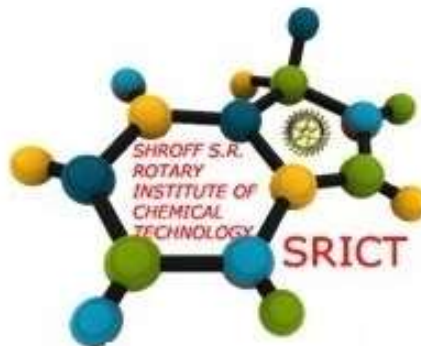




MANUFACTURING PROCESSES-II

Unit No. :- 5

PLASTIC PROCESSING





INTRODUCTION

POLYMER

Term derived from two Greek words:

POLY means **MANY**

MEROS means **PARTS/UNITS**

- Thus polymers are composed of a large number of repeating units called **monomers**.
- Monomers are joined together end to end in a polymerization reaction.



INTRODUCTION

POLYMERIZATION

- ✓ The process of linking together of monomers or obtaining macromolecules is called polymerization.
- ✓ There are two types of polymerization techniques.
 1. Addition Polymerization
 2. Condensation Polymerization

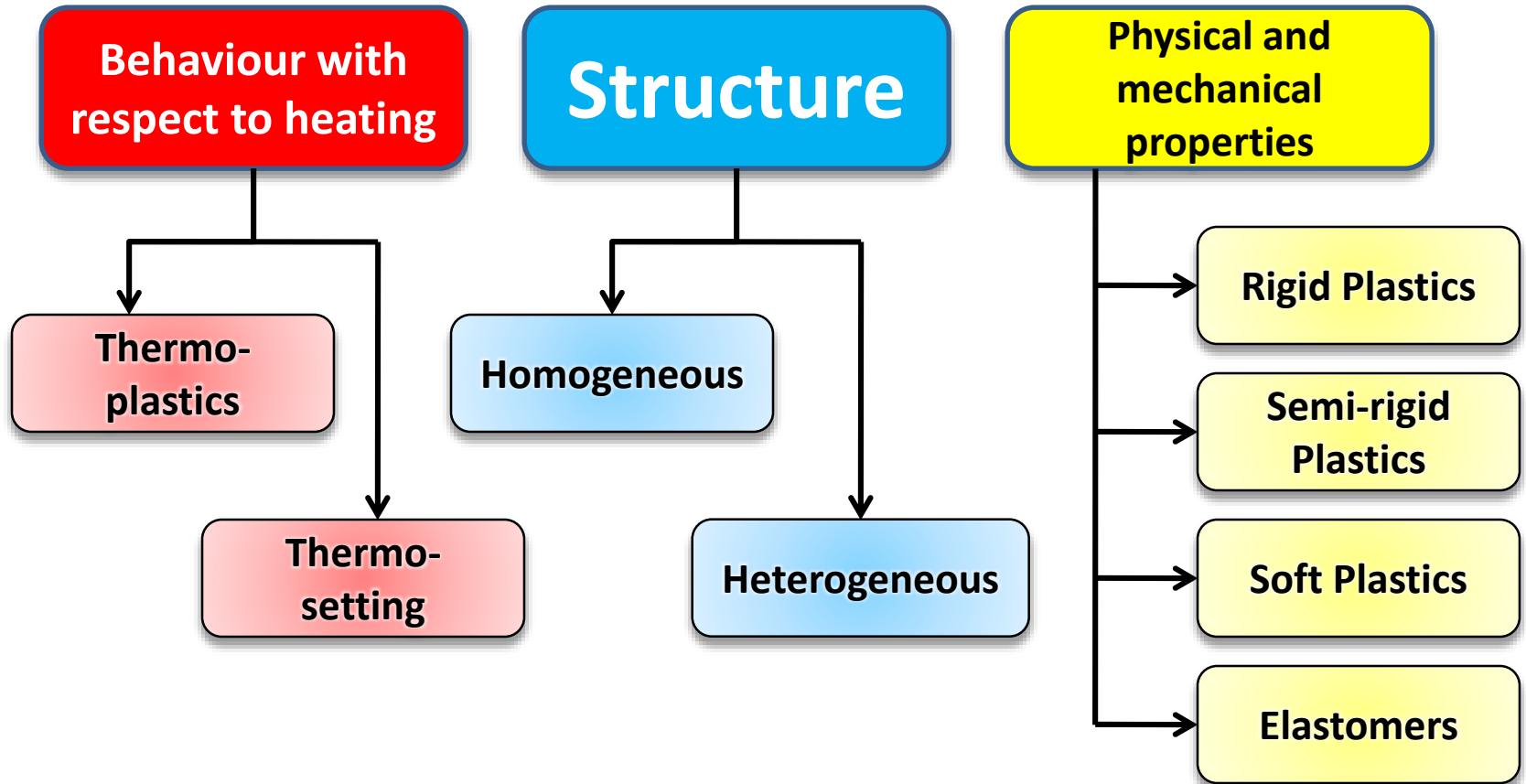


Classification of Plastics

- There are many ways of classifying plastics. They can be classified considering various aspects, as according to their :
1. Behaviour with respect to heating,
 2. Structure, and
 3. Physical and mechanical properties.



Classification of Plastics





Classification of Plastics

1. Behaviour with respect to heating

THERMOPLASTICS	THERMO-SETTING PLASTICS
<ul style="list-style-type: none">❖ Thermoplastics variety softens by heat and hardens when cooled down.❖ It can be used by remolding as many times as required.❖ E.g. Polyethylene, polypropylene, polystyrene, PVC, polyamides, cellulose, polycarbonate.	<ul style="list-style-type: none">❖ Thermosetting plastics can not be reused.❖ This variety requires a great pressure and momentary heat during molding which hardens on cooling.❖ E.g. Phenolics, Unsaturated polyesters, Ureas, melamines, Urethanes.



Classification of Plastics

2. Based on structure

Homogeneous
Plastics

- They contains carbon chain i.e. the plastics of this group are composed only of carbon atoms and they exhibit homogeneous structure.

Heterogeneous
Plastics

- This variety of plastic is composed of the chain containing carbon and oxygen, the nitrogen and other elements and they exhibit heterogeneous structure.



Classification of Plastics

3. Based on physical and chemical properties

Rigid Plastics

- These plastics have a high modulus of elasticity and they retain their shape under exterior stresses applied at normal or moderately increased temperatures.

Semi-rigid Plastics

- These plastics have a medium modulus of elasticity and the elongation under pressure completely disappears, when pressure is removed.



Classification of Plastics

Soft Plastics

- These plastics have a **low modulus of elasticity** and the **elongation under pressure disappears slowly**, when pressure is removed.
- Soft plastics are available in a **large range of colours, sizes and particularly shapes**.
- Used in making children's toys eg: rattles etc., fishing baits.



Classification of Plastics

Elastomers

- These plastics are soft and elastic materials with a **low modulus of elasticity**.
- They **deform considerably under load at room temperature and return to their original shape**, when the load is released.
- **The extensions can range upto ten times their original dimensions.**



Additives In Plastics

1. Plasticizers

- They are liquids of high boiling point, low molecular weight.
- They are added to improve the plastic behavior of polymer.
- They separate the macro molecules, decreasing inter molecule forces, facilitates relative movement between molecules of polymer.
- e.g. Organic solvents, resins, water etc.





