Erosive Wear

- Several different kinds of erosive wear
  - Solid particle impingement
  - Impingement of liquid droplets
  - Flow of hot gases
  - Cavitation of liquid media due to collapsing bubbles

Erosive Wear Due to Solid Particle Impingement

- **Useful Applications**
  - **Grit blasting**
  - **Abrasive cutting (typically with water)**
  - **Water jet cutting (demo in the lab)**

Erosive Wear Due to Solid Particle Impingement

- **Applications adversely affected by erosion**
  - Polymer processing machines and others
  - Coal plants (transport of pulverized coal)
  - Gas turbines
  - Power plants
  - Pipelines
  - Ship propellers
  - Aircraft
    - Windshield
    - Wings
    - Propellers
    - Rotors

Erosive Wear Due to Solid Particle Impingement

- **Erosion as a function of the following variables:**

  Ductility of material being eroded

  Microstructure

  Velocity of particles

  Impingement angle

  Particle size

  Hardness of particles

  Strength of particles

  Temperature

Erosive Wear Due to Solid Particle Impingement

- **Roughly proportional to V^n, where n can be 1.7 to 2.8 for ductile metals and 1.4 to 5.1 for brittle materials**
- **Erosion rate -- (1/250) to (1/1000) by weight of abrasives**
- **Angle dependence -- around 20^o for ductile materials and around 90^o for brittle materials**
- **Particle size dependence -- Once it exceeds a certain size, it is independent of the particle size, similar to abrasive wear.**
- **Temperature dependence is different as a function of material properties. In general, the erosion rate of ductile metals decreases with increase in temperature.**
- **Erosion rate, in general, decreases with increase in hardness and toughness.**

Model of Erosive Wear of Metals

- Cutting model of Finnie

$$m\ddot{x} + p\psi bx = 0$$

$$m\ddot{y} + pJ\psi by = 0$$

$$I\ddot{\phi} + p\psi b\phi = 0$$

$$\psi = \frac{\ell}{y_t}$$

J – ratio of vertical to horizontal force component

p - constant horizontal component of contact stress

Erosion of Ductile Materials

- **Erosive Wear Volume vs Velocity (Finnie Model)**

$$W = \left(\frac{\rho}{p\psi} \frac{MU^2}{J} \right) \frac{J\cos^2\alpha}{6}$$

Erosion of Brittle Materials

- Transition from ring cracking to plastic indentation cracking
  - Yielding

$$a = \left(\frac{4kLR}{3E} \right)^{1/3}$$

$$\sigma_o = \frac{3L}{2\pi a^2}$$

$$L_y = B_2 \left(\frac{k}{E} \right)^2 H^3 R^2$$

  - Hertzian fracture load for large indentation
    - » $L_f = B_1 R_n$

Erosion of Brittle Materials

- Critical Radius

$$R_c = B\left(\frac{E}{k}\right)^2 \frac{1}{H^3}$$

Erosion of Brittle Materials

- Loading due to Impact of Sphere

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See Sections 7.4 and 4.2 in [Suh 1986]: Suh, N. P. *Tribophysics*. Englewood Cliffs NJ: Prentice-Hall, 1986. ISBN: 0139309837.