MODULE 2

Content:

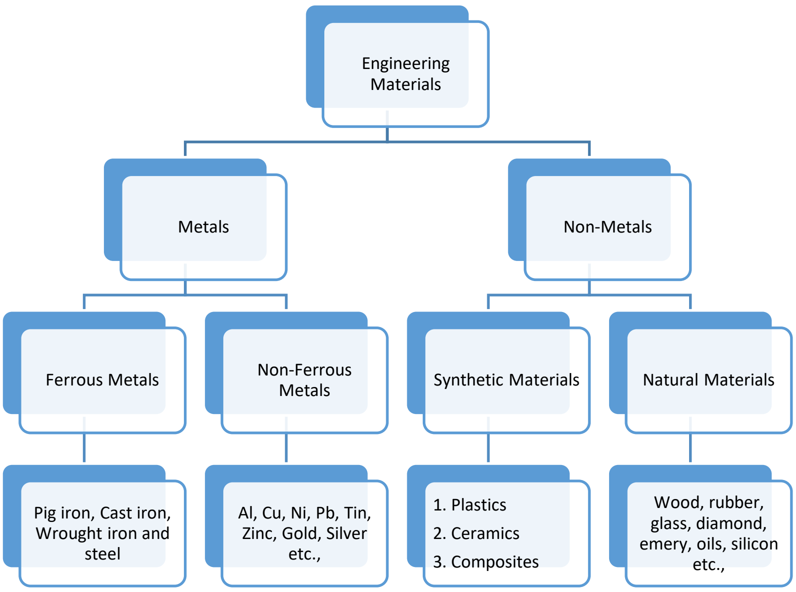
Properties, Composition, and Industrial Application of Engineering Materials: *Metals-Ferrous: Tool steels and stainless steels. Non-ferrous /metals: aluminum alloys. Ceramics- Glass, optical fiber glass, cermet. Composites- Fiber reinforced composites, Metal matrix Composites. Smart materials- Piezoelectric materials, shape memory alloys, semiconductors, and super-insulators.*

Metal Joining Processes: Soldering, Brazing and Welding: *Definitions. Classification and methods of soldering, brazing, and welding. Brief description of arc welding, Oxy-acetylene welding, Introduction to TIG welding and MIG welding.*

Heat Transfer Applications: *Review of modes of Heat Transfer; Automobile Radiators; Condensers and evaporators of refrigeration systems; Cooling of Electrical and Electronic Devices; Active, Passive, and Hybrid Cooling.*

Properties, Composition, and Industrial Application of Engineering Materials:

Classification of Engineering Materials:



Metals are classified as ferrous metals and non-ferrous metals based on the presence or absence of iron as its main element. Ferrous metals contain iron as its main element. Ferrous metals possess high strength and are of relatively low cost.

Pig iron:
Composition- C: 3.5 – 4.5%; Si: 0.5 – 3%; S: 0.04 to 0.2%; Mn: 0.5 – 2.5%; P: 0.04 – 1%
Properties- Brittle
Application- used for making wrought iron, cast iron or steel.

Cast iron:
Composition- C: 2 – 4.5%; Si: 1 – 3%; small amounts of S, Mn, and P.
Properties- strong, brittle, low melting point, wear resistance, good fluidity, good machinability.
Application- machine frames, beds and plates, housing, flywheels, automotive parts such as engine block, cylinder head, gear box case.

Steel:
Steel is an alloy of iron and carbon. Steel generally contains C: 0.5 – 1.5%; small amounts of Si, S, P and Mn.
Classification of steels:

1. Carbon steels
2. Alloy steels
3. Tool steels

Carbon Steel:

i. Low carbon steel or Mild steel:
Composition- C: 0.05 – 0.3%; rest is iron.
Properties- soft and ductile, good weldability, good formability, good machinability, good toughness. Generally low strength.
Application-

i. In lightly stressed parts, nails, chains, rivets, bolts, keys, plain washers etc.,
ii. In structural sections like angles, channels, girders, beams etc.,
iii. In small forgings.
iv. In boiler plates, making shafts, camshafts, gears, and axles for low loads.

ii. Medium carbon steel:
Composition- C: 0.3 – 0.6%; rest is iron.
Properties- high toughness, high tensile strength, high hardness, good bending strength, wear resistance, good torsion strength and good machinability.
Application- transmission shafts, axles, gears, connecting rods, spindles, couplings, springs, washers, forging dies, rotor shafts, crane hook, torque tubes, loco tyres, keys, hand tools etc.,

iii. **High carbon steel:**
Composition- C: 0.6 – 1.5%; Fe: 96 – 97%.
Properties- high hardness, brittle, resistance to wear and tear, surface abrasion resistant, large torque capacity, high tensile strength, high yield strength. Low impact strength, less ductility.
Application- hammers, chisels, screws, punches, knives, saws, drills, taps, reamers, lathe tools, ball races and ball bearings, leaf springs, scrapers, bandsaws, circular saws, wrenches, forming dies, banking dies, shearing dies, shaper tools, planer tools and milling cutters etc.,

Alloy Steel:

Alloy steels are the steels produced by adding elements other than carbon in calculated amounts to provide specific properties. Common types of alloy steels are:

i. Chromium steel: Chromium is the alloying element.

Chromium improves corrosion resistance, hardenability, toughness, resistance to abrasion, resistance to heat.

Application- in balls, rollers and racers for bearings, armor plate, cutting tools.

ii. Nickel steel: Ni: 3% and C: 0.2 – 0.35%.

Application- locomotive forgings, axles, piston rods, parts of ship and components subjected to shocks and fatigue.

An alloy of 36% Ni and 64% Fe has very less coefficient of expansion is used in measuring instruments.

iii. Manganese steel: Mn: 1.5%; C: 0.4 – 0.55%.

Properties- improves strength, hardness, and toughness.

Application- axles, gears, shafts etc.,

iv. Molybdenum steel: Molybdenum is an alloying element.

Properties- increases tensile strength and creep strength at high temperature. Increases wear resistance, heat resistance and corrosion resistance.

Application- used in high temperature heating elements, forging dies, extrusions, radiation shields etc.,

v. Tungsten steel: Tungsten is an alloying element.

Properties- increases strength, hardness, toughness, provides shock resistance at high temperature and wear resistance.

Application- in industrial cutting tools, rocket nozzles etc., Hastelloy and Stellite which are superalloys containing tungsten is used in the blades of turbine.

vi. Stainless steel: Cr: 18%; Ni: 8%; C: 0.03%. Rest in majorly Iron and small amounts of Mn, Si, Mo, P, S and N etc.,

Properties- corrosion resistant.

