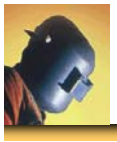
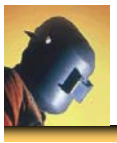


PROSES-PROSES PENYAMBUNGAN - 3

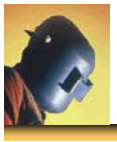
SME 2713 – Manufacturing Processes

Assoc Prof Zainal Abidin Ahmad



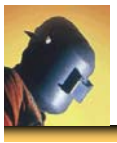
Outlines

1. Introduction
2. Brazing
3. Soldering
4. Welding
5. **Mechanical fasteners**
6. **Adhesives**



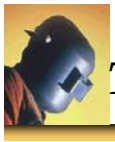
Mechanical Assembly Defined

- Use of various fastening methods to mechanically attach two or more parts together
- In most cases, discrete hardware components, called *fasteners*, are added to the parts during assembly
- In other cases, fastening involves shaping or reshaping of a component, and no separate fasteners are required



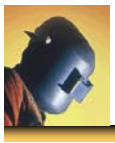
Products of Mechanical Assembly

- Many consumer products are assembled largely by mechanical fastening methods
  - Examples: automobiles, large and small appliances, telephones
- Many capital goods products are assembled using mechanical fastening methods
  - Examples: commercial airplanes, trucks, railway locomotives and cars, machine tools



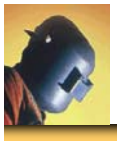
Two Major Types of Mechanical Assembly

1. Methods that allow for disassembly
   - Example: threaded fasteners
2. Methods that create a permanent joint
   - Example: rivets



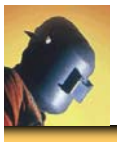
Why Use Mechanical Assembly?

- Ease of assembly – can be accomplished with relative ease by unskilled workers
  - Minimum of special tooling required
  - In a relatively short time
- Ease of disassembly – at least for the methods that permit disassembly
  - Some disassembly is required for most products to perform maintenance and repair



Threaded Fasteners

- Discrete hardware components that have external or internal threads for assembly of parts
- Most important category of mechanical assembly
- In nearly all cases, threaded fasteners permit disassembly
- Common threaded fastener types are screws, bolts, and nuts



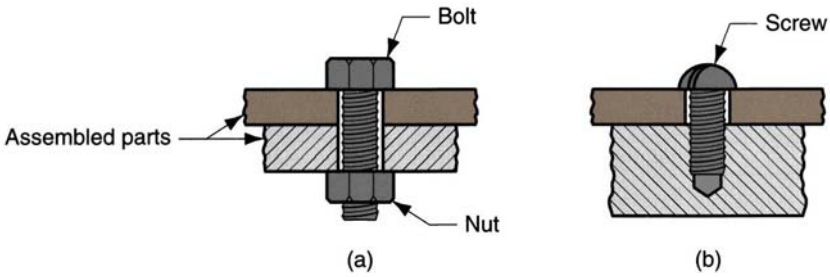
Screws, Bolts, and Nuts

Screw - externally threaded fastener generally assembled into a blind threaded hole

Bolt - externally threaded fastener inserted into through holes and "screwed" into a nut on the opposite side

Nut - internally threaded fastener having standard threads that match those on bolts of the same diameter, pitch, and thread form

Screws, Bolts, and Nuts

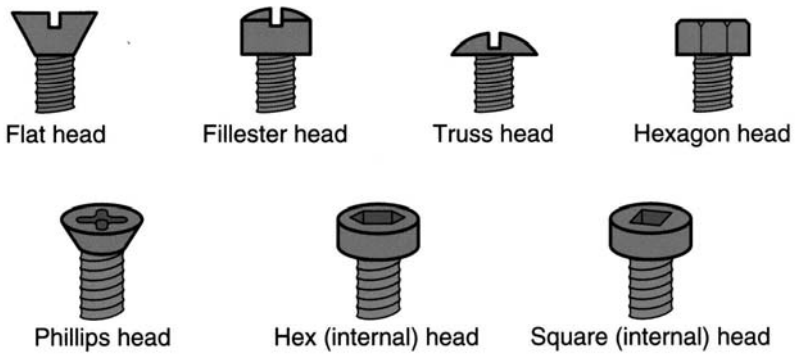


Typical assemblies when screws and bolts are used.

