is expanded with air pressure.
- The size of the bubble is monitored by an electrical eye.
- When the bubble reach the desired shape, air pressure is reduced to a level that maintains the size while the part cools.

Fig 7



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Fig 8

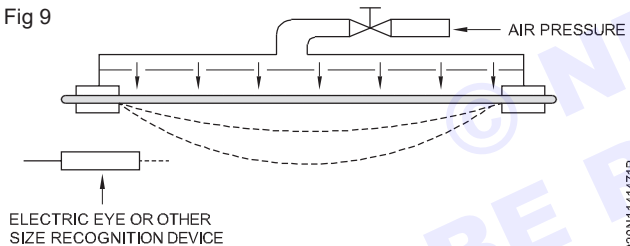


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Matched die forming (Fig 9 & 10 ,11)

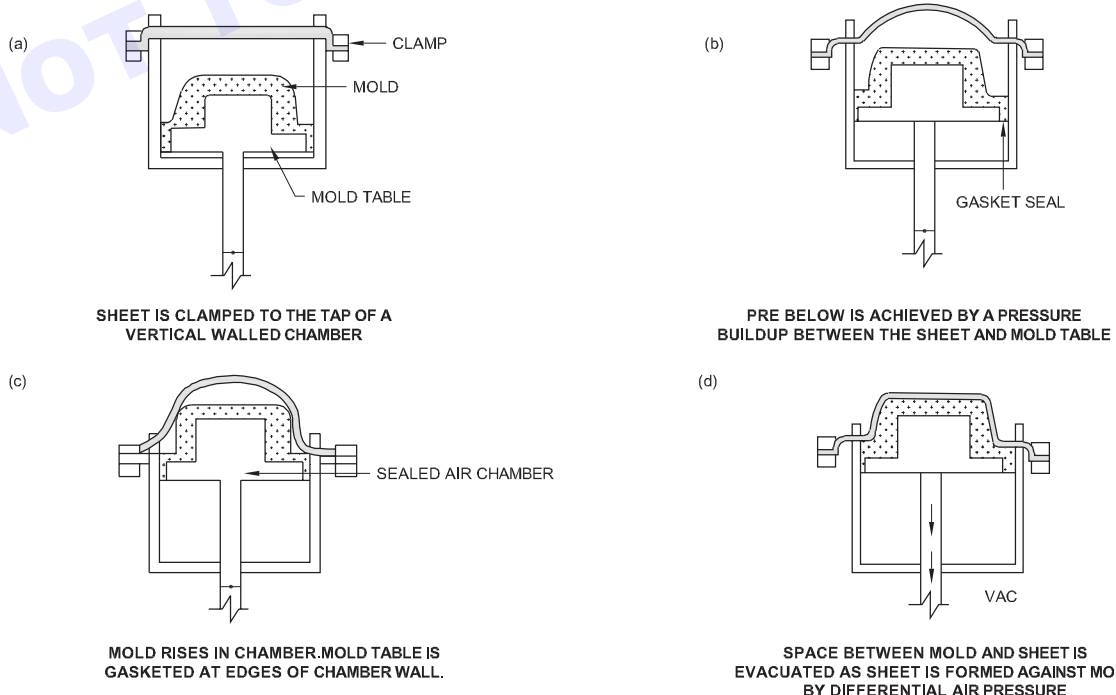
- Some parts with very complicated shapes, can best be formed if both plug and cavity mold are used together.
- These mold must be matched so that it can be fit together.
- Material is heated to the sag point, and then transferred to the molding station. Where the plug and cavity molds are brought together to squeeze the material.
- No vacuum or air pressure is applied during the forming process.
- Material is mechanically pressed into the shape defined by matched molds, and allow to cool while the mold continue to press against it.

Fig 9

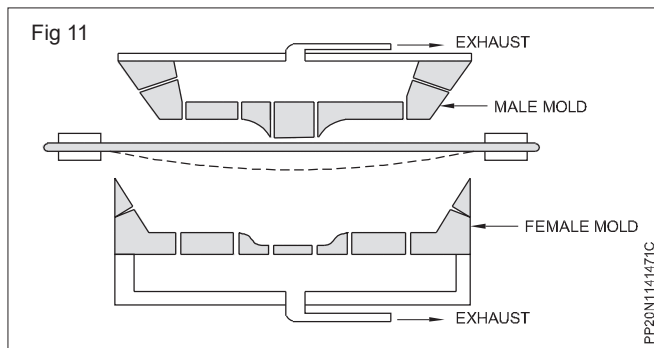


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Fig 10



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Trouble Shooting

Problem	Causes	Solution
Uneven shapes	Un even heating temperatures	Be sure all heaters are functioning Eliminate drafts Baffle heat on all sides
	Clamping frame not hot	Preheat clamping frame Preheat entire sheet
Blisters or bubbles	Heating too rapidly	Lower temperatures Increase distance between heaters and sheet
	Uneven heating	Be sure all heaters are functioning Use screening to balance heat pre - dry
	Excess Moisture	Pre - dry Pre heat Keep masking on sheet until formed Lower the heater temperature Use older material first
Poor Detail, Incomplete Forming	Sheet too cold	Heat sheet longer Raise heater temperature If problem occurs in same area every time, check if all heaters are functioning.
	Clamping frame not hot enough	Heat frame to recommended temperature.
	Insufficient vacuum or pressure	Check if vacuum / pressure at mold is sufficient Remove 90 bends from vacuum system Check vacuum holes for clogging Increase number of vacuum holes
	Vacuum draw not fast enough	Check vacuum system design Back relieve vacuum holes Use vacuum slots instead of holes
Too much sag	Sheet is too hot	Reduce heating time reduce heater temperature

Rearing sheet When forming	Sheet is too hot	Reduce heating time Reduce heater temperature
	Sheet is too cold	Increase heating time increase heater temperature
	Closing speed between mold and sheet too high	Reduce closing speed
Part sticking to	Mold or sheet temperature too high	Lower mold temperature mold Reduce heating time or temperature
	Draft angle too small	Increase draft angle use female mold Remove part from mold as soon as possible
Part War page	Uneven part cooling	Add more water channels to mold Check for plugged water flow
	Mold temperature too low	Raise part temperature
Surface markings	Mold surface too rough	Use proper mold covering (foam, felt, flocking) change mold material
	Mold surface too smooth	Grit blast mold surface
	Poor vacuum	Check vacuum system add vacuum holes
	Mold is too hot	Reduce mold temperature
	Mold is too cold	Increase mold temperature
Uneven edges	Dirt on sheet or mold Excessive forming temperature Differential	Clean with deionizer air Preheat clamping frame
Raised corners	Excessive stress	Heat frames to proper temeptrature before inserting sheet add supple- mental heat to comers.
Cracking in corners	Stress concentration	Heat sheet evenly
		Preheat frames or use heated frames Add supliemental heat to corners.

In - line thermoforming process

Objectives: At the end of this lesson you shall be able to

- **know about thermoforming process**
- **know the operation of the exmoforming machine**
- **know what products are manufactured.**

In line or Roll fed thermoforming (Fig 1)

The inline thermoforming process is designed to utilize heat sheet from the extruder. The sheet is passed through an oven at a suitable temperature for forming and taken to the forming area. The takeup speed of the accelerator and the forming speed must be the same.

Generally in this type of thermoforming the forming sheet is 0.125 4m the size is then and there is no critical

forming method for forming these which is very difficult to control compared to other thermoforming processes.

The main drawback is that the extruder and the former are directly connected and is there is any problem, the work of both will be disrupted.

