

Processing of Plastics



Bachelor of Industrial Technology Management with Honours
Semester I Session 2013/2014

TOPIC OUTLINE

- Introduction of Plastics
- Classification of Plastics
- Types of Plastic
- Plastics Processing
 - ✓ Injection Molding
 - ✓ Extrusion
 - ✓ Blow Molding
 - ✓ Vacuum Forming
 - ✓ Compression Molding
 - ✓ Rotational Molding



LESSON OUTCOMES

1. Understand characteristics of product made from plastics and category of plastics.
2. Able to explain the plastics processing.



Introduction of Plastics

- Definition : The word plastics is from the Greek word '*plastikos*', meaning “able to be shaped and molded”
- Plastics can be shaped into a wide variety of products such as molded parts, extruded sections, films and sheets, insulation coatings on electrical wires and fibers for textiles.
- Plastics are usually supplied as moulding powder, granules or chips which have to be processed.
- Processing includes the thorough mixing of additives with the moulding powder, granules or chips to produce plastic compounds.
- The use of additives allows a relatively small number of base plastics to be transformed into wide range of very versatile materials.

Introduction of Plastics

Advantages of Plastic Products

- 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

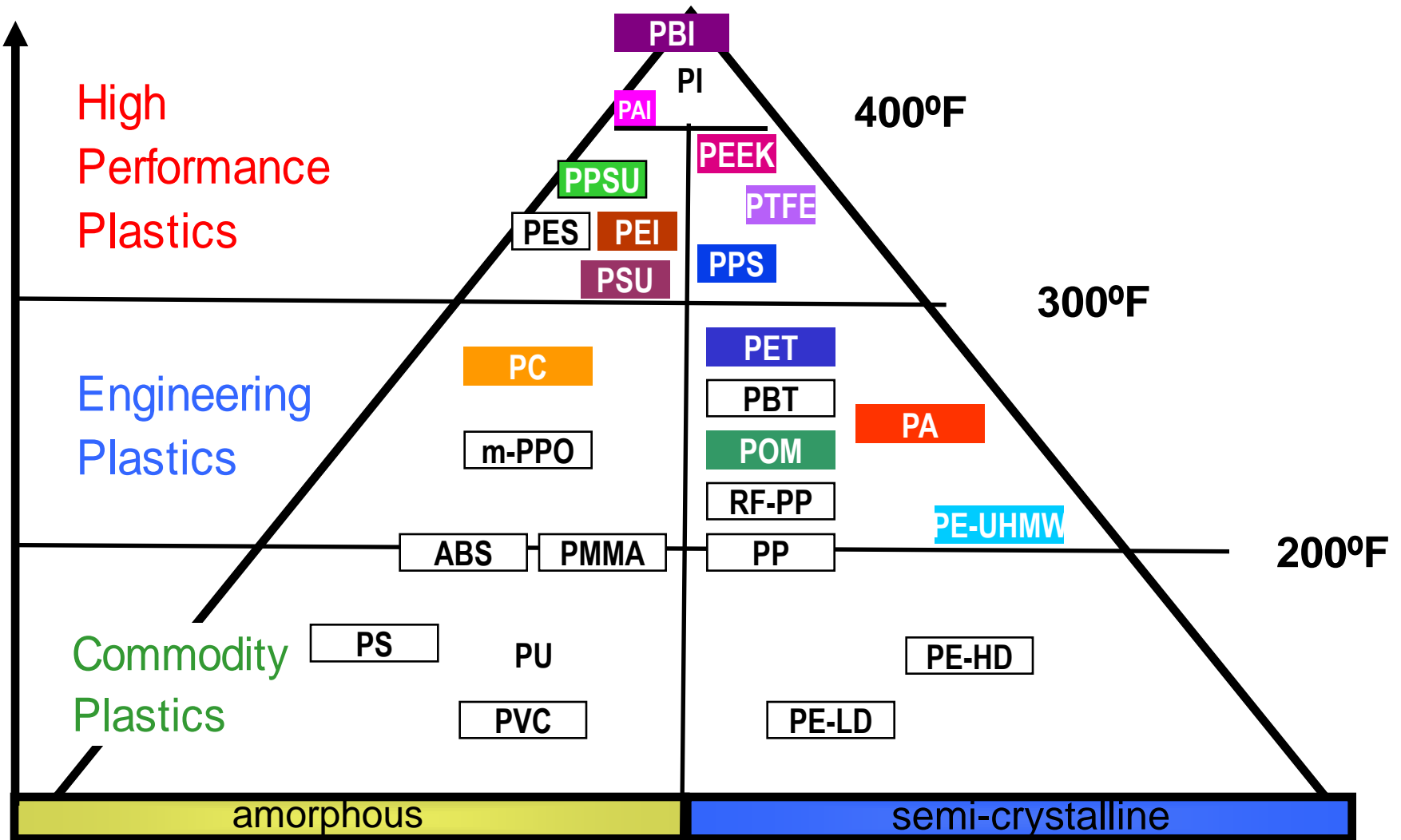
Disadvantages of Using Plastics

- Low strength
- Low useful temperature range (up to 600°F)
- Less dimensional stability over period of time (creep effect)
- Aging effect, hardens and become brittle over time
- Sensitive to environment, moisture and chemicals
- Poor machinability