Application- used in kitchen equipment, cutlery, springs, circlips, chemical handling equipment's, surgical equipment's, shaving blades etc.,

vii. Tool steel: are special steels with carbon content is in the range of 0.8 to 1.2%. Common example of tools steel is High Speed Steel (HSS). It contains 0.7 to 0.8% C, 12 to 20% tungsten, 3 to 5% chromium, 1 to 2% vanadium and 5 to 10% cobalt.

Properties- very hard and exhibit good wear and abrasion resistance. Withstand hardness at elevated temperatures.

Application- in drill bits, lathe tools, milling cutters, reamers etc., They can cut at high speeds without any loss in the hardness.

Aluminium:

Aluminium is a silvery white, soft, and ductile material. In its ore form, aluminium is found as hydrated aluminium oxide or Bauxite.

Properties-

i. Light weight and easy workability.
ii. Corrosion resistance.
iii. Non-magnetic and good reflector of heat.
iv. Highly ductile.

v. Good electrical and thermal conductivity.

Application-

i. Metallurgical application: as de-oxidizer in the production of iron and steels. Used for alloying steels.
ii. Electrical industry: used to make bus bars, cables, induction motors, conductors, rotors, windings etc.,
iii. Aircraft industry: used in making aircraft parts.
iv. Automotive applications: used in making cylinder blocks, panels, suspension, chassis, and other engine components.
v. Packaging industry: to make foils and drinking cans. Beer containers.
vi. Domestic: cooking utensils, ladders, furnishing, lighting fixtures, household electrical appliances.
vii. Construction industry: to make windows, doors, frames, fencing, shutters, curtain walls, insect screens, gates etc.,

Duralumin:

Composition- Al: 92%; Cu: 3.5 to 4.5%; Mg: 0.4 to 7%; Mn, Fe and Si maximum 0.7%.

Properties- Duralumin can he highly strengthened by heat treatment. It is strong. Duralumin can be spun, presses, riveted, machined etc., Low resistance to corrosion hence coated with pure aluminium.

Application- connecting rod of aero engines and automobiles, aircraft structures.

Y-alloy:

Composition- Al: 93%; Cu: 4%; Ni: 1%; Mg: 1%.

Properties- good conductor of heat. Maintains strength at elevated temperatures.

Application- used to make pistons, cylinder head of IC engines. Also used to make connecting rods and blades of propeller.

Ceramics:

Ceramic is an inorganic, non-metallic solid manufactured by baking naturally occurring clays at high temperatures after moulding to shape.

Application- used in the manufacture of knives, high- voltage insulators, high temperature resistant cutting tool tips, dies, engine parts, pottery, tiles, structural and refractory bricks.

Glass:

Glass is an amorphous solid material which is non-crystalline in nature. It is smooth with non-porous surface and is abrasion resistant, a good insulator, good resistant to chemical attacks. Glasses are generally brittle and optically transparent.

Application- used in food containers, laboratory apparatus, doors, furniture utensils, vehicle windows, mirrors, as lenses for spectacles, telescopes, or magnifying glasses.

Optical fiber glass:

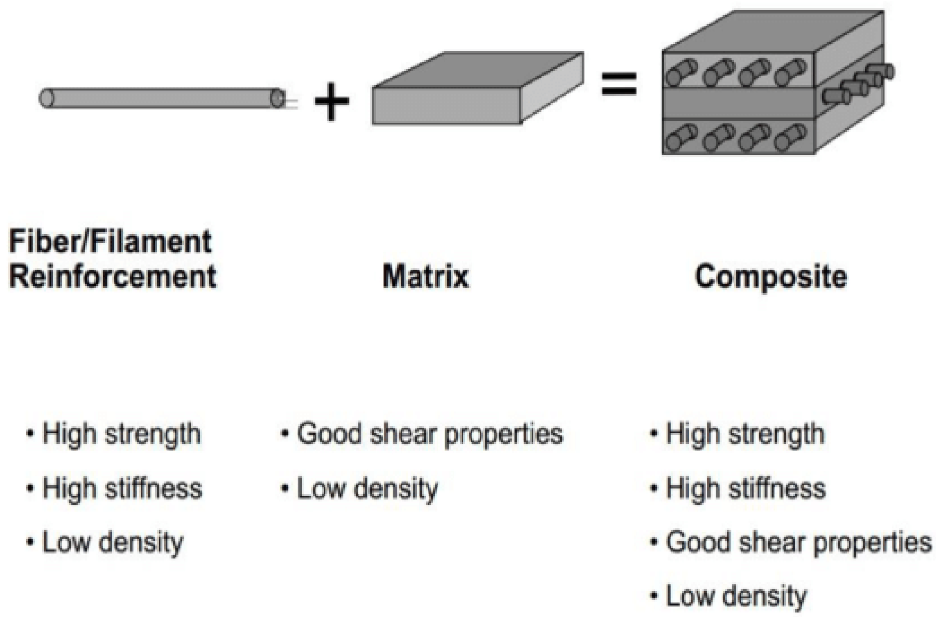
An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair.

Application- Fiber optics are used for data transmission in high-level data security fields of military and aerospace applications. These are used in wirings in aircraft, hydrophones for SONARs and Seismic applications.

Cermet:
A cermet is a composite material consisting of ceramic (cer) and metallic (met) materials. The ceramic in general has high temperature resistance and hardness, and the metal can undergo plastic deformation. A cermet is ideally designed to have the combined optimal properties of a ceramic and a metal.
Application- Cermet's are used in the manufacture of resistors (especially potentiometers), capacitors, and other electronic components which may experience high temperature. Cermet's are used instead of tungsten carbide in saws and other brazed tools due to their superior wear and corrosion properties.

Composites:
A composite is defined as a material which is a combination of two or more materials which have different interfaces between them, and the resulting material properties are enhanced compared to the individual constituent material.

Constituents of a Composites:



The main constituents of composites are the reinforcements and the matrix. In a composite material one material forms a matrix to bond together the other material called reinforcement material. The matrix and composites are chosen in such a way that their mechanical properties complement each other, at the same time their deficiencies are neutralized.

Metal Matrix Composites:
Metal Matrix Composites are composites that contain at least two component parts one of which is metal. The other material may be a metal or ceramic or an organic compound.