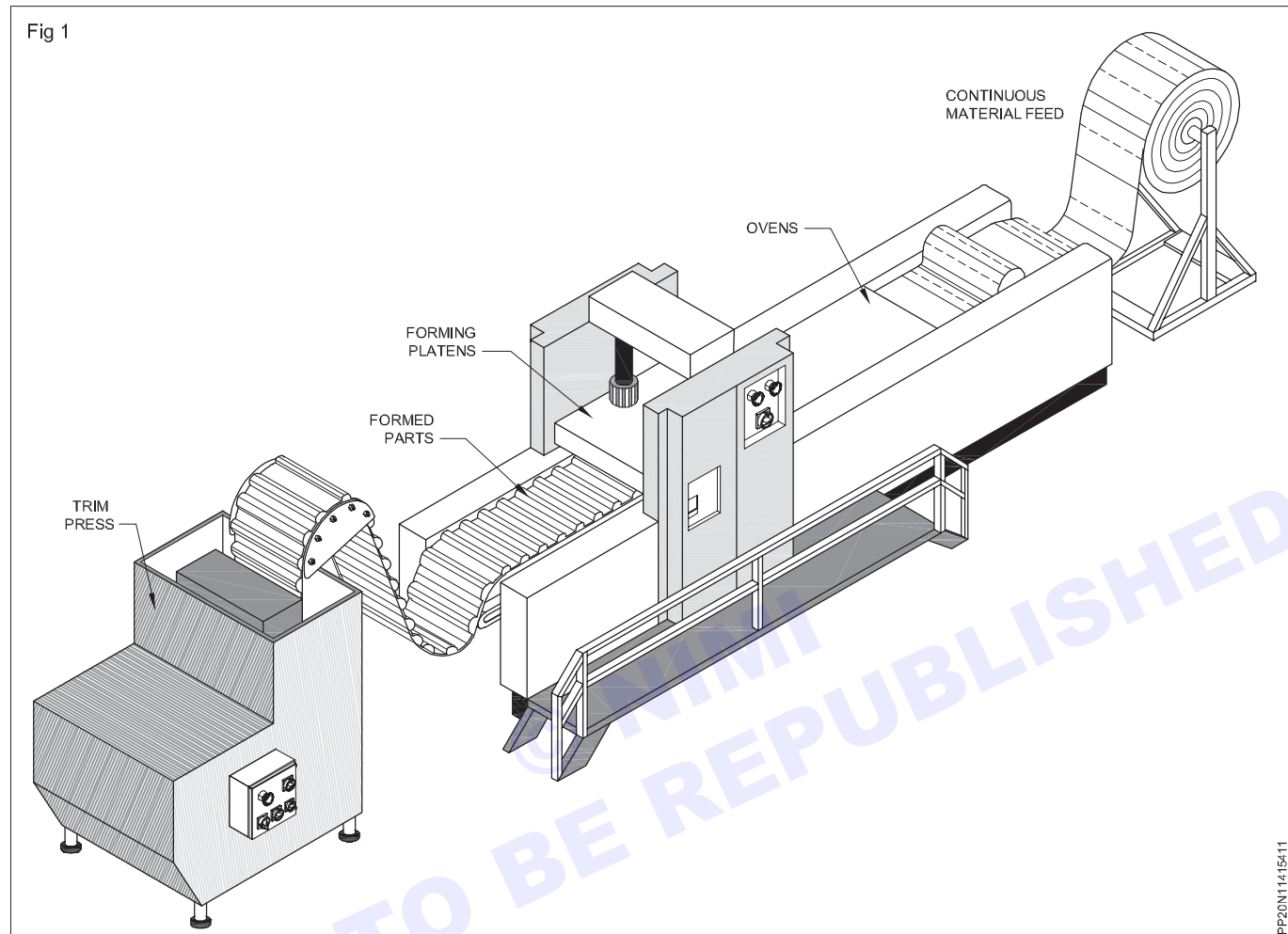
Most roll fed machiries exmoforming machine now what products are manufactured disrupted.

Most roll fed machines or in – line machines typically produce thin walled cups, plates and lids are made. Their wall thickness ranges from 0.003 μm to 0.060 μm (micron)

Due to the speed of these machines, the work in the secondary process is attached according to the stage

which is printing, filling, sealing, die cutting scrap. Cutting or automatic removal and stacking of product.

Normally roll fed machines consist of heating bank station, cooling station and trimming station at the top and the bottom of the roll sheet.



Different forming process

Objectives: At the end of this lesson you shall be able to

- state different forming process
- explain drape forming process.

Method of forming

Method of forming can be divided into

- 1 One step forming
- 2 Multi-step forming
- 3 Other variation (Diaphragm forming)

1 One-Step forming

There are five types of one-step forming

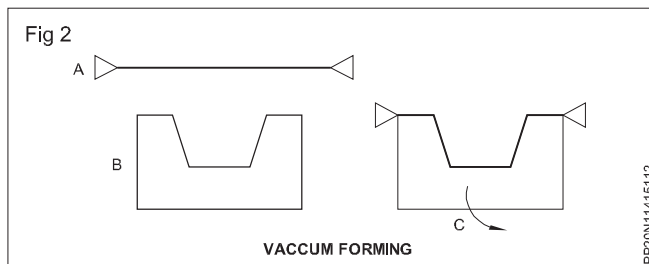
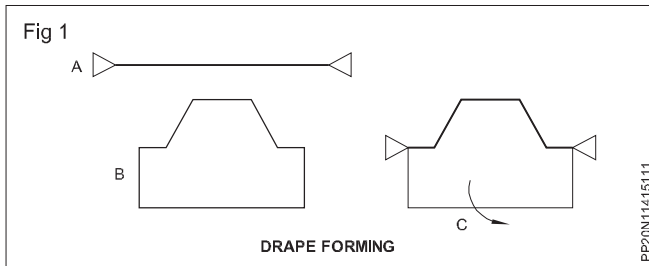
- a Drape forming
- b Vacuum forming
- c Pressure forming
- d Free blowing
- e Matched die forming

The most commonly used are drape forming and vacuum forming.

a Drape forming (Fig 1): In a drape forming, the heated clamped sheet is either lowered on to the male mould or the male mould is raised into the sheet. The sheet in contact with the mould does not stretch. As the mould penetrates and stretches the sheet, the air trapped between the sheet and the mould is evacuated. Either vacuum or air pressure is used to produce the differential pressure to force the sheet against the male mould. In drape forming, the formed part has a thick bottom and thin side walls. The part is thinnest at the rim.

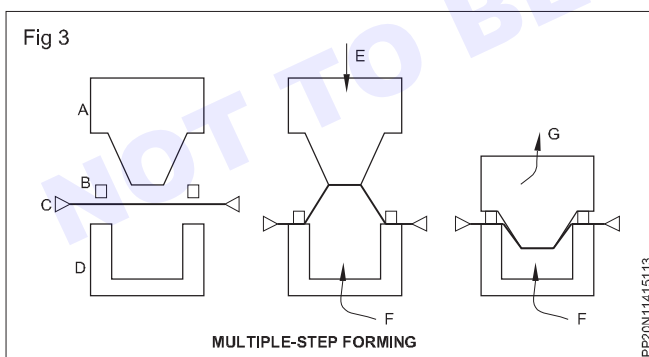
b Vacuum forming (Fig 2): In vacuum forming, the clamped heated rubbery sheet is sealed against the rim of a female mould. vacuum is then applied. This

differential pressure draws the sheet against the mould surface. As noted before, the formed part has a thick rim and is thinnest in the bottom corners. This is also called cavity forming.



2 Multiple-step forming (Fig 3)

In thin-gauge thermoforming, cycle times are very short and shapes are relatively simple. As a result, forming is usually restricted to one of the one-step techniques described above. In heavy-gauge forming, quite complex and quite deep parts are sometimes required. More importantly, wall thickness uniformity becomes a significant design parameter. As a result, forming frequently has more than one step. The first step is usually a form of sheet stretching, such as plug assist or billowing. The prestretched sheet is then pressed against the mould surface.