Classification of Plastics

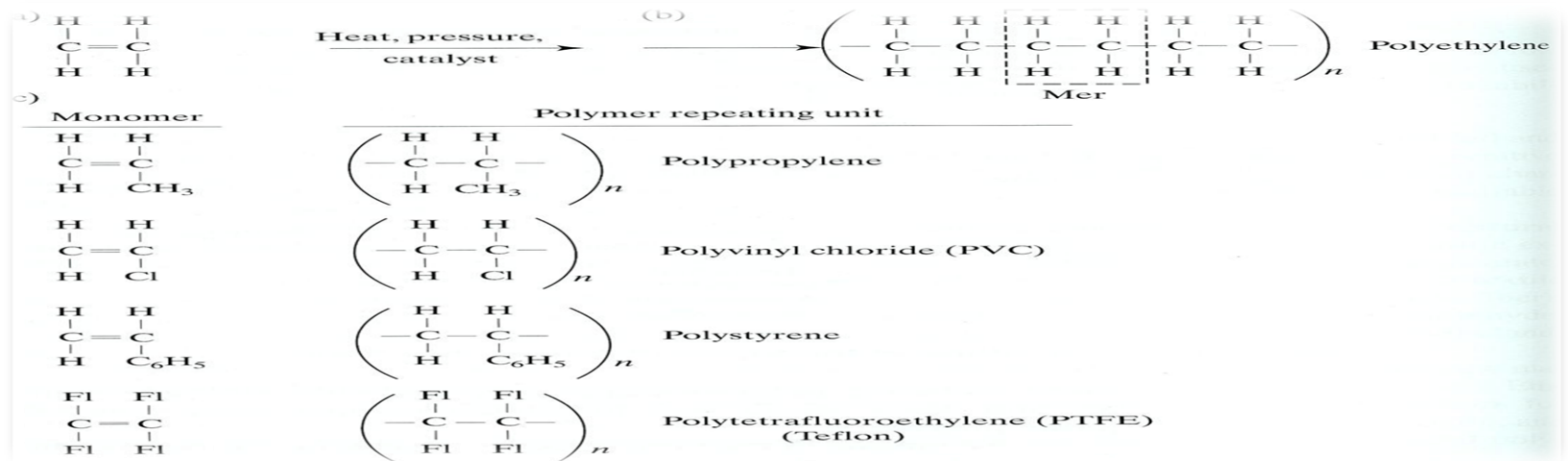
- Plastics are classified into two categories
 - Thermoset : any material that once heated cannot be reheated or reformed
 - Thermoplastic : any material that can be heated and reheated to make a finished part or stock shape
- Plastics are also broken down into two subcategory of amorphous or crystalline. This molecular structure is very important to the performance properties of any plastic material

Classification of Plastics



Classification of Plastics

- The development of modern plastics started in 1920s using raw material extracted from coal and petroleum products (Ethylene). Ethylene is called a building block.
- Polymers are long-chain molecules and are formed by polymerization process, linking and cross linking a particular building block (**monomer**, a unit cell). The term polymer means many units repeated many times in a chainlike structure.
- Most monomers are organic materials, atoms are joined in covalent bonds (electron-sharing) with other atoms such as oxygen, nitrogen, hydrogen, sulfur, chlorine, etc.



Classification of Plastics

Thermoplastics

- As the temperature is raised above the melting point, the secondary bonds weaken, making it easier to form the plastic into any desired shape. When polymer is cooled, it returns to its original strength and hardness. The *process is reversible*. Polymers that show this behavior are known as thermoplastics.

Thermosetting Plastics (Thermosets)

- Thermosetting plastics are cured into permanent shape. Cannot be re-melted to the flowable state that existed before curing, continued heating for a long time leads to degradation or decomposition. *This curing (cross-linked) reaction is irreversible*. Thermosets generally have better mechanical, thermal and chemical properties. They also have better electrical resistance and dimensional stability than do thermoplastics.

Types of Plastics

Thermoset Examples:

- *Phenolic*
- *Bakelite, Melamine*
- *Glass Epoxy systems*
- *Polyester composites*
- *Teflon - PTFE*
- *Torlon*
- *Vespel/Meldin PI*
- *PBI*

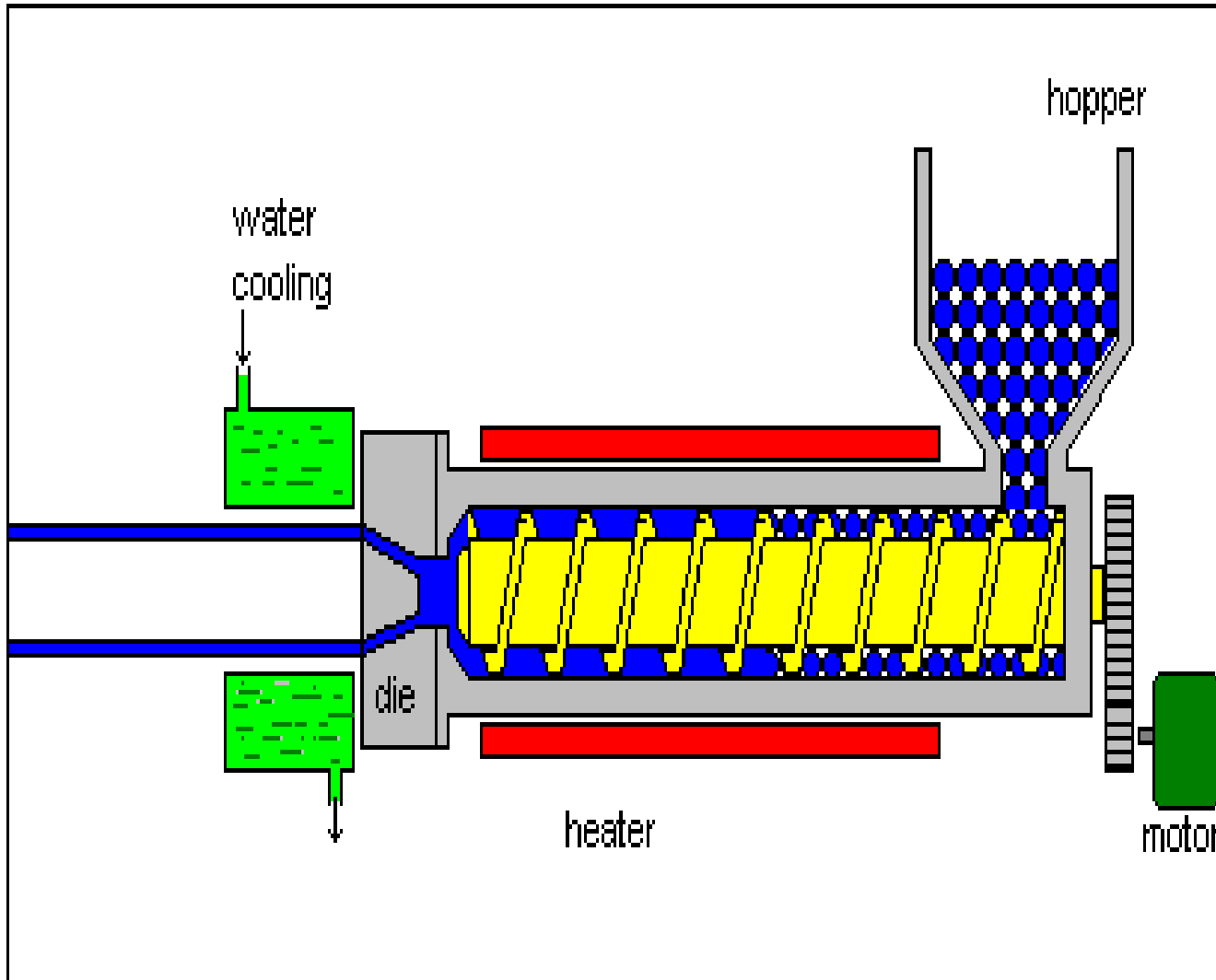
Thermoplastic Examples:

- PVC
- Polyethylene
- Polypropylene
- Nylon
- Acetal
- Acrylic
- Polycarbonate
- PEI
- PET
- PBT

Plastic Processing

- Thermoset materials can only be compression or transfer molded.
- Process usually requires extremely high pressures and elevated temperatures during compression
- Thermoset materials usually require some form of reinforcement for stability and strength
 - Additives include paper, cotton fiber, linen fiber, fiberglass, polyester fiber, Kevlar fiber, carbon fiber
- Thermoplastics can be extruded, injection molded, compression molded, blow molded, thermoformed, bonded to substrates, stamped and machined.
- Additives to thermoplastics enhance many properties:
 - Wear and friction
 - Electrical properties – insulative, conductive, dissipative
 - Fire resistance
 - Increases in compressive, tensile and flexural strength and modulus
 - Improvements in impact strength

Extrusion

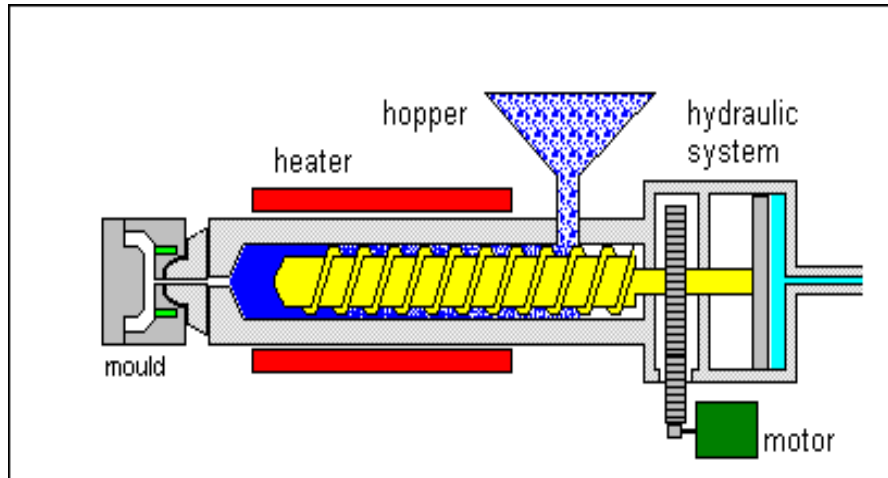


This extrusion is part of a window seal made from thermoplastic elastomer (TPE)

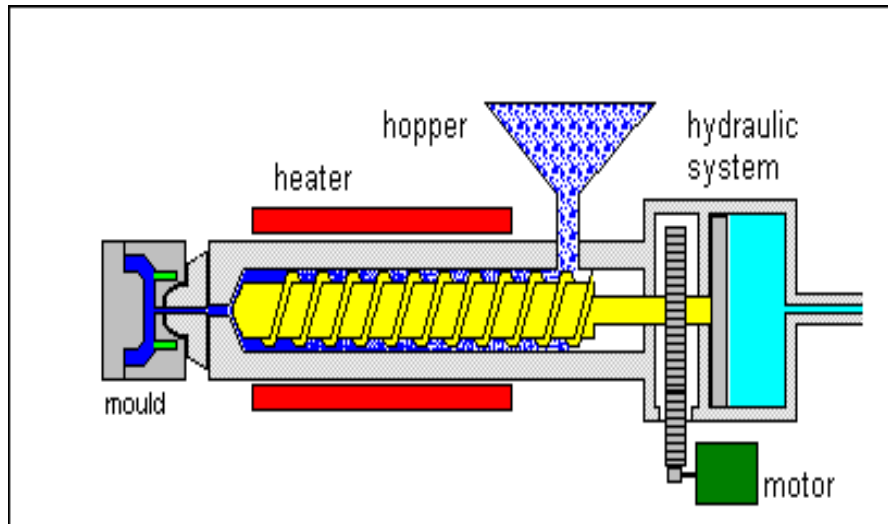
Extrusion

- **Continuous process** used to produce both solid and hollow products that have a constant cross-section.
- Example : window frames, hose pipe, curtain track, garden trellis
- **Thermoplastic granules** are fed from a **hopper** by a **rotating screw** through a **heated cylinder**.
- The **tapered screw** compacts the plastic as it becomes elasticised. The **die** which is fitted to the end of the **extruder barrel** determines the cross-section of the extrusion.
- Thicker cross-sections are extruded more slowly as more time is required for the initial heating and subsequent cooling of the larger quantities of material which are involved. As the extrusion leaves the die it is cooled by passing through a cooling trough (below) containing cold water.

Injection Moulding

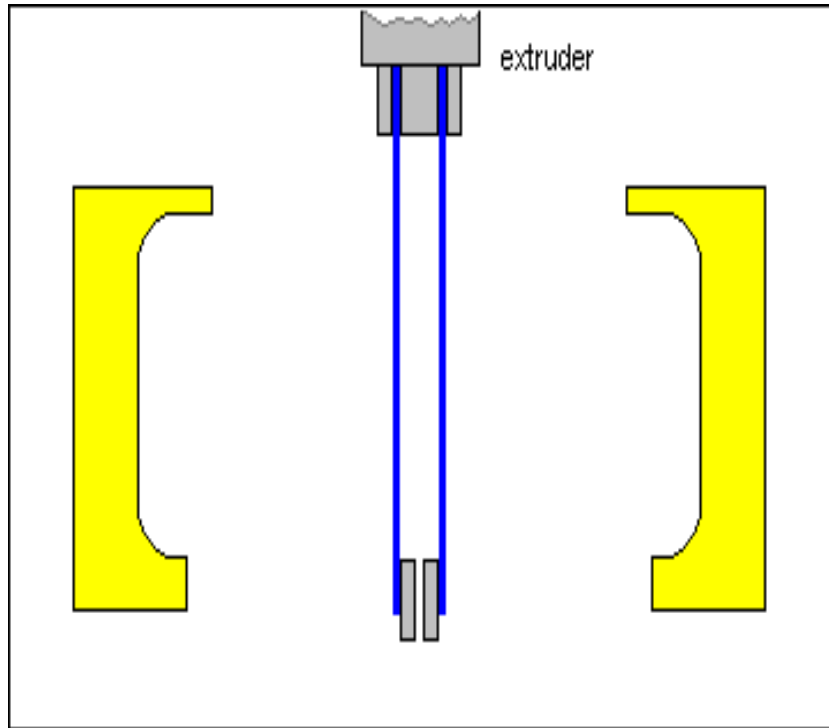


Powder or granules from a hopper into a steel barrel with a rotating screw. The barrel is surrounded by heaters. The screw is forced back as plastic collects at the end of the barrel.