Properties- Higher specific strength, stiffness, higher operating temperature, low coefficient of thermal expansion, greater wear resistance. Lower ductility and cost of fabricating is high.
Applications-
- Used is making piston for diesel engine due to good wear resistance and strength.
- Used in applications where weight saving is vital factor such as robots, high-speed machinery, and high-speed rotating shafts.
- Used in automotive engine and brake parts due to good wear resistance.
- Used in lasers, precision machinery, electronic packaging, spacecraft structures, missile structures, fighter aircraft engine and structures.

Fiber Reinforced Composites: Fiber Reinforced Composites are composed of axial particles in the form of fibers embedded in a matrix material. Reinforcing fibers are usually of metals, ceramics, glasses, or polymers that are turned into graphite. FRC has high strength and high elastic modulus for its weight.
Applications-
- Used in advanced sports equipment like a time-trail racing bicycle frame that consists of carbon fibers in thermoset polymer matrix.
- Used in body parts of racing cars and few other automobiles are of composite material that is made of fiberglass in a thermoset matrix.
- A hybrid mixture of carbon fibers and Kevlar 49 fibers are used as primary material to make wings, fuselage, and tail assembly components of an aircraft.

Properties of Composites:
- Light in weight.
- Excellent specific strength and stiffness.
- High tensile strength to weight ratio.
- Excellent spring-back property with resilience.
- Non-corrosive and resistant to chemicals.
- Fire retardant and fire resistant.
- Low thermal conductivity.

Advantages of Composite materials:
- Less maintenance and repair cost as CM are non-corrosive and resistant to chemicals.
- Lower weight than their metal counter parts. Saving in weight and cost.
- Outstanding strength-to-weight and stiffness-to-weight ratio.
- Good resilience hence application in transport industry.
- Composite structures have good thermal properties and are very good insulators.
- In military applications, high strength composites can give good from blast and ballistic threats.
- FRCs are low in thermal conductivity and are good fire retardants.
- Innovative designs can be obtained from composites

Disadvantages of Composite materials:
- Fabrication cost is high.

- More brittle than wrought metals.
- Repair of composites is not a simple process.
- Must be cleaned thoroughly before cleaning.
- Cost of raw material used for composites is high.
- The matrix of the composite is subject to environmental degradation.

Application of Composite materials:

- Aircraft industry: spoilers and flight controls.
- Automobile industry: car parts such as front end, tail doors, side doors, seating, hoods, fuse boxes, headlamps, engine valve cover, leaf springs, etc.,
- Sports equipment: badminton racket, tennis racket, golf stick, hockey stick, softball bat, table tennis bat, helmets, climbing ropes, high jump pole etc.,
- Construction industry: polymer composites are used in the construction industry in non-load bearing applications like trimmings, kitchenware, vanities etc.,
- Biomedical industry: in orthopaedic applications such as bone fixation plates, hip joint replacement, bone cement and bone grafts. In dental application such as preparation of crowns, repair of cavities or entire tooth replacement.
- Wind energy applications: manufacturing blades of wind turbine.
- Marine applications: construction of ships and marine structures because of their higher stiffness and strength by weight compared to other materials like steel and aluminium. It is used in marine applications in boat hulls, minesweepers, ship superstructures etc.,
- Military applications: used in submarines, armoured vehicles, bullet-proof vests, and military aircraft.

Smart materials: Smart materials are defined as materials that sense and react to environmental conditions or stimuli (e.g., mechanical, chemical, electrical, or magnetic signals).

Types of smart materials

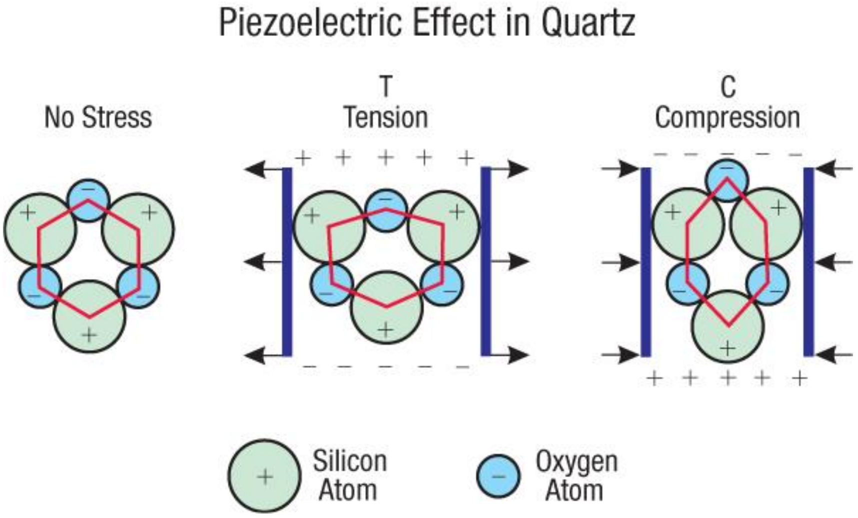
- Piezoelectric materials.
- Shape memory materials.
- Chromoactive materials.
- Magnetorheological materials.
- Photoactive materials.

Piezoelectric materials: Piezoelectric materials or piezoelectrics are the materials that can produce electric energy upon application of mechanical stress. A commonly known piezoelectric material is quartz. The mechanism involves development of electric charge due to movement of electron upon application of stress.

The most produced piezoelectric ceramics are lead zirconate titanate (PZT), barium titanate, and lead titanate. Gallium nitride and zinc oxide can also be regarded as a ceramic due to their relatively wide band gaps.

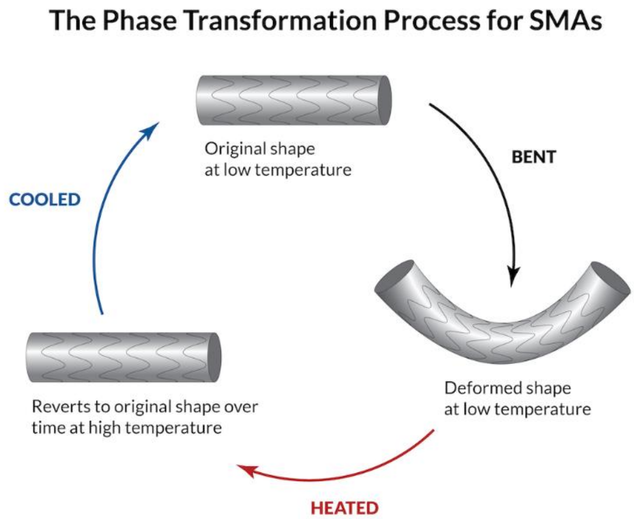
Application: Cell phones, diesel fuel injectors, grill igniters, ultrasonic transducers, acoustic guitar pickups, vibration sensors, certain printers, and musical greeting cards etc. utilizes piezoelectricity. The additional development of manmade piezo materials which includes piezoelectric ceramics.

