Extrusion Blow Molding

- Intermittent extrusion process
- Continuous extrusion process
  - Shuttle
  - rotary
- Extrusion head and die assembly
  - Center-feed assembly
  - Side-feed assembly
- Elements of dies
  - Mandrel
  - bushing

Injection blow molding

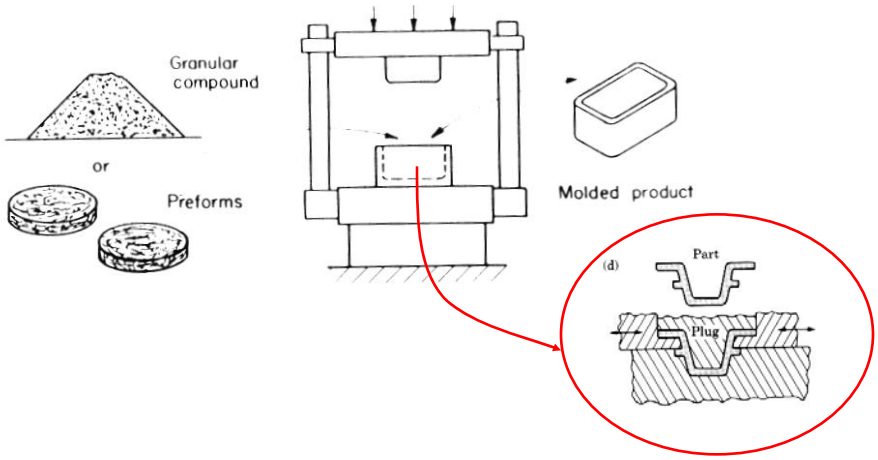
- Injection molding + blow molding

- Injection station
- Blow station
- Strip or eject station

Advanced Blow Molding Processes

- **Biaxial stretch blow molding**
  - Single stage stretch blow molding
  - Two state stretch blow molding
- **Co-extrusion blow molding**
  - 2 ~ 7 layers
  - Products: gasoline tank, motor oil tank, etc.

Compression Molding

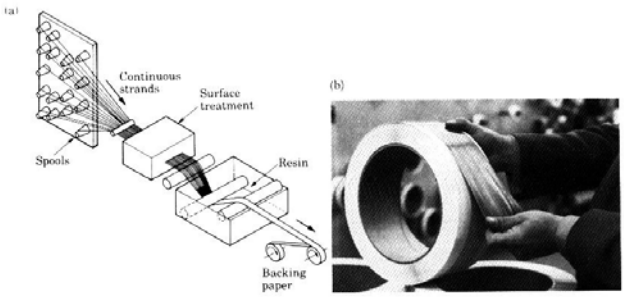


Compression Molding

- A preshaped charge of material, a premeasured volume of powders or a viscous mixture of liquid resin and filler material is placed in a heated mold cavity.
- Mainly used for thermoset polymers
- Lower cost than injection molding
- Typical parts: dishes, container caps, fittings, electrical & electronic components

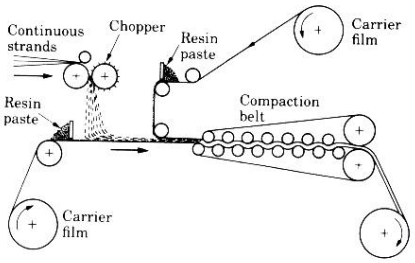
Processing of Reinforced Plastics

- Reinforcements: chopped fibers, woven fabric or mat, roving or yarn, or continuous fibers
- Impregnation: surface treatment of fibers to achieve good bonding between the fibers and the matrix.
- Prepregs:



Processing of Reinforced Plastics

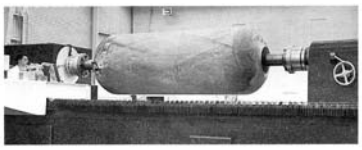
- **Sheet molding compound (SMC)**



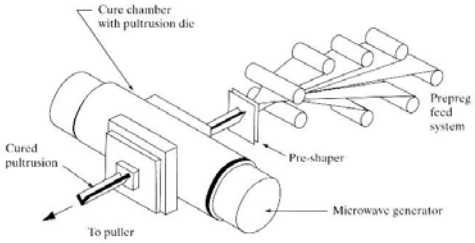
- **Bulk molding compound (BMC):**
  - up to 50 mm in dia
  - made in a similar way to SMC and extruded

Fabrication Methods

- **Filament winding**

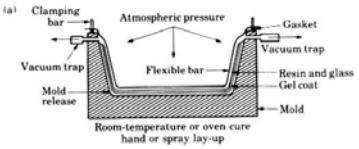


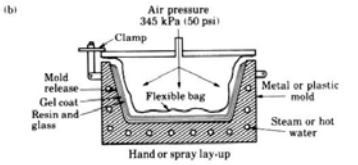
- **Pultrusion:**
  - can produce long shapes with various cross sections

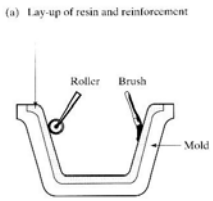


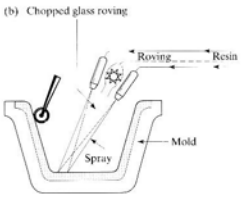
Fabrication Method

- **Molding**
  - Compression molding
  - Vacuum-bag molding
  - Resin-transfer molding









