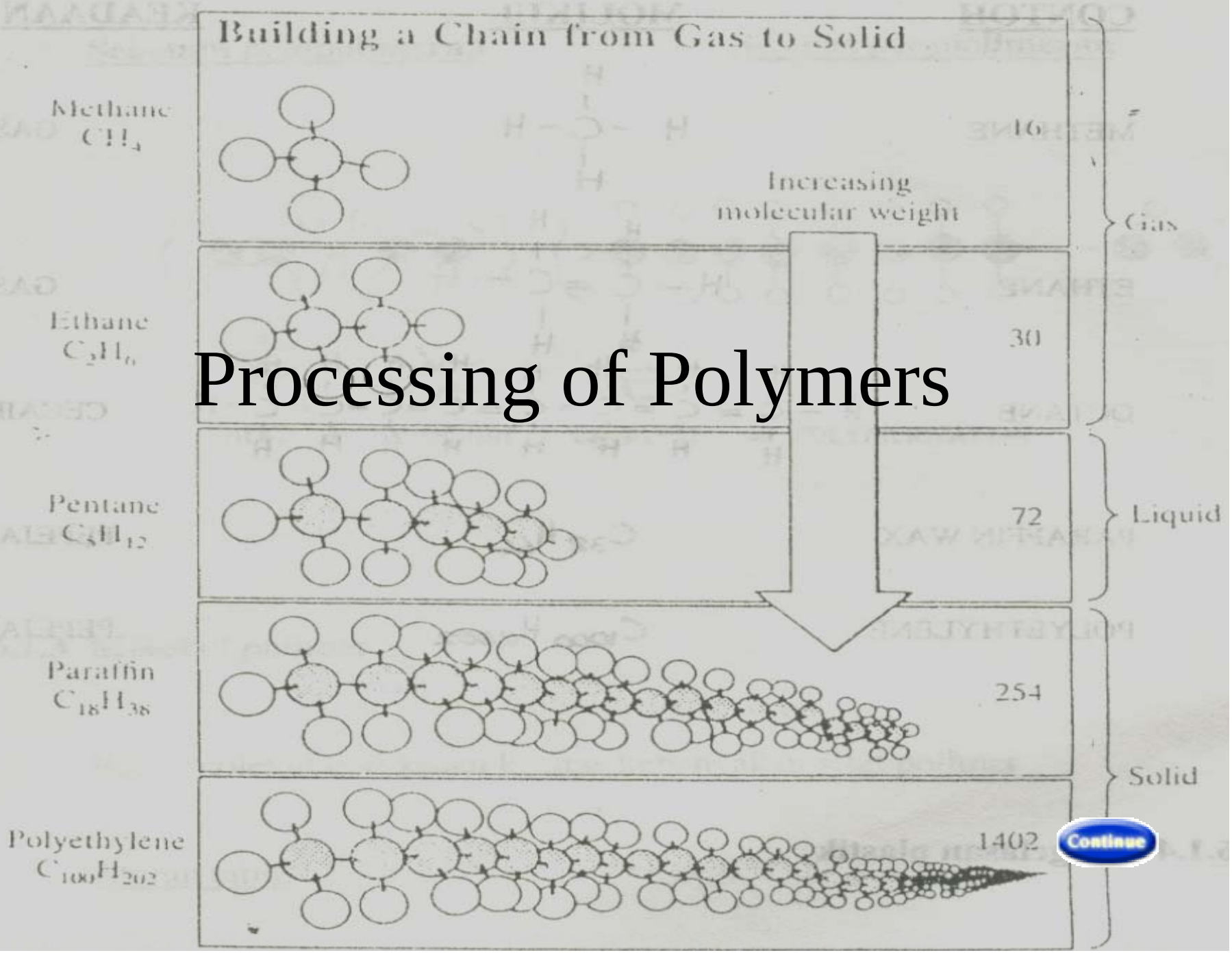
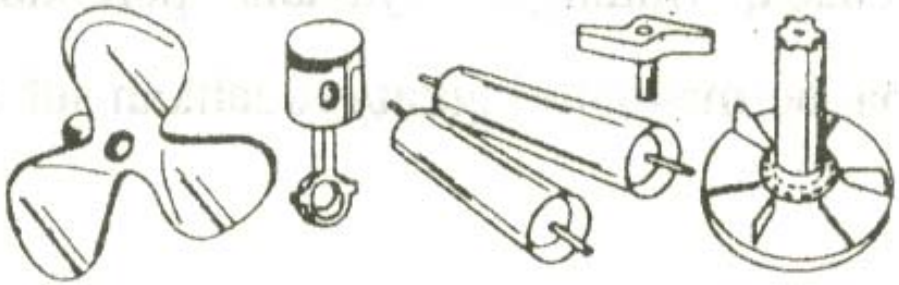
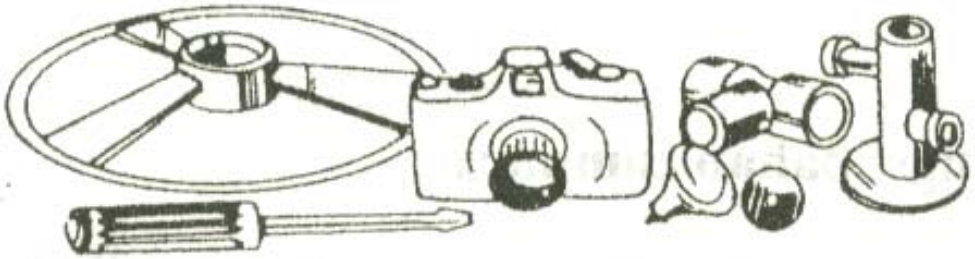
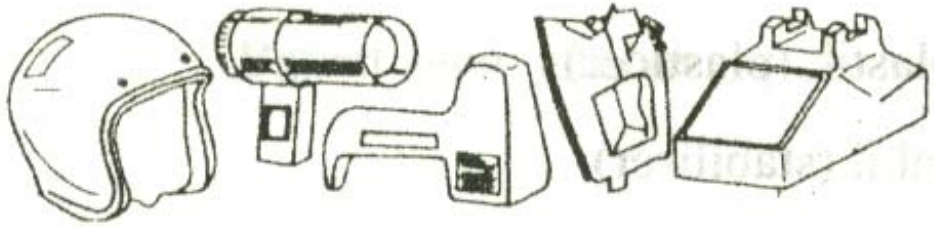
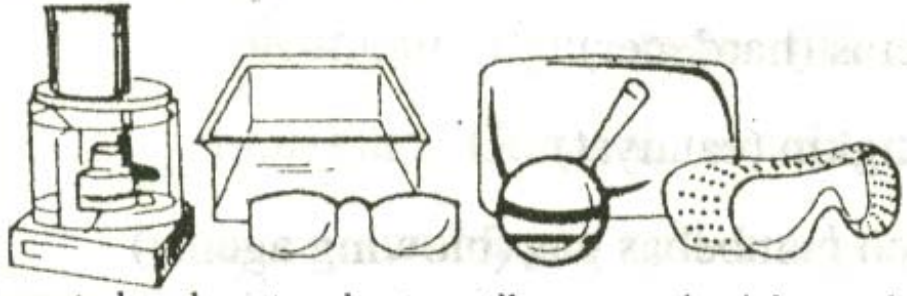
Processing of Polymers



Polymers & Products

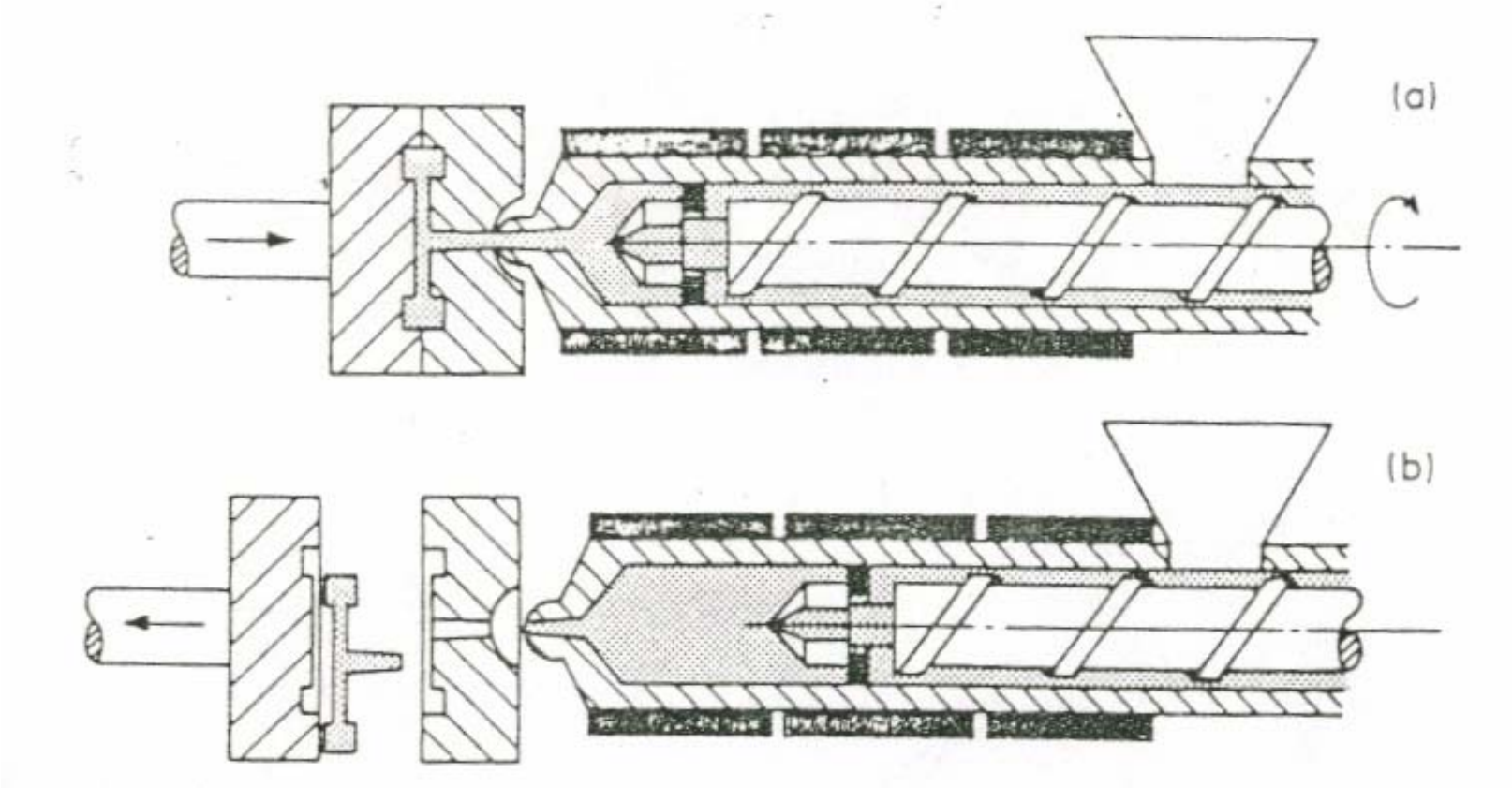
Keperluan rekabentuk	Jenis Plastik
Struktur, kekuatan mekanikal  Gear, sesondol, omboh, penggelek, injap, pendesak pam, bilah kipas	Asetal Nilon Fenolik Polikarbonat Poliester Poliamida Polietilena
Fungsi, perhiasan  Tombol, hendal, bekas bateri, pengapit kabel, bekas kamera, penyambung paip, bingkai cermin mata, stering kereta, hendal perkakas tangan	ABS Akrilik Selulosik Fenolik Polietilena Polipropilena Polistirena PVC

Perumah dan bentuk geronggang  Bekas talipon dan lampu, topi keledar, perumah untuk mesin pejabat, perkakas kuasa, pam dan peralatan kecil	ABS Selulosik Fenolik Polikarbonat Poliester Polietilena Polipropilena Polisterina
Komponen optik atau lutsinar  Cermin mata keselamatan, kanta optik, para peti sejuk, peralatan makmal, peralatan pemproses makanan	Akrilik Polikarbonat Polistirena Polisulfona Poliester (PET)
Merintangi haus  Gear, sesendal, galas, trak, pelapik pelongsor dan penggelek, tayar	Asetal Nilon Fenolik Poliester Poliamida Poliuritena

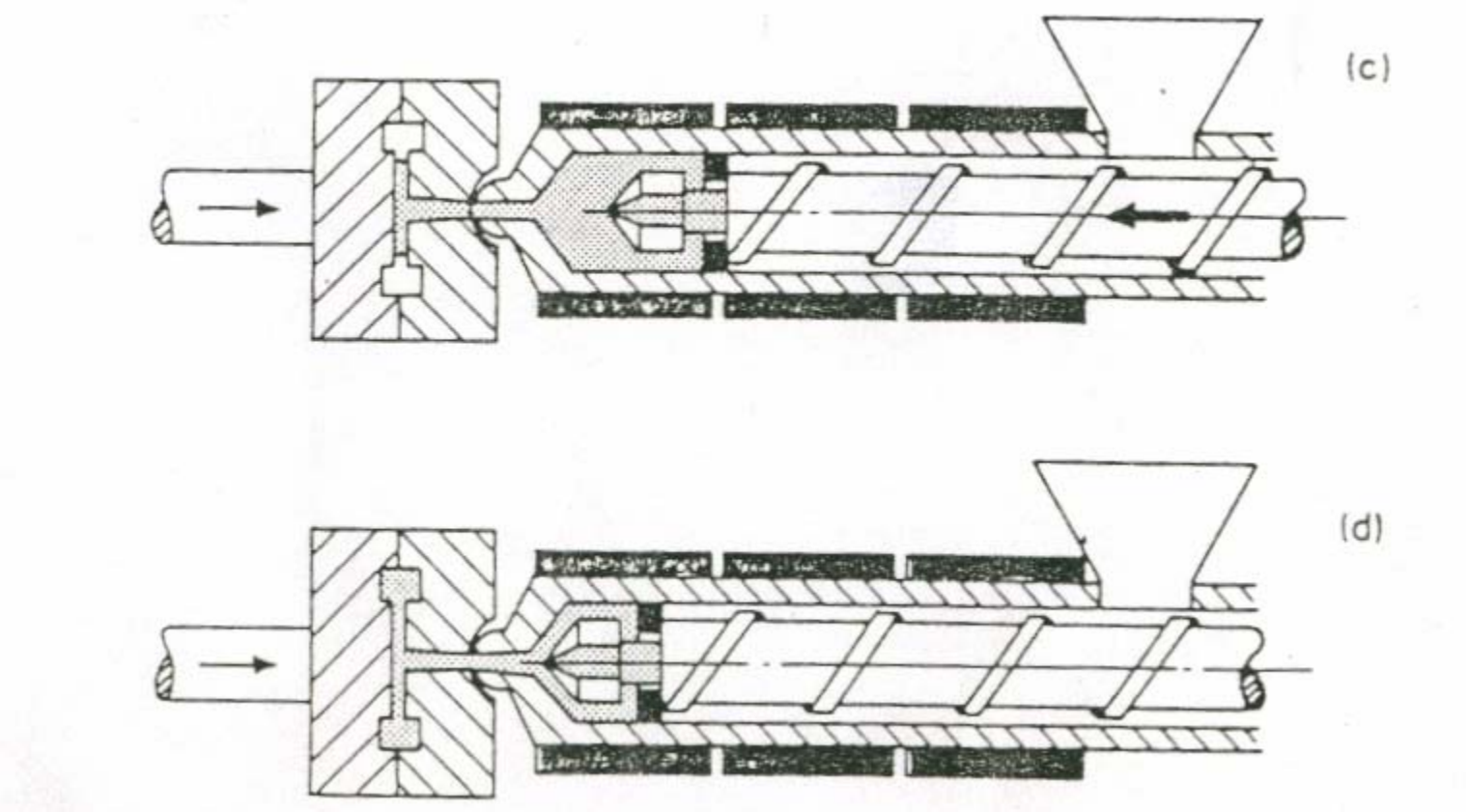
Polymer processing

- Injection molding
- Extrusion
- Blow molding
- Thermoforming
- Compression molding
- Transfer molding

