1 4th Year Materials Engineering

Adhesives and Joints – Lecture 1

2 Joining

2.1 Rationale

- Many products are made from components
- The joining together of components is a complex problem

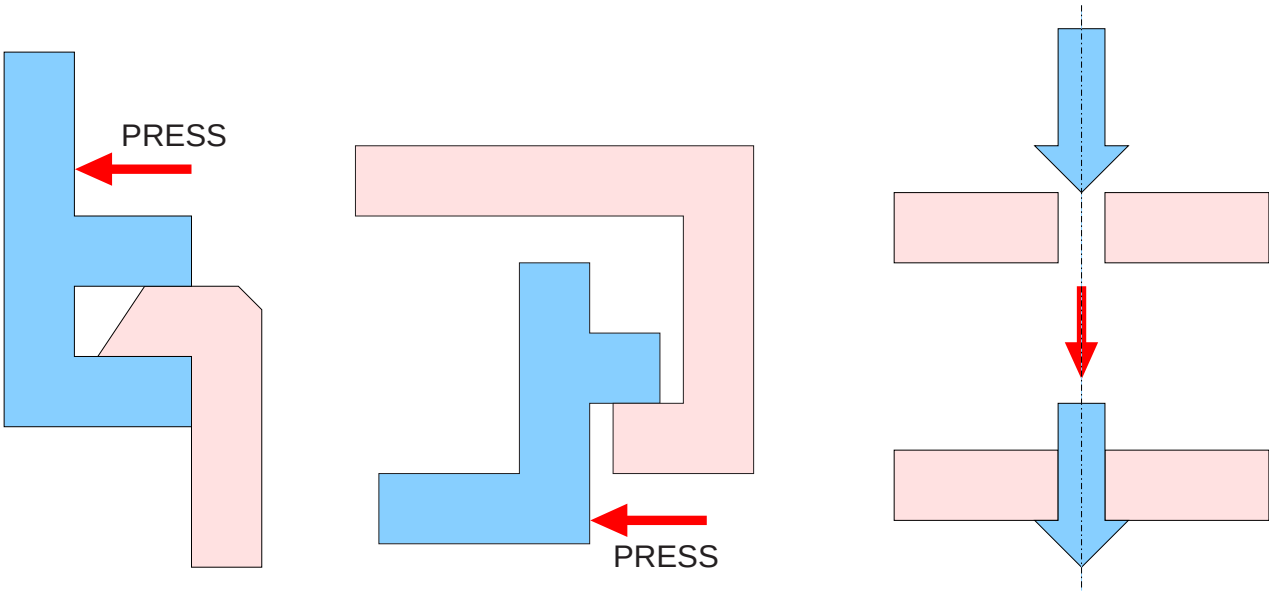
2.2 Traditional Methods

- Traditional methods may be used:
  - Rivets (metal or plastic) Note that metal rivets are prone to tearing out since they are so much stronger than the parent material of the parts. Plastic rivets are more likely to be the point of failure (this is useful as the parts might be successfully rejoined afterwards). Large heads are used on the rivets to spread the load well.
  - Screws (metal or plastic) Some similar problems to rivets. Thread tends to tear out of the parent plate. Special threads are employed to help with this, though at the cost of some accuracy and retention (i.e. joint more likely to loosen). Note that threaded metal inserts can be moulded into the parent parts if greater thread-strength is required. Altogether not unlike screwing into wood (e.g. you can use self threading screws reasonably easily).
  - In general, plastic fasteners are lighter, corrosion resistant, insulating, flexible, durable and cheap. Thermal expansion is same as parent plate. However, strength, shear resistance, torque strength, and heat resistance are lower than for metal fasteners.

3 Non-Traditional Methods

3.1 Snap/Interference Joint

An undercut on one part engages a lip on the other part

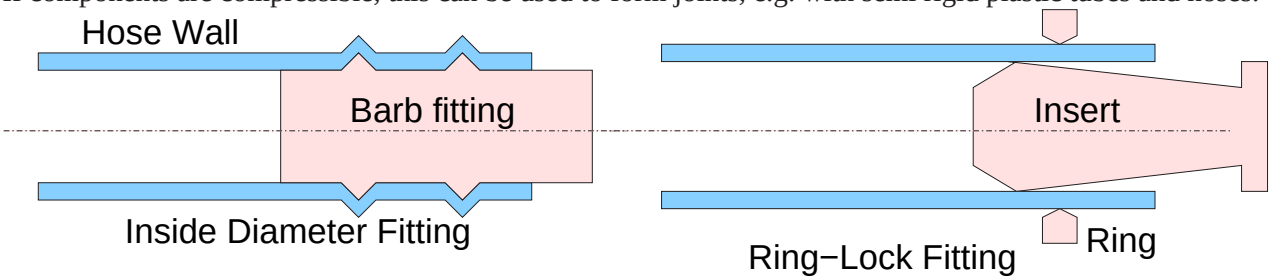


Acetate

4 Non-Traditional Methods

4.1 Flexibility Joints

- If components are compressible, this can be used to form joints, e.g. with semi rigid plastic tubes and hoses.



