

Chapter 2

Fabrication Processes



Polymer processing techniques

Materials and tooling

Ch 2 Sl 2

□ materials

- thermoplastics ~ chips
 - resin + additives
- thermosets ~ molding compound
 - prepolymer + hardener (+ fillers + additives)
 - less economical

□ tooling

- mold
 - single- or multi-cavity
 - compression, injection, blow
- die
 - extrusion, pultrusion

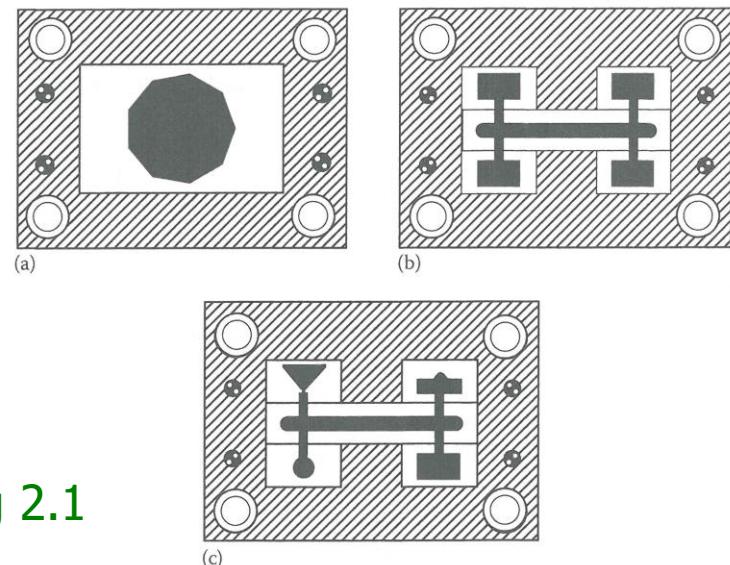


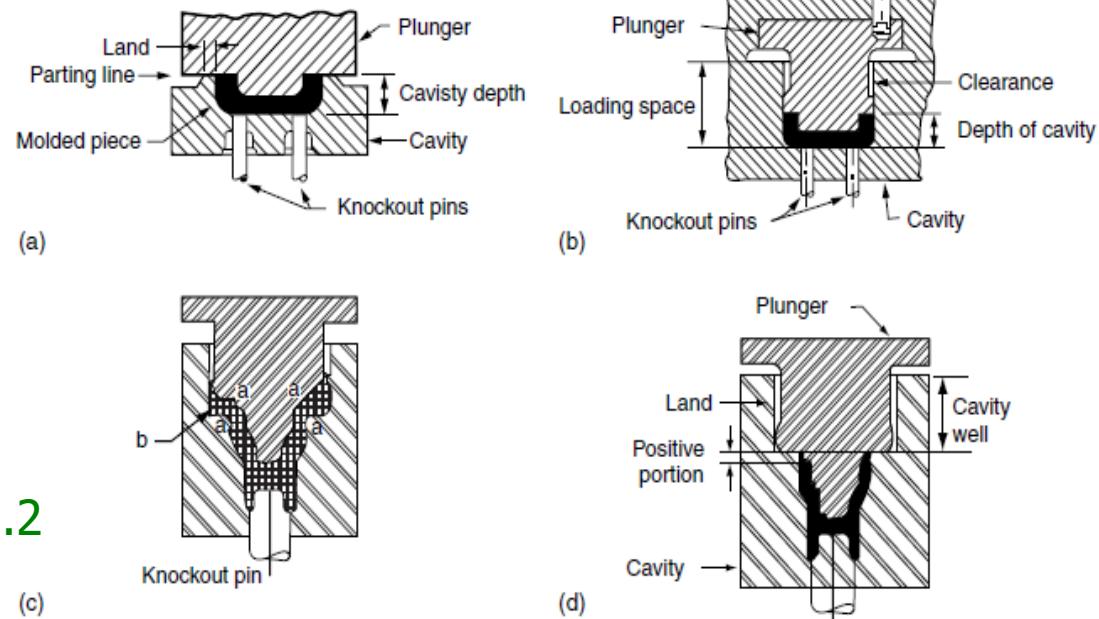
Fig 2.1

Compression molding

Ch 2 Sl 3

- for thermosets
- weigh – preheat – load – compress – hold – open – remove
- holding for curing ~ cooling is not necessary
- molds
 - open flash (a)
 - positive (b)
 - semi-positive (c, d)
 - popular

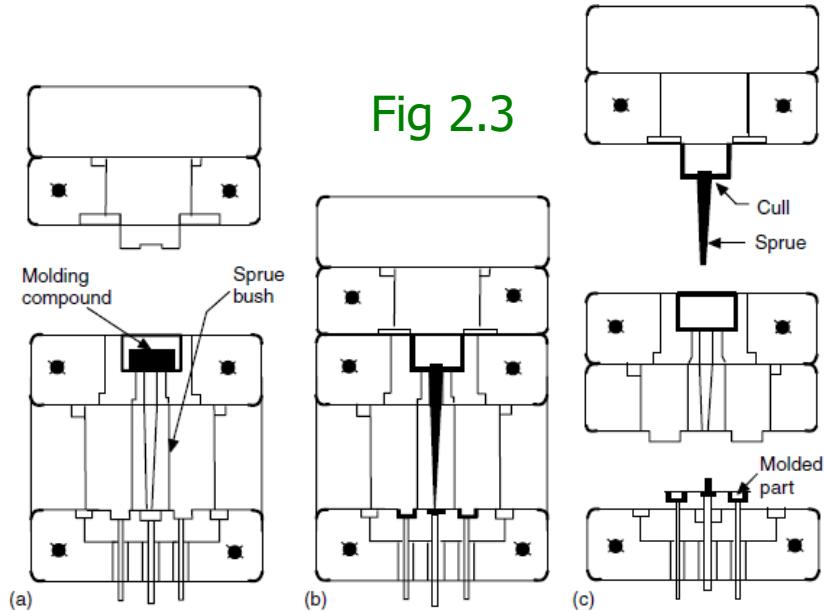
Fig 2.2



Transfer molding

Ch 2 Sl 4

- for thermosets
- injection + compression
 - pot-type Fig 2.3
 - plunger-type Fig 2.4
 - screw-type Fig 2.5



