



**Forming and shaping plastics
& composite materials**

Chapter - 18

Topics

- Introduction
- Extrusion
- Injection molding
- Structured foam molding
- Blow molding
- Rotational molding
- Thermoforming
- Compression molding
- Casting
- Process of composite materials

Extrusion

- Raw materials in the form of thermoplastic pellets, granules, or powder, placed into a hopper and fed into extruder barrel.
- The barrel is equipped with a screw that blends the pellets and conveys them down the barrel
- Heaters around the extruder's barrels heat the pellets and liquefy them

Screw has 3-sections

- Feed section
- Melt or transition section
- Pumping section.

- Complex shapes with constant cross-section
- Solid rods, channels, tubing, pipe, window frames, architectural components can be extruded due to continuous supply and flow.
- Plastic coated electrical wire, cable, and strips are also extruded

Pellets :extruded product is a small-diameter rod which is chopped into small pellets

Sheet and film extrusion :

Extruded parts are rolled on water and on the rollers

Extruder

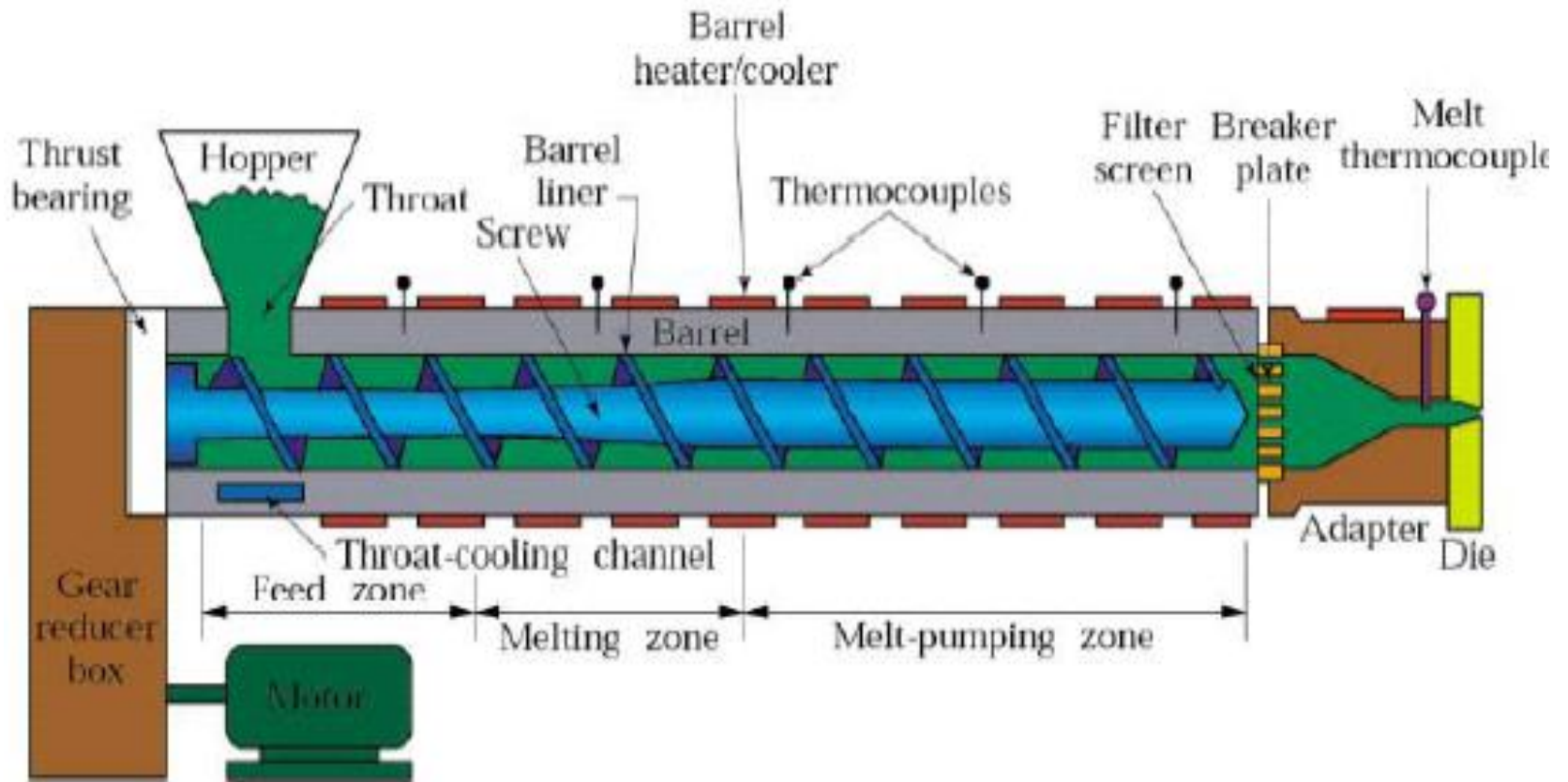


Fig : Schematic illustration of a typical extruder for plastics, elastomers, and composite materials.

Sheet and Film Extruder

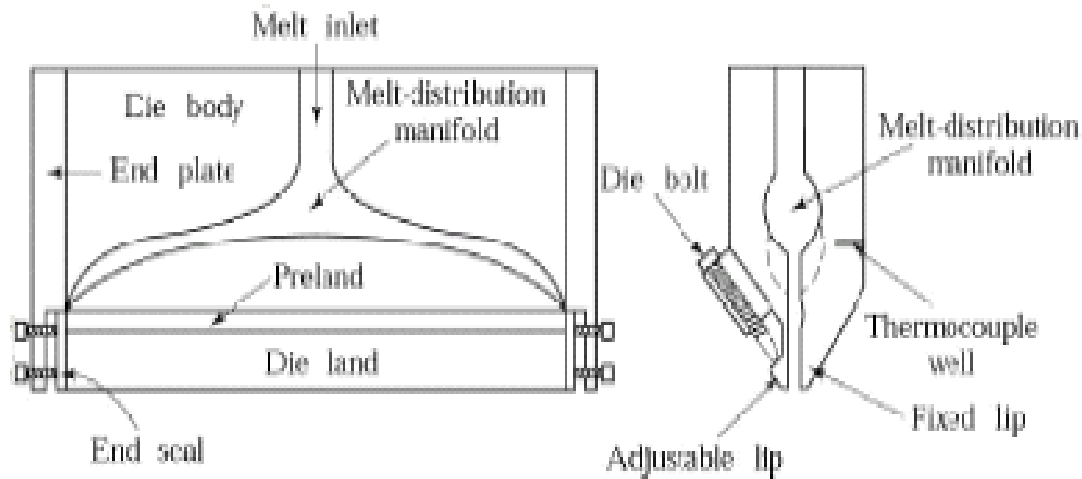


Fig : Die geometry (coat-hanger) for extruding sheet.

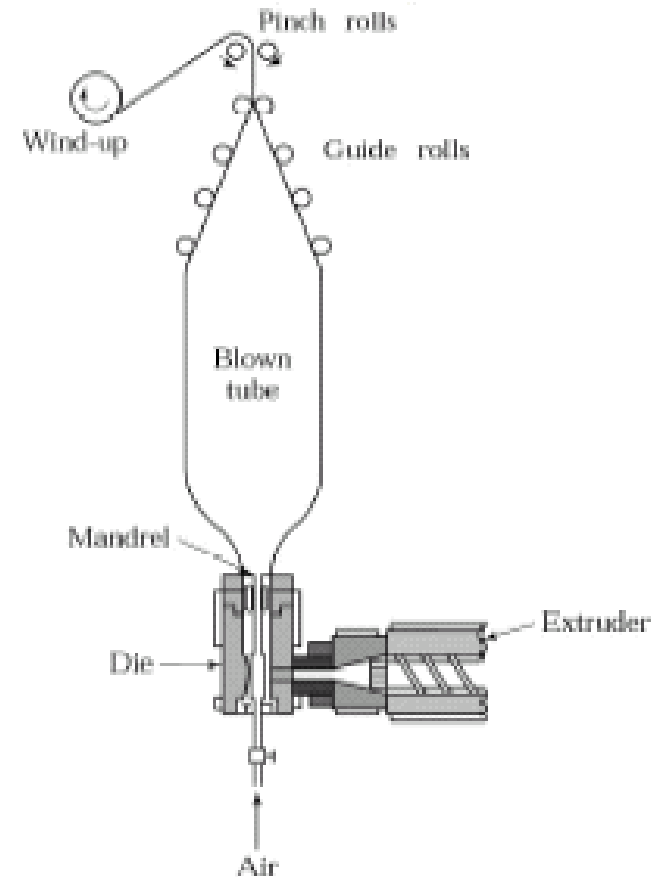


Fig : Schematic illustration of the production of thin film and plastic bags from tube first produced by an extruder and then blown by air.