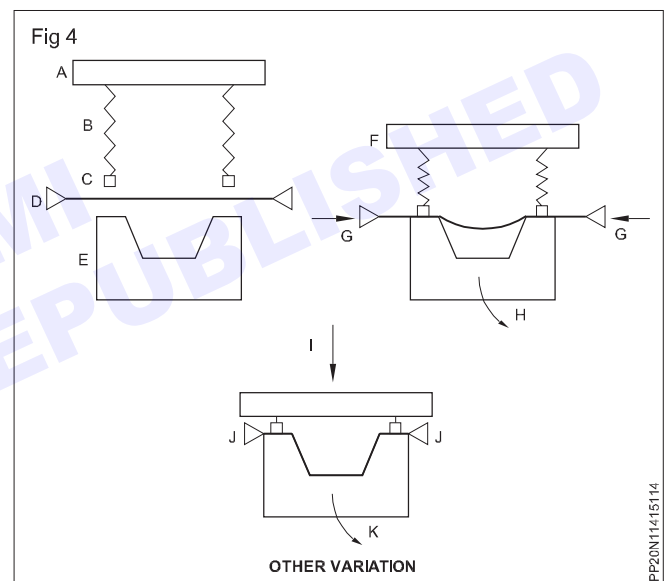


Billow drape forming begins with a clamped heated rubbery sheet that is expanded into a bubble with air pressure. Typical air pressures for inflation are 0.014 to 0.055 MPa (2 to 8 psi gauge). A male mould is then inserted into the bubble, air pressure is cut off and vacuum is applied if needed. The resulting part has a much more uniform wall thickness than that form straight drape forming. If the sheet is prestretched by drawing it into a large rectangular box with vacuum, the technique is called vacuum shape-back forming.

3 Other variation (Fig 4)

In order to form cream types of plastics techniques other than those given above have been devised.

One is trapped sheet forming, for highly oriented (OPS) or temperature sensitive sheet (PP, PE). The clamped sheet is held against a heated porous plate until it reaches forming temperature. Pressure is then applied through the plate, forcing the sheet against the female mould. Alternately, vacuum can be applied, drawing the sheet away from the heater and against the mould.



Comparison thermoforming and injection moulding process

Objectives: At the end of this lesson you shall be able to

- compare thermoforming & injection moulding process
- state defects caused by thermoforming
- explain preventive maintenance in thermoforming.

Comparison thermoforming and Injection moulding process

Thermoforming	Injection moulding
Low forming processes are needed	High pressure are needed
Mould costs are low	Mould costs are high

Large size can be economically fabricated.	Fabricated large size costly.
Thin wall thickness can be easily fabricated economically	Thin wall thickness can be fabricated through specialized costly micro injection moulding
Mould can be made of relatively in expensive materials like wood.	Mould can be made of hardened steel
There will be material wastage in the form of edge trimmings	Where articles come from machine almost finished and need only the removal of the sprue.

Thermoforming Trouble shooting guide

Situation	Probable causes	Suggested courses of action
Blisters or bubbles	1 Over heating	1a Lower the heater temperature
		1b Increase distance of heater from the clamped sheet
		1c Attach masks or bafflers
	2 Wrong sheet type or formulation	2 Obtain correct formulations
	3 Poor storage condition	3 Do not remove material from moisture proof wrap until ready to use.
Blash or change in colour intensity	1 Insufficient heating	1 Lengthen heating cycle
	2 Mould is too cool	2 Warm the mould.
	3 Assist is too cool	3 Warm the assist
	4 Sheet cools before it is completely formed	4a Speed the drape action
		4b Add vacuum holes
	5 Too deep to draw	5 Use heavier gauge sheet or softer formula
Sticking to the mould	1 Rough or improperly designed mould	1a Make mould smoother
		1b Increase the taper on male plugs
		1c Use mechanical relase assist
		1d Use air pressure to blow piece from mould
		1e Use mould release agent
Incompletely or improperly formed pieces	1 Sheet is cold	1a Lengthen the heating cycle.
		1b Bring heater closer to sheet.
	2 Insufficient vacuum	2 Check vacuum system.
	3 Vacuum holes are plugged up	3 Clean, relocate or add vacuum holes.
Warped or distorted pieces	1 Poor mould design	1 Redesign mould using proper tapers and ribs.
	2 Sheet removed while too hot	2a Increase cooling cycle
Webbing or bridging	1 Insufficient vacuum	1a Check vacuum system
		1b Add more vacuum holes
	2 Sheet is overheated	2a Shorten heating cycle
		2b Increase heater distance from the shoot
	3 Long parallel moulds with extrusion direction parallel	3 Move sheet 90° in relation to mould.
	4 Poor mould layout or design	4 Use machanical drape or plug assists
	5 Sharp corners on deep draw	5 Increase radius

Bad surface Markings	1 Mark off (due to trapped air)	1a Slow draping action
		1b Add more vacuum holes
	2 Mark off (due to accumulation of plasticizer on mould)	2a Use a temperature controlled mould
		2b Have mould as far away from the sheet as possible from the heating cycle.
		2c Shorten the heating cycle (if too long)
		2d Wipe the mould
	3 Mould is cool	3a Warm the mould
		3b Bring the heater closer to the sheet
	4 Mold is too hot	4 Provide cooling for mould.
Excessive poor shrinkage	5 Improper mould composition	5 Avoid phenolic moulds with clear transparent sheet.
	6 Mould surface too highly polished	6 Remove high surface gloss from mould.
	7 Mould surfaces too rough	7 Smooth surface.
Pinholding or rupturing	1 Sheet removed from mould while still hot.	1 Increase cooling time
	2 Vacuum hole too large	2 Attach baffles to the top clamping frame.

Preventive maintenance

What to inspect

By far the most wanted information from these starting a PM programme has to been 'Can you give me list of what items to include and how often to inspect'? It would be nice if we could but it is not that easy.

In fact it cannot be done. This part of the tailor-made process everyone has to do for himself. There are general principles, however, to guide the development. We will examine first the 'What to include' part, and attach the 'how often' angle in a subsequent portion.

What should the individual plant decide to include? The answer depends largely on local conditions. A good programmer will include most of the plant's physical property including the following.

- **Process equipment** - furnaces, heat exchangers piping, pumps, compressors, motors, stills, instruments.
- **Safety equipment** - Vacuum and pressure – relief valves, flashbacks or flame arresters, breathing and emergency relief equipment.
- **Utility equipment** - boilers, electric generators, supply, storage, and distribution system of water, steam and compressed air pipelines.
- **Tanks and auxiliary equipment** - Storage tanks, pipelines, drains, gauges and measuring instrument.
- **Plant buildings** - includes shipping and storage areas, also transportation equipment such as tank cars and transfer pumps.

- **Fire protection equipment** - water supply and pipelines, pumps, Permanent fire extinguishing installations of foam, fog, gas, spray or dry powder, first aid extinguishers, fire trucks, alarm systems.

A good PM programme makes sure to include seasonal functions of equipment as well as care of equipment itself. For example it will include duties like pumping down of a refrigeration system not used in winter months. And it will include special measures for preservation of machinery and plant during shutdown for off season layups, schedules vacations, unexpected labour troubles or weather catastrophes.

If maintenance work is not done properly the machine is subjected to malfunction, thus machine may unexpectedly require replacement of parts, interruption of operation and as a result of this the company may ultimately suffer financial loss. Financial loss may also occur for accident due to lack of maintenance. It not only damages the machines but heavy compensation is to be paid in case of loss of life.

The maintenance said above requires neither a great amount of time nor highly advanced technology, nor a large number of manpower.

It is utmost important to perform maintenance without fail.

Advantage of Preventive Maintenance: Preventive Maintenance is not a cure but minimising for excessive downtime or high maintenance cost. There are other maintenance functions, with which PM must be integrated to achieve an efficient plant maintenance programmer a good paper work system, work planning

and scheduling control reports of good workshop and tools. Here are the major returns with which PM has rewarded its users.

- Less production downtime.
- Less overtime pay for maintenance man on ordinary adjustments and repairs than for breakdown repairs.
- Fewer large scale repairs and fewer repetitive repairs.
- Lower repair costs for simple repairs made before breakdowns, because less manpower, fewer skills and fewer parts are needed for planned shutdowns than for breakdowns.
- Fewer product rejects, less spoilage, better quality control.
- Postponement or elimination of cash outlays for premature replacement of plant or equipment.
- Less standby equipment needed, reducing capital investment.
- Decline of maintenance costs. labor and material on asset items in the programmer
- Identification of items with high maintenance costs, leading to investigation and correction of such causes as misapplication, operator abuse.
- Better spare parts control, Leading to minimum inventory.
- Better industrial relations because production workers do not suffer in voluntary layoffs or loss of incentive bonus for breakdowns.
- Greater safety for workers and improved protection for the plant, leading to lower compensation and insurance costs

In a survey it is observed that huge numbers of machines lay die due to only negligence of maintenance. It shows the importance of the maintenance work. Now-a-days most of the industries are having their separate department as a "Maintenance Department". Preventive maintenance activity is an important activity of maintenance department or say maintenance cell.

