

### 3.37 (Class 14)

#### Review

- Solderability testing is empirical
- For solder drops below 1/8" in size, surface tension forces predominate.
- Solder composition must be closely controlled

#### Today

#### Brazing:

- Higher temperatures (>425degC) mean
- More flexibility in choice of fluxes
  - solder fluxes tend to use organics
  - brazing fluxes can use anhydrous salts, more aggressive
- More reactive fluxes mean more base metals/non-metals can be brazed
  - most all base metals can be brazed, many ceramics
  - can almost always find a flux that will work for brazing
  - often used for joining dissimilar metals where welding is a problem
- Room temperature strength of filler metal is greater (1000psi solders, 5,000-10,000psi brazes)
  - Below significant fraction of the melting point
  - For solders have to worry about creep, can't use solders for strength designs above about 1000psi
  - Typically adhesives may only get about 500psi
- Volatilization of alloy elements can be a problem
  - Either from the base metal or the braze metal
  - Zinc or magnesium, high vapor pressures, can get special brazing alloys
  - Designation: BAg21 (B=Brazing, Ag=Silver solder, Type, V=designed for vacuum brazing)
  - Cadmium, toxic metal, have tried to get this out of brazing alloys, not completely successful
  - An aside about cadmium...light switches use a silver-cadmium alloy for higher switch currents without arcing, if put 1% cadmium oxide with silver alloy can tolerate separations of the contacts about twice the distance. Swedes banned cadmium and had problems with houses burning down due to arcing in light switches.
- Intermetallics may form
  - Occurs more often due to higher temperatures
- Thermal stresses may be severe
  - 300degC reach residual stresses that may be at the yield level of the metal (equation on board)
- Erosion of the base metal may occur

- Application in turbine engines, seals between rotating and stationary parts (drawing on board: compressor, burner, turbine), different types, but in one application use thin nickel-based superalloy foil in honeycomb structure, as they grow and stretch (say 2-3%), turbine blade cuts through the honeycomb. These honeycombs are made by brazing (drawing on board), don't want erosion, used to use 82Au-18Ni, worked well but this was pricey. 50oz jar of braze alloy (\$16,000 worth of gold), used a salt shaker to distribute and then paint with Krylon, production started ramping up, as production started ramping down, took braze alloy out of the plant, forced into weighing the parts and logging. Estimated that he had taken out over \$1.5 million of gold, got one year in prison. Developed other alloys.

#### Contact strengthening

- Diffusion bonding, very thin layer of silver (10ksi) between steel (180ksi) didn't fail until about 100ksi
- As the joint thickness gets thinner and thinner, strength of the joint keeps going up (contact strengthening), reach a point where defects makes the joint strength drop again.
- Overhead on contact strengthening, constrained by non-yielding material on either side, triaxial state of tension
- One time in the class that will solve a differential equation
- Resolve the forces (equation on board) and solve the equation
- Moore (sp?) circle
- Yield strength of the material is exponential due to triaxial constrained material
- Material can't yield because it has no where to go (if the joint is thin enough)
- Thin braze joints often outperform expectations, when in tension
- No increase in strength in shear or fatigue
- Better the tolerance of fit-up, the better the strength of the joint, also more expensive to make, works down to about 1/1000"
- Not much difference between TLP bonding and brazing, leave in furnace too long and get a TLP bond from a brazing process

#### Fusion welding

- Melt away the surface, mix two liquid surfaces, solving the problems of surface roughness and contamination