Injection molding

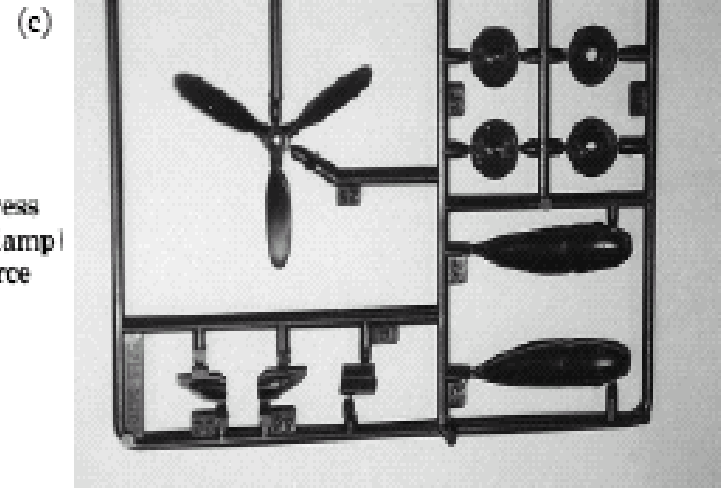
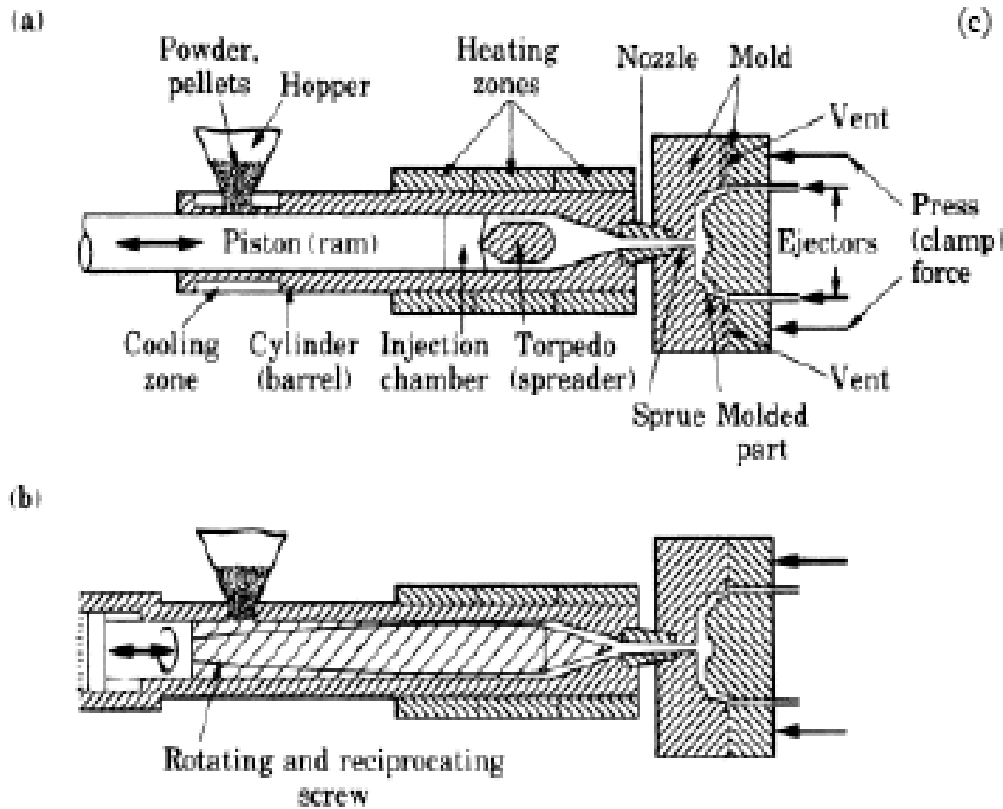


Fig : Injection molding with (a) plunger, (b) reciprocating rotating screw, (c) a typical part made from an injection molding machine cavity, showing a number of parts made from one shot, note also mold features such as sprues, runners and gates.

Injection molding

- Similar to extrusion barrel is heated
- Pellets or granules fed into heated cylinder
- Melt is forced into a split-die chamber
- Molten plastic pushed into mold cavity
- Pressure ranges from 70 Mpa – 200 Mpa
- Typical products : Cups, containers, housings, tool handles, knobs, electrical and communication components, toys etc.

Injection molding

- Injection molds have several components such as runners, cores, cavities, cooling channels, inserts, knock out pins and ejectors

3-basic types of molds

- Cold runner two plate mold
- Cold runner three plate mold
- Hot runner mold

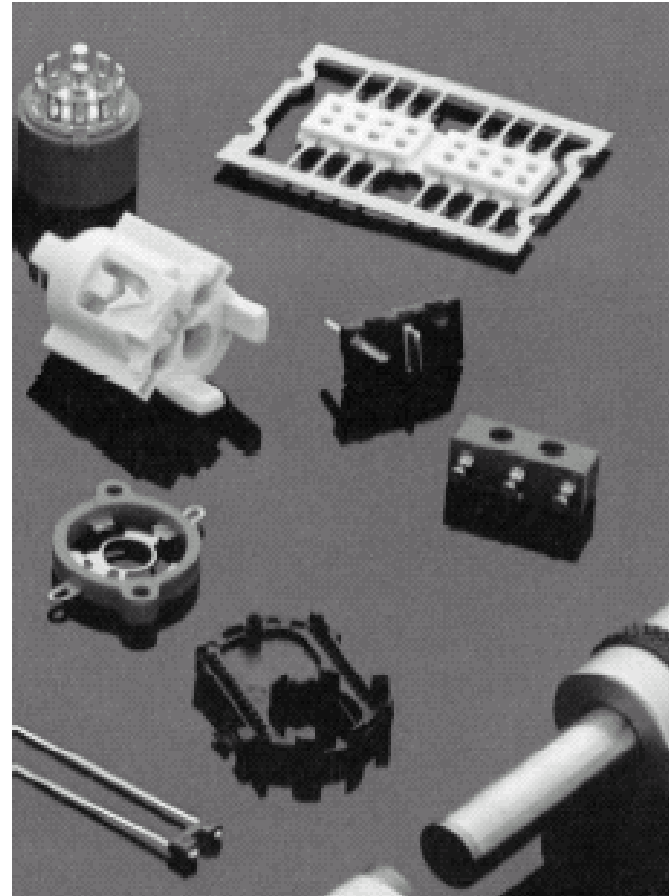


Fig : Examples of injection molding

Injection Molding Machine

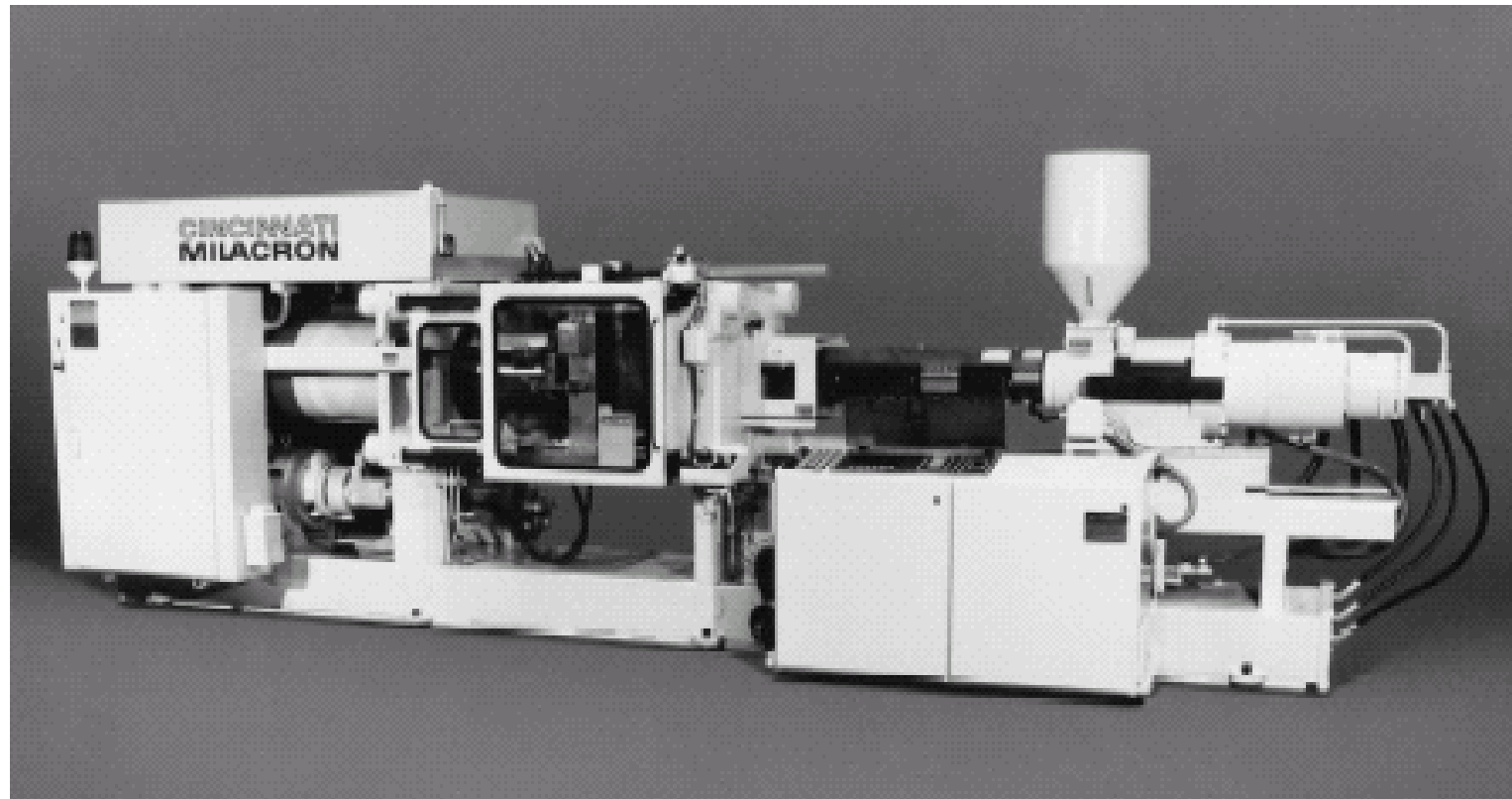


Fig : A 2.2-MN (250-ton) injection molding machine. The tonnage is the force applied to keep the dies closed during injection of molten plastic into the mold cavities.