Additives In Plastics

2. Fillers

- They are inexpensive materials used for reducing the cost of plastics and/or to vary the properties of plastic to some extent.



- It must be **chemically inert** with parent material.
- e.g : **wood flour** (improve mouldability), **cellulose**, **cotton flock**, **paper** (improving mechanical strength), **mica** and **asbestos** (heat resistance), **talc** (acid resistance).
- Reinforcing filler agents are **fibers of glass**, **aramid**, **graphite**.



Additives In Plastics

3. Catalysts

- They are added to promote faster and more complete polymerization.
- They are also known as accelerators.
- e.g : ester is used as catalyst for urea formaldehyde.

4. Initiators

- Added to initiate or allow polymerization process to begin.
- e.g : H₂O₂





Additives In Plastics

5. Dyes & Pigments

- Added to impart a desired colour.
- E.g : titanium oxide (white pigment), iron oxide (yellow/brown/red), carbon black (black pigment + UV light absorbent).





Additives In Plastics

6. Lubricants

- They are added for following purposes.
- To reduce the friction during processing, Prevents parts from sticking to mould walls, Prevent polymer films from sticking to each other, to impart elegant finishing.
- E.g : oils, soaps, waxes etc.





Additives In Plastics

7. Flame Retardants

- Added to enhance non inflammability.
- It can be done by producing them from less inflammable materials or by adding Flame Retardants.
- e.g : compounds of chlorine, bromine and phosphorous.

8. Stabilisers

- Stabilisers and anti-oxidents are added to retard the degradation of polymres due to heat, light and oxidation.



Additives In Plastics

9. Solvents

- They are useful for dissolving certain fillers or plasticizers.
- E.g : alcohol is added in cellulose nitrate plastics to dissolve camphor.
- Subsequently, **Solvents** must be removed by evaporation.





Additives In Plastics

10. Elastomers

- They are added to enhance elastic properties of plastic.



Properties of Plastics

- a. Density of plastics is very low as compared to metals.
- b. Strength of plastics is sufficient to make low weight, high strength machine parts.
- c. Antifriction and self-lubricating properties of plastics enables it to be a good replacement of metal parts.
- d. Plastics components offer noiseless operation of moving parts, corrosion resistance, water proofing ,leak proof joints, etc.
- e. Its production is very easy due to low melting point and excellent flow ability in liquid state into the mold cavity.



Properties of Plastics

- f. Low cost of manufacturing in case of plastics.
- g. Plastics exhibits insulation for heat and electricity.
- h. Plastics are chemically stable when subjected to solvents, oxidizing agents, gases, etc.
- i. Plastics are less brittle than glass, yet they can be made equally transparent and smooth.
- j. They possess good toughness.



Properties of Plastics

- k. Plastics can be easily molded to desired shape.
- l. They having very good damping characteristics, colour ability, deformability and weather ability.



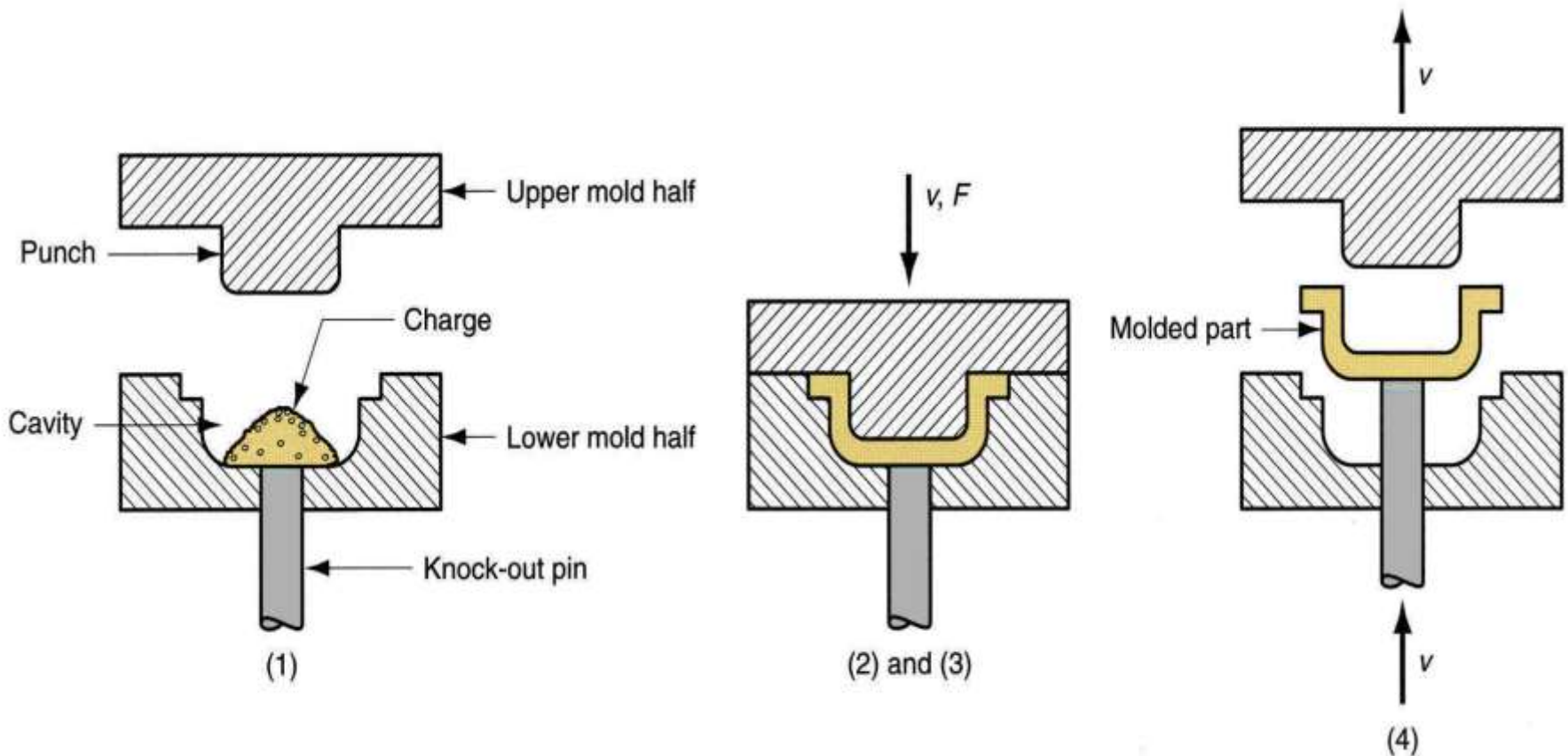
Plastic part manufacturing processes

- Plastic manufacturing processes are used to convert plastic materials in the form of pellets, powders, sheets etc.
- Different types of plastic manufacturing processes are:
 - a. compression moulding
 - b. Transfer moulding
 - c. Injection moulding
 - d. Extrusion moulding
 - e. Blow moulding
 - f. Calendaring
 - g. Thermoforming
 - h. slush moulding
 - i. laminating



Plastic part manufacturing processes

Compression Moulding





Compression Moulding

- First, the charge is loaded into the lower half of mold which is preheated to maintain the temperature of charge during the process.
- The placed charge is compressed by bringing both halves of mold close together.
- The charge is heated by means of the hot mold to polymerize and cure it into a solidified desired shaped molded plastic component.
- Then, the halves are opened & molded plastic part is removed by pressing knockout pins towards inside.



