Joining Processes

Bachelor of Industrial Technology Management with Honours

Semester I Session 2013/2014

TOPIC OUTLINE

- Mechanical Assembly
- Welding
- Adhesive Bonding

LESSON OUTCOMES

Able to explain the different methods of joining process applicable for different types of joint.

Introduction

- Commercial product is an assembly (a composition of single parts) or subassemblies (groups of single parts combined to serve certain purpose and forming part of a larger assembly), e.g. a simple ballpoint pen.
- Manufacturing processes for joining and assembling – processes in which single parts are combined to form an assembly or subassemblies are joined to form final product.
- Reasons for joining:

1. A complex shaped component may be possible/cheaper to make it in several parts and then join them.
2. Some products are better made as assemblies so they can be disassembled for maintenance.
3. Transporting disassembled products are easier or feasible compared to transporting the entire product.

Introduction

Can be divided to 2 categories:

1. Processes for non-permanent combining - disassembly would not result in severe damages to the components in the assembly.
2. Processes for permanent combining - disassembly would result in severe damages to the components in the assembly and the subsequent assembly if attempted would not be possible any more.

Introduction

Classification according to the <u>operational methods</u>:

1. **Mechanical assembly** - use of various fastening methods to mechanically attach two (or more) parts and/or subassemblies together; they are either:
   i. Permanent – e.g. riveting, press or shrink fitting
   ii. Non-permanent – e.g. assembly with threaded fasteners such as screws, bolts, studs and nuts

2. **Joining processes** – use of various fastening methods to form a permanent assembly. E.g. welding, adhesive bonding, brazing and soldering.
   - Factors determining the selection of joining methods:
     1. Type of joint
     2. Required strength
     3. Materials of the components being joint
     4. Geometry of the components
     5. Costs issues

Mechanical Assembly

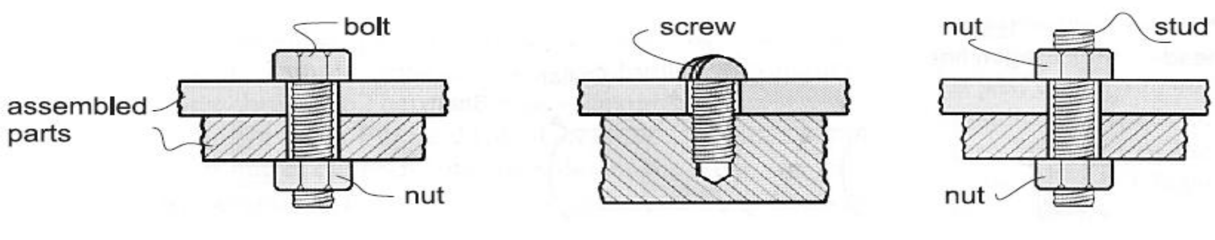
Processes for Non-Permanent Assembly

- For forming detachable joints.
- Use threaded fasteners - have external or internal threads for assembly of parts.
- Advantages:
  1. Fairly easy application
  2. Low capital for equipment needed to apply
  3. Nominal labour and provides good product aesthetics
  4. Dissimilar materials
  5. Different thicknesses
- Disadvantages:
  1. Higher component costs leads pre-fabricated fasteners inventory
  2. Expensive preparation
  3. Smaller contact limits bond to materials lowers the load performance
  4. Prone to loosening, weakening, rusting increases noise source
  5. High stress around the holes

Mechanical Assembly

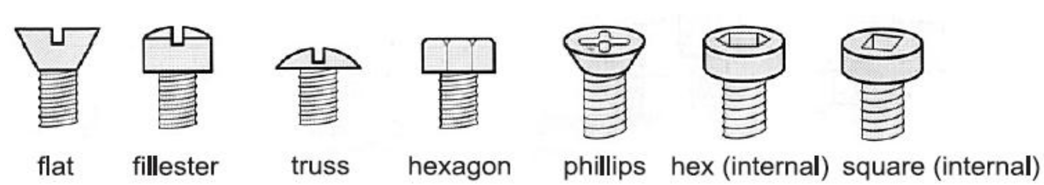
Types of threaded fastener:

1. *Bolt* - an externally threaded fastener that is inserted through holes in the parts and screwed into a nut on the opposite side.
2. *Screw* - an externally threaded fastener that is generally assembled into a blind threaded hole and no nut is required.
3. *Stud* - an externally threaded fastener, but without the usual head possessed by a bolt. Also be used to assemble two parts using a nut. They are available with threads on one end or both.
4. *Nut* - an internally threaded fastener having standard threads.



(a) (b) (c)

Fasteners come in a variety of sizes, threads and shapes.
Numerous head styles are available on bolts and screws.



Captive Fasteners

- Avoid the problems of lost, dropped or misplaced hardware
- Captive to the panel
- Wide variety: standard thread, fast-lead thread, inserts, and plungers

CAPTIVE SCREWS

- Industry's widest variety of captive screw styles
- Metric and Imperial thread sizes
- Options in driver recesses, headstyles, thread sizes, installation methods, and finishes
- Full screw retraction styles available

QUARTER TURN FASTENERS

- Quick access combined with captive fastening
- Designed for quick access
- Assembly remains captive to the panel; prevents lost hardware
- Wide variety of headstyles, receptacles, and retainers
- Assemble with or without spring-ejection

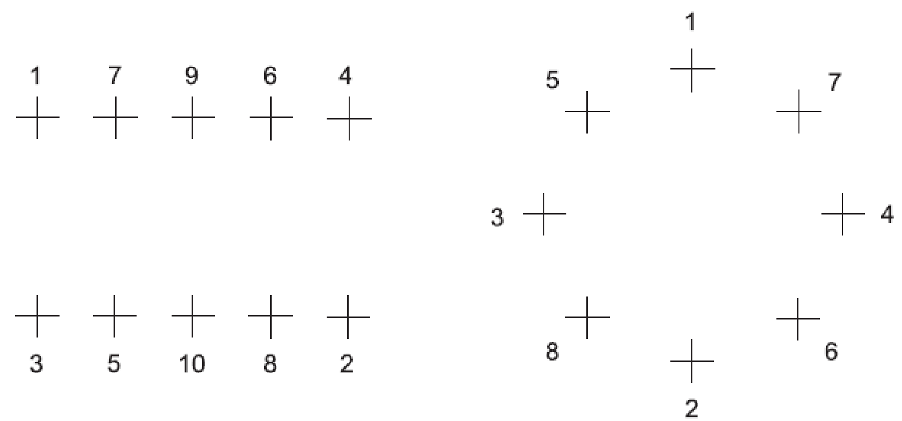
Mechanical Assembly

<u>Tightening Of Threaded Fasteners</u>

- Once the threaded fastener has been rotated until it is seated against the part surface, additional tightening will increase the amount of tension in the fastener.
- Various methods are employed to apply the required torque, including:
  1. *Operator feel - not very accurate, but adequate for most assemblies;*
  2. *Torque wrenches;*
  3. *Powered wrenches - stall when the required torque is reached.*
- Tightening of multiple threaded joints - needs to select the proper sequence of tightening.

Tightening is typically done in 3 steps:

1. 1/3 torque
2. 2/3 torque
3. Full amount of specified torque.



Sequence of tightening for multiple threaded joints.

Mechanical Assembly

Processes for Permanent Assembly

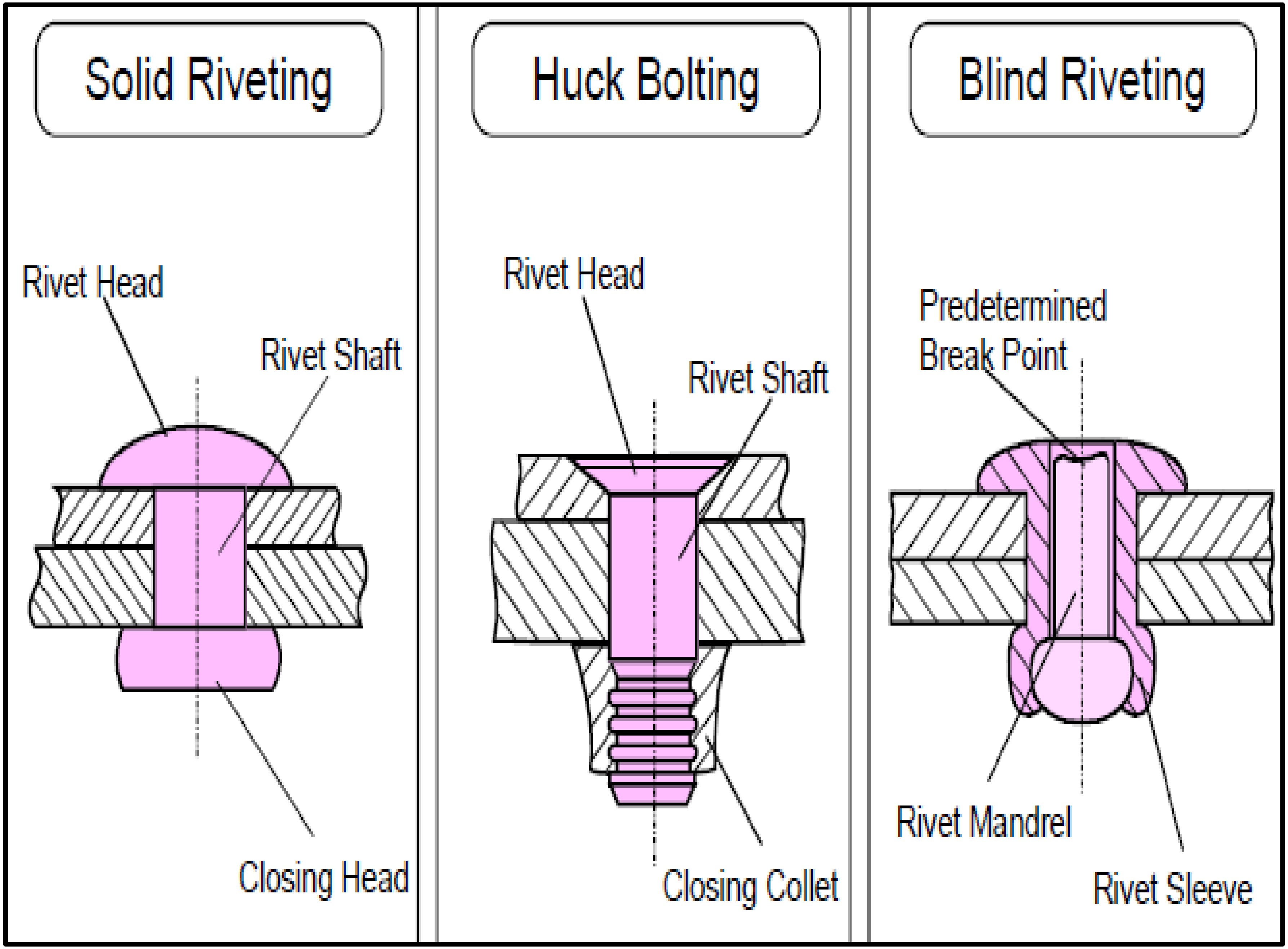
Riveting

- An unthreaded, headed pin used to join two (or more) parts by passing the pin through holes in the parts and then forming (upsetting) a second head in the pin on the opposite side.
- Performed hot or cold and by hammering or steady pressing.
- Cannot be removed except by breaking one of the heads.
- Used as one of the primary fastening processes in the aircraft and aerospace industries for joining skins to channels and other structural members.
- Much of the equipment is portable and manually operated. Automatic drilling are available for drilling the holes and riveting machines then inserting and upsetting the rivets.
- Advantages: high production rates, simplicity, dependability and low cost.

