Manufacturing Process - I

UNIT –III

Plastic Processing

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Introduction

- Term “polymer”: greek poli (many) + meros (unit) = many units
- Polymers are a large class of materials consisting of many small molecules (called monomers) that can be linked together to form long chains, thus they are known as macromolecules (term introduced by H. Staudinger in 1920’s).
- A typical polymer may include tens thousands of monomers. Because of their large size, polymers are classified as macromolecules.
- Polymers occur naturally in the form of proteins, cellulose(plants), starch(food) and natural rubber.
- Engineering polymers, however, are usually synthetic polymers.

- A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are mouldable.
- Plastics are typically organic polymers of high molecular mass, but they often contain other substances.
- They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural.

- **POLYMERIZATION:** The simplest substances consisting of one primary chemical are known as the monomers or monoliths. They are to be combined or synthesized to form polymers by the process known as the **polymerization**.

Properties of plastics

- Less brittle than glass ,hence can be made transparent and smooth.
- Corrosion resistance.
- Low electrical and thermal conductivity, insulator.
- Easily formed into complex shapes, can be formed, casted and joined.
- Wide choice of appearance, colors and transparencies.
- Light weight but posses good strength and rigidity.
- Low moisture absorption.
- Heat resistance.

- Plastics can be divided into two classes.
  1. **Thermo plastics**
  2. **Thermo setting plastics,**

  depending on how they are structurally and chemically bonded & depending on Mechanical response at high temperature.

THERMO PLASTICS

- These plastics can be softened by heating and hardened by cooling any number of times without changing the properties of the material.
- It is thus possible to shape and reshape these plastics by means of heat and pressure.
- One important advantage of this variety of plastics is that scrap obtained from old and worn-out articles can be effectively used again.
- **Properties** :

1. Softens and liquefies on heating and hardens up to cooling.
2. Retains shape after manufacture.
3. Suitable for recycling.
4. Can be reshaped by heat.
5. It may melt before passing to a gaseous state.
6. Allow plastic deformation when it is heated.
7. They are soluble in certain solvents.
8. Swell in the presence of certain solvents.

- Examples and applications of thermoplastic plastic materials:

  1. High pressure polyethylene as applied to rigid material covered with electrical machines, tubes, etc...
  2. Low pressure polyethylene elastic material used for insulation of electrical cables, etc...
  3. Polystyrene applied for electrical insulation, handles of tools...
  4. Polyamide used for making ropes, belts, etc...
  5. PVC or polyvinyl chloride for the manufacture of insulation materials, pipes, containers, etc.

- Examples of thermoplastic adhesives:

  1. Acrylates
  2. Cyanoacrylates
  3. Epoxy cured by ultraviolet radiation
  4. Acrylates cured by ultraviolet radiation

THERMOSETTING PLASTICS

- These plastics are either originally soft or liquid or they soften once upon heating, they harden permanently.
- When they are heated in the temperature of 127 degree centigrade to 177 degree centigrade , they set permanently and further application of heat does not alter their form of soften them.
- The thermo setting plastics are durable, strong and hard.
- They are available in a variety of beautiful colours.
- They are mainly used in engineering applications of plastics.

- **Properties :**

1. Permanently hard on heating above a certain temperature.
2. Undergoes chemical changes during manufacture.
3. Cannot be melted and reshaped.

- **Examples and uses:**

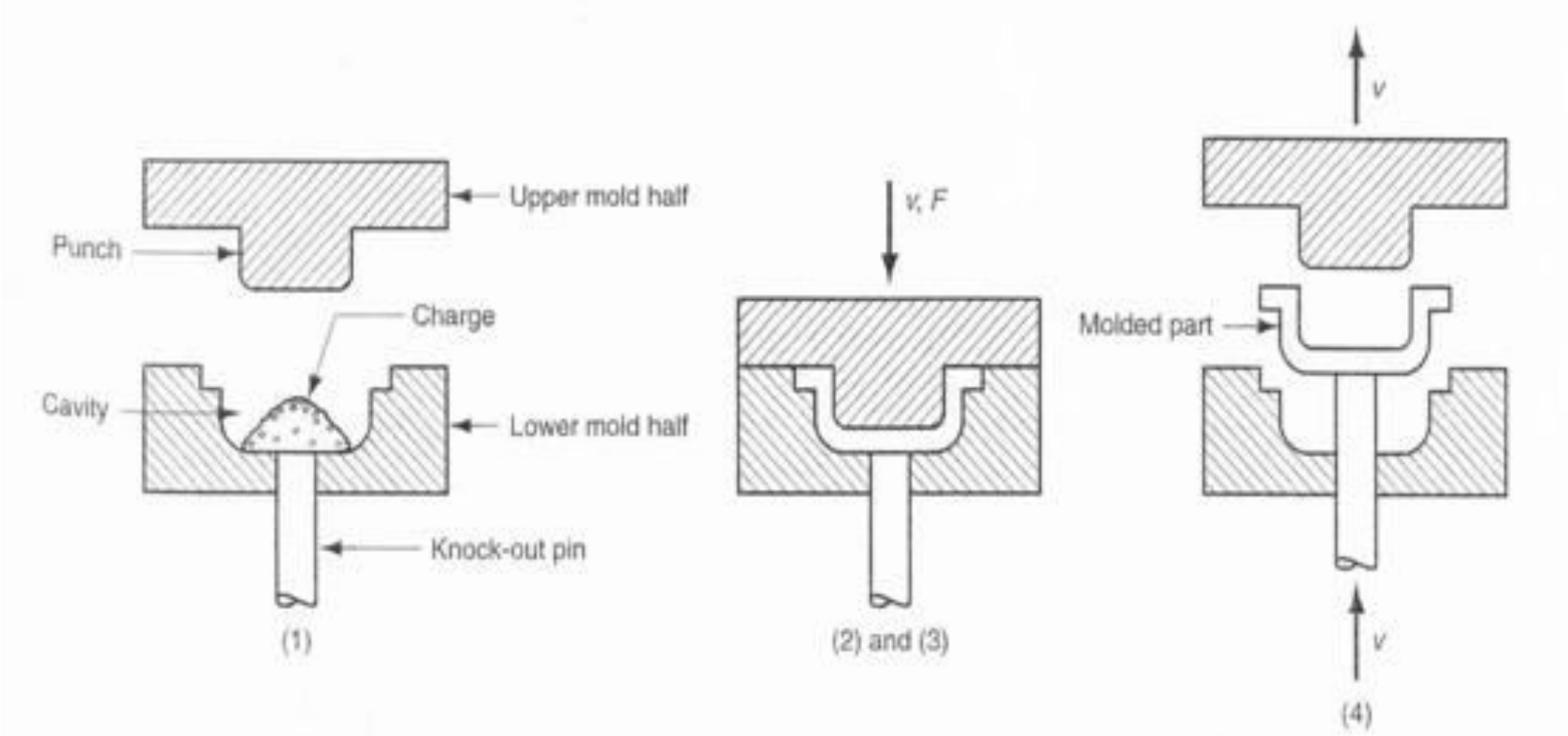
1. Polyester fibreglass systems: sheet moulding compounds and bulk moulding compounds)
2. Polyurethanes: insulating foams, mattresses, coatings, adhesives, car parts, print rollers, shoe soles, flooring, synthetic fibers, etc. Polyurethane polymers are formed by combining two bi- or higher functional monomers.
3. Vulcanized rubber
4. Bakelite, a phenol-formaldehyde resin used in electrical insulators and plastic wares
5. Epoxy resin used as the matrix component in many fiber reinforced plastics such as glass-reinforced plastic and graphite-reinforced plastic)

Sr. No	Thermosetting plastics	Thermo plastic plastics
1	When subjected to heat and pressure undergo permanent deformation	Do not undergo any permanent change by heat and pressure
2	Cannot be reused	Can be reused
3	They are stronger and have more resistance to heat,	They are softer and has less resistance to heat
4	Cheap and durable	costlier and less durable
5	Used for telephone receivers, radio, automobile parts and TV cabinet, camera box, etc	Used for toy, toilet goods, photographic films, insulating tapes, etc

Processing of plastics

- A) Processing of thermo setting plastics
  1. Compression moulding
  2. Transfer moulding
- B) Processing of thermo plastic plastics
  1. Injection moulding
  2. Blow moulding
  3. Thermo moulding/ thermo forming
  4. Extrusion

Compression moulding



- Pre-measured amount of polymer introduced into the heated mold then the top half comes down and applies pressure.
- Usually uses thermosetting plastics.
- produces products like dishes, container caps, etc.