Fundamentally Preventive Maintenance is essence of the two proverbs viz. "Prevention is better than cure" and ASTITCH IN TIME SAVES NINE it aims to maintain a factory and its planned capacity by most economical means. Literary speaking "Preventive Maintenance" is system for making inspection and implementation of schedule work on each machine for managed maintenance to cut down the cost for upkeep and repair". The Maintenance department has to plan and schedule of work for Preventive Maintenance activity.

Aim of Preventive Maintenance

- To prevent controllable breakdown.
- To minimise the uncontrollable breakdown.

Basic Activities: All the preventive maintenance work may be contained in the following main basic activities

Planning - What to do and how to do?

Scheduling - When to do?

These activities may be introduced in other words i.e. plan - Determination - Implementation.

Thus Preventive Maintenance is a group of work as below

Planning: To inspect the workshop assets like machines, equipment's, fitting tools etc. time to time, based on a well 'Planned' schedule to observe the conditions which might be bad for production, and to find out breakdown, harmful depreciation or safety hazardous and do the needful correction Immediately.

Schedule: Execution of maintenance work under the preventive maintenance schedule which will be prepared well in advance Refer to Chart.

Basic aspects

Inspection - What to inspect and how to inspect?

How often to inspect? - Frequency.

When to inspect? - Schedule.

Who inspects? - Maintenance person/operator.

Records and Reports - Paper work.

Since all the machines are having sliding and rotating components the friction between the mating parts is unavoidable. These friction can be minimised by regular oiling and greasing.

The oiling and greasing spots are provided in the designing of structure and are indicated in respective operation manual.

The aim of lubricating is to keep mating surfaces apart by the help of agent known as lubricant.

Lubricant

Lubricant is an agent which works to keep separate two mating surfaces and to reduce the friction when they are sliding on each other.

Main Function

A lubricant has two main functions.

- The minimisation of damage to the sliding surfaces.
- The reduction of friction between them.

If the surfaces are separated completely by means of a fluid film, it will avoid the damage and also it will minimise friction.

Purpose of Lubricant

We have seen the two main functions of lubricant Apart from these functions lubricant serves several purposes as given below.

- Minimise the friction
- Dissipate the heat to cool
- Reduce wear and tear
- Enhance life of the mating parts
- Aid in distribution of load
- Prevent corrosion
- Act as a seal
- Assist to wash
- Absorb shocks.

Rotational moulding

Objectives: At the end of this lesson you shall be able to

- explain rotational molding process
- state advantage disadvantage of roto moulding
- describe the material of rotational moulding.

Introduction

Rotational moulding rotomolding is a relatively young industry. with its roots found in poly vinyl chloride (PVC) plastisol moulding of the late 1950s. With lower than 2000 companies worldwide even today, it has remained a small but exciting niche within the plastics world that reaches almost every conceivable market yet typically enjoys growth rates above the industry average. It offers much in the way of design flexibility and scale of product, with products ranging from simple bulk storage containers to sophisticated automotive, medical, and aerospace applications. Regularly used to produce parts of great complexity with a constantly growing range of applications, rotational molding lends itself to hollow complex forms as does no other process. Small parts such as dolls' heads can be made in essentially the same manner as that used for huge 22,000-gallon (80,000-liter) storage tanks. Intricate parts such as fuel tanks and components for aircraft ducting are now more common as rotational molding is recognized by a broader group of designers and engineers. Rotational molding, however, remains in something of an infancy in terms of development. The apparent simplicity of the process and the low-tech markets. Commonly pursued have caused it to be overlooked somewhat. Current market trends to consolidate components and shorter product life cycles with lower total volumes have brought an increased level of interest. Importantly, this interest by the market has attracted the interest and development efforts of major material suppliers, a key factor in the future development of the industry.

Advantages and Limitations of Rotational Molding

- The main advantages of rotational molding can be summarized as follows
- It is ideally suited to the manufacture of hollow, complex shapes ranging in size from table tennis balls to industrial tanks over 20,000 gallons (75,700 liters) in capacity
- Both moulds and machines are simple and relatively low in cost. It is a low- pressure process that allows thin walled low-strength molds to be used. Small production runs can be cost effective.
- Low pressure and low shear rates lead to parts that have low levels of molded in stress.
- Parts have good wall thickness distribution compared to processes such as blow molding and thermoforming. External corners tend to thicken, which can be an advantage in applications where wear is critical.

- Parts can have thin walls relative to their size and volume (ie, large tanks)
- Different sizes of parts can be produced simultaneously on the same machine at the same time.
- Parts made of different materials can be molded simultaneously on the same machine and even on the same arm at the same time
- Large metal inserts and graphics can be molded directly into parts. A wide range of surface textures and details can be reproduced
- Color changes can be made quickly and easily. There is no purging process such as that found in injection molding or extrusion processes. Parts can be molded in a new color without loss of material or parts
- Multiple-layer parts can be formed using the same low cost molds. Multicolored parts and parts with foamed layers can be produced using simple techniques,
- All material placed in the mold is used to form the part. Scrap is limited to those areas that are removed from the part during finishing. Insulated sections of the mold can be used to minimize this runoff.

The main limitations of rotational molding can be summarized as follows

- The process is typically not well suited to very large production runs of smaller parts. For smaller parts, blow molding or even injection molding may be more competitive.
- The number of materials that are available for rotational molding is limited in comparison to other processes.
- Material costs are higher, due to the need for grinding pellets of raw material to a fine powder for molding. Developments in micropellets may help to reduce this penalty.
- Cycle times are long in comparison to other processes, as both the mold and material must be heated and cooled. The materials used require more thermal stabilization and therefore cost more than for other processes.
- Loading of molds and unloading of parts is labor intensive by comparison to other processes, especially for complex parts.

- Release agents are required to ensure that the material does not stick to the mold during demolding. This demands constant attention by the machine operator.
- Bosses and ribs for stiffening cannot easily be molded into parts; designers must depend more on part geometry and design to produce stiff parts:
- Large flat surfaces are difficult to produce, due to warpage. Designers will typically use ribbing and surface details to avoid them in parts.
- The inner surface of a part is formed freely during molding. This means that dimensions cannot be controlled with the same degree of accuracy as, for example, injection molding.
- A part is free to shrink during cooling; dimensional accuracy can therefore be more difficult to predict.

Cycle of roto moulding

Four basic steps

- 1 Loading
- 2 Heating
- 3 Cooling
- 4 Unloading

Grinding Process

The bulk of materials ground for rotational molding are polyethylene (95% + of the market) Polyethylene is a relatively tough material that can be difficult to divide. The most common method of pulverizing is performed using high -speed attrition mills that grind pellets approximately 3/16 to 1/4 in in (5 to 6mm) in diameter to the particle size distribution required.

(0.125 mm). The settings are affected by initial pellet size, material toughness, over all throughput rate, and so on. Optimizing the settings for a single mill will differ from a dual-mill system, as the single mill acts as a secondary mill also, resizing larger particles from the first cut.

Cutting teeth The number and condition of the cutting teeth on the wheels will affect grind quality. A 360-tooth disk is coarser and will produce larger particle sizes a 480-tooth wheel is finer and a smaller particle is produced. The design of the cutting edges is also important, as the valley between the teeth affects the amount of material sheared during cutting the larger the angle, the larger the particles produced. A sharp edge on the cutting blades is important for a clean shearing action Dull cutters generate more heat as pellets roll through the blades producing more fine particles

Grinding Temperature Monitoring temperatures during grinding is important for smooth operation and final powder quality. Overheating at the mill face can cause a meltdown situation that can cause the mill to stop rotating. Mills will typically have a thermocouple sensor in this area to prevent this from happening. Also, as

particles are drawn away from the mills for sifting, the air temperature plays an important role in “polishing” the particles. A sufficiently high temperature is required to soften the to ensure that the mold heats up evenly, to assure even distribution of the material inside the mold. The most efficient design will deliver the air at 90° to the mold-carrying arm assembly to promote uniform heating between spiders of tightly packed molds. Air is typically changed in the oven 25 to 30 times per minute to provide effective uniform heating Figure shows how airflow in one style of oven might circulate.