Mechanical Assembly

Types of rivet

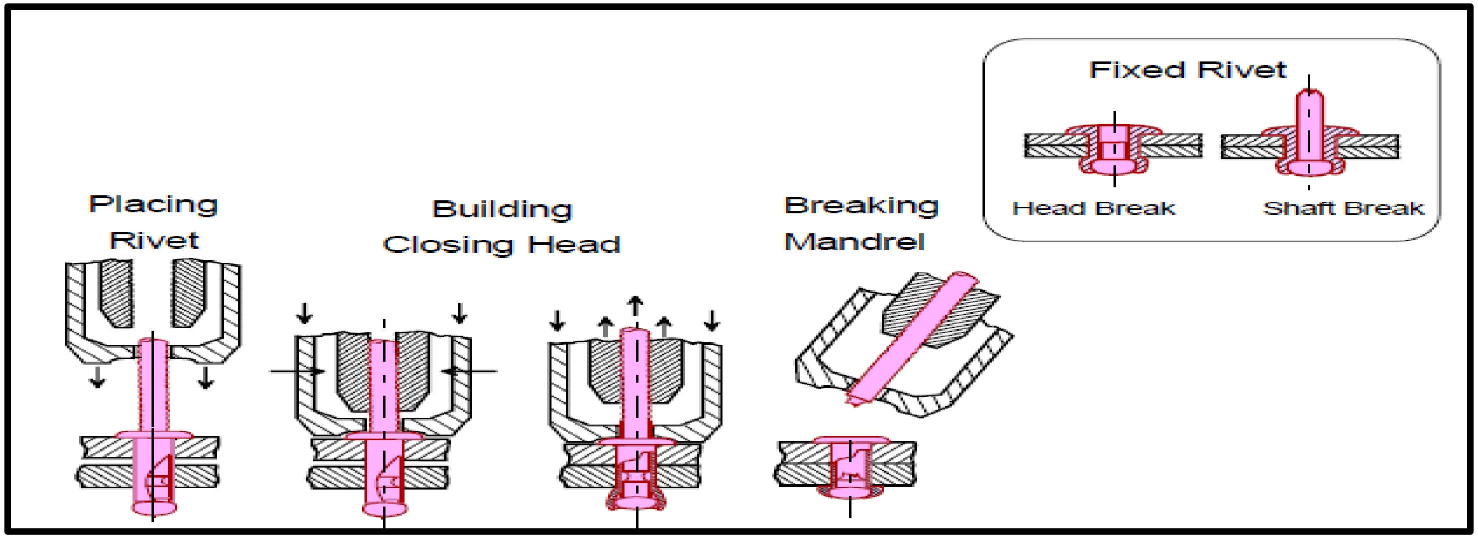
1. Solid rivets
   - One-piece joining elements in which the rivet shaft is plastically formed into the closing head.
   - Used for components which are accessible from both sides.
2. Huck bolts (screw rivets)
   - Used for highly stressed rivet joints.
   - Closing collate (self-locking nut) is fixed on to the rivet.
3. Blind (Chobert, pop) rivets
   - Consist of one or more elements and require only one accessible side for mounting.
4. Punch rivets
   - Designed to be self-piercing, making it unnecessary to form holes previously in the parts to be fastened.


Solid Riveting
Rivet Head
Rivet Shaft
Closing Head
Huck Bolting
Rivet Head
Rivet Shaft
Closing Collet
Blind Riveting
Predetermined
Break Point
Rivet Mandrel
Rivet Sleeve

Mechanical Assembly

<u>Working Principle of a Blind (Pop) Rivet</u>

- Consist of a hollow shaft and a pull-stem (mandrel) which serves as a tool for forming the closing head.
- Rivet is mounted by pulling the stem out with a special tool, whereby the stem head is drawn into the protruding rivet material to form the closing head.
- When the pulling force exceeds a certain level, the stem breaks at a predetermined position (notched or break-stem).
- The breaking point can be chosen to lie either in the shaft or at the rivet head.



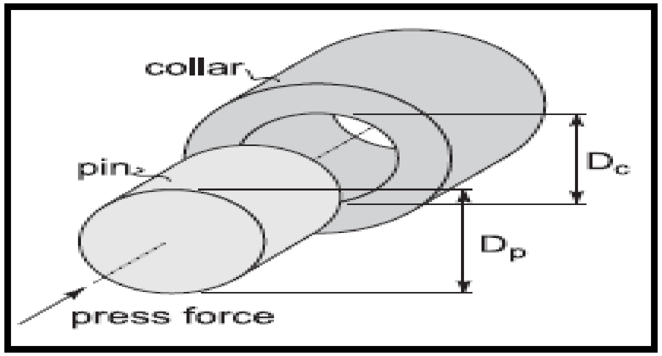
Mechanical Assembly

Press and Shrink Fits

- Based on mechanical interference between the two mating parts being joined.

  Press fit assembly

  - The two components have an interference fit between them.
  - Typical case - a pin of a diameter Dp is pressed into a hole of a slightly smaller diameter Dc.
  - Application - include locating and locking the components such as the assembly of collars, gears, pulleys and similar components onto shafts.
  - Limitations - necessity of a substantial press force and the possible damage to the surfaces of components.



Mechanical Assembly

Shrink Fitting

- External part is heated to enlarge by thermal expansion and the internal part either remains at room temperature or is cooled to contract its size.
- The parts are assembled and brought back to room temperature so that the external part shrinks and, if previously cooled, the internal part expands to form a strong interference fit.
- Heating equipment - includes torches, furnaces, electric resistance heaters, and electric induction heaters.
- Cooling methods include conventional refrigeration, packing in dry ice, and immersion in cold liquids, including liquid nitrogen.
- Application - to fit gears, pulleys, sleeves, and other components onto solid and hollow shafts but the most popular application is to fit bearing onto shafts.

Joining Processes

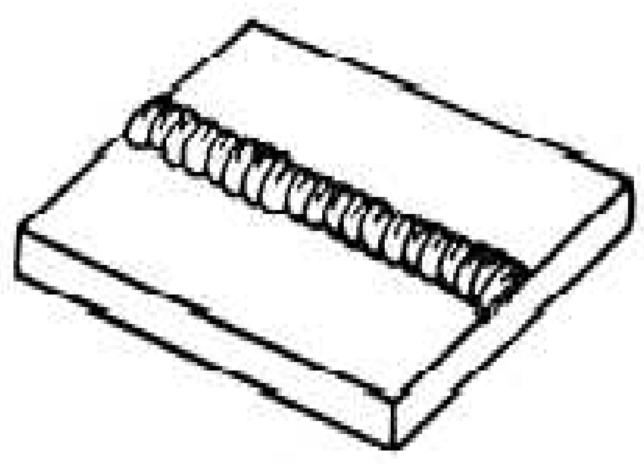
Welding

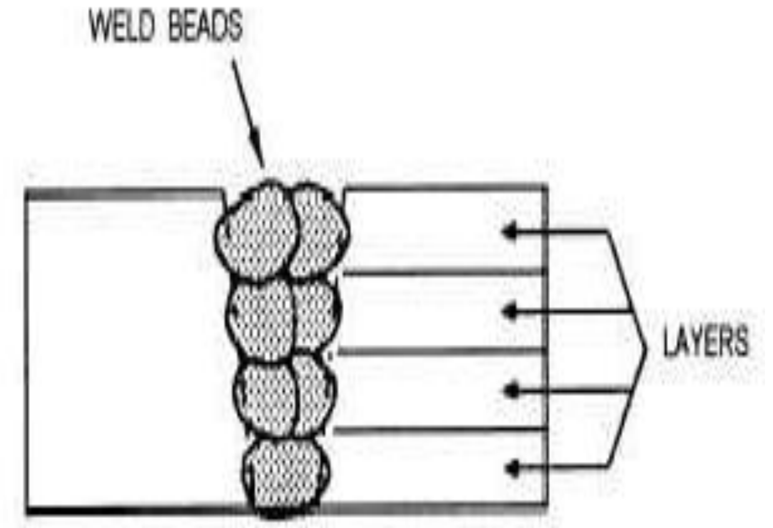
- Material joining process for a permanent combining of two (or more) parts that involves melting and subsequent solidification of the material from two parts thus forming a strong joint between them.
- Types of welds (joints):

1. Bead
2. Groove
3. Fillet
4. Surfacing
5. Tack
6. Plug
7. Slot

Bead Weld

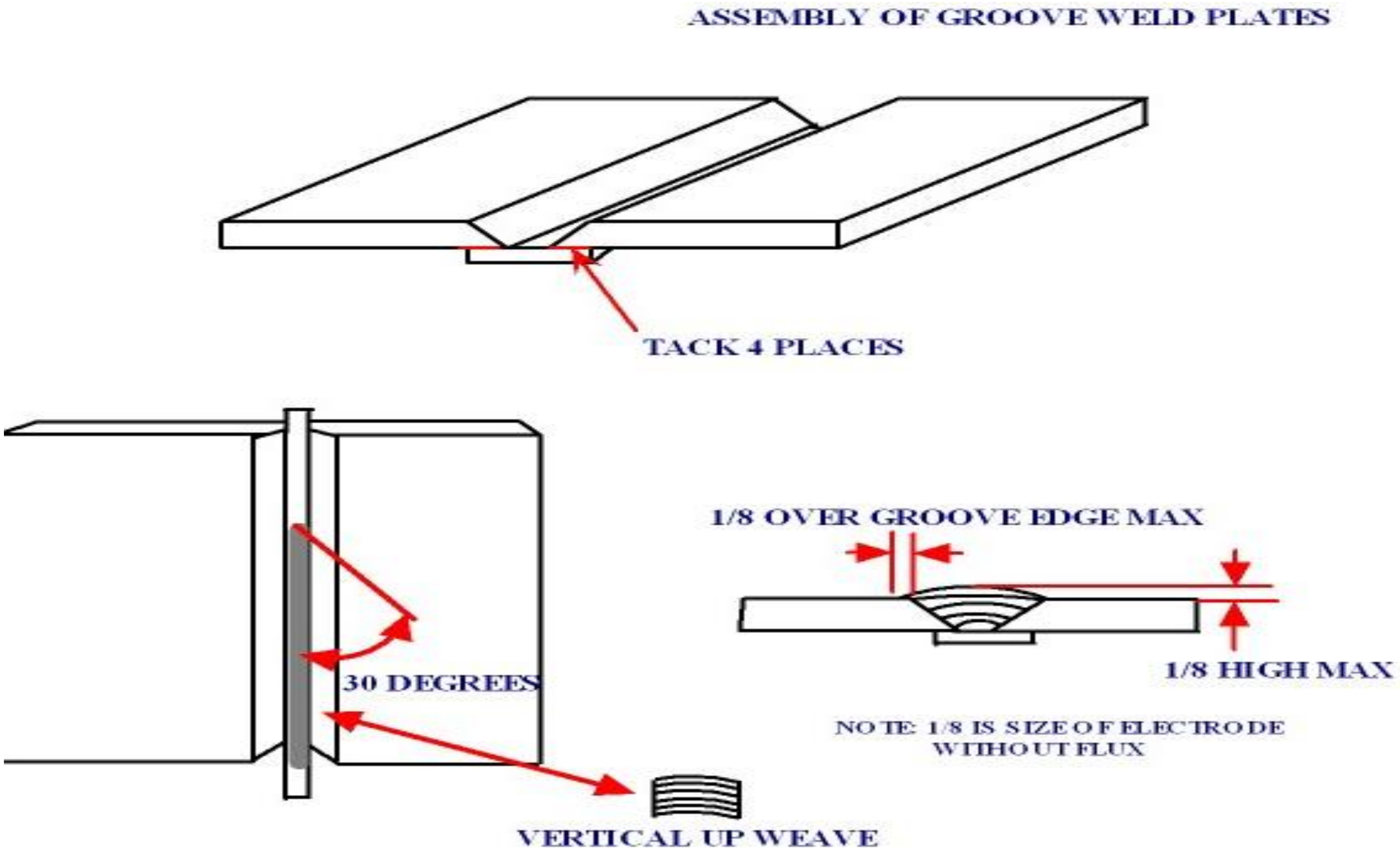
- Produced by a single pass
- Stinger Bead - which is made without weaving motion.
- Weave Bead - made by side-side oscillation