Some Facts About Screws and Bolts

- Screws and bolts come in a variety of sizes, threads, and shapes
- Much standardization in threaded fasteners, which promotes interchangeability
- U.S. is converting to metric, further reducing variations
- Differences between threaded fasteners affect tooling
  - Example: different screw head styles and sizes require different screwdriver designs

Head Styles on Screws and Bolts



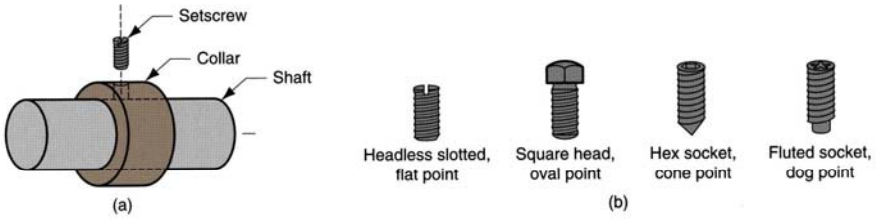
Various head styles available on screws and bolts.

Types of Screws

- Greater variety than bolts, since functions vary more
- Examples:
  - Machine screws - generic type, generally designed for assembly into tapped holes
  - Capscrews - same geometry as machine screws but made of higher strength metals and to closer tolerances

Setscrews

Hardened and designed for assembly functions such as fastening collars, gears, and pulleys to shafts

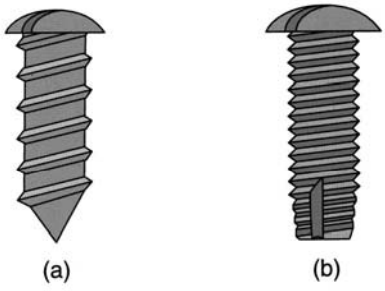


(a) Assembly of collar to shaft using a setscrew;
(b) various setscrew geometries (head types and points).

Self-Tapping Screws

- Designed to form or cut threads in a pre-existing hole into which it is being turned
- Also called a *tapping screw*

Self-tapping screws: thread-forming, and thread-cutting.

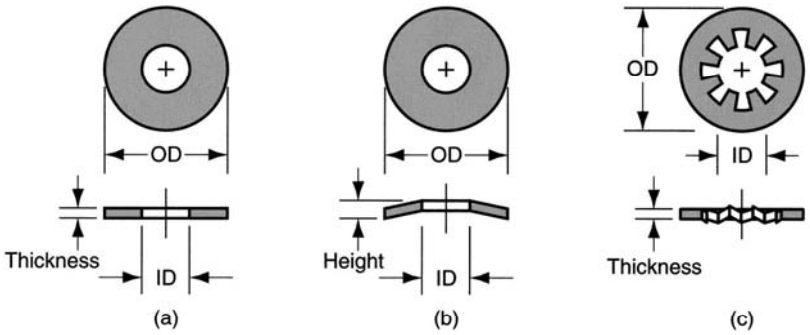


Washer

Hardware component often used with threaded fasteners to ensure tightness of the mechanical joint

- Simplest form = flat thin ring of sheet metal
- Functions:
  - Distribute stresses
  - Provide support for large clearance holes
  - Protect part surfaces and seal the joint
  - Increase spring tension
  - Resist inadvertent unfastening

Washer Types



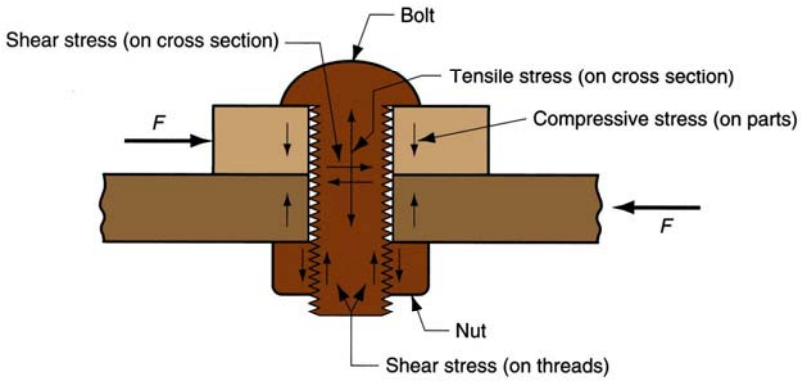
Types of washers: (a) plain (flat) washers; (b) spring washers, used to dampen vibration or compensate for wear; and (c) lockwasher designed to resist loosening of the bolt or screw.