Injection Molding



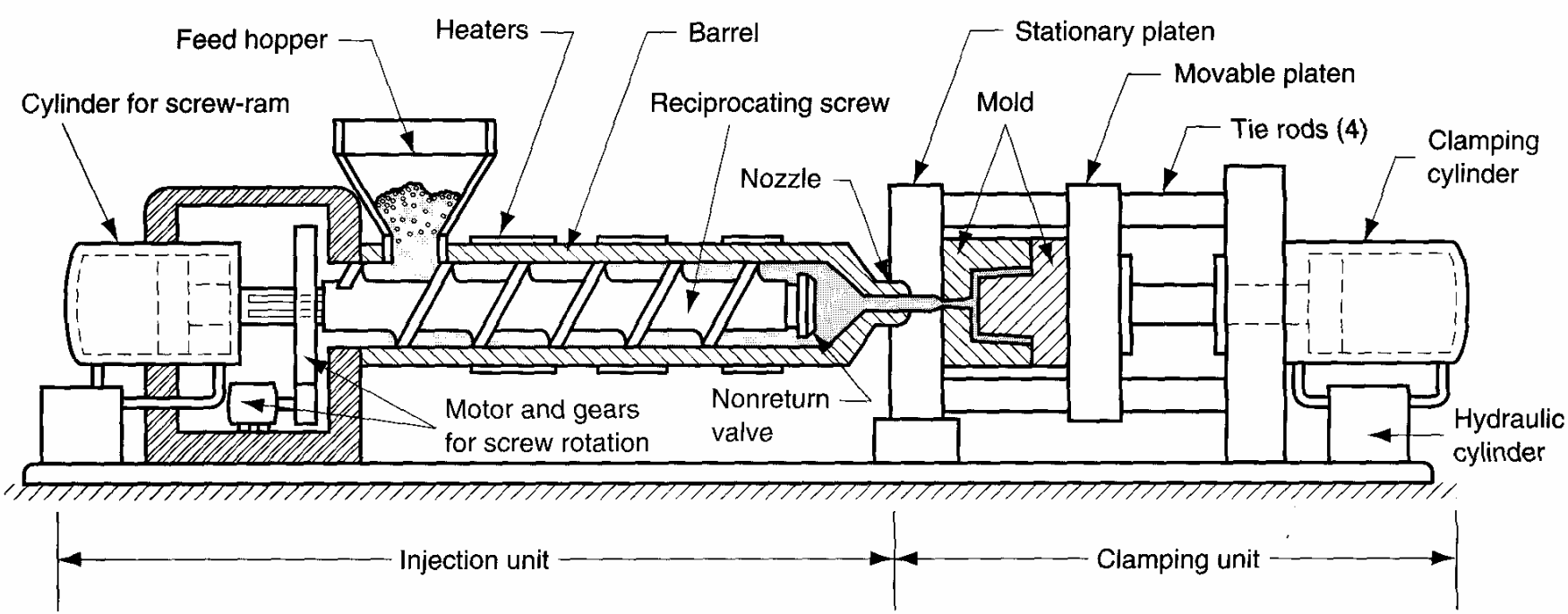
Injection Molding



Operation Procedures

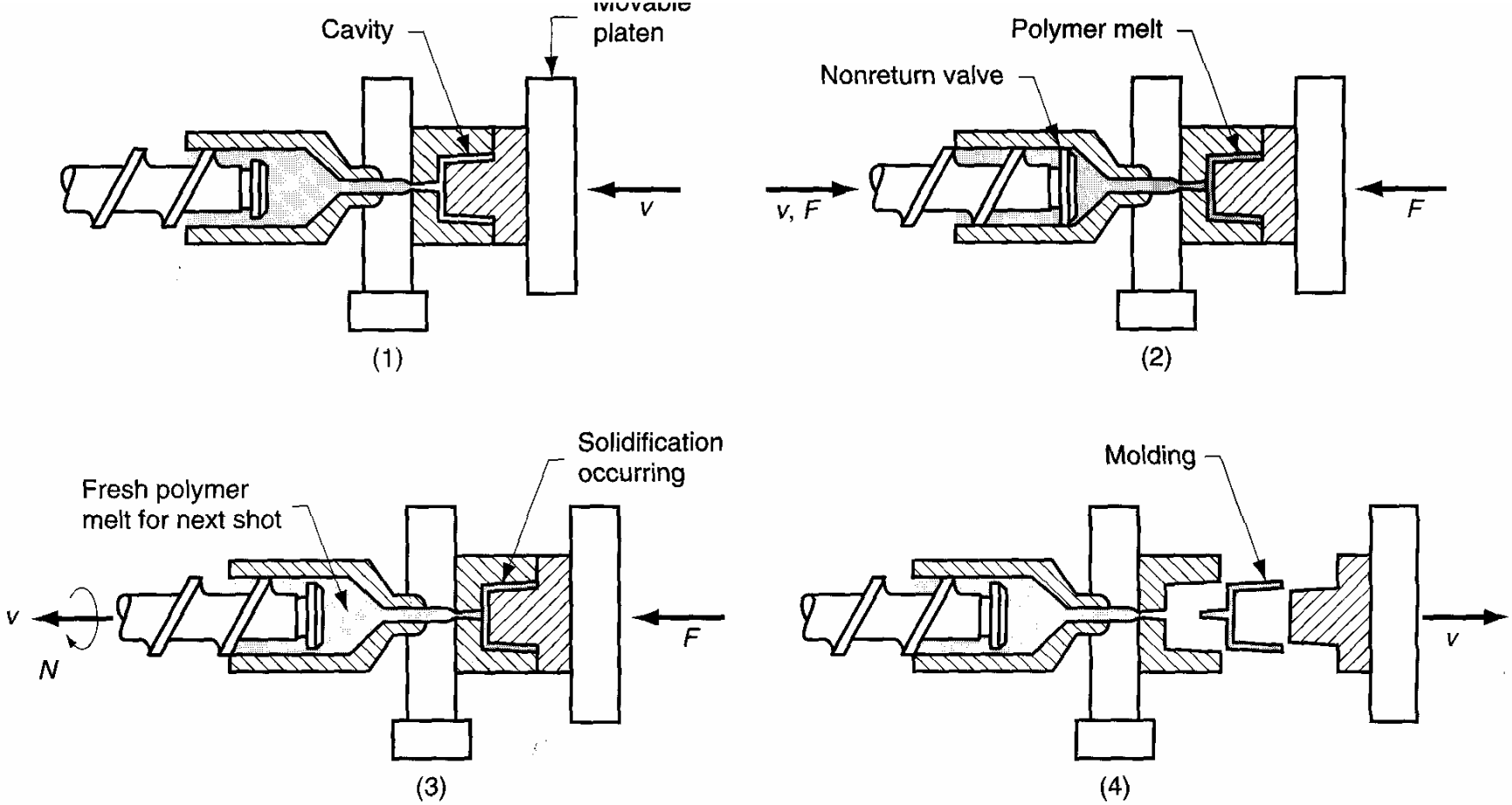
- Fill hooper with plastic material (pallet/granular)
- Plastic then heated in the barrel gradually to the state that its' able to flow sufficiently
- Melt plastic is forced thru orifice to the mold cavity
- Open the mold when solidification completed
- Eject part and inspection

Injection Molding Machine



The injection molding process depends on the injection pressure, injection velocity, melt temperature, mold temperature, and holding time.

Molding Cycle



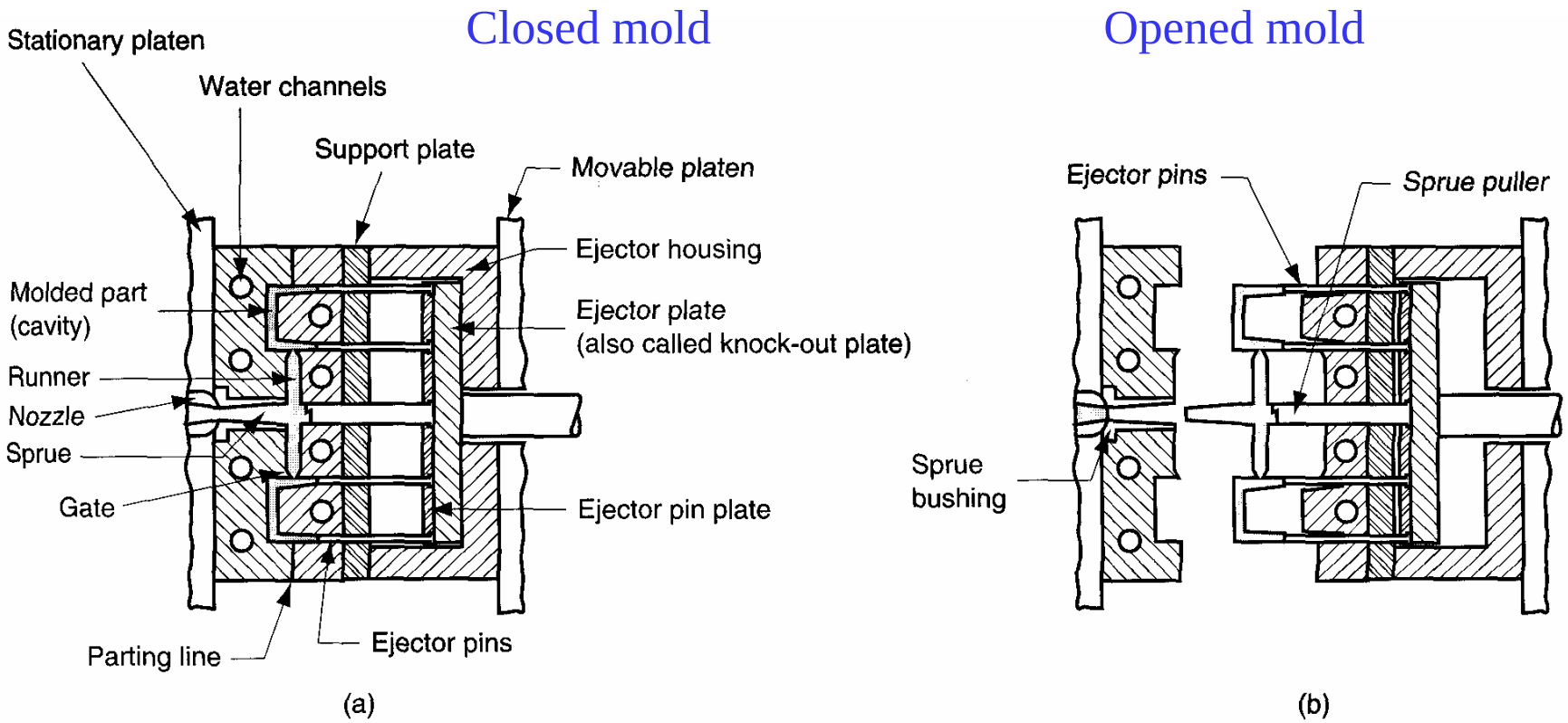
(1) Mold closing

(2) Melt injection into cavity

(3) Screw retraction

(4) Mold opening and part ejection

Injection Mold



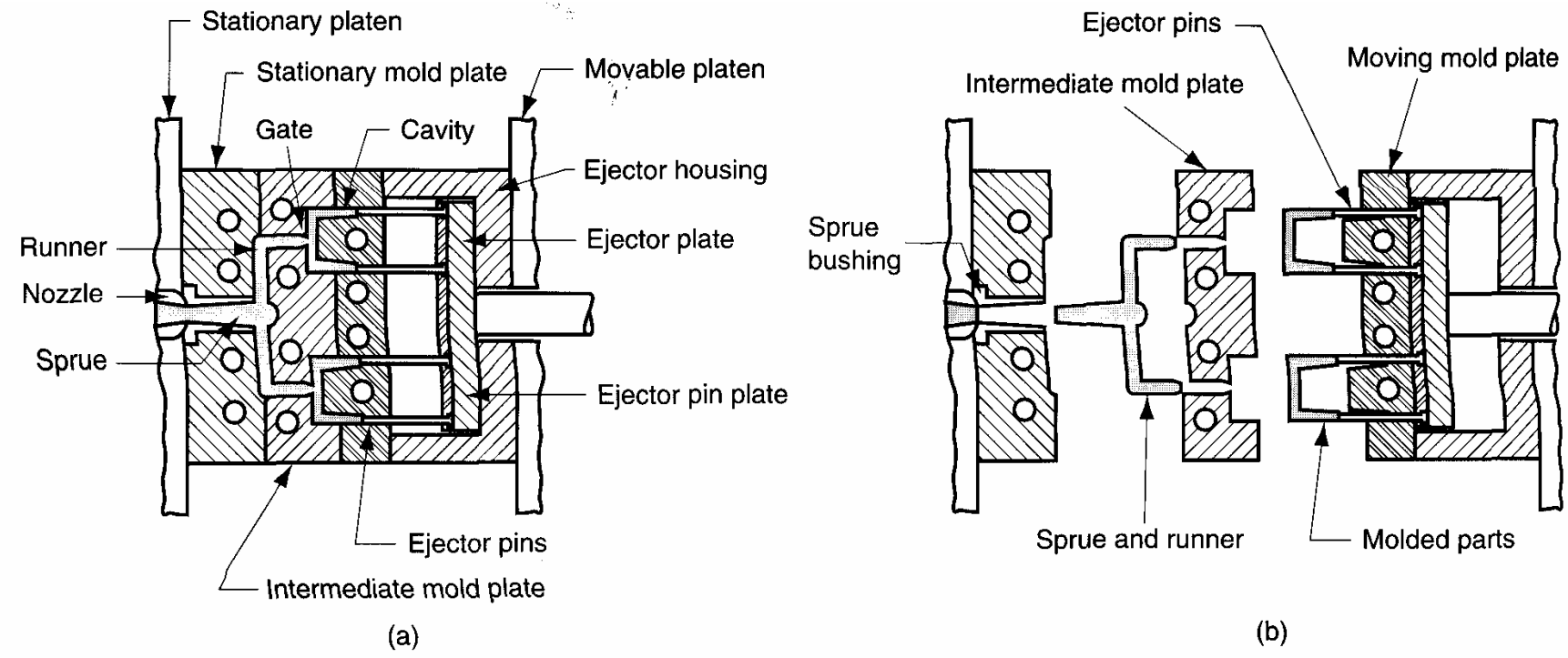
stationary platen and the *moving platen* of the molding machine.

- The mold halves each contains the *core* and *cavity* to form the part geometry.

Injection Mold

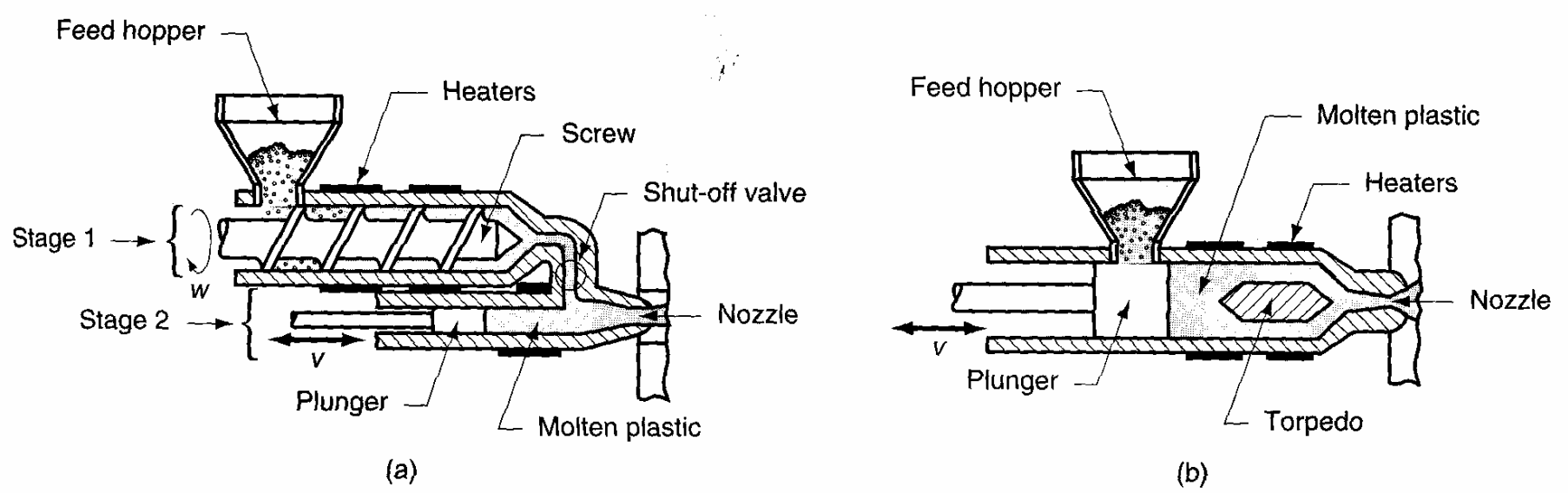
- The mold has *water channels* to control the temperature of the mold.
- The *cavity* may have *multi-cavities* to improve the efficiency of the production.
- The core may consist of *sliding cores* to cater for intricate geometry.
- The *sprue*, *runner* and *gate* form the feeding system.
- *Hot runners* are sometimes used to eliminate melt solidification at the sprue and runner.
- The *ejector pins* are used for part ejection.
- The gate and ejector location should be chosen not to affect the aesthetic design of the part.
- Air venting should be provided for via the ejector pin clearance or *air vents*.