- Living hinge:
  - Connecting strip of plastic between two larger sections.
  - All moulded as a single unit. After moulding, the part is flexed to align molecules in hinge correctly (along direction of hinge).

5 Joining Methods

5.1 Adhesive Joints

- Things to be joined: adherends
- Joining substance: adhesive
- Not just for joining polymers (although that is the main focus in these lectures)

- Metals
- Ceramics
- etc.,

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6 Joining Methods

6.1 Adhesive Joints

Properties required of adherends:

- Surface must “wet” easily. Adhesive must coat the surface easily. This can be helped by: This can be understood in terms of energy. If the surface has a high energy and the fluid has a low energy then wetting will occur easily. If the reverse is true, then wetting will be difficult.
  - Surface cleaning Often grease/oil is left on the surface from injection moulding. Also debris/dirt may have been picked up
  - Chemical etching Chemical used reacts with adherend surface, changing its characteristics (for the better, hopefully).
  - Flame treatment (often used on Polyethylene and polypropylene) (oxidation)
  - Corona (spark) treatment, another way to oxidise
  - Plasma treatment
  - Coupling agents : coatings added to promote bonding to the desired adhesive. More common with ceramic adherends (like fibreglass).
- Mechanical Abrasion Does not change thermodynamics and so wetting is unaffected. However, surface area is increased and there are more imperfections where the adhesive can enter and mechanically bond with the adherend

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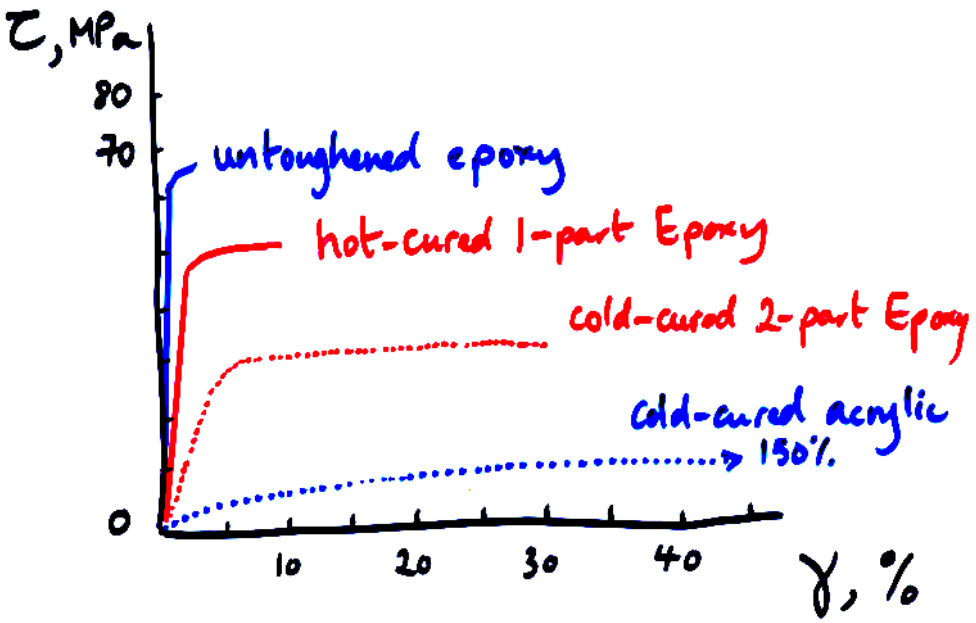
7 Joining Methods

7.1 Adhesives

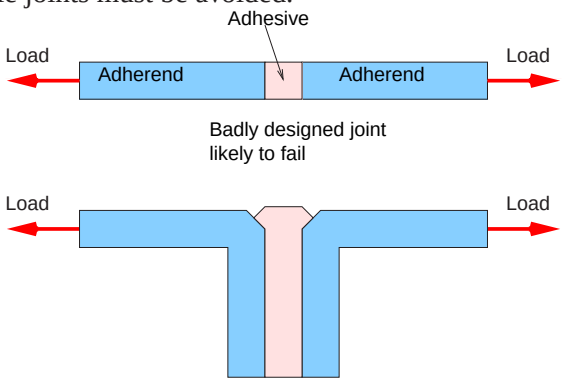
The shear strength of most adhesives is much less than that of metals, but strain at failure is often very high



8 Adhesives

8.1 Joint Design

Joint design is critical to the successful use of adhesives. Because of the low cohesive (as opposed to interfacial strengths) of adhesives, purely tensile joints must be avoided.