Compression Moulding

Advantages

- Low initial setup costs and fast setup time
- Heavy plastic parts can be molded
- Complex intricate parts can be made
- Good surface finish of the molded parts
- Wastes relatively little material as compared with other methods
- The molding process is cheaper as compared to injection molding

Disadvantages

- Low production rate
- Limited largely to flat or moderately curved parts with no undercuts



Compression Moulding

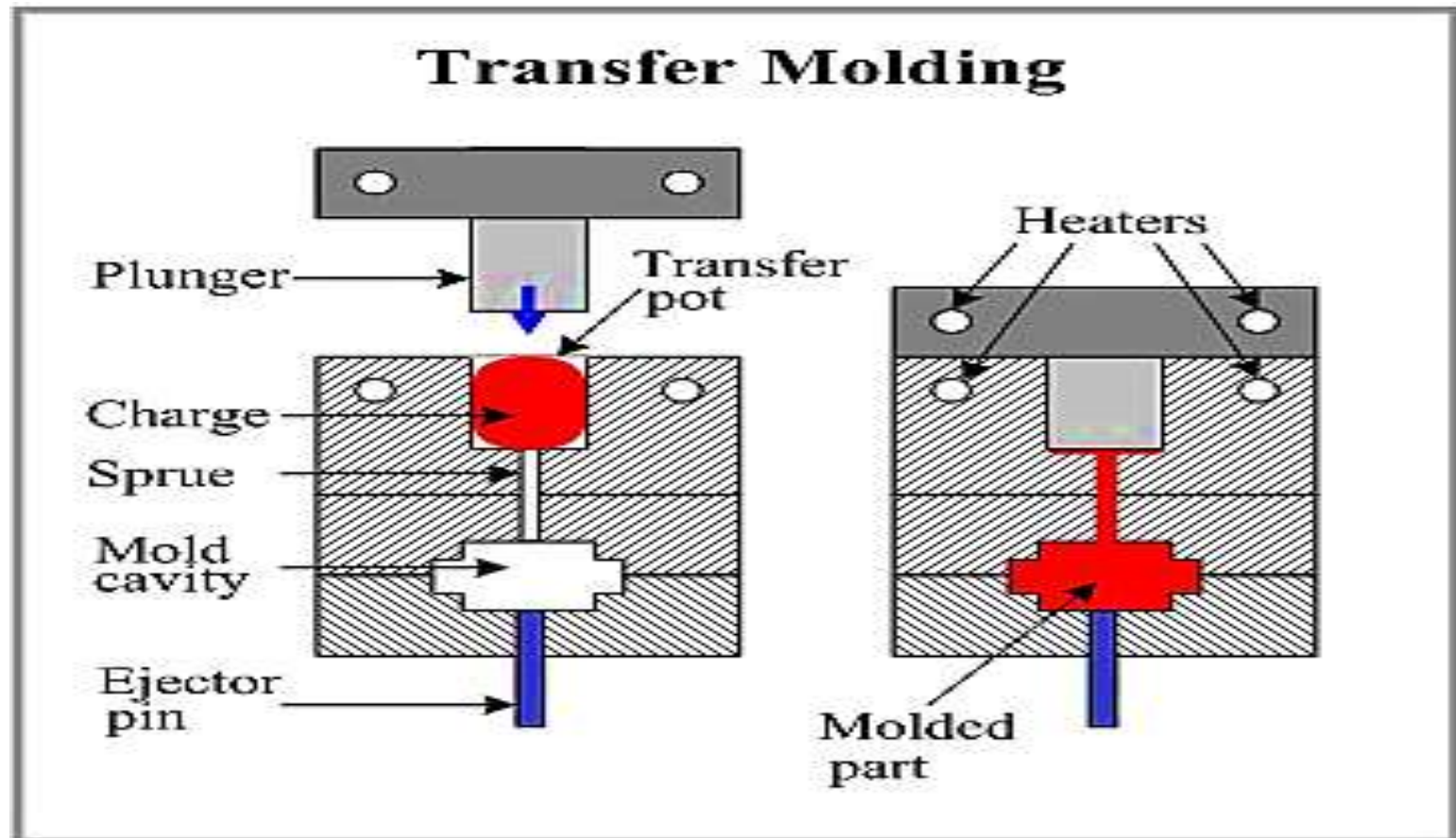
Applications

- Electrical and electronic equipments, brush and mirror handles, trays, cookware knobs, aircraft main power terminal housing, pot handles, dinnerware plates, automotive parts.



Plastic part manufacturing processes

Transfer Moulding





Transfer Moulding

- It is similar to compression molding. The difference is, instead of loading the polymer into an open mold, the plastic material is preheated and loaded into a holding chamber called **pot**.
- The material is then forced into a preheated mold cavity using a ram or hydraulic plunger through a channel called **sprue**.
- The mold remains closed until the material inside is cured.
- Then, the final molded part is removed by using ejector pin.



Transfer Moulding

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

Disadvantages

- Wastage of material
- Production rate lower than injection molding
- Air can be trapped in the mold



Transfer Moulding

Applications

- Integrated circuits, plugs, connectors, pins, coils, studs, radio, television cabinets and car body shells.