Piezoelectric effect: A piezoelectric crystal is placed between two metal plates. At this point the material is in perfect balance and does not conduct an electric current. Mechanical pressure is then applied to the material by the metal plates, which forces the electric charges within the crystal out of balance.



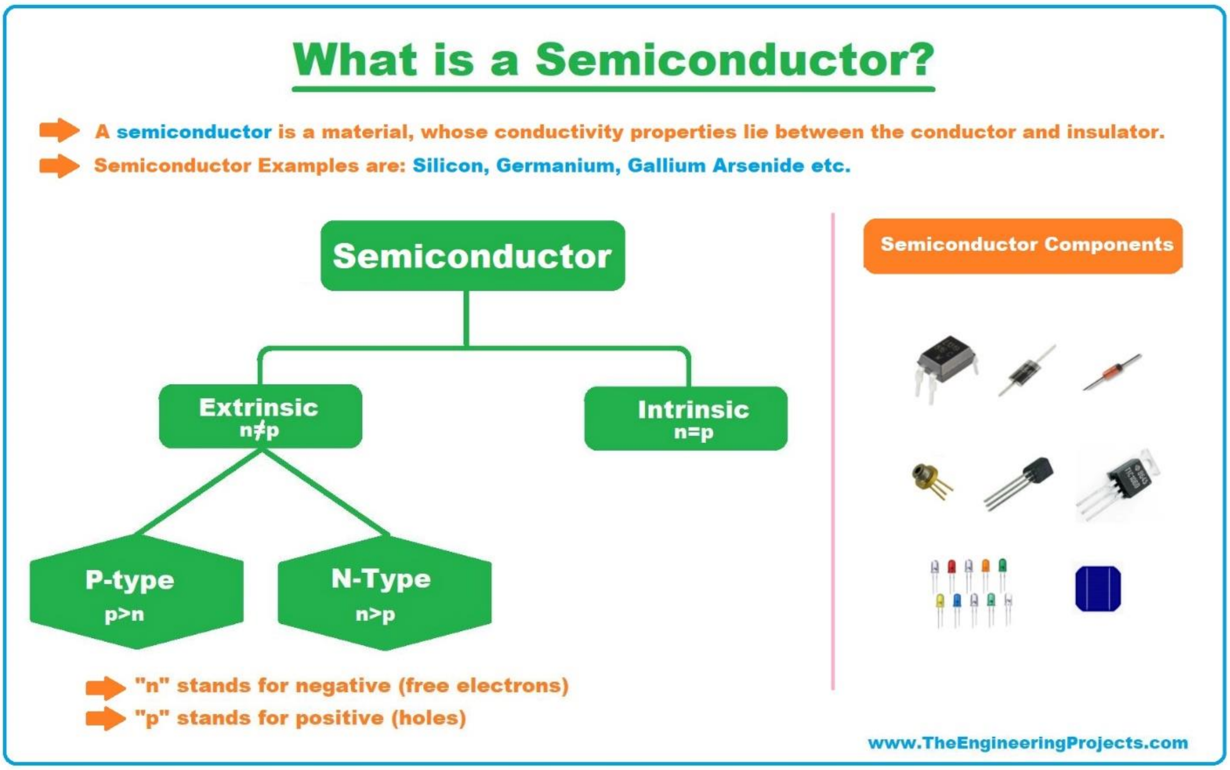
Shape memory alloys: In metallurgy, a shape-memory alloy (SMA) is an alloy that can be deformed when cold but returns to its pre-deformed ("remembered") shape when heated. It may also be called memory metal, memory alloy, smart metal, smart alloy, or muscle wire.

When a shape memory alloy is in its martensitic form, it is easily deformed to a new shape. However, when the alloy is heated through its transformation temperatures, it reverts to austenite and recovers its previous shape with great force. This process is known as shape memory.



Applications: They are used as wires and tubes in applications with hot fluids flowing through them. These materials are ideal as they can retain their shape even in a heated environment. Another application of SMAs is in civil engineering. For example, they have been used in bridge structures.

Semiconductors: Semiconductors are materials which have a conductivity between conductors (generally metals) and nonconductors or insulators (such as most ceramics). Semiconductors can be pure elements, such as silicon or germanium, or compounds such as gallium arsenide or cadmium selenide.



Applications: Semiconductors are employed in the manufacture of various kinds of electronic devices, including diodes, transistors, and integrated circuits. Such devices have found wide application because of their compactness, reliability, power efficiency, and low cost.

Super-insulators: thin film A super-insulator is a material that at low but finite temperatures does not conduct electricity, i.e., has an infinite resistance so that no electric current passes through it.
Discovered by: Valerii Vinkur, Tatyana Baturina and colleagues. At temperature close to absolute zero, super insulators have a resistance 100,000 times higher than that at room temperature. Scientists prepared the super-insulator on a very of Titanium Nitride.
Super-insulators could potentially be used as a platform for high-performance sensors and logical units. Combined with superconductors, super-insulators could be used to create switching electrical circuits with no energy loss as heat.

Metal Joining Processes: Soldering, Brazing and Welding:

Soldering: Soldering is a method of uniting two thin metal pieces using a dissimilar metal or an alloy by the application of heat.
The alloy of lead and tin, called soft solder is used in varying proportions for sheet metal work, plumbing work, and electrical connections. The melting temperature of soft solder is 150 to 3500C. Zinc chloride is used as flux in soft soldering. A soldering iron is used to apply the heat produced from the electrical source.
Alloy of copper, tin and silver known as hard solder is used for stronger joints. The soldering temperature od hard solder is from 600 to 9000C.

Method of Soldering:

- Cleaning the joining surface: make free from dust, oil, scales etc.,
- Application of flux: joining surface is coated with flux, usually rosin or borax.
- Tinning the surface to be soldered: the copper bit is heated and then rubbed with a file clean it properly and then rotating with solder using resin. This causes the formation of thin film of solder over the copper bit. This whole process is called tinning.
- Heating: the soldering iron is then heated, and the flowing molten metal fills the joint interface. Allow the soldered area to cool and solidify.
- Final clean up: clean the joint with steel wool or solvent to remove left-over flux.

Advantages of Soldering:

- Low cost and easy to use.
- Soldered joints are easy to repair or do rework.
- The soldered joint can last for many years.
- Low energy is required to solder.
- An experience person can exercise a high degree of control over the soldering.
- Soldering does not change the microstructure or composition of base material.