Oven exhaust fans are employed to evacuate noncombustible, and other products of combustion, from the factory. Efficient oven designs have a modulated (adjusting) exhaust fan that accounts automatically for the burner setting and extracts only as much air as necessary to maintain a safe atmosphere within the factory. Nonmodulated exhausts must be sized for the maximum energy input of the burner, this means that they will extract more heat than necessary when the burner modulates (slows down) at the point when the oven has reached its set point.

Cooling Stage

The primary goals of the cooling stage are:

- To cool the material within the mold uniformly
- To control the rate of cooling to produce good part properties and dimensional stability.
- To reduce the mold and part temperature to a safe handling temperature

Cooling is normally carried out in a separate chamber, although single-station machines combine both heating and cooling in a single chamber, hot oil and electrical. Typical air circulation pattern in an oven during molding. (Courtesy of ferry industries, inc.)

Material of rotational moulding

Range of material available

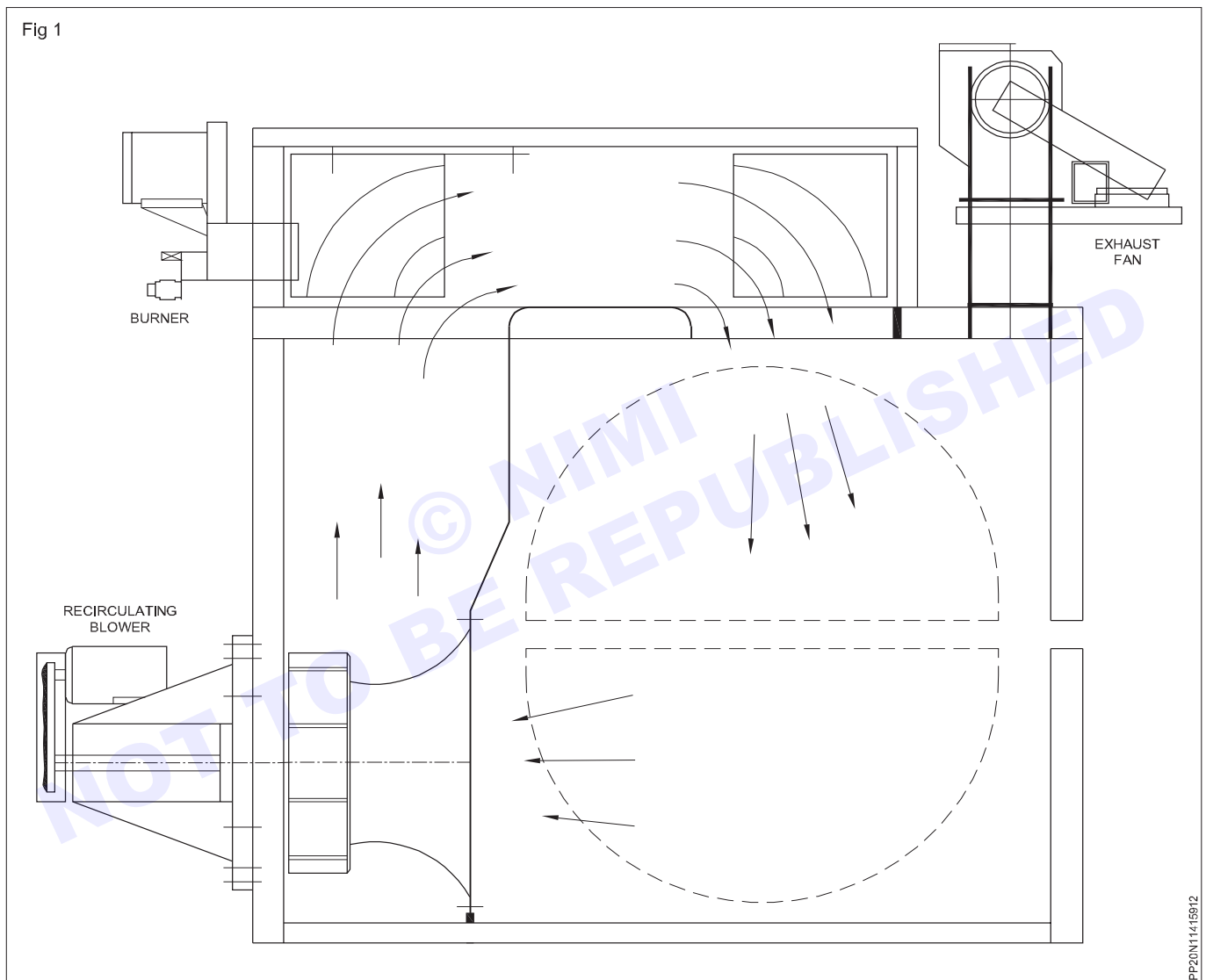
Of the many polymers available to all plastics processes, there is only a fairly narrow group of materials that can be processed easily by rotational molding. The group is gradually growing as more material suppliers and end markets recognize the potential of the process. From a market perspective, the principal materials in the today are ranked as follows:

Polyethylene (LDPE, LLDPE, HDPE, XLPE, MLLPE, EVA)	95%
Polyethylene chloride	3%
Nylons (nylon 6, 6,6, 11, 12)	<0.5%
Polypropylene	<0.5%
Polycarbonate	<0.2%
Fluoropolymers (ETFE, ECTFE, PFA, MEA, PVDF)	<0.1%

There are, however, a range of polymers that have either been successfully molded over the past 30 years or are being used in small quantities for specialist applications. These include:

- Acetyl copolymer
- Acrylic
- Acrylonitrile-butadiene-styrene (ABS)
- Cellulosic
- Epoxy
- Ionomers
- Phenolic
- Polybutylene
- Polyester
- Polyester elastomer
- Polystyrene
- Polystyrene, impact modified
- Polyurethane
- Silicone

Fig 1



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Materials

Rotational moulding is a materials dependent process. This manufacturing technique could not exist without suitable plastic materials. The process related material requirements of (1). Availability in a power (or) liquid form (2), Thermal stability (3), Good flow; combine to eliminate many plastic materials from consideration. Five of the plastic materials that over came these limitations are listed in descending order of usage.

- 1 PE
- 2 PP
- 3 PVC
- 4 NYLON
- 5 PC

These are the commonly rotationally molded materials. In addition to these five industry leaders, there are other plastics that are also molded in some instances. These other materials are:

- 1 ABS
- 2 Acetal
- 3 Acrylic
- 4 Epoxy
- 5 Fluorocarbons
- 6 Phenolic
- 7 Polybutylene
- 8 Polyester
- 9 Polystyrene
- 10 PU
- 11 Silicone.

Mould Material

Moulds used in rotational molding are among the easiest and least expensive to fabricate. Two - piece molds are standard, but three - piece molds are some times required for proper finished part removal. Molds can be simple; round object shape (or) a complex design with under cuts, ribs and tapers In rotational mold design, it is important to consider.

Heat transfer of the mould material

How is it to be mounted ?

What type of parting lines are needed

What types of clamping mechanisms are required ?

What type of venting is required ?

How well the material will stand up to the anticipated number of heating and cooling cycles.

Cast Aluminum

Cast Aluminum Molds are by far the most popular and most frequently used mold type. Most small to medium sized parts are made with a cast mold. Cast aluminum has good heat – transfer characteristics and is cost effective when several molds of the same part are required. A draw back of cast molds is that they porous and can be damaged easily.