Injection Mold



Three-plate mold provides better automation and more room for gate adjustment.

Injection Molding Machine

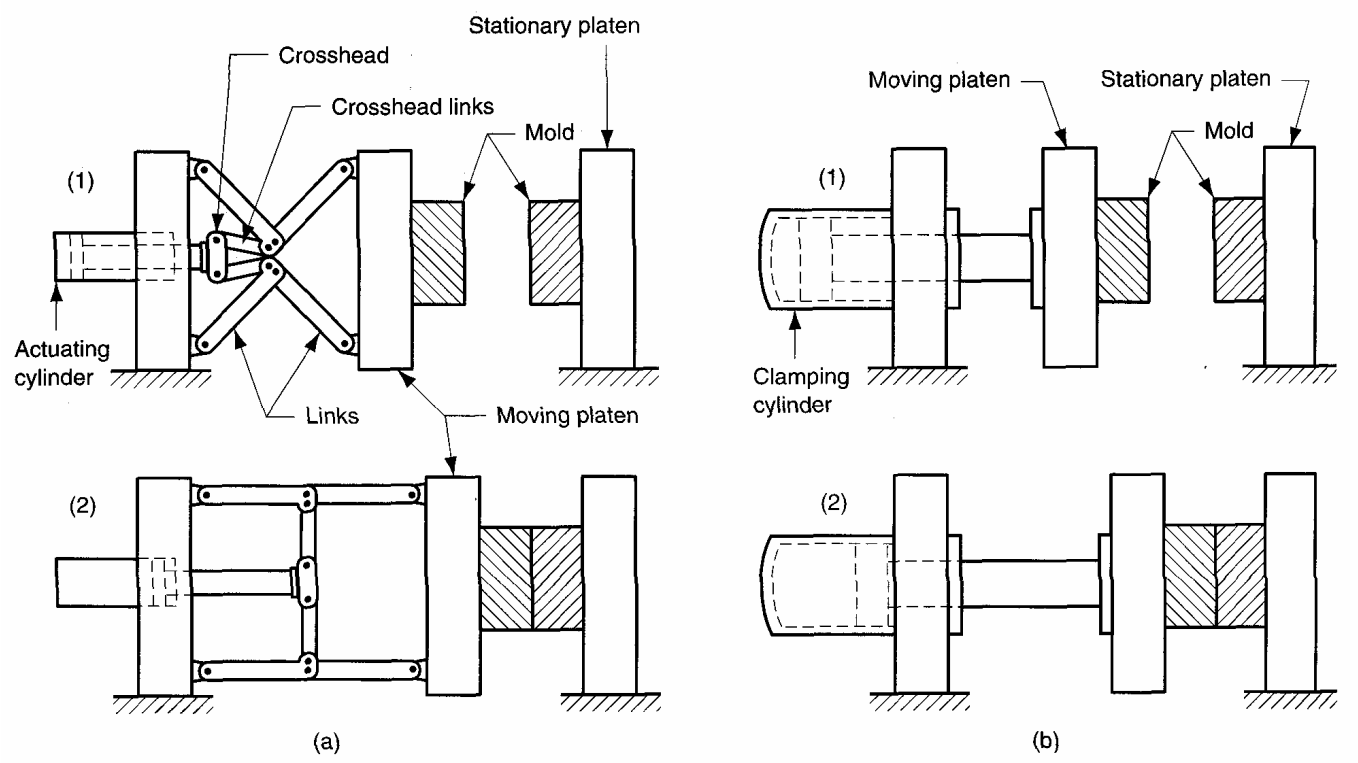


Injection units: The two types being shown are the screw preplasticizer and plunger type. The most common injection system is to use the plasticizing screw to work also as an plunger.

Injection Molding Machine

Open

Closed



Clamping units: The clamping unit could be mechanical or hydraulic operated. The mechanical clamping system uses toggle clamps while the hydraulic system uses a hydraulic cylinder to provide the actuation.

Molding Defects

- Shrinkage
- warpage
- short shots
- Flashing
- Sink marks and voids
- Weld lines

Other Injection Molding Processes

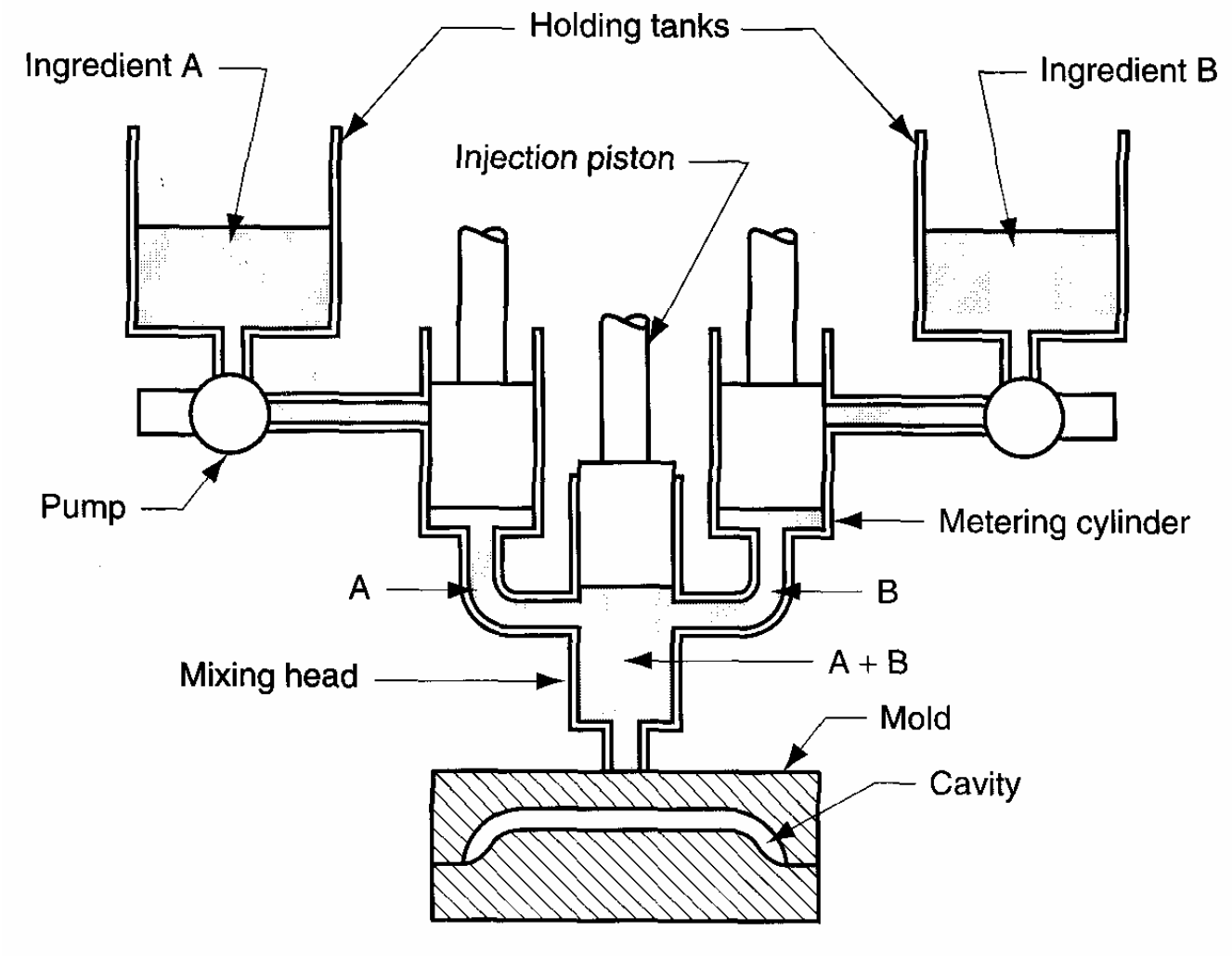
- Thermoplastics foam injection molding
  - introducing gas into melt or mixing a gas-producing ingredient with starting pellet.
  - Producing part with high stiffness-to-weight ratio.
- Multi-injection molding process
  - sandwich molding
  - bi-injection molding
- Injection molding of thermosets
  - mostly with high filler content

Other Injection Molding Processes

- Reaction Injection Molding
  - Mixing of two highly reactive liquid and injected it immediately into the cavity to create thermosets typically of large size.
  - Low energy requirement.
  - Equipment and mold cost are less than injection molding.
  - Good process reliability.
  - Wide choice of chemical systems.

Other Injection Molding Processes

- Reaction Injection Molding



Design Considerations

- Production Cost:
  - material cost
  - mold cost
  - operating cost
    - cycle time
    - labor cost
    - QC cost
    - finishing cost

The unit cost per part is the most important item.

Design Considerations

- Part complexity
  - The part complexity will increase the cost of the mold, not only in terms of mold finishing, but may incur sliding cores and other mechanisms.
  - The trade off is between mold cost and the additional cost of having more parts.

Design Considerations

- Material selection
  - Viscosity (at processing temperature and pressure)
  - Coefficient of thermal expansion (shrinkage factor)
  - Strength and stiffness
  - Impact resistance
  - Service temperature
  - Degradation

Design Considerations

- Wall and rib thickness - even thickness is molded part is important.
- Corner radii and fillets - avoid sharp corners which leads to poor melt flow and stress concentration.
- Holes - Careful treatment in design to avoid obstruction of mold opening.
- Drafts - thermosets 1/2 ° to 1°

  thermoplastics 1/8° to 1/2°

Design Considerations

Plastic	Tolerances for: [a] 2.0-in. (50-mm) Dimension	3/8-in. (10-mm) Hole
Thermoplastic:		
ABS	±0.007 in. (±0.2 mm)	±0.003 in. (±0.08 mm)
Polyethylene	±0.010 in. (±0.3 mm)	±0.005 in. (±0.13 mm)
Polystyrene	±0.006 in. (±0.15 mm)	±0.004 in. (±0.1 mm)
Thermosetting:		
Epoxies	±0.006 in. (±0.15 mm)	±0.002 in. (±0.05 mm)
Phenolics	±0.008 in. (±0.2 mm)	±0.003 in. (±0.08 mm)

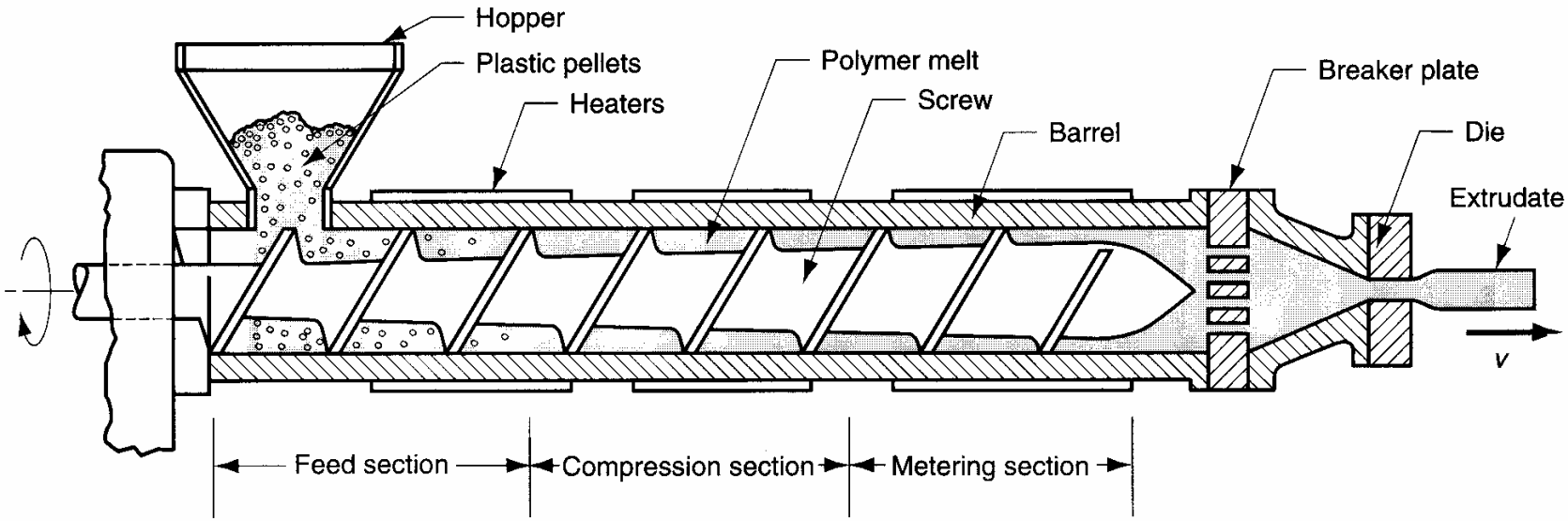
Values represent typical commercial molding practice.

Compiled from [2], [6], [14], and [17].

[a] For smaller sizes, tolerances can be reduced. For larger sizes, more generous tolerances are required.

Extrusion

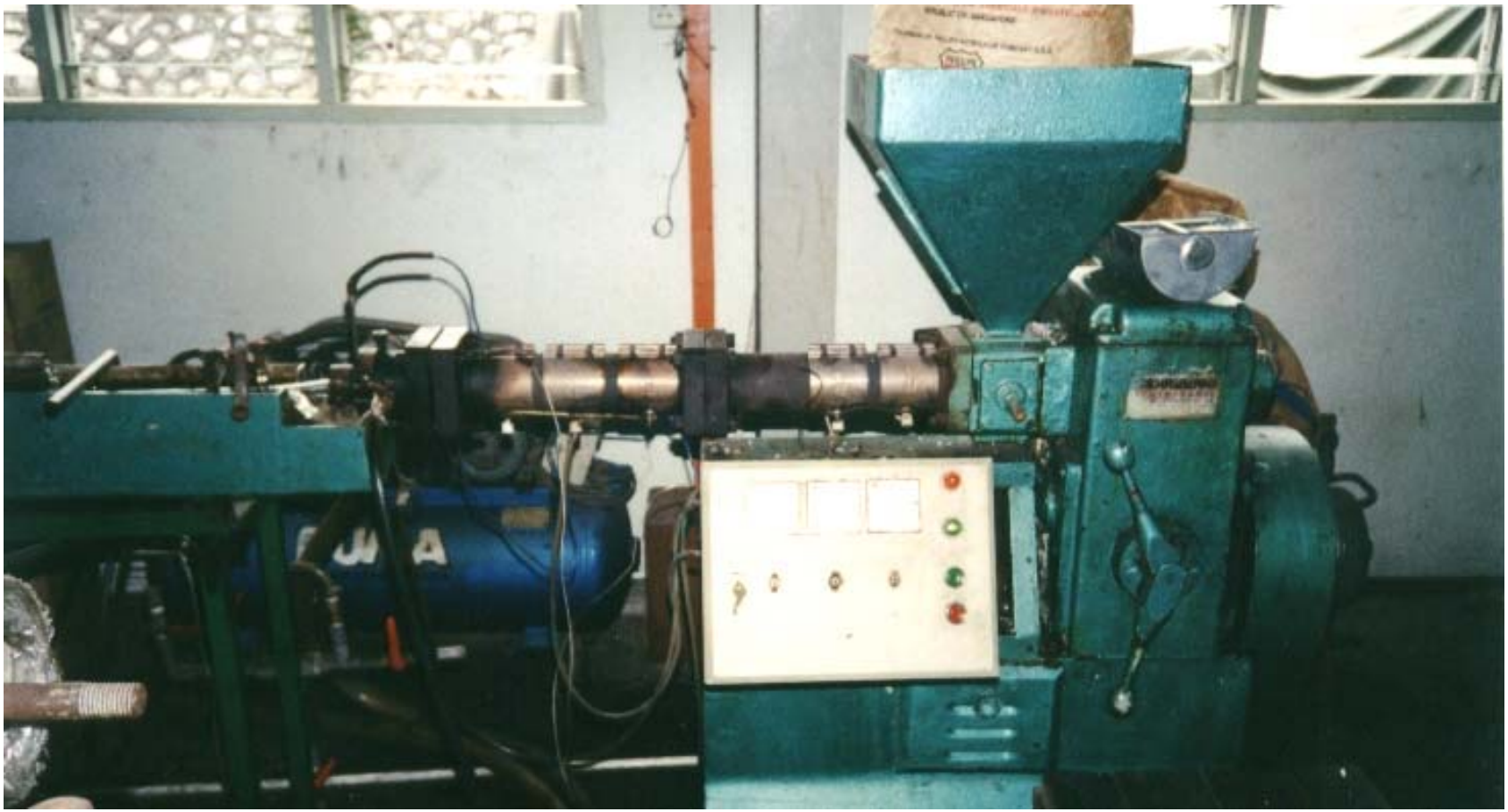
A compression process in which the material is forced to flow through a die orifice to provide long, continuous product with regular shape controlled by the orifice shape.



