POLYMER PROCESSING

MODULE - V

COMPRESSION MOLDING

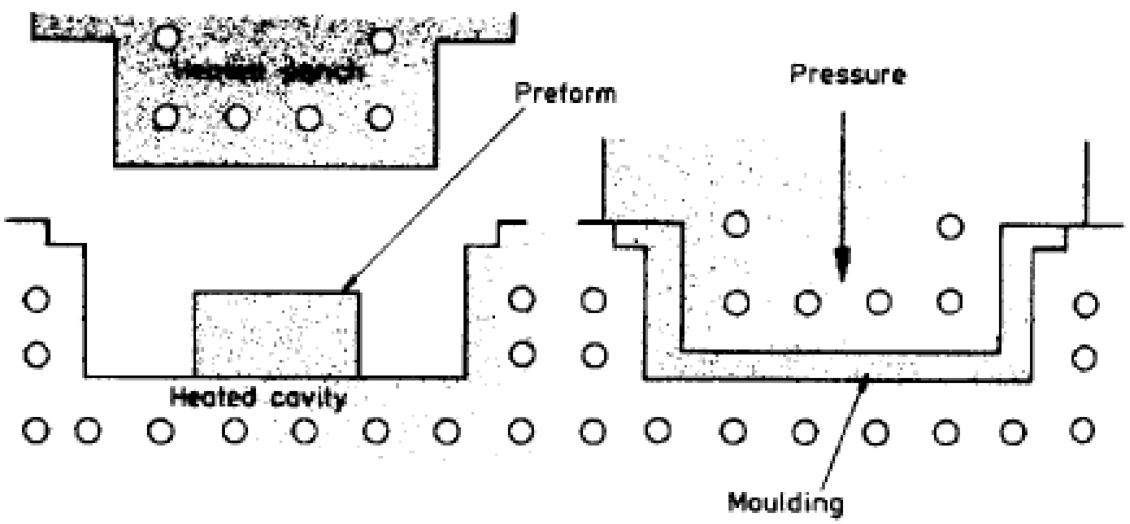
COMPRESSION MOLDING

•It is one of the oldest processing techniques, usually used for thermoset plastics but can also be used for thermoplastics.

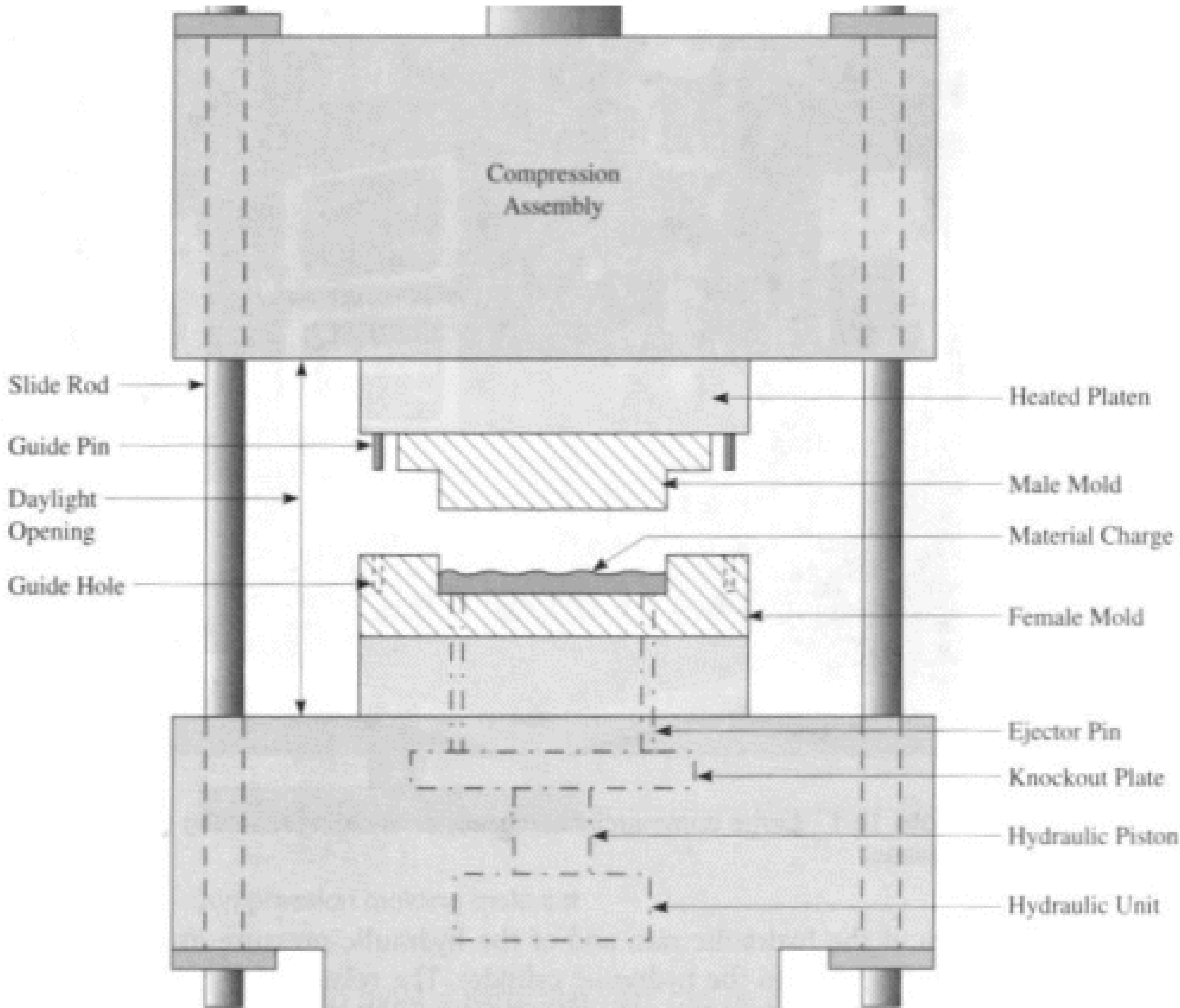
•The material is in the form of powders, liquids, or granules of Pre-heated pre-weighed charge is placed in the lower half (Cavity) of a heated mold and the upper half (Core) is then forced down, causing the material to flow and completely fill the cavity.