- A material is generally powder form or pre-form shape and it is loaded directly into the hot die cavity
- Then required shape is given by application of heat & pressure
- The combined effect of heat and pressure causes the plastic to flow into the mould cavity
- After compression, the component solidifies, the upper half of the dies opens & component is removed with the help of ejector pins.
- Temp. during the process is from 125 to 250degree centigrade's
- Advantages:

  1) moulds are simple & less expensive

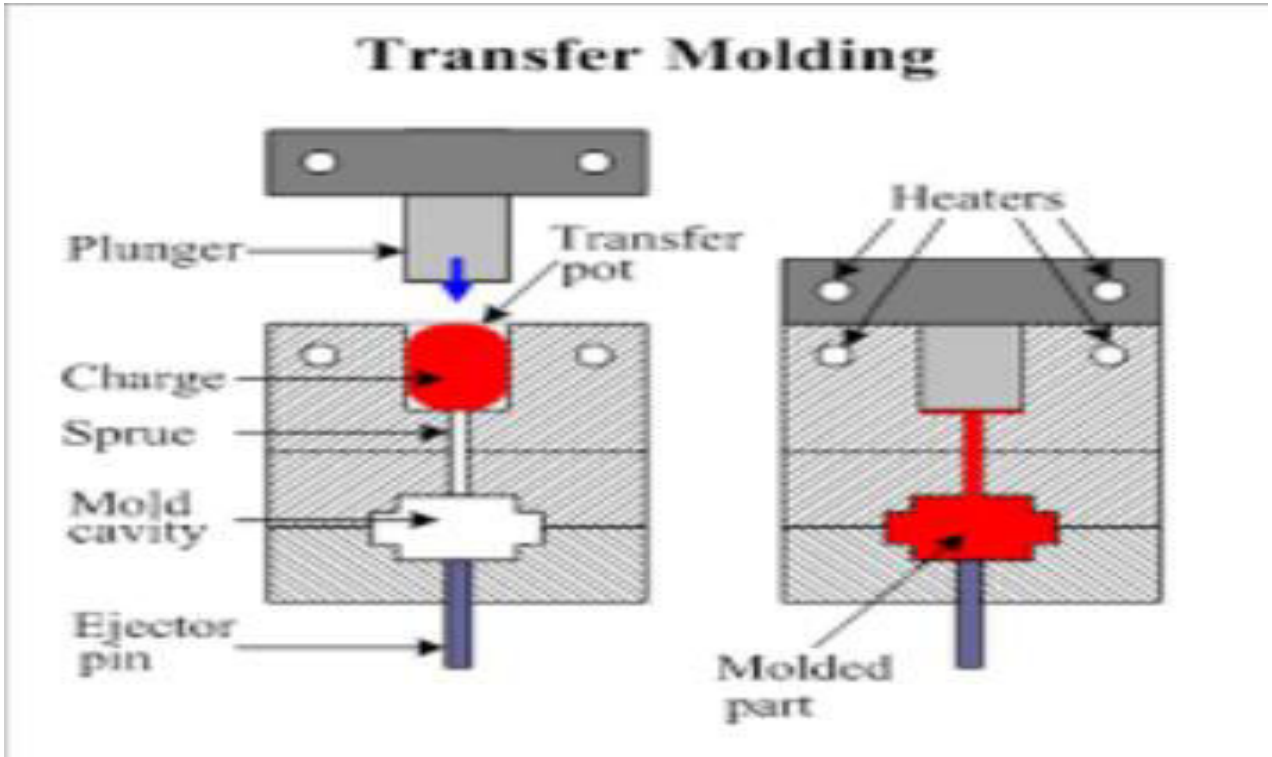
  2) Low residual stresses, low maintenance

  3) Good surface finish
- Disadvantages:

  1)Cycle time is long, low production rate

Transfer molding

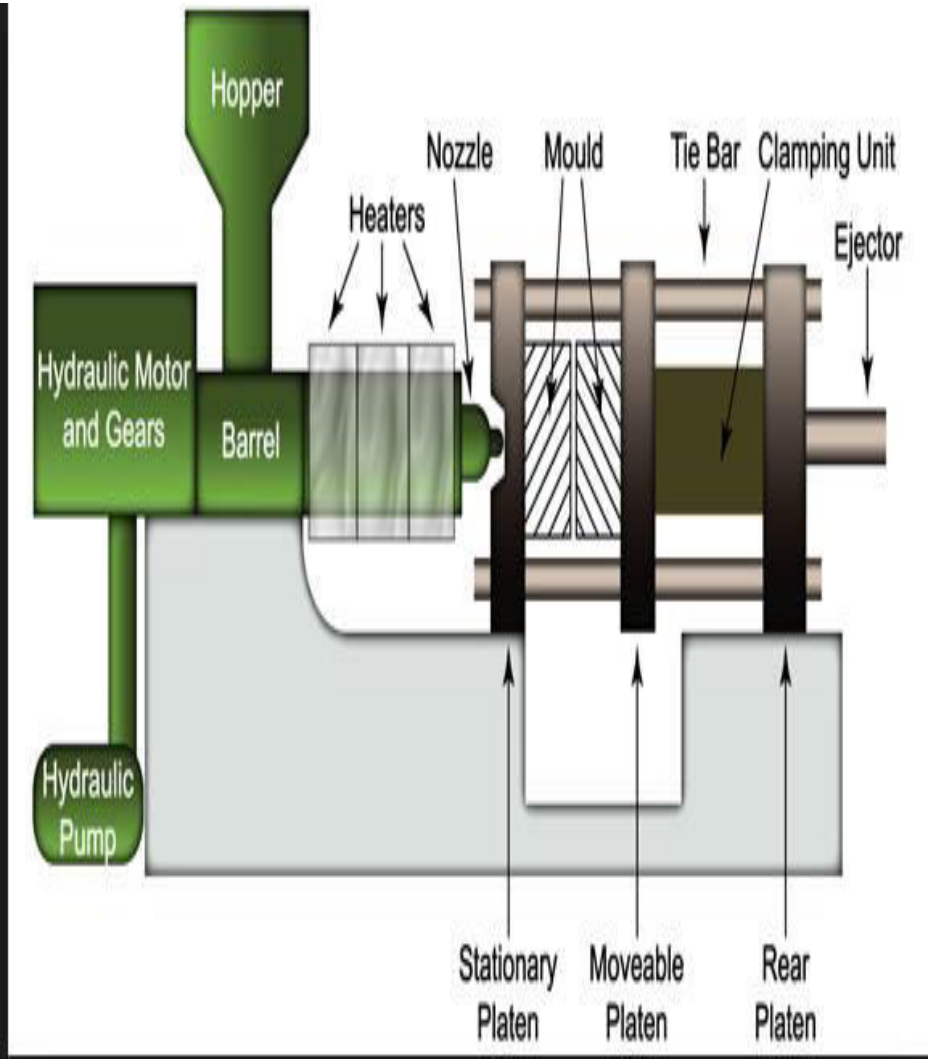
- It is a process where the amount of material is measured and inserted before the **molding** process takes place.
- The material is then preheated and loaded into a pot and a plunger is then used to force the material from the pot through the runner system into the mold cavities.