Disadvantages of Soldering:

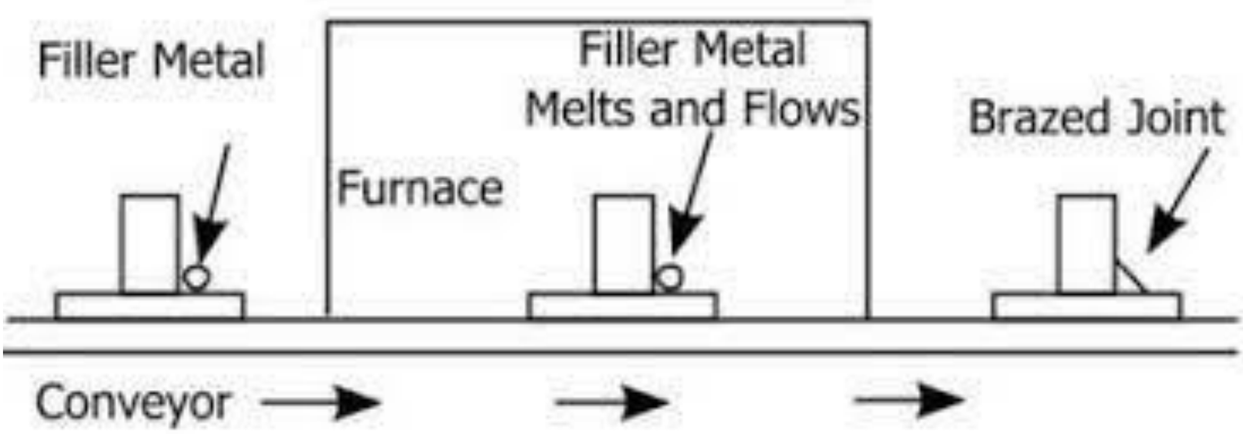
- Very limited strength.
- Detrimental to components that are heat sensitive.
- It is difficult to disconnect soldering connections.
- The heat of the soldering iron or the flame of the torch can cause damage to the adjacent components.
- Solder contains lead which is toxic in nature. The fumes can cause negative effects on health and environment.

Brazing: Brazing is a method of joining two similar or dissimilar metals using a special fusible alloy. It produces joints stronger than soldering.
During brazing, the base metal of the two pieces to joined is not melted. The filler material must have the ability to wet the surfaces of the base metal to which it is applied. Some diffusion or alloying of the filler metal with the base metal takes place even though the base metal does not reach its melting temperature.
The materials used in brazing are copper base and silver base alloys.

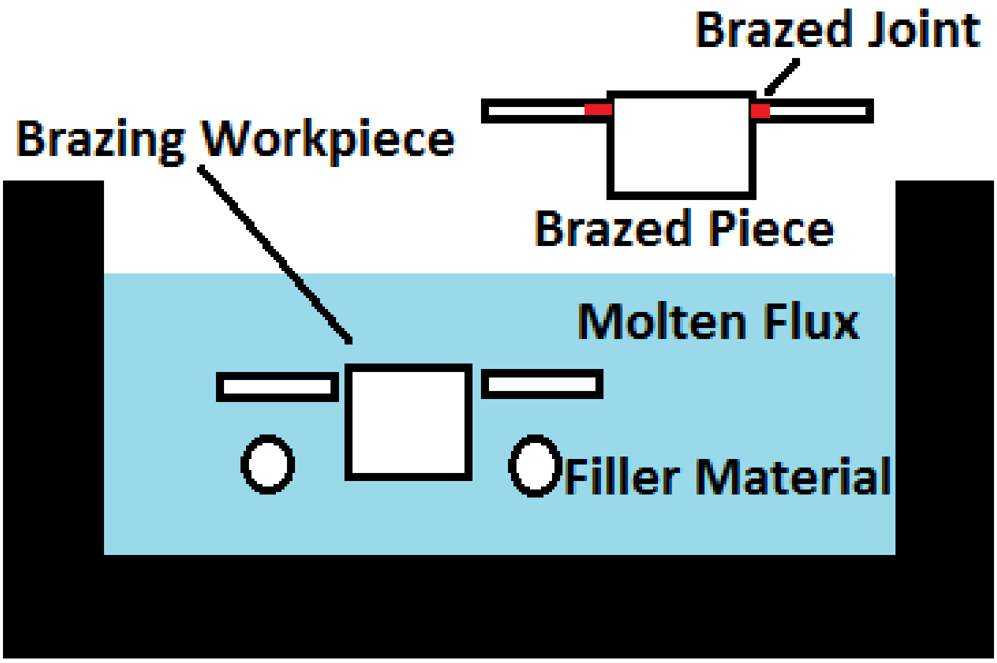
Types of Brazing:

Torch Brazing: Torch brazing, as the name implies, employs a hot gas torch on or near a joint to heat the workpieces and melt the filler alloy being used to fill the gap. Because the filler materials chosen should melt significantly below the workpieces' oxidizing temperature, the joint is protected from oxidization.

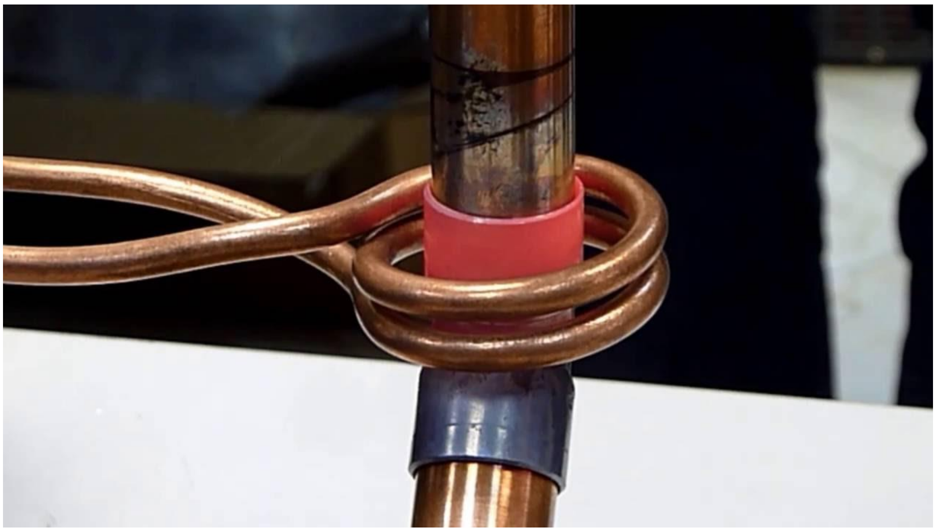
Furnace Brazing: Furnace brazing is a semi-automated process by which metal components are joined using a dissimilar lower filler metal. Furnace brazing allows design and manufacturing engineers to join simple or complex designs of one joint or multi-joint assemblies.