Plastic part manufacturing processes

Injection Moulding

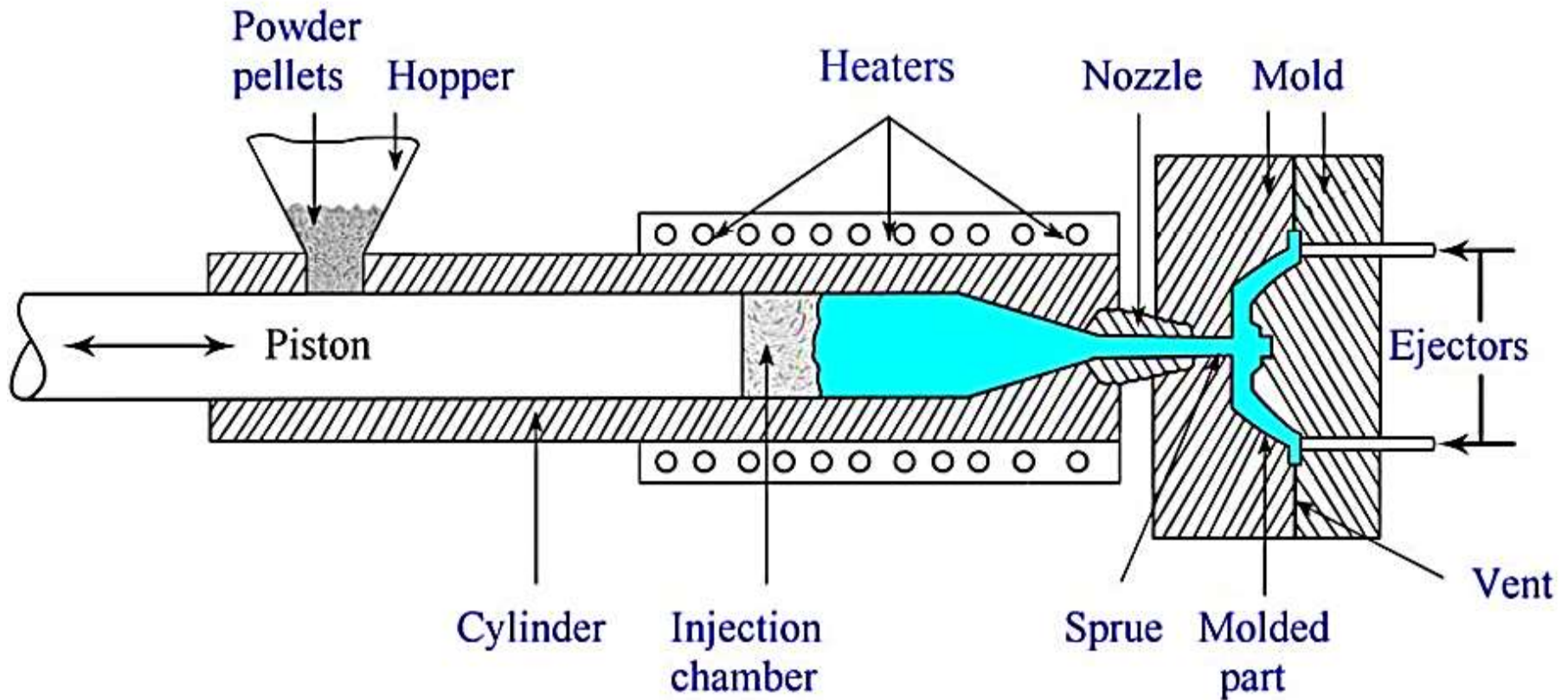


Figure 1 Injection molding setup



Injection Moulding

- Palletized material is fed with use of hopper into a cylinder where material melts due to heating coils.
- Molten metal is impelled through nozzle into the enclosed cavity.
- Outstanding characteristic of this moulding process is cycle time is very less. i.e. rate of production is very high.
- The complete injection molding process is divided into four stages: clamping, injection, cooling and ejection.



Injection Moulding

- ❖ **Clamping:** The two halves of the mold must be tightly closed, before the molten plastic material is injected into the mold.
- One half of the mold is attached to the injection unit (nozzle) and other half is allowed to slide on the guide ways.
- ❖ **Injection:** During this process, the plastic material is melted by the application of heat and forwarded through the piston towards the nozzle and finally into the mold.
- The amount of material that is injected into the mold is referred to as the **shot volume**.



Injection Moulding

- ❖ **Cooling:** The injected molten plastic begins to cool as soon as it comes in contact with the mold surfaces.
 - As the molded part cools, it will solidify into the desired shape of the product.
- ❖ **Ejection:** The molded part, which is attached to the rear half of the mold has to be ejected from the mold.
 - An ejector mechanism is used to push the part out of the mold.
 - Force must be applied to eject the plastic part because during cooling the molded part shrinks and adheres to the mold surface.
 - A **mold release agent** should be sprayed onto the mold surfaces prior to injection of the material.



Injection Moulding

Advantages

- Higher production rate
- Close tolerances on small intricate parts
- Minimum wastage of material
- Complex geometry can be easily produced

Disadvantages

- Tooling cost higher
- High setup cost
- Large undercuts can't be formed

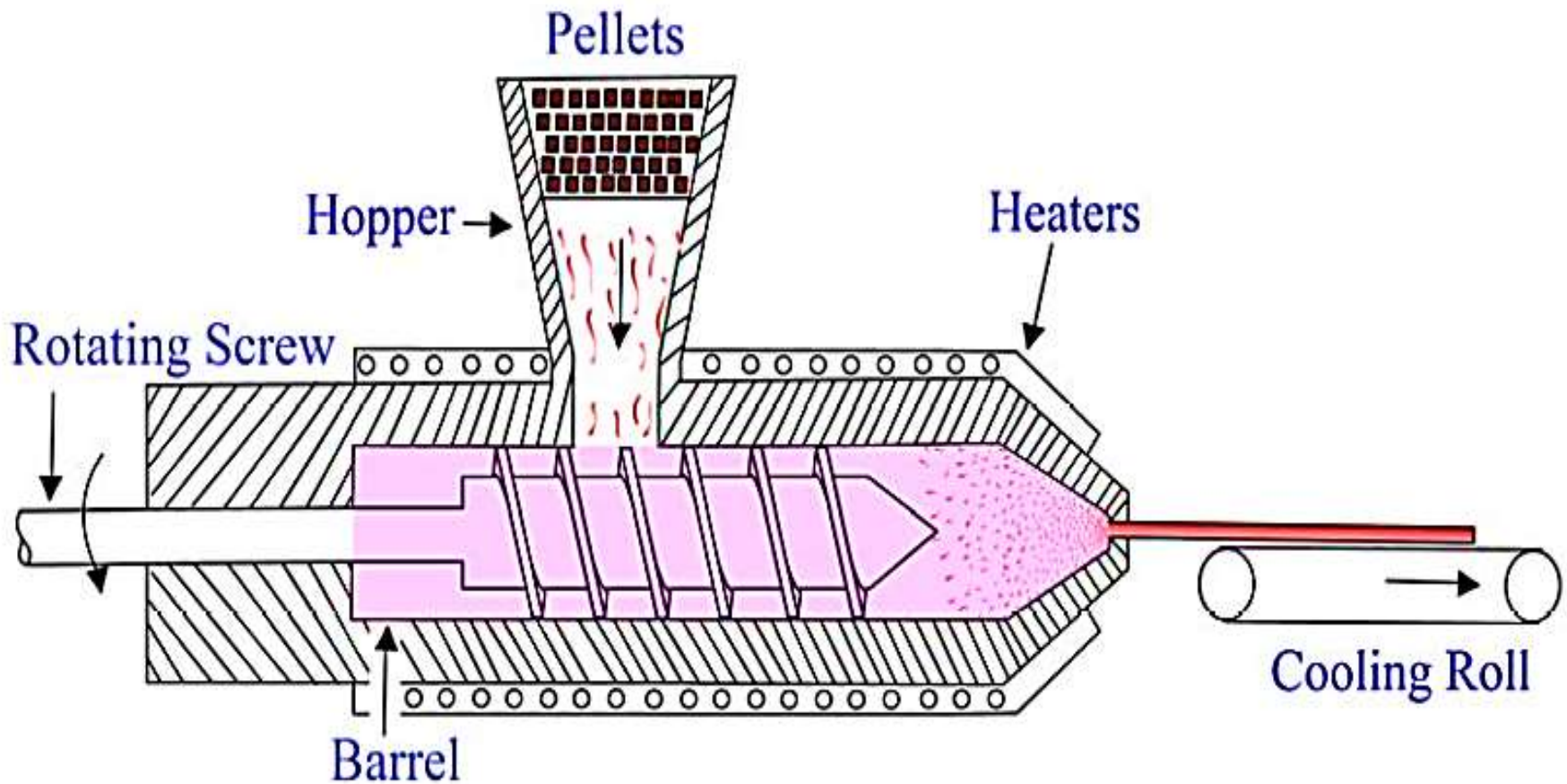
Applications

- household appliances, electronics, and automotive dashboards, buckets etc...