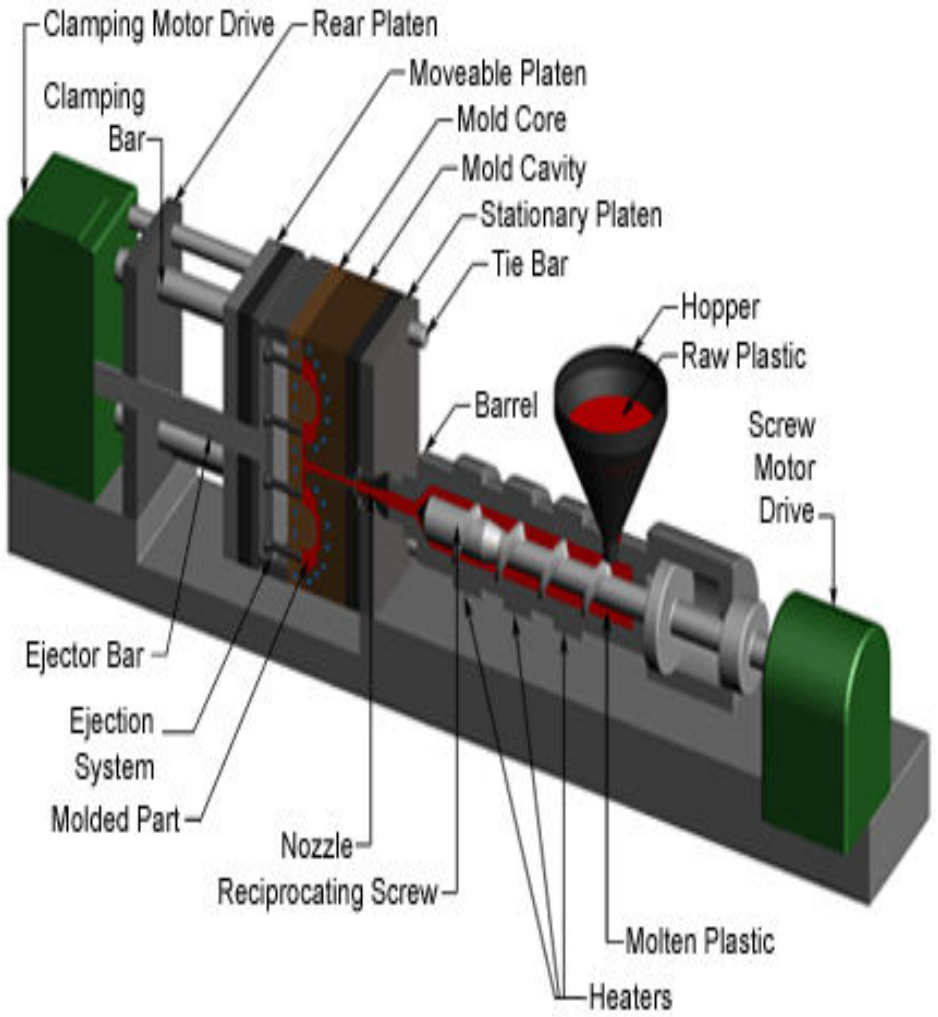


- Transfer molding process combines the principle of compression and transfer of the polymer charge. In the transfer molding, polymer charge is transferred from the transfer pot to the mold.
- The mold is cooled and molded part is ejected.
- In this process, the required amount of polymer charge is weighted and inserted into the transfer pot before the molding process.
- The transfer pot is heated by the heating element above the melting temperature of the polymer charge.
- The plunger is used to push the liquid polymer charge from the transfer pot into the mold cavity under pressure.
- This is used for mass production.
- It has short production cycle and smaller tolerances and more intricate parts can be achieved.
- It produces more waste material; therefore it is the more expensive process

- **Materials Used:**
- Generally, thermoset plastics (such as epoxy, polyester, phenol-formaldehyde, vinyl ester,
- silicone) are processed by transfer molding process, but certain thermoplastic materials can also be processed.
- **Advantages:**
- Fast setup time and lower setup costs
- Low maintenance cost
- Plastic parts with metal inserts can be made
- Design flexibility
- Dimensionally stable
- Uniform thickness of parts
- Large production rate
- **Disadvantage:**
- Wastage of material
- Production rate lower than injection molding
- Air can be trapped in the mold