Bolt Strength

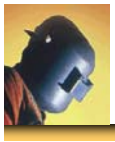
Two measures:

- Tensile strength, which has the traditional definition
- Proof strength - roughly equivalent to yield strength
  - Maximum tensile stress without permanent deformation

Stresses in a Bolted Joint



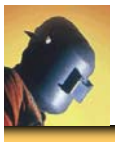
Typical stresses acting on a bolted joint.



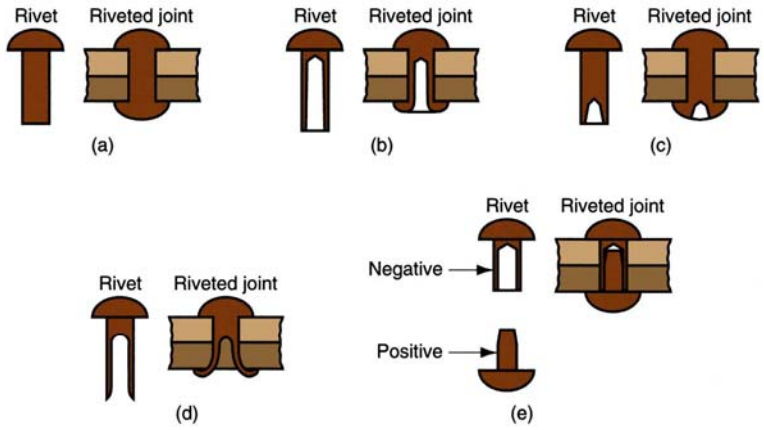
Rivets

Unthreaded, headed pin used to join two or more parts by passing pin through holes in parts and forming a second head in the pin on the opposite side

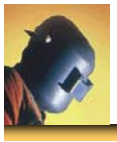
- Widely used fasteners for achieving a permanent mechanically fastened joint
- Clearance hole into which rivet is inserted must be close to the diameter of the rivet



Types of Rivets

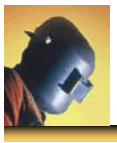


Five basic rivet types, also shown in assembled configuration: (a) solid, (b) tubular, (c) semitubular, (d) bifurcated, and (e) compression.

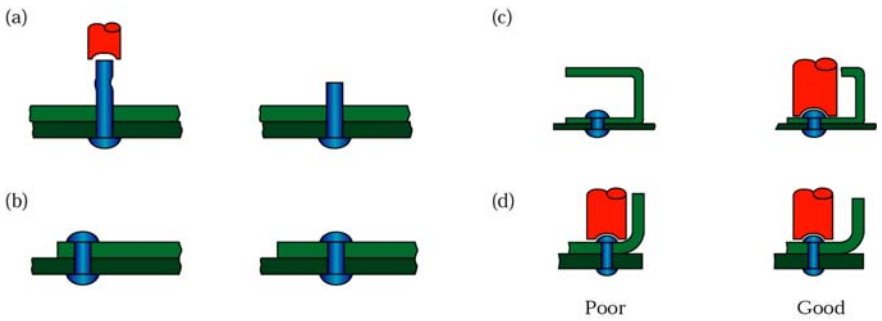


Applications and Advantages of Rivets

- Used primarily for lap joints
- A primary fastening method in aircraft and aerospace industries
- Advantages:
  - High production rates
  - Simplicity
  - Dependability
  - Low cost



Design Guidelines for Riveting



Design guidelines for riveting. (a) Exposed shank is too long; the result is buckling instead of upsetting. (b) Rivets should be placed sufficiently far from edges to avoid stress concentrations. (c) Joined sections should allow ample clearance for the riveting tools. (d) Section curvature should not interfere with the riveting process. *Source*: J. G. Bralla.