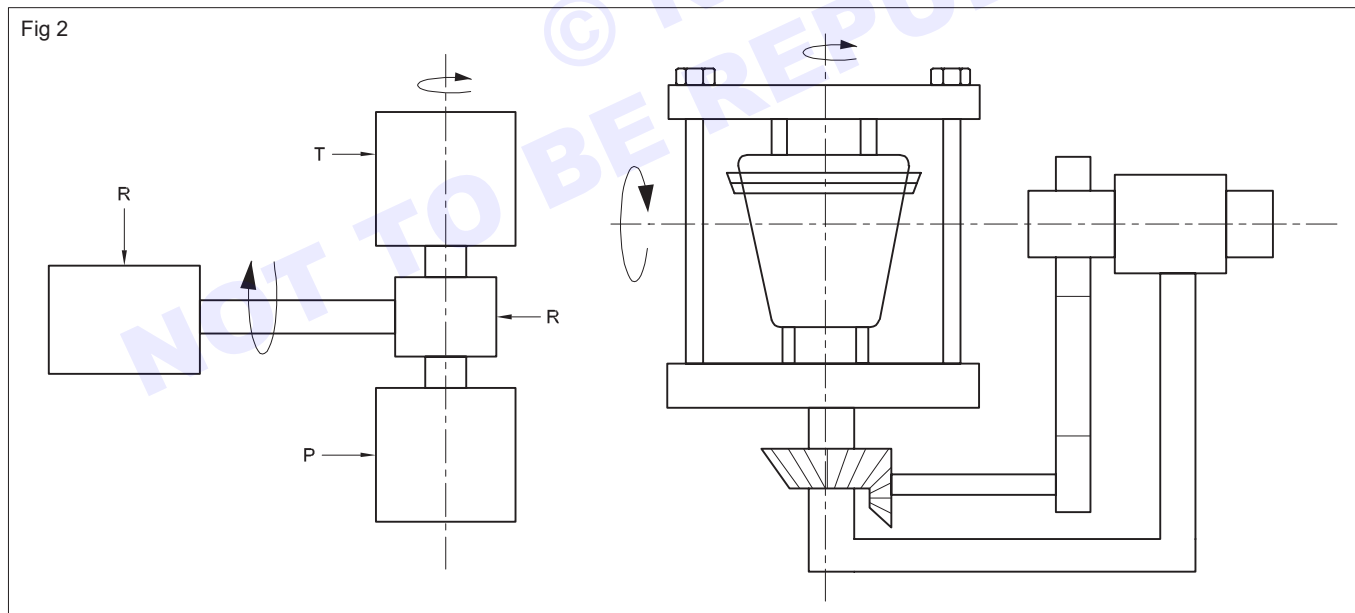
Sheet metal molds

Sheet metal molds are used for larger parts. They are easy to fabricate: in many cases, mold sections simply have to be welded together. Sheet metal molds are cost effective when larger single molded parts are required.

The mounting of molds at the end of an arm is shown in (Fig 2)

In the straight – arm arrangement (O), two molds (T), and (P) are mounted symmetrically on a spider (S), which imparts one rotation, the spindle (R) imparts the other rotation.

The offset arm arrangement (F) is suitable for single, but longer molds. It also minimizes variations in wall thickness by bringing the center of volume of mold close the intersection of the primary and secondary axes of rotation.



Application

Rotationally molded PE, components have now captured applications in many markets, including the following.

Industrial products: Tanks, drums containers, Floor maintenance machine components, medical carts, Video game housings, pump bodies, septic tanks, lifting units, machine instrument and appliance housings, utility sheds and portable toilets. Transportation products:

Truck – bed boxes, toolboxes, ventilating ducts, fuel tanks, battery cases, motorcycle saddlebags and bumpers.

Consumer products: Infant and adult furniture such as tables, chairs, beds, desks and benches, insulated food and beverage containers and mailboxes. Recreational products

Ride – on and ride – in toys play ground equipment, motor and sailboats, toy storage boxes and exercise equipment's

- Agricultural products
- Water tanks

Polypropylene

PP is specified for many of the same applications as PE. PP's higher stiffness and increased temperature resistance allow to perform in applications where PE is not quite good enough.

One example is a steam – auto cleavable, portable tissue culture chambers, as a replacement for heavier and more costly stainless steel. This application takes advantage of PP's chemical resistance, stiffness, and heat deflection temperature.

Other applications include large chemical shipping drums, radioactive material containers, and high – temperature air ducts.

Polyvinyl chloride

The first plastic material to be rotationally molded on a commercial basis was PVC.

Industrial products

Flexible and rigid air ducts, machine air and water filters, gaskets, and tires.

Medical products

Examination, chair arms, flexible anesthesia facemasks, ear and ulcer irrigating syringe bulbs, blood pumps.

Transportation products

Traffic cones and highway barriers, dust covers and gearshift boots, arm and head rests.

Consumer products

Soft cushioning furniture, picture frames, artificial fruit and toys.

Recreational Products

All types of play balls, noise – making squeeze toys; doll and animal heads and body pans; toy wheels.

Nylon

Nylon was the first high performance engineering plastic suitable for the rotational molding process.

Nylons compete primarily with PE in the market place. Both materials are used many of the same application. End users specify PE wherever possible because of its low cost and ease of processing. Nylon becomes the choice when PE is not quite good enough.

Typical uses for nylon include fuel storage tanks, high temperature ducts, truck radiator surge tanks, larger chemical shipping bottles, air horns, pressurized water treatment tanks, fuel tank level indicating floats, and Air intake manifolds.

Polycarbonate

The first rotationally moldable plastic material that provided both transparency and a high service temperature was PC.

The largest single market for PC is as transparent and translucent lighting globes of all types. PC's impact strength allowed it to take this application away from breakable glass.

This material's excellent outdoor weather ability is another important consideration in this application. Other uses:

- Pressurized beer containers
- Air – cleaner housings
- Components requiring precise dimensions and minimum of warpage.

Advantages

- 1 This is a low – pressure process that allows the use of light – duty molds and machines.
- 2 This process uses little (or) no pressure in comparison to other closed – molding processes that require higher processing pressures to force the material to flow, (or) form, into the cavity.
- 3 The heating and cooling of plastic under low – pressure conditions results in molded parts that exhibit low levels of molded – in stress (This reduction of residual stress results in improved impact strength and chemical resistance, with a reduction in post mold warpage).
- 4 Rotational molding is the ideal plastics process for running family molds. Widely different shapes of large and small parts, in single and multiple cavities, can be efficiently run simultaneously on a machine.
- 5 There is no time lost in purging from one kind of material (or) color to the next. This is a distinct advantage over the melt flow processes, which can require several hours of purging.
- 6 This process has the ability to produce two – color (or) two – material parts without multiple molds (or) sophisticated two – material molding machines. Two and – three layer hollow parts can be solid foamed (or) combinations of both.
- 7 Rotational molding is an excellent process for producing parts with molded in inserts – Metal plastic, rubber and wooden inserts in lengths of one meter have been successfully molded into one piece composite parts.
- 8 Parts produced by this process are free of weld lines, gate vestiges, and scars left by ejection mechanisms.
- 9 Rotational molding is the best plastics manufacturing process for producing deep – draw, hollow parts with closely spaced parallel walls. Cooler chests, food insulating containers, and boats with inner and outer hulls molded as one piece are examples of double – walled parts of this type.
- 10 Rotational molding produces a minimal amount of scrap material “There are no sprues (or) runners as there are in injection molding.

Trouble shooting

There are many potential variables in the rotational molding process that can affect the size of the part being produced.

- 1 If there is variation in the amount of plastic material charged into the cavity, The wall thickness will change accordingly. The shrinkage and part dimensions will also vary with a change in wall thickness.
- 2 The molding – machine speed, ratio of rotation, oven temperature, and other processing parameters must accommodate all the parts being molded. The machine settings in these cases are always a compromise between the most and least demanding part being molded.
- 3 Variations in oven time, temperature, and air velocity can affect the final part size. The hotter the plastic material becomes, the more it expands. The material will then contract (or) shrink more as it returns to room temperature.

- 4 The speed with which a plastic material is cooled will affect shrinkage. Cooling the material quickly results in a low shrinkage factor. Cooling the material slowly increases shrinkage ,but the shrinkage will be more uniform.
- 5 A product produced in a mold that does not cool uniformly will have different amounts of shrinkage in different locations on the part. These variation is shrinkage encourage war page and make id difficult to maintain uniform dimensions.
- 6 Dimensions that cross the parting line of the mold will change if the mold is not closed to the same location each cycle. Powdered plastic spilled on the mold's flanges at the parting line can prevent the mold from being closed completely.
- 7 Variations in the amount of mold release used can increase (or) decrease the tendency of a hollow part to pull away from the cavity as the parts cools and shrinks.