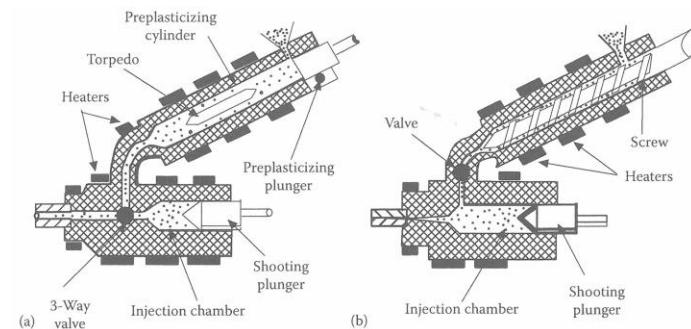
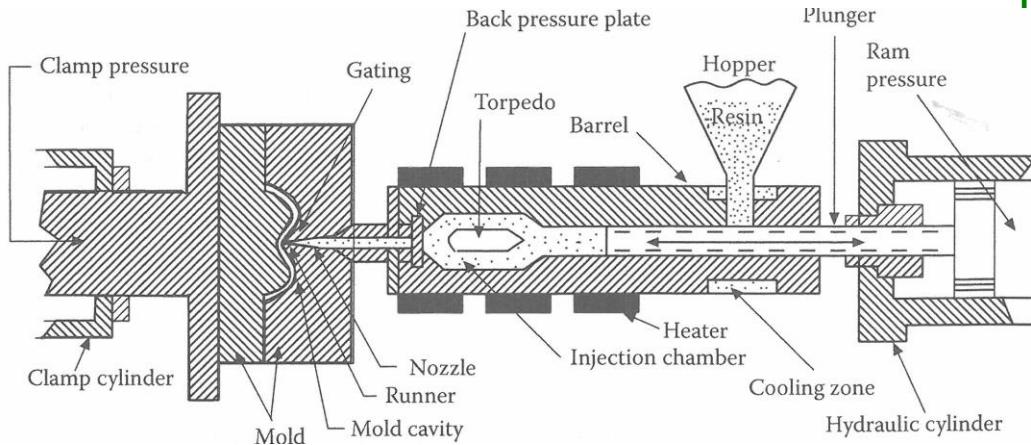
- compared to compression molding;
 - need (3x) larger pressure
 - use fluid not powder
 - better heat transfer → shorter cycle time
 - smaller and finer objects ~ multi-cavity

Injection molding [射出成形]

Ch 2 Sl 5

- thermoplastics softened, injected, hardened
- 1 of the 2 most important processes for thermoplastics
 - The other is extrusion. ~ for continuous 2-D cf) resin ~ injection-grade vs extrusion-grade
- injection unit
 - plunger-type ~ less popular
 - w or w/o preplasticizer

Fig 2.6,7



□ injection unit (cont'd)

- reciprocating screw-type ~ popular
 - rotating – accumulating – injecting – hold

