Blow Molding

A. Parison extrusion
B. Blowing
C. Cooling
D. Ejection

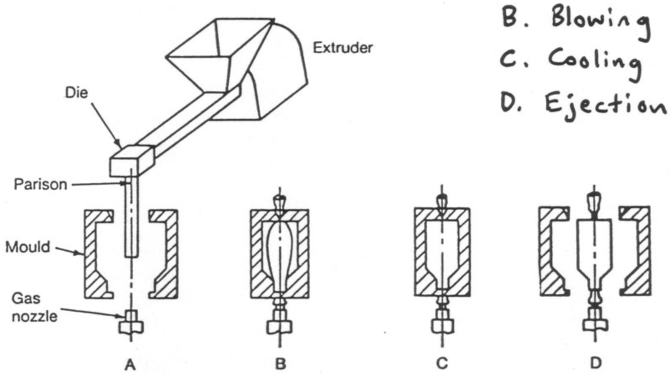


Fig. 7.40. Extrusion-blow moulding (after Crawford).

VENTS ARE CRUCIAL

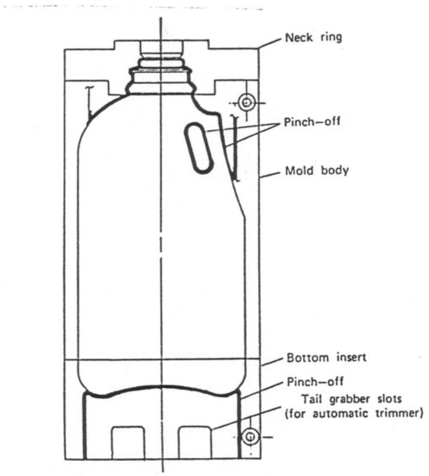
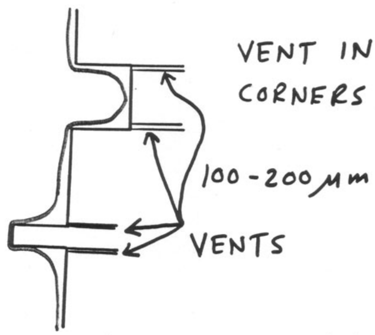


Fig. 15.14 A blow molding mold for a container with a handle. from J. D. Frankland, *Trans. Soc. Rheol.*, **19**, 371 (1975).]



GENERALLY VENT IN THE "TRAPPED" LAST PLACES OF THE MOLD TO FILL.

Blow Molding
STRETCH-BLOW MOLDING

STAGE 1
PREFORM

STAGE 2
STRETCH
AND BLOW

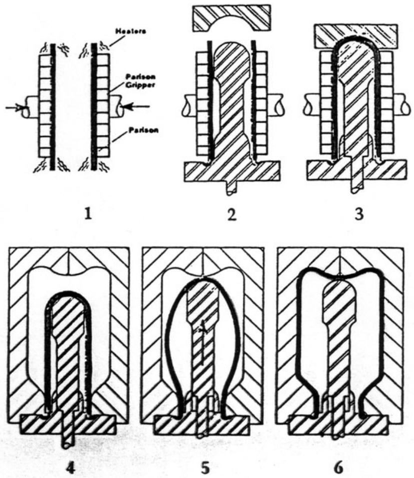
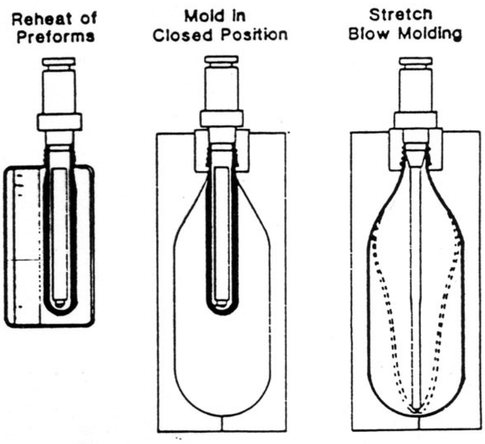