Process capabilities :

- High production rates
- Good dimensional control
- Cycle time range 5 to 60 sec's
- Mold materials- tool steels, beryllium - Cu, Al
- Mold life- 2 million cycles (steel molds)
10000 cycles (Al molds)

Machines :

- Horizontal or vertical machines
- Clamping – hydraulic or electric

Reaction Injection molding :

- Mixture of resin with 2 or more reactive fluids forced into the mold cavity at high speed .
- Applications : Bumpers, tenders, thermal insulation, refrigerators and freezers, water skis, stiffness

Reaction-Injection Molding

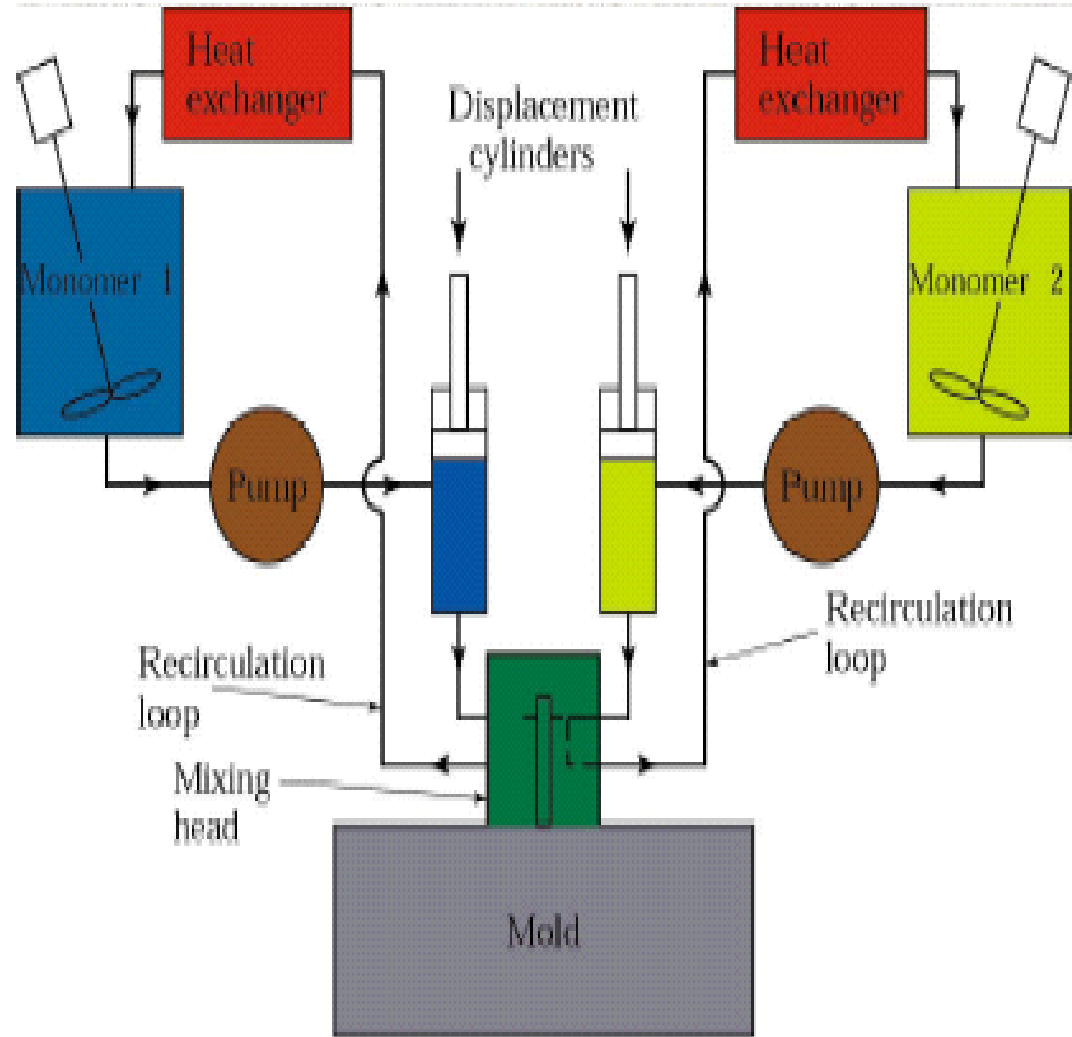


Fig : Schematic illustration of the reaction-injection molding process.

Blow molding

- Modified extrusion and Injection Molding process.
- A tube extruded then clamped to mold with cavity larger than tube diameter.
- Finally blown outward to fill the cavity
- Pressure 350Kpa-700Kpa

Other Blow Molding processes

- Injection Blow molding
- Multi layer Blow molding

Blow molding

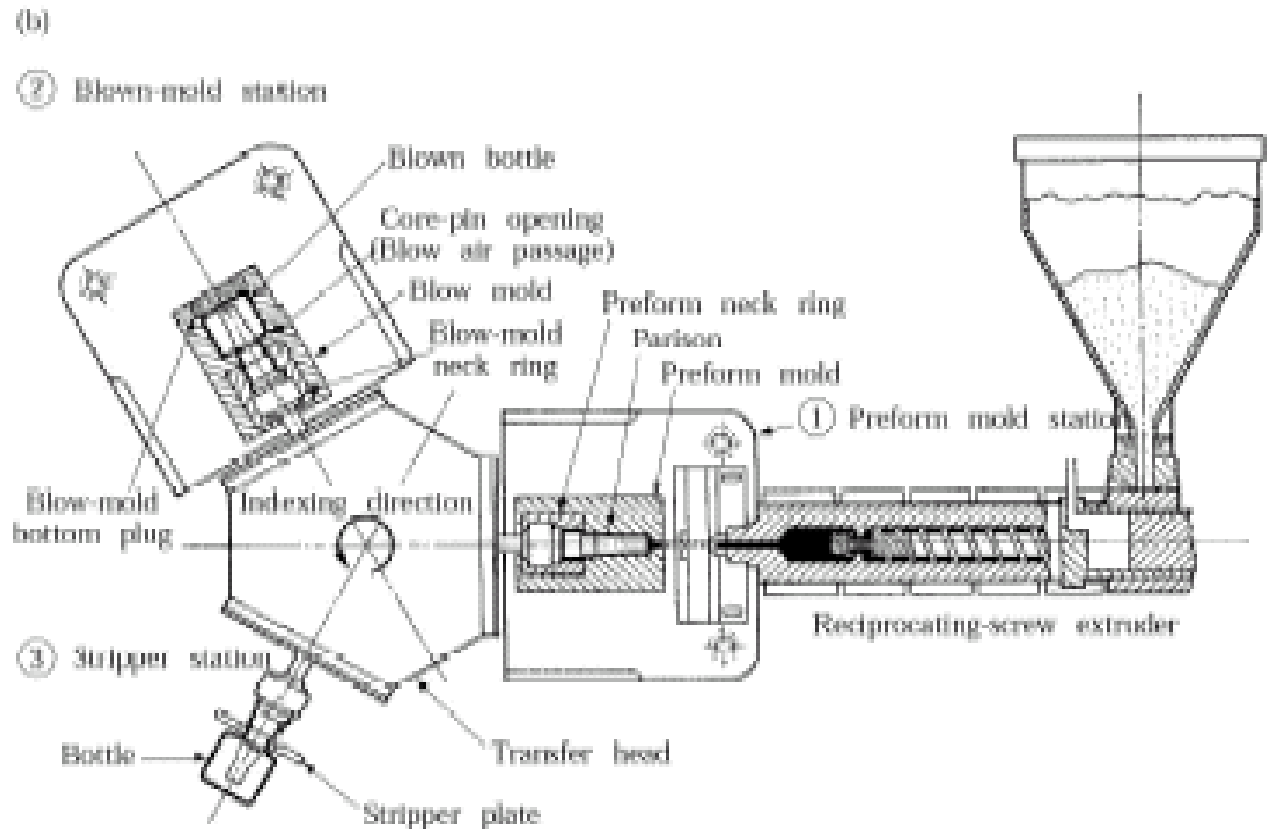
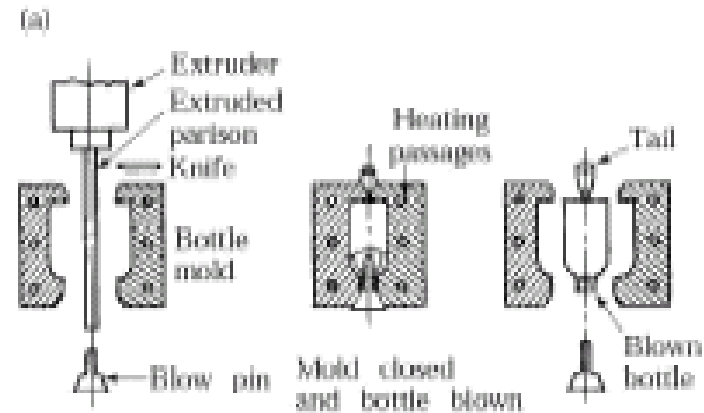


Fig : Schematic illustration of (a) the blow-molding process for making plastic beverage bottles, and (b) a three-station injection blow-molding machine.