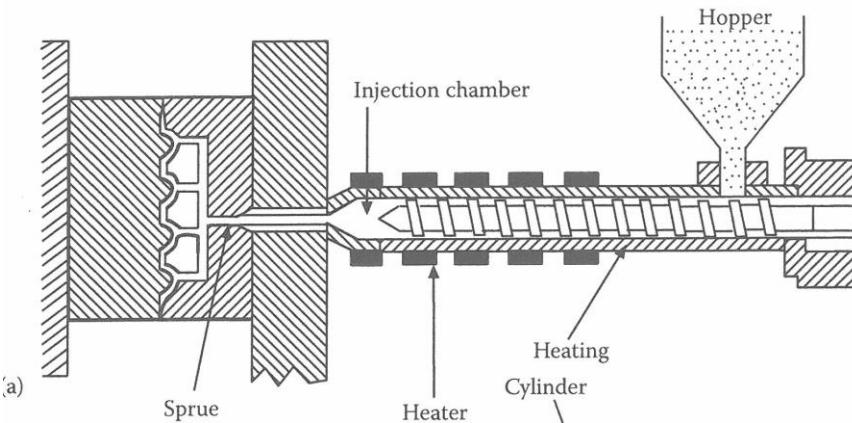


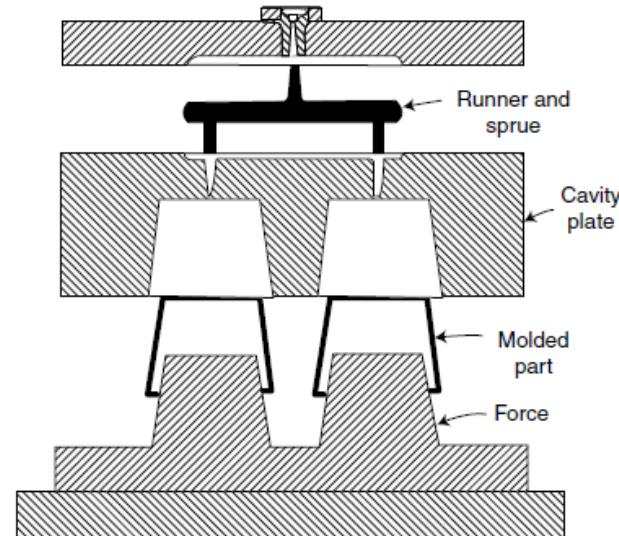
Fig 2.8,10

□ clamping unit

- press ~ ton
spec ~ ton/gram

□ mold ~ gram

- sprue – runner – gate – cavity



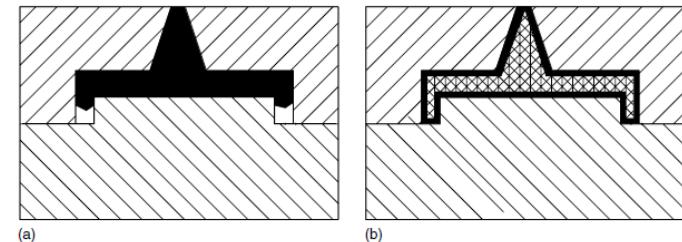
Variations of injection molding

Ch 2 Sl 7

□ structural foam (injection) molding

- short shot of {melt + gas or foaming agent}
- resin skin + foam core

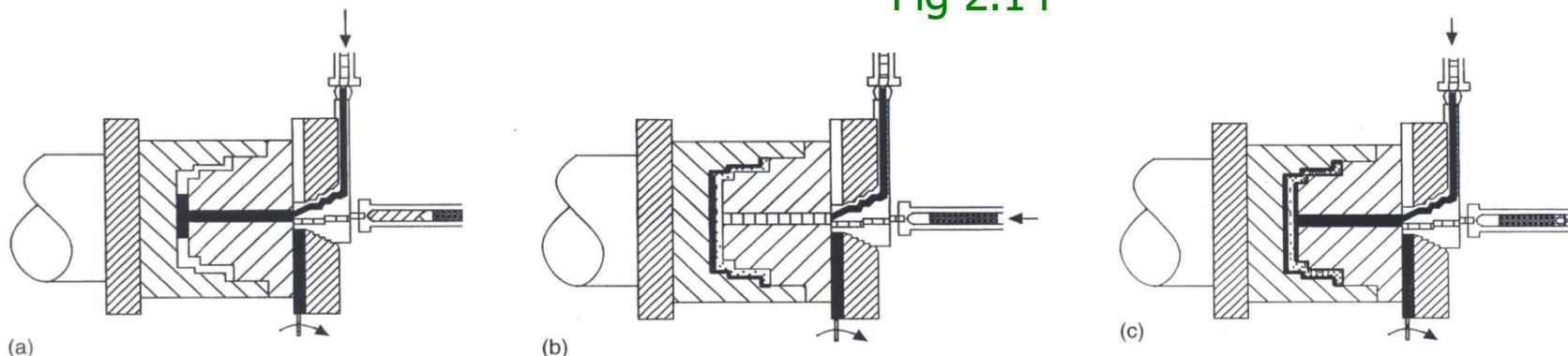
Fig 2.13



□ sandwich molding [co-injection]

- skin polymer – core polymer – skin polymer
- for performance or cost

Fig 2.14



□ gas(-assisted) injection molding

- resin injection – gas injection
- for hollow parts
- 'cimpres' (controlled injection pressure)

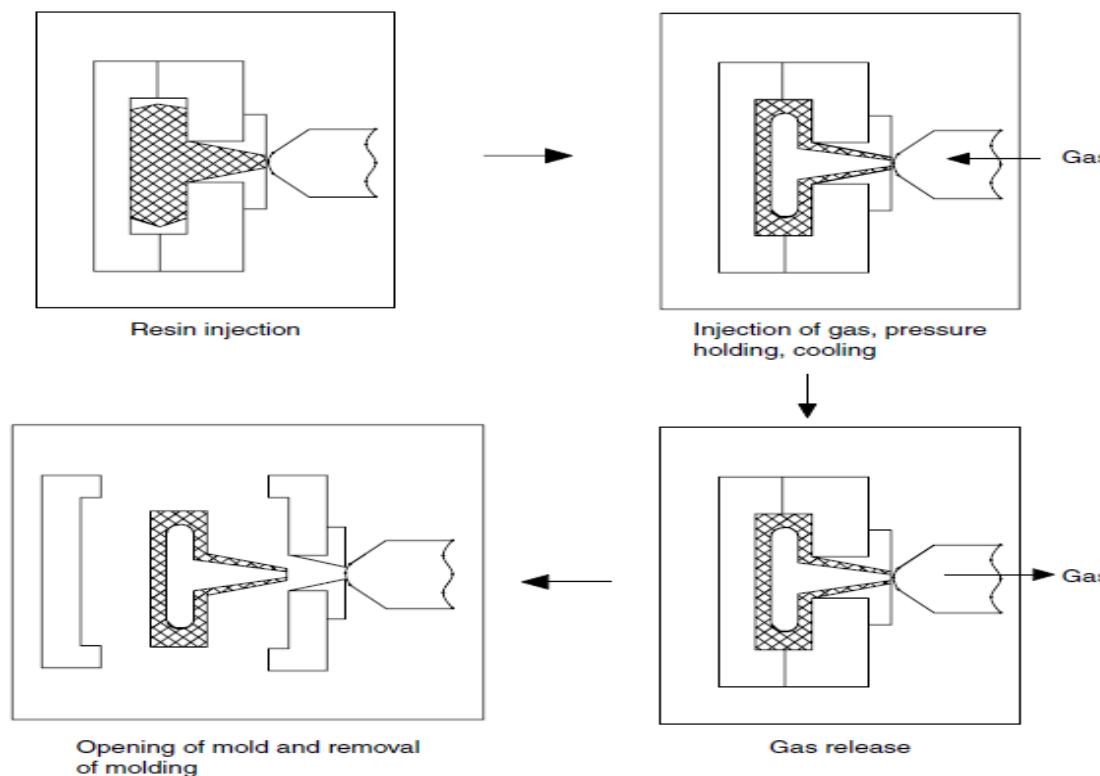


Fig 2.15

□ injection molding for thermosets

- screw transfer molding
- warm barrel + hot mold
- for thermosets and reinforced thermosets