Plastic injection molding



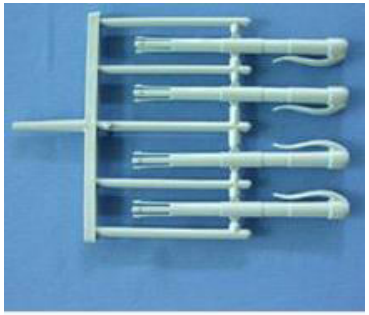


- Probably the most common, most important, most economical process

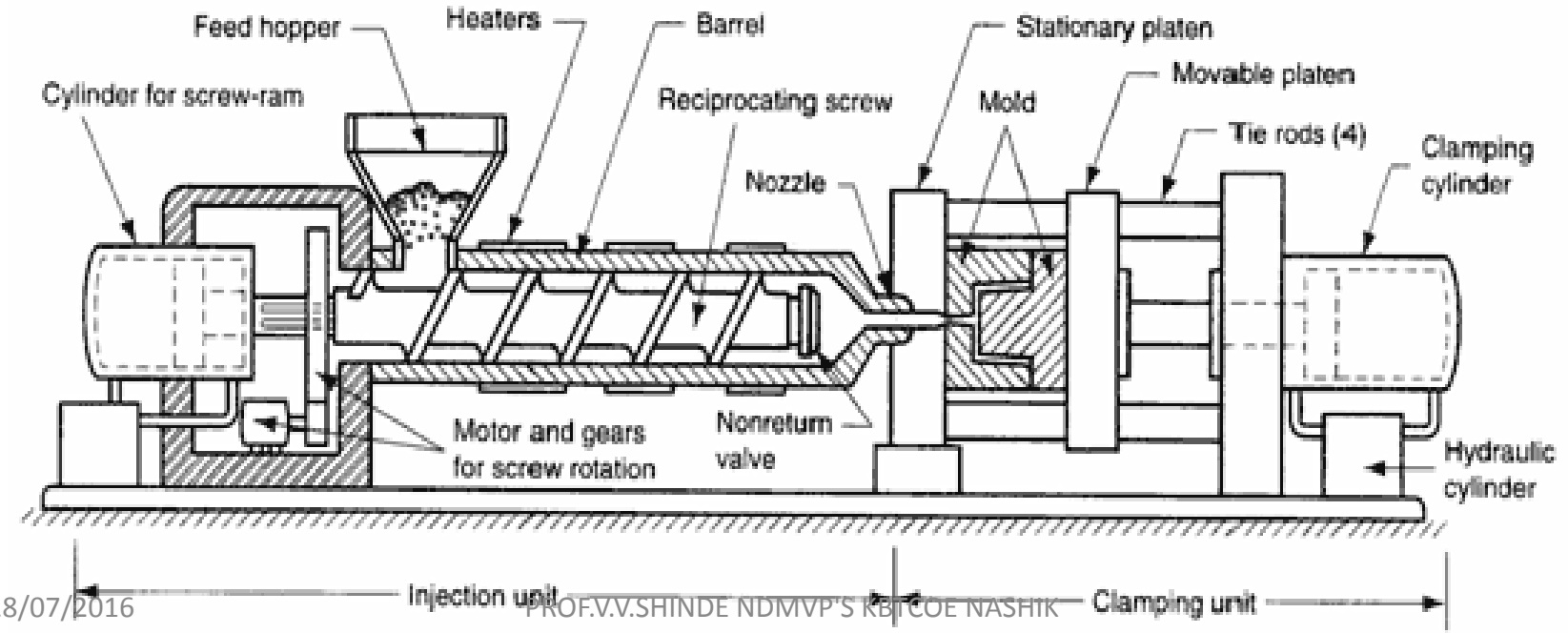
Mobile Phone

Wireless Phone

Plug



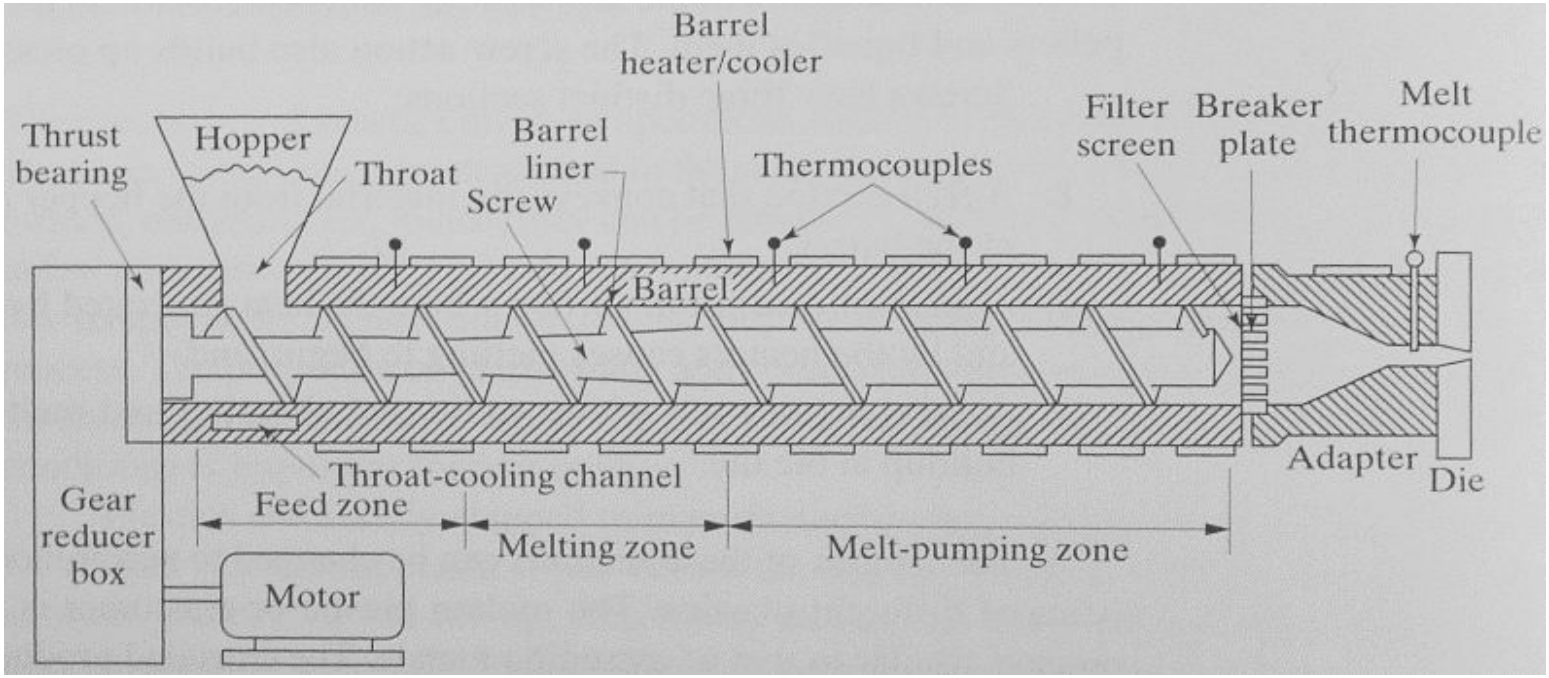
Rubber Pen

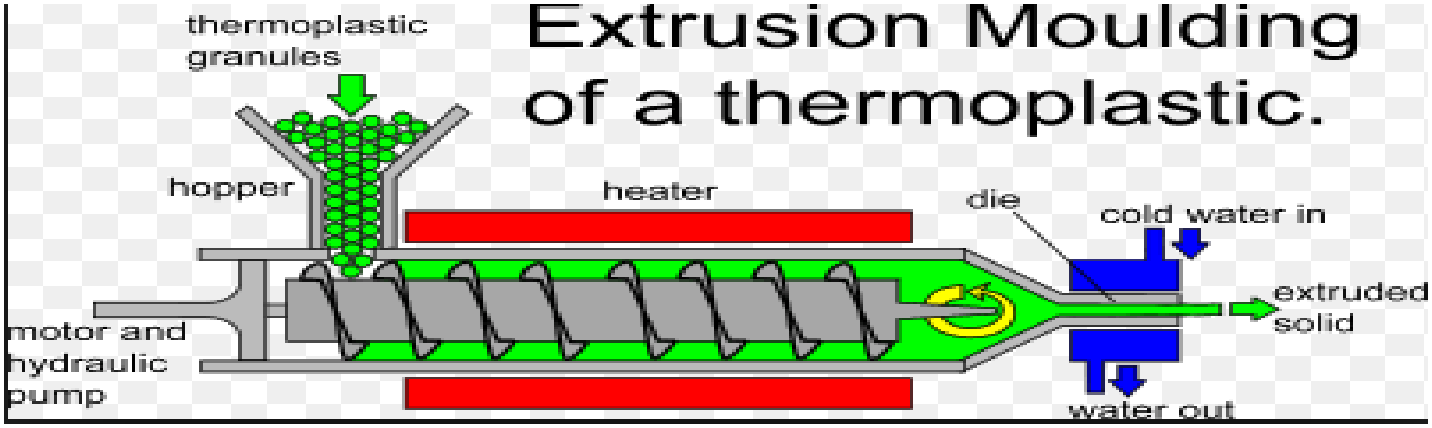


Injection moulding

- Machine consist of two units, one is plastic injection unit & another is clamping unit
- It mainly has two parts upon which the machines operates.
- On one end of the machine, the plastic is fed in the form of pellets or granules which is then heated and melted at higher temperatures prevalent inside the first compartment.
- The molten solution is the squeezed and collected at the other end in mold structure of a desired shape held by the clamping units.
- The clamping unit is removed and the mold is opened after a while for the collected solution to cool.
- Upon cooling down, the molten solution solidifies and takes the shape of the mold which collected it.
- In this way highly quality molds are manufactured by various plastic injection molding companies.

Plastic extrusion

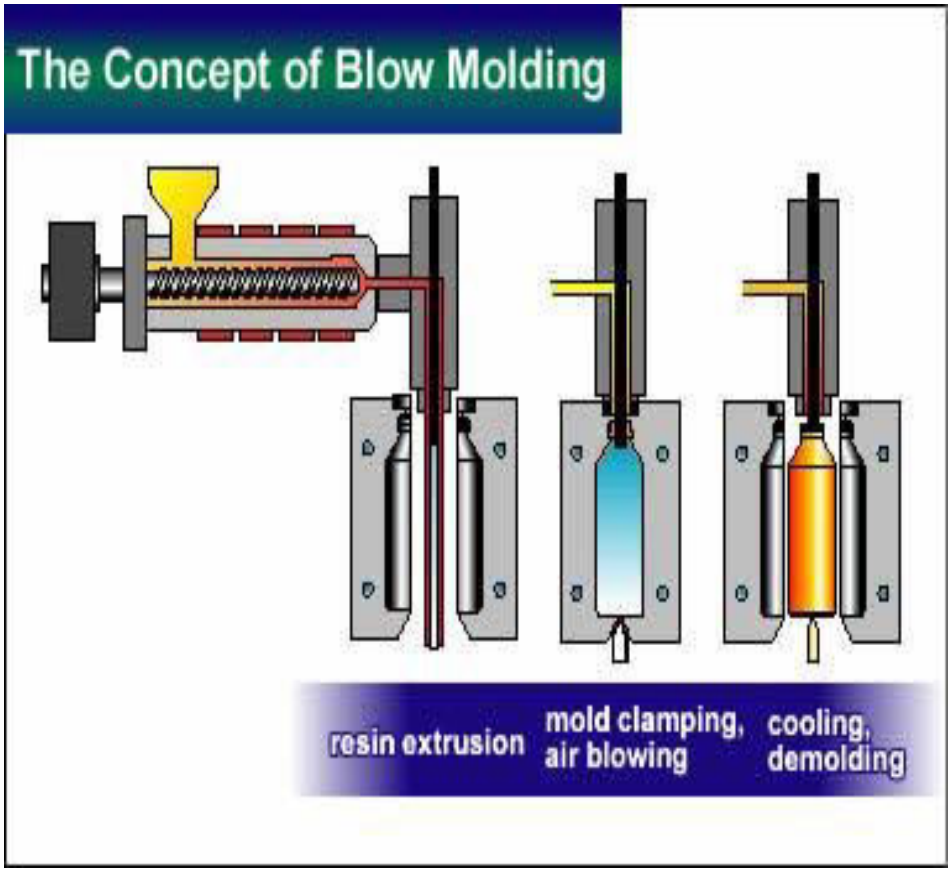




- **Extrusion** is a process used to create objects of a fixed cross-sectional profile.
- A material is pushed or drawn through a die of the desired cross-section.
- The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections, and to work materials that are brittle, because the material only encounters compressive and shear stresses.
- It also forms finished parts with an excellent surface finish.

Blow molding

- Blow Molding
  - Modified extrusion and injection-molding process
- Characteristics
  - Hollow thin-walled parts of various sizes
  - High production rates
  - Low cost for making beverage and food containers