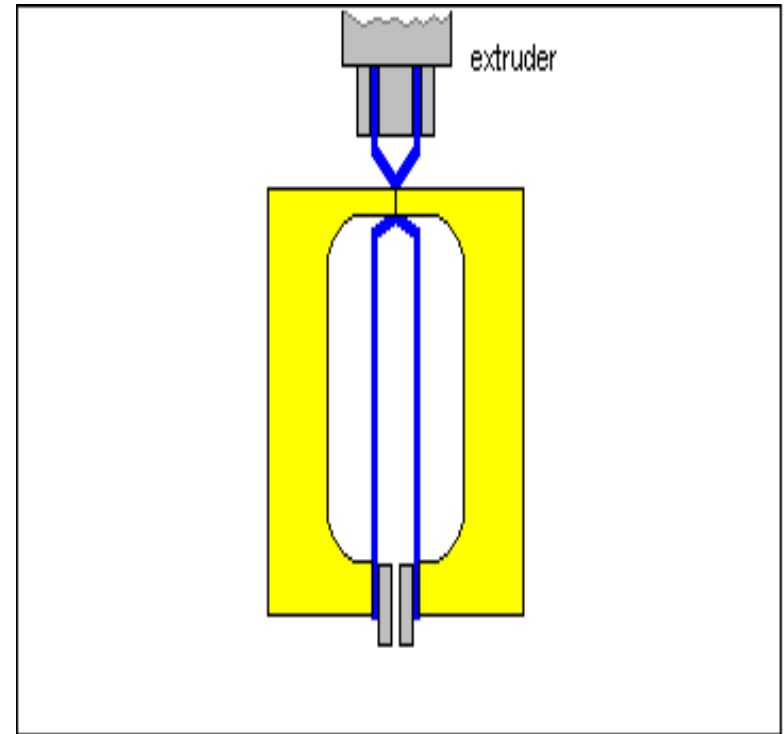


Once a sufficient charge of melted plastic has accumulated a hydraulic ram forces the screw forward injecting the thermoplastic through a sprue into the mould cavity.

Blow Moulding

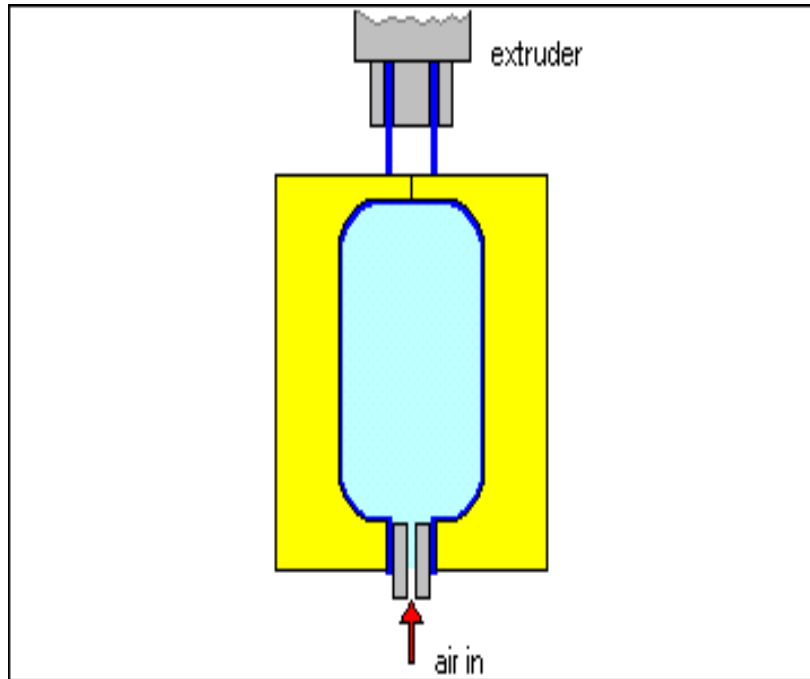


A hollow length of plastic, called a parison, is extruded down between the two halves of the mould.

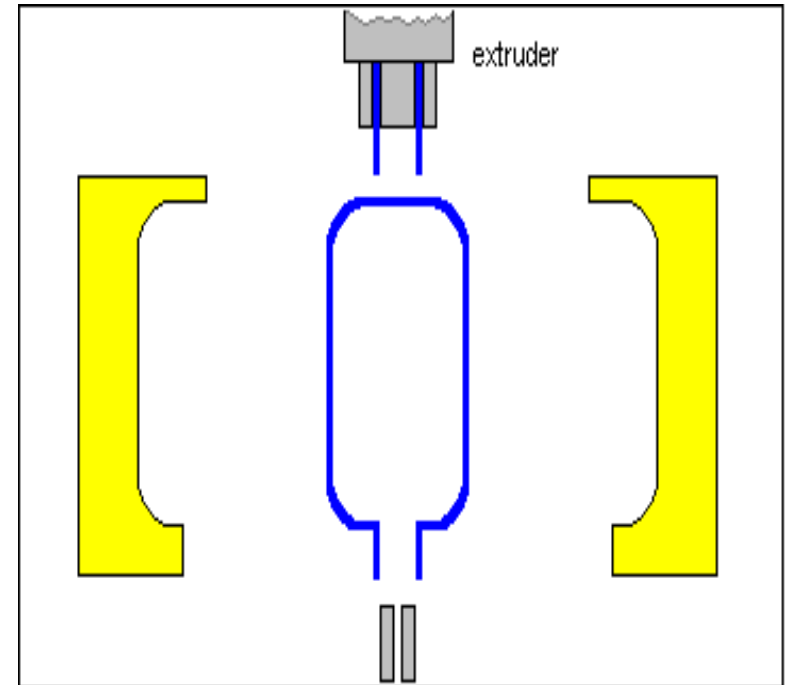


The mould closes.