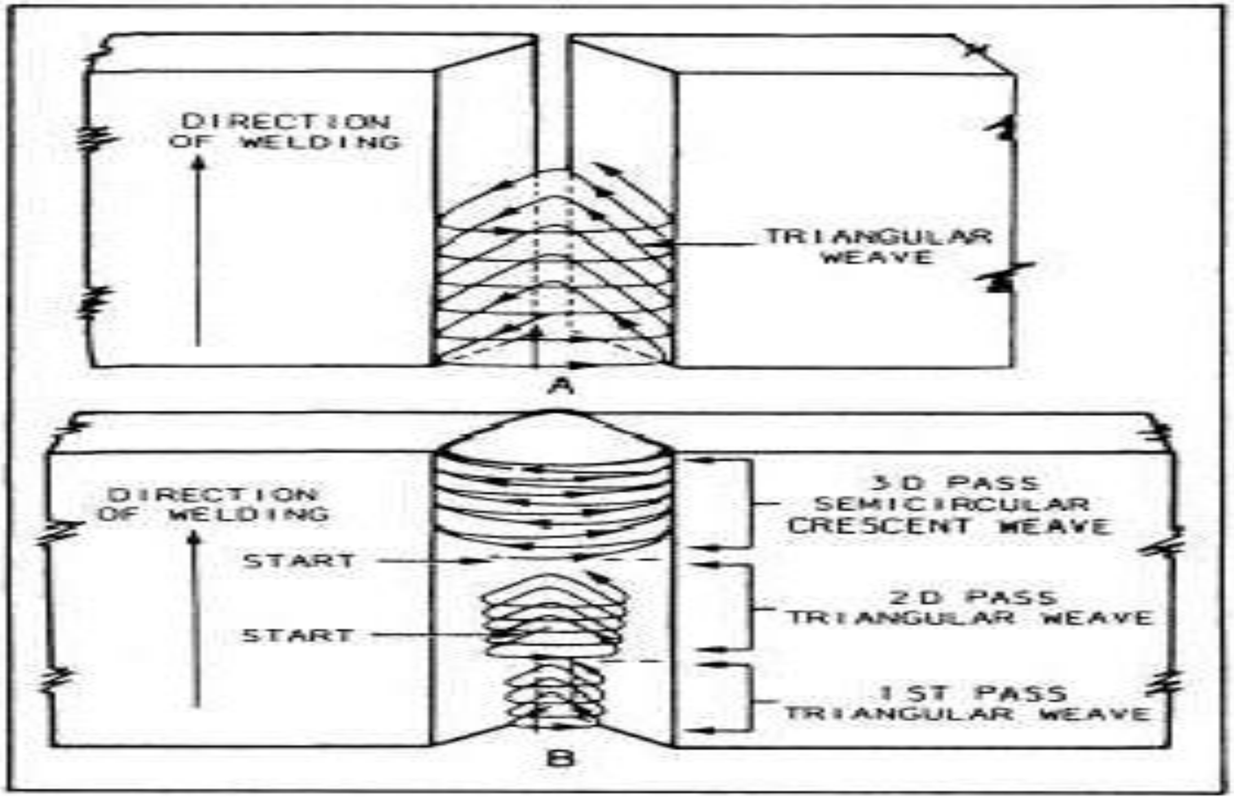
Groove Weld

- Made in the groove between two parts to be joined.



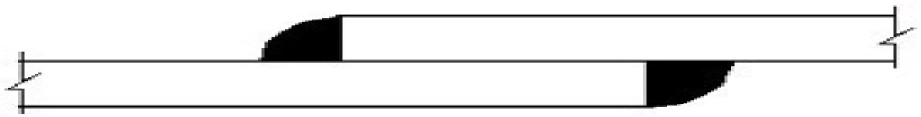
Surfacing Welds

- Composed of one or more stringer or weave beads.
- Often used to build up worn shafts, gears or cutting edges

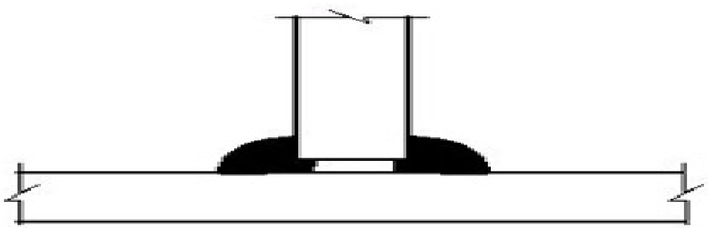


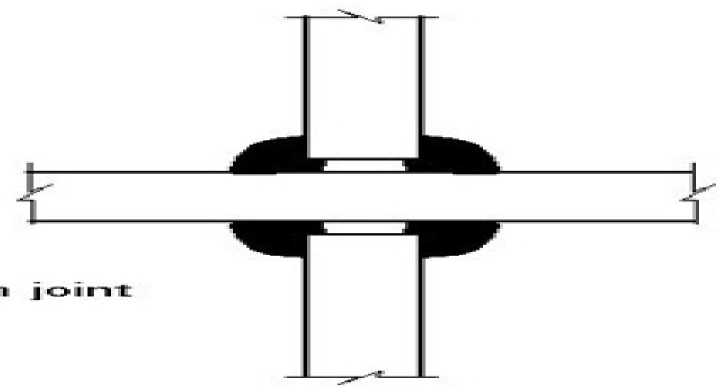
Fillet Weld

- Used to join two surfaces that are at approximately right angles to each other in a lap, tee or corner joint



(a) Lap joint



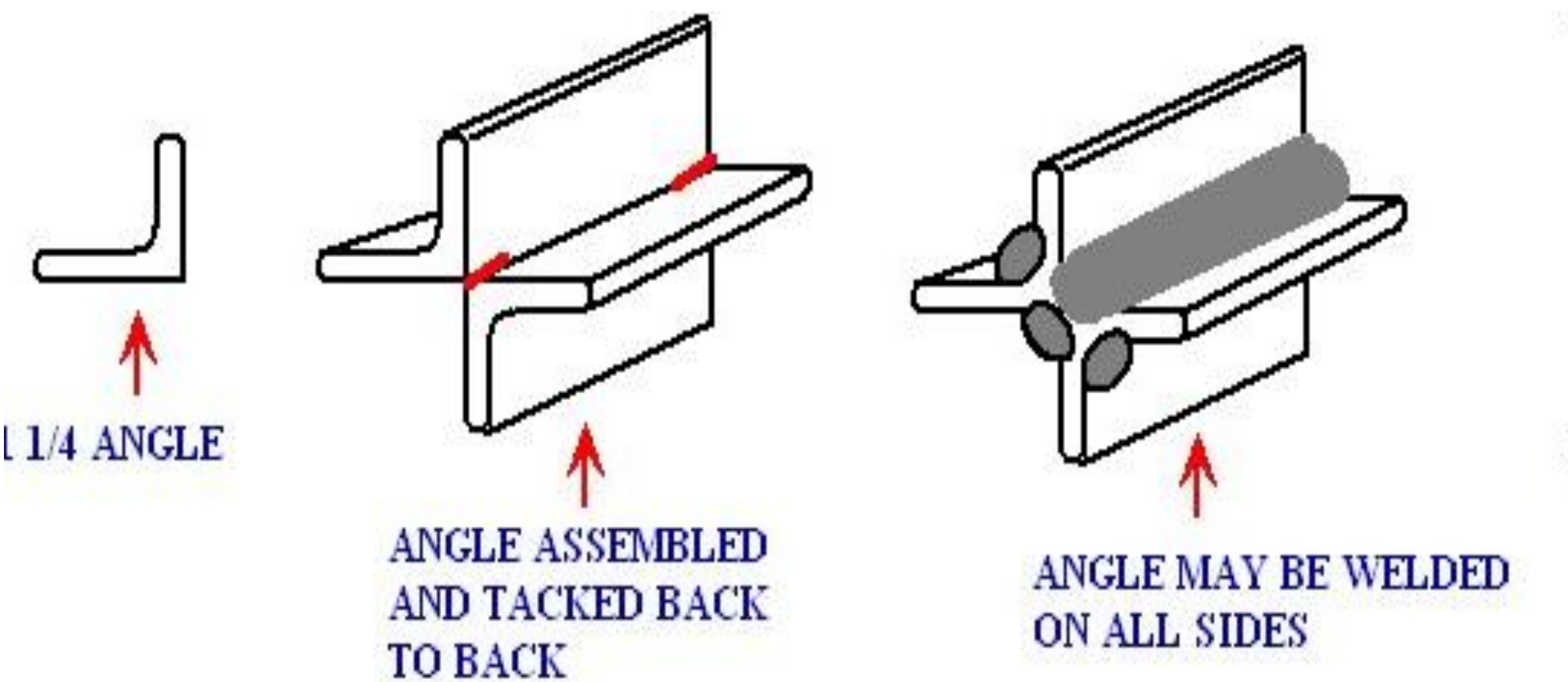


(b) Tee and cruciform joint

(c) Corner joint

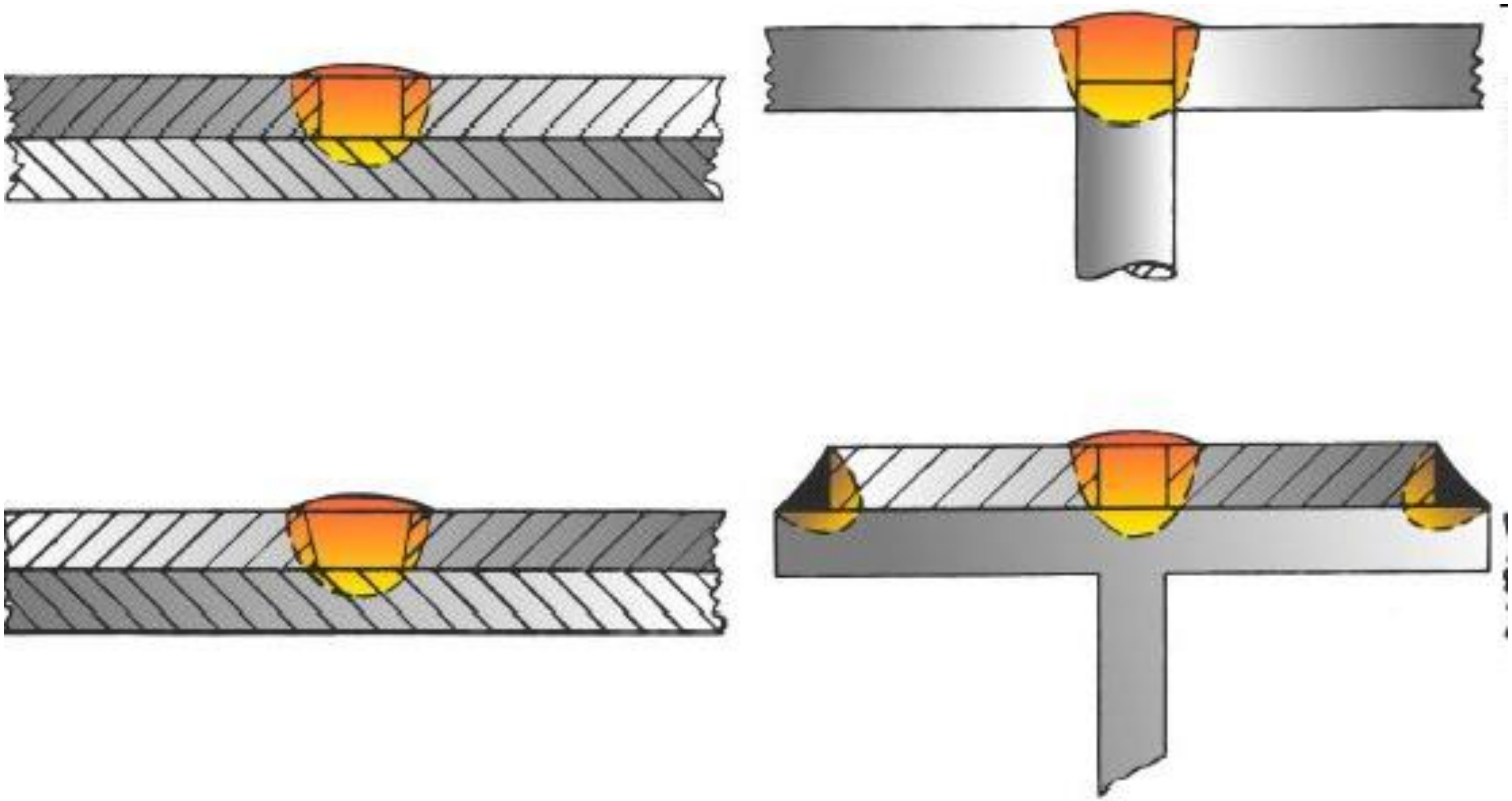
Tack Weld

- A weld made to hold parts of an assembly in proper alignment temporarily until the final welds are made.
- They are normally between 1/2 inch to 3/4 inch in length, but never more than 1 inch in length.