Rotational Molding

- Thermo plastics are thermosets can be formed into large parts by rotational molding
- A thin walled metal mold is made of 2 pieces
- Rotated about two perpendicular axes
- Pre-measured quantity of powdered plastic material is rotated about 2-axes
- Typical parts produced-Trash cans, boat hulls, buckets, housings, toys, carrying cases and foot balls.

Rotational Molding

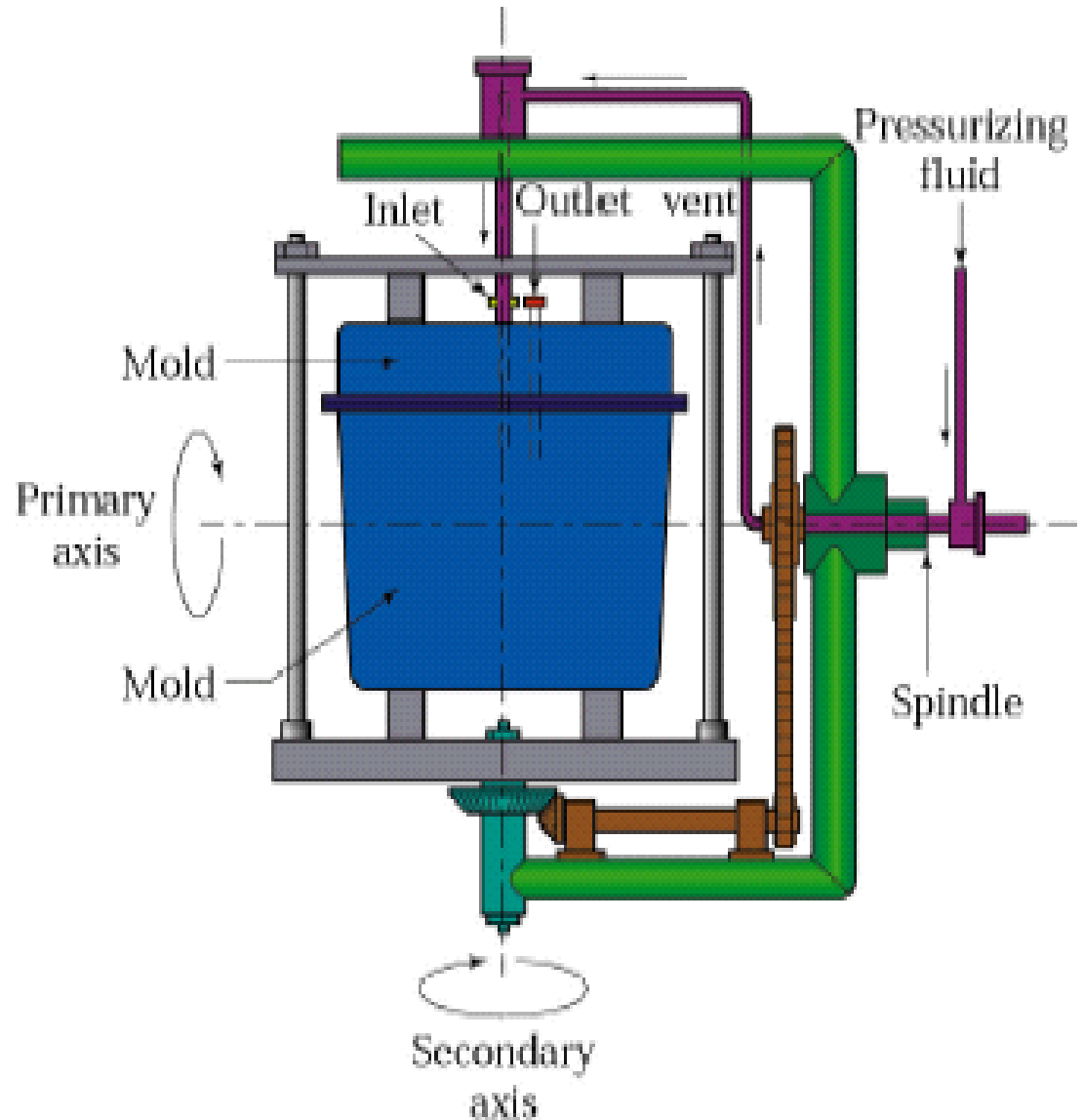


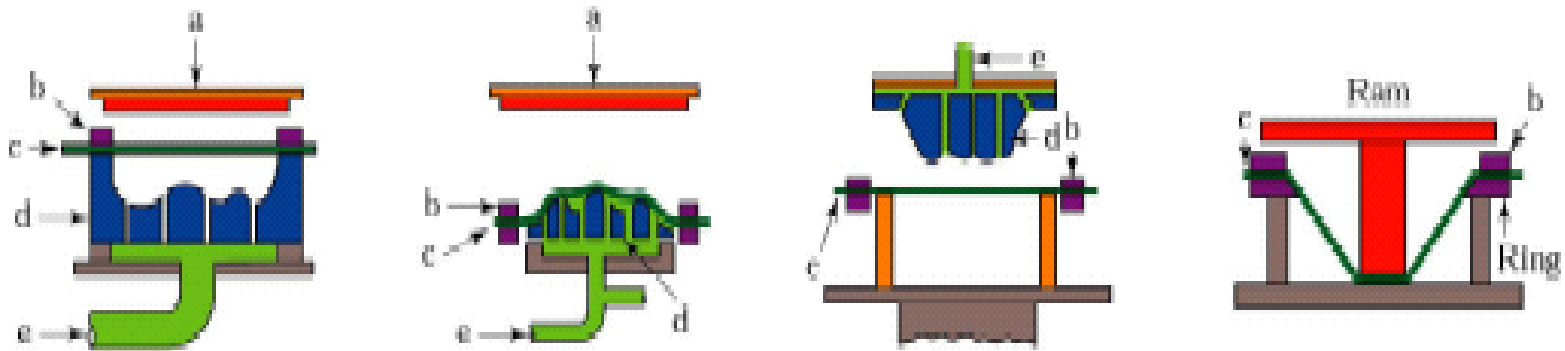
Fig: The rotational molding (rotomolding or rotocasting) process. Trash cans, buckets, and plastic footballs can be made by this process.

Slush-molding

- Plastisols are used in slush molding
- Plastic materials are forced against the inside walls of the heated mold by tumbling action.
- The part is cooled while it is still rotating and then removed by opening the mold

Thermoforming

- Series process for forming thermoplastic sheet or film over a mold by applying heat and pressure.
- Typical parts : advertising signs, refrigerator liner, packaging , appliance housing, and panels for shower stalls .



1. Straight vacuum forming

2. Drape vacuum forming

3. Force above sheet

4. Plug and ring forming

- | | |
|------------------|----------------|
| a. Heater | d. Mold |
| b. Clamp | e. Vacuum line |
| c. Plastic sheet | |

Fig : Various Thermoforming processes for thermoplastic sheet. These processes are commonly used in making advertising signs, cookie and candy trays, panels for shower stalls, and packaging.