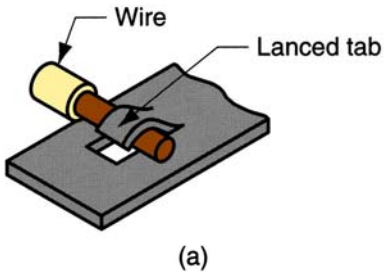
Integral Fasteners

Components are deformed so they interlock as a mechanically fastened joint

- Methods include:
  - Lanced tabs
  - Seaming
  - Beading

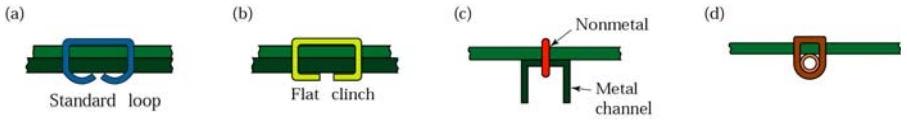
Lanced Tabs

To attach wires or shafts to sheetmetal parts

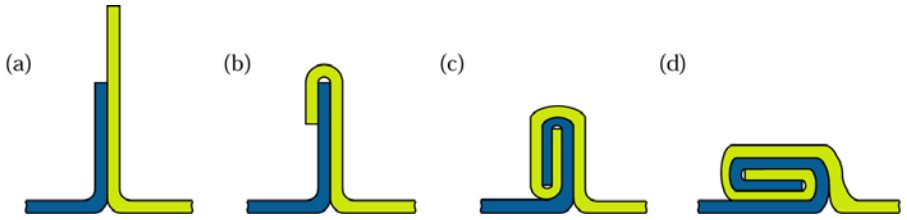


(a) lanced tabs to attach wires or shafts to sheet metal.

Metal Stitching and a Double-Lock Seam

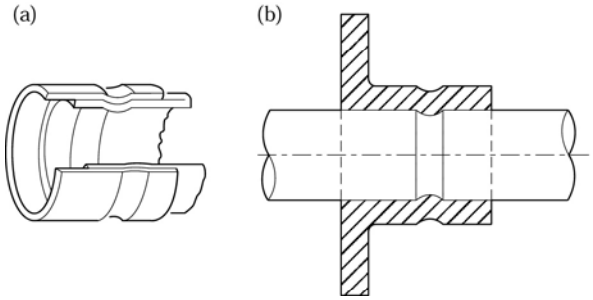


Various examples of metal stitching.



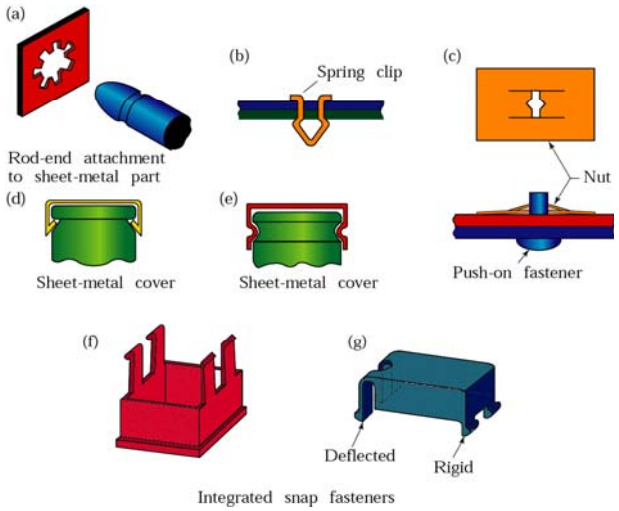
Stages in forming a double-lock seam.

Crimping



Two examples of mechanical joining by crimping.

Spring and Snap-In Fasteners

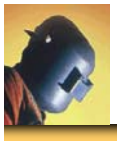


Examples of spring and snap-in fasteners used to facilitate assembly.

6. Adhesive Bonding

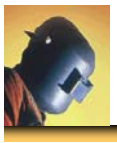
Joining process in which a filler material is used to hold two (or more) closely-spaced parts together by surface attachment

- Used in a wide range of bonding and sealing applications for joining similar and dissimilar materials such as metals, plastics, ceramics, wood, paper, and cardboard
- Considered a growth area because of opportunities for increased applications



6. Terminology in Adhesive Bonding

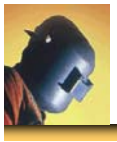
- *Adhesive* = filler material, nonmetallic, usually a polymer
- *Adherends* = parts being joined
- *Structural adhesives* – of greatest interest in engineering, capable of forming strong, permanent joints between strong, rigid adherends



6. Curing in Adhesive Bonding

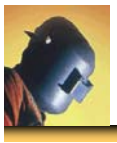
Process by which physical properties of the adhesive are changed from liquid to solid, usually by chemical reaction, to accomplish surface attachment of parts