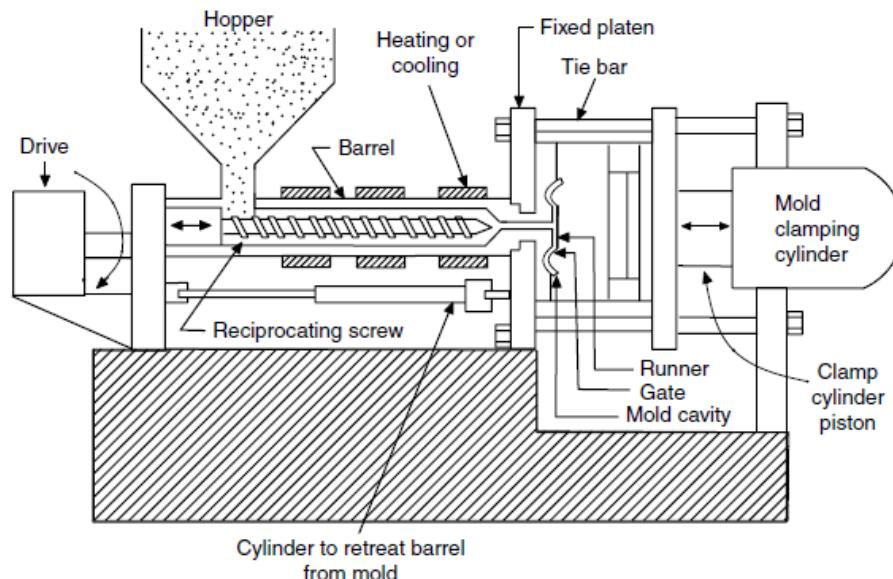


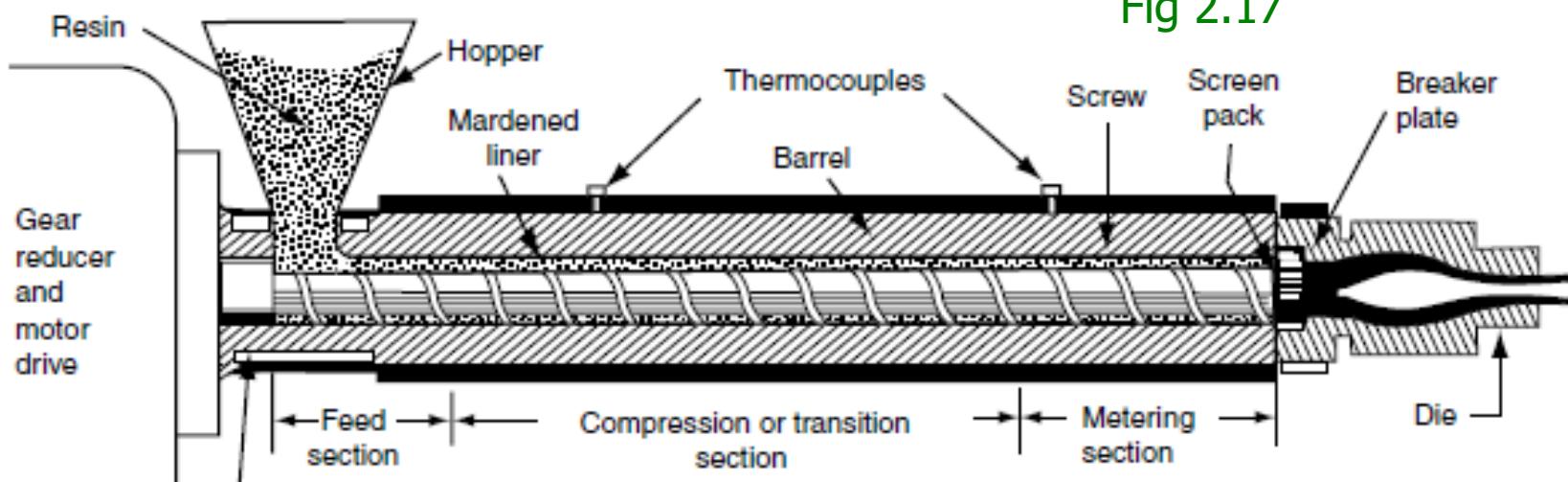
Fig 2.16

Extrusion [壓出]

Ch 2 Sl 10

- 4 zones [sections] of extruder
 - feed zone ~ preheating and conveying
 - compression or transition zone ~ pressurizing
 - metering zone ~ homogenizing
 - die zone ~ providing back-pressure and profiling
 - screen pack/breaker plate ~ back-pressure, filtering, memory-erasing

Fig 2.17



□ design and operating

■ extruder spec

- barrel diameter and L/D
- like 40ϕ 30

■ screw and die design

- special designs ~ mixing zone, venting zone

■ temperature and rpm

□ twin-screw extruder

■ better mixing

■ for compounding additives, blends

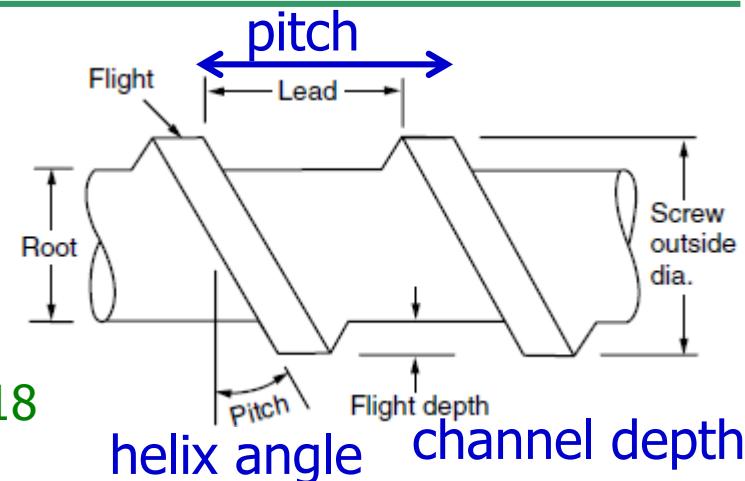


Fig 2.18

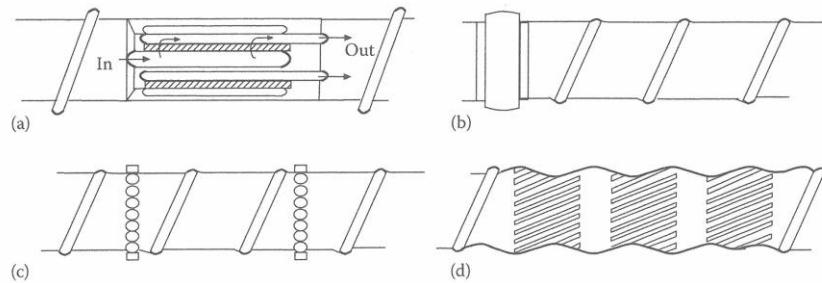


Fig 2.19

Extrusion-based processing

Ch 2 Sl 12

□ profile extrusion

- film, sheet ($t > .01''$)
 - orientation
 - biaxial stretching
- pipe (id), tube (od/wt)
- complex
 - die-swell