Plastic part manufacturing processes

Extrusion moulding





Extrusion Moulding

- Similar to injection molding except long uniform sections are produced.
- The material which is fed through hopper, is conveyed forward by a feeding screw & forced through a die, converting to continuous polymer product.
- Heating is done in order to soften or melt the polymer. The temp is controlled by thermocouples.
- The product going out of the die is cooled by blown air or in water bath.



Extrusion Moulding

Advantages

- High production volumes
- Relatively low cost as compared with other molding process
- Design flexibility
- Short lead times
- Coating of wire can be done to achieves desired properties
- Continuous part can be produced

Disadvantages

- Limited complexity of parts
- Uniform cross section can only be produced



Extrusion Moulding

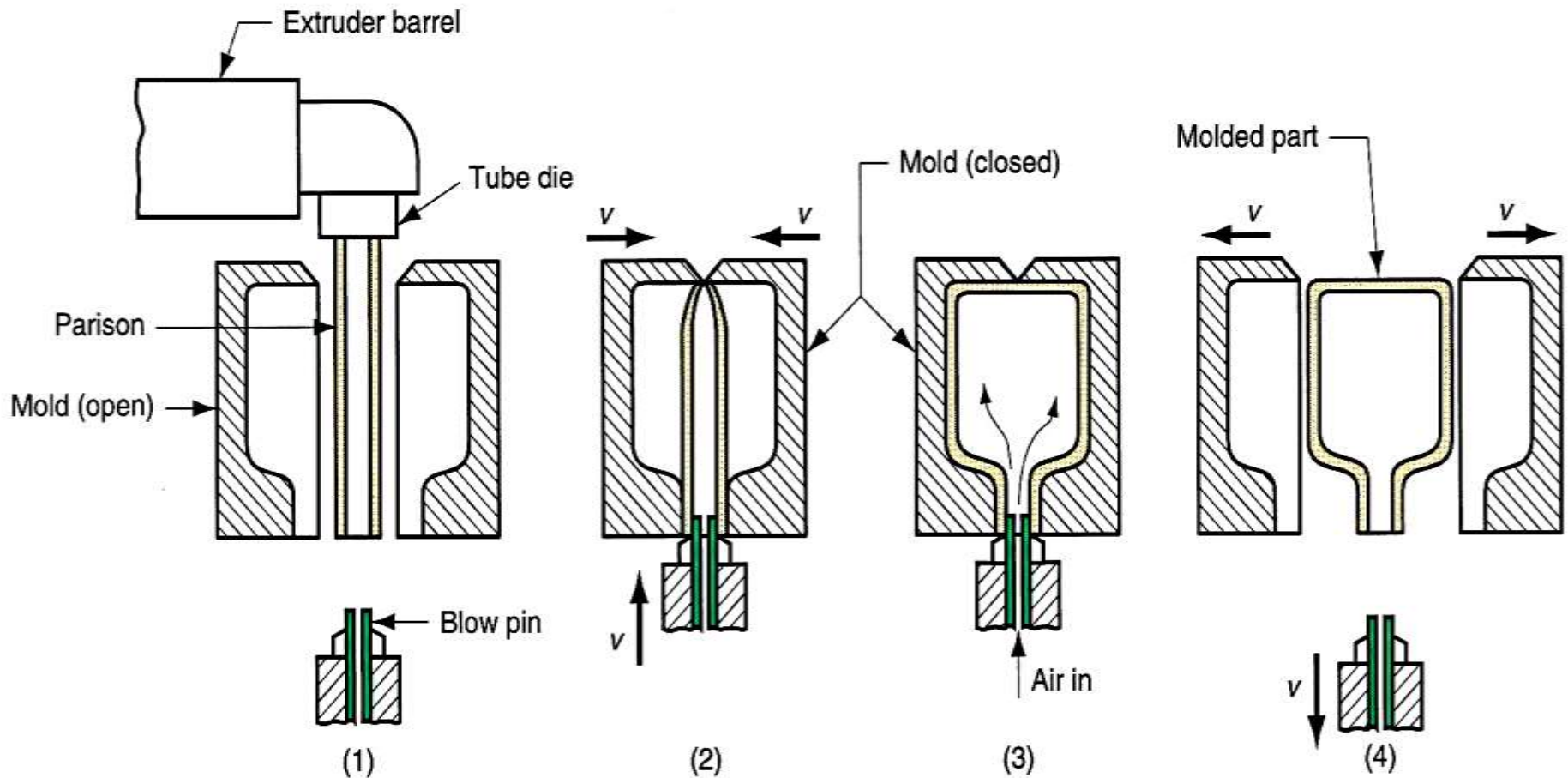
Applications

- The extrusion process is used for manufacturing rods, plates and tubes, wire and cable coating, hose liners, hose mandrels, filaments, sheet, multilayer film, medical packaging and food packaging, etc.