- Curing often aided by heat and/or a catalyst
  - If heat used, temperatures are relatively low
- Curing takes time - a disadvantage in production
- Pressure sometimes applied between parts to activate bonding process



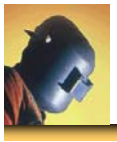
6. Joint Strength

- Depends on strength of:
  - Adhesive
  - Attachment between adhesive and adherends
- Attachment mechanisms:
  - Chemical bonding – adhesive and adherend form primary bond on curing
  - Physical interactions - secondary bonding forces between surface atoms
  - Mechanical interlocking - roughness of adherend causes adhesive to become entangled in surface asperities



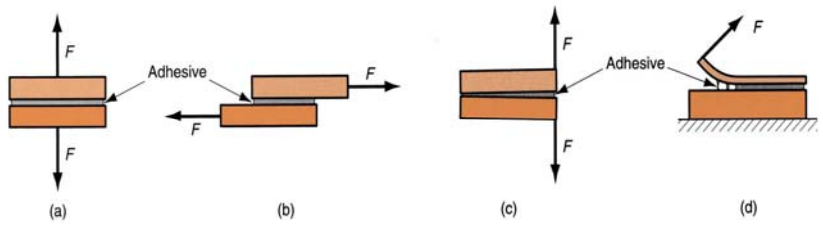
6. Joint Design

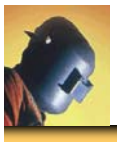
- Adhesive joints are not as strong as welded, brazed, or soldered joints
- Joint contact area should be maximized
- Adhesive joints are strongest in shear and tension
  - Joints should be designed so applied stresses are of these types
- Adhesive bonded joints are weakest in *cleavage* or *peeling*
  - Joints should be designed to avoid these types of stresses



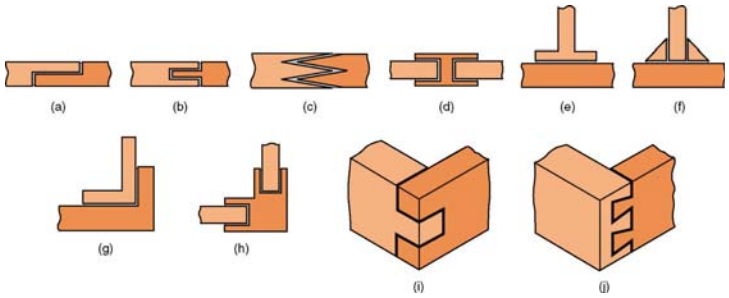
6. Types of Stresses in Adhesive Bonding

Types of stresses that must be considered in adhesive bonded joints: (a) tension, (b) shear, (c) cleavage, and (d) peeling.



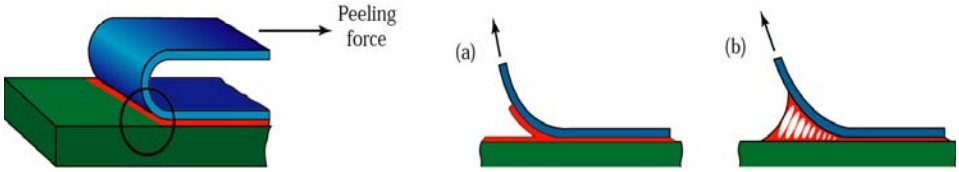


6. Joint Designs in Adhesive Bonding



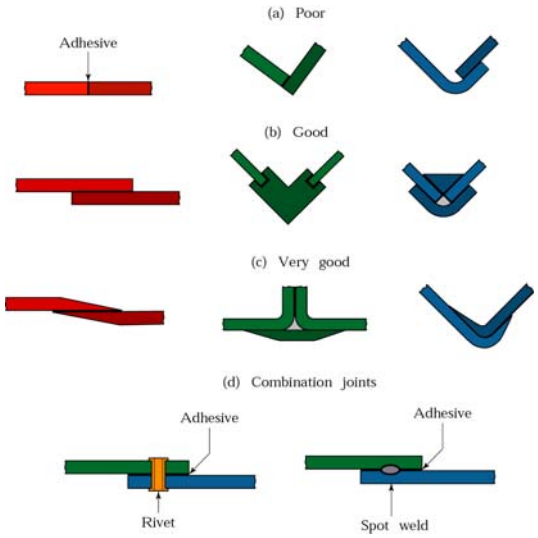
Some joint designs for adhesive bonding: (a) through (d) butt joints; (e) through (f) T-joints; (b) and (g) through (j) corner joints.