•The application of heat and pressure accelerates the polymerisation of the thermoset and once the cross-linking (curing) is completed, the article is solid and may be ejected while still very hot.

•Mold temperatures are usually in the range of 130-200°C. Cycle times may be long, hence it is desirable to have multi-cavity molds to increase production rates.



COMPRESSION MOLDING



COMPRESSION MOLDING

•The presses involve either upstream of the bottom plate or down-stroke of the top plate.

•Heating can be in Electric resistance heating, steam or hot oil circulation.

•Materials include Allyls, Aminos, Epoxies, Phenolics, Polyesters, Silicones, uretanes and elastomers.

•The material is preheated to reduce the temperature difference between it and mold.

•Applications are Electric plugs, sockets and housings, pot handles, etc.,

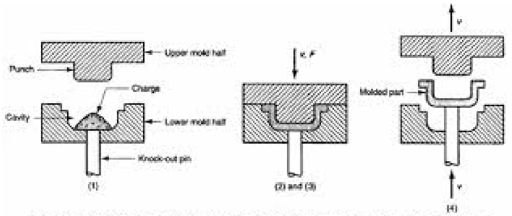
•PROCESS CYCLE: Loading a precise amount of molding compound called the charge into the bottom half of a heated mold.

•Bringing the mold halves together to compress the charge, forcing it to flow & conform to the shape of the cavity.

•Heating the charge by means of hot mold to polymerize and cure the material into a solidified part. Opening the mold halves and removing the part from cavity.

•Time required to harden the thermosetting mtls is cure time.

•After initial application of pressure the usual practise is to open the mold slightly to release the gases is called breathing time.



Compression molding for thermoplastics: (1) charge is loaded, (2) and (3) charge is compressed and cured, and (4) opening the mold halves and removing the part from the cavity.

COMPRESSION MOLDING

•Advantages are Simpler molds, Less expensive, Less Scrap, Low maintenance, Low stresses in the molded parts, High impact strength and low mold shrinkage.

•Disadvantages are longer cycle time, Lower production time and difficult to create intricate parts.

•Common types of compression mold designs are Open Flash, Semi-positive and Fully Positive.

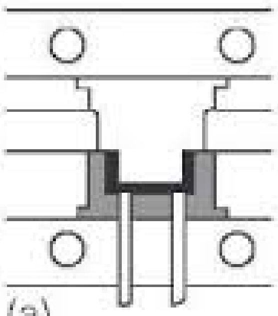
•OPEN FLASH: Slight excess of molding powder is loaded into the mold cavity.

