Metal Fasteners, Joining, and Adhesives

**Fasteners**
- Metal assemblies are often held together with fasteners, hardware devices that mechanically join or affix two or more objects together.
- Assembling with most types of fasteners allows components to be repeatedly assembled and disassembled.
- This is important where a product is expected to undergo modifications, repairs, or where it may provide access into an assembly.

**Bolts**
- Threaded shafts that use a threaded nut to fasten metal together.
- Bolts are sized by length and thread.
- Bolts are stronger than screws.
- Bolts are classified by the type of head.
  - Stove bolts and machine screws (actually bolts) are turned with a screwdriver.
  - Hexagonal- and square-head bolts are held in place with a wrench while the nut is turned to tighten.
Types of Bolts

- **Carriage bolt**
  - Smooth round head & course thread that starts part way down the shaft.
  - Usually used to attach a wooden part to metal.

- **Machine bolt**
  - Hexagonal head & only partially threaded.
  - Used for precision attachment using threads to secure materials together.

- **Tap bolt**
  - Similar to a machine bolt but the whole body is threaded.

- **Stove bolt**
  - Round or flat head with course thread along the whole body.
  - General purpose fastener used when precision fit is not necessary.

- **Stud bolt**
  - No head and threaded on both ends.
  - One end is driven into material & the other end is left exposed so that other parts can be fastened to it.

Types of Machine Screws

- **Machine & cap screws**
  - Come with a variety of head & thread types.
  - Used for precision fit into thread holes in metal.

- **Setscrew**
  - Made with square heads or no heads.
  - Typically used for safety reasons to hold a sleeve, collar or gear on a shaft to prevent relative motion.

- **Thumbscrews**
  - Has one or two wings or a knurled head.
  - Used where a screw must be turned by hand using the thumb and a finger.

Sheet Metal Screws

- Short thick screws that are **self-threading** (cut or form their own threads as driven into soft metals).
- Used in the economical assembly of sheet metal.
- Threaded all the way down the shank.
- Come in a variety of head types depending on application.

Lag Screw

- Bolt is a bolt head with a screw body.
- Has either a square or hexagonal head.
- Used in fastening where maximum holding power is needed (i.e. holding a vise to a work bench).
Nuts

- Type of hardware fastener with a threaded hole.
- Usually hexagonal to permit tightening with a wrench but may also be square, knurled, winged or otherwise shaped.
- Along with a bolt, nuts are designed to capture and fasten objects together.

Type of Nuts

- Machine screw nut (Hex nut)
  - Square or hexagonal shaped with fine or coarse thread.
- Jam nut (Lock nut)
  - Thinner than an ordinary nut.
  - Used as a lock to keep another nut from loosening.
- Castle nut
  - Has slots cut into the top of the nut that extend upward making it look like a castle.
  - A hex nut with a slightly reduced slotted cylindrical section on one end.
  - Used with a cotter pin to prevent loosening.
- Wing nut
  - A nut with two thin flat wings.
  - Used in place of a regular nut and can be turned with the thumb and forefinger.

Washers

- Placed under the bolt head or the nut for a firmer fasten.
- Designed to protect the surface under a bolt or nut.
- Used to spread load of a mechanical connection out over a greater area.

Type of Washers

- Plain washers
  - Circular, small flat piece to widen the bearing surface of a bolt head or nut.
  - Measured by the diameter of the bolt that fits into it.
- Lock washer
  - Used to lock a nut or screw in place, prevent it from moving from vibrations.
  - Helical spring - looks like a coil from a spring that tightens when applied to prevent movement.
  - Toothed - has teeth that wedge into bearing surface when applied to prevent movement.
Pins

- Used to hold mechanical parts together or limit travel of moving parts.
- Cotter pin
  - Made of soft wire.
  - Placed through a hole in a bolt behind a castle nut to prevent the nut from turning.
- Tapered pin
  - Used to hold a collar or pulley against a shaft.
- Roll pins
  - Made from sheet steel that is rolled into a tube.
  - Driven into holes slightly larger than a standard hole size so they grip tightly when pounded in.

Keys

- Used to keep pulleys and gears from moving on shafts.
- Half the key fits into the keyway (a slot on the shaft), the other half fits into a slot that is on the pulley or gear.
- Square key
  - Most commonly used.
- Gib-head key
  - Toothed key that is useful when you need to remove the key from one side of the pulley or gear.
  - Can be removed with a wedge.
- Woodruff key
  - Semicircular in shape and fits a matching semicircular pocket in the shaft.
  - Key becomes locked in position and cannot be knocked loose due to vibration.

Joining Metal

- As with wood, there are many ways of joining metal permanently.
- The method used will depend on the function of the product, the strength needed and the quality of the product.
- There are several ways of joining metal permanently.
  - riveting
  - soldering and brazing
  - welding
- The later two of these techniques rely upon heat.
  - With soldering and brazing, the two metals are joined by melting a second metal between them.
  - With welding, the two metals are melted and fused together.