Adhesive Peeling Test

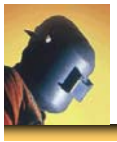


Characteristic behavior of (a) brittle and (b) tough adhesives in a peeling test. This test is similar to the peeling of adhesive tape from a solid surface.

Joint Designs in Adhesive Bonding

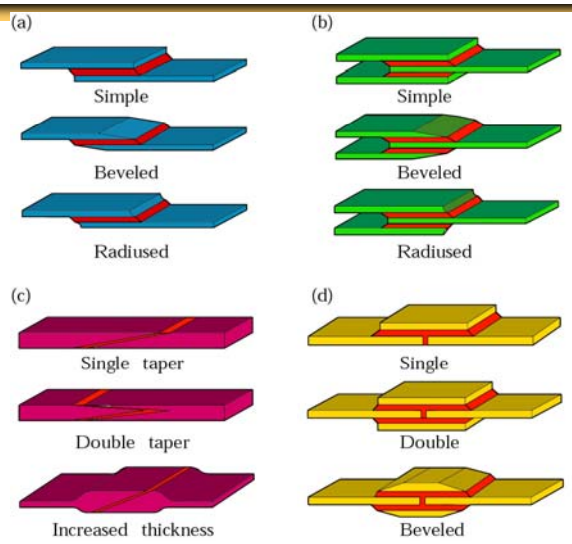


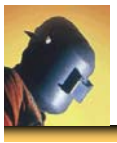
Various joint designs in adhesive bonding. Note that good designs require large contact areas between the members to be joined.



Configurations of Adhesively Bonded Joints

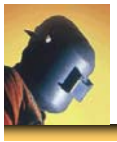
Various configurations for adhesively bonded joints: (a) single lap, (b) double lap, (c) scarf, (d) strap.





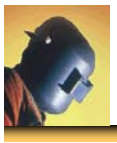
6. Adhesive Types

- Natural adhesives - derived from natural sources, including gums, starch, dextrin, soya flour, collagen
  - Low-stress applications: cardboard cartons, furniture, bookbinding, plywood
- Inorganic - based principally on sodium silicate and magnesium oxychloride
  - Low cost, low strength
- Synthetic adhesives - various thermoplastic and thermosetting polymers



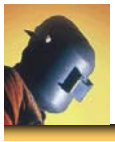
6. Synthetic Adhesives

- Most important category in manufacturing
- Synthetic adhesives cured by various mechanisms:
  - Mixing catalyst or reactive ingredient with polymer prior to applying
  - Heating to initiate chemical reaction
  - Radiation curing, such as UV light
  - Curing by evaporation of water
  - Application as films or pressure-sensitive coatings on surface of adherend



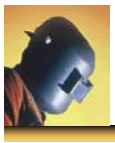
6. Applications of Adhesives

- Automotive, aircraft, building products, shipbuilding
- Packaging industries
- Footwear
- Furniture
- Bookbinding
- Electrical and electronics



6. Surface Preparation

- For adhesive bonding to succeed, part surfaces must be extremely clean
- Bond strength depends on degree of adhesion between adhesive and adherend, and this depends on cleanliness of surface
  - For metals, solvent wiping often used for cleaning, and abrading surface by sandblasting improves adhesion
  - For nonmetallic parts, surfaces are sometimes mechanically abraded or chemically etched to increase roughness



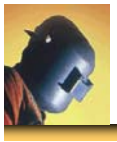
6. Application Methods

- Manual brushing and rolling
- Silk screening
- Flowing, using manually operated dispensers
- Spraying
- Automatic applicators
- Roll coating

Adhesive is dispensed by a manually controlled dispenser to bond parts during assembly (photo courtesy of EFD Inc.).