Operation Procedures

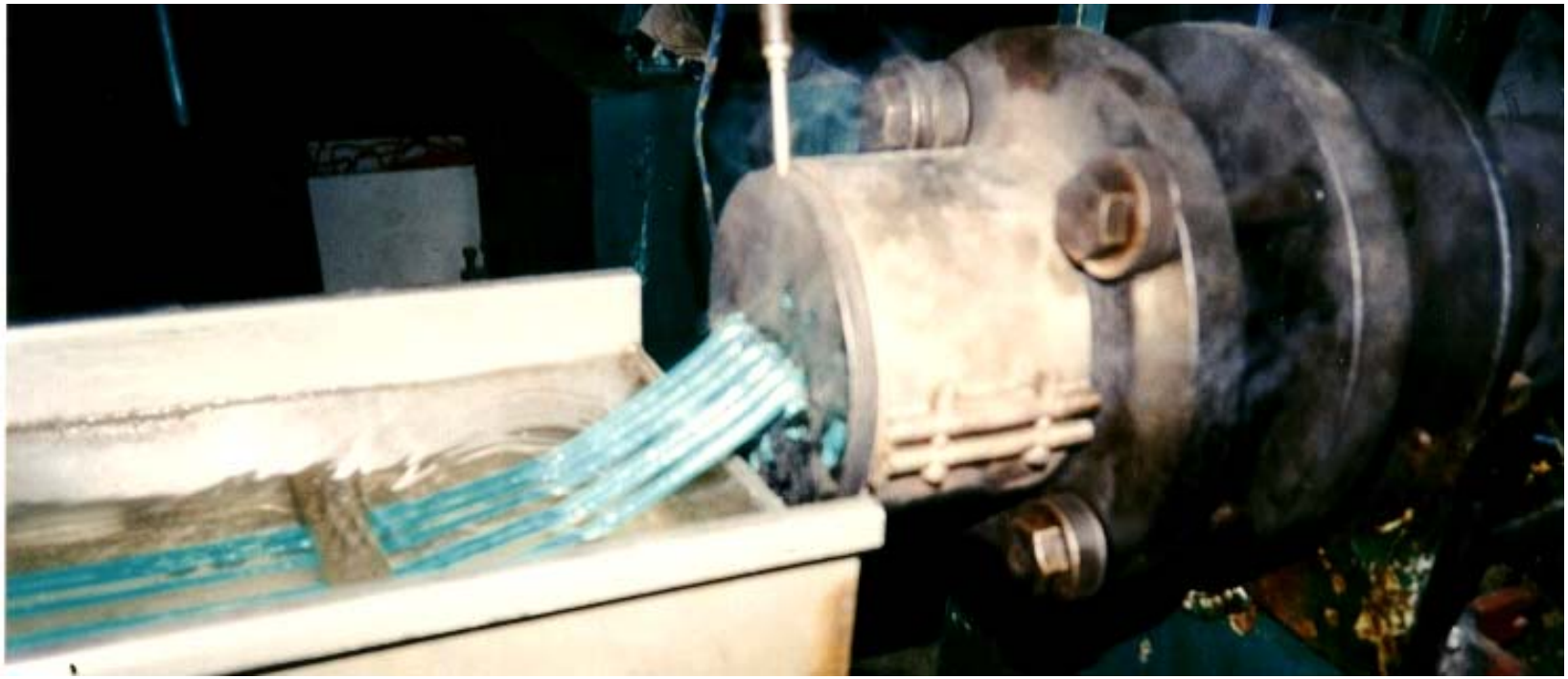
- Fill hooper with plastic material (pallet/granular)
- Plastic then heated in the barrel gradually to the state that its' able to flow sufficiently
- Melt plastic is forced by screw press or plunger thru die opening and convey on conveyor or cooling bath/channel
- Letting the product cool and cut to length

Extrusion Machine



Extrusion in Progress

Extrusion in Progress



Sheet & Wire Coating Extrusion

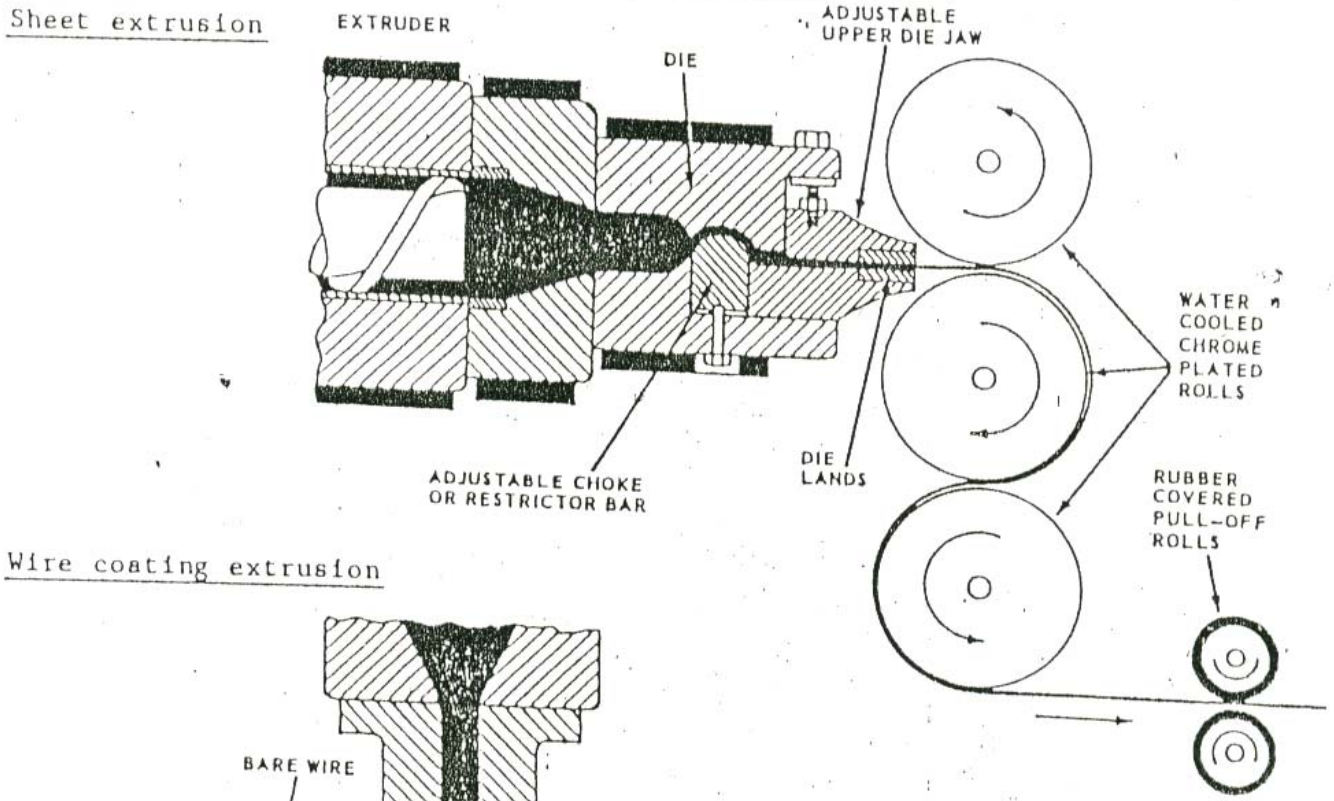
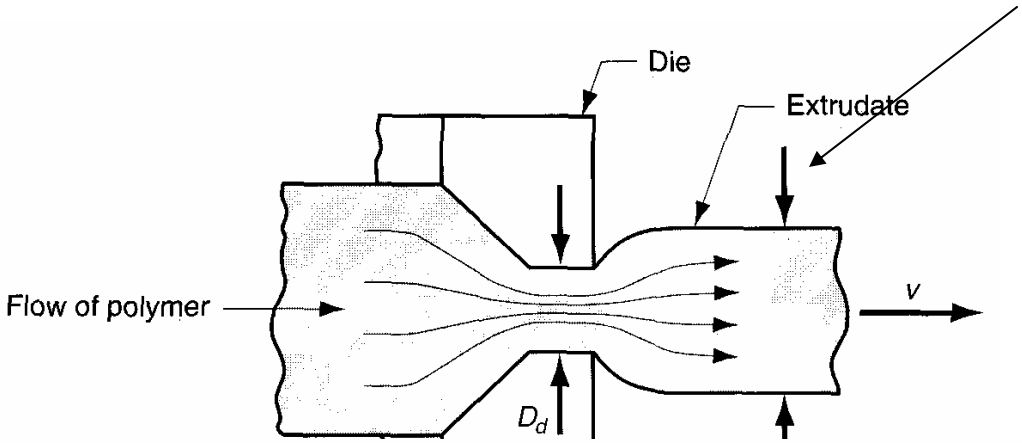
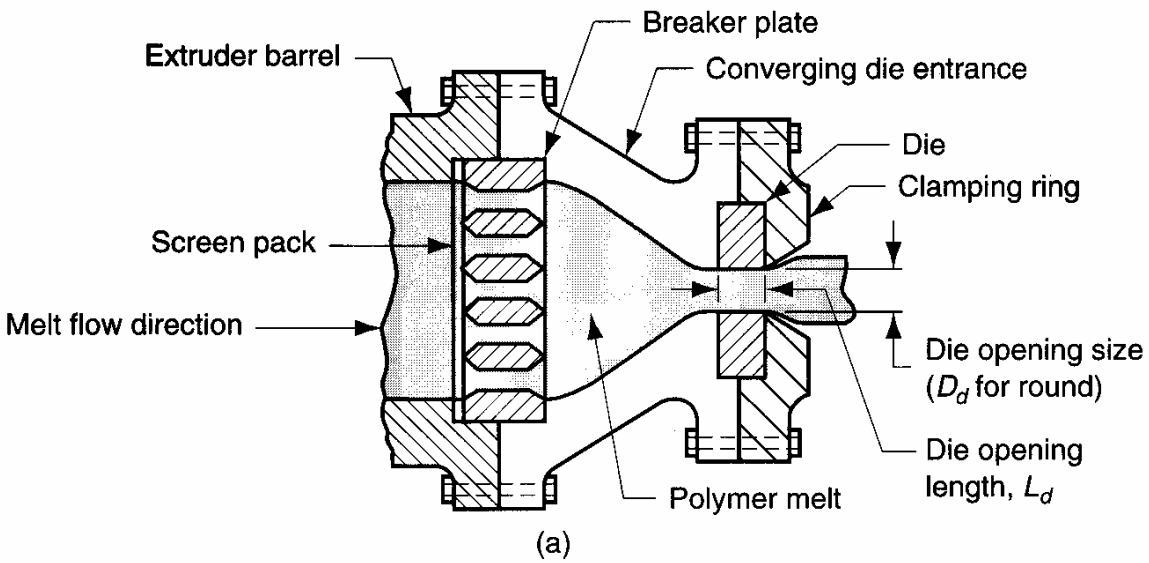


Fig. 6-18. A crosshead holds the wire-coating die and the tapered guider as the soft plastic flows around the moving wire.