Blow Moulding



Compressed air is blown into the inside of the parison which inflates it, pushing the soft plastic hard against the cold surfaces of the mould.



The mould is then opened the moulding ejected and the waste (called flash) is trimmed off with a knife.

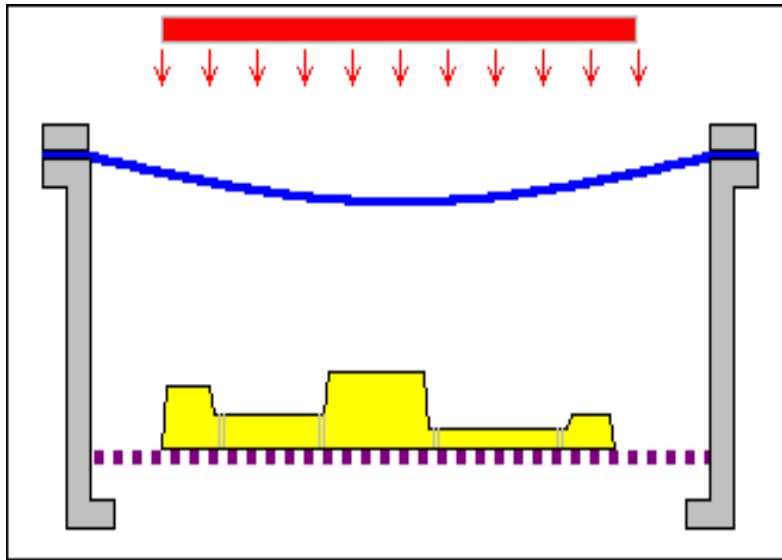
Materials Used in Blow Moulding

High density polyethylene (HDPE) and low density polyethylene (LDPE) are both commonly used for blow moulding as are other types of thermoplastics. The thermoplastic used in blow moulding needs to be more viscous (flow less easily) than that used for injection moulding as the parison must retain its form before the mould closes around it.

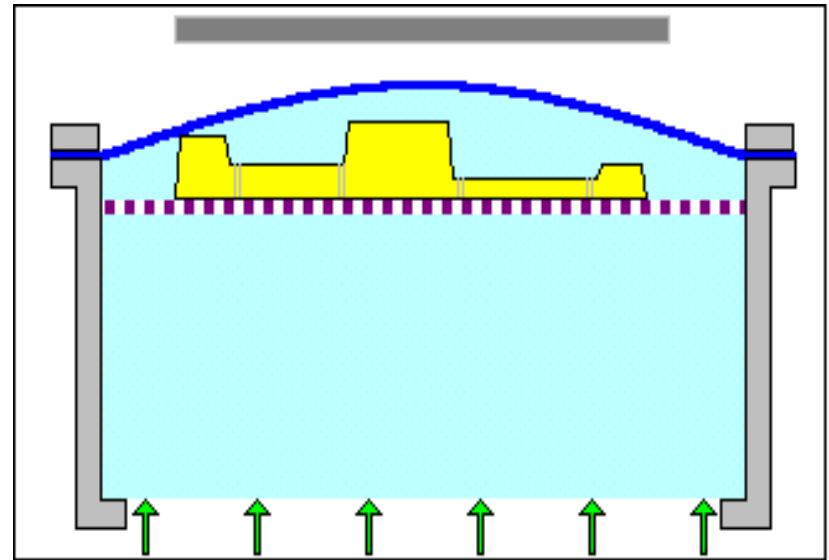
Used extensively to make bottles and other lightweight, hollow parts



Vacuum Forming

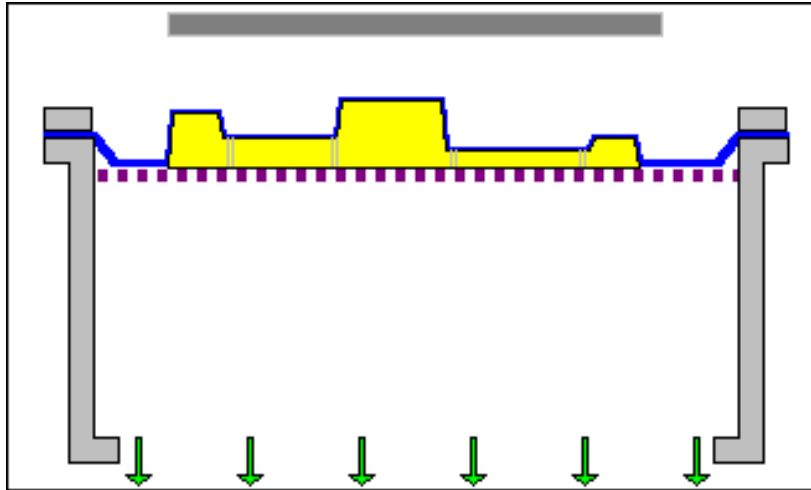


Mould is attached to a platen (support plate). The platen and mould are then lowered and a rigid thermoplastic sheet material is clamped onto an air tight gasket and usually heated from above.



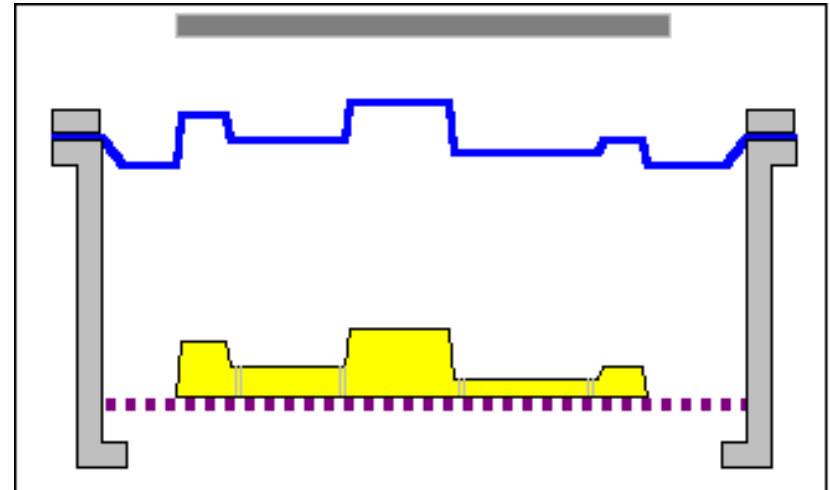
Once the thermoplastic sheet is softened enough (reaches a plastic state) then air is blown in to raise the sheet in a slight bubble before the platen is raised bringing the mould into contact with the plastic.

