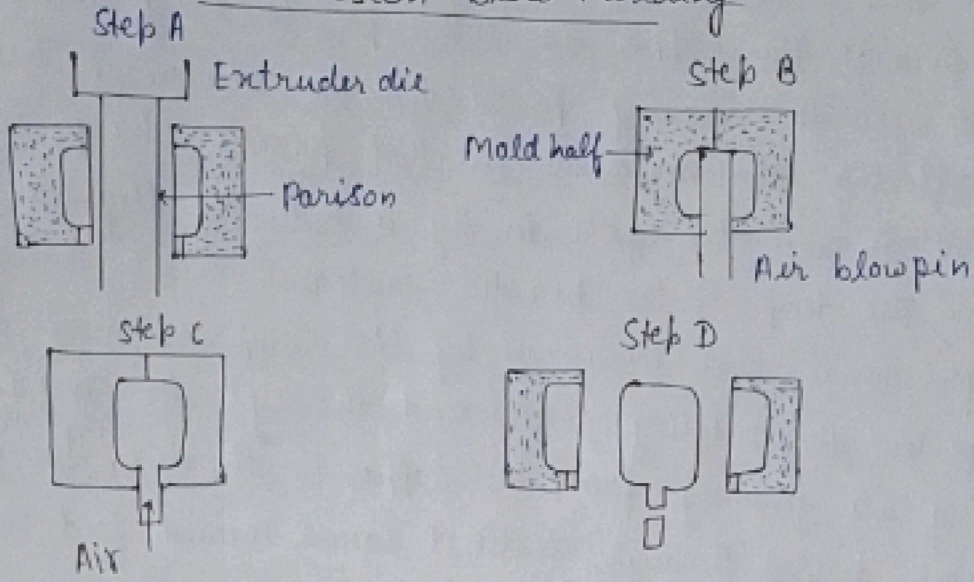
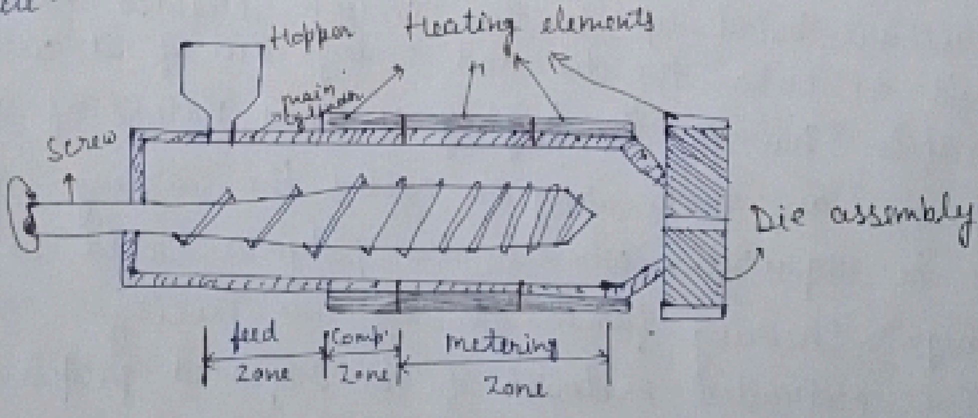
Extrusion Blow Molding



Extrusion Moulding —

Extrusion is one of the cheapest methods available for producing many common plastic products such as films, filaments, tubes, sheets, pipes, rods, hoses and straps, all in continuous lengths. The profile of a continuous extrudate is obtained by employing a suitable die. The molten plastic under suitable conditions is forced through the die orifice which imparts the desired profile to the extrudate.



Schematic diagram of a simple extrusion machine.

In this machine, the compounded plastic material is fed through the hopper as either powder or granules into a cylinder having provision for electrical heating for softening the material. The hot plastic charge is further worked through the cylinder by a helically flighted revolving screw. The temp. of the plastic material rises owing to the frictional heat produced by the compression of the charge b/w the rotating screw and the cylinder surface. During its journey from the hopper to the die, the plastic material passes through distinct zones named feed zone, compression zone and metering zone, as shown in the figure. each zone contributes in its own way to the overall extrusion process. The feed zone, for instance, receives the charge from the hopper and sends it over to the compression zone. No heating takes place in the feed zone. In the compression zone, however, the powdered charge melts due to heat conducted from the heating elements and is compressed by the working of the screw. The pasty molten plastic material is then sent to the metering section, where it acquires a constant flow rate, imparted by the helical flight of the screw. The pressure built up in this section enables the polymer melt to enter the die and emerge out of it with the desired profile. Due to the highly viscous nature of some polymer however, one more region called the working zone may also be required, wherein the polymer could be subjected to high shearing forces for effective mixing.