Compression molding

- Pre-shaped charge ,pre-measured volume of powder and viscous mixture of liquid resin and filler material is placed directly into a heated mold cavity.
- Compression mold results in a flash formation which is a n excess material.
- Typical parts made are dishes, handles, container caps fittings, electrical and electronic components and housings
- Materials used in compression molding are thermosetting plastics & elastomers
- Curing times range from 0.5 to 5 mins

3- types of compression molds are

- Flash type
- Positive type
- Semi-positive

Compression Molding

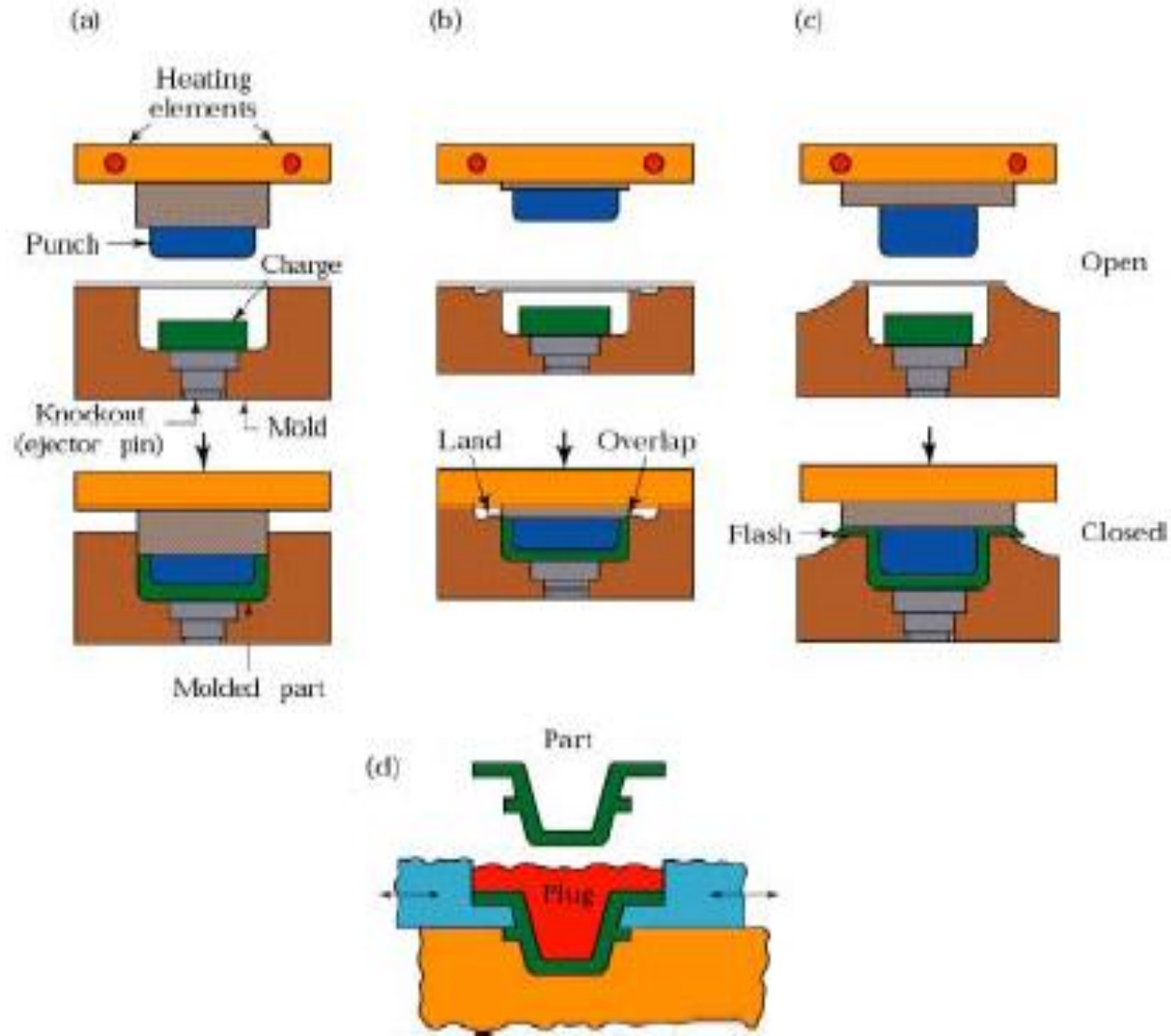


Fig : Types of compression molding, a process similar to forging; (a) positive, (b) semi positive, (c) flash (d) Die design for making compression-molded part with undercuts.

Transfer molding

- Transfer molding is an improvement of compression molding
- Uncured thermosetting material placed in a heated transfer pot or chamber, which is injected into heated closed molds
- Ram plunger or rotating screw feeder forces material into mold cavity through narrow channels
- This flow generates heat and resin is molten as it enters the mold

Typical parts : Electrical & electronic components,
rubber and silicone parts

Transfer molding

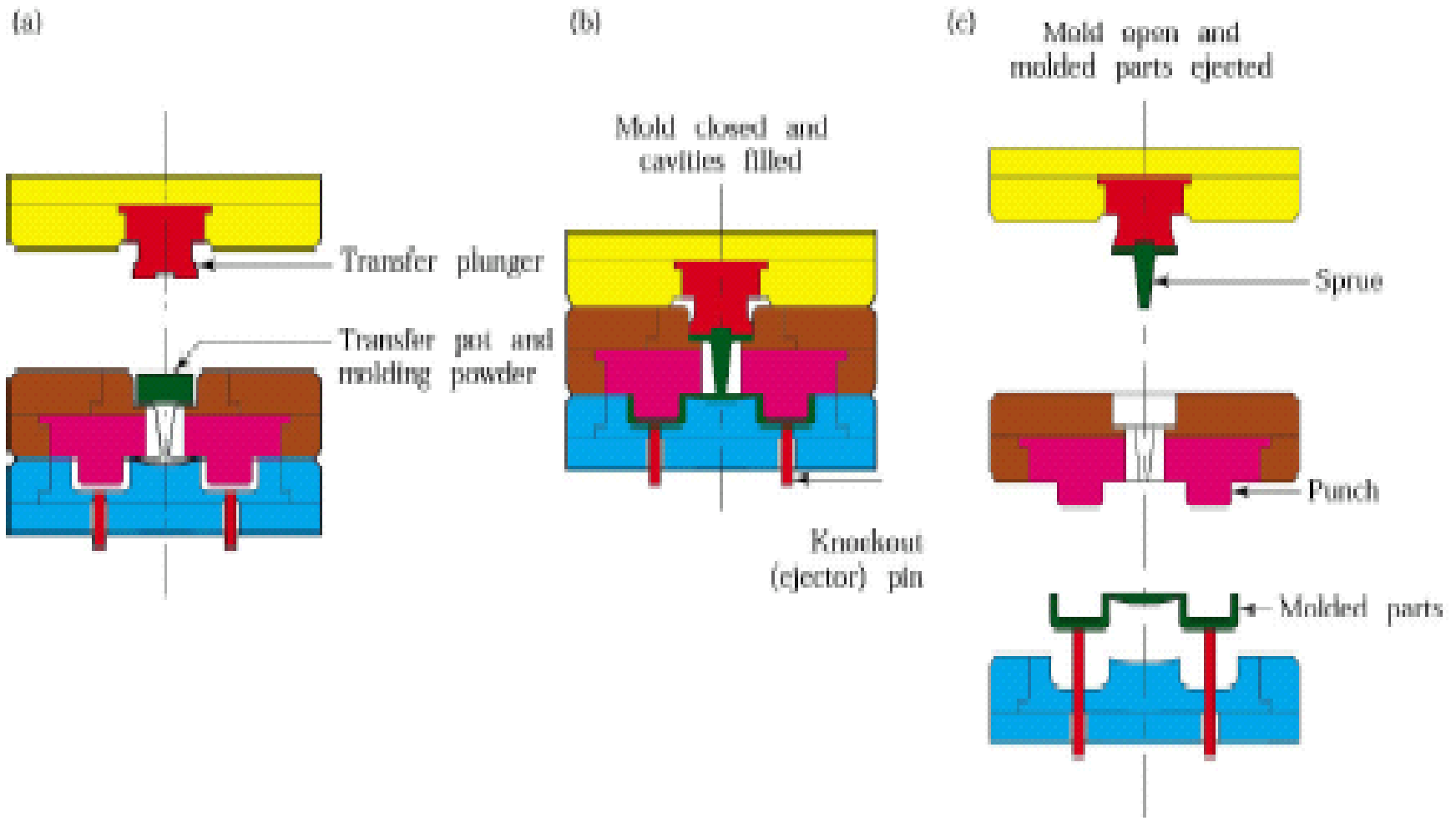


Fig : Sequence of operations in transfer molding for thermosetting plastics. This process is particularly suitable for intricate parts with varying wall thickness.

Casting

Conventional casting of thermo plastics :

- Mixture of monomer, catalyst and various additives are heated and poured into the mould
- The desired part is formed after polymerization takes place.