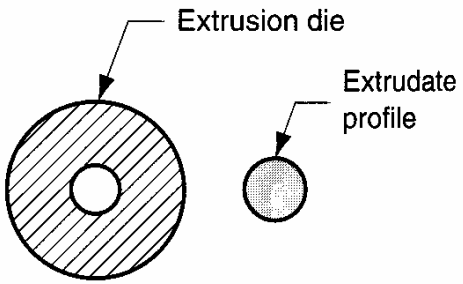
Extrusion

Die swell

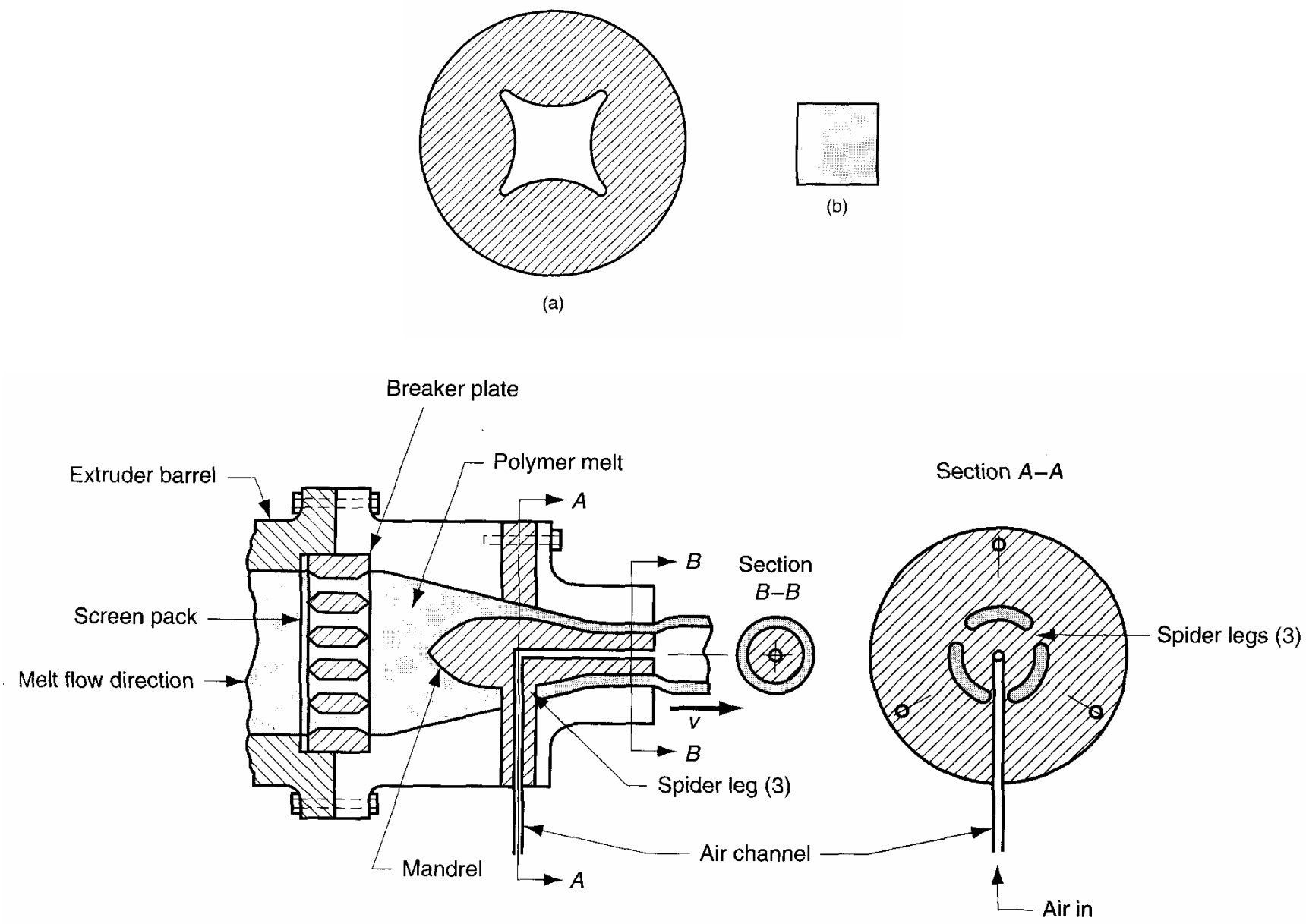




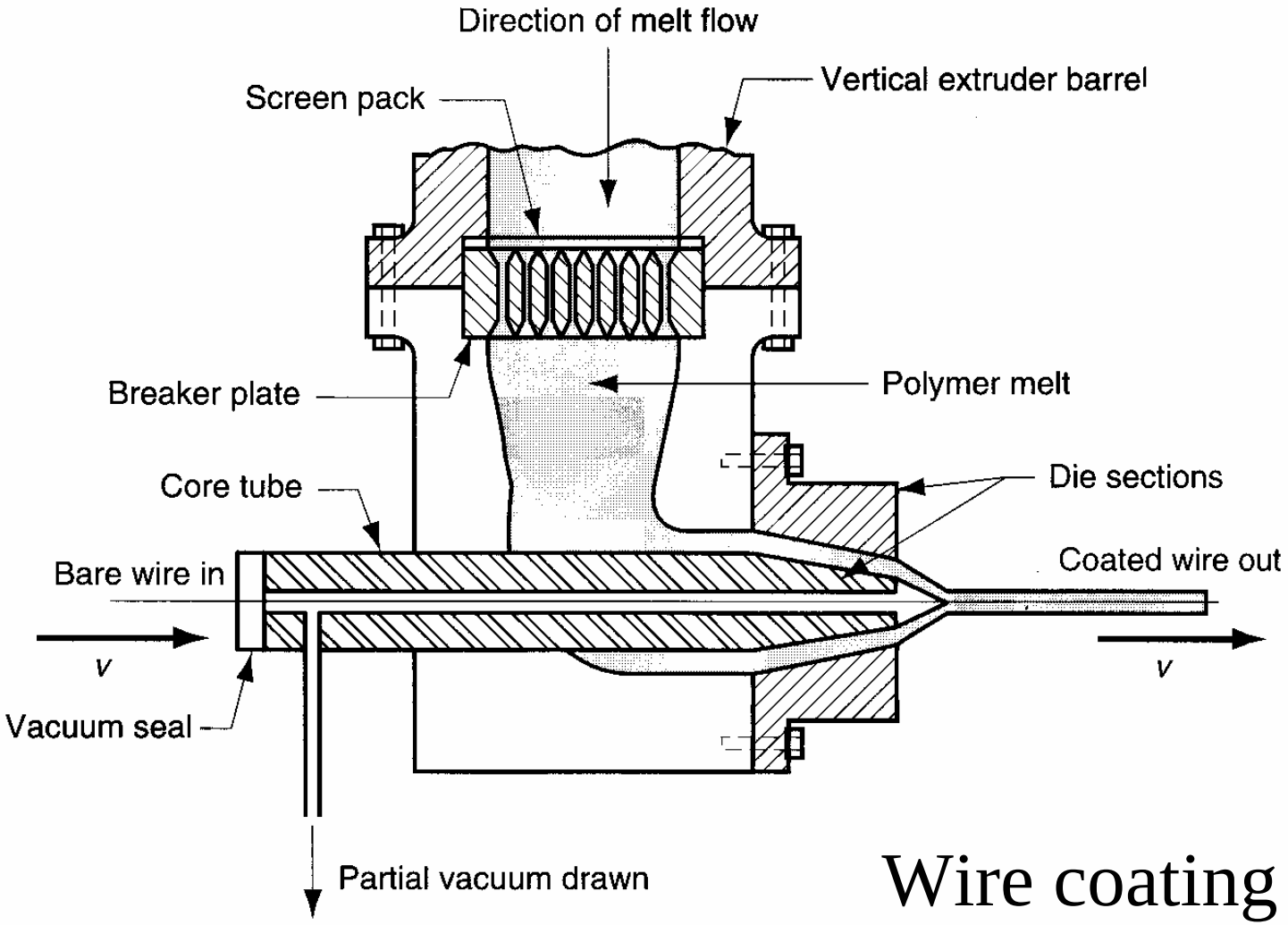
(a)



(b)

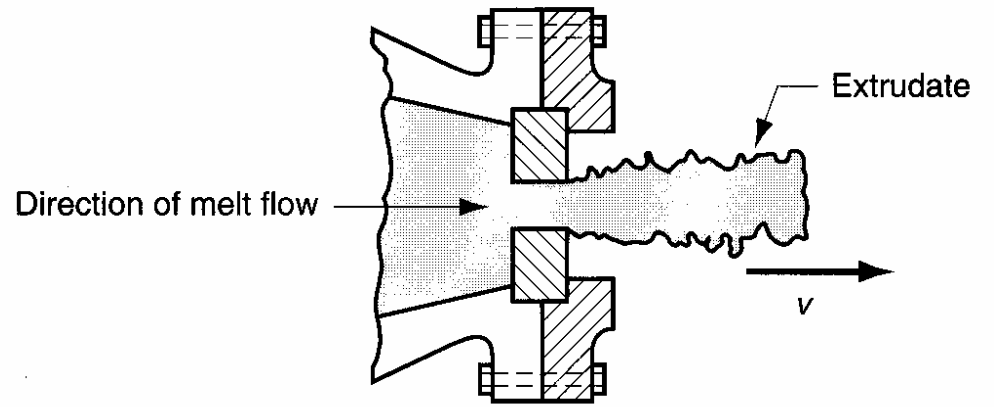

(a)
(b)
Breaker plate
Extruder barrel
Polymer melt
A
B
Section
B–B
Screen pack
Melt flow direction
v
B
Spider leg (3)
Mandrel
Air channel
A
Section A–A
Spider legs (3)
Air in