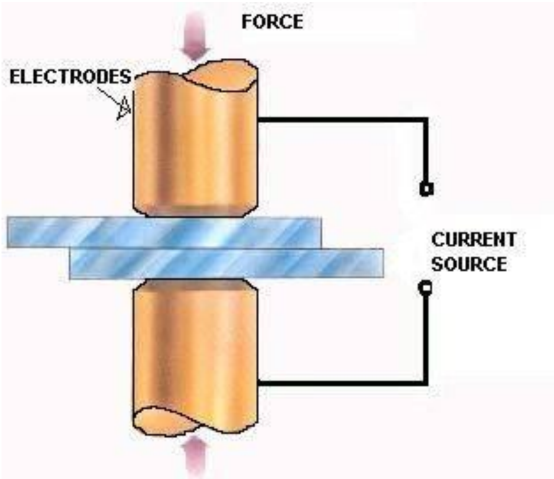
Dip Brazing: Dip brazing is a process that allows simultaneous joining of multiple joints with different material thicknesses. A component that is being dip brazed first gets flux applied that will help keep the filler metal in place while being immersed in the brazing salt bath. Suitable for brazing of aluminium.



Induction Brazing: Induction brazing is when two or more materials are joined together by a filler metal that has a lower melting point than the base materials using induction heating.



Resistance Brazing: RESISTANCE BRAZING (RB) is a resistance joining process. The workpieces are heated locally, and the filler metal that is preplaced between the workpieces is melted by the heat generated from resistance to the flow of electric current through the electrodes and the work.

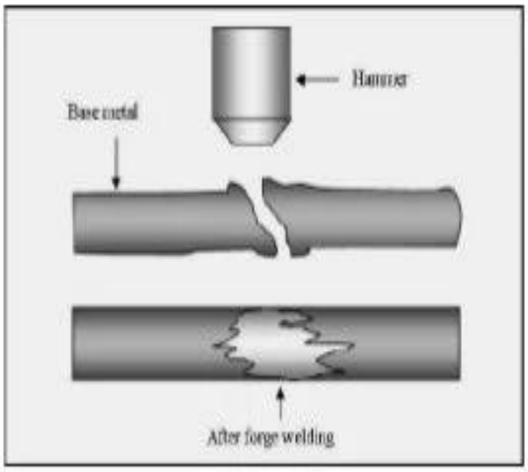


Advantages of Brazing:
- It is easy to learn.
- It is possible to join virtually any dissimilar metals.
- The bond line very neat aesthetically.
- Joint strength is strong enough for most non-heavy-duty applications.
- The distribution of the stress is evenly spread over a large area.
- No effect or negligible effect on the composition and microstructure of the base material.
- It is cost effective to braze complex and multi-part assemblies.

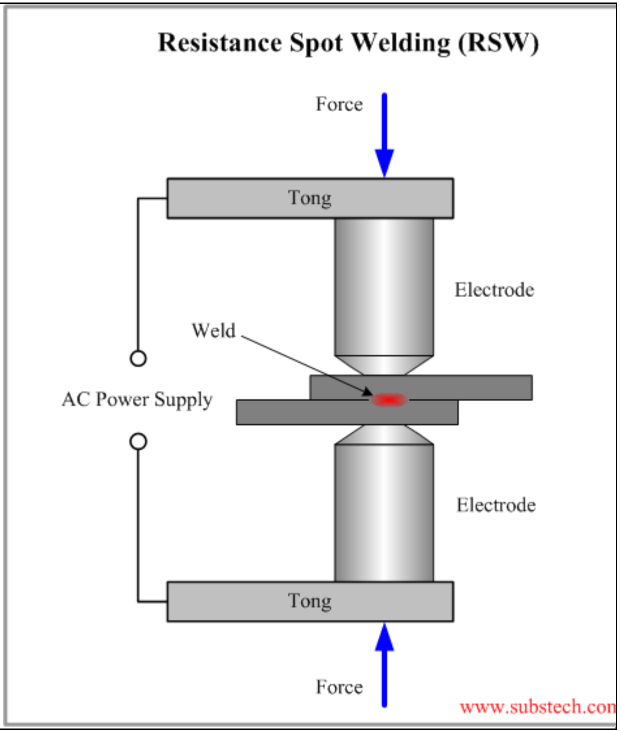
Disadvantages of Brazing:
- Since filler metals are sued, the joint strength is less compared to welding.
- Joints may be damaged while operating at very high temperatures.
- Requires extensively cleaned joint and use of proper fluxing agents.
- The flux residues must be removed to avoid corrosion.
- It is difficult join large sections with brazing.
- Filler material is expensive and hence will add up to the brazing process cost.

Welding: Welding may be defined as the metallurgical joining of two metal pieces together to produce essentially a single piece of metal.
Welding is extensively used in the fabrication work in which metal plates, rolled steel sections, castings of ferrous materials are joined together. It is also used for repairing broken, worn-out, or defective metal parts.
Principle of welding: A welding is a metallurgical process in which the junction of the two parts to be joined are heated and then fused together with or without the application of pressure to produce some continuity of the homogeneous material of the same composition and the characteristics of the parts which are being joined.

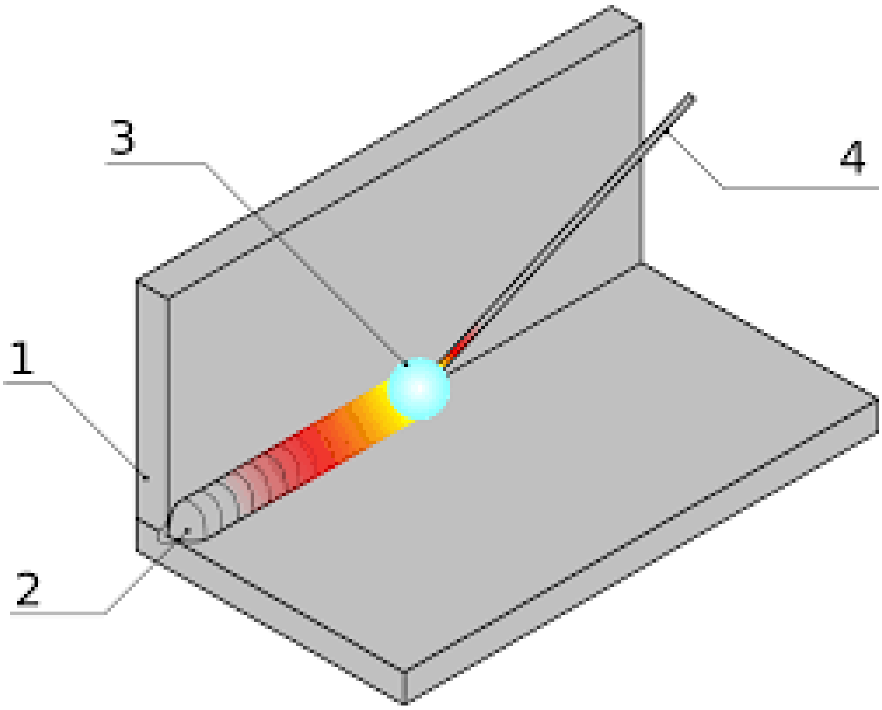
Types of Welding:
Pressure welding: in pressure welding the parts to be joined are heated up to plastic state and then fused together by applying the external pressure. The two types of pressure welding are: forge welding and resistance welding. Figure below shows forge welding and resistance welding.