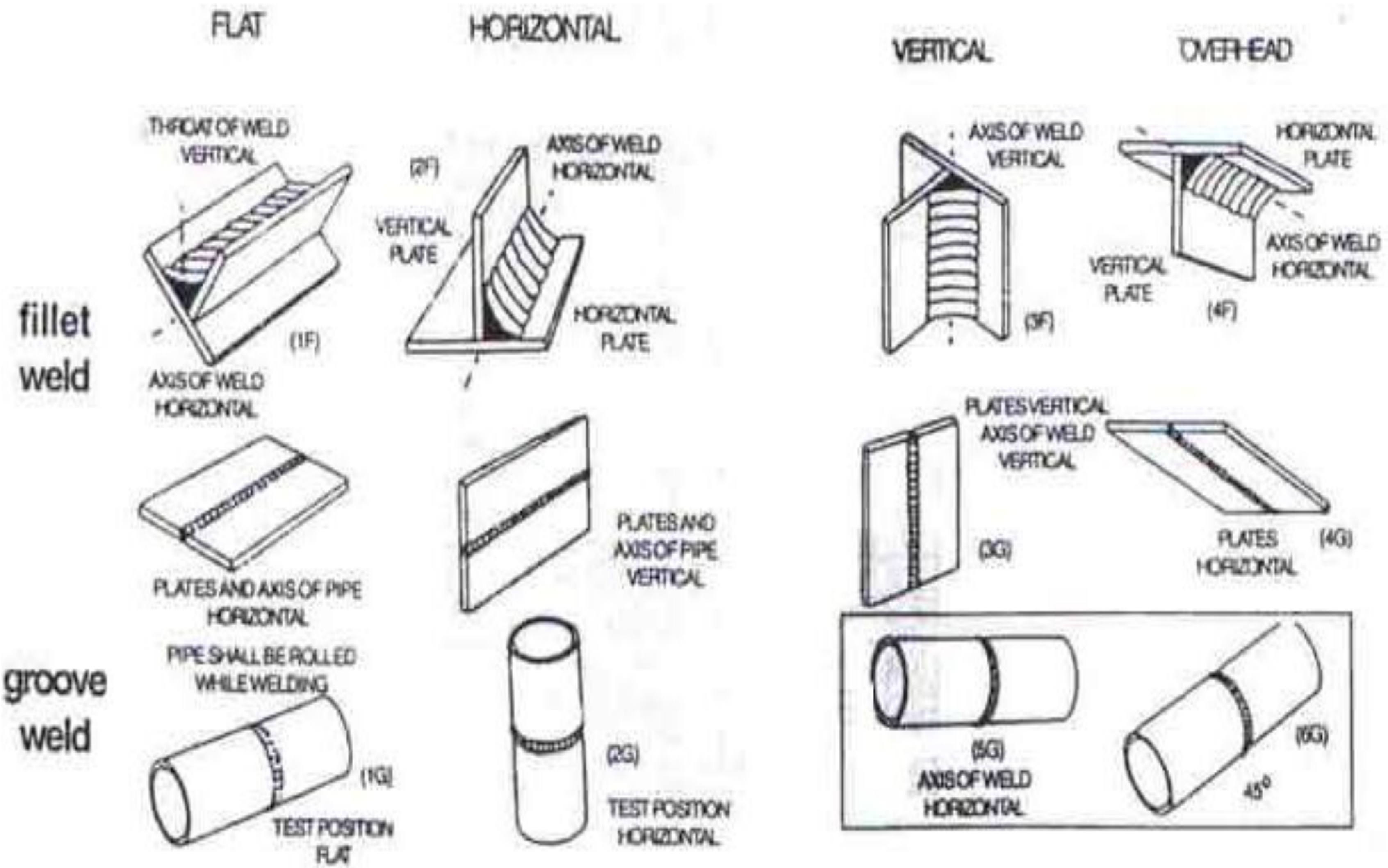


Plug and Slot Weld

- Welds made through holes or slots in one member of a lap joint.



Basic Welding Positions



Types Of Welding Process

Two groups of welding processes according to the state of the base material:

1. Liquid-state welding (fusion welding) : Base material is heat to melt.
2. Solid-state welding

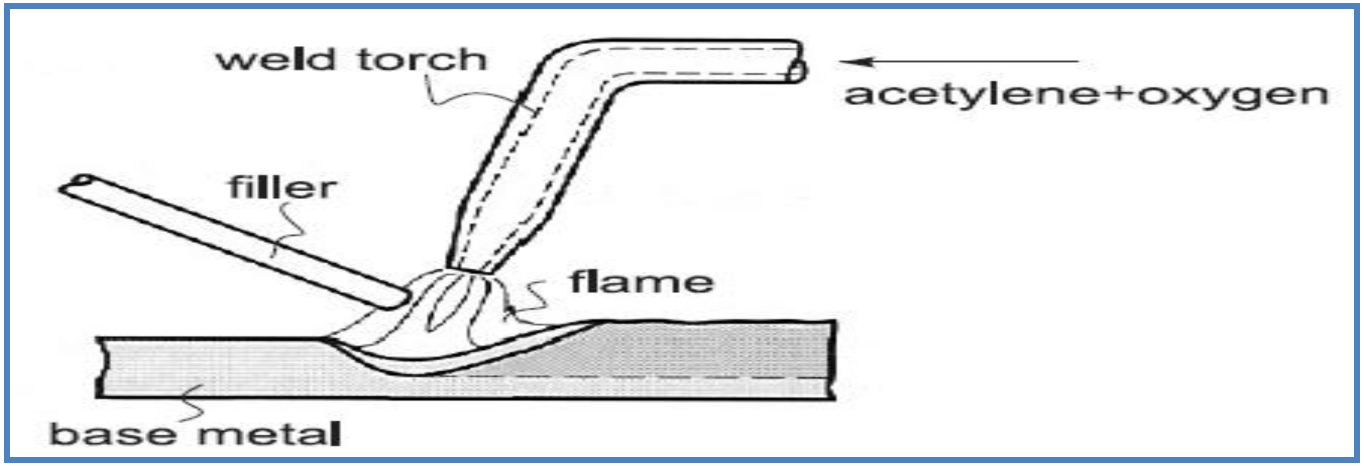
Fusion Welding

1. Oxy-fuel gas welding

- Most important type is oxyacetylene welding.

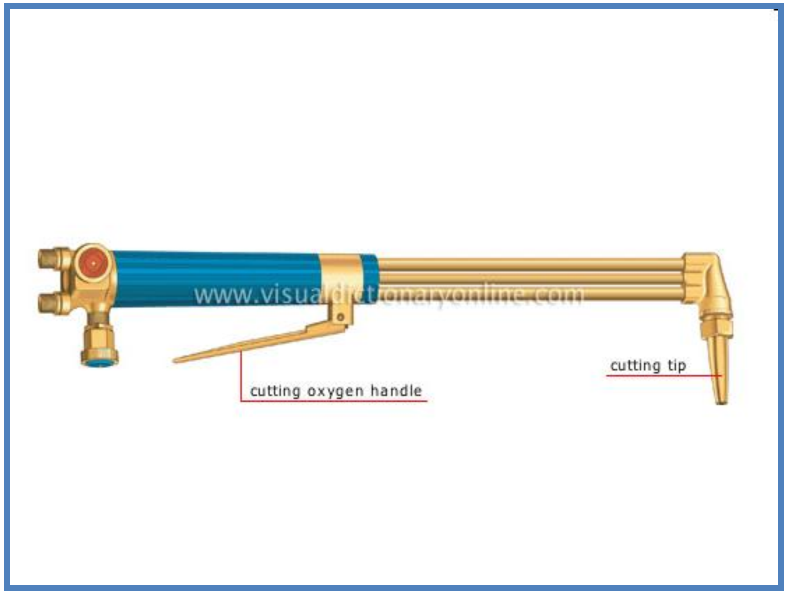
Oxyacetylene Welding (OAW)

- Performed by a high temperature flame from combustion of acetylene and oxygen.
- The flame is directed by a welding torch and a filler metal in the form of rod is added if the process is applied to weld.
- Composition of the filler must be similar to that of the base metal.



Fusion Welding

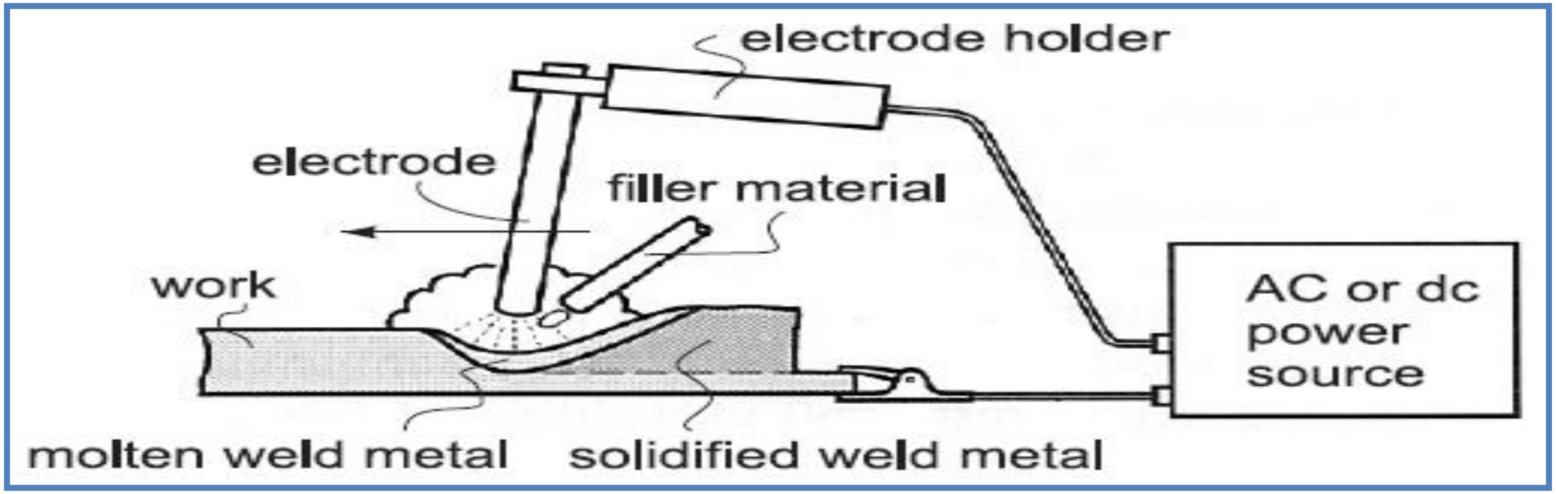
- Uses equipment that is relatively inexpensive and portable - economical, versatile process that is well suited to low-quantity production and repair jobs.
- Normally used on the welding of sheet and plate stock thinner than 5 mm.
- Usually performed manually and is hence dependent on the skill of the welder to produce a high-quality weld joint.