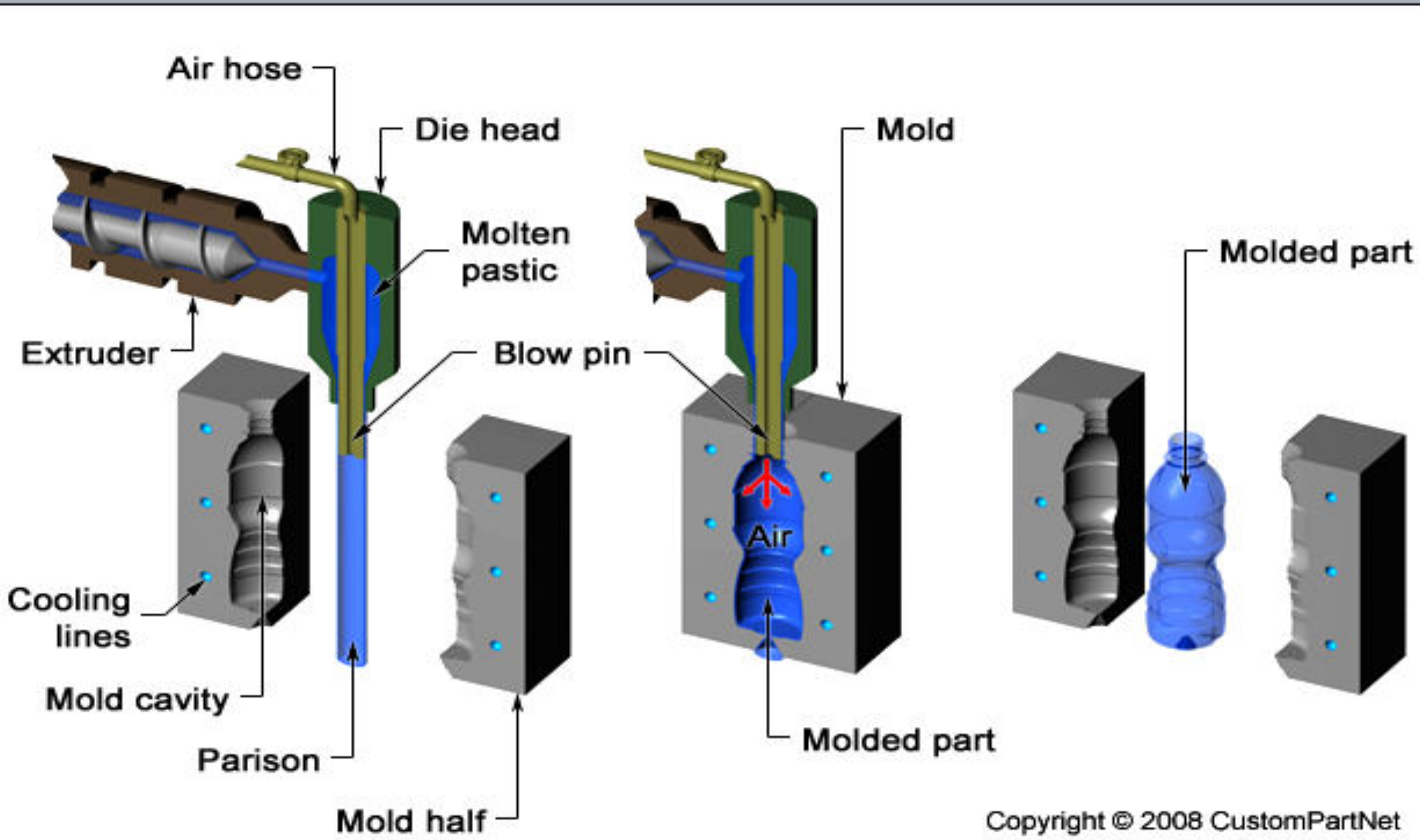


Blow Molding

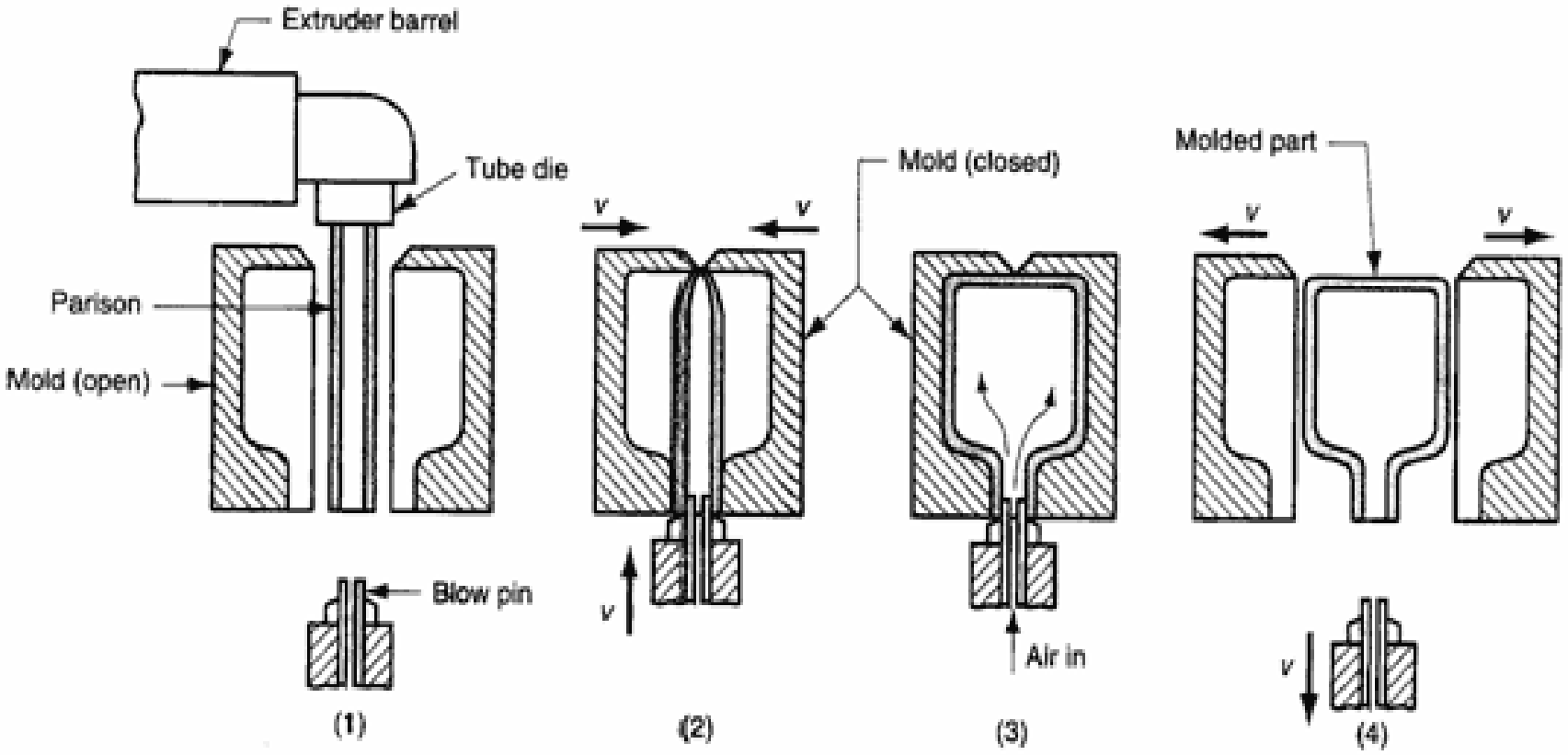
- Blow molding (also blow forming) is a manufacturing process by which hollow plastic parts are formed.
- In general, there are three main types of blow molding:
  - Extrusion blow molding
  - Injection blow molding

Blow molding process

- The blow molding process begins with melting down the plastic and forming it into a parison or preform.
- The parison is a tube-like piece of plastic with a hole in one end in which compressed air can pass through.
- The parison is then clamped into a mold and air is pumped into it.
- The air pressure then pushes the plastic out to match the mold.
- Once the plastic has cooled and hardened the mold opens up and the part is ejected.


Parison Extrusion
(Cross-section)
Blow Molding
(Cross-section)
Part Formed
Air hose
Die head
Molten pastic
Extruder
Blow pin
Cooling lines
Mold cavity
Parison
Mold half
Mold
Air
Molded part
Molded part
Copyright © 2008 CustomPartNet

Extrusion Blow Molding



(1) and (2) parison is pinches at the top and sealed at the bottom around a metal blow pin as the two halves of the mold come together

(3) the tube is inflated so that it takes the shape of the mold cavity

(4) mold is opened to remove the solidified part.

Application

✓Most thermoplastics can be blow molded

Some typical applications are

- HDPE : High Density Polyethylene (stiff bottle, toys, cases, drum)
- LDPE : Low Density Polyethylene (flexible bottle)
- PP : Polypropylene (higher temperature bottle)
- PVC : Polyvinyl Chloride (clear bottle, oil resistant containers)
- PET : Polyethylene terephthalate (soda pop bottle)

Thermo forming/ Vacuum forming

- Thermoforming is the process involving heating a plastic sheet and forming it into a cavity or over a tool using vacuum, air pressure, and mechanical means.
- TYPES OF THERMOFORMING

1) Vacuum Thermoforming
2) Pressure Thermoforming

- **Vacuum Forming**

- The process involves shaping a preheated thermoplastic sheet by means of vacuum produced in the mold cavity space.
- The atmospheric pressure forces the soft sheet to deform in conformity with the cavity shape.
- When the plastic comes into the contact with the mold surface it cools down and hardens.