Extrusion

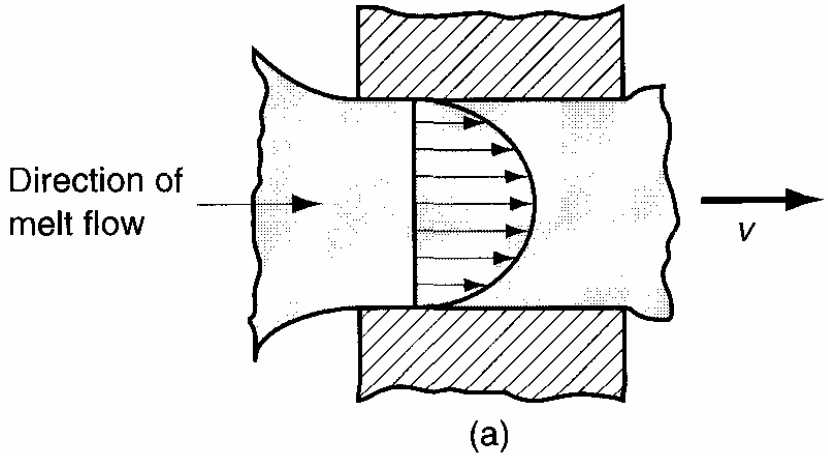


Wire coating

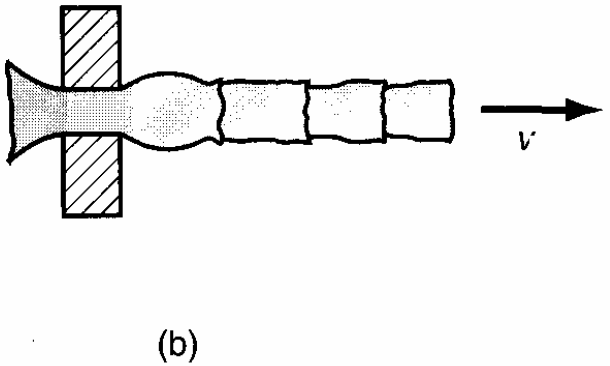
Extrusion Defects



Melt fracture

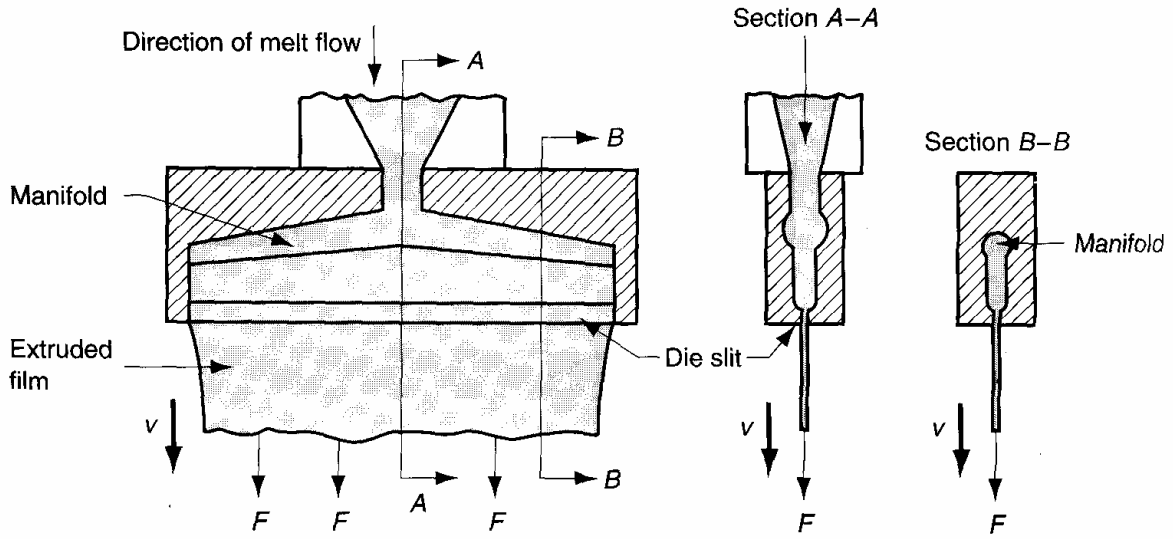


Sharkskin



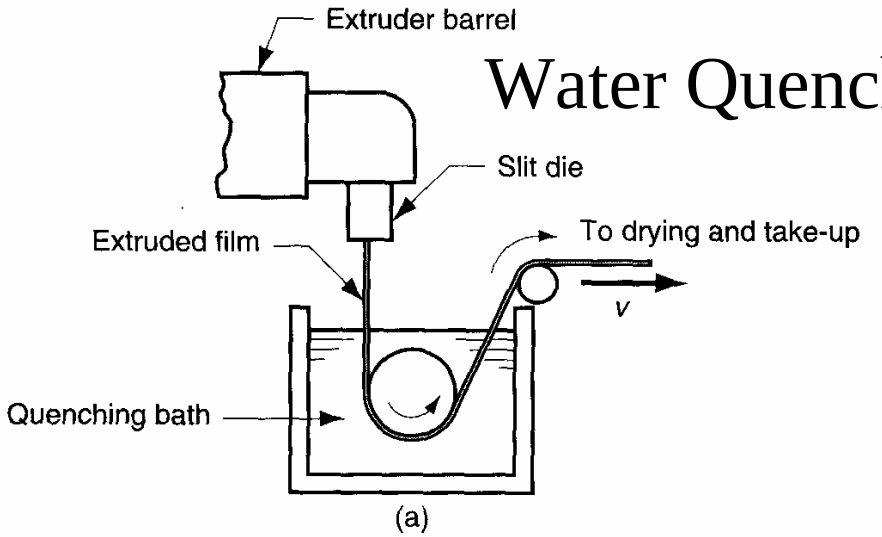
Bambooing

Sheet & Film Extrusion

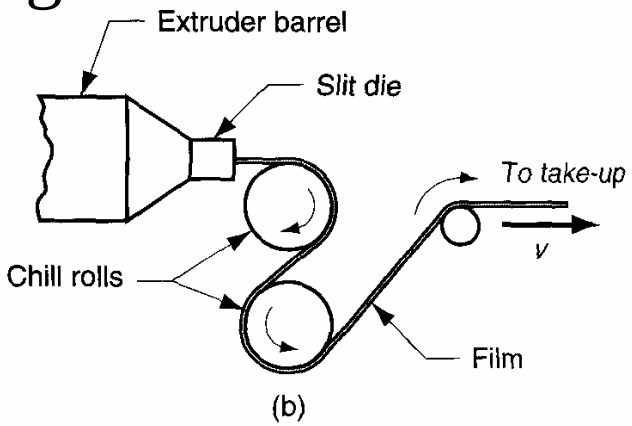


Slit die

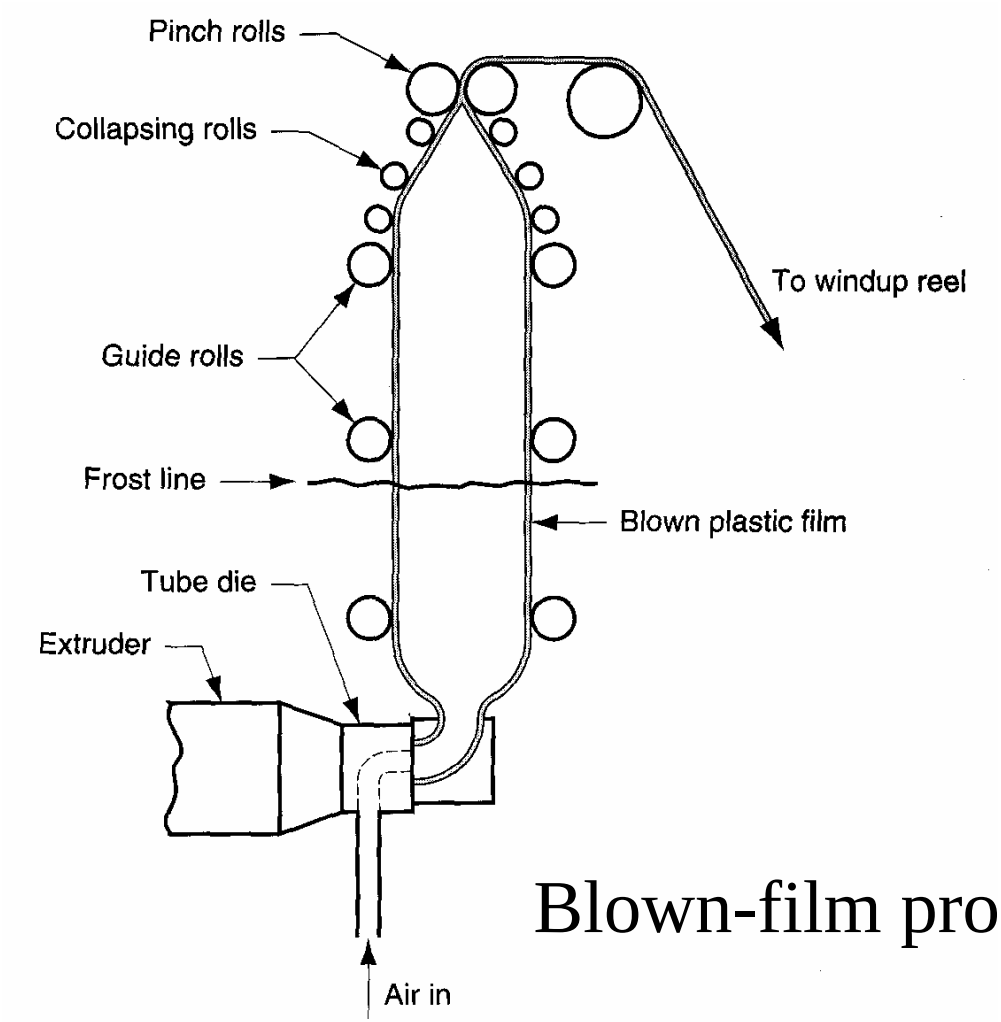
Water Quenching



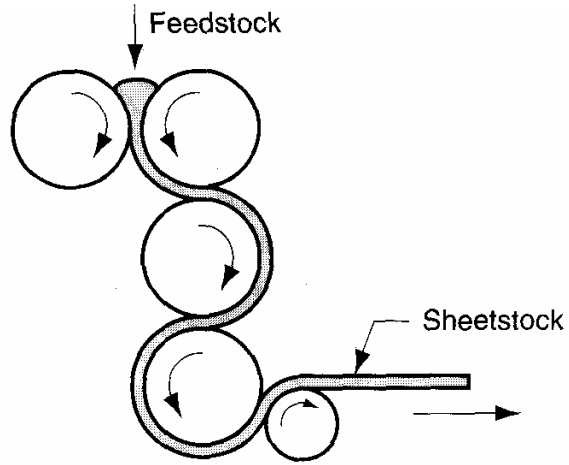
Chill rolls



Extrusion

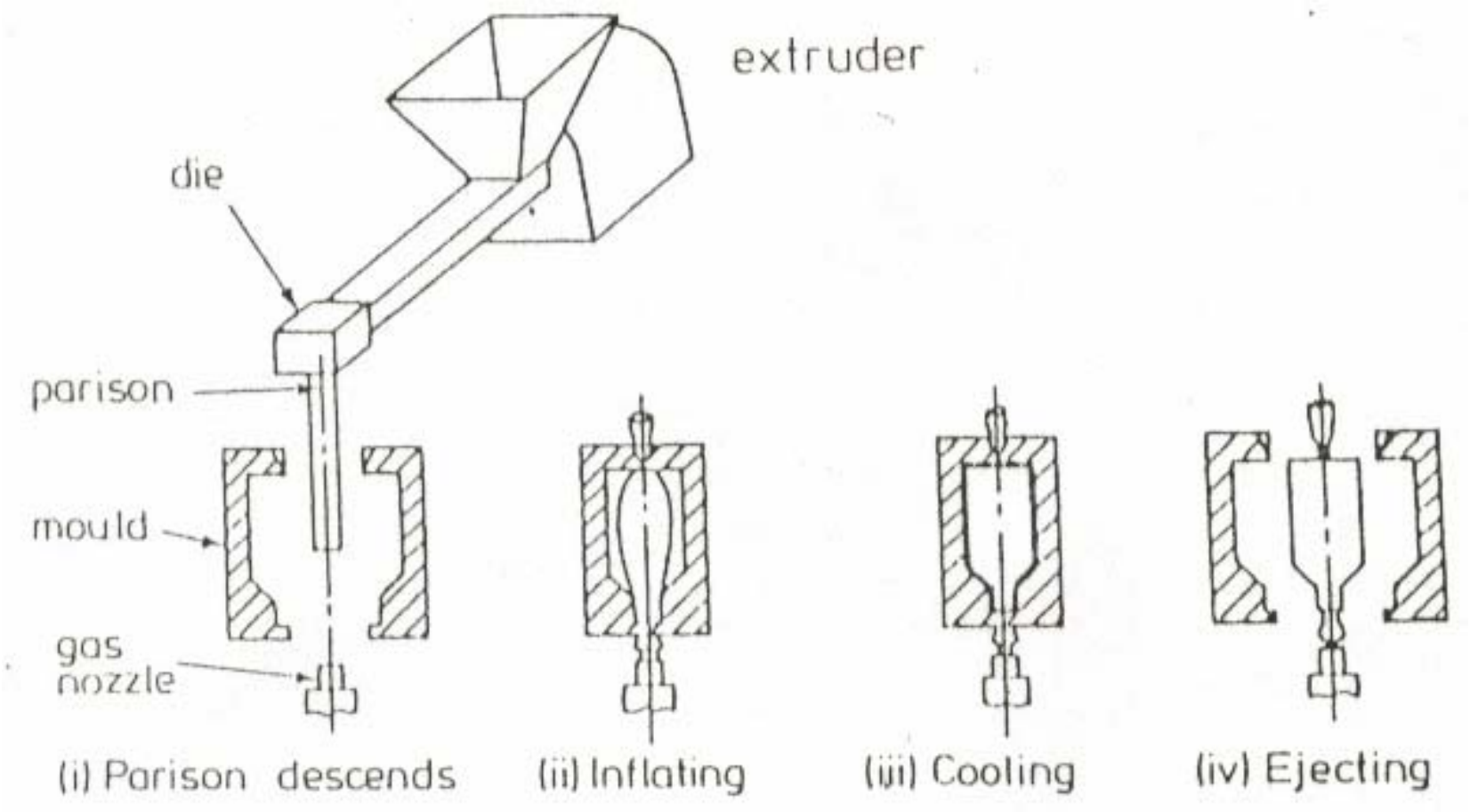


Blown-film processing



Calendering

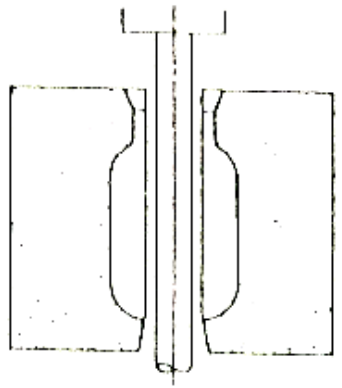
Stages in Blow Moulding



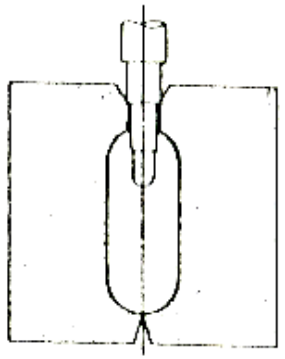
Operation procedures

- Extruded parison is positioned in between mold
- Mold closure and tight
- Hot air blowing expands parison and shapes it to take the mold contour
- Letting the product to cool down
- Open mold and eject the product

Bottle Manufacturing

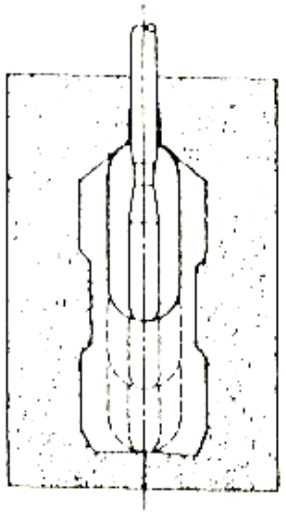


(i) Extrusion

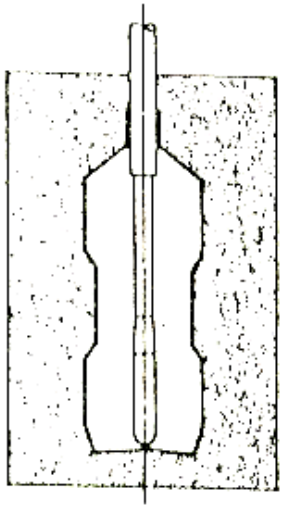


(ii) Inflation of preform

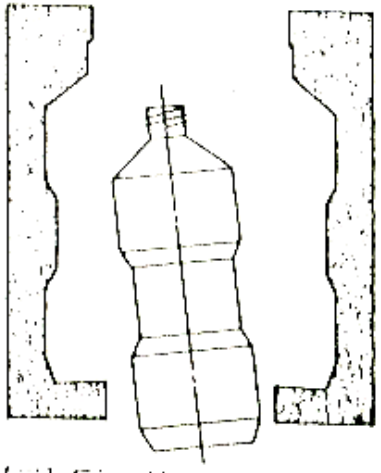
(a) Manufacture of preform



(i) Stretching

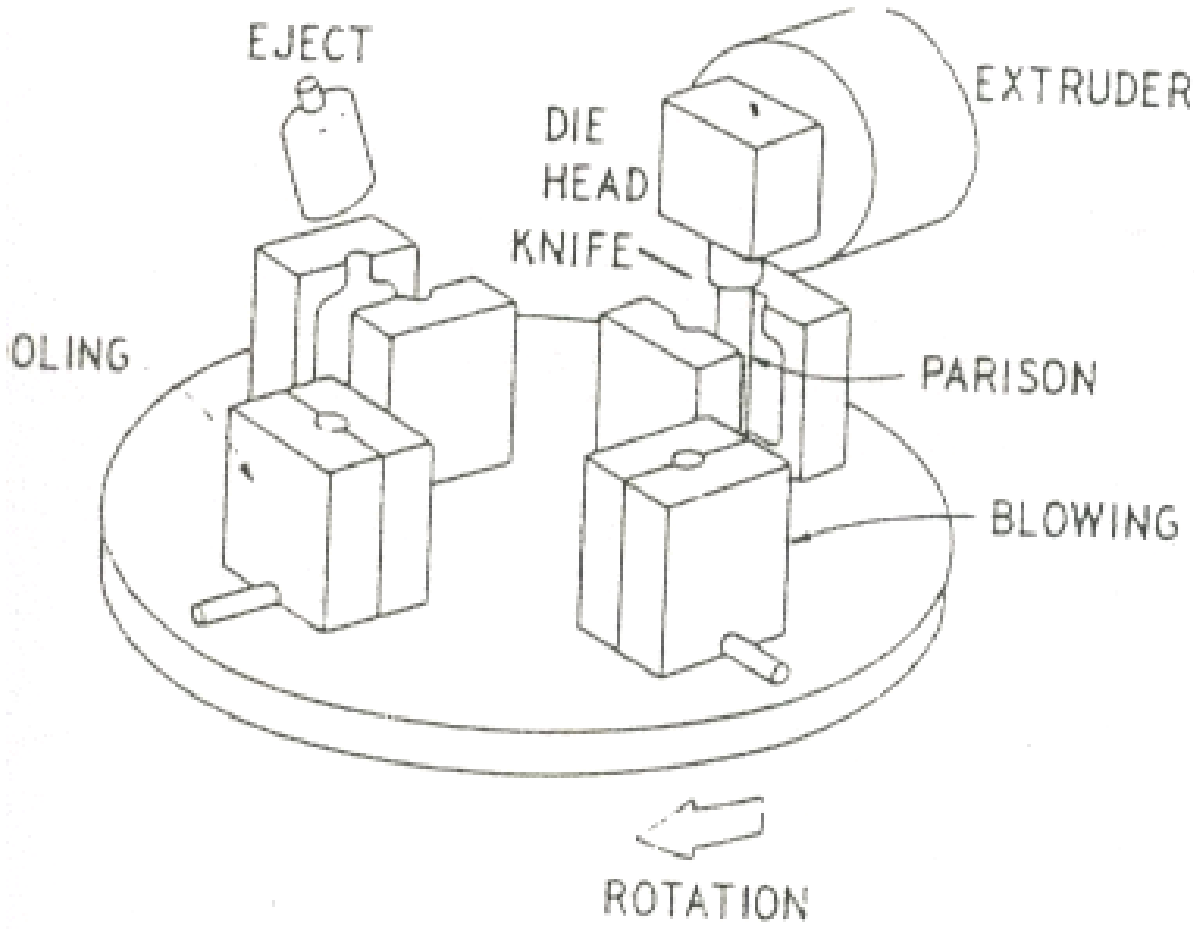


(ii) Inflation

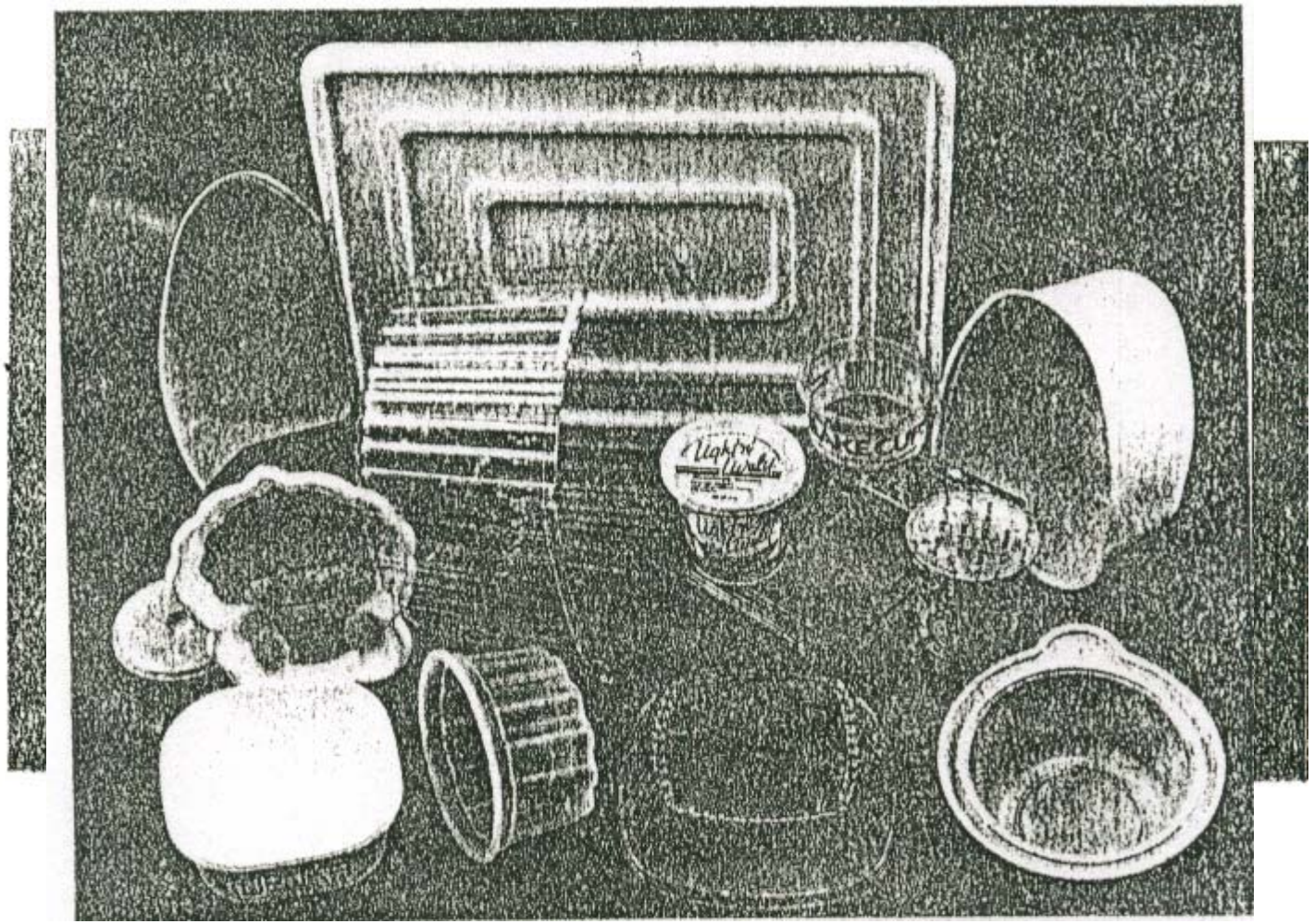


(iii) Ejection

Rotating Horizontal Table



Thermoforming



Thermoforming

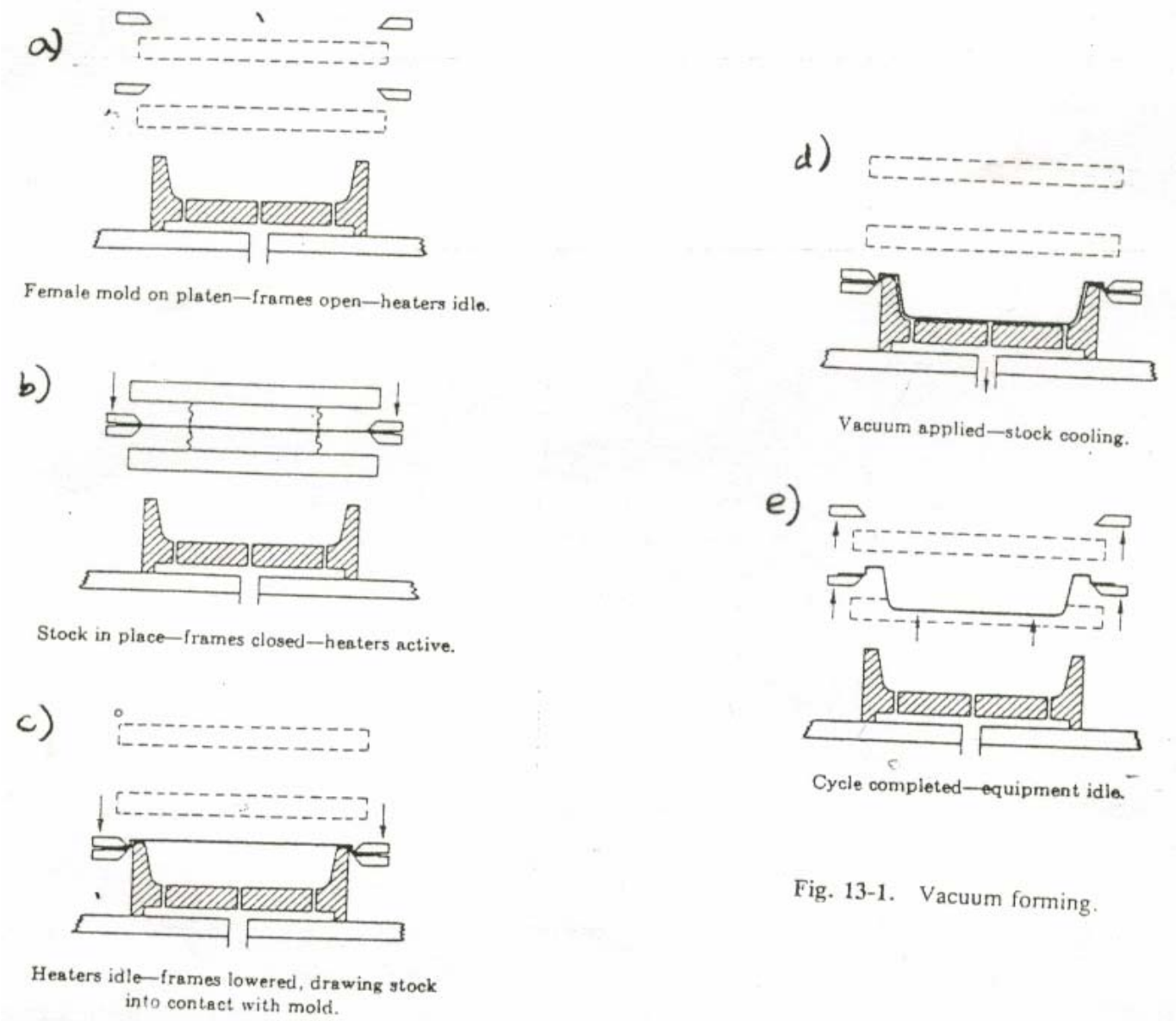


Fig. 13-1. Vacuum forming.