Fusion Welding

2. Arc welding with consumable electrodes

- Coalescence of the metals is achieved by the heat from an electric arc between an electrode and the work.



- Electric arc is a discharge of electric current across a gap in a circuit.
- To initiate the arc in an AW process, the electrode is brought into contact with the work and then quickly separated from it by a short distance.

Fusion Welding

- The electric energy from the arc thus formed produces temperatures of 5000^{o}C or higher, sufficiently hot to melt any metal.
- A pool of molten metal, consisting of base metal(s) and filler metal (if one is used), is formed near the tip of the electrode. In most arc welding processes, filler metal is added during the operation to increase the volume and strength of the weld joint.
- As the electrode is moved along the joint, the molten weld pool solidifies in its wake.
- Movement of the electrode relative to the work is accomplished by either a human welder (manual welding) or by mechanical means (machine welding, automatic welding, or robotic welding).
- Manual - quality of the weld joint is very dependent on the skill and experience of the human welder.
- The weld quality is much better in the machine, automatic and robotic welding.

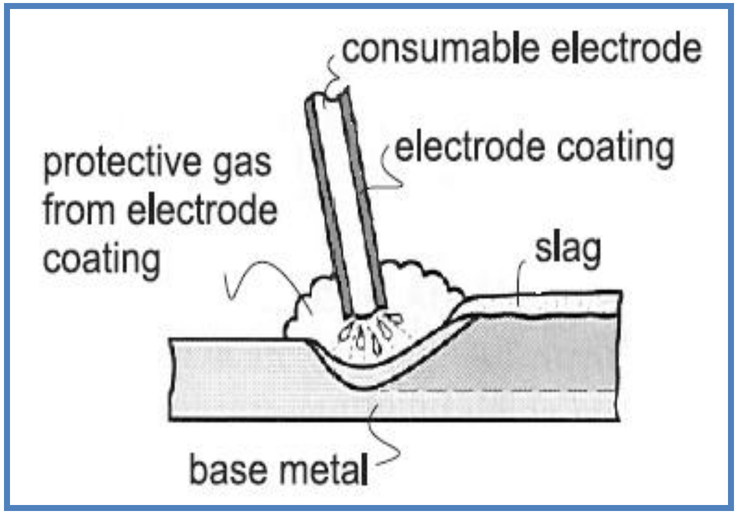
Fusion Welding

Electrodes are classified as:

1. **Consumable** - melts continuously in the process of arc welding thus providing the required filler material
2. **Non-consumable** - filler material must be supplied separately.

Shielded Metal Arc Welding

- Uses a consumable electrode consisting of a filler metal rod coated with chemicals that provide flux and shielding.
- The coated welding is typically 200 to 450 mm long and 1.5 to 9.5 mm in diameter. The heat of the welding process melts the coating to provide a protective atmosphere and slag for the welding operation.
- Shielded metal arc welding is usually performed manually. Common applications include construction, pipelines, machinery structures, shipbuilding and repair work.

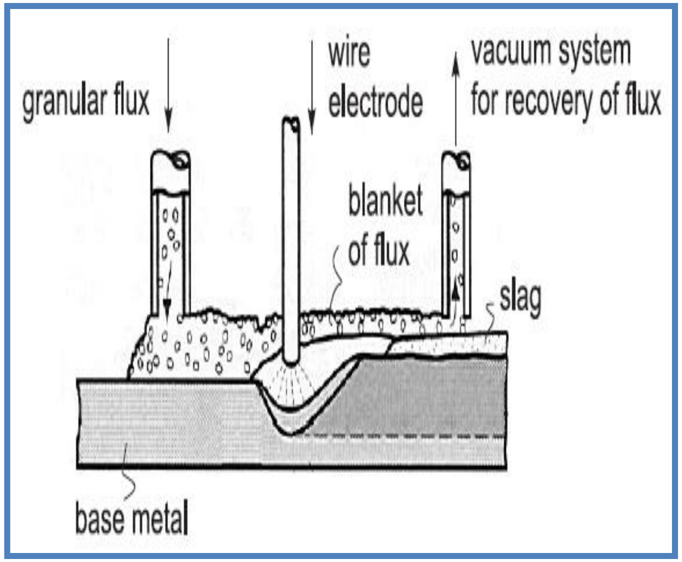


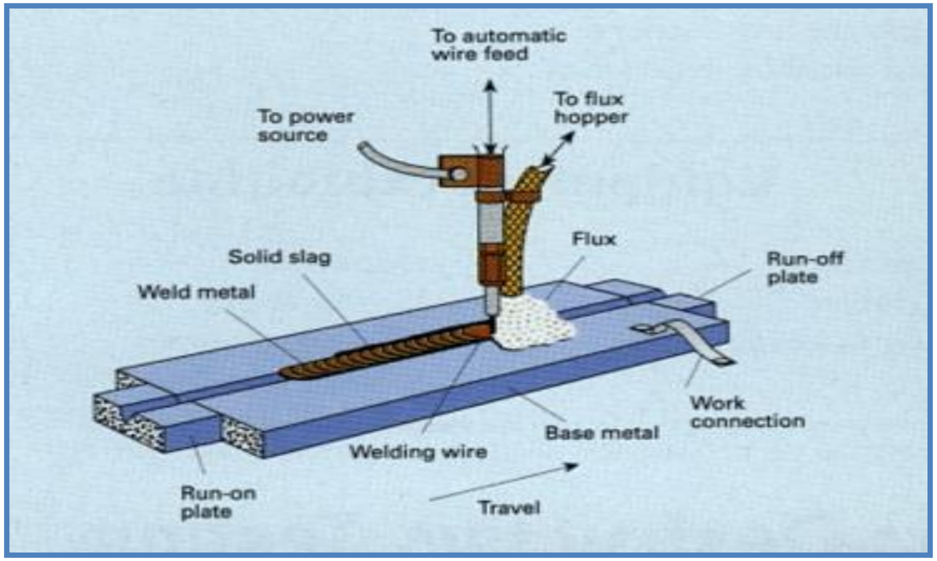
Shielded Metal Arc Welding

- During operation the bare metal end of the welding stick is clamped in an electrode holder connected to the power source.
- The holder has an insulated handle so that it can be held and manipulated by a human welder.
- Currents typically used in SMAW range between 30 and 300 A at voltages from I5 to 45 V depending on the metals being welded, electrode type and length and depth of weld penetration required.
- It is preferred over oxy-fuel welding for thicker sections above 5 mm because of its higher power density.
- The equipment is portable and low cost, making SMAW highly versatile and probably the most widely used of the AW welding processes.
- Base metals include steels, stainless steels, cast irons, and certain nonferrous alloys.

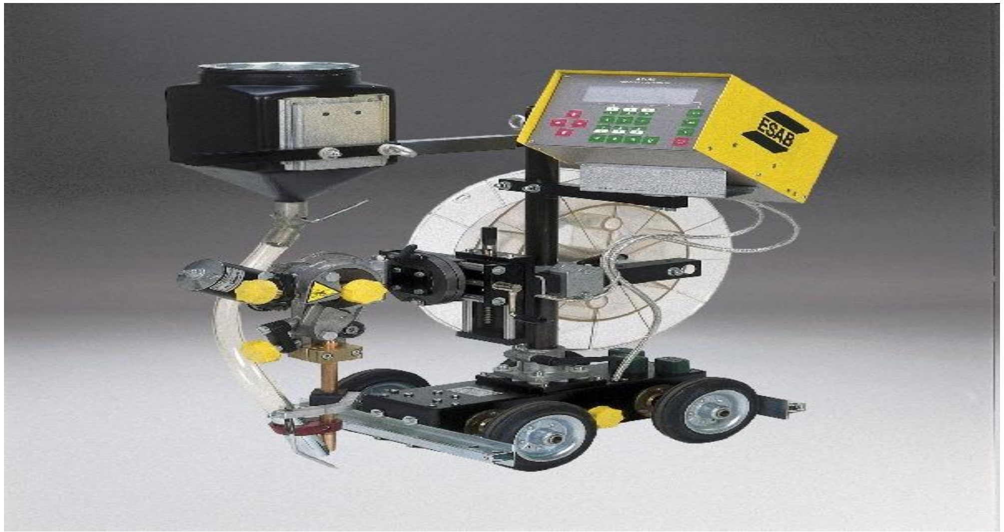
Submerged Arc Welding

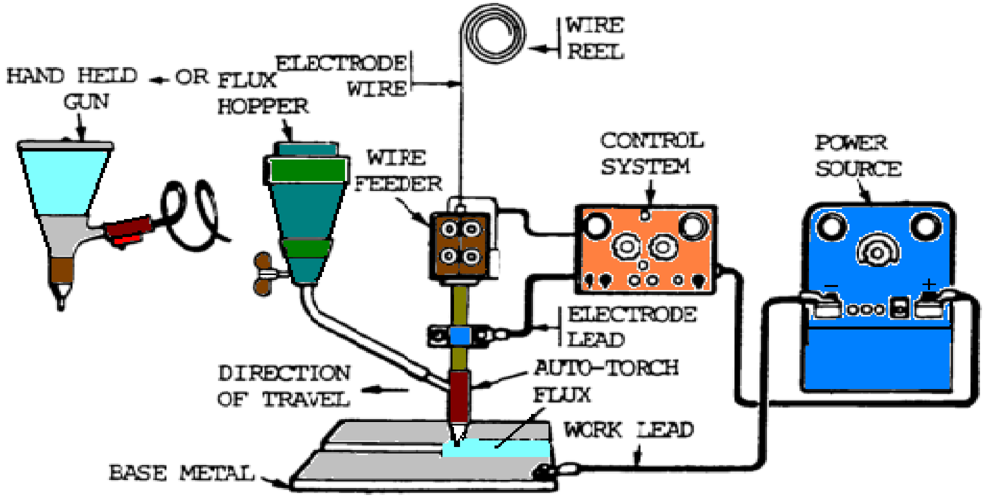
- Uses a continuous, consumable bare wire electrode.
- The arc shielding is provided by a cover of granular flux. The electrode wire is fed automatically from a coil into the arc. The flux is introduced into the joint slightly ahead of the weld arc by gravity from a hopper.
- Blanket of granular flux completely submerges the arc welding operation, preventing sparks, spatter, and radiation that are so hazardous in other arc welding processes.





Submerged Arc Welding





Submerged Arc Welding

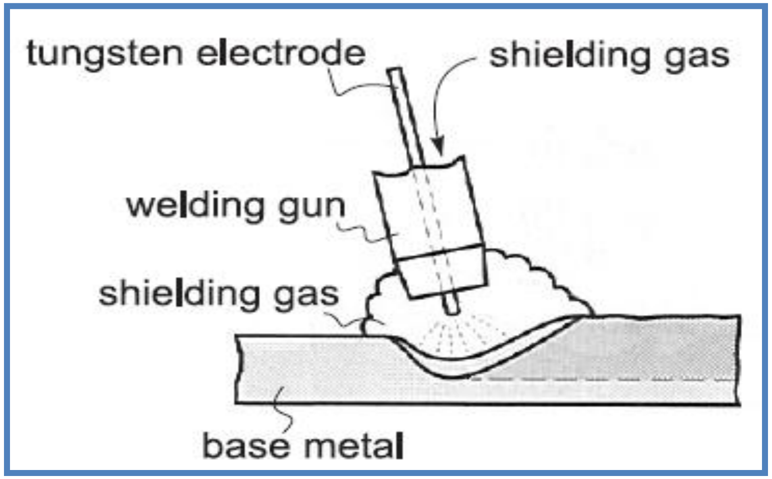
- Flux closest to the arc is melted, mixing with the molten weld metal to remove impurities and then solidifying on top of the weld joint to form a glasslike slag.
- The slag and infused flux granules on top provide good protection from the atmosphere and good thermal insulation for the weld area and lead to a high-quality weld joint.
- The infused flux remaining after welding can be recovered and reused. The solid slag covering the weld must be chipped away usually by manual means.
- This process is widely used for automated for large-diameter pipes, tanks, and pressure vessels.
- Because of the gravity feed of the granular flux, the parts must always be in a horizontal orientation.

