Unit-5

INTRODUCTION TO POLYMER PROCESSING

Compounding: Polymer Additives: Fillers, Plasticizers, antioxidants, thermal stabilizers, fire retardants and colorants. Processing Techniques: Calendaring, die casting, compression moulding, injection moulding, blow moulding and reinforcing.

COMPOUNDING OF PLASTICS (OR) MOULDING CONSTITUENTS

Compounding is the process by which specific type of additives are added into the resin in order to incorporate certain properties to plastics.

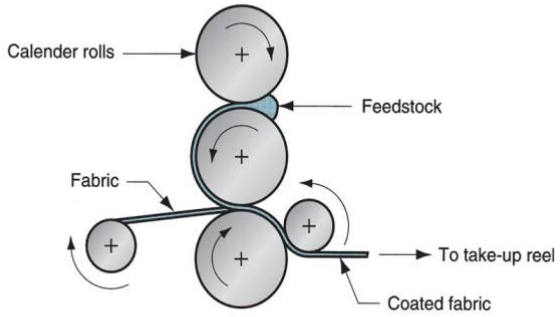
Plastics are compounded to enhance features like:

- Mechanical/Physical and Thermal Properties
- Optical (color/visuals), Functional properties
- Reduced cost
- Polymer additives: foreign substances are called additivities are intentionally introduced to enhance or modify many of these properties, related to and controlled by the molecular structure and thus render a polymer more serviceable.
- **Fillers**: filler are most often added to polymers to improve tensile and compressive strengths, abrasion resistance, toughness, dimensional and thermal stability and other properties.
- **Plasticizers:** theflexibility, ductility and toughness of polymers may be improved with the aid of additives called plasticizers. Their presence also produces reduction in hardness and stiffness.
- **Stabilizers:** additives counteract deteriorative processes are called stabilizers (uv light and oxidation)
- **Colorants:** substance that are soluble in the medium (water or oil) is to be colored.
- **Flame retardants**: it is referring to a variety of substances that are added to combustible materials to prevent fires from starting or to slow the spread of fire and provide additional escape time.
- **Antioxidants**: polymers when subjected to oxygen attack, if These exists high concentration of unsaturated c-c bonds, residual polymerization catalyst, it is subjected to highly oxidizing conditions, then it undergo oxidation.

5.2Processing techniques: the polymeric materials are used in many forms such as rods, tubes, sheets, foams, coatings or adhesives and also as mould ed and fabricated articles. The important processes are calendaring, die casting, compression moulding, blowmoulding melt spinning etc.…

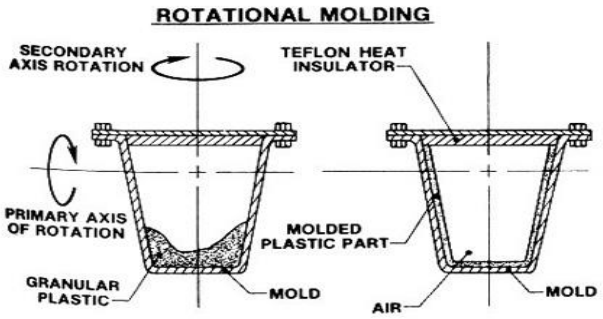
5.2.1 calendaring process:

- A calendar is a device used to process a polymer melt into a sheet or film.
- When the first it was mainly used for processing rubber, but it is commonly used for producing thermoplastic sheets, coatings and films.
- The basic idea of the machine is that squishes a heat softened polymer between two oe more rollers to form a continueous sheet.to begin this process the polymer must go through blending and fluxing before it goes through the calender.it make it a consistency easier for the calender to hadle.the thickness of the polymer sheet is dependent mainly on the gap between the last two rollers.
- the last set of rollers also dictate the surface finish and texture of the surface.
- Polymer is ready for going through the rollers tends to follow the faster moving roller of the two that it is in contact with and it also sticks more to the other rolls. Hats why calendar typically end with a smaller roller ata a higher speed to peel the sheet off.it is also the middle roller is kept cooler so that the sheet wont stick to the other rollers nor will it split by sticking to both rollers which can be happen