- **Pressure Thermoforming:-**

- The process involves shaping a preheated thermoplastic sheet by means of air pressure.
- The air pressure forces the soft sheet to deform in conformity with the cavity shape.
- When the plastic comes into the contact with the mold surface it cools down and hardens.

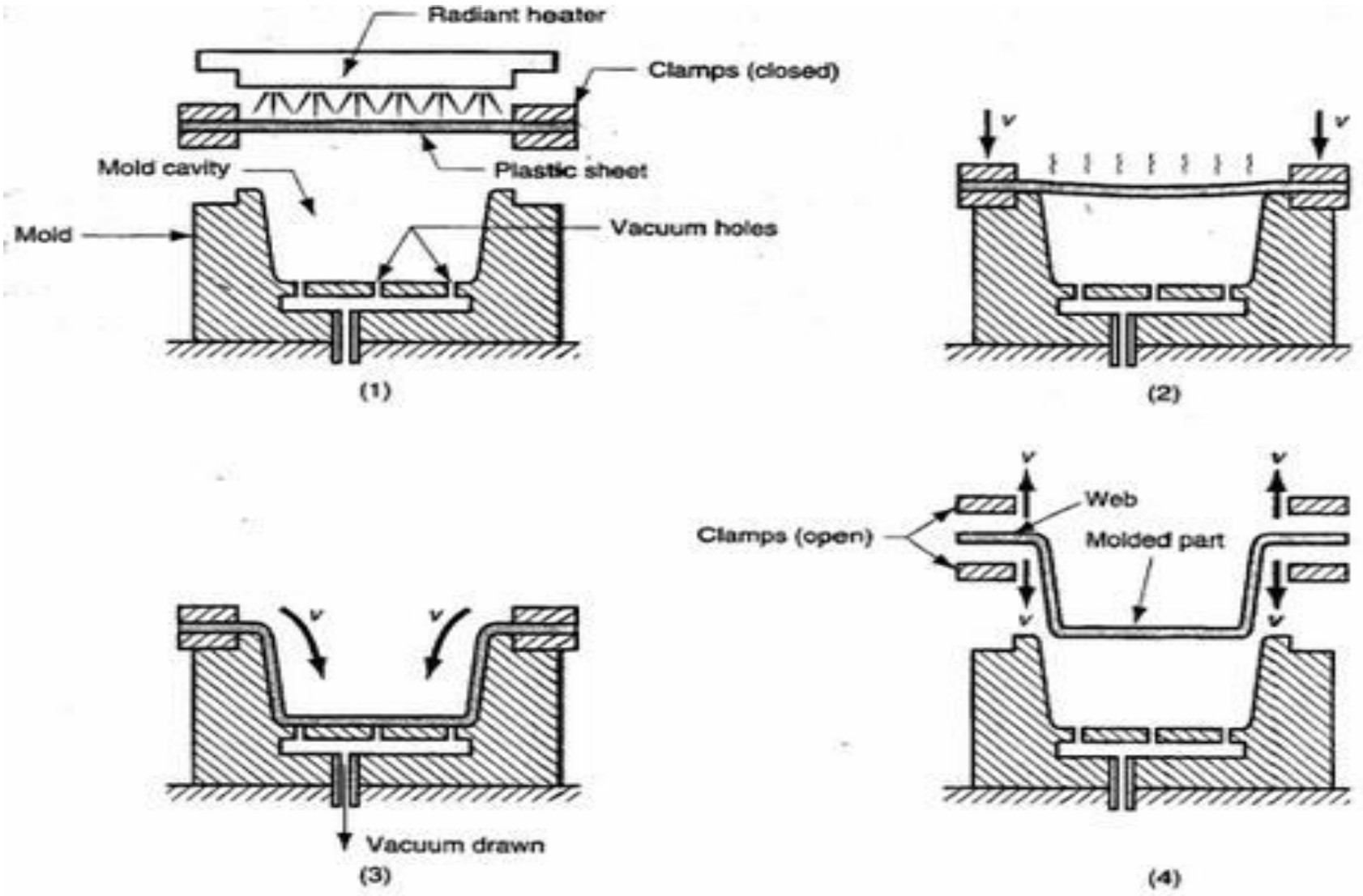
Vacuum forming

- It is one of the type of the Thermoforming Process in which vacuum is used to get the desired shape.
- The process involves heating a plastic sheet until soft and then draping it over a mould. A vacuum is applied sucking the sheet into the mould. The sheet is then ejected from the mould.
- **Process in Detail**

1) Clamping

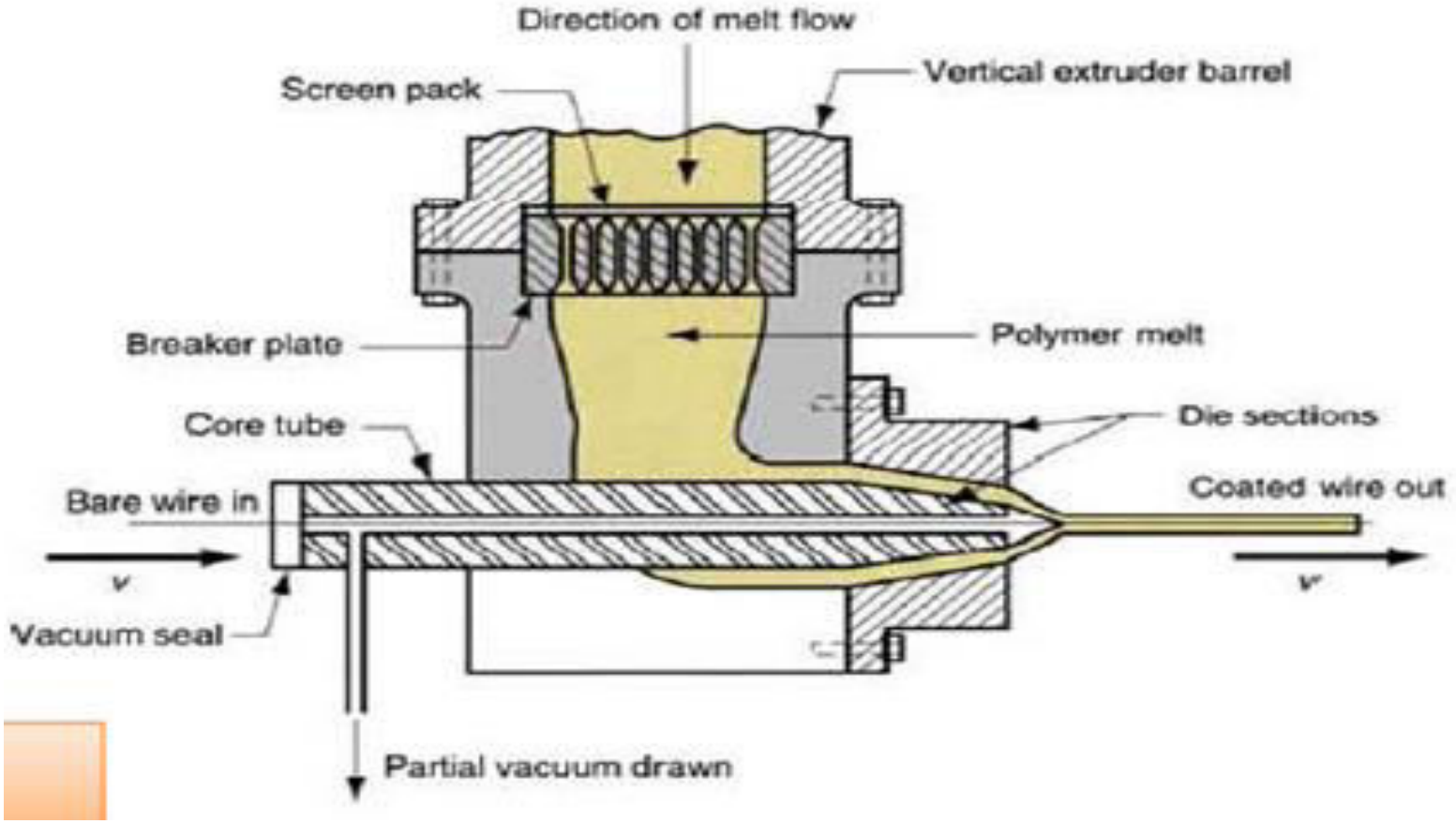
The clamp frame ensures the plastic sheet is held firmly in place during the forming process.