Fusion Welding

3) Arc welding with non-consumable electrodes

<u>*Gas Tungsten Arc Welding*</u>

- Uses a non-consumable tungsten electrode and an inert gas for arc shielding. Shielding gases typically used include argon, helium or a mixture of these gases.
- When thin sheets are welded to close tolerances, filler metal is usually not added.
- When a filler metal is used, it is added to the weld pool from a separate rod or wire.



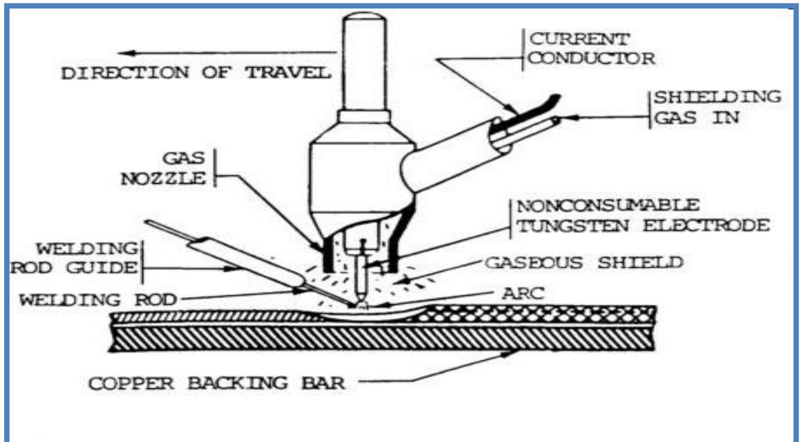
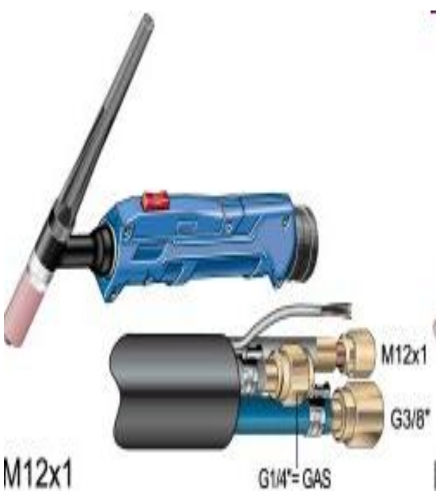
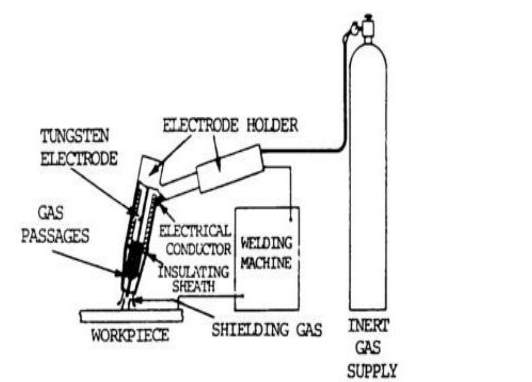


Figure 10-32. Gas tungsten arc (TIG) welding (GTAW).

Fusion Welding

- Applicable to nearly all metals in a wide range of stock thickness.
- It can also be used for joining various combinations of dissimilar metals. Its most common applications are for aluminium and stainless steel.
- The process can be performed manually or by machine and automated methods for all joint types.
- Advantages include high-quality welds, no weld spatter because no filler metal is transferred across the arc, and little or no post-weld cleaning because no flux is used.





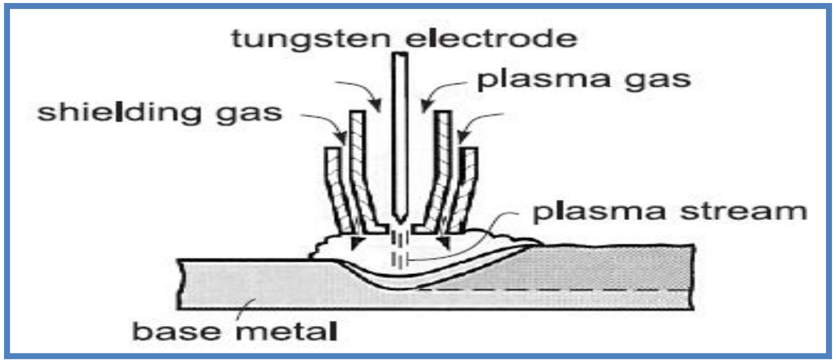
NOTE
A water-cooled welding torch is used when cooling from the inert gas shield is inadequate.

Figure 10-33. Gas tungsten arc welding equipment arrangement.

Fusion Welding

Plasma Arc Welding

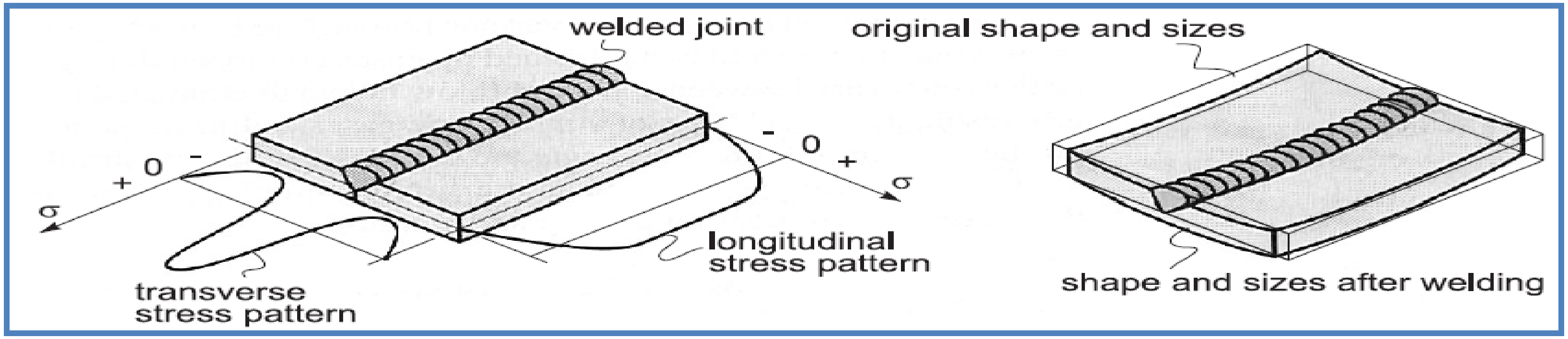
- Special form of gas tungsten arc welding in which a plasma arc is directed at the weld area.
- The tungsten electrode is contained in a specially designed nozzle that focuses a high-velocity stream of inert gas (for example, argon or argon-hydrogen mixtures, and helium) into the region of the arc to produce a high-velocity plasma jet of small diameter and very high-energy density. Temperatures reach 30,000°C or greater, hot enough to melt any known metal.
- A substitute for GTAW in applications such as automobile subassemblies, metal cabinets, door and window frames, and home appliances.
- Can be used to weld almost any metal, including tungsten.



Weld Quality in Arc Welding

Defect which might occur:

1. Distortion of the welded assembly - rapid heating and cooling in localized regions of the work during fusion welding, especially arc welding, result in thermal expansion and contraction, which cause transverse and longitudinal residual stresses in the weldment.



Techniques to minimize distortion in a weldment:

i. Welding fixtures - physically restrain movement of the parts during welding;
ii. Tack welding at multiple points along the joint to create a rigid structure prior to continuous welding;
iii. Preheating the base parts, which reduces the level of thermal stresses experienced by the parts;
iv. Stress relief heat treatment of the welded assembly.

Weld Quality in Arc Welding

2. *Cracks* - Fracture-type interruptions either in the weld or in the base metal adjacent to the weld. It constitutes a discontinuity in the metal that causes significant reduction in the strength of the weldment and must be repaired.
3. *Cavities* - include various porosity (small voids in the weld metal formed by gases entrapped during solidification) and shrinkage voids (cavities formed by shrinkage during solidification).
4. *Solid inclusions* - any non-metallic solid material entrapped in the weld metal.
5. *Incomplete fusion* - fusion does not occur throughout the entire cross section of the joint.

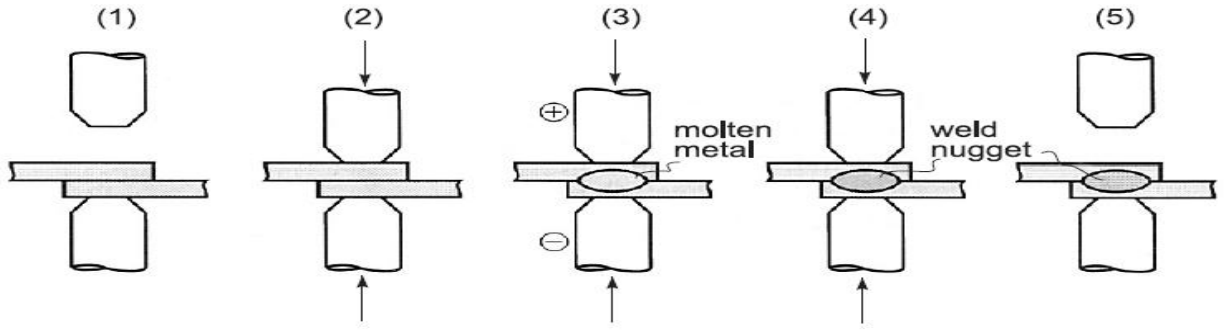
Fusion Welding

4. Resistance Welding

- Utilizes a combination of heat and pressure to accomplish coalescence. The heat required is generated by electrical resistance to current flow at the interface of two parts to be welded.

__Resistance Spot Welding__

- Fusion of the base metal is achieved at one location by opposing electrodes. The cycle in a spot welding operation consists of the steps depicted in the figure:

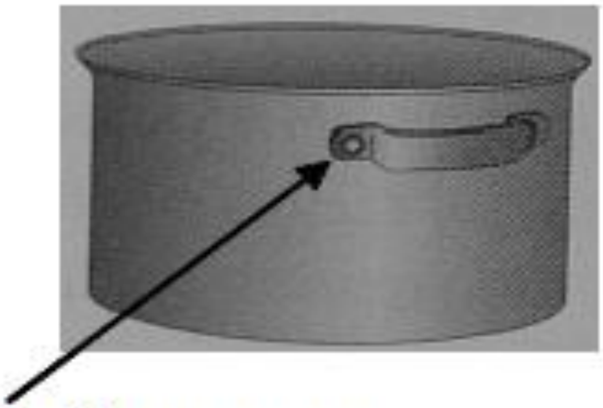


Steps in a spot welding cycle: (1) parts inserted between open electrodes, (2) electrodes close and force is applied, (3) weld time (current is switched), (4) current is turned off but force is maintained, and (5) electrodes are opened, and the welded assembly is removed.

Fusion Welding

- Widely used in mass production of automobiles, appliances, metal furniture, and other products made of sheet metal of thickness 3 mm or less.
- For large, heavy work, portable spot welding guns are available in various sizes and configurations. They are widely used in automobile final assembly plants to spot-weld the sheet-metal car bodies.
- Human workers operate some of these guns, but industrial robots have become the preferred technology.

