3.37 (Class 9)

Review

- Stephan equation explains the effect of adhesive joint thickness and adhesive viscosity on joint strength
- Viscosity can be increased by solvent removal, chemical reaction or solidification

Today

- Examples of adhesives, What type?
    - Egg: solidification, proteins as a great adhesive, also probably some chemical reaction when cooking
    - Putting tongue on something cold: solidification
    - Wallpaper paste: solvent, add water back and can peel it off easier
    - Glue on soles of shoes: contact cement, solvent remover, also has something in it call a tackifier (sp?)
    - Scotch tape has tackiness: can put it down and then remove it, have rubbery "strings" that pull it back
    - Post-it-notes: array of adhesive dots, looks like a perforated adhesive, fracture mechanics working for you, on some can start to see the pattern of dots if contaminate with fine dirt, only breaking one bond at a time instead of trying to break full rows of adhesive
    - Wood glue: solvent removal, water-based, like children's school glue, reason it doesn't work on metal is that it is not porous
    - Postage stamp: water wicks away into the paper, if put it on a piece of glass the water will not wick away and will take longer to bond.
    - Airplane glue: solvent removal, model glue, also has chemical reaction, some of the solvent that comes off dissolves the substrate, helps clean and soften the surface to create a "forging" action when push together
    - Plexiglas, chloroform used to "weld" the glass, eyedropper, wicks down into the tight Plexiglas joint
    - Plastic hard to bond to since it has low surface energy (40erg/cm^2)
    - Many times have multiple things going on including both adhesive bonding and welding
    - Hot melt glue gun, asphalt are examples of temperature-based solidification, apply hot and as cools it solidifies
    - Epoxy: chemical reaction
    - Crazy glue, super glue: cyanoacrylate, pricey, found when an experiment went awry, glued prisms together, very low viscosity so can get down into the pores for mechanical interlocking, polymerize very rapidly, but did not add any B component, this is actually water, the hydroxyl ions, why don't work as well on wood, acidic, can paint the surface with Drano (basic solution), have more hydroxyl ions, skin is slightly basic, that's why it glues skin together so well

    - Anerobics, loc-tite, certain types of polymers that polymerize in the absence of oxygen, actually subtract a B-component, oxygen, that's why it hardens when put on threads of bolt, bottle of loc-tite has a hole, small enough not to leak out, but need to have oxygen so that it doesn't solidify
- Handbook of Adhesives, 1977, 2nd edition
    - Chapter by Zisman (sp?) great article, not in 3rd edition
    - Many other examples of types of adhesives
        - Gurry, used to be a major product of MA, old fish heads and fish bones, not much can do with it, used to just dump it, fish proteins can be used to make glues, "fish glue", used on tax envelopes
        - Soybean glues
        - Blood glues
        - Starch-based, corn stalks
        - Rubber-based adhesives, have tackiness to them
        - Silicon adhesives
- Costs vary widely
    - Some very cheap, indoor plywood, can used a very cheap water-based adhesive (say 10 cents/lb), outdoor, need to use an oil-based adhesive (say 20 cents/lb)
    - Others like cyanoacrylate can be much more expensive ($100's /lb)
    - Polyamides can be up to $400/lb
- Cars, wanted to make more resistant to rust, everything except the roof is galvanized, to extend the rust-through warranty, in early 80's tried to adhesively bond instead of spot welding, around doors could spot weld bare steel, but problems with galvanized, went to adhesives, worked well for a few years, but the adhesive would debond from the surface, in 90's started using better adhesives ($10-$12/lb, pushes the limits on reasonable costs for automobile)
- Weight savings over life of automobiles vs. aircraft
    - Two sheets of material adhesively bonded (diagram on board)
        - Put in tension
        - When is strength of base material equal to the shear strength of the adhesive
        - Get an aspect ratio length/thickness to find overlap distance
        - Adhesively bonded joint is very good in a fatigue loaded situation, good distribution
    - Boeing uses expensive adhesives in aircraft, until recent years would also put rivets in these joints, "just to make sure"
- Mechanical interlocking of the adhesive (diagrams on board)
    - Low viscosity allows adhesive to penetrate more easily, reason crazy glue works so well
    - Teflon: challenge is to get good mechanical interlocking
        - Say sprinkle water on Teflon, has a high contact angle with Teflon (one of lowest surface energies, Fl-C bond very stable), freeze it and drops can be flicked off
        - How can get water down into the Teflon?, instead of putting liquid on as a solid, use water vapor and create a temperature gradient