•On closing, the excess material is forced out and flash is formed.

•The flash blocks the plastic remaining in the cavity and causes the mold plunger to exert pressure on it.

•Advantages are cheap and very slight labor costs are necessary in weighing out the powder.

•Disadvantages are excess material loading is needed, wastage of material.



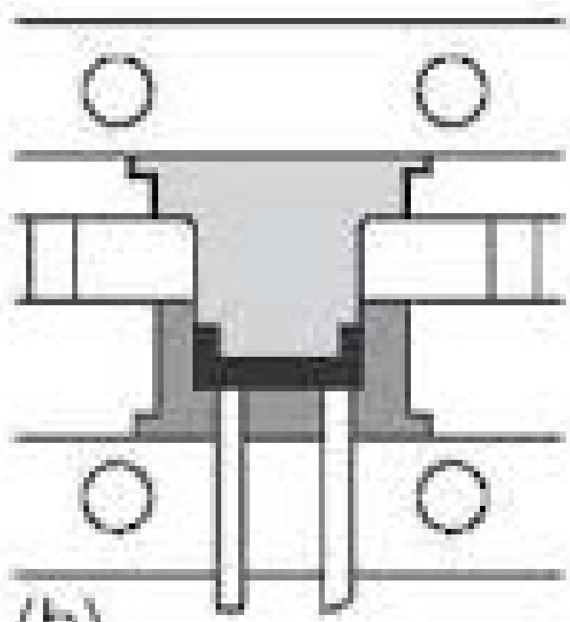
(a)

COMPRESSION MOLDING

•FULLY POSITIVE: No allowance is made for placing excess powder in cavity.

•If excess powder is loaded, the mold will not close. If less powder is loaded, results in reduced thickness.

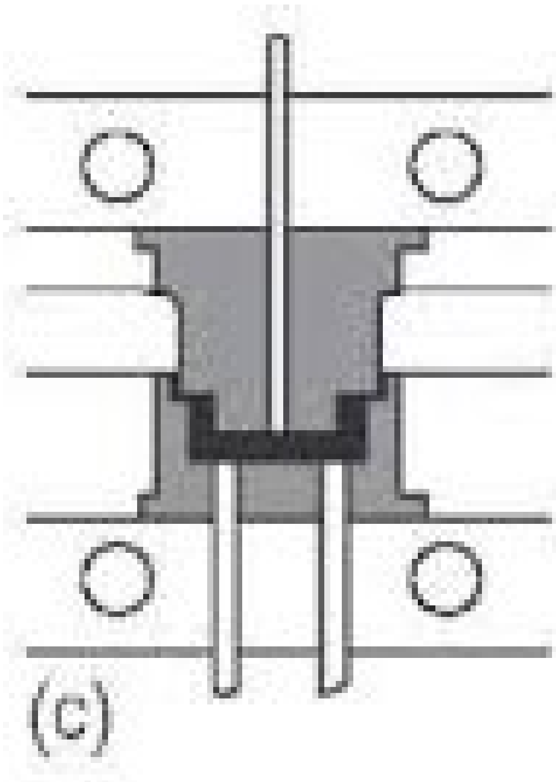
•Disadvantages are gases liberated during curing reaction are trapped inside and show as blisters on molded surface. Excessive wear on the sliding fit surface.



(b)