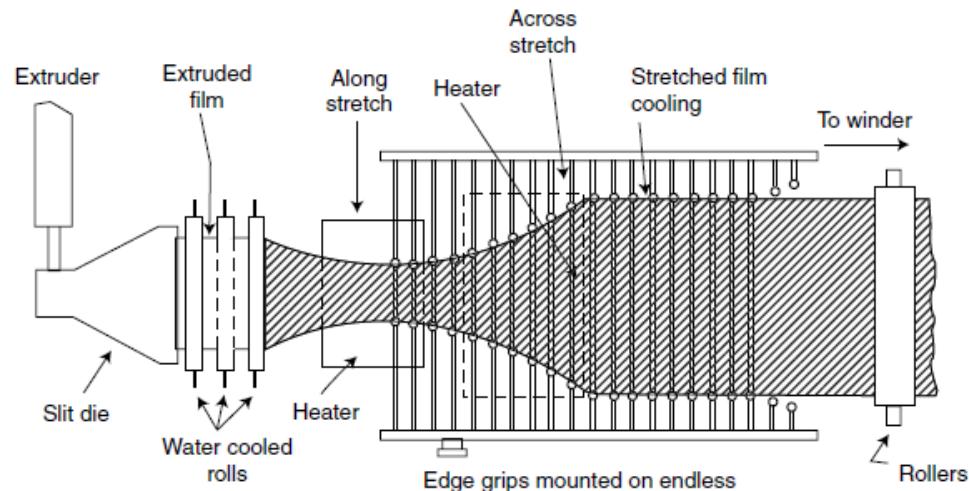


Fig 2.27

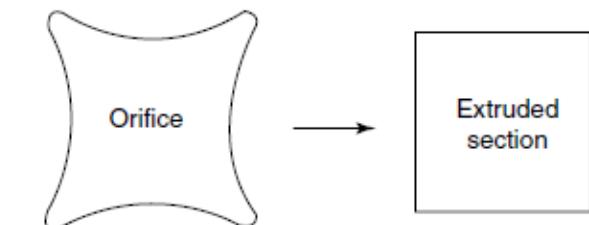


Fig 2.31



□ blown-film extrusion = film-blowing

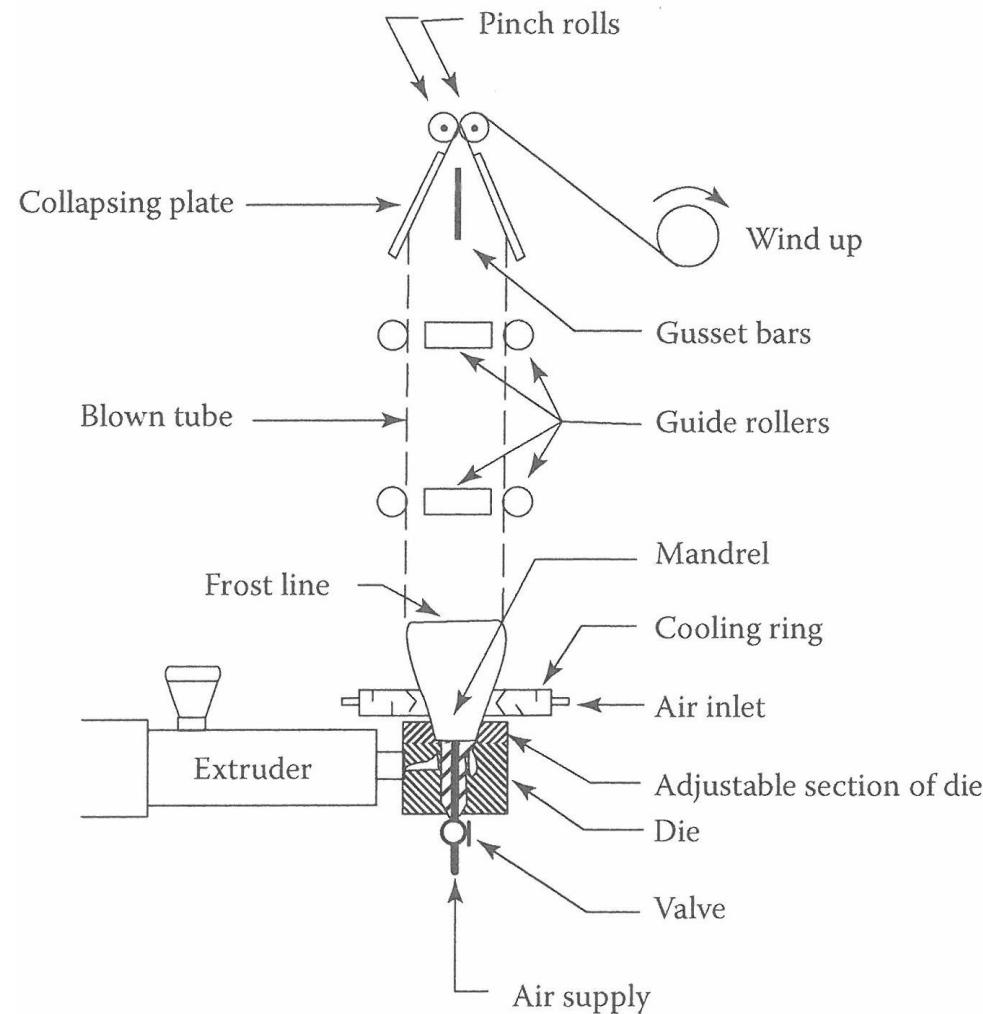
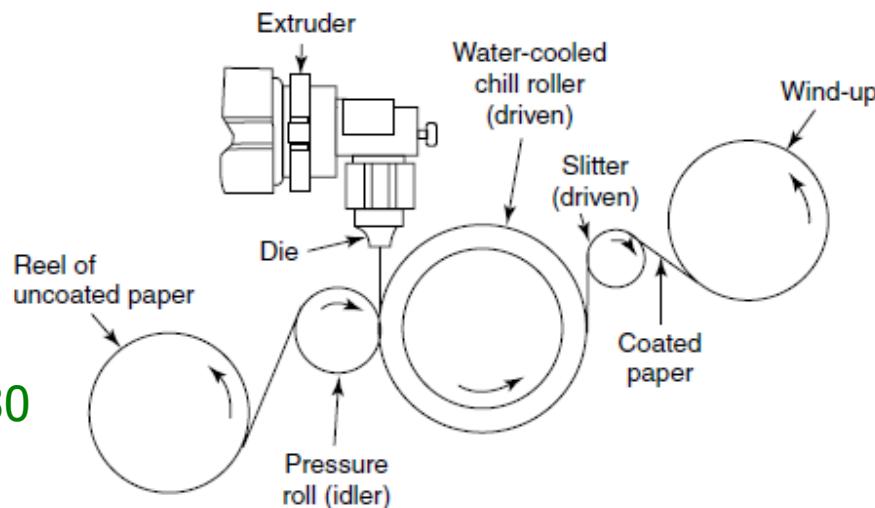