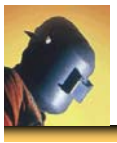
6. Advantages of Adhesive Bonding

- Applicable to a wide variety of materials
- Bonding occurs over entire surface area of joint
- Low temperature curing avoids damage to parts being joined
- Sealing as well as bonding
- Joint design is often simplified, e.g., two flat surfaces can be joined without providing special part features such as screw holes



6. Limitations of Adhesive Bonding

- Joints generally not as strong as other joining methods
- Adhesive must be compatible with materials being joined
- Service temperatures are limited
- Cleanliness and surface preparation prior to application of adhesive are important
- Curing times can limit production rates
- Inspection of bonded joint is difficult

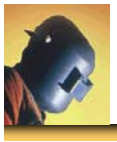


Typical Properties and Characteristics of Chemically Reactive Structural Adhesives

TABLE 30.3

	Epoxy	Polyurethane	Modified acrylic	Cyanoacrylate	Anaerobic
Impact resistance	Poor	Excellent	Good	Poor	Fair
Tension-shear strength, MPa (10^3 psi)	15.4 (2.2)	15.4 (2.2)	25.9 (3.7)	18.9 (2.7)	17.5 (2.5)
Peel strength, N/m (lbf/in.)	< 525 (3)	14,000 (80)	5250 (30)	< 525 (3)	1750 (10)
Substrates bonded	Most materials	Most smooth, nonporous	Most smooth, nonporous	Most nonporous metals or plastics	Metals, glass, thermosets
Service temperature range, °C (°F)	–55 to 120 (-70 to 250)	–160 to 80 (-250 to 175)	70 to 120 (-100 to 250)	–55 to 80 (-70 to 175)	–55 to 150 (-70 to 300)
Heat cure or mixing required	Yes	Yes	No	No	No
Solvent resistance	Excellent	Good	Good	Good	Excellent
Moisture resistance	Excellent	Fair	Good	Poor	Good
Gap limitation, mm (in.)	None	None	0.75 (0.03)	0.25 (0.01)	0.60 (0.025)
Odor	Mild	Mild	Strong	Moderate	Mild
Toxicity	Moderate	Moderate	Moderate	Low	Low
Flammability	Low	Low	High	Low	Low

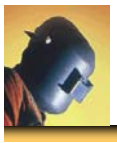
Source: Advanced Materials & Processes, July 1990, ASM International.



General Properties of Adhesives

TABLE 30.4

Type	Comments	Applications
Acrylic	Thermoplastic; quick setting; tough bond at room temperature; two component; good solvent chemical and impact resistance; short work life; odorous; ventilation required	Fiberglass and steel sandwich bonds, tennis racquets, metal parts, plastics.
Anaearobic	Thermoset; easy to use; slow curing; bonds at room temperature; curing occurs in absence of air, will not cure where air contacts adherents; one component; not good on permeable surfaces	Close fitting machine parts such as shafts and pulleys, nuts and bolts, bushings and pins.
Epoxy	Thermoset; one or two component; tough bond; strongest of engineering adhesives; high tensile and low peel strengths; resists moisture and high temperature; difficult to use	Metal, ceramic and rigid plastic parts.
Cyanoacrylate	Thermoplastic; quick setting; tough bond at room temperature; easy to use; colorless.	"Crazy glue." ™
Hot melt	Thermoplastic; quick setting; rigid or flexible bonds; easy to apply; brittle at low temperatures; based on ethylene vinyl acetate, polyolefins, polyamides and polyesters	Bonds most materials. Packaging, book binding, metal can joints.
Pressure sensitive	Thermoplastic; variable strength bonds. Primer anchors adhesive to roll tape backing material, a release agent on the back of web permits unwinding. Made of polyacrylate esters and various natural and synthetic rubber	Tapes, labels, stickers.



General Properties of Adhesives (cont.)

TABLE 30.4 (continued)

Type	Comments	Applications
Phenolic	Thermoset; oven cured, strong bond; High tensile and low impact strength; brittle, easy to use; cures by solvent evaporation.	Acoustical padding, brake lining and clutch pads, abrasive grain bonding, honeycomb structures.
Silicone	Thermoset; slow curing, flexible; bonds at room temperature; high impact and peel strength; rubber like	Gaskets, sealants.
Formaldehyde: -urea -melamine -phenol -resorcinol	Thermoset; strong with wood bonds; urea is inexpensive, available as powder or liquid and requires a catalyst; melamine is more expensive, cures with heat, bond is waterproof; resorcinol forms waterproof bond at room temperature. Types can be combined	Wood joints, plywood, bonding.
Urethane	Thermoset; bonds at room temperature or oven cure; good gap filling qualities	Fiberglass body parts, rubber, fabric.
Water-base -animal -vegetable -rubbers	Inexpensive, nontoxic, nonflammable.	Wood, paper, fabric, leather, dry seal envelopes.