COMPRESSION MOLDING

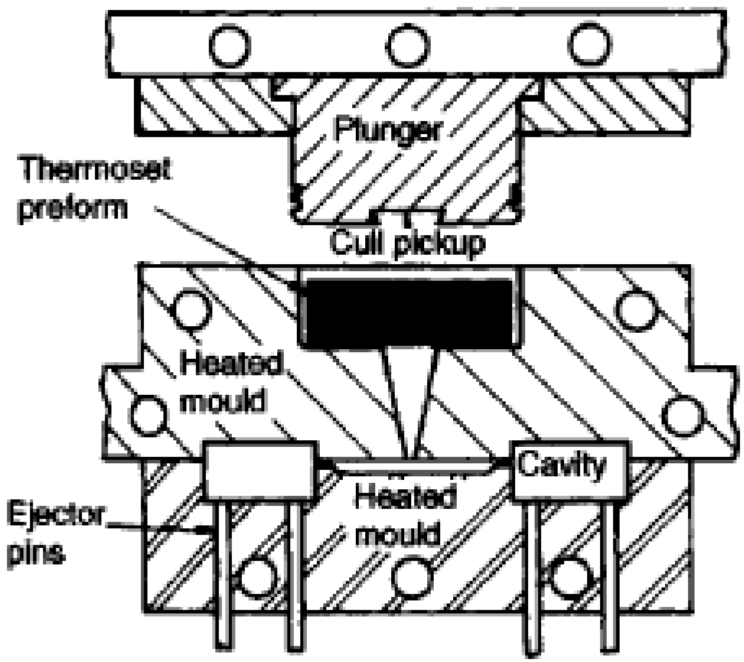
- SEMI POSITIVE: It combines both open flash and fully positive type.
- It means allowance for excess powder and flash.
- Also possible to get horizontal and vertical flash.
- Mold also given 2-3.8 deg taper on each side, this allows the flash to flow and the entrapped gases to escape.
- Disadvantages are more expensive, and maintenance than other molds.



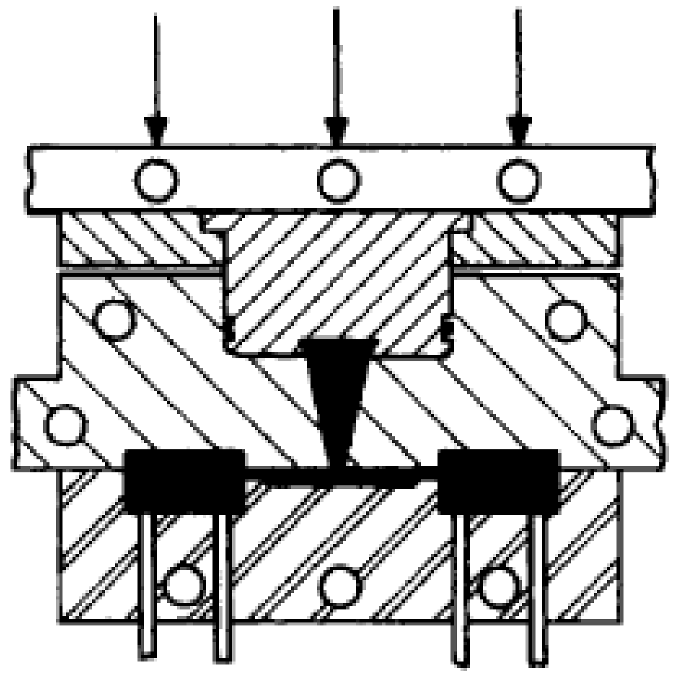
TRANSFER MOLDING

•It is similar to compression molding, except the molding material being pressurized in the cavity, it is pressurized in a separate chamber and then forced through an opening into a closed mold.

•The main advantage of this process are that the preheating of the material and injection through a narrow orifice improves the temperature distribution in the material as a result cycle times are reduced.