The extruded material of the required profile emerging from the die is quite hot (usually 125°C to 350°C) and has to be cooled rapidly to avoid deshaping. The extrudate is accordingly carried over a conveyor belt through a tub containing cold water. During this process, the material dissipates heat to the water and gets set. Cold air blast and cold water spray can also be used for cooling. The product formed is cut to the desired length or wound on to rolls.

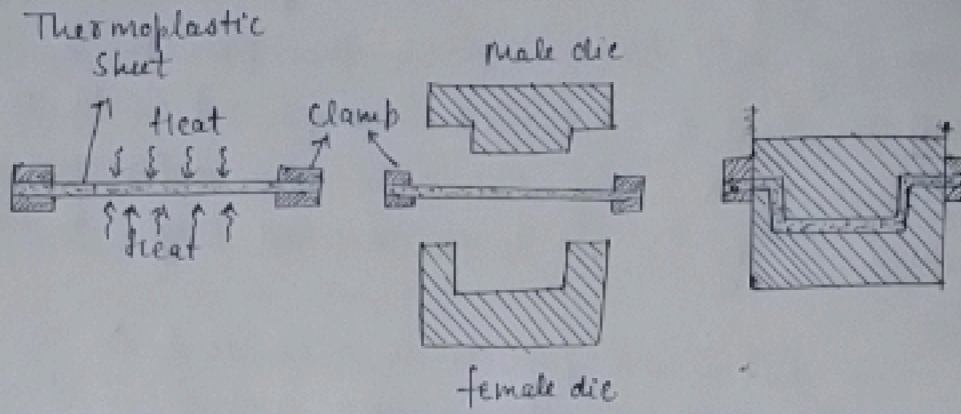
The extrusion process is also used for coating wires and cables with PVC or rubber and for coating roll-formed metal strips with suitable thermoplastics.

Thermoforming

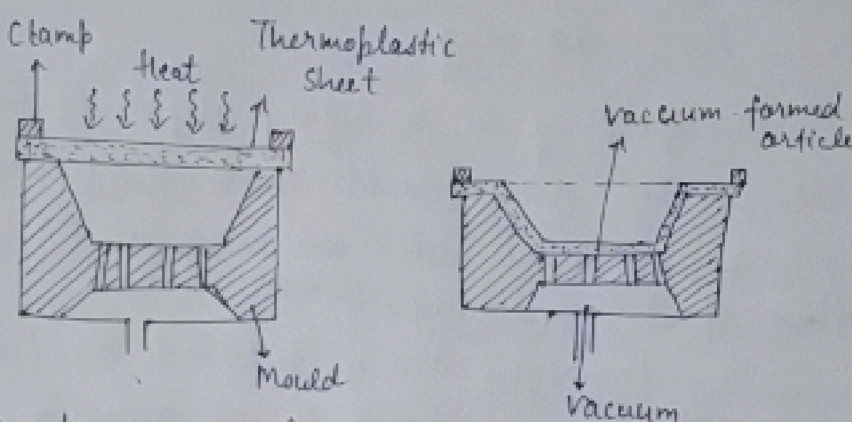
Thermoforming is a highly useful process for fabricating 3-D articles from plastic sheets. Even some large products, such as submarine hulls are made of ABS sheets by thermoforming techniques.

The technique can be outlined as follows. The thermo-plastic sheet is heated to its softening temp. The warm flexible sheet is then pressed into the female half of a matched metal die duly assisted by the male half. Now, the sheet assumes the required shape of the mould. On cooling, the shaped article becomes rigid and can be removed from the mould.

In a modified method, the hot plastic sheet is sucked into the cavity of the female mould under the influence of vacuum to give the desired shape. This method is called vacuum forming.



Schematic diagram explaining thermoforming process



Schematic diagram explaining vacaum-forming process

Foaming

Foaming is an ingenious process for producing expanded or spongy materials. special prop^s of this class of materials with cushioning ability, light weight and low thermal conductivity make them eminently suitable for several appli^s. The usual foamable polymers are polyurethanes, polystyrene, polyethylene, polypropylene silicones, epoxy, PVC and the like. The foam structure consists either of discrete unit cells or of interconnecting cells. The discrete unit cells are closed cells and may enclose gases while the interconnecting cells are of the open type. The open type and closed type cell structures are schematically.