Fig 2.23

□ extrusion coating

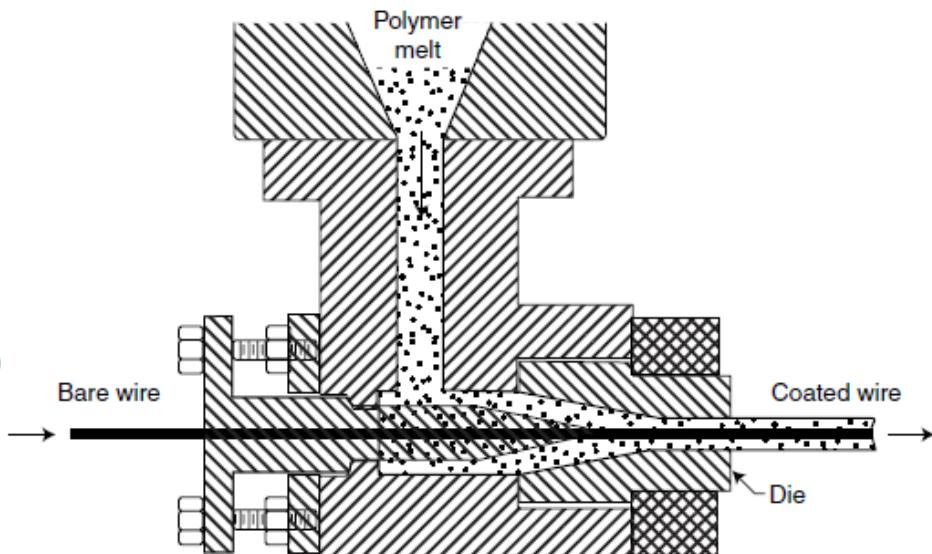
Fig 2.30



□ crosshead extrusion

■ wire and cable covering

Fig 2.29



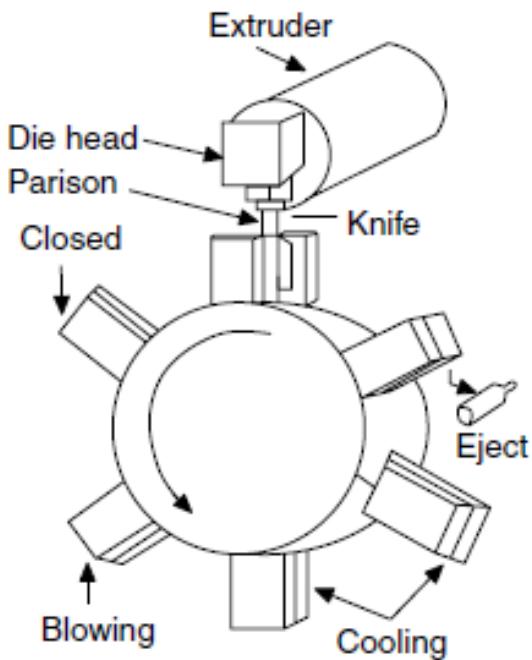
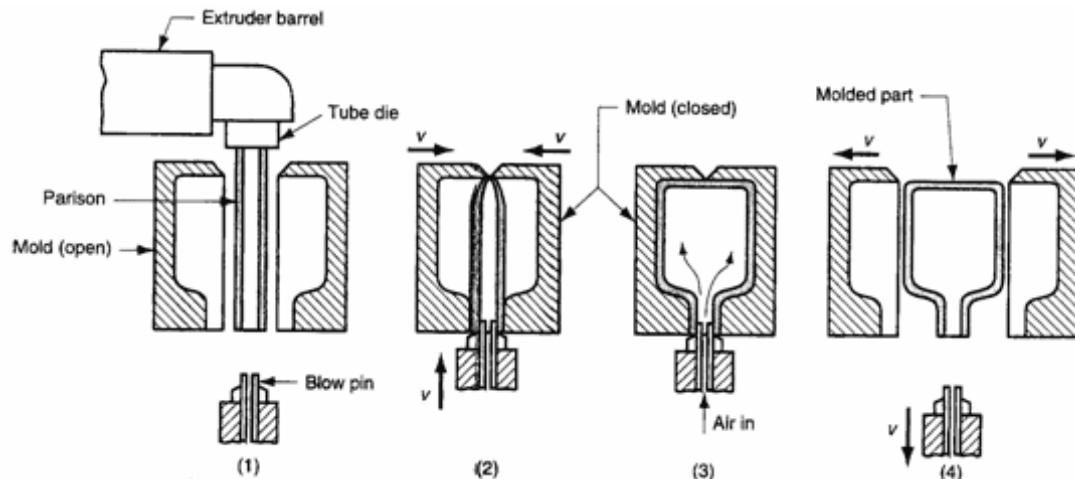
Blow molding

Ch 2 Sl 15

□ extrusion BM

- extrude 'parison' – close mold – blow – cool
- 1 mold
- for PE bottles

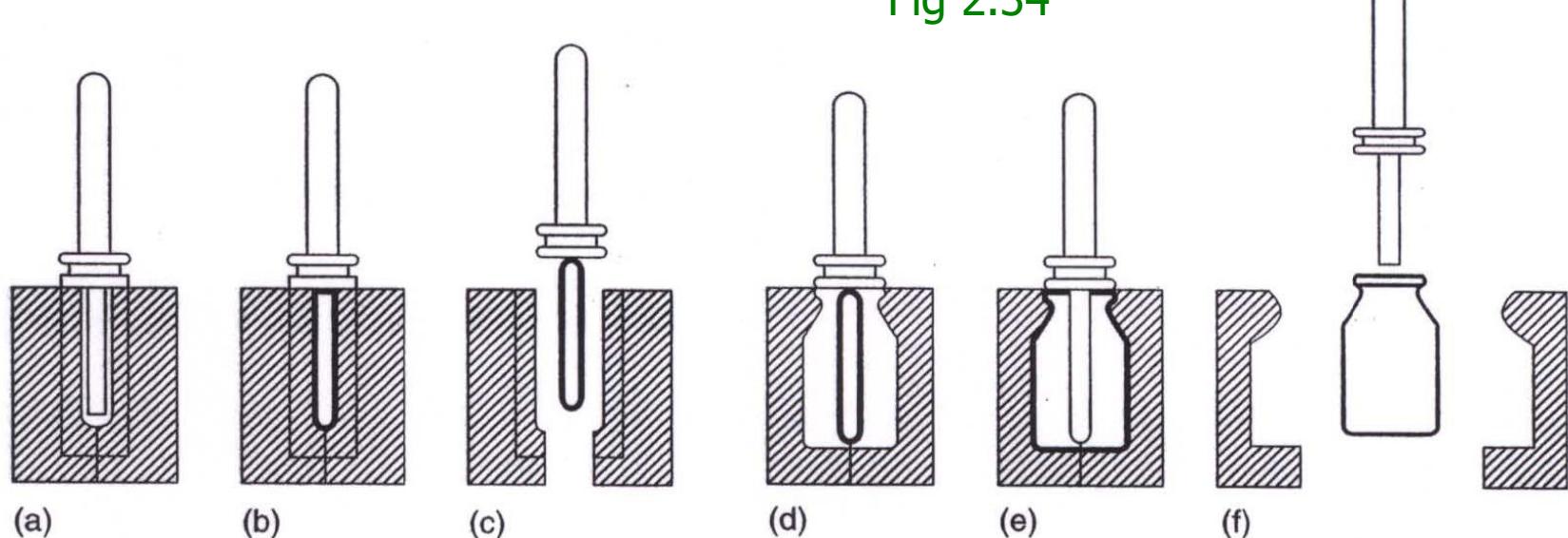
Fig 2.32



□ injection BM

- injection-mold 'preform' (onto metal core) – transfer to 2nd mold – blow
- for PET bottles
 - quench in 1st mold – reheat – blow in 2nd mold
 - 'stretch blow molding'