Vacuum Forming



Trapped air remaining between the platen and the heated plastic sheet is then evacuated by a vacuum pump.

Atmospheric pressure acting over the top surface completes the forming process by pressing the plastic sheet onto the mould.



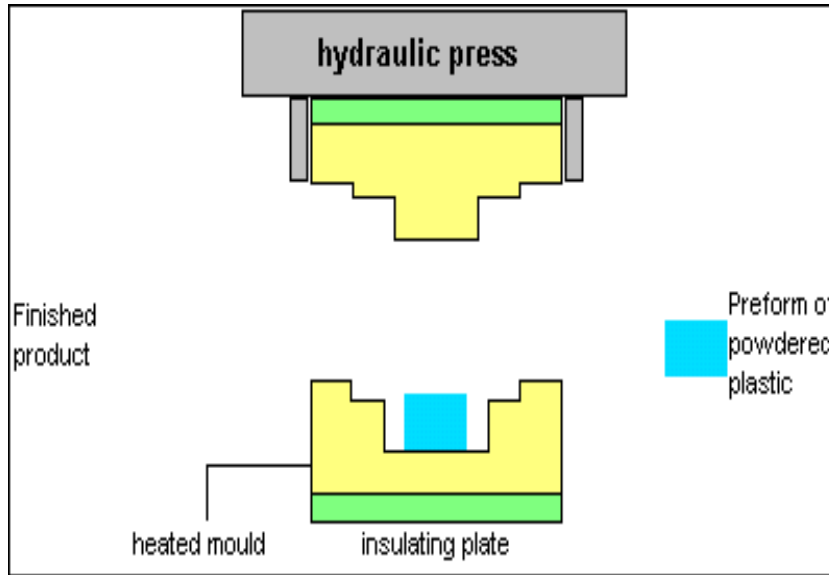
Once the plastic sheet has cooled down to below its freeze point the air flow is reversed to lift the forming off the mould and the mould lowered.

Materials Used in Vacuum Forming

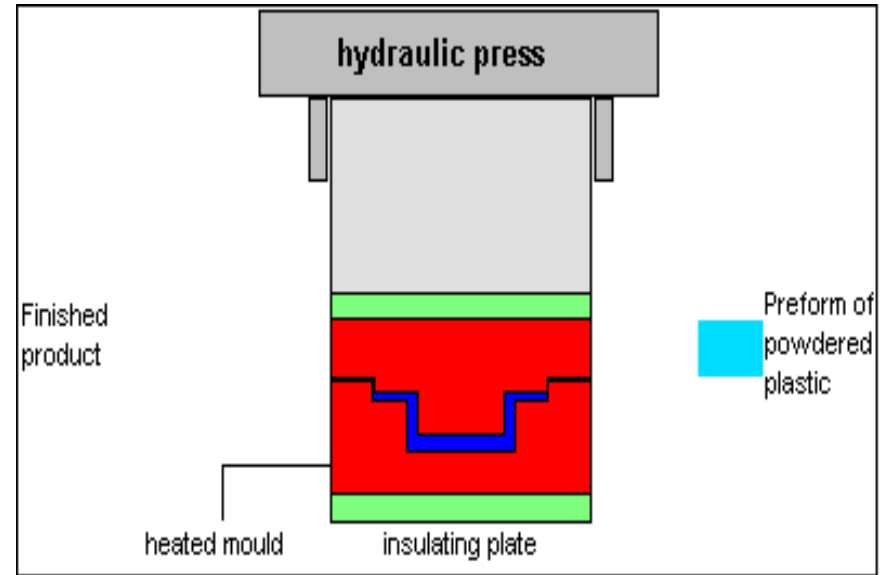
- Many types of thermoplastics are suitable for vacuum forming. The most popular is High Impact Polystyrene (HIPS). It is relatively cheap, comes in a wide range of colours and is easy to form. This process is used to manufacture a variety of products in thermoplastic materials. These products range in size from garden pond liners to food trays used in supermarkets.



Compression Moulding

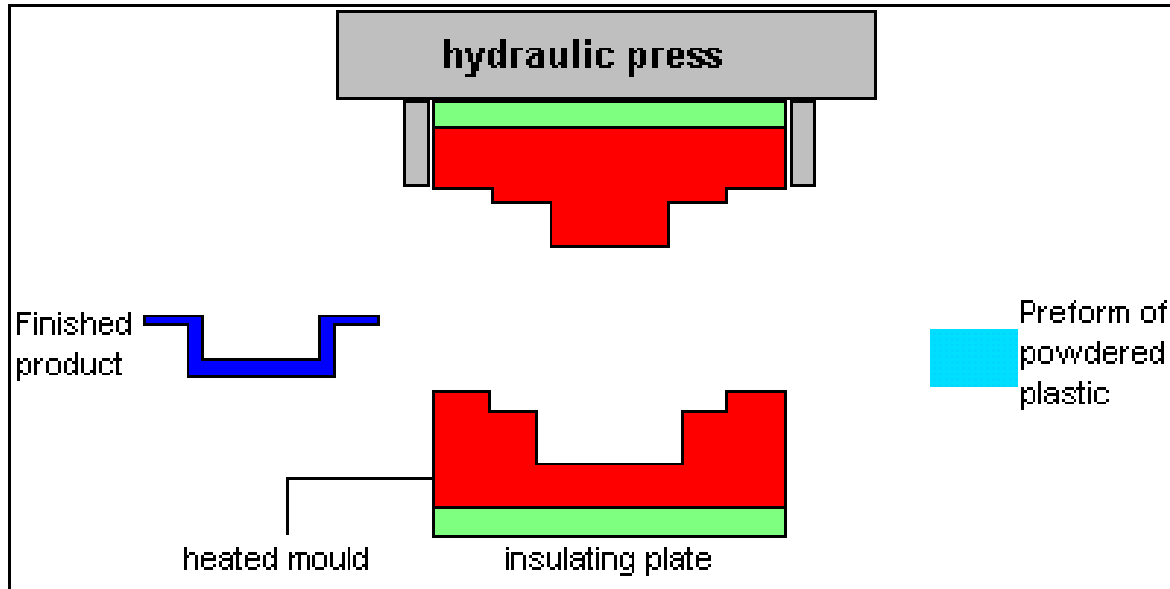


The mould is charged with a measured amount of powder or granules ready to be compressed. Sometimes plastic charge is first compacted into a shape called a preform.