Centrifugal casting :

- Centrifugal force used to stack the material onto the mold
- Reinforced plastics with short fibers are used

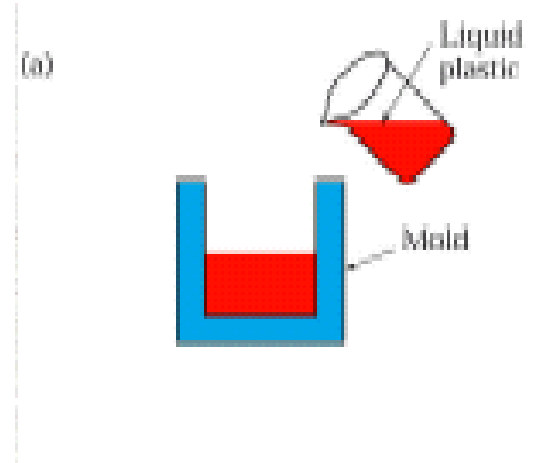


Fig : Casting

Potting & Encapsulation

- Casting the plastic around an electrical component to embed it in the plastic is potting
- In both the plastic is Dielectric

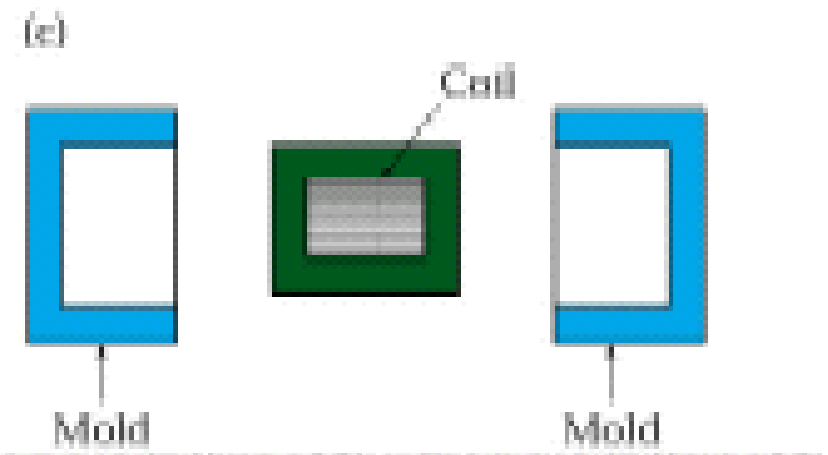
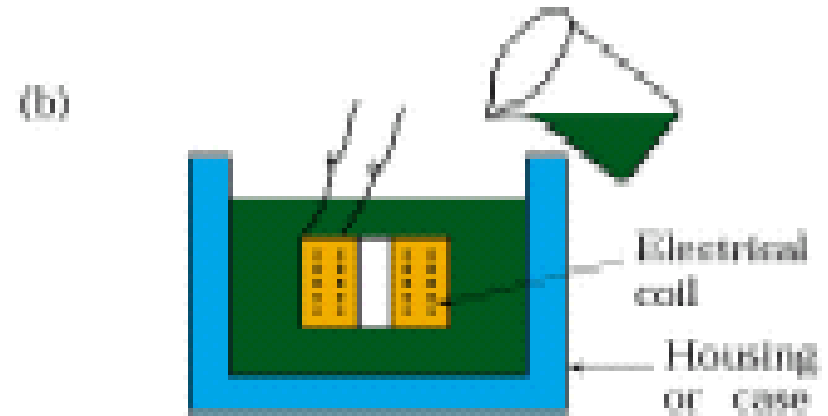


Fig : Potting & Encapsulation

Cold forming

- Processes such as rolling ,deep drawing extrusion closed die forging ,coining and rubber forming can be used for thermoplastics at room temperatures
- Typical materials used : Poly propylene, poly carbonate, Abs, and rigid PVC

Considerations :

- Sufficiently ductile material at room temperature
- Non recoverable material deformation

Solid Phase forming

- Temperatures from 10°C to 20°C are maintained, which is below melting point

Advantages :

- Spring-back is lower
- Dimensional accuracy can be maintained

Calendaring and Examples of Reinforced Plastics

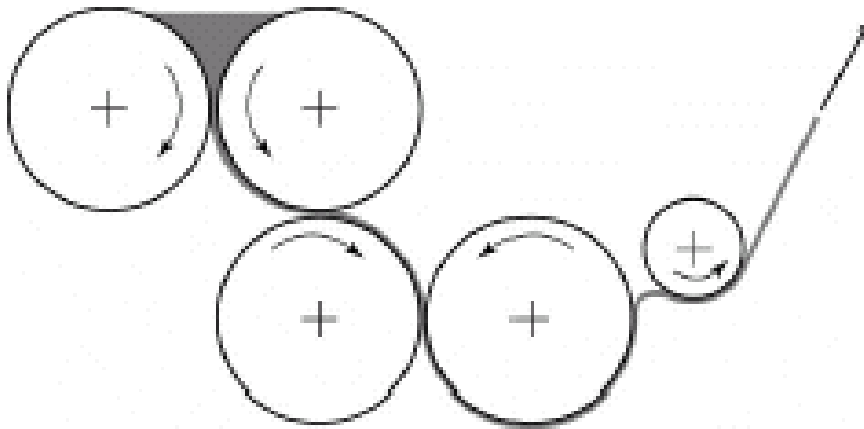
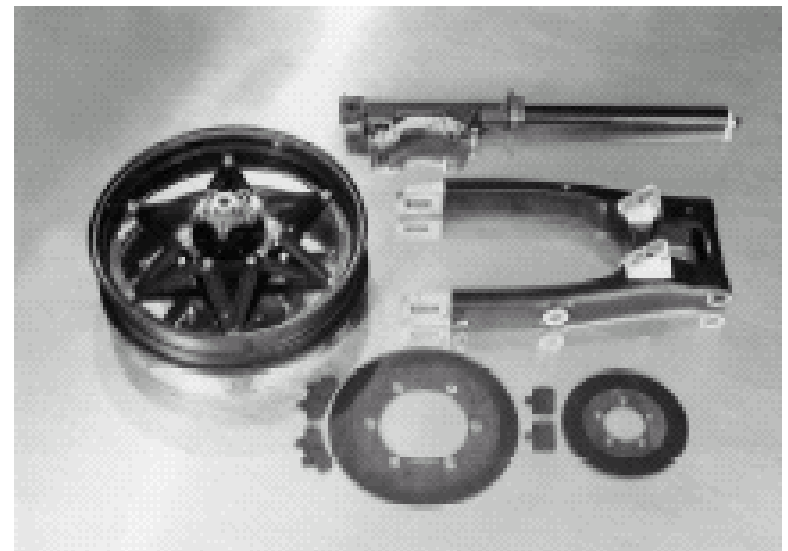


Fig : Schematic illustration of calendaring, Sheets produced by this process are subsequently used in thermoforming.

Fig : Reinforced-plastic components for a Honda motorcycle. The parts shown are front and rear forks, a rear swing arm, a wheel, and brake disks.



Prepegs

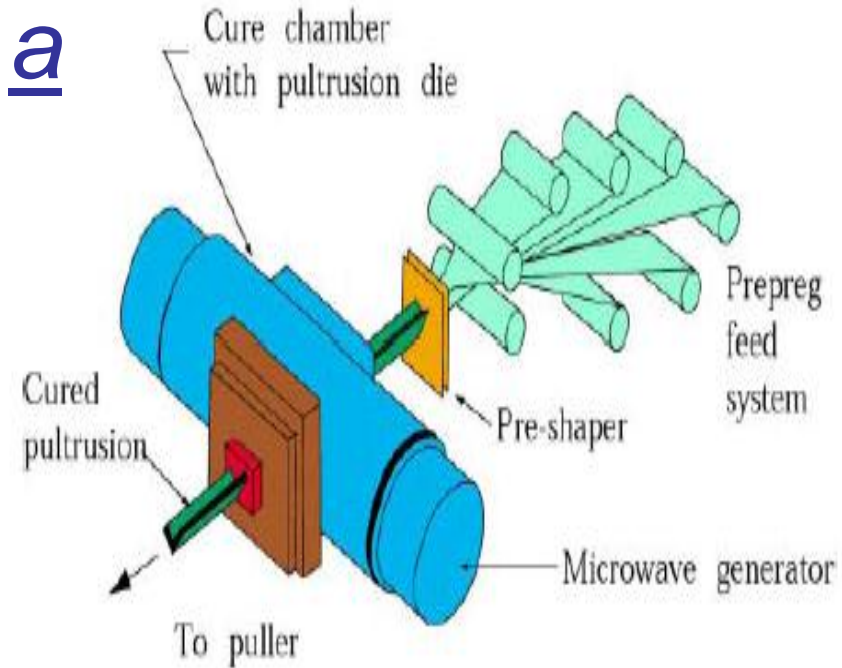


Fig : (a) Manufacturing process for polymer-matrix composite. (b) Boron-epoxy prepeg tape.

Tape Laying

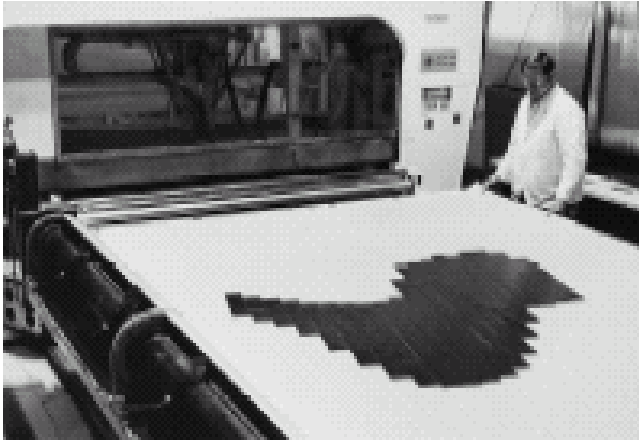


Fig : (a) Single-ply lay-up of boron-epoxy tape for the horizontal stabilizer for F-14 fighter aircraft. (b) A 10 axis computer-numerical controlled tape-laying system. This machine is capable of laying up 75 mm and 150 mm (3 in. and 6 in.) wide tapes, on contours of up to 30 and at speeds of up to 0.5m/s.