Robotic Spot welding on auto body

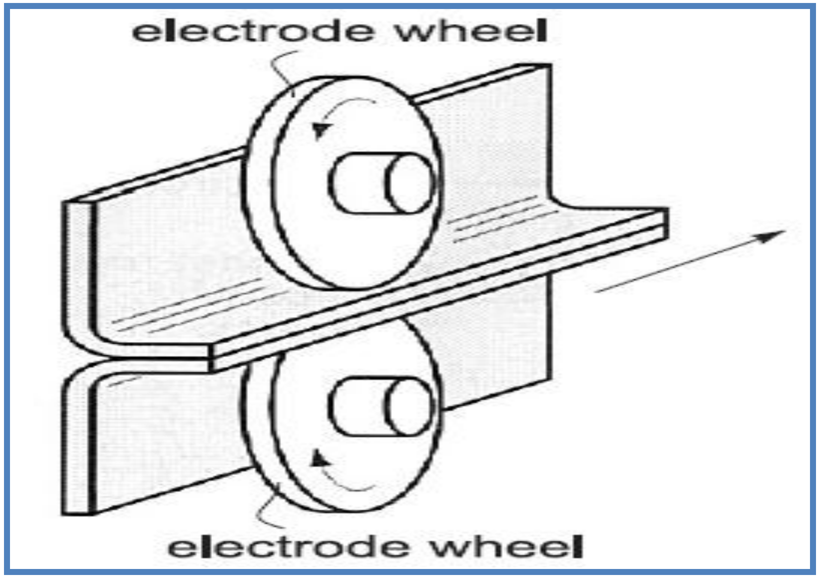


Spot welds on a pan

Fusion Welding

<u>*Resistance Seam Welding*</u>

- The electrodes are two rotating wheels as shown in the figure:

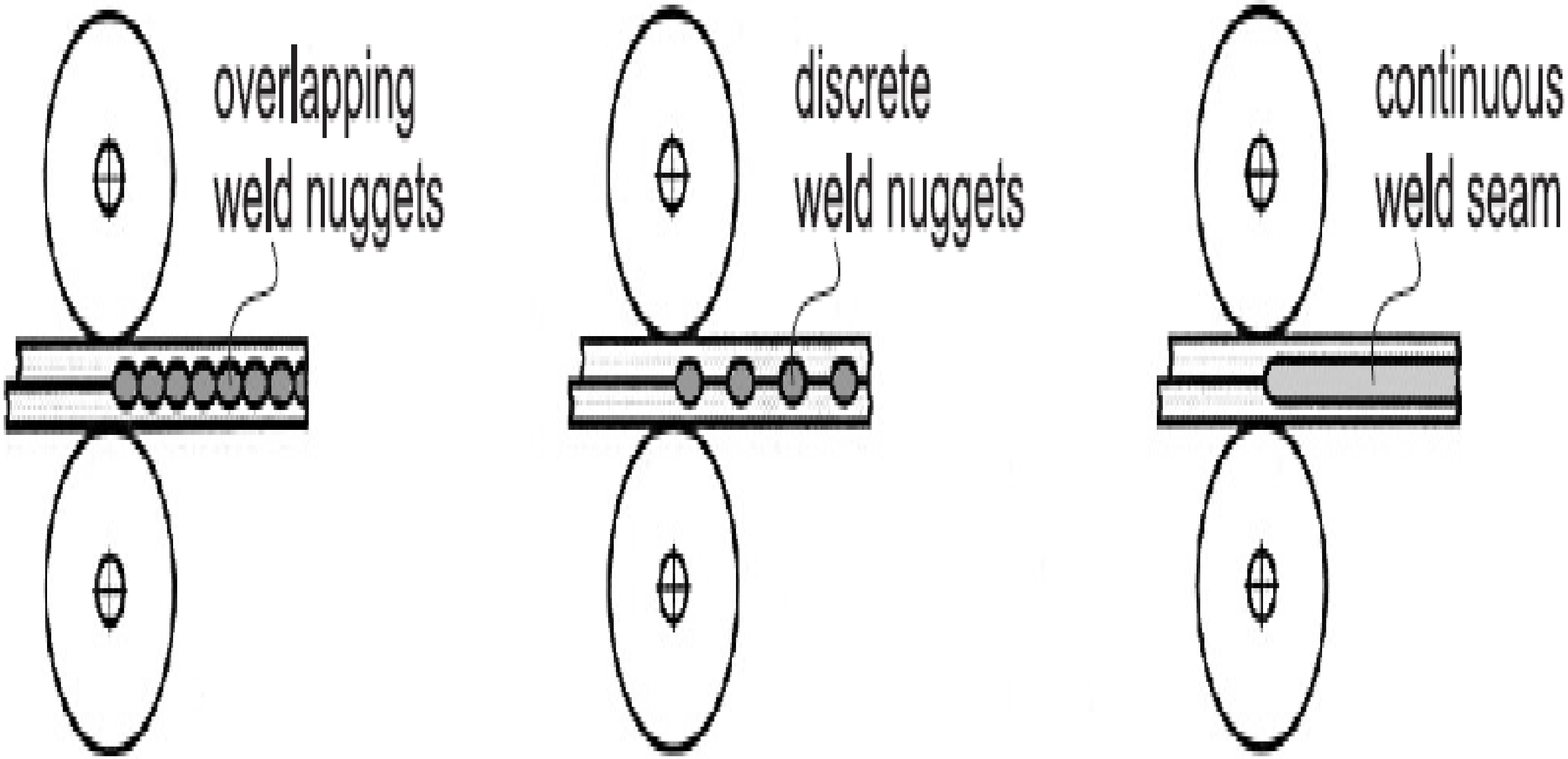


resistance welded petrol tank

- A series of overlapping spot welds is made along the lap joint. The process is capable of producing airtight joints, and its industrial applications include the production of gasoline tanks and various others fabricated sheet-metal containers

Fusion Welding

- The spacing between the weld nuggets depends on the motion of the electrode wheels relative to the application of the weld current.
- Conventional seam welding - wheel is rotated continuously at a constant velocity, and current is turned on at timing intervals consistent with the desired spacing between spot welds along the seam so that overlapping weld spots are produced.
- Roll spot welding - if the frequency of current switching is reduced sufficiently there will be spacing between the weld spots.
- Continuous resistance seam welding - welding current remains on at a constant level so that a truly continuous seam is produced. These variations are depicted in the figure:



Different types of seam welding, (from left to right) conventional seam welding, roll spot welding, continuous resistance seam welding.

Solid State Welding

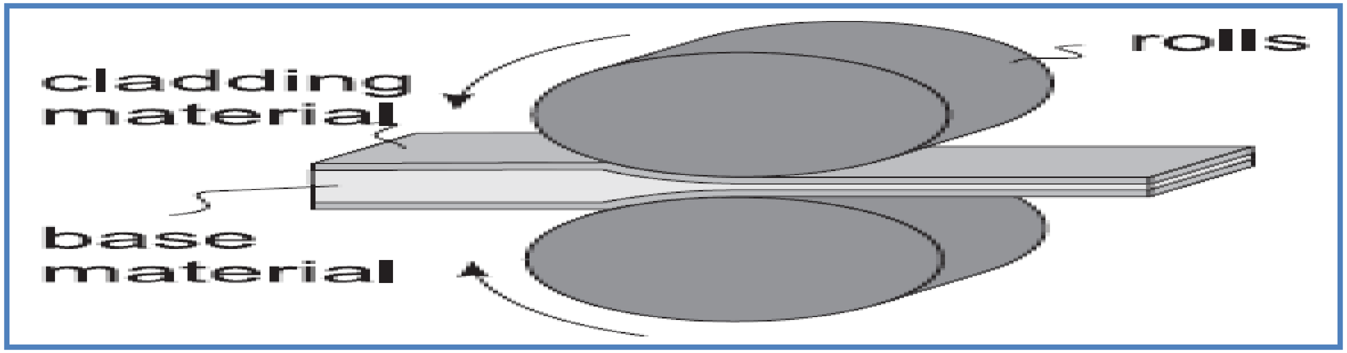
- Two parts are jointed together under pressure or a combination of pressure and heat.
- If heat is applied, the contact temperature is below the melting point of the base metal.
- There are a few types:

1. **Forge Welding**
    - Components to be joined are heated to hot working temperatures and then forged together by hammer or other means.
    - Considerable skill was required by the craftsmen who practiced it to achieve a good weld. It is of minor commercial importance today.

Solid State Welding

2. Cold Roll Welding

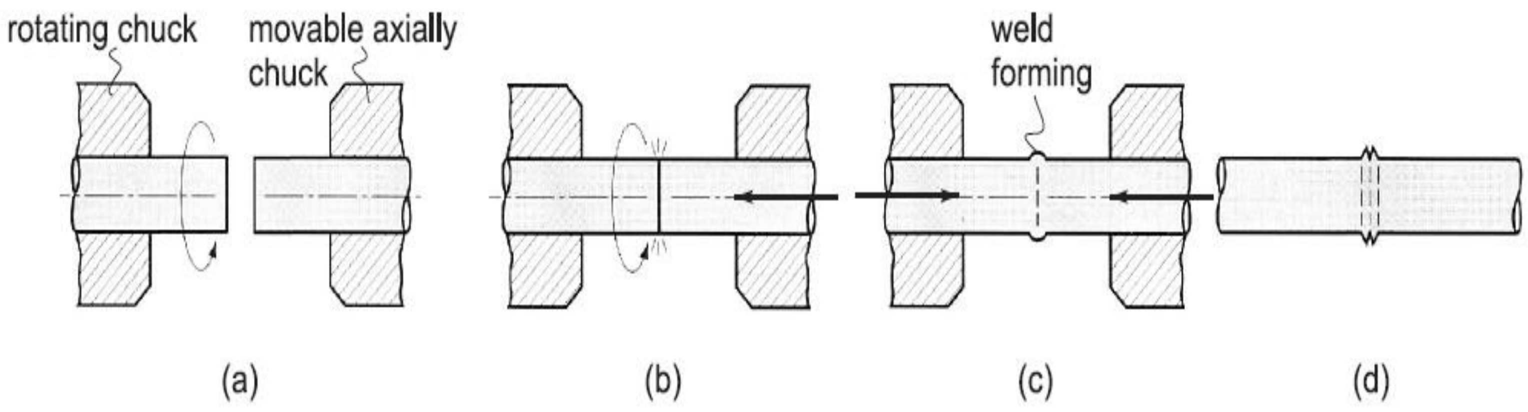
- Accomplished by applying high pressure by means of rolls between clean contacting surfaces at room temperature.
- Metals to be welded must be very ductile and free of work hardening. Contact surfaces must be exceptionally clean.
- Metals such as soft aluminium, copper, gold and silver can be readily cold-welded.
- For small parts, the forces may be applied by simple hand operated tools. For heavier work, powered presses are required to exert the necessary force.
- Applications include producing sandwich strips for coins.



Solid State Welding

3. Friction Welding

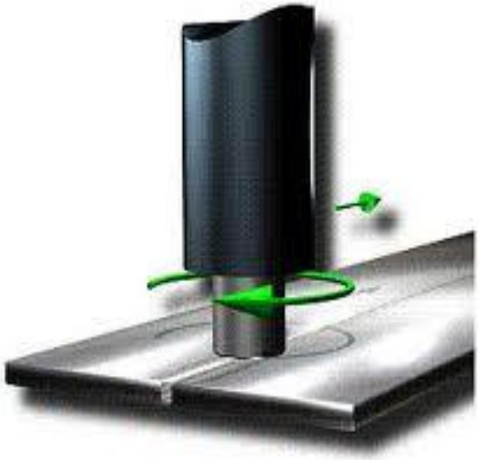
- Coalescence is achieved by frictional heat combined with pressure.
- Heat is generated by the friction between the two components surfaces, usually by rotation of one part relative to the other. Then the parts are driven toward each other with sufficient force to form a metallurgical bond.



Friction welding: (a) no contact, (b) parts brought into contact to generate friction heat, (c) rotation stops and axial pressure applied, (d) final product showing the flash.