(a) Preform in position



(b) Material forced into cavities

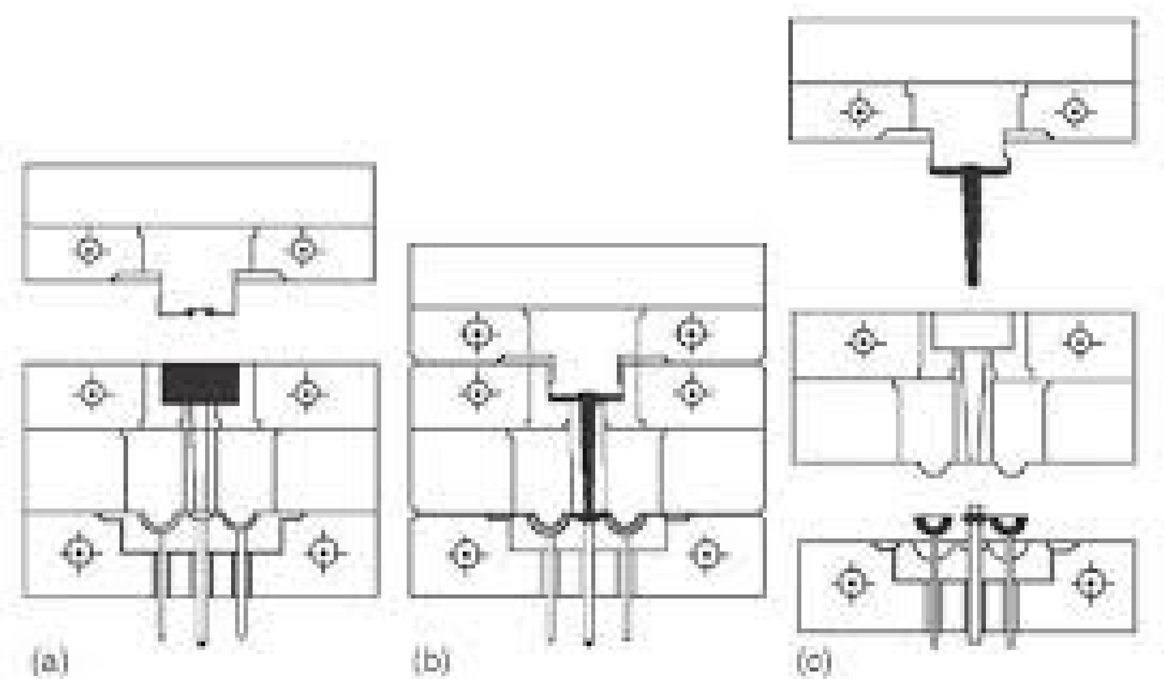
TRANSFER MOLDING

•Two types of Transfer molding: POT transfer molding and PLUNGER transfer molding.

•POT: In this type, the mold design provides a pot, into which the compound is placed and the press closed.

•The clamping pressure exerted by the press also serves to force the compound from the pot into a runner system and then into a cavity.

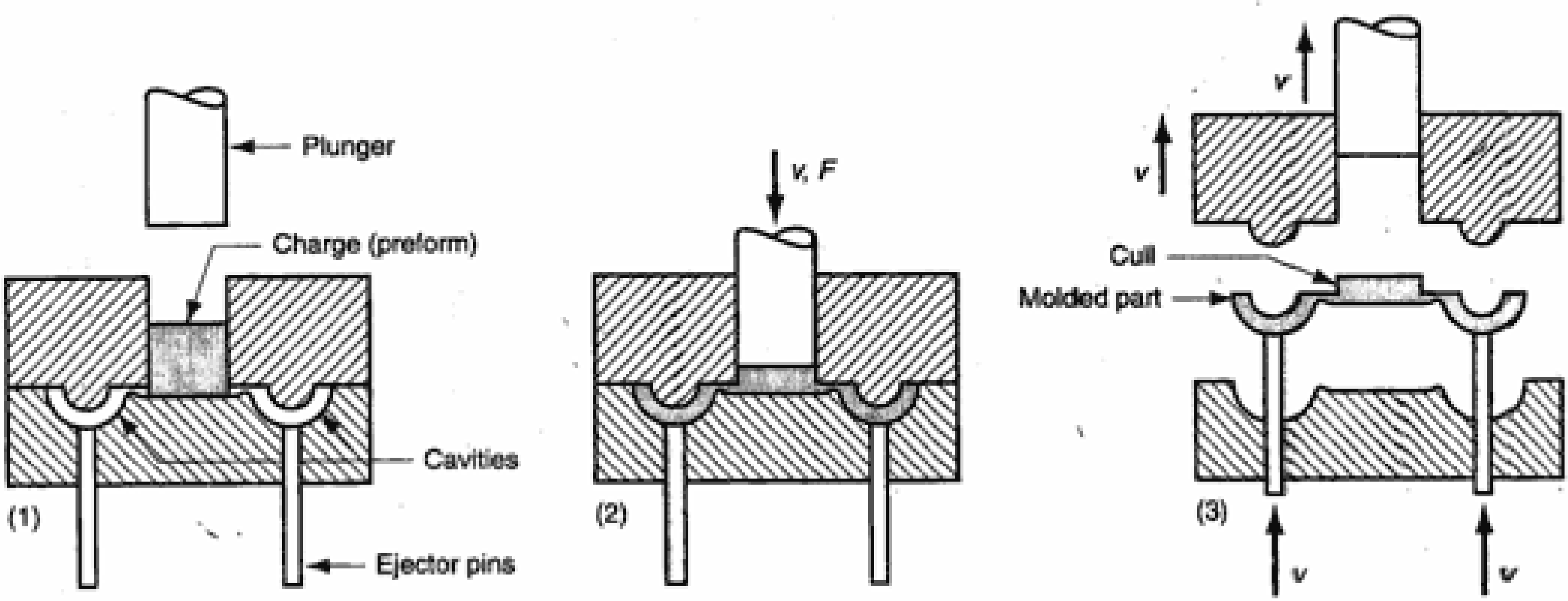
•The bottom of the plunger is undercut to serve as means of pulling the cull from the pot as the press opens.