Thermoforming

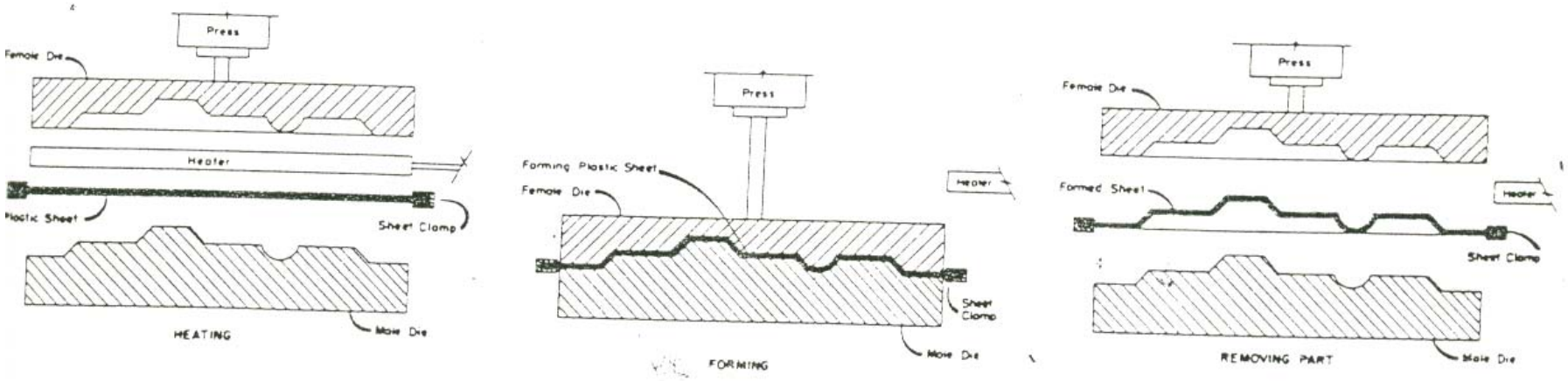


Fig. 13-7. Matched mold forming. (*Courtesy Dow*)

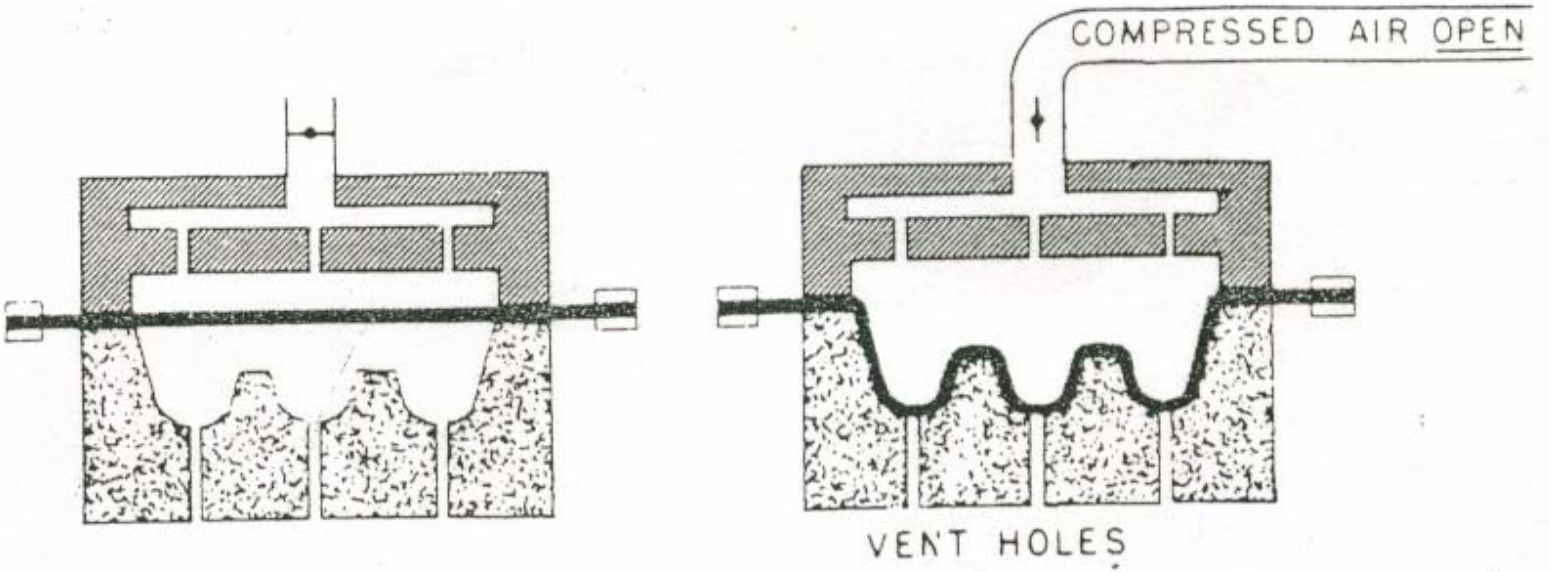


Fig. 13-2. Pressure forming into female cavity. Heated sheet is clamped over cavity, and compressed air pressure forces the sheet into the mold. (*Courtesy Dow*)

Thermoforming

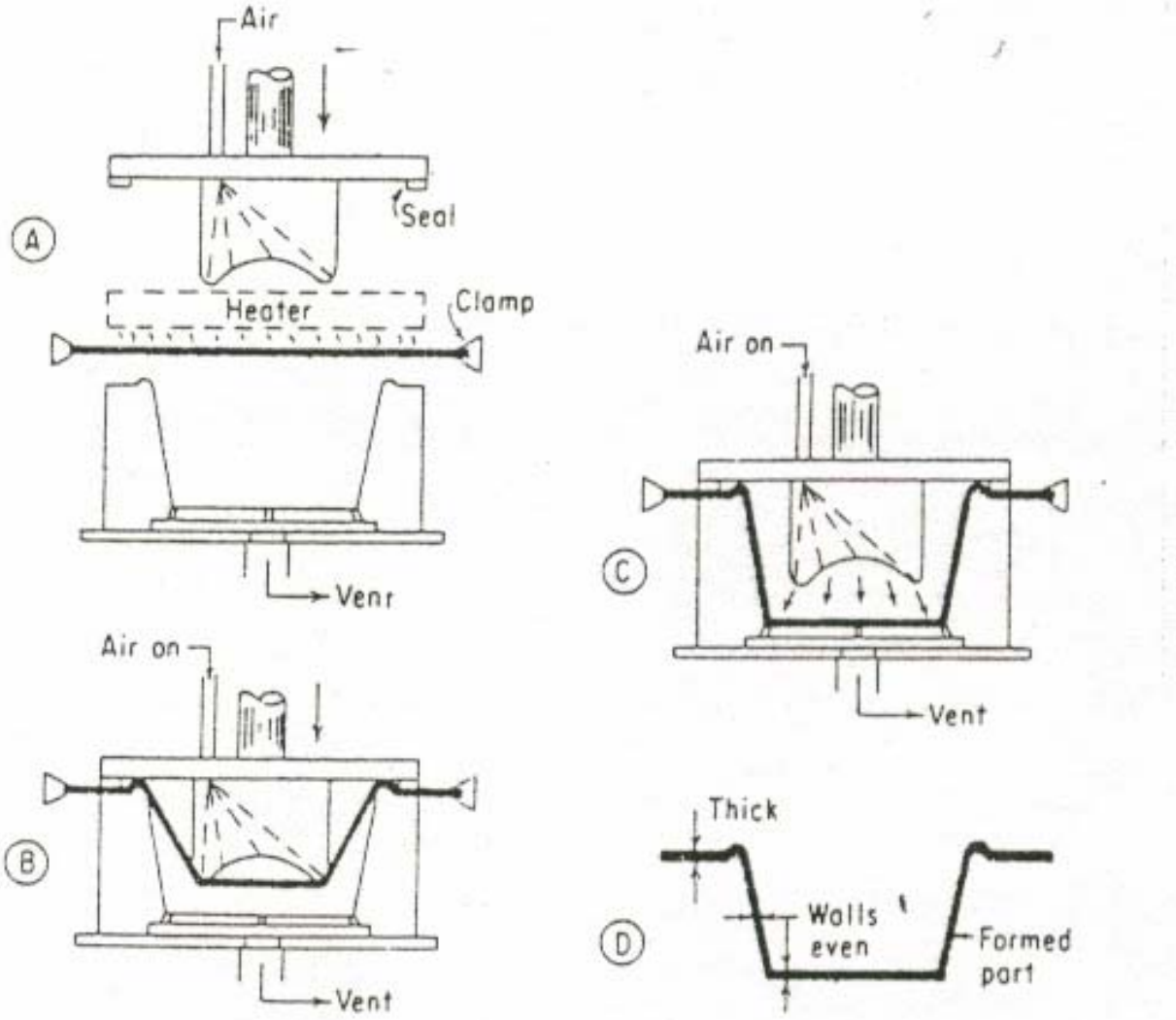


Fig. 13-5. Plug-assist pressure forming. (*Courtesy McGraw-Hill*)

Calendering

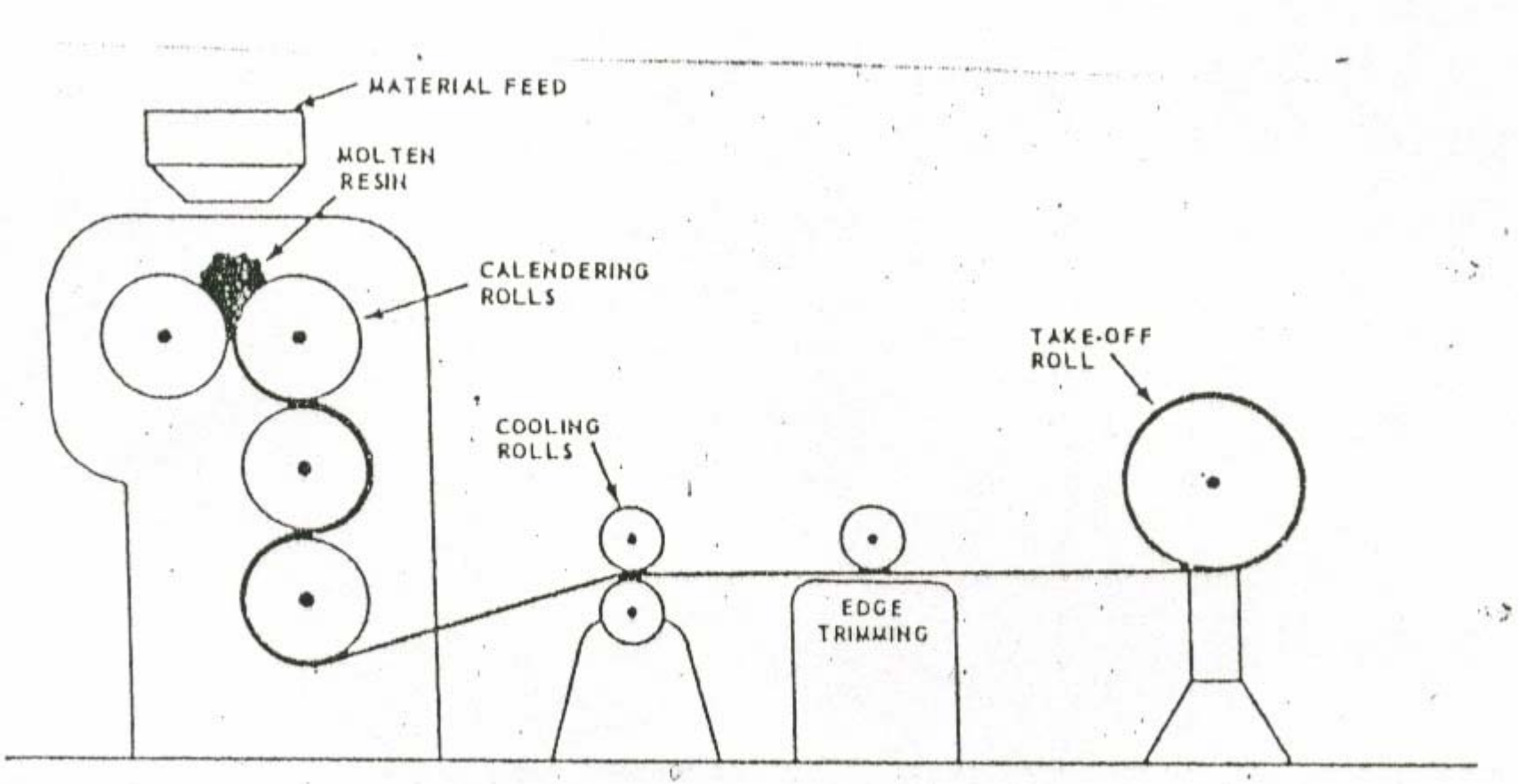


Fig. 9-1. Schematic illustrating the main stages in the calendering of polyvinyl chloride film.