When the two halves of the mould are brought together the plastic material is forced under compression to flow rapidly around the cavity. Heat from the platens causes the plastic to cure resulting in a permanent change in shape.

Compression Moulding



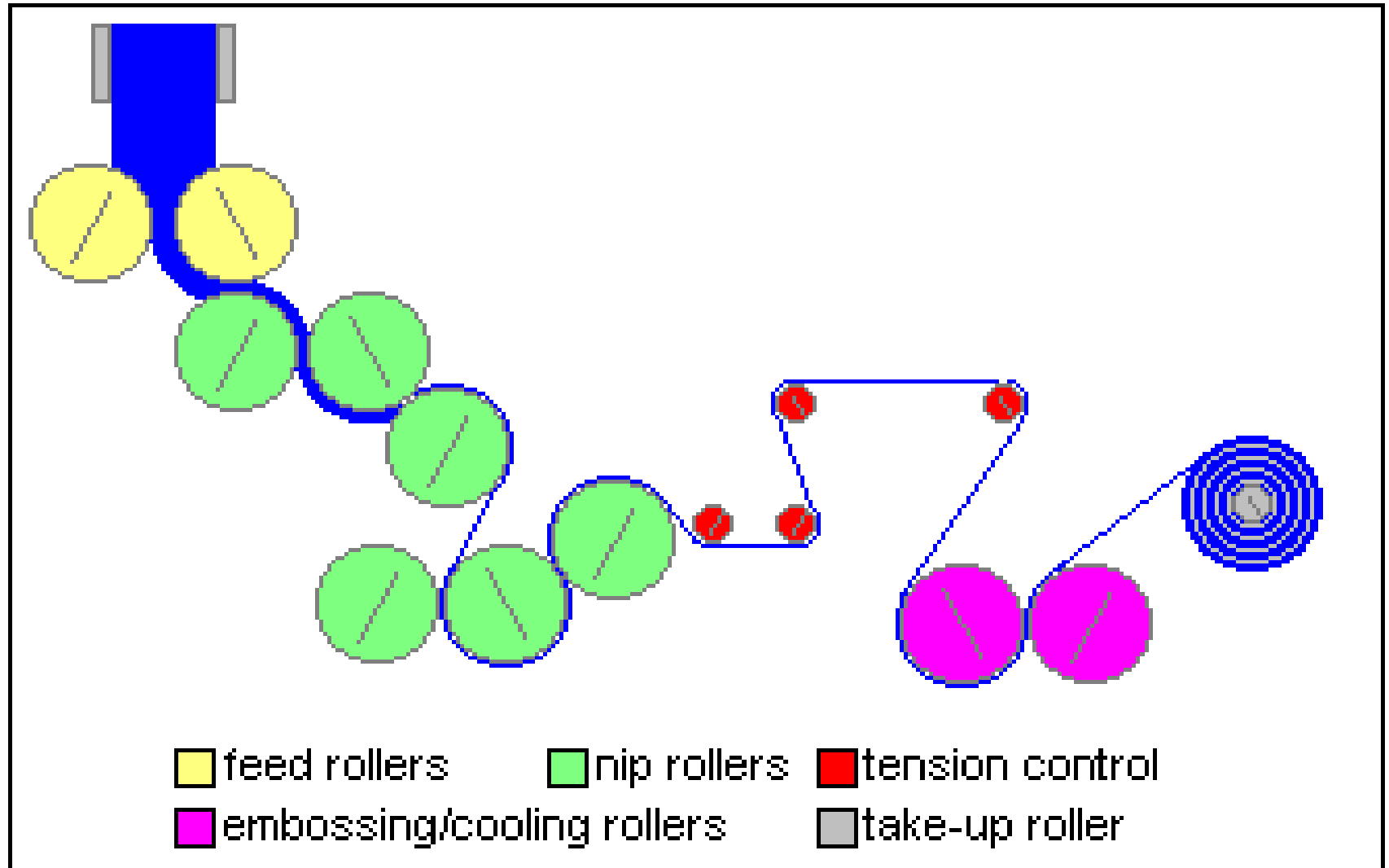
The component is ejected from the mould and any excess material formed at edges (flash) is removed.

Materials used.

Typical thermosetting plastics used in compression moulding are urea formaldehyde and phenol formaldehyde.



Calendering



Calendering

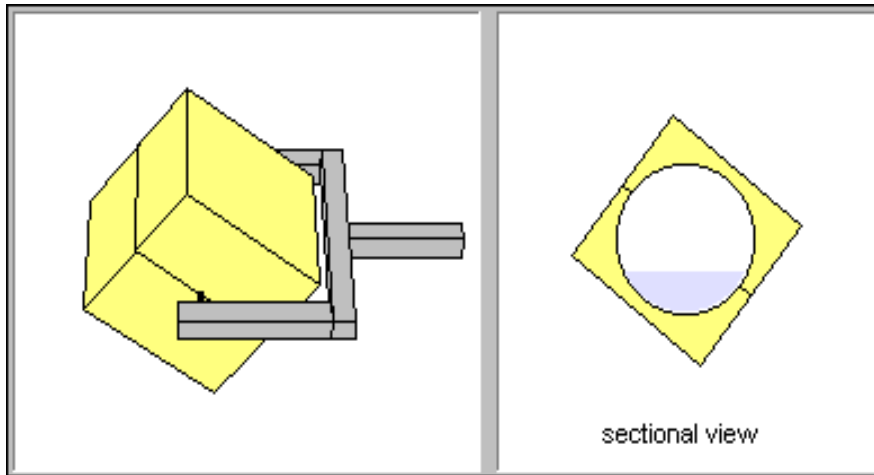
Involves rolling out a mass of premixed plastics material between large rollers to form a continuous and accurately sized film.

The process begins with the ingredients being blended and fluxed in a mixing mill at approximate 100°C. Nip rollers control the thickness of the sheet material can be gradually reduced in thickness. Rolls of semi-rigid PVC which will be used to manufacture transparent A4 folder 'pockets'.