TRANSFER MOLDING

•PLUNGER: In which the charge is injected by means of a plunger from a heated well and lateral channels called the cull to the cavity.

•Advantages are greater hole depth/length ratio, Faster cycle time, minimum compound waste.



TRANSFER MOLDING

- FEED SYSTEM: It consists of sprue, runner and gate. Similar to Injection mold.
- EJECTION: Ejection of molded plastic can be achieved by using ejector pins, stripper plate similar to injection mold.
- CULL PICK UP: Similar to injection mold of sprue puller.

- ADVANTAGES are provides more product consistency than compression molding, Cycle times are shorter than compression molding, Useful for more intricate products
- DISADVANTAGES are transfer pad is scrap.

TRANSFER MOLDING

•PROCESSING PARAMETERS:

•MOLD TEMP: Higher temp. may degrade some of the physical properties as well as it will cause blisters and burn spots on the finished articles.

•Temp which are too low do not allow the mtl to flow propertly and results in incompleted cured product.

•So, maintain optimum temp which produces the best flow characteristics.

•PRESSURE: Molding with thermosetting plastics requires pressure for two reasons: To ensure that the plastic fills all of the cavity and has relatively uniform density throughout and Ensure better heat transfer to the material.

•CURE TIME: If cure time is less, parts will not be hard enough, hence shrinkage. If cure time is more, longer cycle time. To achieve minimum cure time, the material have to be pre heated.

•QUANTITY OF RESIN INTO THE MOLD: Excess quantity leads to material wastage, less quantity gives incomplete products.

TRANSFER MOLDING

- PROPERTIES OF MATERIALS RELATED TO MOLDING:
- PLASTICITY: The plasticity of a material is its softness or stiffness as it flows in the cavity. Softer materials requires less pressure to mold. Proper plasticity material to produce high quality parts with a minimum of pressure.
- PRESSURE REQUIREMENT: Minimum molding pressure are desirable to hold mold maintenance to a minimum. Excessive pressure could cause mold damage.
- SHRINKAGE: Parts must be of proper density to assure consistent shrinkage value. Excessive pressure may cause over-densification and the parts will expand when removed from the mold.
- CURE VALUE: It measures how fast the material is formed.

TRANSFER MOLDING

- FACTORS AFFECTING PRODUCT QUALITY:
- PREFORM WEIGHT: Preform must be of weight adequate to provide for complete cavity filling.
- PREFORM DENSITY: It must be dense & free of trapped air.
- Consistency of pressure in all cavities.

- TROUBLESHOOTING:
- Air entrapment: Cavity will not fill properly ---- Sufficient vents.
- Blisters ----- air trapped inside the mold.
- Long cure cycles – mold temp too long.
- Short shot ----- exact amount of preform into the cavity.
- Molded in flash ---- mold close properly
- Mold sticking ---- raise mold temp, clean mold and increase cure time
- Warpage --- uniform mold temp, mold closes properly, preheat longer.

COMPRESSION MOLDING

•ANALYSIS OF COMPRESSION MOLDING:

•If the material is at a uniform temp in the mold, then the process may be analysed as follows:

•Consider a 'CAKE' of molding resin between the compression platens.