- **Heating**
  Radiant heaters are normally used to heat the sheet which has been positioned over the aperture of the vacuum forming machine. For thicker sheet both surfaces may need to be heated and more sophisticated machines allow this. Heaters move into position both above and below the sheet.
- **Vacuum**
  A vacuum is applied, the sheet is drawn into intimate contact with the mould and the mould detail is picked up.
- **Cooling and Release**
  The material is allowed to cool. The cooling process may be shortened with blown air or even a fine water spray. The molding may then be released from the mould by introducing a small air pressure.
- **Finishing**
  After molding, any mould finishing may be performed, trimming, cutting, drilling, polishing, decorating etc.


Radiant heater
Clamps (closed)
Mold cavity
Plastic sheet
Mold
Vacuum holes
(1)
V
V
(2)
Clamps (open)
Web
Molded part
V
V
V
V
Vacuum drawn
(3)
(4)

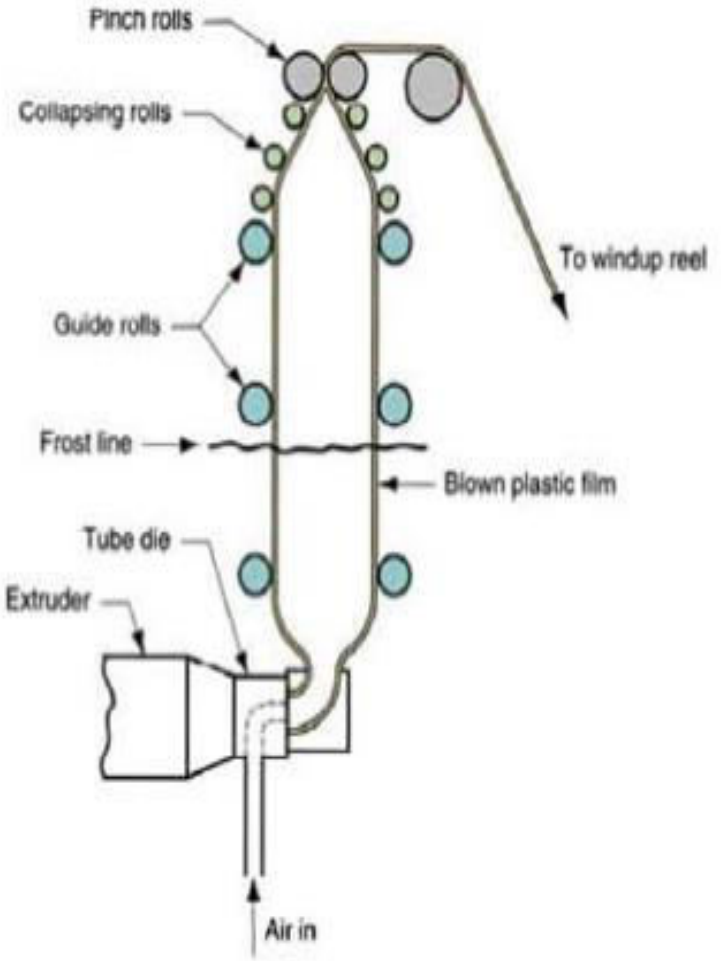
Sr. No	Feature	Vacuum forming	Pressure forming
1	Material formed	Thermoplastic plastics	Thermoplastic plastics
2	Force applied	Pressure differential caused by vacuum	Pressure differential caused by positive pressure
3	Amount of pressure	Lesser	Higher
4	Conformity with the mould shape	Lesser	Higher

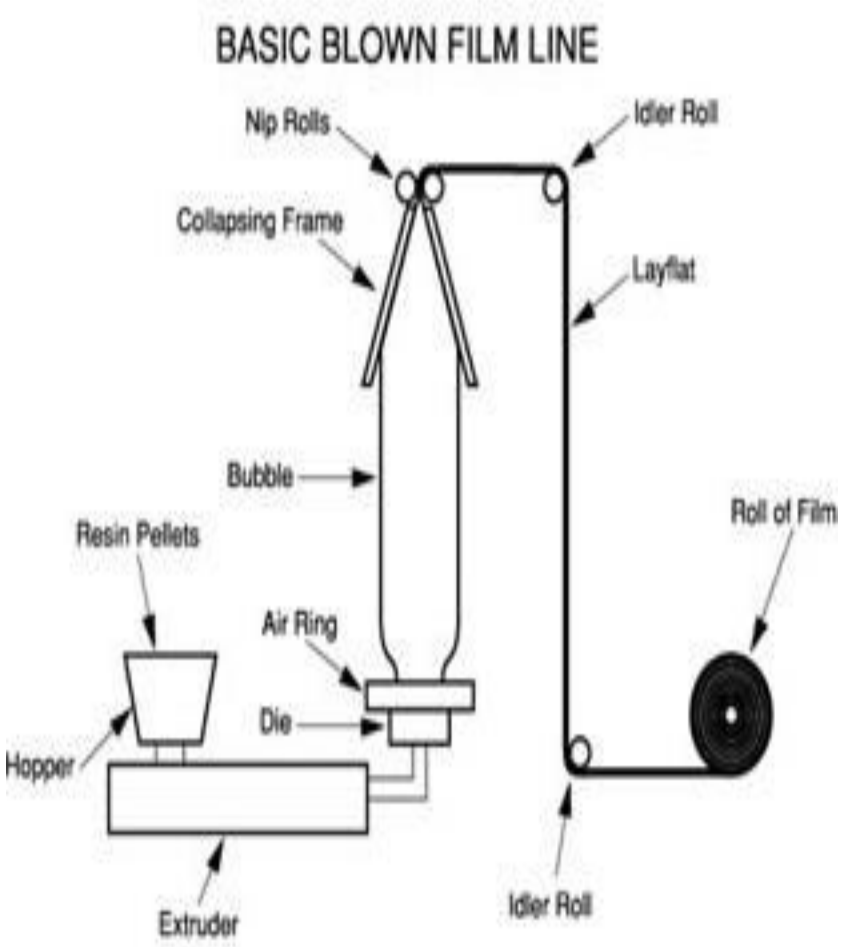
Wire/cable extrusion/Coating of cable wire



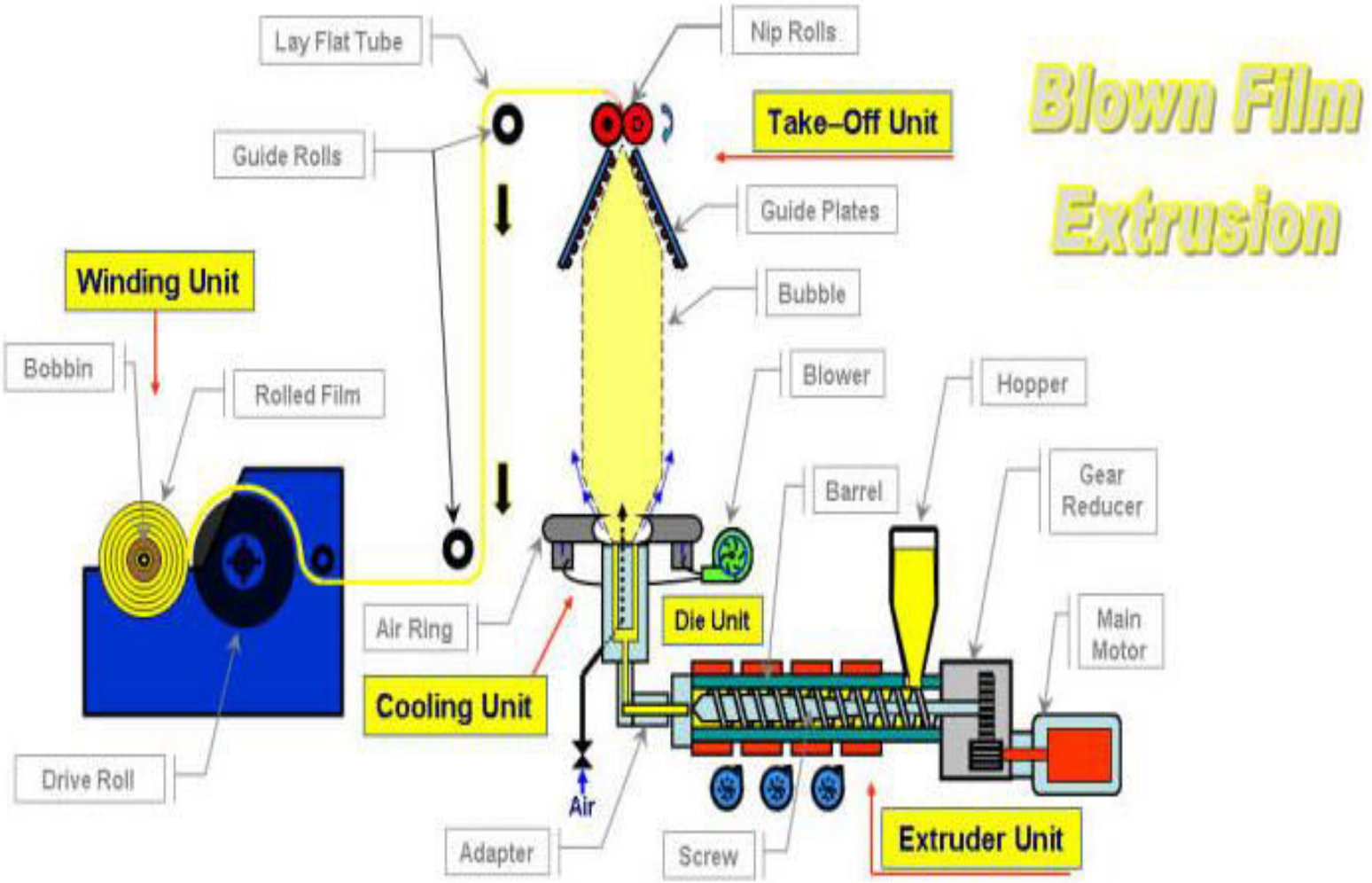
- In wire coating process bare wire is pulled through the center of the die similar to tubing die.
- The wire is coated as it is pulled through a die at high speed
- A slight vacuum is maintained between polymer and the wire to help in proper adhesion of the coating
- The wire as it is pulled through the die provides rigidity
- the coated wire after passing through a water trough is wound on large spools