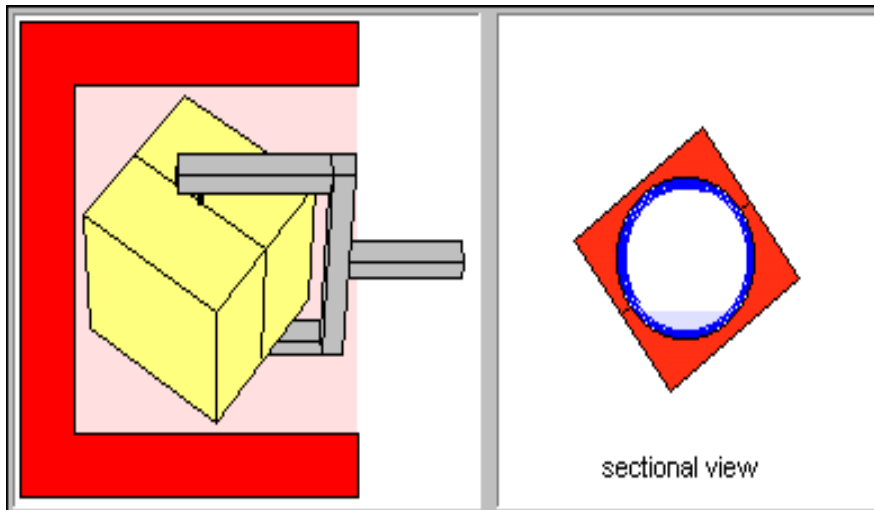
Materials Used

The main material used is PVC, others include ABS and cellulose acetate. PVC ranges from flexible to rigid and the final product is composed of a number of basic materials which must be combined in a uniform mixture of measured ingredients. These ingredients include a resin of a specified molecular weight, stabilisers, lubricants, reinforcing materials, colorants and plasticisers.

Rotational Moulding

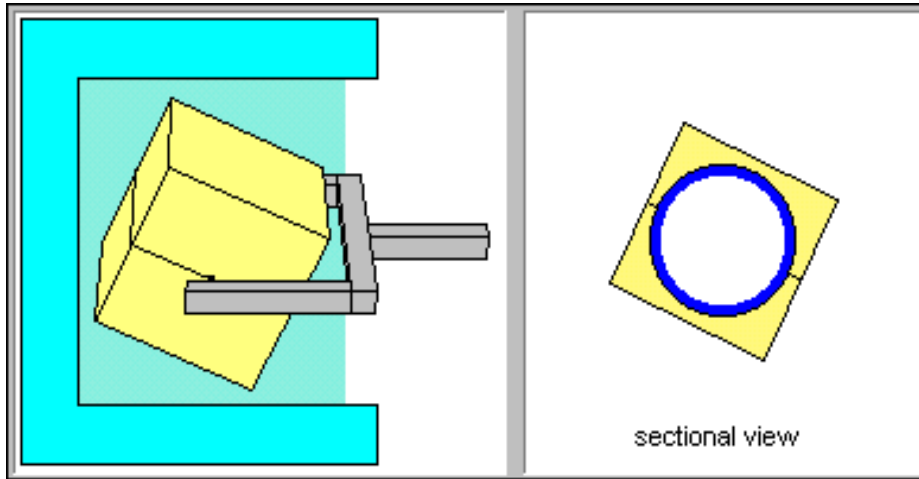


A measured weight of thermoplastic is placed inside a cold mould. The mould is then closed and moved into an oven chamber

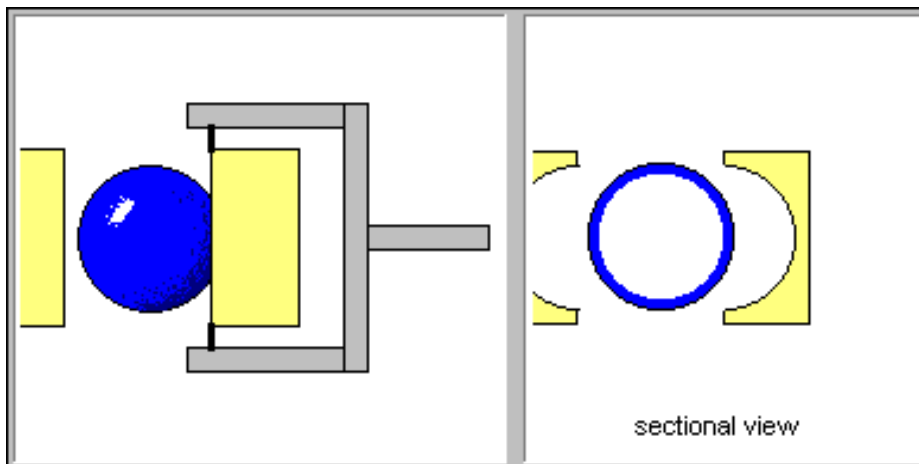


Heated to a temperature of 230-400°C whilst being rotated around both vertical and horizontal axes. As it rotates the mass of powder at the bottom of the mould fuses and sticks to the mould surface.

Rotational Moulding



The mould moves into a cooling area or chamber where it is cooled by air or water jets.



The hollow moulding can be removed as soon as it is cool enough to hold its shape.

Materials Used in Rotational Moulding

90% of rotational mouldings are made from polyethylene (PE), used mainly to manufacture hollow shaped products such as footballs, road cones and storage tanks up to 3m³ capacity.



So What Material Do I Use????

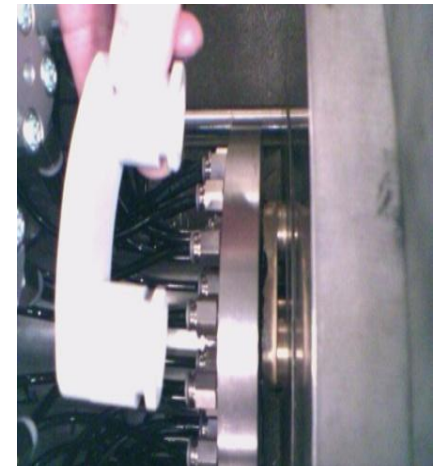
The process for determining which material is appropriate for an application is a step by step procedure.

1. Is the application for a structural component or wear component?
2. What temperatures will the part see?
3. What are the physical demands on the part?
4. For bearing applications, what are the bearing loads, speeds?
5. What is the environmental condition?
6. What are the cost considerations?
7. What is the service life expectation?

Where Do We Apply Plastics In Bearings??



Where Do We Apply Plastics In Structural Components?



Plastic Materials Are Versatile!

- With the correct material selection, there are few applications where plastics can't be a cost effective, easy to apply alternative to metals.
- All structural and bearing applications of plastics are purely a material selection process.
- Understand the limitations and you will understand the capabilities.