Calendering

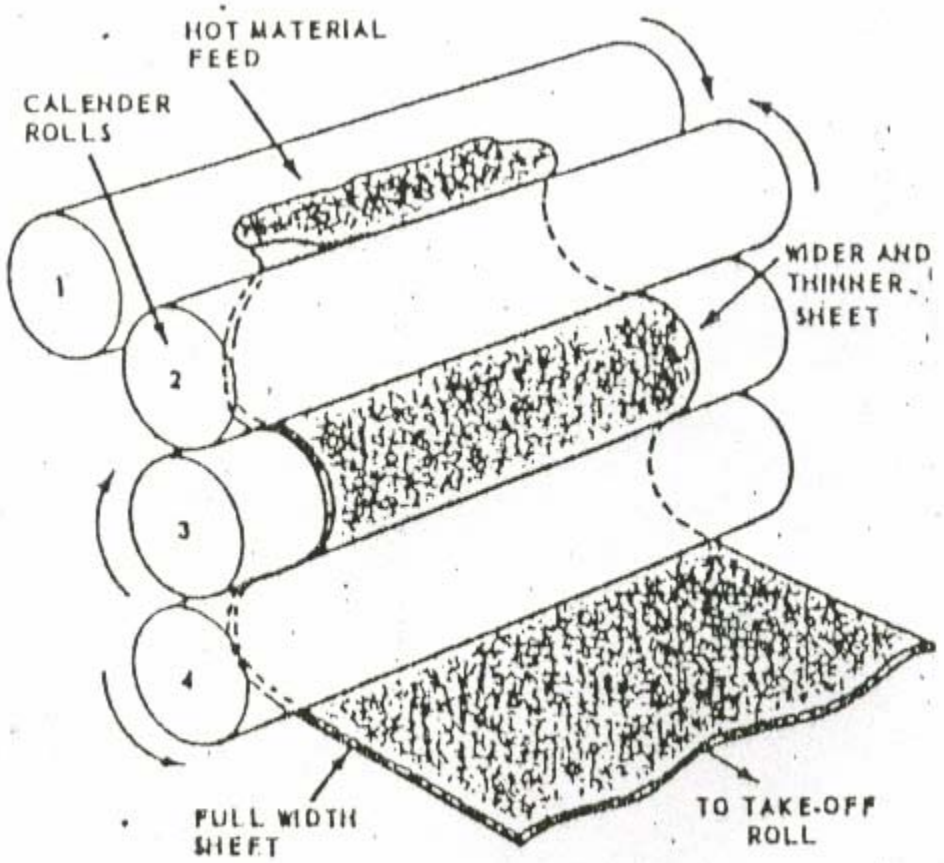
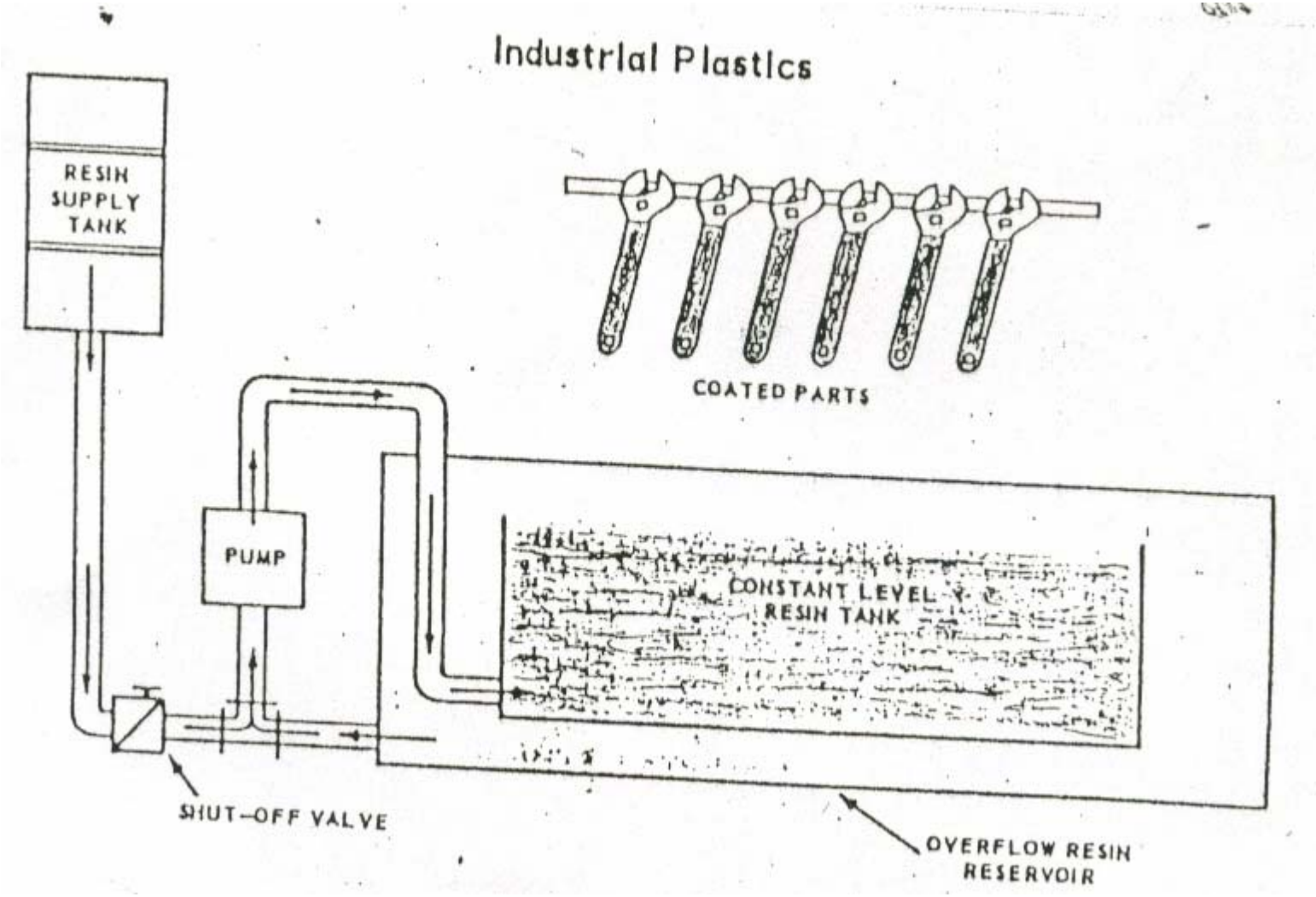
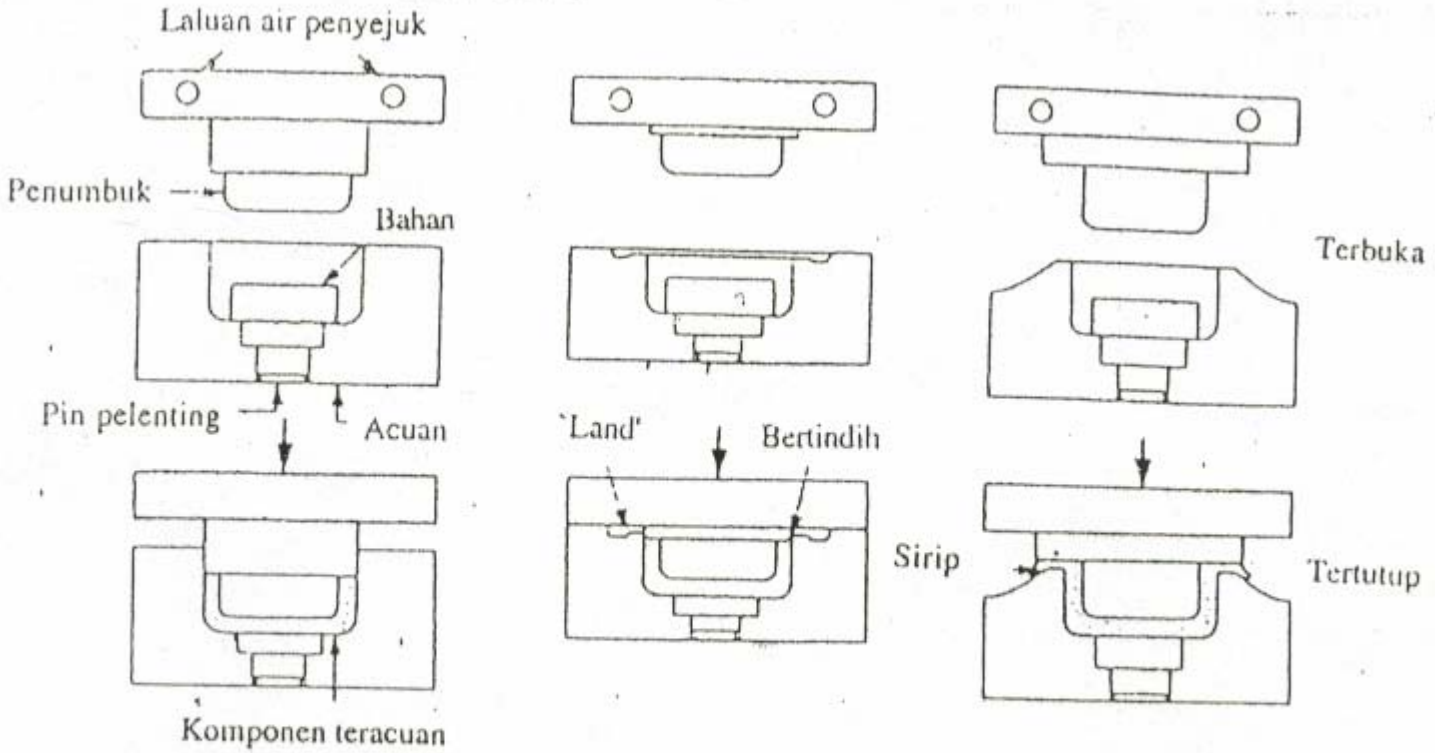


Fig. 9-2. Widening and thinning of calendered sheet as it passes through the rolls.

Plastisol


Industrial Plastics
RESIN SUPPLY TANK
COATED PARTS
PUMP
CONSTANT LEVEL RESIN TANK
SHUT-OFF VALVE
OVERFLOW RESIN RESERVOIR

Compression Moulding



Rajah 11 : Proses pengacuanan mampatan a) Jenis positif, b) Jenis separa positif dan c) Jenis sirip atau lelebih

Transfer Moulding

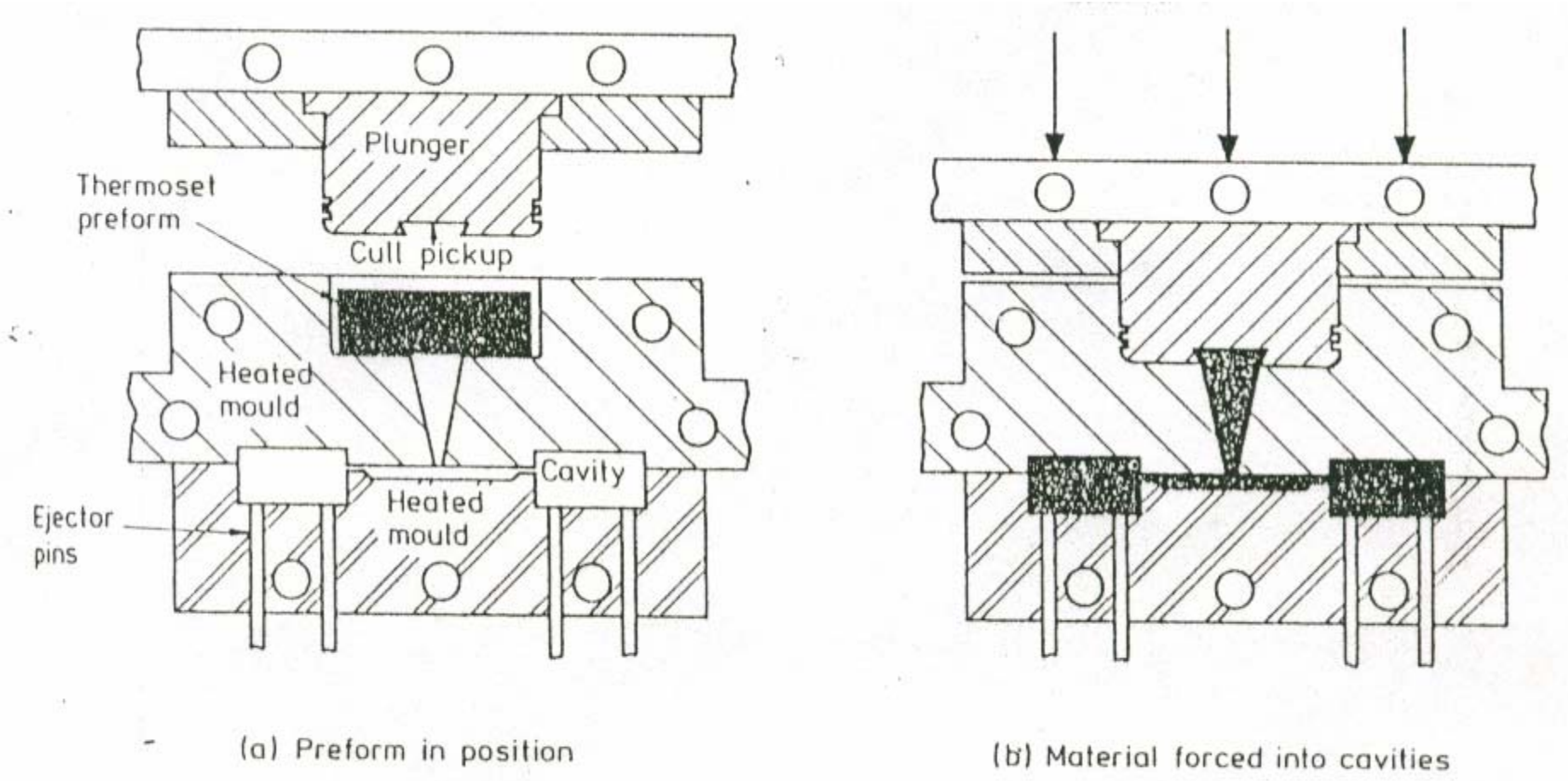


Fig 4.44 Transfer moulding of thermosetting materials

Filamen Winding

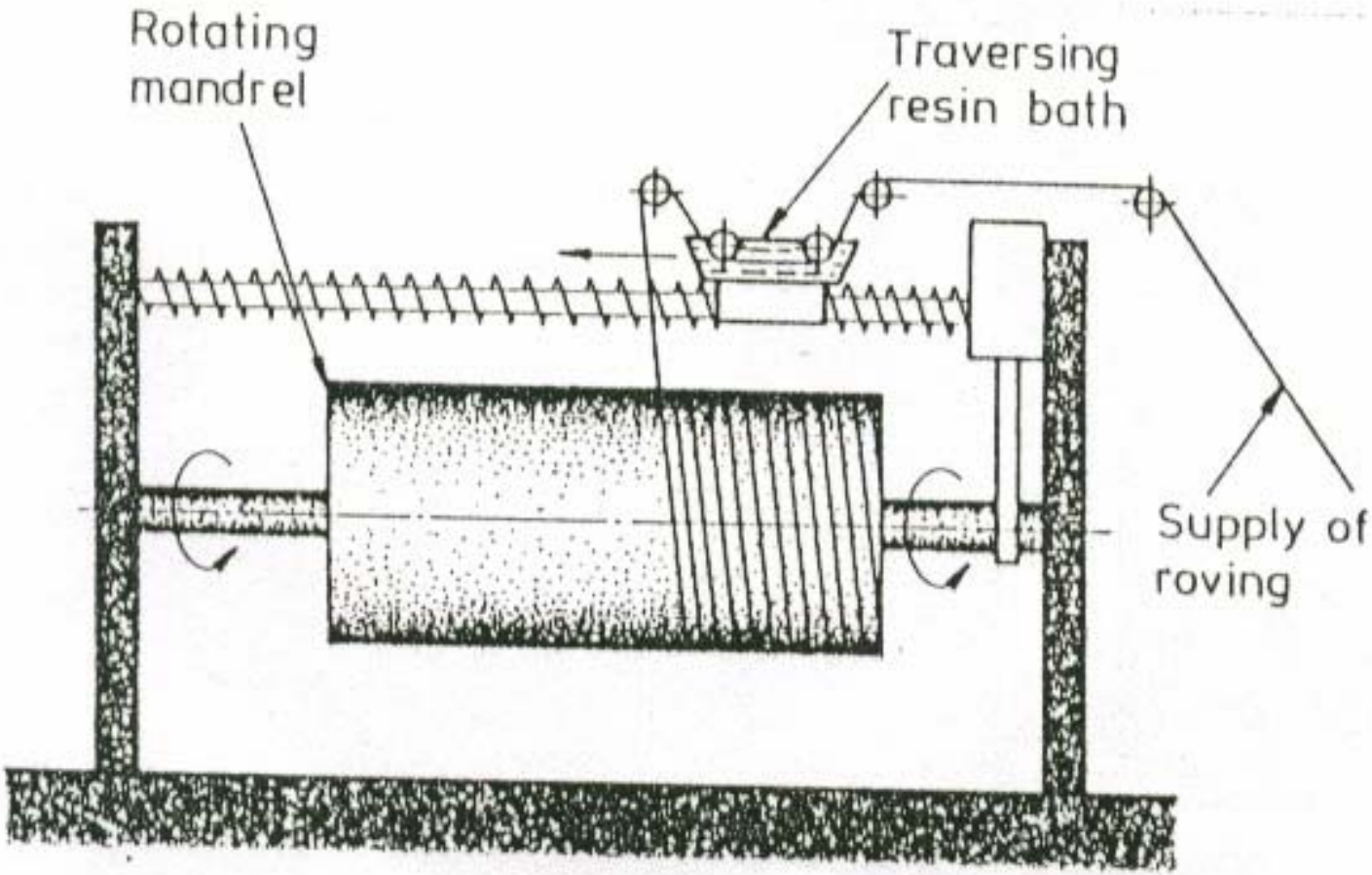


Fig. 4.52 Filament winding process