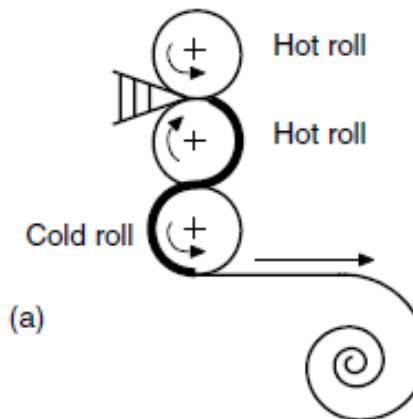
Fig 2.34



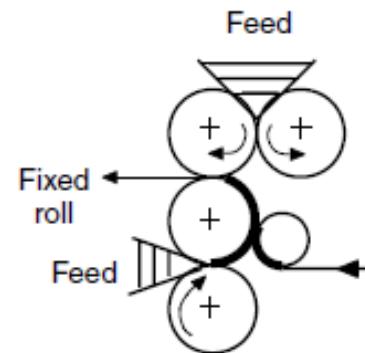
Calendering

Ch 2 Sl 17

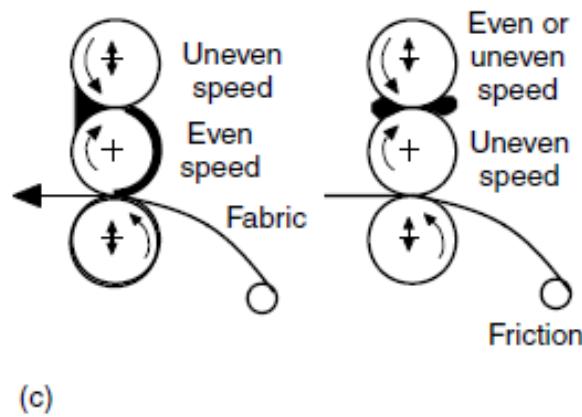
- for films, sheets, coatings of
 - plasticized PVC
 - rubbers



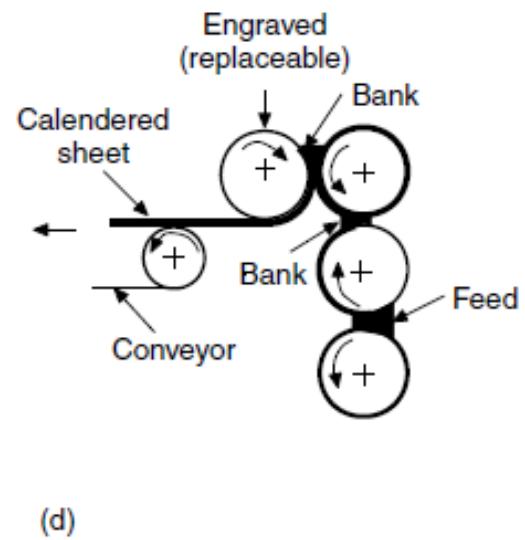
(a)



(b)



(c)



(d)

Fig 2.35

Fiber spinning

Ch 2 Sl 18

❑ for fibers

- spinning through spinneret, then cold-drawing

❑ 3 types

- melt ~ melt – cooled
- dry ~ solution – solvent removed by heated gas
- wet ~ solution – polymer ppt by nonsolvent

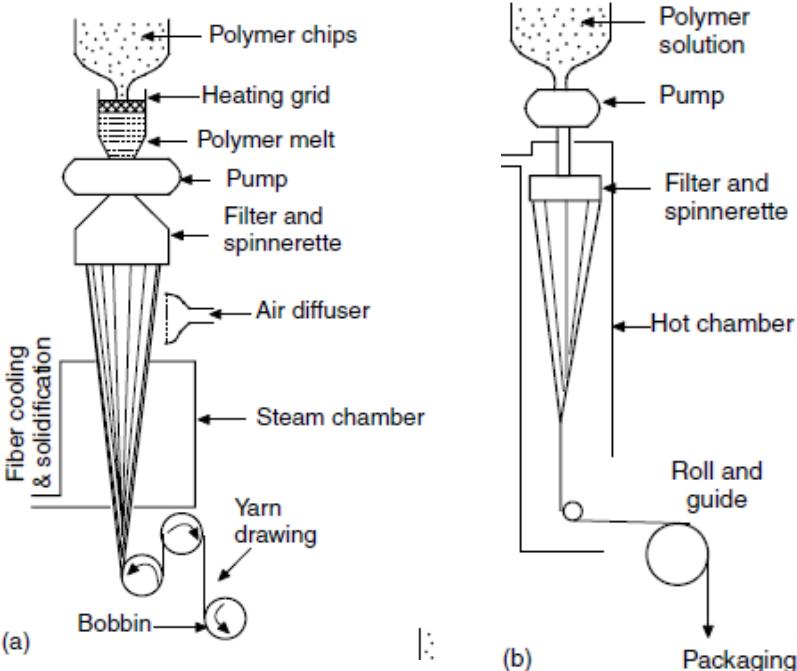


Fig 2.36

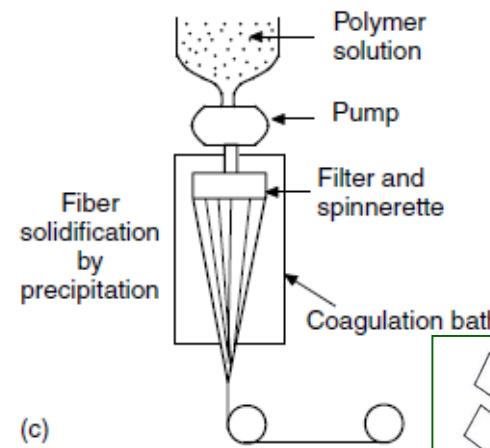
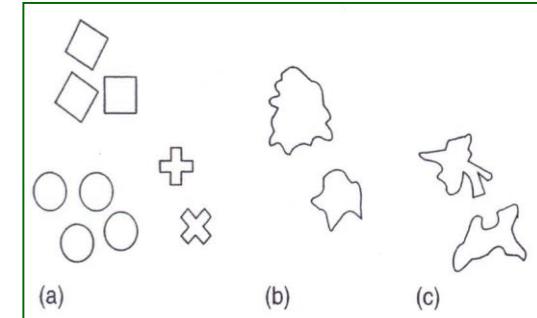