Cost Comparison

COMPARATIVE COSTS AND PRODUCTION VOLUMES FOR PROCESSING OF PLASTICS

	EQUIPMENT CAPITAL COST	PRODUCTION RATE	TOOLING COST	TYPICAL PRODUCTION VOLUME, NUMBER OF PARTS
				10 10^2 10^3 10^4 10^5 10^6 10^7
Machining	Med	Med	Low	
Compression molding	High	Med	High	
Transfer molding	High	Med	High	
Injection molding	High	High	High	
Extrusion	Med	High	Low	*
Rotational molding	Low	Low	Low	
Blow molding	Med	Med	Med	
Thermoforming	Low	Low	Low	
Casting	Low	Very low	Low	
Forging	High	Low	Med	
Foam molding	High	Med	Med	

Source: After R.L.E. Brown, *Design and Manufacture of Plastic Parts*. Copyright © 1980 by John Wiley & Sons, Inc. Reprinted by permission of John Wiley & Sons, Inc.
*Continuous process.

Ceramics

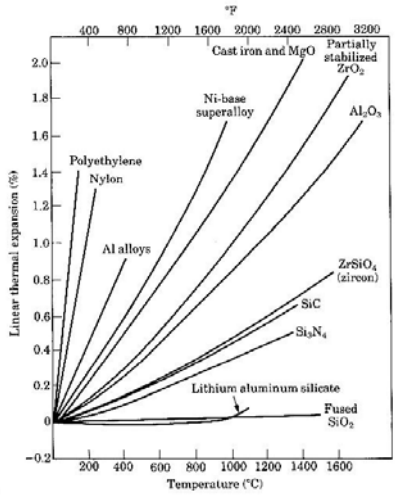
- **Compounds of metallic and nonmetallic elements**
- **Properties**
  - High hardness, thermal and electrical resistance than metals
  - Brittle
- **Type**
  - Oxide ceramics: alumina (Al_2O_3), zircornia (ZrO_2), partially stabilized zircornia (PSZ)
  - Other ceramics
    - Carbides: WC, TiC, SiC
    - Nitrides: CBN, TiN, Si_3N_4
    - Sialon: Si_3N_4 with Al_2O_3, yttrium oxide or TiC
    - Cermets: ceramics + metal matrix

Properties of Ceramics

PROPERTIES OF VARIOUS CERAMICS AT ROOM TEMPERATURE

MATERIAL	SYMBOL	TRANSVERSE RUPTURE STRENGTH (MPa)	COMPRESSIVE STRENGTH (MPa)	ELASTIC MODULUS (GPa)	HARD-NESS (HK)	POISSON'S RATIO (ν)	DENSITY (kg/m^3)
Aluminum oxide	Al_2O_3	140–240	1000–2900	310–410	2000–3000	0.26	4000–4500
Cubic boron nitride	CBN	725	7000	850	4000–5000	—	3480
Diamond	—	1400	7000	830–1000	7000–8000	—	3500
Silica, fused	SiO_2	—	1300	70	550	0.25	—
Silicon carbide	SiC	100–750	700–3500	240–480	2100–3000	0.14	3100
Silicon nitride	Si_3N_4	480–600	—	300–310	2000–2500	0.24	3300
Titanium carbide	TiC	1400–1900	3100–3850	310–410	1800–3200	—	5500–5800
Tungsten carbide	WC	1030–2600	4100–5900	520–700	1800–2400	—	10,000–15,000
Partially stabilized zirconia	PSZ	620	—	200	1100	0.30	5800

Properties of Ceramics

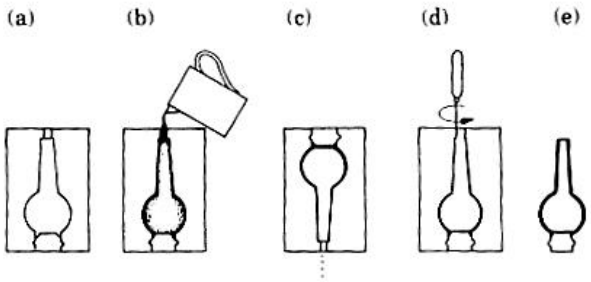


Processing of Ceramics

- **Crushing →mixing with additives →shaping, drying & firing**
- **Types of processing**
  - Slip casting
  - Extrusion
  - Dry, wet or hot pressing
  - Isostatic pressing
  - Injection molding

Slip Casting

- **Slip: a suspension of ceramic particles in water**
- **Mold: porous plaster of paris**
- **Application: plumbing ware, art objects, dinnerware**



Example

- A solid cylindrical ceramic part is to be made whose final length must be L=20 mm. It has been established that for this material, linear shrinkages during drying and firing are 7% and 6%, respectively, based on the dry dimension L_d. Determine (1) the initial length L_0 of the part and (2) the dried porosity P_d if the porosity of the fired part, P_f is 3%.

Solution

Processing of Metal Matrix Composites

- Liquid phase processing: casting the liquid matrix and the solid reinforcements
- Solid phase process: powder metallurgy
- Two phase (liquid/solid) process: a slurry is produced in a mixer and delivered into the mold or a die
- Direct laser deposition/sintering