PROCESSING TECHNIQUES OF POLYMERS
Injection Molding
Extrusion
Film Blowing
Blow Molding
Thermoforming (vacuum moulding)
Calendering
Transfer Molding
Rotation Molding
Compression moulding
Filament winding
Hand lay-up
PRODUCTS

www.lotusoverseas.com/lotusortho.html

Smith and Nephew

Medtronic

www.biomet.com

www.conmed.com
WHY PROCESSING?
<table>
<thead>
<tr>
<th>THERMOPLASTICS</th>
<th>THERMOSETS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt with increasing temperature</td>
<td>Impossible to melt after cure</td>
</tr>
<tr>
<td>Easy to reprocess</td>
<td>Difficult to reprocess</td>
</tr>
<tr>
<td>High viscosity</td>
<td>Low viscosity before cure</td>
</tr>
<tr>
<td>Difficult wetting, adhesion and combination with long fibres</td>
<td>Good wetting, adhesion and combination with long fibres</td>
</tr>
<tr>
<td>Processing demands application of high temperature and pressure</td>
<td>Processing with low temperature and pressure</td>
</tr>
<tr>
<td>Part solidification through cooling</td>
<td>No need for cooling during processing (solidification during cure)</td>
</tr>
<tr>
<td>Costly processing equipment</td>
<td>Low cost processing equipment</td>
</tr>
</tbody>
</table>
PROCESSING ROUTINE

Raw material

HEATING (Melting/softening)

FORMING

COOLING (Solidification)
THERMOPLASTIC PROCESSING METHODS

Extrusion (based)
- Continuous profiles
  - General
  - Co-extrusion
  - Blown film
  - Calendering
  - Blow molding

Injection moulding
- General
- Gas
- Sandwich
- Multi-component
- Overmoulding

Thermoforming
- Complex shapes
- Hollow parts
- Rotational Moulding

General
- Co-extrusion
- Gas
- Sandwich
- Multi-component
- Overmoulding

Complex shapes
- Hollow parts
- Rotational Moulding
EXTRUSION EQUIPMENTS AND PRODUCTS
PLANAR FILM EXTRUSION LINE
PLANAR FILM EXTRUSION LINE
EXTRUSION (MEDICAL) PRODUCTS

Bilateral Cooperation with Industrialised Countries

BEAM - Master Joint Mobility Project
an EU Australian cooperation in Biomedical Engineering
Grant Agreement, 2014-1543/001/001-CPT EUA/DEP

ICVS/3B's
FILM BLOWING
FILM BLOWING

Tubular film
FILM BLOWING EXTUSION LINE
COMPRESSION MOULDING

1. MEASURED POWDER

2. MOLD CLOSES UNDER HEAT & PRESSURE

3. MOLD OPENS

4. FINAL PRODUCT
COMPRESSION MOULDING
COMPRESSION MOULDING PRODUCTS
THERMOFORMING (OR VACUUM FORMING)

1. Radiant heater
2. Clamps (closed)
3. Mold cavity
4. Plastic sheet
5. Mold
6. Vacuum holes
7. Vacuum drawn
8. Web
9. Molded part
10. Clamps (open)
THERMOFORMING (OR VACUUM FORMING)
THERMOFORMING (OR VACUUM FORMING)
THERMOFORMING (OR VACUUM FORMING)
THERMOFORMING PRODUCTS
THERMOFORMING PRODUCTS
THERMOFORMING LARGE PRODUCTS
INJECTION MOULDING SEQUENCE
MOULDS

Fixed part

Moving part
OPERATING PARAMETERS

• Injection speed (or profile of injection speeds)
• Injection pressure
• Holding pressure
• Holding time
• Profile of temperature along the cylinder
• Mould temperature
• Back pressure
• Screw rotation speed
• Speed of the clamping system
• Cooling time
INJECTION MOULDED MEDICAL PRODUCTS
MEDICAL INJECTION MOULDING PLANTS
REACTION INJECTION MOULDING

1. Plastic 1
   Plastic 2
   Pressure cylinder
   Mixing head

2. Mould

3. Plastic 1
   Plastic 2
   Pressure cylinder
   Mixing head

4. Mould
EXTRUSION BLOW MOULDING

1. Mould
2. Extruder
3. Blowing
4. Extruded plastic
EXTRUSION BLOW MOULDING

Parison Extrusion
(Cross-section)

Blow Molding
(Cross-section)

Part Formed

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EXTRUSION BLOW MOULDING PRODUCTS
INJECTION BLOW MOULDING
INJECTION BLOW MOULDING PREFORM
1. Mould charging
FILAMENT WINDING

Courtesy: Nuplex.com
EXTRUSION

Materials: Thermoplastics (granules, powder)
Production output: Continuous
Cost: Moderate to high
Other features: Complex forms (profiles)
No inserts
Possibility of manufacturing hollow parts (pipes)
Good surface appearance
Thick parts possible
No relevant internal stresses
BLOW MOULDING

**Materials:**
Thermoplastics (granules, powder).
PVC, PE, PP, PET.

**Production output:**
Over 10000 parts

**Cost:**
Moderate

**Other features:**
Inserts possible
Good surface appearance
Thick parts not possible
Low internal stresses
THERMOFORMING

Materials: Thermoplastics (foil, sheet). PVC, PP, PC, PET, PS

Production output: between 1000 and 50000

Cost: low to moderate

Other features: Big thick parts can be produced (machine and mould size limitation). Some complexity of forms can be obtained. Inserts possible. Good surface appearance, with poor reproduction of fine details. Low internal stresses. Cycle time: 2 to 10 min
ROTATIONAL MOULDING

Materials: Thermoplastics (powder, liquid). PE (>90%), PVC plastisol

Production output: between 500 and 15000

Cost: low

Other features: Big thick parts
Complex forms can be obtained
Inserts possible
Medium surface appearance, with poor reproduction of fine details
No internal stresses
Long cycles: 30 to 60 min
INJECTION MOULDING

**Materials:**
Thermoplastics and thermosets (granules).

**Production output:**
Over 10000 parts

**Cost:**
Moderate to high

**Other features:**
Versatility (very small to big parts – up to 90 kg)
Maximum thickness: 4 mm
Complex forms
Inserts possible
Not for hollow parts
Excellent surface appearance, with reproduction of fine details
High internal stresses
Cycle times: 4 to 90 s