Solid State Welding

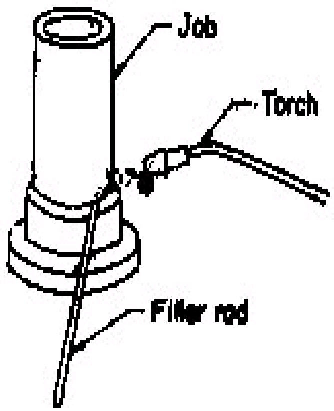
- The axial compression force upsets the parts, and the material displaced produces a flash. The flash must be subsequently trimmed to provide a smooth surface in the weld region.
- No filler metal, flux, or shielding gases are required.
- With its short cycle times, the process is suitable for mass production. It is applied in the welding of various shafts and tubular parts of similar or dissimilar metals.



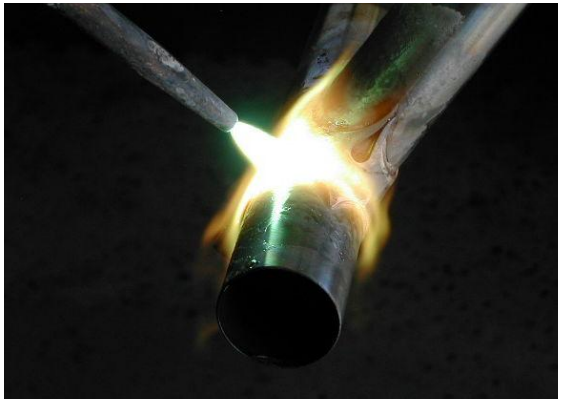
Brazing

- It's a low temperature of joining process. It's performed at temperatures above 840ºF and it generally affords strengths comparable to those of the metal which it joins.

- Brazing can be classified as:
  i. Torch brazing
  ii. Dip brazing
  iii. Furnace brazing
  iv. Induction brazing



BRAZING



Brazing

Advantages

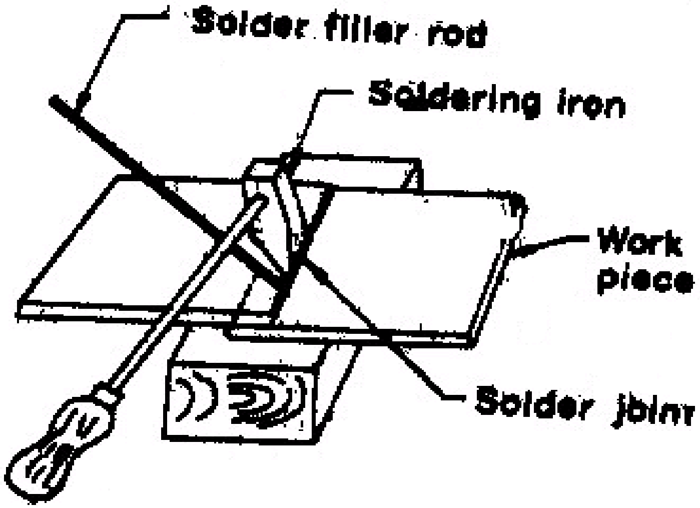
- Dissimilar metals which cannot be welded can be joined by brazing
- Very thin metals can be joined
- Metals with different thickness can be joined easily
- In brazing thermal stresses are not produced in the work piece. Hence there is no distortion
- Using this process, carbides tips are brazed on the steel tool holders

Disadvantages

- Brazed joints have lesser strength compared to welding
- Joint preparation cost is more
- Can be used for thin sheet metal sections

Soldering

- It is a low temperature joining process. It is performed at temperatures below 840ºF for joining.
- Soldering is used for:
    - Sealing, as in automotive radiators or tin cans
    - Electrical connections
    - Joining thermally sensitive components
    - Joining dissimilar metals



Adhesive Bonding (Gluing)

Basic Properties - to function effectively as an adhesive, a material must be capable of two things:

i. Wetting the surface to generate intimate contact between the adhesive and substrate surfaces

ii. Hardening to generate a cohesively strong solid (curing by chemical, solvent loss or cooling)

There are thousands of different adhesives; they might be divided into three major types:

1. Thermoplastic adhesives
2. Thermosetting adhesives
3. Rubber-resin blends

Adhesive Bonding (Gluing)

Adhesive type	Notes	Applications
Acrylic	two component thermoplastic; quick setting; impact resistant, strong impact and peel strength	fiberglass, steel, plastics, motor magnets, tennis racquets
Anaerobic	thermoset; slow, no-air curing – cures in presence of metal ions	sealing of nut-and-bolts, close-fitting holes and shafts, casting micro-porosities etc.
Epoxy	strongest adhesive; thermoset; high tensile strength; low peel strength	metal parts (especially Nickel), ceramic parts, rigid plastics
Cyanoacrylate	thermoplastic; high strength; rapid aerobic curing in presence of humidity	[common brand: Crazy glue™] plastics, rubber, ceramics, metals
Hot melt	thermoplastic polymers; rigid or flexible; applied in molten state, cure on cooling	footwear, cartons and other packaging boxes, book-binding
Polyacrylate esters (PSA)	Pressure sensitive adhesives	all types of tapes, labels, stickers, decals, envelops, etc.
Phenolic	thermoset, oven curing, strong but brittle	acoustic padding, brake lining, clutch pads, abrasive grain bonding
Silicone	thermoset, slow curing, flexible	gaskets and sealants
Formaldehyde	thermoset	joining wood, making plywood
Urethane	thermoset, strong at large thickness	fiberglass body parts, concrete gap filling, mold repairs
Water-based	cheap, non-toxic, safe	wood, paper, fabric, leather

Thermoplastic Adhesives

- They are fusible, soluble and poor heat and creep resistant. They are normally used for low load assemblies under gentle service conditions

Thermosetting Adhesives

- They are essentially infusible, insoluble and show good creep resistance. They are used for high load assemblies and severe service conditions such as heat, cold, radiation etc.

Rubber-resin Blends

- As the name indicates, rubbers and resins mixed together in order to obtain combinations of desired properties.

Anaerobics

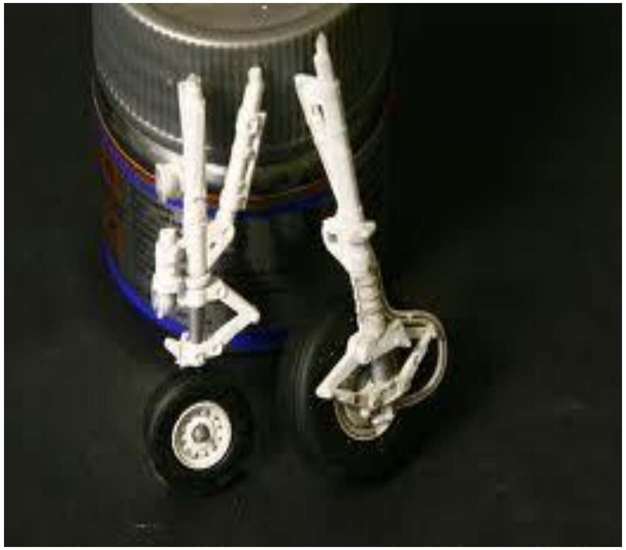
- Anaerobic adhesives cure when in contact with metal, and the air is excluded, e.g. when a bolt is home in a thread. They are often known as "locking compounds", being used to secure, seal and retain turned, threaded, or similarly close fitting parts. They are based on synthetic acrylic resins.

Acrylic Based Adhesives

- Advantages: They are cross-linkable and deliver good resistance to varying temperature ranges, chemicals, ultraviolet light and oxidation. They are very color stable and can be easily removed and reinstalled in the application if done incorrectly.
- Disadvantages: Generally, acrylic based PSAs have poor adhesion to polyolefins. The initial bond or tack strength of acrylic adhesive is low.

Cyanoacrylates

- Cyanoacrylate adhesives cure through reaction with moisture held on the surface to be bonded. They need close fitting joints and usually solidify in seconds.
- Cyanoacrylate are suited to small plastic parts and to rubber. They are a special type of acrylic resin.



Toughened Acrylics

- Toughened acrylics are fast curing and offer high strength and toughness. Both one and two part systems are available.
- In two part systems, no mixing is required because the adhesive is applied to one substrate, the activator to the second substrate and the substrates joined.
- They tolerate minimal surface preparation and bond well to a wide range of materials.

Epoxy

- Epoxy adhesives consist of an epoxy resin plus a hardener. They allow great versatility in formulation since there are many resins and many different hardeners.
- Epoxy adhesives can used to join most materials. These materials have good strength, do not produce volatiles during curing and have low shrinkage.

Polyurethanes

- Polyurethane adhesives are chemically reactive formulations that may be one or two part systems and are usually fast curing. They provide strong resilient joints which are impact resistant and have better low temperature strength than any other adhesive. Polyurethanes are useful for bonding glass fibre reinforced plastics (GRP).

Silicones

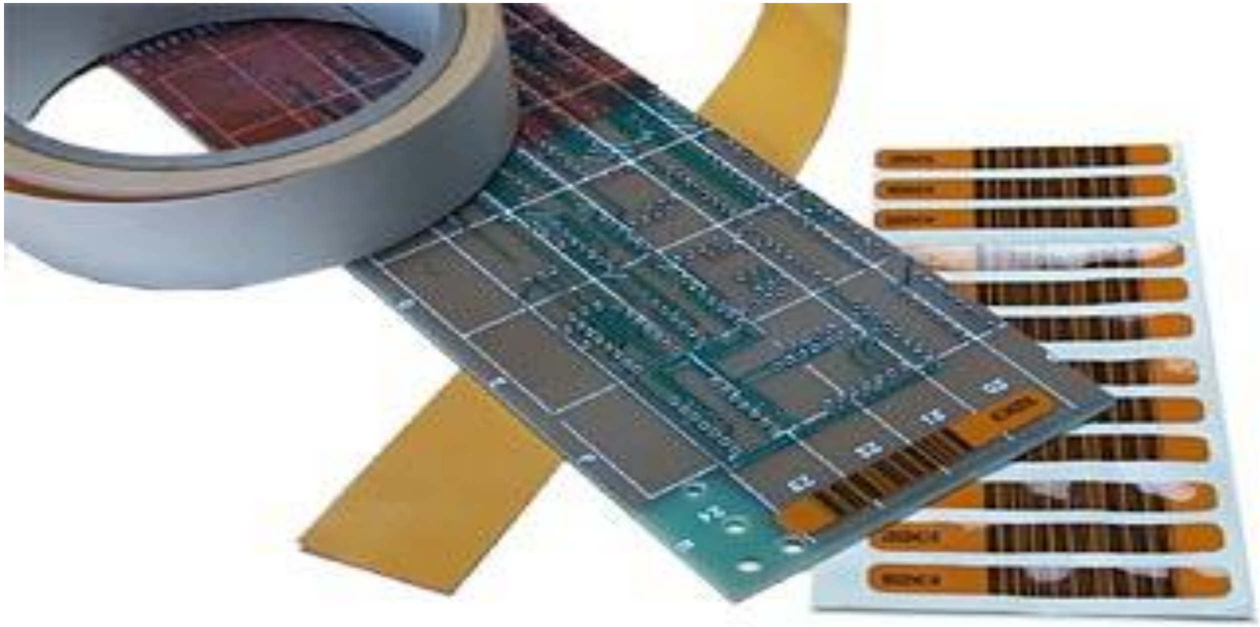
- Silicones are not very strong adhesives, but are known for their flexibility and high temperature resistance. They are often used as bath and shower sealants. Their adhesion to surfaces is only fair but like their flexibility, their durability is excellent.

Phenolics

- Phenolics were the first adhesives for metals and have a long history of successful use for joining metal to metal and metal to wood. They require heat and pressure for the curing process.

Polyimide

- Polyimide adhesives are based on synthetic organic chains. They are available as liquids or films, but are expensive and difficult to handle.
- Polyimide are superior to most other adhesive types with regard to long term strength retention at elevated temperatures.



Applications

- Protective Films: Acrylic/Polyester, Silicone/Polyester
- Heat Activated Dry Films Plating Tapes: Crosslinked Silicone
- Splicing Tapes
- Building Components
- Furniture
- Footwear
- Doors and Millwork
- Masking tapes
- Aerospace Speciality Products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