Fig 2.37



Electrospinning

Ch 2 SI 19

□ nanofibers (of $d < 100 \text{ nm}$)

- solution or melt at spinneret forms 'Taylor cone'

- by electrostatic forces [repulsion + coulombic]

- at high V , jet ejected

- breaks surface tension
 - stretch and whip to form
 - non-woven nanofiber mat

□ control of diameter and structure

- variations ~ woven, emulsion, coaxial, ---

□ rate of production

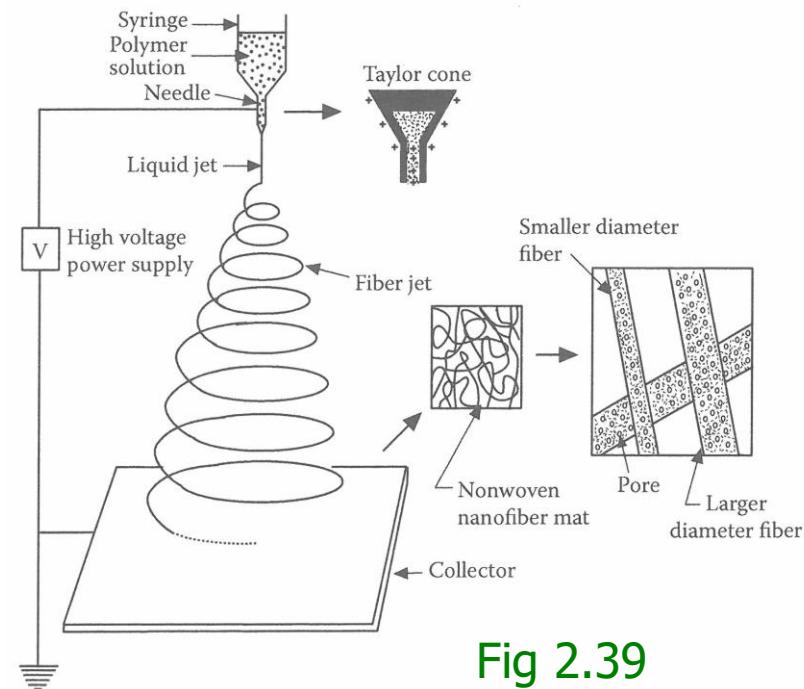


Fig 2.39

Thermoforming

Ch 2 SI 20

- ❑ thermoplastics sheet heated and formed

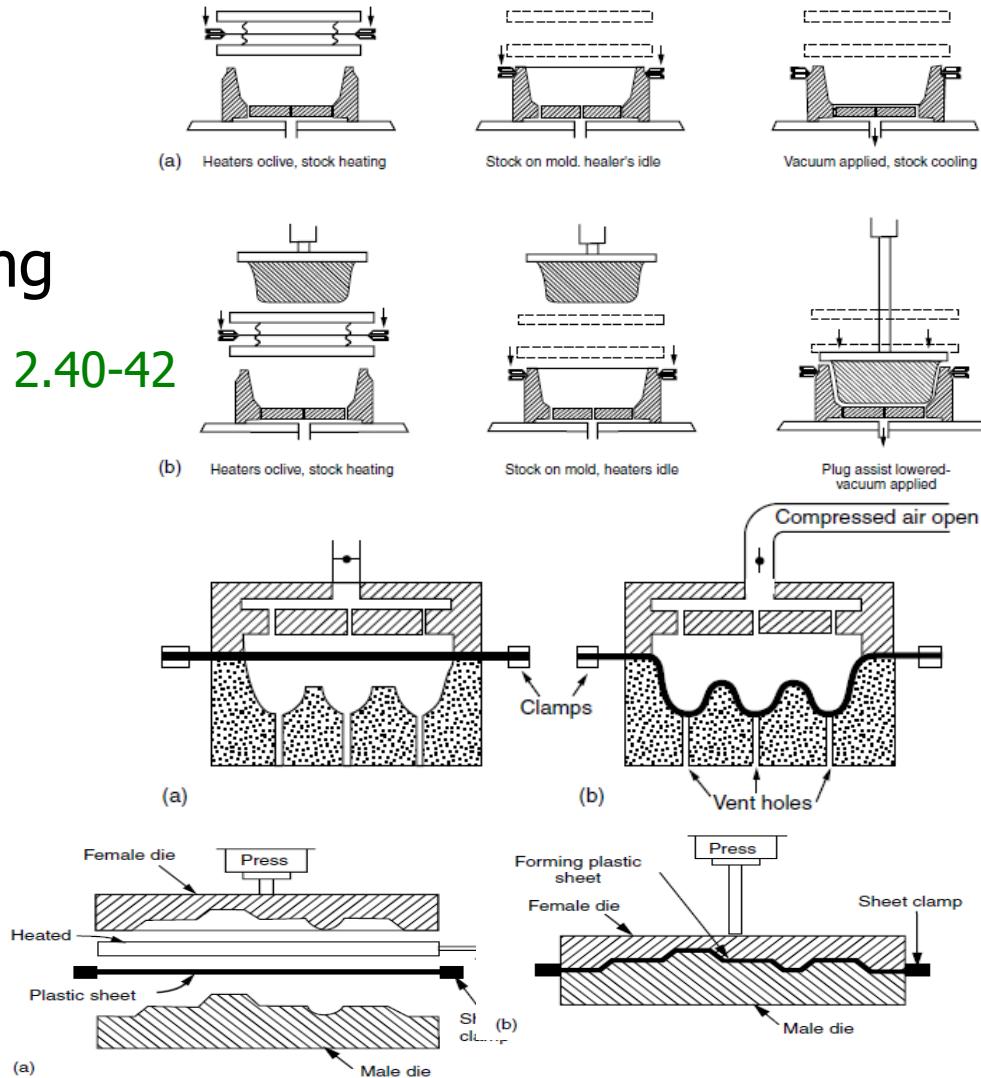
- ❑ types

- vacuum forming
- plug-assisted vac forming
- pressure forming
- mechanical forming

- ❑ for simple shapes

- cups
- bathtubs
- packaging

Fig 2.40-42



Casting

Ch 2 Sl 21

□ simple casting

- TP or TS poured to molds or on the drum, belt
- cast polymerization ~ Plexiglas®

□ plastisol casting

- for plastisol or PE powder
 - * plastisol ~ paste of fine particle PVC + plasticizer
- dip casting
- slush casting (or molding)
- rotational molding (or rotocasting)

Fig 2.44

