Compression Test

- A specimen is subjected to a compressive load.
- Carried out by compressing a solid cylindrical specimen between two well-lubricated flat dies.
- The cylindrical specimen’s surface begins to bulge, known as barreling.
• Compression test developed for brittle materials such as ceramics and glass.

• A disk shaped specimen is loaded between two solid platens. Tensile stresses build up perpendicular to the centerline along the disk, fracture begins, and the disk will split vertically.

• Tensile stress from this test can be calculated with the following equation: $\sigma = \frac{2P}{\pi dt}$
P is load at fracture, $d$ is diameter of disk, $t$ is thickness.
Torsion Test

• Torsion test: used for determination of properties in “shear.” Usually performed on a thin tubular specimen.

• Shear stress can be calculated with formula: \( \frac{T}{2\pi r^2 t} \)
  - \( T \) is torque, \( r \) is average radius of tube, \( t \) is thickness of tube.

• Shear strain is calculated with formula: \( \frac{r\Phi}{l} \)
  - \( r \) is radius of tube, \( \Phi \) is angle of twist in radians, and \( l \) is length of tube.
Bend / Flexure Test

- Rectangular specimen supported at its ends.
- Load is applied vertically at 1 or 2 pts.
- The stress at fracture in bending is known as the modulus of rupture, flexural strength, or transverse rupture strength.
Density

• Mass per Unit Volume

\[ \rho = \frac{m}{V} \]

– Typical units include
  • kg/m\(^3\)
  • lb/ft\(^3\)

• Specific Gravity
  – Density with respect to water
  – No units
Density

- Strength-to-Weight ratio
  - Specific Strength
  - Tensile strength / density
- Stiffness-to-Weight ratio
  - Specific Stiffness
  - Elastic modulus / density
- Units of length

<table>
<thead>
<tr>
<th>TABLE 3.3</th>
<th>Ratio of Maximum Yield Stress to Density for Assorted Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy</td>
<td>Maximum yield stress/density (in. $\times 10^3$)</td>
</tr>
<tr>
<td>Titanium</td>
<td>1250</td>
</tr>
<tr>
<td>Aluminum</td>
<td>800</td>
</tr>
<tr>
<td>Steels</td>
<td>750</td>
</tr>
<tr>
<td>Magnesium</td>
<td>675</td>
</tr>
<tr>
<td>Nickel</td>
<td>550</td>
</tr>
<tr>
<td>Copper</td>
<td>500</td>
</tr>
<tr>
<td>Tantalum</td>
<td>375</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>215</td>
</tr>
<tr>
<td>Lead</td>
<td>5</td>
</tr>
</tbody>
</table>
Specific Heat

- The energy required to raise the temperature of a unit mass by one degree

\[ Q = \text{cm} \Delta T \]

- Units of J/kg °K
- Important consideration in the forming or machining operations
Thermal Conductivity

• The rate at which heat flows within and through a material
• Units of W/m °K
• Very low thermal conductivity of Titanium
  – Can result in excessive tool wear during machine operations
Thermal Expansion

- The expansion or contraction of a material when exposed to a thermal cycle
- Units of $\mu\text{M/m °C}$

- Hot rivets are installed through holes in steel plate
- When the rivets cool they contract causing an extremely tight compressive stress on the joint
Electrical, Magnetic and Optical Properties

- **Electrical Properties**
  - **Conductivity**
    - The ratio of the current density to the electric field strength
  - **Dielectric Strength**
    - A material's resistivity to direct electrical current
Electrical, Magnetic and Optical Properties

- **Electrical Properties**
  - Conductors
  - Superconductors
  - Semiconductors
  - Piezoelectric effect
    - A reversible interaction between an elastic strain and an electric field
    - Typical applications include pressure transducers, sensors, and strain gauges
• Magnetic Properties
  – Ferromagnetism
  – Ferrimagnetism
  – Magnetostriction
    • The expansion or contraction of a material when subjected to a magnetic field
    • The principle behind ultrasonic machining equipment
Electrical, Magnetic and Optical Properties

- Optical Properties
  - COLOR
  - darkness
Corrosion Resistance

- Corrosion
  - Typically used to describe metal or ceramic deterioration
  - Similar phenomena occur in plastics
Corrosion Resistance

- Types of corrosion
  - Pitting
  - Inter granular
  - Crevice
  - Galvanic cell
  - Stress-corrosion cracking
  - Selective Leaching
  - Oxidation
  - Passivation
Corrosion Resistance

- **Pitting**
  - Can occur over the entire surface or be local

- **Inter grainy**
  - Occurs along grain boundaries
Corrosion Resistance

• gap
  – Occurs at the interface of bolted or riveted joints

• Galvanic cell
  – Occurs between dissimilar metals when an electrolyte is present
  – Not as common in pure metals or single-phase alloys
Corrosion Resistance

- Stress-corrosion cracking
  - Cold worked metals
- Selective leak
  - Occurs when metalworking fluid attacks specific elements in tool and die materials
• Oxidation
  – A chemical reaction which leaves a small layer of oxidized material on the surface
  – Resists further corrosion
    • Aluminum & Titanium
• Passivity
  – The development of a protective film by chemical reaction
    • Stainless Steel
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