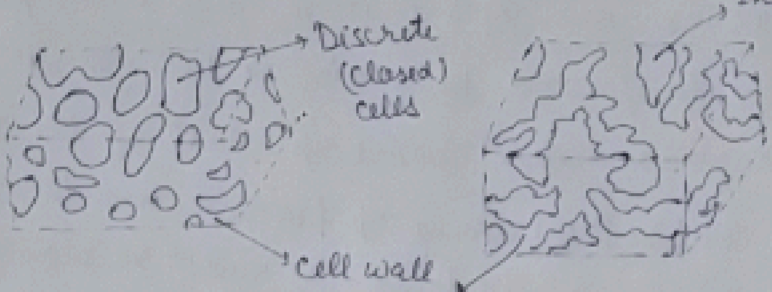
There are different methods for producing foamed or cellular plastics. One method is to melt a compounded thermoplastic material and blow air or nitrogen in such a way that the whole matrix foams up. Add^n of the surface active agents helps the foaming up process. When the required degree of foaming is achieved in the midst or blowing air or nitrogen the matrix is cooled to the ambient temp. In this process, the material is allowed to solidify in the foamed-up condition.

Thermosetting liq. prepolymers can be blown up cold and then heated to complete the cure in the foamed up condition. usually, however, foaming is achieved by the add^n of a foaming agent or blowing agent. Such agents are solvents with a low boiling point or certain chemical compounds.

Solvents such as n-pentane or n-hexane, under normal cure temp. of polymeric materials, boil off and liberate large volumes of vapours. Certain chemicals, on the other hand, can be thermally decomposed to generate inert gases. Azobis isobutyronitrile can decompose thermally and liberate large volumes of nitrogen. Carbon dioxide gas, produced as an in situ blowing agent by the rxn b/w the isocyanate and water can also be used for producing foams, for instance, polyurethane foams –

$$R-N=C=O + H-O-H \longrightarrow R-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-OH \longrightarrow CO_2\uparrow + R-NH_2$$

Polyurethane is produced by a polyol reacting with a diisocyanate, and we have to only add some additional isocyanate and water to get the foam.



Reinforcing

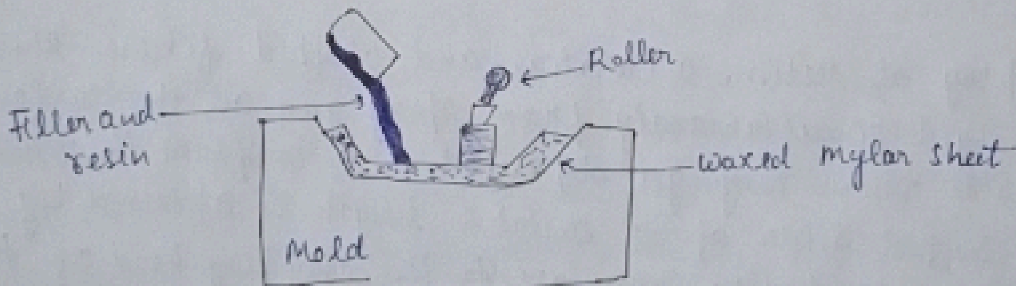
Reinforcing is plastic matrix with a strength fibre material results in the formation of are called fibre reinforced materials. It having high strength weight ratio and excellent corrosion resistance and are easy to fabricate. Reinforced plastics are produced by suitably bonding a fibre material with a resin matrix and curing the same under pressure and heat. The reinfo-rcement 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 polyamides.

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. 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 on elevatd temp.
- 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 the 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.