Plastic part manufacturing processes

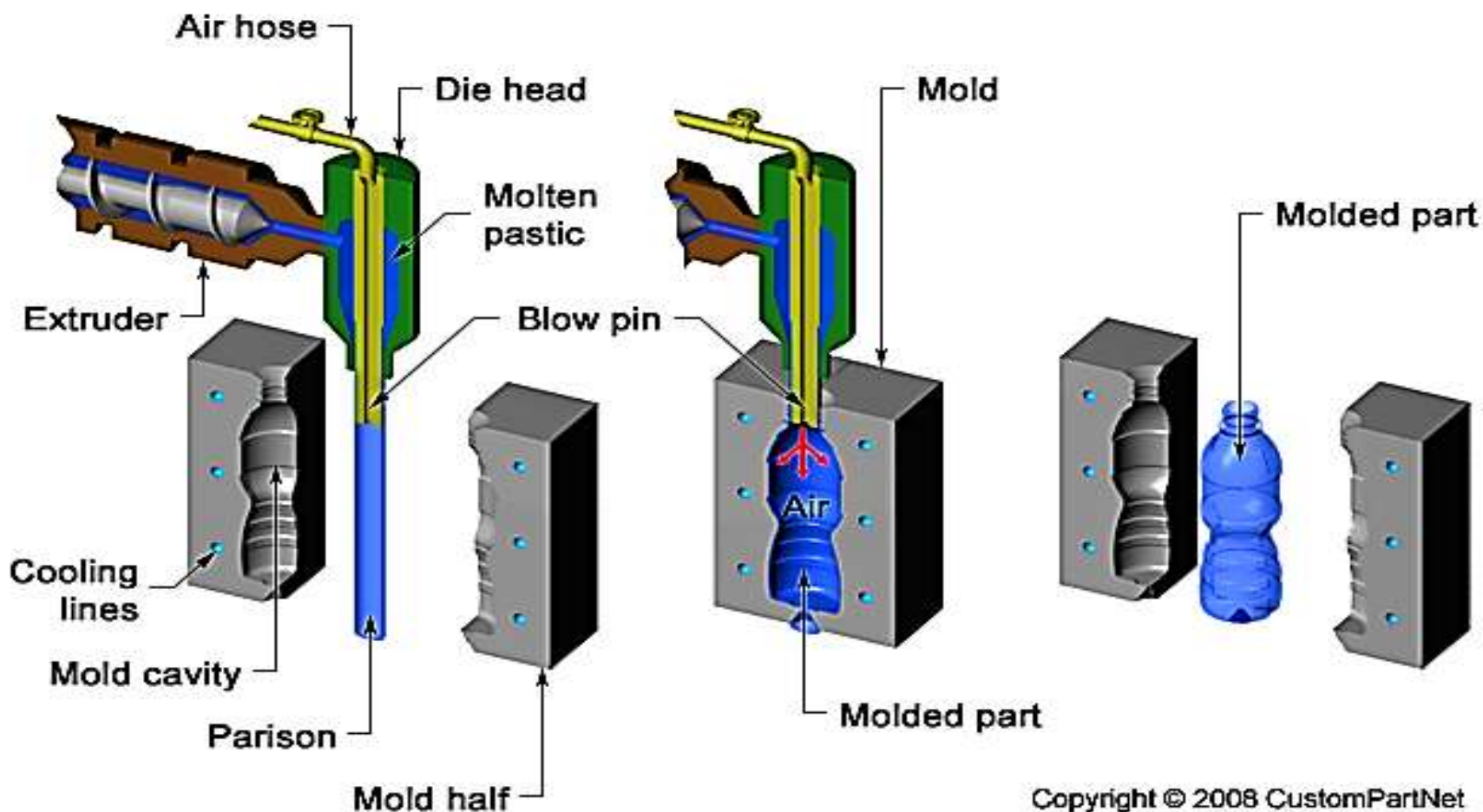
Blow moulding





Plastic part manufacturing processes

Blow moulding





Blow Moulding

- Using this manufacturing process blind parts are made like bottle or sphere etc.
- Air is blown into a thin walled plastic cylinder called **the parison**. The parison is formed by melted plastic material being pushed through an extruder.
- When the parison reaches a certain length, the two halves of the mould close around the parison sealing it at the bottom.
- **Compressed air** is then used to inflate the parison to form the shape of the cavity inside the mould.



Blow Moulding

Advantages

- Low tooling cost
- Fast production rates
- Ability to mold complex part with uniform thickness
- Little scrap generated
- Large hollow shape can be produced
- Produced parts can be recycle

Disadvantages

- Limited to hollow parts
- Thick parts can't be manufactured



Blow Moulding

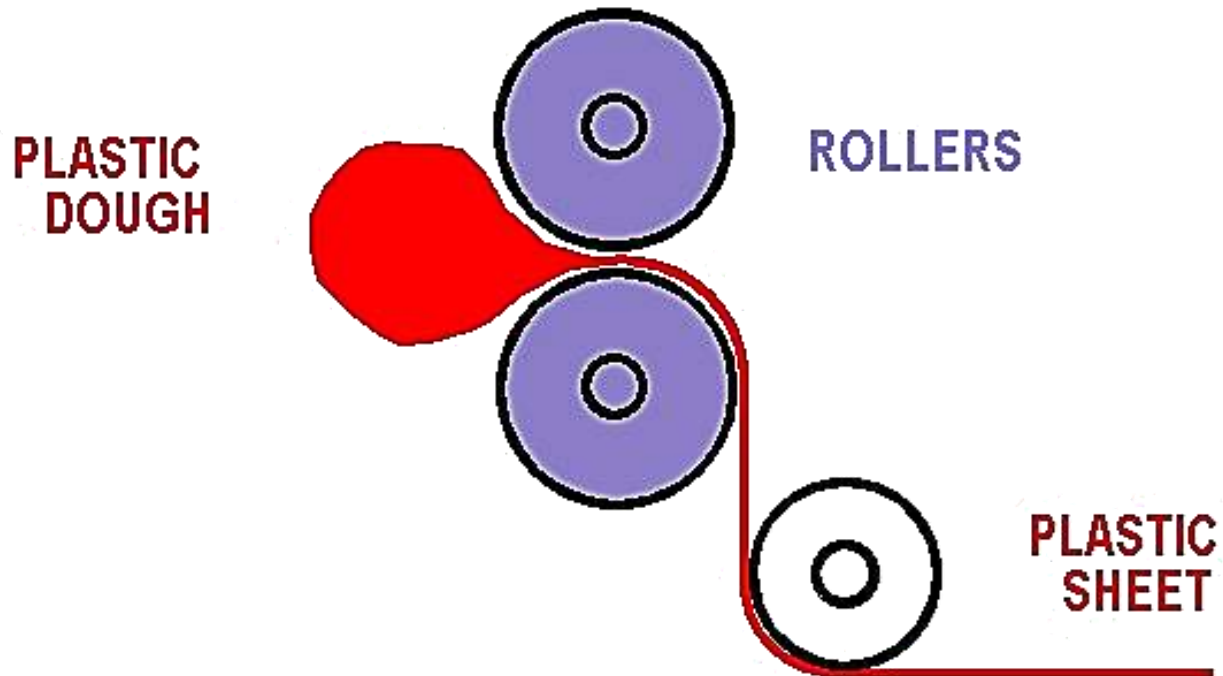
Applications

- bottles in different shape and size, jars, and containers, ducting, fluid oil tanks, mugs, and toys etc.