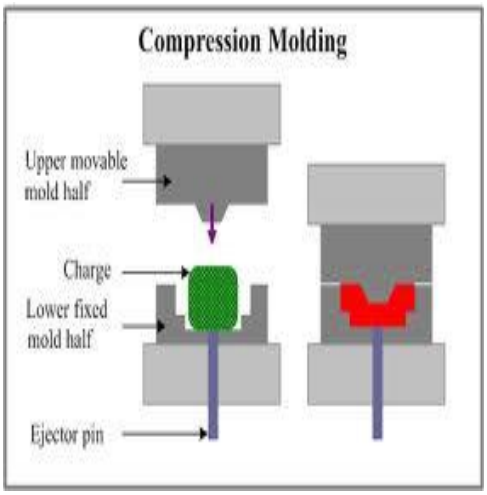


5.2.2Die casting

- Die casting is a low-cost process.
- Converting a liquid prepolymer to a solid object with a desired shape.
- sheets, tubes, rods with limited length can be produced by the casting process.
- Examples: acrylics, epoxies, polyesters, phenolics and urethanes.
- There are two types of die casting methods
- Rotational casting
- Film casting



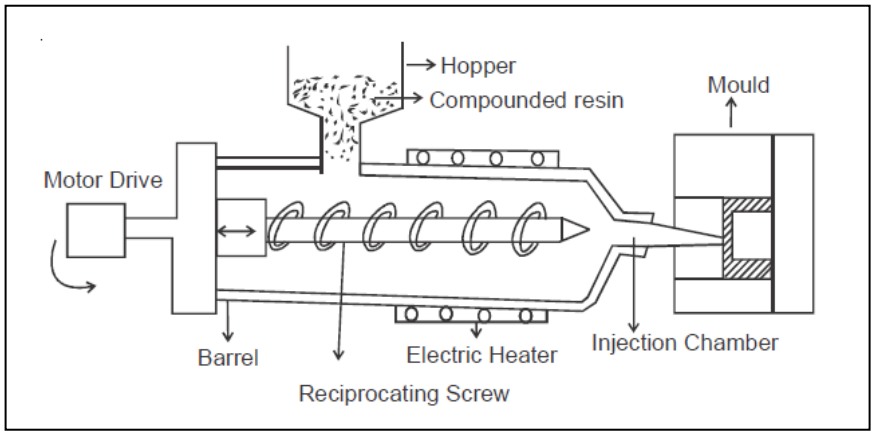
5.2.3Compression moulding

- The compression moulding materials is very widely used to produce articles from thermosetting materials.
- The moulds is made up of two halves.
- Upper and lower halves.
- Lower half usually contains a cavity when mould is closed.
- Upper half is has a projection which fits into the cavity when mould is closed.
- The gap between the projected upper half and the cavity in the lower one gives the shape of the moulded article.
- Moulding pressure and temperature can be high as 200C and 70 kg/cm2.
- 

- The compounded material is placed in the cavity of the mould so as to fully fill the cavity.
- As the mould closes down under pressure,
- the material is squeezed or compressed between the two halves and compacted to shape inside the cavity.
- The excess material flows out of the mould as a thin film.
- This film is expelled out of the mould is known as the flash.
- Under the influence of heat, the compacted mass gets cured and hardened to shape.

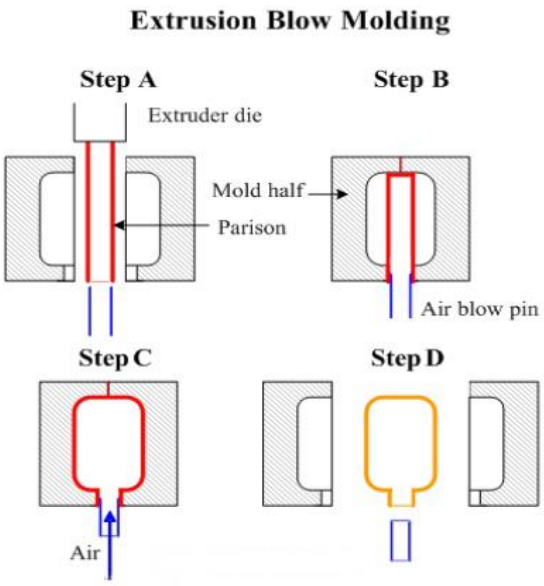
- The mould can be opened while it is still hot to release the moulded product.