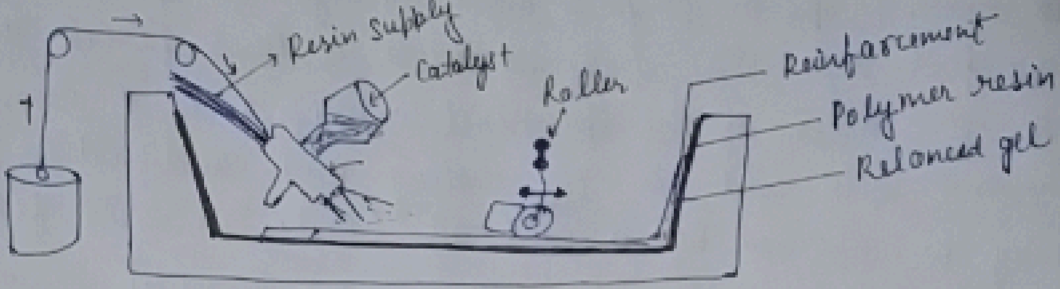
- A spray of resin, a curative and chopped fibers are discharged simultaneously from spray gun on the surface of a mold where they get deposited to a uniform thickness.
- The chopped fiber of a suitable length is obtained by continuously feeding rovings to the chopping head of the apparatus.
- Once the 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 ~~mol~~ molds.
- Many present-day reinforced plastic articles such as truck bodies, storage vessels, lorry cabs and boat hulls are produced by the Spray-up technique.

The molten polymer the enters a constant rate pump which in turn, pumps the polymer melt through the spinneret at a specified rate. The polymer melt is thus forced through the fine holes of the spinneret solidifies as it comes in contact with cold air. The cooling and solidification process may be enhanced by a cold air blast. The solid filaments emerging from the spinneret are subsequently wound upon spindles.

One important point to remember in the melt-spinning process is that the diameter of the filament depends as much on the rate at which the molten polymer streams through the holes as on the rate at which the filament is pulled and wound up as on the hole diameter.

<u>Dry Spinning</u> —

Many common polymers such as polyacrylo-nitrile or polyvinyl chloride are converted to fibres on a large scale by using the dry spinning process. The polymer is dissolved in an appropriate solvent to get a sol^n of high $conc^n$. The viscosity is controlled by increasing the temp. of the solution. The hot viscous sol^n is pumped through the spinneret when fine continuous jets of the sol^n come out of the orifices. The filament is formed from these jets by the simply evaporation of the solvent. Solvent evaporation can be enhanced by passing dry nitrogen in a counter-current manner. Filaments formed from the polymer sol^n ultimately reach the spindle where they are wound. The rate at which the fibres are spun could be as high as 1000 m/min. Manufacture of cellulose acetate fibres from a 35% sol^n of the polymer in acetone at 40°C



Fiber spinning —

Fibres are made from polymers by a process called spinning. There are three principal spinning methods viz. melt spinning, dry spinning and wet spinning. In the melt spinning process, the polymer is used in the molten state, while, in the other two cases, the polymer is used as a solⁿ in an appropriate solvent. In all the three cases, however, the polymer is streamed through a spinneret which is a special kind of plate with extremely fine holes for the fibres to emerge.

Melt - spinning —

In its simplest form the melt - spinning process may be described as follows. polymer chips are electrically heated and melted in a heating grid. This converts the solid polymer into a viscous mobile liquid. Sometimes, during this heating ~~grid~~ process, cross- linking or thermal degradation of the polymer may occur leading to formation of lumps. These lumps can be easily removed from the hot molten polymer by using a filter pack. Furthermore, the hot molten polymer should be protected from the surrounding oxygen to avoid oxidative degradation. This is effected mostly by creating an inert environment around the molten polymer with N, CO_2 or steam.

could be cited as a typical example of the utility of the dry spinning process.

<u>wet spinning</u> —

wet spinning, like dry spinning, employs a fairly concentrated polymer sol^n. The rise in polymer sol^n viscosity is controlled by spinning the sol^n at an elevated temp. The wet spinning also converts a viscous polymer sol^n into fine jets through a spinneret. These jets, however, are led into a coagulation bath containing a large volume of a non-solvent which can precipitate the polymer from its sol^n. when continuous jets of the polymer sol^n come in contact with a non-solvent, they precipitate in the form of fine filaments. The filaments formed are gathered on a spindle after undergoing washing, drying etc. One important point to be borne in mind while carrying out wet spinning is that sometimes droplets are formed instead of continuous filaments. this happens as a result of the breaking of continuity in the jet as it emerges from the spinneret hole and is caused by the forces of interfacial tension acting on the newly formed jet. This could be avoided by $\uparrow$ing the viscosity of the polymer sol^n.

Coagulation, an essential step in wet spinning, is a rather slow process. Hence, compared to the other two processes, the rate of wet spining may be as low as 50 m/min. The wet spinning process is employed commercially to make fibres from cellulose, viscose rayon, polyacrylonitrile etc.