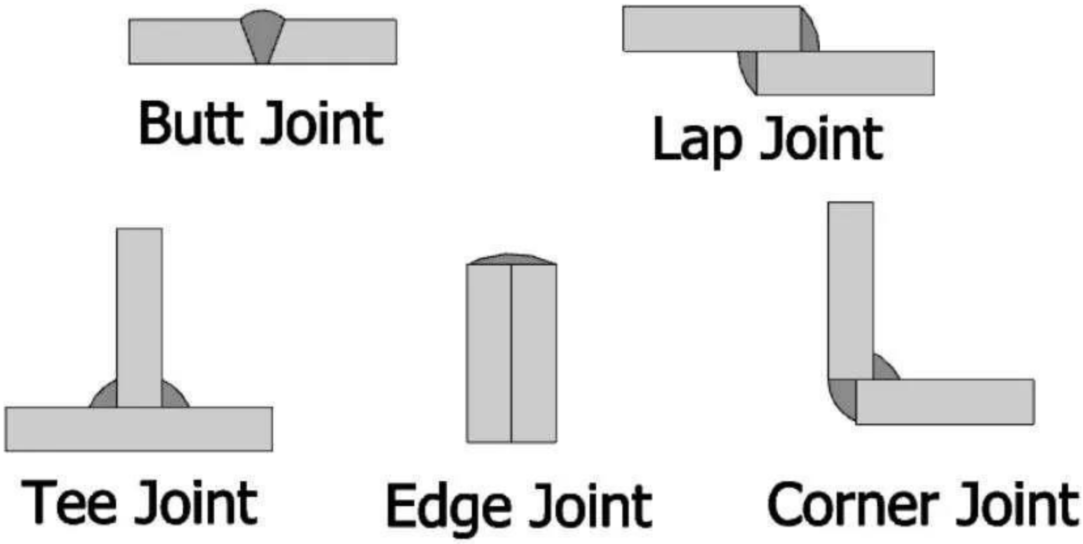
Schematic representation of FORGE welding using Hammer



Fusion welding: in fusion welding, which is also known as non-pressure welding, the joint of the two parts is heated to the molten state and allowed to solidify. The two types of fusion welding are: arc welding and gas welding. Figure below shows arc welding.



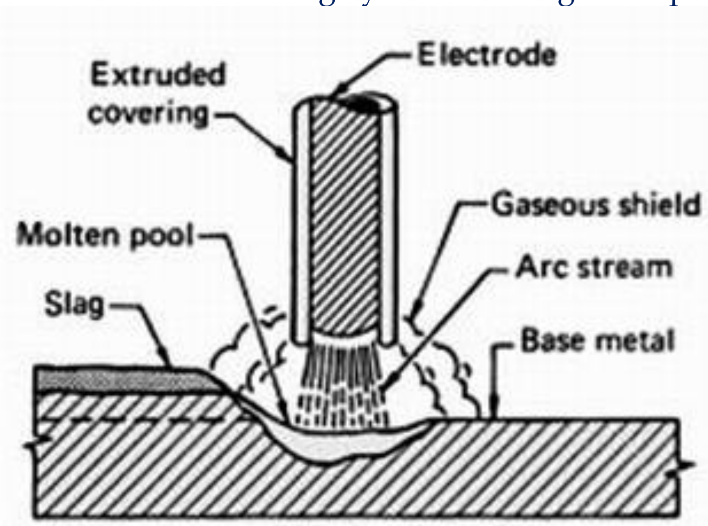
Welding joints:

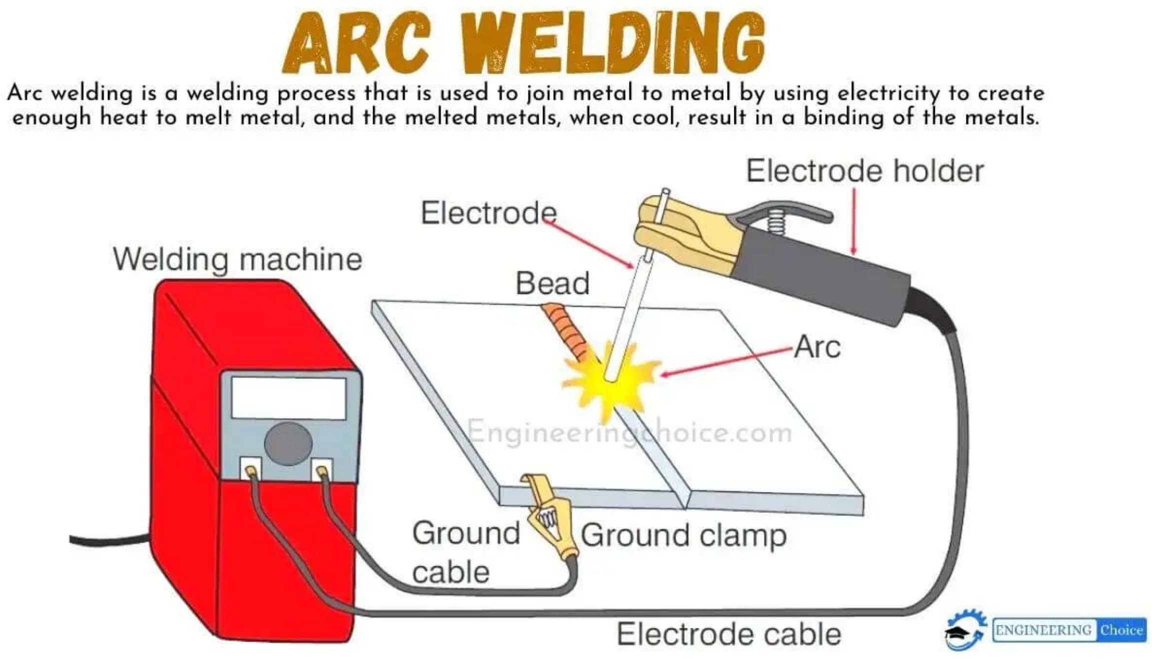


Arc Welding:

Arc welding is a type of welding process using an electric arc to create heat to melt and join metals. A power supply (high current of 50-300A at relatively low voltage 10-50V) creates an electric arc between a consumable or non-consumable electrode and the base material using either direct (DC) or alternating (AC) currents. Concentrated heat is produced throughout the length of the arc at a temperature of 5000 to 6000^{0}C.