Sheet Molding

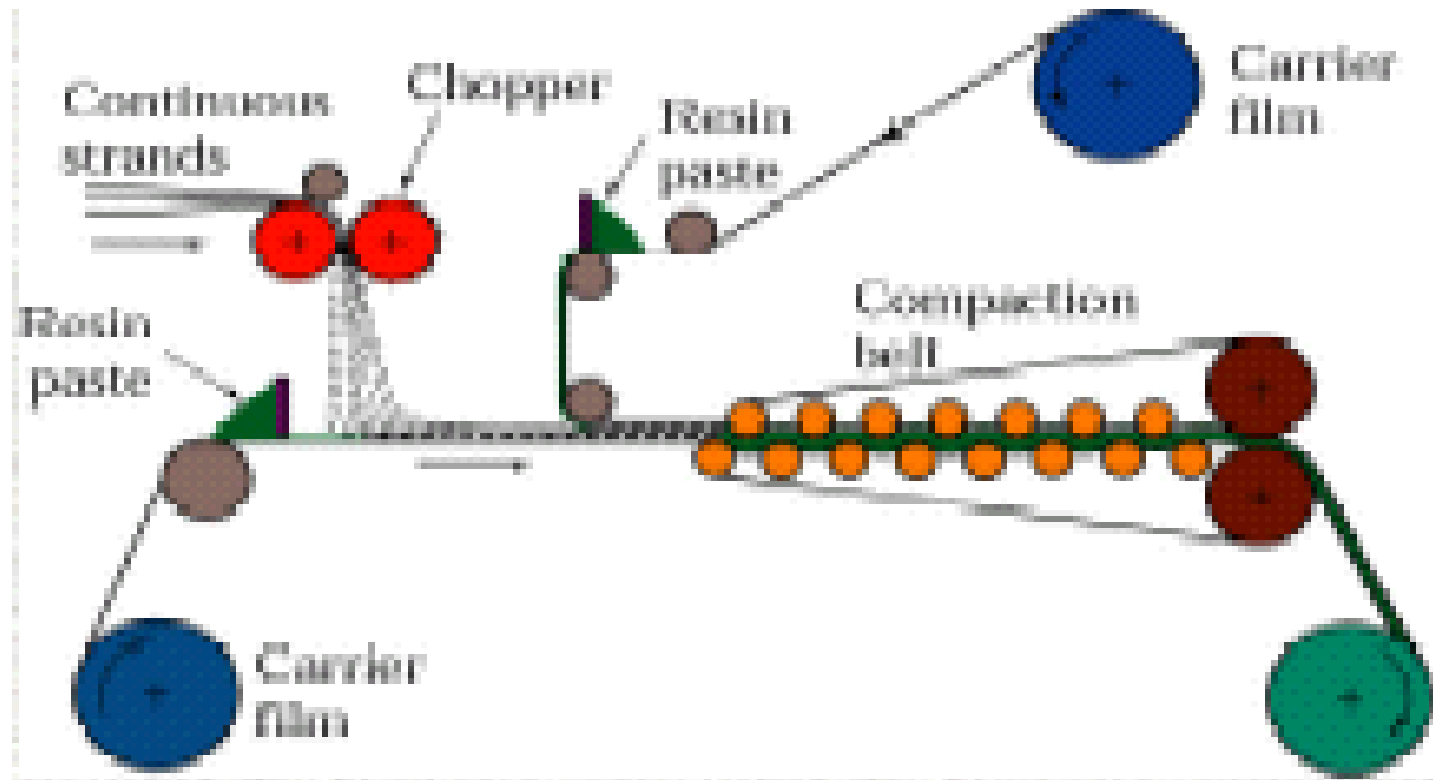


Fig : The manufacturing process for producing reinforced-plastic sheets. The sheet is still viscous at this stage; it can later be shaped into various products.

Examples of Molding processes

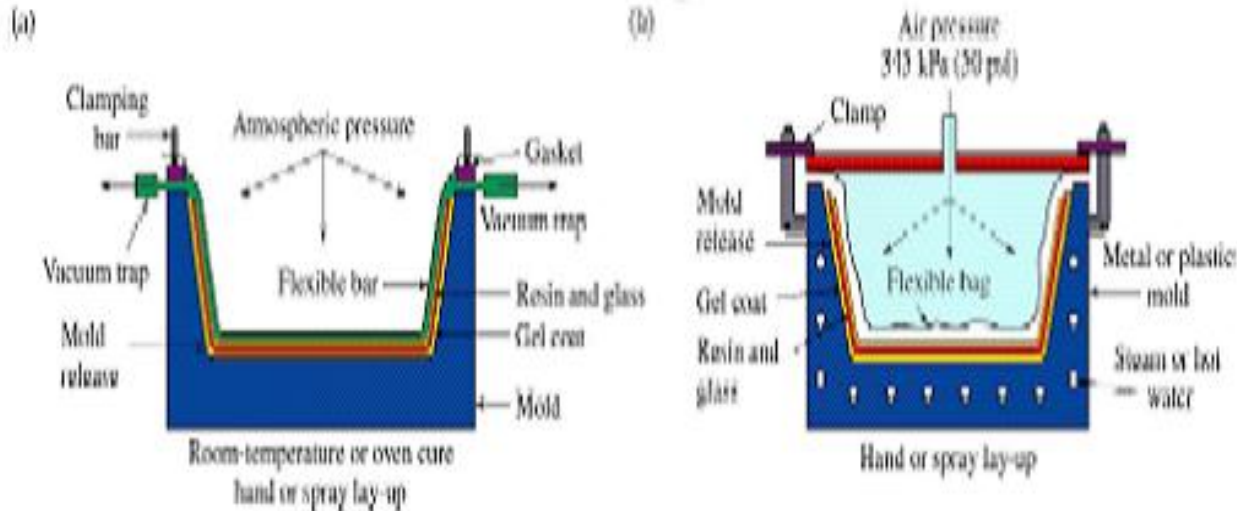


Fig : (a) Vacuum-bag forming.
(b) Pressure-bag forming.

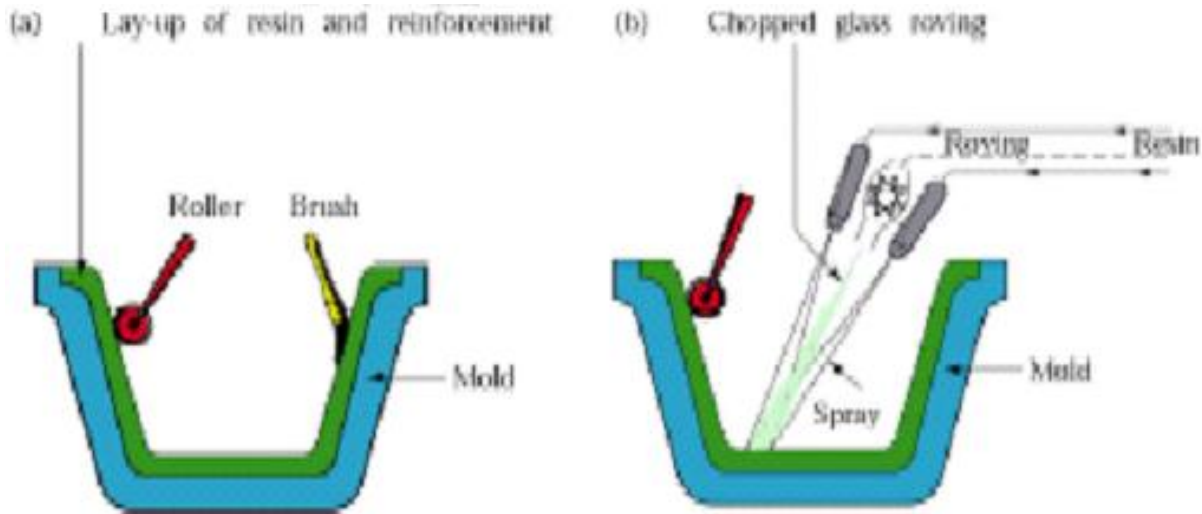


Fig : Manual methods of processing reinforced plastics: (a) hand lay-up and (b) spray-up. These methods are also called open-mold processing.