Rivets

- Metal pins that look like bolts with no threads.
- Used to hold pieces together permanently.
- Used when fastening metals together that are not easily welded, or where welding is not practical.
Rivet Characteristics
- May be either solid or tubular.
- Made from different materials such as soft steel, aluminum, copper, and brass.
- Come with a variety of different shapes and heads.
- For application, rivets are placed in holes, pre-drilled in materials and fastened together.
  - With solid rivets, the headless head is pounded to form a head.
  - Hollow rivets are clinched at the headless end with a special riveting tool.

Spot Welding
- Form of resistance welding done with a spot welder.
- High current at a low voltage passes through a spot on two pieces of metal (usually sheet metal) for a short period of time.
  - Resistance to the flow of current through the metal at the spot causes heat, which melts the metal and makes a spot weld.
  - Most frequently used to weld metal joints but sometimes used to weld sheet metal to small diameter rods or small flat bars.

Soldering
- Process of fastening two metals together with solder, a nonferrous metal that has a lower melting point than the parts being joined.
- Parts being joined are heated until the solder, when brought into contact with them, melts and flows between the surfaces.
- When the solder solidifies, it adheres (sticks) tightly and forms a strong bond between the two surfaces.

Soft Soldering
- Occurs at temperatures below 800 degrees Fahrenheit.
- For general work, a solder called rosin core 60-40 (60% tin, 40% lead) is often used.
- Solder often comes in a coil of wire 1/16" in diameter but can come in other pre-cut shapes, sizes, and forms.
- Heat for soft soldering is applied using soldering gun or a soldering copper.
Hard Soldering

- If solder melts above 800 degrees Fahrenheit, it is called hard soldering.
- Used where a strong joint is needed or where the parts will be used in greater heat than the melting point of soft solder.
- The most widely used hard solders are silver alloy solders that come in ribbons, sheets, wire, or pre-cut pieces of various shapes and sizes.
- Often used in jewelry and art metalwork for joining copper, silver, and gold.
- Heat for hard soldering is applied directly with the flame of a torch.

Brazing

- Hard soldering processing where the filler material flows into the joints using capillary action (the natural tendency of a liquid to be drawn in between two close fitting surfaces).
- Filler material used is brazing rods (60% copper, 40% zinc).

Adhesive Bonding of Metals

- Process of fastening parts of metal products together permanently with non-metallic materials.
- Often used as an alternative to mechanical fasteners.
- When using adhesives, the entire joint must be given even more consideration than when using mechanical fasteners.
  - Unlike a bolt or rivet, an adhesive’s properties may change depending on where it is used.
- Light-gauge materials are often good candidates for adhesive bonding.

Advantages of Using Adhesives to Join Metals

- Many adhesives easily join dissimilar materials if proper surface treatments are used.
- Adhesively joined structures and products are inherently smooth.
  - Exposed surfaces are not defaced, and contours are not disturbed as with other types of fastening systems.
  - This is important both to function and appearance.
- Adhesives are sometimes used with mechanical fasteners for sealing flange joints or holding the parts together while the bond forms.
- Thin or fragile metal parts can be bonded. Adhesives do not usually impose heavy loads on materials, such as in riveting, or localized heating, such as in soldering or welding.
Cyanoacrylates (superglue)

- Adhesives developed for production situations requiring *instant bonds* and immediate handling strength, particularly when bonding rubber, metals and plastics.
- These adhesives are especially well-suited for *trim attachment and light assembly*.
- Cure through reaction with moisture held on the surface to be bonded.
- Good environmental resistance; therefore, they offer excellent resistance to weathering and aging.

Epoxies

- Synthetic adhesive made of two components, a *liquid resin* and the *hardener* to convert the liquid resin into a solid.
- Create superior bonds for a wide variety of materials including metals, rubber, and plastics.
- Widely used in the automotive industry.
  - Many cars and light- and heavy-duty trucks feature body panels bonded with epoxy adhesives.
- Excellent environmental and chemical resistance.
  - They resist the effects of dilute acids, alkalis, solvents, greases, oils, moisture, sunlight and weathering.
- Flexible cure rates.
  - Allow great versatility in formulation since amount of hardener can be adjusted to increase work time or decrease set time.
- Low shrinkage and good creep properties.

Urethanes

- Primerless adhesive that is ideal for prepared metals, rubber and fiber reinforced plastics.
- Create strong flexible bonds that bring excellent structural integrity to assemblies made of plastic, metal, foams and elastomers.

Anaerobics

- Specialty adhesives designed to cure on metals in the absence of oxygen.
- Primarily used to anchor threaded joints and shafts against breaking free due to vibration.
- Can eliminate the need for lock washers and press fitted metal joints.
- Often known as "locking compounds."
- Based on synthetic acrylic resins.