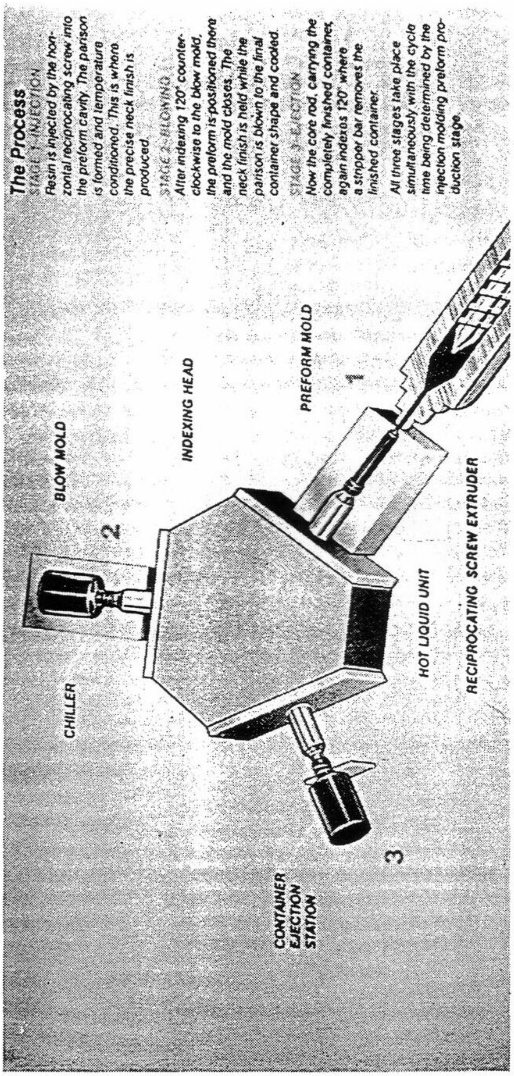
Figure 4-2 Cold tube process, product forming steps. (1) Precut cool pipe length is heated. (2) Neck finish is die formed. (3) Bottom end is closed. (4) Preform in stretch blow mold. (5) Forming mandrel produces axial stretching. (6) Blow air produces hoop stretching.



PRODUCES
BIAXIAL
ORIENTATION
(GREATLY
IMPROVES
STRENGTH)

Figure 4-6 Two-stage reheat blow molding.

Blow Molding
INJECTION-BLOW MOLDING



No pinch-off scrap
Excellent thickness control
Fewer surface defects

Blow Molding
BLOW MOLDING DEFECTS

Axial thickness variations in parison

Surface defects: Mottle, Extrusion Die Lines

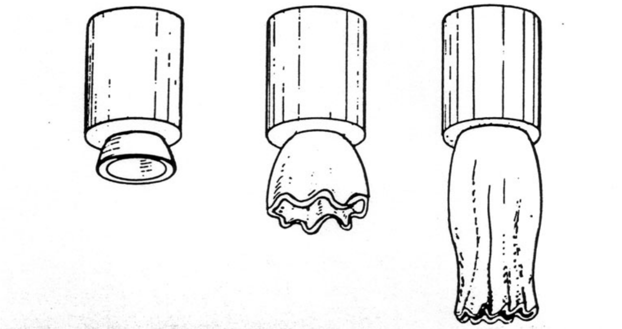


Fig. 15.15 Parison pleating, illustrating initially smooth partison becoming pleated with **increased length.** [Reprinted with permission from J. S. Schaul, M. J. Hannon and K. F. **Wissbrun,** *Trans. Soc. Rheol.*, **19**, 351 (1975).]

Pinch-off scars, trimming

TABLE 9-3 Advantages and Disadvantages of Blow-Molding Operations

Operation	*Advantages*	*Disadvantages*
Extrusion blow molding	High production rates; low tooling costs; wide selection of equipment	Large amount of scrap; uses recycled scrap; limitations on wall thickness; trimming facilities needed
Injection blow molding	No scrap; excellent thickness control; accurate neck finishes; outstanding surfaces, can produce low volume of products	High tooling costs; larger objects not possible
Stretch blow	Economical; improved properties; accurate control of wall thicknesses; reduced weights allowed	