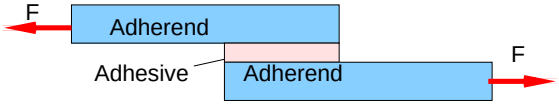


T−Peel Test: joint tends to peel open

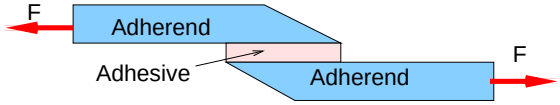
9 Adhesives

9.1 Joint Design

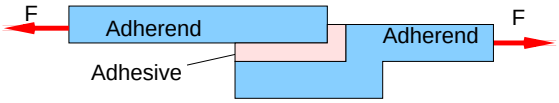
Some better joint designs



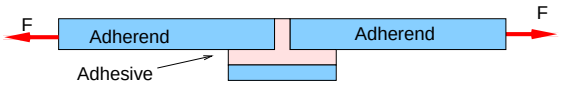
(a) Simple Lap Joint



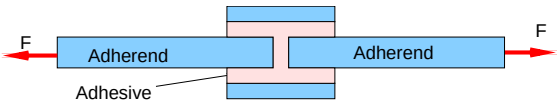
(b) Tapered Lap Joint



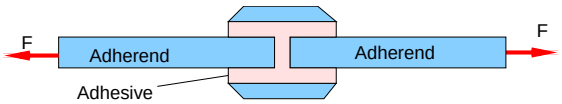
(c) Rebated Lap Joint



(d) Single Strap Joint



(e) Double Strap Joint



(f) Double Strap Joint

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10 Adhesives

10.1 Joint Design

- It is important to avoid asymmetric tensile loads on important adhesive joints.
- Anticipate and suppress peel and cleavage forces
  - Mechanical support (weld, rivet, etc.,)
  - Clever design of joint geometry

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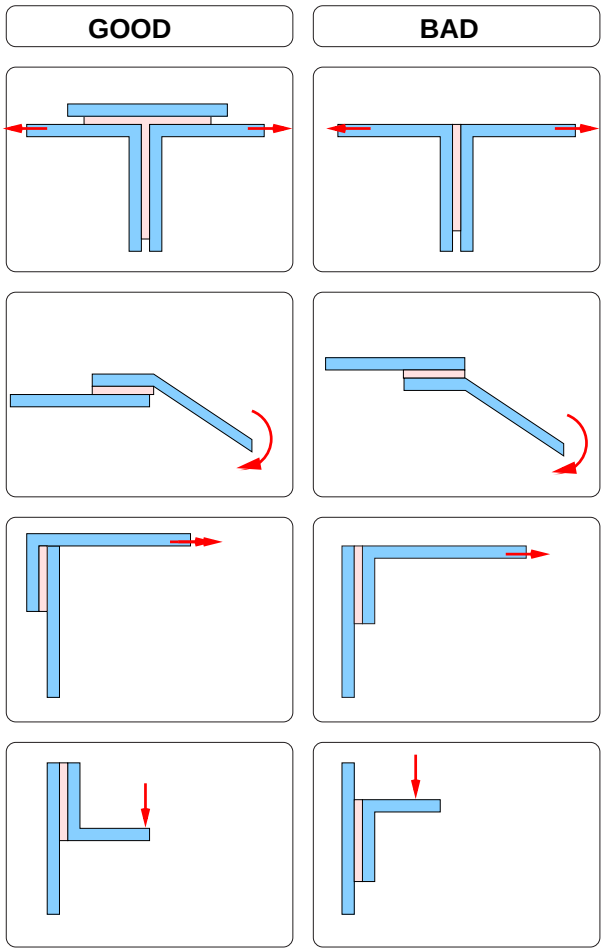
11 Adhesives

11.1 Joint Design



Acetate

12 Joining

12.1 Nonadhesive Bonding

- Fusion Bonding
  - Areas to be joined are heated to softening, then pressed together
  - No adhesive used
  - No additional welding material added/melted
  - Good to have wide melting point
  - Good to have good melt strength
  - Plate bonding heats over a large area

13 Joining

13.1 Nonadhesive Bonding

- Ultrasonic Welding
  - Ultrasonic signal generator pressed against area where join is to be created.
  - Vibrations in material cause softening.
  - Under moderate pressure, the two surfaces fuse.
  - An “energy director” (bump on the plastic) can be used to concentrate the effect
  - Can be used for “staking” also

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14 Joining

14.1 Nonadhesive Bonding

- RF Welding
  - Like Ultrasound, but higher frequency and electromagnetic
  - Plastic molecules move back and forth $\Rightarrow$ heat up
  - “High loss rate” plastics especially susceptible (ABS, PVC).
- Friction Welding
  - Surfaces are moved rapidly while in contact
  - Heat is generated
  - Plastic softens and fusion occurs
  - Useful for joining cylindrical components to flat plates (spin the cylinder)
  - Useful to weld a rod inside a matching hole
  - Recommends clean surfaces, low melting points, and small joint areas.