

3.37 (Class 12)

Review

Pass-arounds

- Tantalum tube
- Zirconium, vapor deposited on wire
- Zircalloy tubing, zirconium has low neutron capture cross-section, ability of nucleus of atoms to absorb neutrons, one of the most transparent materials to neutrons. High melting point, refractory metal, excellent corrosion resistance
- Boron has high capture ability for neutrons

TLP Bonding starts as a braze and ends as a diffusion bond. It reduces pressure and time required for bonding.

Today

- Pass arounds, TLP bonds
- TLP sintering, end up with 2-3% porosity typically, used to make gears, found way to achieve 100% density by pushing the liquid through, but if have something that reacts with the base material, can't get silver more than about 1/2mm deep, trick was to coat copper powders with nickel, silver and nickel don't mix, put a coating to slow down the dissolution but eventually this fuses away, probably thickest diffusion bonded joint in the world.
- Superplasticity, aluminum-zinc alloy, can get ultrafine grain size, just put 50-100psi gas pressure and will slowly extrude, can be done in few minutes to a few hours, late 60's IBM wanted to make machine parts, multimillion dollar project but never really worked since unless get larger grain size later, will continue to creep.
- Whole industry in last 15 years for making very complex aerospace components by superplastic forming and diffusion bonding, blowmolding of metal parts at high temperatures

Soldering

- Solid material with contamination, clean and interpose a low melting liquid
- One of the most complex joining processes (handout)
- Complex chemical and thermal process
- Has been around for 1000's of years, but a lot of it is still an art
- Need right balance of surface energies, solder, flux, and base material
- Soldering v. brazing is temperature, below 800degF (425degC) is soldering, above is brazing
- Why distinction? There is a natural separation, nature doesn't provide soldering or brazing materials at this temperature, zinc at 781degF then aluminum at 1200degF (do have aluminum alloys below this), but no common metal that melts

between zinc and aluminum alloys, no class of alloys for about 200deg temperature range, sometimes would like to do processing in this temperature range (approx 900degF) so this is sometimes a problem.

- Silver-based alloys “silver-soldering” are actually brazing alloys
- Diagram on board: base metal, solder, flux
 - Equation for force balancing
 - Need a flux that will properly wet the liquid solder and solid base material but not have such a strong affinity for the base material that the liquid solder cannot displace it
 - Usually talk about soldering metals since they have a high surface energy. They will bond with most anything, not a problem for the base solid, but need a right balance of interfacial energies,
 - solders mostly metals, fluxes typically non-metal (organics) to get the right balance
- Flux requirements:
 - Chemical activity to clean the oxide
 - Aluminum more difficult to solder
 - Titanium and zirconium cannot be soldered, oxide so stable below 800degF, have not found a flux that is active enough to clean the oxide
 - Spreading activity, low wetting angle
 - Thermal stability, must not decompose at soldering temperature
 - Non-corrosive
- Howard Manko, Solders and Soldering, gives examples of Cu with Pb-Sn eutectic 183degC, using various fluxes:
 - Oxalic acid as the flux, starts to flow but then stops, oxalic acid boils at 182degC (water-based acid), not thermally stable
 - Glucose, has chemical activity and will clean the surface, caramelized sugar, move the ball around the surface, looks like a “slug track” on the surface of the copper, get some contact, but have lousy contact angle
 - Abetic acid (main component of rosin flux), has ability to clean off thin layers of copper oxide, but if the tarnish layer is thicker can’t do it, add little bit of chlorine and it’s great
 - Freshly cleaned copper can use abetic acid, but if has been sitting around for awhile (copper oxide layer grown) will not wet unless put chlorine in it
- Types of rosin solders:
 - R, no chlorine
 - RA,
 - RMA, 1% chlorine, takes about a second for the chlorine to clean the surface
- Getting the lead out of solders
 - Cannot use lead-tin solder in water piping, use a 95 tin solder, but flows so well that when making the fitting, falls out of the gap and creates drips (wasn’t true of the lead-tin solders, 90% of the time, no leaks)
 - Different ways to change the potable water chemistry, in New England have soft water, not from aquifer where the water is harder like in the Midwest, but want to have a little bit of hardness in the water so that you

don't corrode the copper pipes. Small layer of calcium carbonate that protects the pipes. Langolier (sp?) index, want slightly positive to get this thin (transparent) layer of calcium. Negative index, will slowly dissolve away limestone and will go through the copper. This can happen quickly, in less than 6 months. Often water authorities don't worry about this, just worry about the lead.