Blow Molding
PARISON SAG

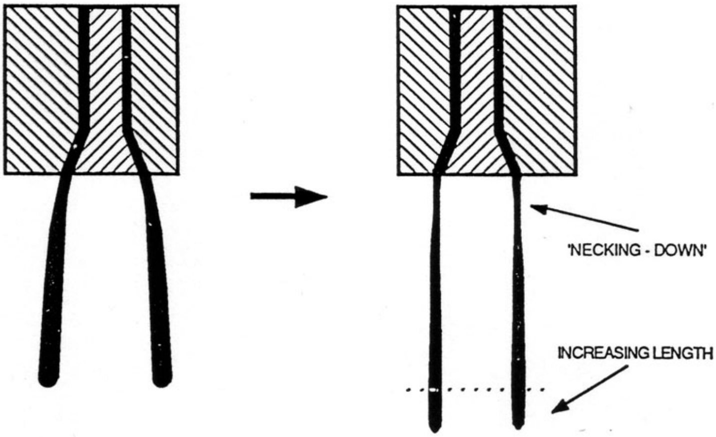


Figure 16-10 Sagging behavior of parison.

Stress due to parison's own weight:

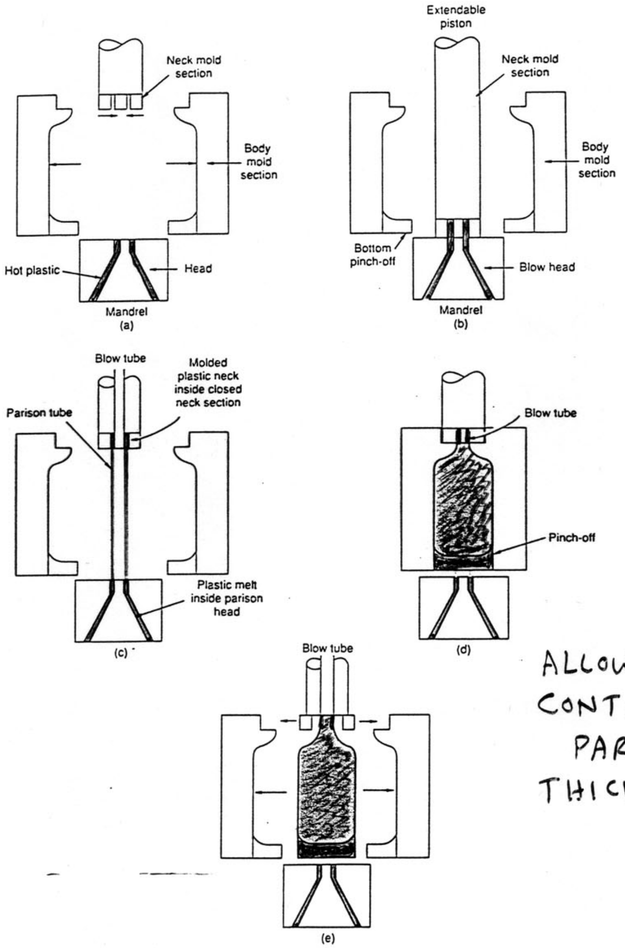
$$\sigma_e = \frac{lA\rho g}{A} = l\rho g$$

$$\text{Strain Rate} \qquad \dot{\varepsilon} = \frac{\sigma_e}{\eta_e} = \frac{\sigma_e}{3\eta_0} = \frac{l\rho g}{3\eta_0}$$

$$\text{Sag Velocity} \qquad v = \dot{\varepsilon} l = \frac{l^2 \rho g}{3\eta_0}$$

To minimize sag:
1. Use short parison
2. Use polymer with a **high zero-shear viscosity**

Blow Molding
NECK RING BLOW MOLDING PROCESS



ALLOWS MORE CONTROL OF PARISON THICKNESS

Figure 1-9 Neck ring process. (a) Body section open, neck section closed, neck section retracted. (b) Neck section extended to mate with parison nozzle (plastic fills neck section). (c) Neck section retracted with parison tube attached. (d) Body section closed, making pinch-off (parison blown to body sidewalls). (e) Body molds open, neck molds open, bottle about to be ejected. Courtesy of John Wiley and Sons.

