Lecture 10

Chapter 19
Forming and Shaping Plastics and Composite Materials

TABLE 18.1

<table>
<thead>
<tr>
<th>Process</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrusion</td>
<td>Long, uniform, solid or hollow complex cross-sections; high production rates; low tooling costs; wide tolerances.</td>
</tr>
<tr>
<td>Injection molding</td>
<td>Complex shapes of various sizes, eliminating assembly; high production rates; costly tooling; good dimensional accuracy.</td>
</tr>
<tr>
<td>Structural foam molding</td>
<td>Large parts with high stiffness-to-weight ratio; less expensive tooling than in injection molding; low production rates.</td>
</tr>
<tr>
<td>Blow molding</td>
<td>Hollow thin-walled parts of various sizes; high production rates and low cost for making containers.</td>
</tr>
<tr>
<td>Rotational molding</td>
<td>Large hollow shapes of relatively simple shape; low tooling cost; low production rates.</td>
</tr>
<tr>
<td>Thermoforming</td>
<td>Shallow or relatively deep cavities; low tooling costs; medium production rates.</td>
</tr>
<tr>
<td>Compression molding</td>
<td>Parts similar to impression-die forging; relatively inexpensive tooling; medium production rates.</td>
</tr>
<tr>
<td>Transfer molding</td>
<td>More complex parts than compression molding and higher production rates; some scrap loss; medium tooling cost.</td>
</tr>
<tr>
<td>Casting</td>
<td>Simple or intricate shapes made with flexible molds; low production rates.</td>
</tr>
<tr>
<td>Processing of composite materials</td>
<td>Long cycle times; tolerances and tooling cost depend on process.</td>
</tr>
</tbody>
</table>
Single Screw Extruder

Coat Hanger Die for Extruding Sheets

- Thickness of sheet is adjusted by the die bolt
Production of Thin Polymers

1. Extruded tube
2. Blown air causes
   - Increase in diameter
   - Decrease in thickness

Injection Molding

- Pressurized polymer fills mold
  - Plunger type
  - Reciprocating screw
- Part is held in mold
  - Solidification
  - Curing
  - Further crosslinking
- Ejection
Example of Injection Molded Parts:
Model Airplane

- 100 Ton Machine
  - $60k - $90k
- 300 Ton Machine
  - $85k - $140k
Making of Plastic Bottles

- Extrusion and blowing
- Injection and blowing

Rotational Molding

- Most thermoplastic are formed in this manner
  - Trash cans
  - Boat hulls
  - Buckets
  - Housings
  - Footballs
Polymer Matrix Composite Tapes

- Prepreg – plastic fibers impregnated with resin
  - Electrical insulation
  - Structural aircraft components
  - Military aircraft components

Sheets of Reinforced Plastic
Filament Winding Process

- Reinforced pressure vessels
- Nonsymmetric parts
- Aircraft engine ducts
- Fuselages

Pultrusion

- Cure chamber with pultrusion die
- Prepreg feed system
- Microwave generator
- To puller
Design Considerations

• Material properties
  – Stiffness
    • Larger cross-sections
    • Reinforcing structures
    • Tolerances
  – Strength
    • Larger cross-sections
    • Reinforcing structures

• Physical Properties
  – Coefficient of thermal expansion
    • Sink marks
    • Tolerances
Comparison of Methods for Plastic Part Formation

**TABLE 18.2**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Production rate</th>
<th>Tooling cost</th>
<th>Typical production volume, number of parts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital cost</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Machining</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Compression molding</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Transfer molding</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Injection molding</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Extrusion</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Rotational molding</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Blow molding</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Thermoforming</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Casting</td>
<td>Low</td>
<td>Very low</td>
<td>Low</td>
</tr>
<tr>
<td>Forging</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Foam molding</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>


*Continuous process.