“The best approach to molding parts to close tolerances is to establish the optimum molding cycle and the maintain those conditions.”

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Importance of pre - drying

Objective: At the end of this lesson you shall be able to

- **state the importance of pre-drying process.**

Importance of pre-drying (plastic moulding)

Pre-drying is a crucial step in the plastic molding process, especially when working with hygroscopic materials, which have a tendency to absorb moisture from the environment. The importance of pre-drying in plastic molding can be highlighted in several key aspects.

Prevention of Hydrolysis

Many plastics, such as PET (polyethylene terephthalate) and nylon, are susceptible to hydrolysis chemical reaction with water that can lead to a decrease in the polymer's molecular weight. Pre-drying helps prevent hydrolysis by removing moisture before the plastic is processed.

Reduced Defects in Molding

Moisture content in plastic resins can result in defects such as bubbles, voids and surface imperfections in the molded parts. Pre-drying ensures that the material is free from moisture, reducing the likelihood of these defects and improving the overall quality of the finished products.

Enhanced Melt Flow and Homogeneity

Moisture in plastic resins can affect the melt flow characteristics and homogeneity of the material. Pre-drying helps achieve a more consistent and uniform melt, leading to improved flow properties during the molding process and better part quality.

Minimized Mold Corrosion:

Moisture in plastic resins can lead to the release of acidic byproducts during processing, which may contribute to mold corrosion. Pre-drying minimizes the presence of moisture, reducing the risk of corrosion and extending the lifespan of molds.

Improved Strength and Mechanical Properties

The presence of moisture in plastic resins can weaken the molecular structure of the material, affecting its mechanical properties such as tensile strength and impact resistance. Pre-drying ensures that the plastic maintains its intended structural integrity and performance.

Various pre-drying equipments

Pre-drying equipment is used to remove moisture from plastic resin before it is processed in molding extrusion, or other plastic manufacturing processes. Proper pre-drying is essential for achieving high quality plastic products. Several types of equipment are available for

pre-drying plastics, and the choice depends on the type of material, production volume, and specific processing requirements. Here are various pre-drying equipment commonly used in the plastics industry:

Desiccant Dryers

Description

Desiccant dryers use desiccant materials, such as molecular sieves or silica gel, to absorb moisture from the plastic resin. These dryers consist of two drying hoppers—one in use while the other is being regenerated.

Applications

Suitable for drying hygroscopic materials like PET, nylon, and ABS.

Hot Air Dryers

Description

Hot air dryers use heated air to remove moisture from plastic resin. The resin is typically conveyed through a hopper with hot air circulating around it.

Applications

Widely used for drying non-hygroscopic materials, including polyethylene and polypropylene.

Vacuum Dryers

Description

Vacuum dryers operate under reduced pressure, lowering the boiling point of water and facilitating the removal of moisture from the plastic resin at lower temperatures.

Applications

Suitable for heat-sensitive materials or materials that may be damaged at higher temperatures.

Infrared Dryers

Description

Infrared dryers use infrared radiation to heat the plastic resin directly, enabling quick and efficient moisture removal.

Applications

Effective for rapid drying of small batches of resin.

Compressed Air Dryers

Description: Compressed air dryers utilize compressed air to remove moisture from the plastic resin. The compressed air is dried using a refrigeration or desiccant system.

Applications:

Suitable for small to medium-sized operations where compressed air is readily available

Rotary Wheel Dryers

Description: Rotary wheel dryers use a rotating wheel filled with desiccant material to adsorb moisture from the plastic resin. The wheel rotates between the drying and regeneration phases

Applications: Suitable for continuous and energy-efficient drying of hygroscopic materials

Hopper Dryers

Description: Hopper dryers are compact units that attach directly to the processing machine's hopper. They use hot air or desiccant technology to dry small quantities of plastic resin.

Applications: Commonly used for injection molding and extrusion machines with moderate throughput.

Pre - drying temperature and time for various materials

Objective: At the end of this lesson you shall be able to

- state pre-drying temperature and time for various material.
-

Pre-drying temperature and time for various materials

Pre-drying of materials is a crucial step in certain manufacturing processes, particularly in plastic processing, to remove moisture and prevent defects in the final product. The specific temperature and time required for pre-drying vary depending on the material being used. Here are some general guidelines for pre-drying temperature and time for various materials:

ABS (Acrylonitrile Butadiene Styrene)

Temperature: 80-85°C (176-185°F)

Time: 2-4 hours

Nylon (Polyamide)

Temperature: 80-90°C (176-194°F)

Time: 4-6 hours

PET (Polyethylene Terephthalate)

Temperature: 140-160°C (284-320°F)

Time: 3-4 hours

PC (Polycarbonate):

Temperature: 120-140°C (248-284°F)

Time: 2-4 hours

PP (Polypropylene)

Temperature: 60-70°C (140-158°F)

Time: 2-3 hours

PS (Polystyrene)

Temperature: 80-90°C (176-194°F)

Time: 2-3 hours

PVC (Polyvinyl Chloride)

Temperature: 70-80°C (158-176°F)

Time: 2-3 hours

PE (Polyethylene)

Temperature: 60-70°C (140-158°F)

Time: 1-2 hours

POM (Polyoxymethylene -Acetal)

Temperature: 80-90°C (176-194°F)

Time: 2-4 hours

These recommended pre-drying parameters are general guidelines, and actual requirements may vary based on factors such as the moisture content of the raw material, the equipment used, and the specific processing conditions. It's essential to consult the material supplier's guidelines and the equipment manufacturer's recommendations for precise instructions.

Safety observed while operating pre-drying equipment

Objective: At the end of this lesson you shall be able to

- explain safety observed while operating pre-drying equipment.
-

Operating pre-drying equipment requires adherence to strict safety protocols to protect individuals and ensure the integrity of the plastic manufacturing process. Safety measures are crucial to prevent accidents, injuries, and damage to equipment. Here are safety guidelines to observe while operating pre-drying equipment

Personal Protective Equipment (PPE)

Wear appropriate PPE, including safety glasses, gloves, and, if necessary, respiratory protection, to safeguard

against potential hazards associated with handling plastic resins and operating drying equipment

Training and Familiarity

Ensure that operators are adequately trained on the specific pre-drying equipment being used. Familiarity with the equipment's controls, emergency shutdown procedures, and safety features is essential.

Equipment Inspection

Conduct routine inspections of pre-drying equipment before operation. Check for any signs of wear, damage, or malfunction. Ensure that all safety guards, interlocks, and emergency stops are functional.

Ventilation

Operate pre-drying equipment in well-ventilated areas to minimize the risk of exposure to fumes or vapors. Adequate ventilation helps maintain a safe working environment.

Temperature Control

Monitor and control the temperature settings of the pre-drying equipment within recommended ranges. Avoid overheating, which can lead to equipment damage or pose a fire hazard.

Proper Loading and Unloading

Follow proper procedures for loading and unloading plastic resin into and from the pre-drying equipment.

Ensure that materials are evenly distributed and that the loading and unloading processes are carried out safely.

Avoid Overfilling

Do not overfill the pre-drying equipment beyond its designed capacity. Overloading can compromise the effectiveness of the drying process and may lead to safety hazards.

Fire Safety

Have fire safety measures in place, including fire extinguishers, emergency exits, and clear evacuation routes. Ensure that the pre-drying area is free from flammable materials.

Electrical Safety

Follow proper electrical safety procedures. Ensure that all electrical components are in good condition, and use equipment with grounded power cords. Avoid overloading electrical circuits.

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PPO - Machining operation on plastic sheet and block**Methods of joining and machining of plastics**

Objective: At the end of this lesson you shall be able to

- explain the methods of joining and assembling on plastic sheet.

Acrylic sheet fabrication can be done using various methods. depending on the desired end product and the tools and equipment available. Here are some common methods for acrylic sheet fabrication

1 Cutting

- **Manual Cutting:** Acrylic sheets can be cut manually using tools such as acrylic scoring knives or handsaws. This method is suitable for simple straight cuts
- **Machine Cutting:** Laser cutting and CNC (Computer Numerical Control) routers are often used for precision cutting and intricate designs.