Blow Molding
STRETCH-BLOW MOLDING OF SOFT-DRINK BOTTLES

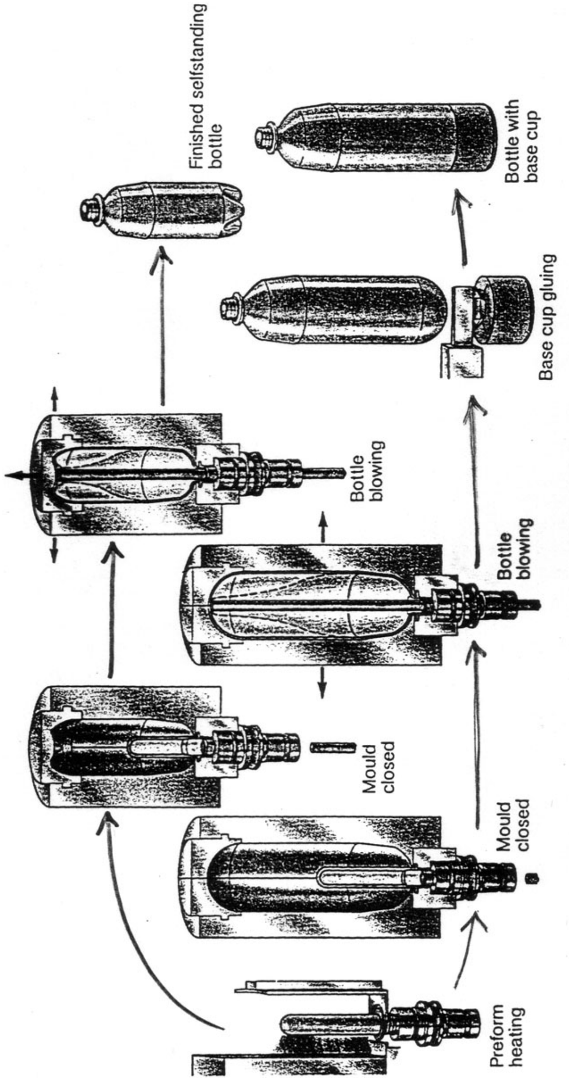


Figure 4-12 Two-stage PET injection stretch blow molding machine. First station: Condition the preform. Second station: Condition the preform. Third station: Stretch blow PET bottles. Fourth station: Eject bottles. Courtesy of Krupp Corpoplast, West Germany.

Blow Molding
BRANCHED VS. LINEAR RHEOLOGY

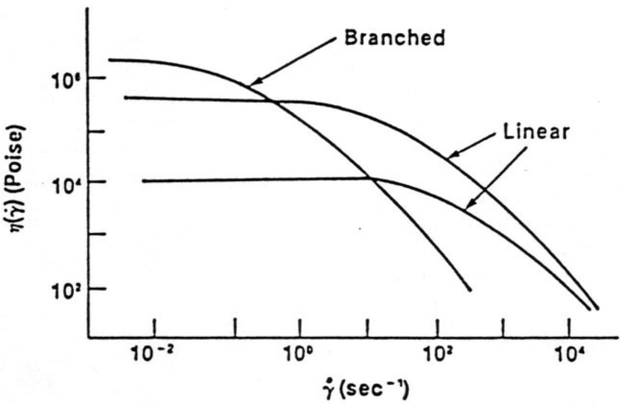


FIGURE 46. Alteration of viscosity–shear rate behavior due to the presence of long branches.

Branched vs. Linear rheology
Branched have higher η_0

$$\text{Linear} \qquad \eta_0 \sim M_W^{3.4}$$

$$\text{Branched} \qquad \eta_0 \sim M_W^{5-6}$$

Branched are more shear-thinning

$$\text{at high} \quad \dot{\gamma} \qquad \eta \sim \dot{\gamma}^{-(1-n)}$$

$$\begin{aligned} n &\cong 0.3 \quad \text{for linear} \\ n &\cong 0.2 \quad \text{for branched} \end{aligned}$$

Branched polymers are better blow molding resins