Filament Winding

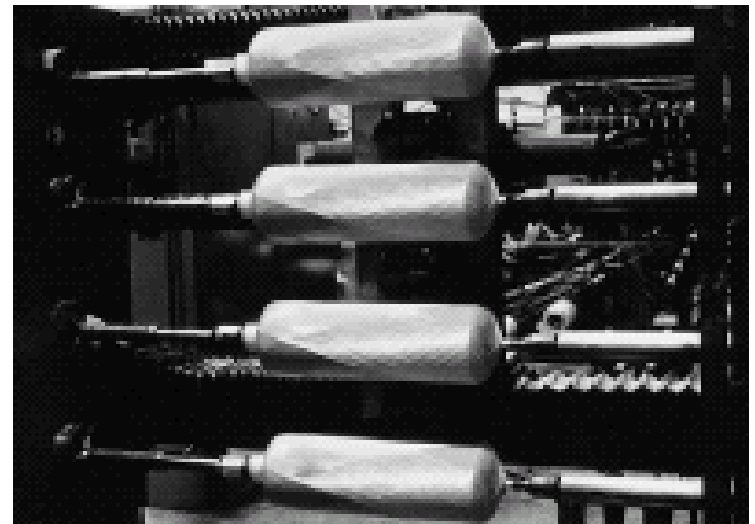
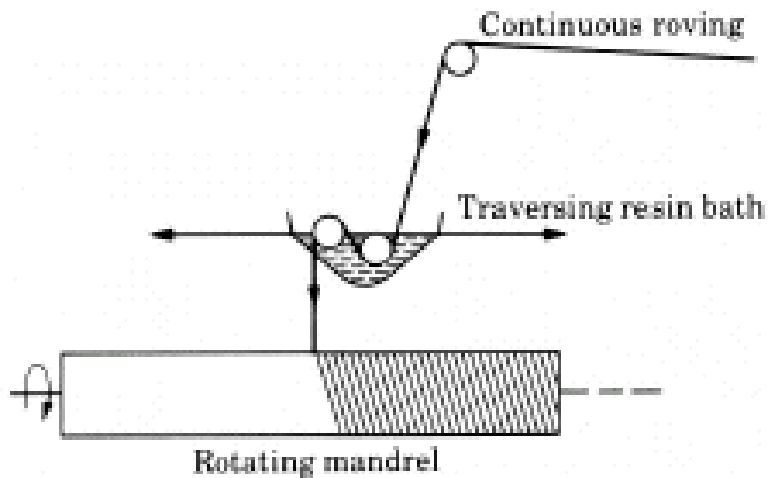


Fig : (a) Schematic illustration of the filament-winding process. (b) Fiberglass being wound over aluminum liners, for slide-raft inflation vessels for the Boeing767 aircraft.

Pultrusion

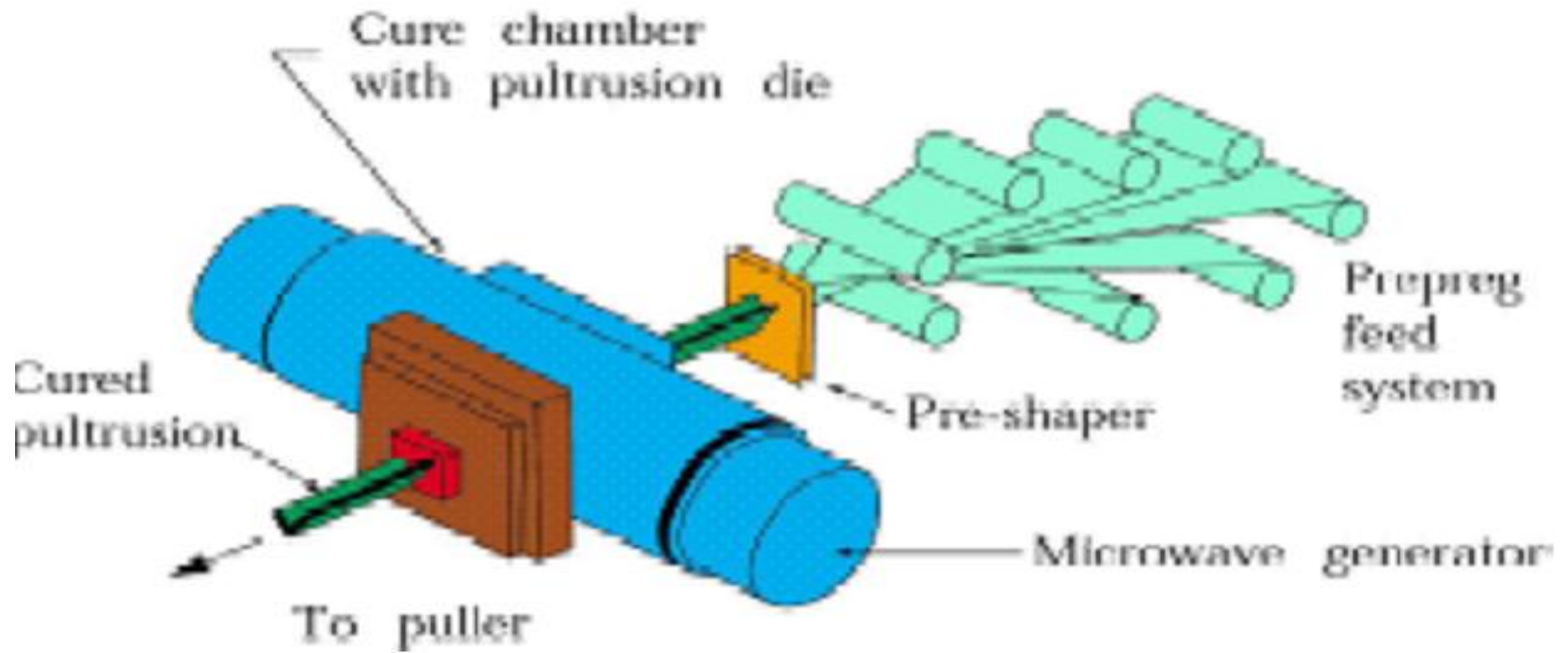


Fig: Pultrusion Process

Design Modifications to Minimize Distortions

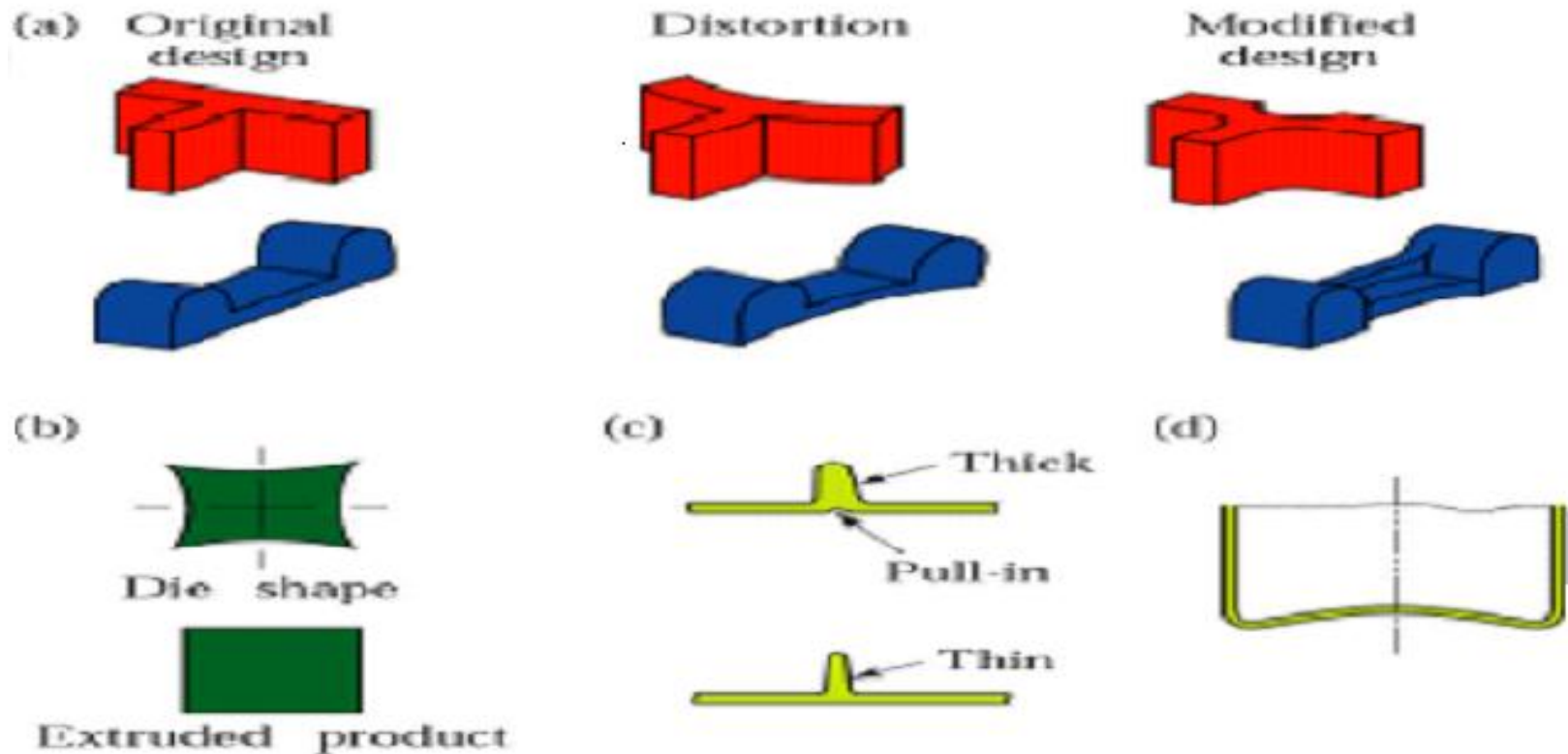


Fig : Examples of design conditions to eliminate or minimize distortion of plastic parts. (a) Suggested design changes to minimize distortion. (b) Die design for extrusion of square sections. Without this design, product cross sections swell (c) Design change in a rib, to minimize pull-in caused by shrinkage during cooling. (d) Stiffening the bottoms of thin plastic containers by doming- this technique is similar to the process used to make the bottoms of Al. beverages cans.

THE END