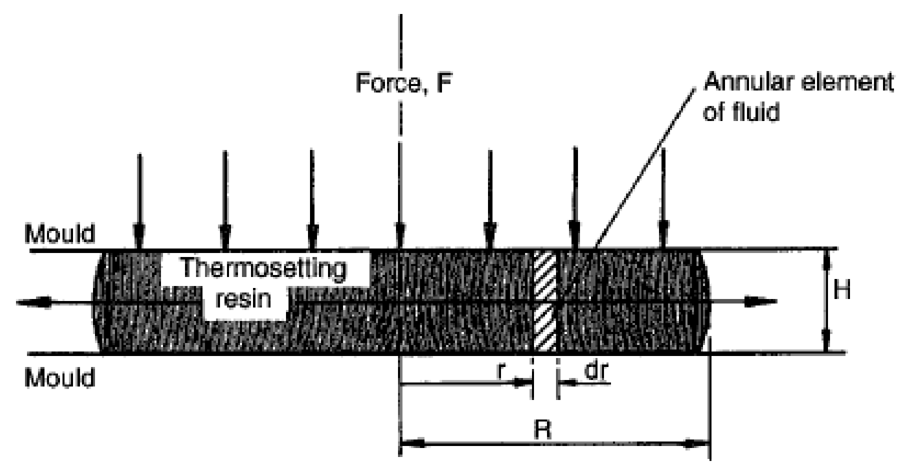
•When the constant force 'F' is applied to the upper platen, the resin starts flow as a result of pressure gradient.

•If the flow is assumed to be Newtonian then the pressure flow equation is:

$$\text{flow rate, } Q_p = \frac{1}{12\eta}\left(\frac{dP}{dz}\right) T H^3$$

•For the annular element of radius, r, it is more convenient to use cylindrical coordinates.

$$Q_p = \frac{1}{12\eta}\left(\frac{dP}{dr}\right) \cdot (2\pi r) H^3$$



COMPRESSION MOLDING

- ANALYSIS OF COMPRESSION MOLDING:
- If the top platen moves down by a distance, dH, then the volume displaced is

$$(\pi r^2 dH)$$

- And the volume flow rate is $\pi r^2 (dH/dt)$
- Therefore:

$$\pi r^2 \left(\frac{dH}{dt}\right) = \frac{1}{12\eta}\left(\frac{dP}{dr}\right) \cdot (2\pi r)H^3$$

- $$\frac{12\eta}{H^3} \cdot \frac{dH}{dt} = \frac{2}{r}\frac{dP}{dr}$$ equation 1.

COMPRESSION MOLDING

- ANALYSIS OF COMPRESSION MOLDING:
- Assume:

$$\frac{2}{r}\frac{dP}{dr} = A \text{ where } A = f(H)$$

$$\int_0^P dP = \frac{A}{2}\int_R^r r\,dr$$

$$P = \frac{A}{4}(r^2 - R^2)$$

- Now the force on the element is $2\pi r dr(P)$ so the total force is given by:

$$F = \int_0^R 2\pi r\left(\frac{A}{4}\right)(r^2 - R^2)dr = -\frac{\pi A R^4}{8}$$

COMPRESSION MOLDING

- ANALYSIS OF COMPRESSION MOLDING:
- Rearrange:

$$A = -\frac{8F}{\pi R^4} = -\frac{8\pi F H^2}{V^2} \qquad \text{where } V = \pi R^2 H$$

- Substitute A in equation 1:

$$-\frac{8\pi F H^2}{V^2} = \frac{12\eta}{H^3}\frac{dH}{dt}$$

$$-\int_0^t \frac{2\pi F}{3\eta V^2} dt = \int_{H_0}^{H} \frac{dH}{H^5}$$

$$\frac{2\pi F t}{3\eta V^2} = \frac{1}{4}\left(\frac{1}{H^4} - \frac{1}{H_0^4}\right)$$

COMPRESSION MOLDING

- ANALYSIS OF COMPRESSION MOLDING:

Since $H_0 >> H$ then $(1/H_0^4)$ may be neglected.

- The force F is given by:

$$F = \frac{3\eta V^2}{8\pi t H^4}$$

- Where H is the platen separation at time, t.

COMPRESSION MOLDING

•ANALYSIS OF COMPRESSION MOLDING:

Example 4.10 A circular plate with a diameter of 0.3 m is to be compression moulded from phenol formaldehyde. If the preform is cylindrical with a diameter of 50 mm and a depth of 36 mm estimate the platen force needed to produce the plate in 10 seconds. The viscosity of the phenol may be taken as 10^3 Ns/m^2.

Solution

Volume, $$V = \pi \left(\frac{50}{2}\right)^2 \times 36 = \pi \left(\frac{300}{2}\right)^2 H$$

So $$H = 1 \text{ mm}$$

$$F = \frac{3\eta V^2}{8\pi t H^4} = \frac{3 \times 10^3 \times (\pi \times 625 \times 36)^2}{10^6 \times 8\pi \times 10 \times (1)^4} = 59.6 \text{ kN}$$