Plastic part manufacturing processes

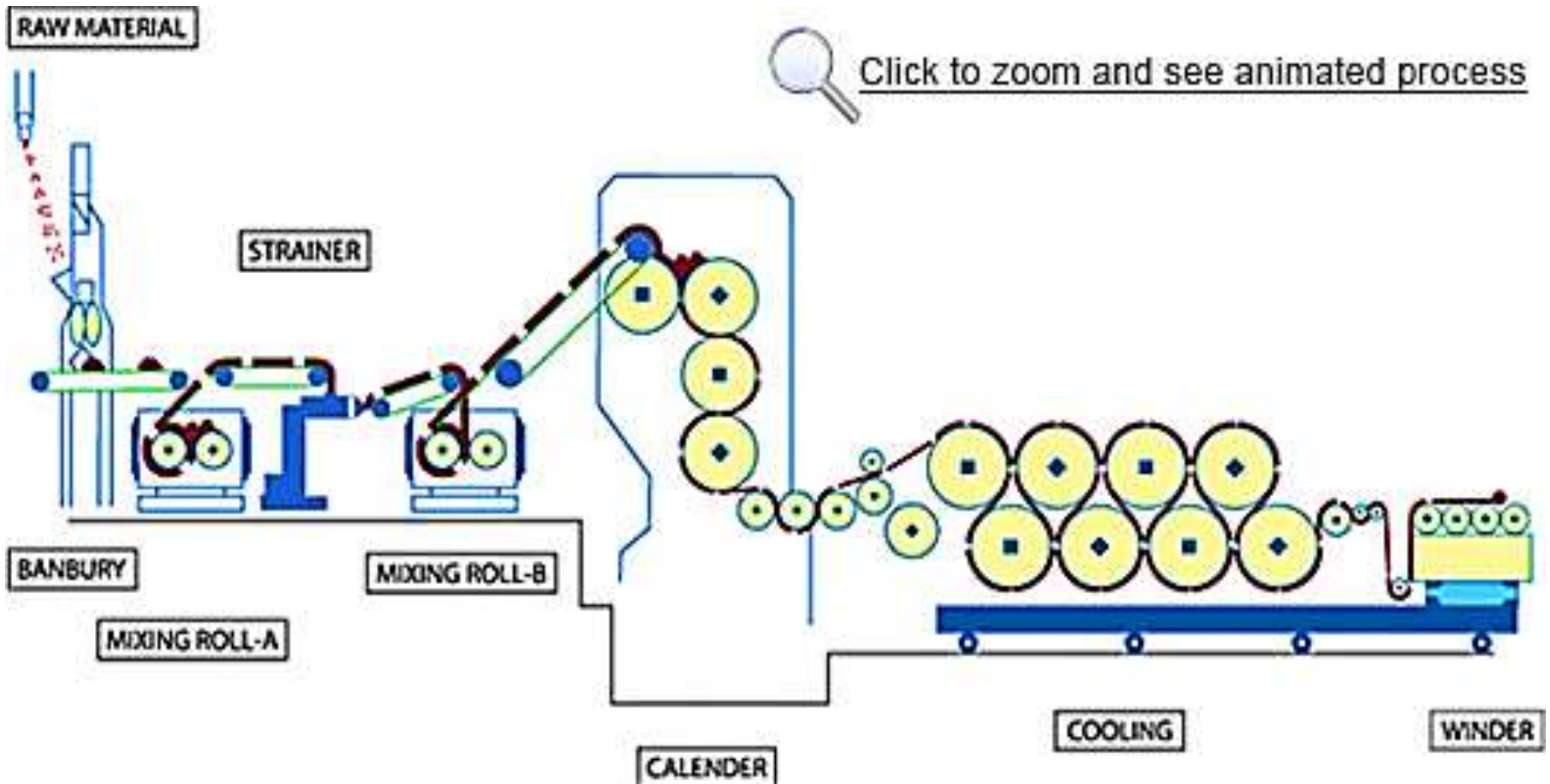
Calendaring





Plastic part manufacturing processes

Calendering





Calendaring

- 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.



Plastic part manufacturing processes

Thermoforming

- Thermoforming is a plastic manufacturing process in which the thermoplastic sheets are formed with the application of heat and pressure in a mold.
- The thermoplastic sheet is held horizontally over a mold surface and clamped with a holding device. The sheet is heated up to predetermined temperature using a heating element called heater.
- The thermoplastic sheet softens with the application of heat and is pressed into or stretched over the mold surface by application of air pressure or by any other means.



Plastic part manufacturing processes

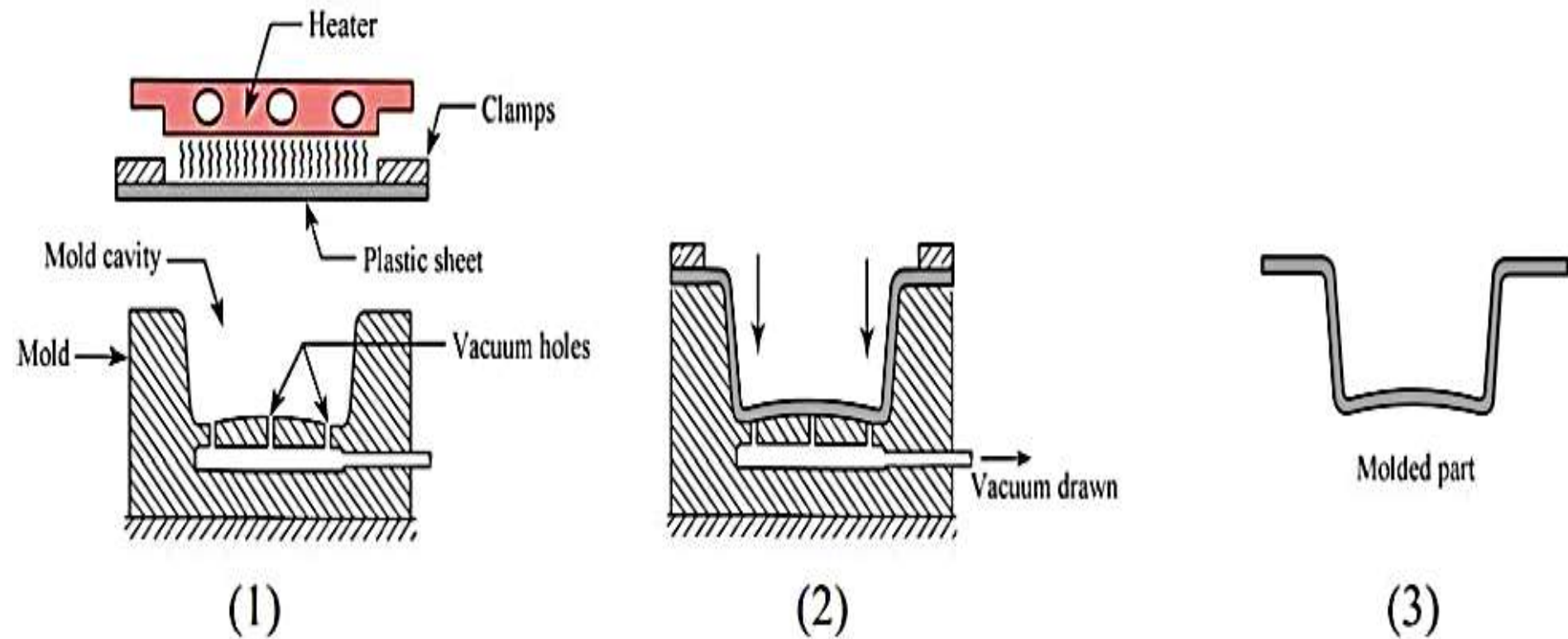
Thermoforming

- The softened sheet conforms to the mold shape and it is held in place until it cools.
- The mold cavity is opened and the thermoformed part is released.
- The excess material is then trimmed out from the formed part. Excess material can be reground, mixed with unused plastic, and again reformed into thermoplastic sheets.
- There are mainly three different types of thermoforming process depending upon the pressure required i.e., vacuum thermoforming, pressure thermoforming and mechanical thermoforming.