2 Bending Thermoforming

- **Heat Bending:** Acrylic sheets can be bent into desired shapes using heat. This can be done with strip heaters, heat guns, or ovens. Once heated to the appropriate temperature, the acrylic becomes pliable and can be shaped.
- **Vacuum Forming:** In this process, the acrylic sheet is heated and then stretched over a mold using vacuum pressure to create specific shapes.

3 Bonding/Joining

- **Solvent Bonding:** Acrylic solvent cement can be used to chemically bond acrylic pieces together. This method involves applying the solvent to the joint, which softens the acrylic, and then pressing the pieces together. The solvent evaporates, leaving a strong bond.

- **Mechanical Fastening:** Screws, bolts, or other mechanical fasteners can be used to join acrylic sheets. Proper drilling and careful handling are essential to prevent cracking.

4 Engraving and Etching

- **Laser Engraving:** Laser machines can be used to engrave designs, text, or patterns onto acrylic surfaces.
- **Chemical Etching:** Chemical processes can be used to etch designs into the acrylic. This method involves applying a chemical solution to the surface, which reacts with the acrylic to create the desired pattern.

5 Polishing and Finishing

- **Flame Polishing:** This method involves briefly exposing the edges of the acrylic to an open flame, which melts the surface and creates a polished finish.
- **Mechanical Polishing:** Using abrasive materials to polish the edges or surfaces of the acrylic.

6 Printing and Coating

- **Digital Printing:** Acrylic sheets can be printed with designs using digital printing techniques.
- **Spray Coating:** Applying coatings for protection, aesthetics, or specific functionalities.

Always follow safety guidelines and wear appropriate protective equipment when working with acrylic, especially when using heat or chemicals. The specific method chosen depends on the project requirements and the equipment available.

Buffing and sanding

Objective: At the end of this lesson you shall be able to

- comprehend and explain the functions of buffing and sanding machines.

Buffing produces smooth reflective surfaces. It is the re-arrangement and refinement of component scratch and has the ability to level surfaces where the scratch is only visible under high magnification. Buffing is accomplished by bringing a work piece into direct contact with the revolving cloth or sisal buffing wheel which is having a suitable compound over it.

Following types of buffing are centrally used

Hard Buffing

It is used to cut down or smooth the surface of material that may or may not have been previously polished.

Bufs used for hard buffing are usually made of cloth with a high thread count (86-80). Hard buffing entails both cutting action and smoothing action, an abrasive compound is generally used.

Color buffing

It is used for high finish and and lustrous, scratch-free condition. Any marks left on the surface after hard buffing can be removed by color buffing. Bufs made out of clothes with a lower thread count (64-68).

Contact buffing

This is a most conventional process. Contact buffing is done by manual process. A densely packed wheels are used in a rotating shaft; the speed of the shaft is usually higher than 1200 r.p.m.

Mush buffing

In this process a broad wheel is used to cover much larger area. In mush buffing, the wheel itself flexes and envelopes the contours of component.

Compound systems

The prime purpose of buffing wheel is to carry the compound which is usually sprayed on the wheel with the use of pneumatic gun.

Compounds

Following are the compounds used generally

- Tripoli, and/or silica, for most non-ferrous materials and plastics.
- Fused aluminum oxide for finishing ferrous products.
- Calcined alumina's for ferrous and non-ferrous materials.
- Red rouge for high coloring or finishing of brass products.

Methods of machining of plastics

Objective: At the end of this lesson you shall be able to

- describe the methods of machines of plastics.

Machining of plastics involves the process of shaping or altering plastic materials through various techniques to achieve desired shapes, dimensions, and surface finishes. The choice of machining method depends on factors such as the type of plastic, part complexity, and precision requirements. Here are some common methods of machining plastics

Milling

Description: Milling involves removing material from a work piece using rotating cutting tools. It is suitable for creating flat or contoured surfaces in plastics.

Applications: Ideal for producing prototypes, molds, and parts with intricate details

Turning

Description: Turning is a process in which a work piece rotates on a spindle, and a cutting tool removes material to create cylindrical shapes. It is commonly used for plastic rods and tubes

Applications: Produces components such as bushings, shafts, and fittings.

Drilling

Description: Drilling involves creating holes in plastic materials using a rotating cutting tool. It is a versatile method suitable for various plastics.

- Green chrome oxide flours for high coloring or finishing of non-ferrous materials and stainless steel and finishing of plastic products.

Buffing wheels

A buffing wheel carries the abrasive buffing compound across the work surface and produces a cutting and colouring action. Buffing wheels are classified as under:

- a Bias buff
- b Full-desk buff
- c Finger buff
- d Pieced buff

Second blasting

It is a process of abrasive blast cleaning, sand blast cleaning entails the forceful direction of sand particles against the surfaces of parts.

Uses

- It is used for the following purposes:
- To remove rust, scale, burrs etc.
- To prepare a rough surface for bonding, painting, coating etc.
- To produce mat surface finish.
- To remove flash from moulding operation.

Applications: Used for creating holes in components or assembling plastic parts.

Routing

Description: Routing uses a rotating cutting tool to trim, shape, or hollow out plastic materials. It is often used for large, flat sheets:

Applications: Suitable for producing signs, displays, and complex shapes

Sawing

Description

Sawing is a cutting process that uses a blade to remove material from a plastic work piece. It is effective for cutting plastic sheets, blocks, and rods.

Applications

Commonly used for straight cuts in plastic materials

Waterjet Cutting

Description

Waterjet cutting uses a high-pressure stream of water mixed with abrasive particles to cut through plastic materials. It is a cold-cutting method.

Applications

Suitable for cutting a wide range of plastics, including heat-sensitive materials

Laser Cutting

Description:

Laser cutting employs a focused laser beam to melt or vaporize material along a programmed path. It provides high precision and can create intricate designs.

Applications: Used for cutting, engraving, and shaping plastic sheets.

Electrical Discharge Machining (EDM)

Description: EDM involves removing material from a work piece using electrical discharges. It is suitable for complex shapes and hard-to-machine plastics

Applications: Used in the production of molds, dies, and intricate components.

Thermoforming

Description: Thermoforming is a heat-based process where a plastic sheet is heated and formed over a mold. After cooling, the formed part is trimmed

Decoration of plastics

Objective: At the end of this lesson you shall be able to

- describe the decoration of plastics.

Applications: Commonly used for producing plastic packaging, trays, and covers.

CNC Machining

Description: Computer Numerical Control (CNC) machining uses computer-controlled tools to remove material from a work piece. It offers high precision and repeatability.

Applications: Suitable for various plastic components, including prototypes, custom parts, and production runs.

Ultrasonic Machining

Description: Ultrasonic machining uses ultrasonic vibrations to abrade material from the work piece. It is effective for hard and brittle plastics

Applications: Used in the production of micro-parts and components requiring high precision.

1 Printing

- Methods
- Pad Printing Used for irregular surfaces
- Screen Printing: Suitable for flat surfaces
- In-Mold Labeling (IML) Labels are placed in the mold before injection
- Application: Logos, graphics, and text

2 Painting and Coating

- **Process** : Applying paint or coating to the plastic surface.
- **Application** : Automotive parts, consumer electronics

3 Hot Stamping

- **Process** : A foil with the desired design is transferred to the plastic surface using heat and pressure
- **Application** : Decorative elements on packaging, consumer goods.

4 Hydrographics (Water Transfer Printing)

- **Process** : A printed design on a water-soluble film is transferred to the plastic surface
- **Application** : Custom designs on various products

5 Embossing and Debossing

- **Process** : Raising (embossing) or lowering (debossing) the plastic surface to create a texture or pattern.
- **Application** : Textures on surfaces, branding

6 Laser Engraving

- **Process** : Using a laser to remove material and create a permanent design
- **Application** : Detailed designs, serial numbers

7 Insert Molding

- **Process** : Adding decorative elements (such as metal or other plastics) during molding process
- **Application** : Combining functionality and aesthetics.