5.2.4Injection moulding



- **Principle:** In Injection molding the molten polymer is injected into a closed and cooled mould under a high pressure where it solidifies to give the product of desired shape.
- **Process:** this technique is used to produce articles from thermoplastic resin. The system consists of two parts namely a cold movable mould and a stationary horizontal cylinder. The compounded material is fed
- into the horizontal cylinder through the hopper where it gets softened by electrical heating. Then the molten plastic material is injected under a high pressure (1500Kg/cm^2) into a cold movable mould where it solidifies and takes the shape of the mould.
- **Advantages:**
- Injection moulding is capable of high production rates of 1–50 components/min
- The wastes can be reclaimed and reused.
- **Disadvantages:**
- The capital cost is more.
- Relatively high pressure (1500Kg/cm^2) is required.
- **Applications:** Injection moulding is the most common manufacturing technique for plastic components. It is used for the fabrication of computer parts, automotive and aerospace components.
- **5.2.5Blow moulding**
- Most of the hollow plastic articles are produced by the blow moulding technique.
- Containers, soft drink bottles and numerous hollow articles are produced by this process.
- Thermoplastic materials such as propylene, polycarbonate, PVC, polystyrene,Under pressure, the parison ultimately assumes the shape of the hollow cavity on the mould.
- The mould is allowed to cool and the rigid thermoplastic article formed is removed by opening the mould.

- The parison needed for blow moulding can be made either by the injection or extrusion process, and the technique can accordingly be called injection or extrusion blow moulding.
- nylon, polypropylene, acrylics, acrylonitrile, and ABS polymer can be blow moulded.
- Blow moulding basically belongs to the glass industry.
- A hot, thermoplastic tube, usually called parison, is properly placed inside a two-piece hollow mould.
- When the two halves of the mould are closed, it pinches and closes one end of the parison and encloses a blowing pin at the other end.
- The parison is now blown by pressurizing from within by blowing compressed air through the blowing pin.
- The hot parison is inflated like a balloon and goes on expanding until it comes in intimate contact with the relatively cold interior surface of the hollow mould.



5.2.6 **REINFORCING**

REINFORCING is plastic matrix with a strength fibre material results in the formation of are called fibre reinforced materials. It having high strength weight ratio and excellent corrosion resistance and are easy to fabricate. Reinforced plastics are produced by suitably bonding a fibre material with a resin matrix and curing the same under pressure and heat. The reinforcement could be in different forms for instance it could be short chopped fibres, continuous filaments or wove fabrics. The common resins fabrics are used in FRPs includes polyesters, epoxy, phenolic, silicone, melamine, vinyl derivatives and polyimides.

There are several methods available for the production of reinforced plastics. Three of the most techniques are

- The hand lay-up technique
- The filament-winding technique
- The spray-up technique

- **Hand Lay-up technique:** The Hand Lay-up Technique This is probably the simplest method for producing reinforced plastic articles. The quality of the end product depends to a large extent on the skill of the operator. The whole process consists of the following steps.

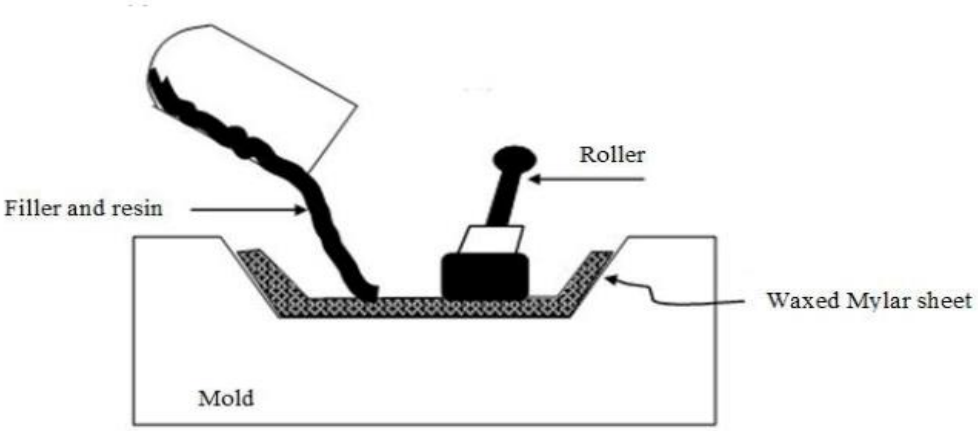
- To begin with, the mold is given a thin coating of a release agent such as polyvinyl alcohol, silicone oil or wax. (This is done to prevent the final fabricated article from sticking to the mold.) The mold is then coated with a resin matrix.

