Lecture 8

Chapter 15

Extrusion of Metals

• Extrusion
  – The process of forcing a cylindrical billet through a die
  – Material experiences high triaxial compressive forces
  – Materials
    • Al, Cu, Steel, Mg, Pb
  – Semicontinuous Process
  – Costs are generally low
Schematic of Forward Die-Extrusion Process

- Flow stress
  - Same as yield stress
  - Material experiences plastic deformation (non-recoverable) and can take on different shapes permanently

Shapes Attainable

- Materials take on the many different shapes that a die can have
  - Sprockets
  - Hangers
  - Brackets

- All extruded shapes have a constant cross section
Other Types of Extrusion

- A) Indirect
- B) Hydrostatic
- C) Lateral

Process Variables in Extrusion

- \( \frac{A_0}{A_f} \) is the **extrusion ratio**
- Other variables
  - Temperature of billet
  - Speed of ram
  - Lubricant type
• Extrusion Force: $F = A_0 \cdot k \ln(A_0/A_f)$

Temperature Ranges for Extrusion Processes

<table>
<thead>
<tr>
<th>Material</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>200–250</td>
</tr>
<tr>
<td>Aluminum and its alloys</td>
<td>375–475</td>
</tr>
<tr>
<td>Copper and its alloys</td>
<td>650–975</td>
</tr>
<tr>
<td>Steels</td>
<td>875–1300</td>
</tr>
<tr>
<td>Refractory alloys</td>
<td>975–2200</td>
</tr>
</tbody>
</table>
Poor and Good Examples of Cross-Sections to be Extruded

(a) Poor
- Sharp outside corner
- Unbalanced die tongue
- Sharp inside corner
- Knife edge
- Unbalanced section wall
- Inadequate section thickness

(b) Good
- Balanced voids
- More balanced die tongue; no sharp corners
- Adequate, balanced wall thickness

Impact Extrusion

Stripper plate
Punch
Blank
Part
Die
Drawing of Metals

- **Drawing**
  - The process of pulling material through a die
  - Material experiences high triaxial compressive forces
  - Materials
    - Al, Cu, Steel, Mg, Pb
  - Rod and wire products
    - Electrical wiring
    - Paper clips
    - Spokes for bike
    - Structural members
  - Costs are generally low

Wire Drawing

- **Drawing Force:** \( F = A_f Y_{avg} \ln(A_o/A_f) \)
Drawing Using a Mandrel

(a) Die

(b) Stationary mandrel

(c) Die

(d) Moving mandrel

Die Terminology

Bell (angle or radius)
Entering angle
Approach angle
Bearing surface (land)
Back relief angle

Steel casing

Tungsten - carbide insert (nib)
Electrical Wire Drawing

- Wire can be drawn at rates of 165 ft/s (> 1 mi/min!)