Extrusion of films

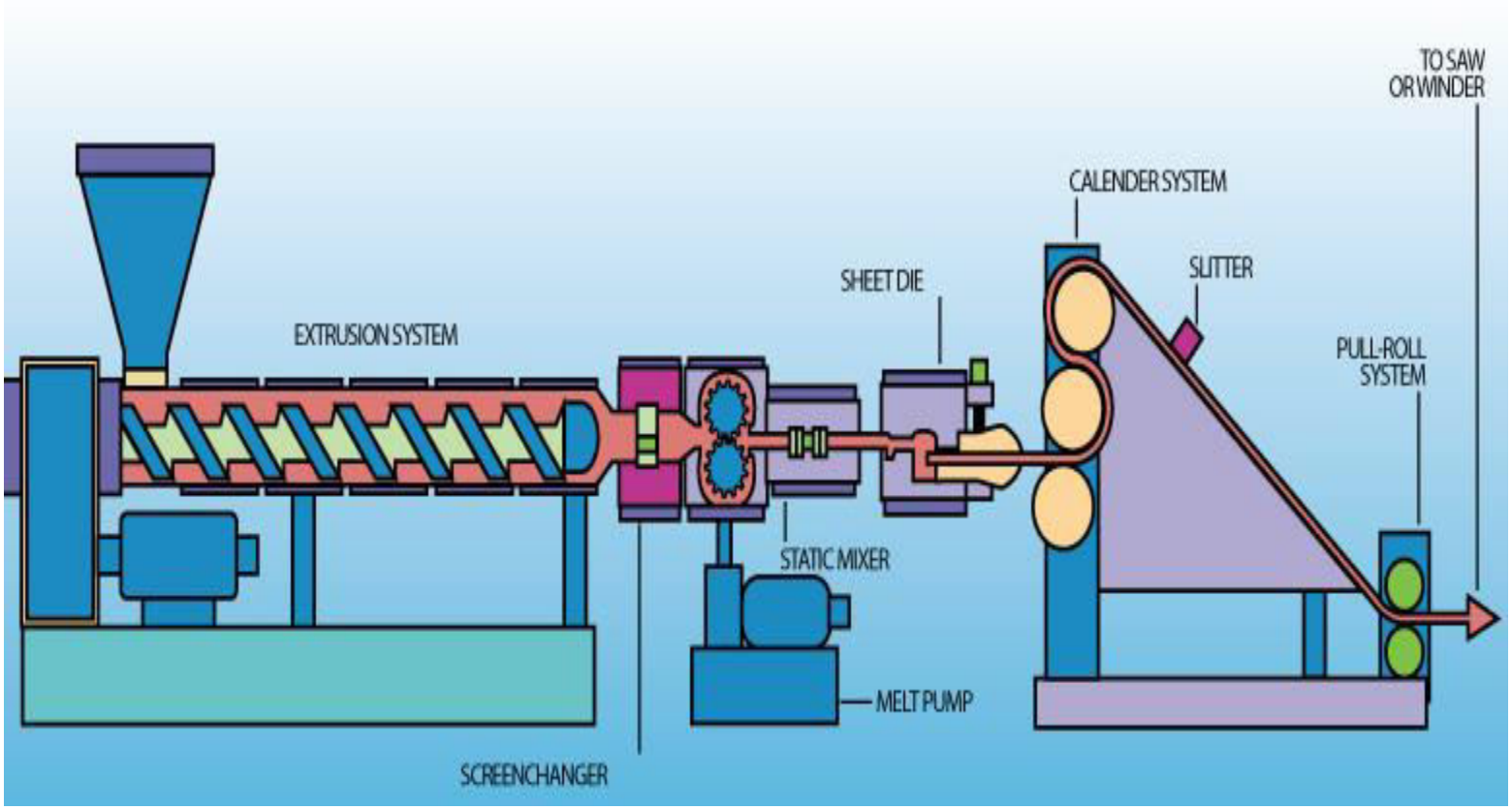




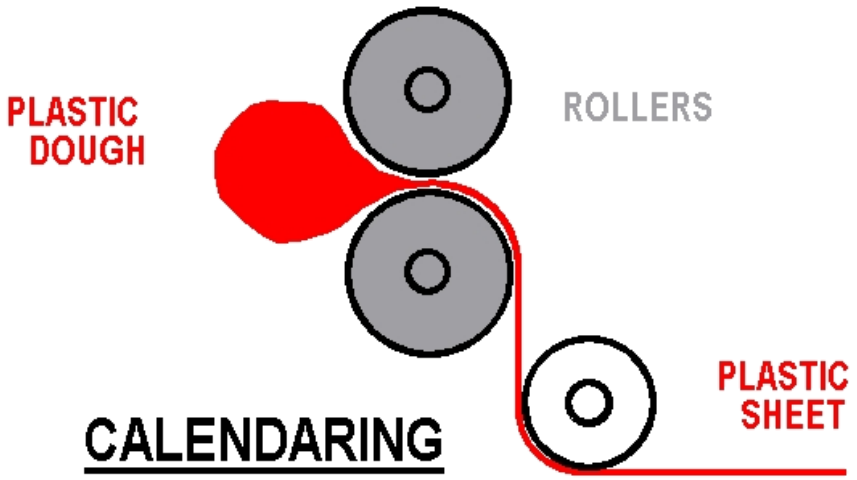
- Extrusion is one of the most common methods of forming thermoplastic Films
- Combination of principles of extrusion and blowing to form a thin film
- The operation starts by extrusion of a tube through the extruder which is immediately forced upward and simultaneously expanded in the size by blowing air into it through the die mandrel
- The air pressure in the tube id kept constant to ensure that the tube diameter and thickness are uniform
- The guide rolls and collapsing rolls restrain this bubble and direct it to the pinch rolls. here the air in the tube is sequenced out and the tube gets cooled
- The flat tube is collected by the wind up reel.


Blown Film Extrusion
Lay Flat Tube
Nip Rolls
Take-Off Unit
Guide Rolls
Guide Plates
Winding Unit
Bubble
Bobbin
Rolled Film
Blower
Hopper
Barrel
Gear Reducer
Air Ring
Die Unit
Main Motor
Cooling Unit
Drive Roll
Air
Adapter
Screw
Extruder Unit

Calendaring /Extrusion of sheets



- In this process the plastic material is allowed to pass between the cylindrical rollers.
- The process is used to prepare plain flat sheets of plastics.
- The roller may be provided with artistic designs which will appear on the finished product



- The term “sheet” refers to stock with thickness between 0.5mm to 6mm
- Calendaring is the process of making films and sheets of plastics
- In this method a mixture of resin, filler, plasticizer and color pigments passed between a series of heated rollers
- This process is similar to rolling process in that the material is compressed between rolls and emerges as a sheet
- Thickness of the produced sheet depends on the spacing between the rollers
- During the process, first roll gap serves as a feeder, the second as a metering device, and third one sets the guege of the gradually cooling plastic which is then wound on the coiler
- It is high production process and mostly suitable for flexible P.V.C