4th Year Materials Engineering

Adhesives and Joints – Lecture 2

Adhesive

Adhesive Components

Adhesives may be made from different components. These can include:

- Adhesive base/binder (e.g. epoxy)
- Hardener
  - Used in two part adhesives to cure the adhesive
  - Catalyst may also be used
- Solvents
  - Reduce viscosity
  - Generally evaporate during cure

Adhesive Components cont'd

- Diluent
  - Reactive ingredient, reduces viscosity too.
  - Diluent reacts with binder during cure, does not evaporate
- Fillers:
  - Inorganic particulates added to improve properties,
  - e.g. strength, permanence, electrical properties, thermal expansion, etc.,
  - Can reduce cost
- Carrier
  - Thin fabric used to support a semicured adhesive
  - Can reinforce adhesive, and/or act as a spacer

Types of Adhesive

A broad classification of adhesives would be:

- Thermoplastic
- Thermosetting
- Elastomeric
- Alloy Blend

Thermosetting and alloy adhesives are noted for high strength, crep resistance, and resistance to environmental hazards (heat, moisture, solvents, oil). Used in structural applications.

Elastomeric and thermoplastic adhesives are not suitable for use under continuous load due to tendency to creep. Also supject to environmental hazards. Good in low-strength applications (sealants, hot-melt products, etc.,)

Types of Adhesive

Epoxy

- Good adhesion to most substrates
- Thermosetting molecular structure
- Excellent tensile-shear strength, poor peel strength
- Low cure shrinkage, high creep resistance
- Curing temperature can be varied
- Very versatile:
  - Variation of curing agent allows control of properties and processing

Types of Adhesive

Toughened Epoxy

- Incorporation of rubbery particles can toughen epoxy
- Typically 5-10% by weight
- Peel strength increases
  - Reduced crack propagation
- Impact resistance increases
- Temperature and chemical resistance unchanged

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Types of Adhesive

Epoxy Alloy

- Blending/Coreacting polymers with epoxy allows tailoring of properties
- Epoxy Phenolic
  - Good for higher temperature use
  - Good resistance to oil/solvents
  - Rigid, so poor peel strength
  - Rigidity also means low thermal shock resistance
- Epoxy Nylon
  - Excellent shear strength
  - Excellent peel strength
  - Used to bond aluminium skins to honeycomb core in aircraft
  - Good low temperature performance
  - Not such a good high temperature range

Types of Adhesive

Epoxy Alloy

- Epoxy Polysulfide
  - Excellent flexibility
  - Good peel strength
  - Excellent chemical resistance
  - Bond well to a wide range of substrates
  - Poorer shear strength
  - Poorer high temperature resistance
  - Good low temperature resistance

Types of Adhesive

Modified Phenolics

- Phenolic or Phenol Formaldehyde
- Used to bond wood
- Brittle

- Flexibility can be increased by modifying synthetic rubbers and thermoplastic materials
- Nitrile Phenolic
  - Modified with nitrile rubber
  - Peel strength and shear strength increase
  - High impact strength
  - Good solvent, oil, water resistance

Types of Adhesive

Modified Phenolics

- Vinyl-Phenolic
  - Polyvinyl resin added to phenolic resin
  - Excellent peel and shear strength
  - Excellent impact resistance
  - Not good at high temperatures due to softening of thermoplastic constituent
  - Excellent chemical resistance
  - Often used to bond copper sheet to plastic laminate in PCB manufacture

Types of Adhesive

Modified Phenolics

- Neoprene-Phenolic
  - High creep resistance
  - Excellent fatigue and impact strengths
  - Shear strength lower, temperature range lowish
  - Sensitive to processing conditions

Types of Adhesive

Polyaromatics

- Excellent temperature resistance due to highly crosslinked structures
- Volatiles are released during cure, so structure can be porous
- Peel strength poor due to brittle porous bondline

Polyester

- Diverse class of resins
- Unsaturated resins are fast-curing two-part systems hardened by the addition of catalysts at room or higher temperature

- Unsaturated resins exhibit shrinkage cure and poorer chemical resistance than epoxy adhesives
- Saturated polyester resins have high peel strengths, excellent clarity and color stability.

Types of Adhesive

Polyurethane

- Tough and flexible
- High peel strength
- Cure at room or elevated temperatures
- Exceptionally high strength at cryogenic temperatures
- Poorer high temperature performance
- Bonds well to most surfaces
- Due to flexibility, often used to bond films, foils and elastomers

Types of Adhesive

Anaerobic Adhesives

- E.g. Cyanoacrylate resins
- Cure when air is exclued from the resin
- Simple to use, one-part, fast cure at room temp
- Expensive, but only small volume required
- Cyanoacrylate cures in seconds, but has generally poor temperature resistance

Thermosetting Acrylics

- Two-part system, fast cure at room temperature
- High shear strength
- Rigid – poor peel strength
- Excellent weather and moisture resistance

Types of Adhesive

Nonstructural Adhesives

- Low shear strength and poor creep resistance at even slightly elevated temperatures
- Based usually on elastomers and thermoplastics
- Easy to use, fast setting.

- Often used in assembly line fastening or as sealants.
- Examples
  - Elastomer-based adhesives (rubbery adhesives)
  - Silicone
  - Thermoplastic adhesives (e.g. hot melt adhesives)

Selecting an Adhesive

Metal

- Most adhesives wet clean metal well
- Select based on bonding requirements
- Nonstructural adhesive may be used for fast production, low cost, low to medium strength applications

Selecting an Adhesive

Plastics

- Consideration must be given to physical and chemical properties of the adhesive and the substrate
- Thermal expansion differences can cause problems
- Glass transition temperature must be above operating temperature
- Adhesive likely to be the weakest thermal link
- Operating too far below T_g can lead to brittleness
- Aging of a plastic surface may damage joints
- External agents (e.g. water) can lead to desorption

Composites

- Adhesives that are satisfactory on resin matrix alone are usually suitable to bond composites
- Common adhesives used: epoxies, acrylics, urethanes