

3.37 (Class 5)

Review:

- Metals have high surface energies
 - Share electrons from several levels below the atomic surface
 - Longer range distance of attraction
- Friction welding has high interfacial shears
 - For good friction welder need a good brake so that don't break the weld when it stops
 - Inertial friction welding uses large flywheel
 - Extrudes contamination out of the joint
- Ultrasonic welding has low macroscopic displacements but only buries the contamination
 - A form of friction welding, essentially the same, except displacements much smaller

Today:

Question: What is a wetting angle?

- If put a liquid on a surface, it is the contact angle of the liquid with the surface
- Magic Sand, children's toy

Forge welding and other processes used for joining railroad rails

- Forging is one of the oldest native processes
- Still use it in different processes
- Used to join railroad rails (diagram on the board)
 - If bolted, even tightly, get wear on the ends of the rail, more maintenance
 - Most track is now welded
 - Different types of rail welds
 - Forge welding using oxyacetylene torches with hydraulic ram
 - Shear off the hot flash
 - 5-10 minutes to heat the rails up
 - Flash Welding
 - Tractor trailer with electric generator
 - Bring rails together then pull them apart slightly to form arc
 - Slowly bring back together as arc melts,
 - Then ram squeezed them together
 - Some do stick welding
 - Not a good process for rails
 - Mostly care about a good weld on the head
- Rails for a large telescope or microwave radar
 - 1' thick, 2-3' wide

- Want to avoid the wear and bounce
- Tolerance is very tight
- Wanted to try welding
- Using narrow groove arc welding
- Themit Welding
 - See diagram on board
 - $\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe} + \text{Heat}$
 - Raises to about 2000 degC
 - Start with a small blasting cap to start the chemical reaction
 - Molten iron flows down, makes a small casting
 - Get about 50% defective welds
 - Cheap, equipment on the order of \$100
 - See rounded, cone-shaped surface
 - Story: MIT prank, thermit welding trolley car wheels
 - Navy: Steel hull,
 - Build aluminum superstructures so not top heavy
 - Used explosive bonding to bond the plates together
 - Get aluminum-steel transition
 - Get aluminum in the presence of rust, start of a thermit reaction
 - Aluminum will burn
 - British ship lost
 - Belknap disaster
 - Jet fuel ignited thermit reaction
 - Aluminum superstructure

Explosive Bonding

- After WW II
- Take two plates, say one steel plate, with another stainless or nickel alloy plate on top, at an angle (see diagram)
- Put explosive on top to drive top plate onto the other plate
- Drives out contaminant
- Can put a very thin layer of expensive plate on top of steel to make process vessel, etc.
- Dupont did this after WW II, now out of this business
- Firm out of Boulder, in a canyon, “Explosive Fabricators”
- Can use with tube sheet (12” thick plate) heat exchanger
 - Explosive weld all the way down the length
 - Can do explosive welding in a vacuum so no noise
 - Not used much here anymore, rolling process has been worked out
- Airbag
 - Sodium azide (sp?) explodes in approx 1ms
 - Do this inside a fairly heavy cylinder to reduce force of impact
 - Generate approx 200psi

Question: Stresses in joined materials?

- Railroad rails

- Diurnal heating and cooling (day and night)
- How to avoid these thermal stresses
 - Expansion joint
 - Curves in the track
- Concrete
 - Pretension or posttension of steel reinforcing elements
 - Sometimes need to repair, even tear down building

Question: Changing metallurgical properties of the rails?

- High carbon steels
- Used to be mostly hot-rolled rails, these don't really degrade
- Some heat-treated rails
- Starting to use 1% Cr rails (not heat treated)
- Some starting to be more sophisticated (like for the specialized telescope track described above)

Question: Use joint for rails with more joining surface area?

- Asymmetric loading kills this

Full penetration joint

- Back gouging
- Need to grind or air arc gouging to burn out defects at the root