Thermoforming

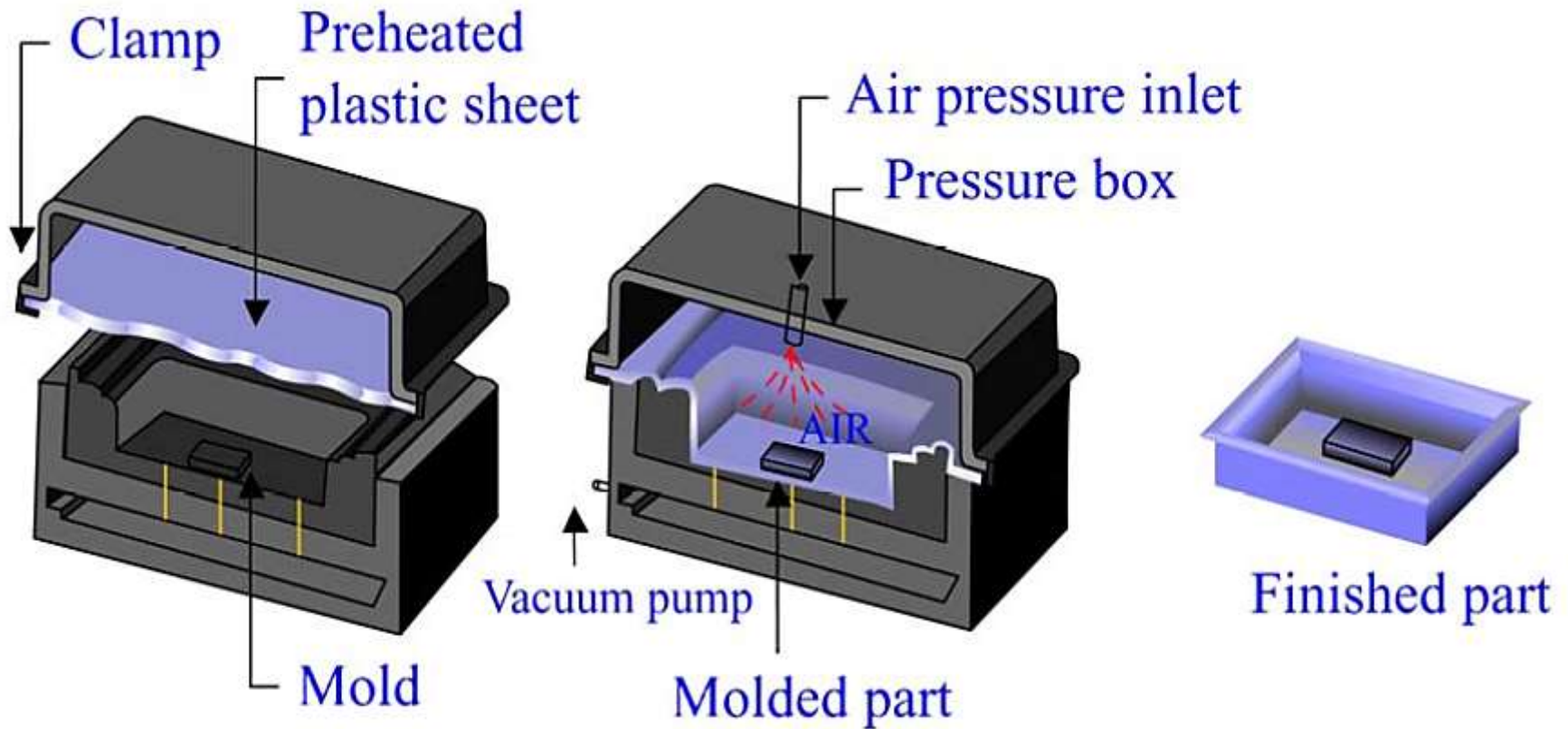
a. vacuum thermoforming





Thermoforming

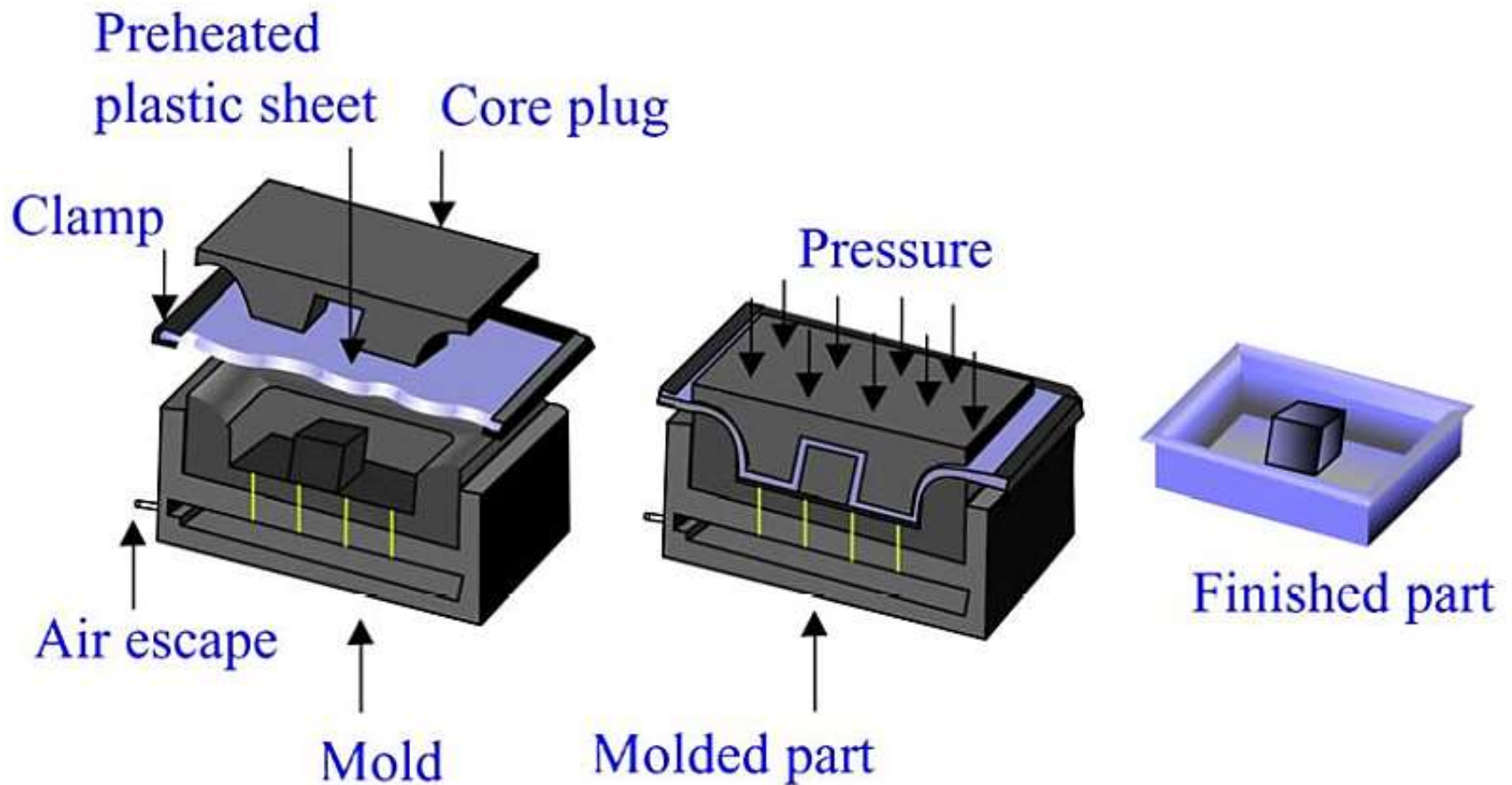
b. pressure thermoforming





Thermoforming

c. mechanical thermoforming





Thermoforming

Advantages

- Extremely adaptive to design requirement
- Rapid prototype development
- Low initial setup costs
- Low production costs
- Less thermal stresses than injection molding and compression molding
- Good dimensional stability

Disadvantages

- Poor surface finish
- Parts may have non-uniform wall thickness.
- All parts need to be trimmed
- Ribs and bosses cannot be molded easily
- Very thick plastic sheets can't be formed



Thermoforming

Applications

- food packaging, automotive parts, trays, building products, aircraft windscreens, medical equipment, material handling equipment, electrical and electronic equipment, spas and shower enclosures etc.



Plastic part manufacturing processes

slush moulding and laminating



SELF STUDY