- A precut glass cloth or mat is then laid over the resin layer. Now, another layer of the resin coating is given over the glass cloth.

- Rollers are used to press the glass cloth on the resin uniformly and also to remove the entrapped air bubbles.

- Alternate layers of resin and glass cloth are laid in a similar sequence until the required thickness is built up. The whole set-up is then cured either at the ambient or elevated temperature.

- After the curing is completed, the reinforced plastic material thus formed is removed from he mold and subjected to trimming and finishing. Sheets, auto body parts, boat hulls, ducts and building components are produced by this



Hand Lay-up Technique

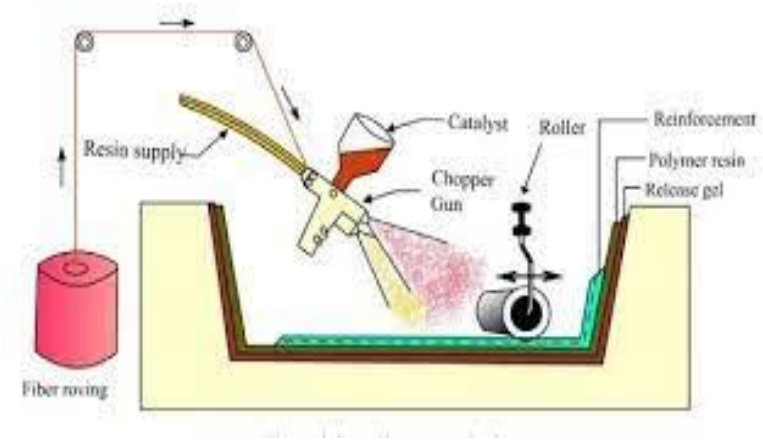
- **Filament-winding Technique:** This is a very widely used method for producing reinforced plastic articles such as high-pressure cylinders, storage tanks and rocket motor bodies.

- In this process a continuous length of strand, roving or woven tape of the fiber is passed through a bath of resin and curative.

- As the strand comes out of the bath, the excess resin is squeezed out. The resin-dipped filament or strand is then wound S a mandrel of the required shape and subsequently cured under and influence of heat.

- The winding machine is designed in such a fashion that the fibers can be Wound in a predetermined pattern to suit the job.

- The tension of the fiber and the pattern of winding are very important factors as they influence the ultimate tensile property of the finished product.

- **Spray-up Technique:** This technique employs a multiple headed gun.
- A spray of resin, a curative and chopped fibers are discharged simultaneously from Spray gun on the surface of a mold where they get deposited to a uniform thickness.
- The chopped fiber of a suitable length is obtained by continuously feeding roving's to the chopping head of the apparatus.
- Once the required thickness is built up by
- spraying, it is cured under heat. The spray-up technique is a quick method to cover large surface area molds.
- Many present-day reinforced plastic articles such as truck bodies, storage vessels, Iorry cabs and boat hulls are produced by the spray-up technique.
- 

- **Other Techniques:** from the techniques described above, there are several other techniques available in the ever-growing reinforced plastic industry, having a specific use.
- For example, a continuous laminating technique is used for producing continuous sheets of reinforced plastic laminates with varying thicknesses.
- In this process, individual layers of woven fabric are fed from individual rolls and impregnated with the resin and curative, and then pressed into a single layer by passing through a set of hot laminating rollers.
- The single layer coming out is cured by applying heat, which results in a laminate of a desired thickness.
- The thickness can be adjusted by selecting the number of layers.
- In yet another technique, known as 'pultrusion', articles such tubing or fishing rods are produced from continuous strands Of fiber.
- The process is relatively simple. The continuous strands a pretreated by passing through a resin-curative bath and then pu through a die of a suitable profile .

REFERENCE:

Textbook of polymer chemistry.,Gowarikar,Vishwanathan