In arc welding, usually the parts to be welded are wired as one pole of the circuit and the electrode held by the operator forms the other pole. When the arc is produced, the intense heat quickly melts the workpiece metal which is directly under the arc, forming a small molten metal pool. At the same time, the tip of the electrode at the arc also melts, and this molten metal of the electrode is carried over by the arc to the molten metal pool of the workpiece. A solid joint will be formed when the molten metal cools and solidifies. The flux coating over the electrode produces an inert gaseous shield surrounding the arc to protect the molten metal from oxidizing by encountering atmosphere.





Arc Welding Electrodes:

The two types of electrodes used in arc welding are:

i. Consumable electrode: consumable electrodes melt along with the workpieces and fill the joint
ii. Non-consumable electrode: when non-consumable electrodes are used, an additional filler material is also required. Here the amount of metal deposited by the filler rod can be controlled which is not possible with consumable type of electrode.

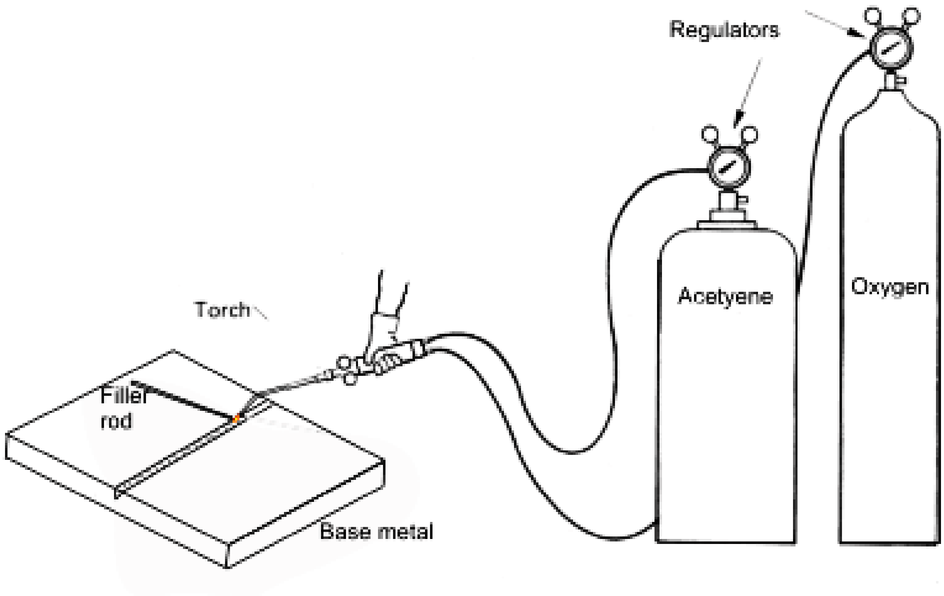
Gas Welding: Gas welding is a fusion method of welding, in which a strong gas flame is used to raise the temperature of the workpieces to melt them. As in arc welding the filler material is used to fill the joint. The gases that can be used for heating are:

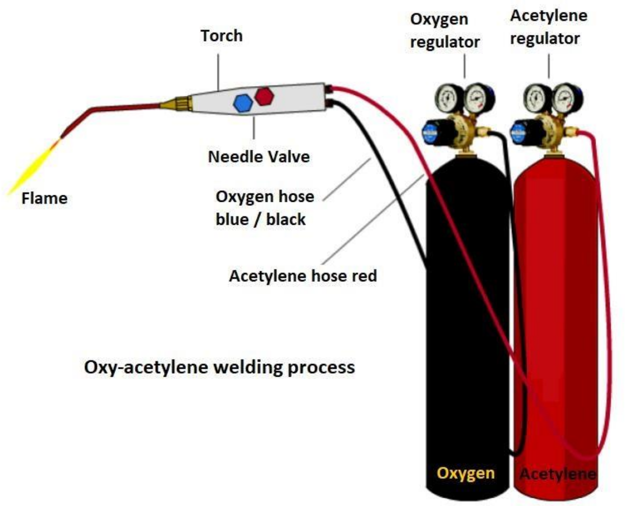
i. Oxygen and acetylene mixture
ii. Oxygen and hydrogen mixture.

The oxy-acetylene mixture is the most used in gas welding.

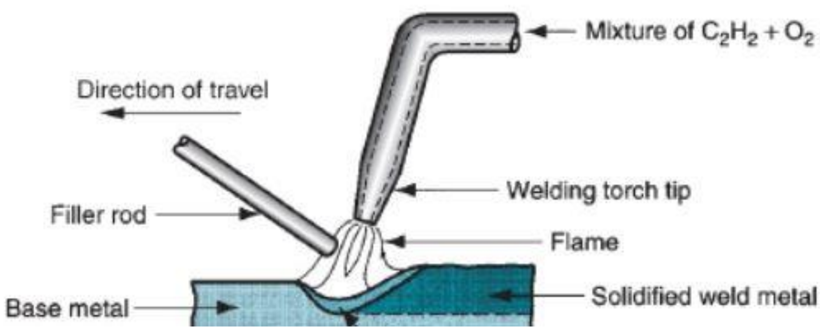
Oxy-acetylene Welding: when right proportions of oxygen and acetylene are mixed in the welding torch and then ignited, the flame produced at the nozzle tip is called as the oxy-acetylene flame. This flame when used in welding is known as oxy-acetylene welding. The temperature attained by the oxy-acetylene flame is around 3200^0C and therefore can melt all commercial metals.

The oxy-acetylene gas equipment consists of two large cylinders, one containing oxygen at high pressure and the other dissolved acetylene at high pressure, rubber tubes, pressure regulators and blow torch.





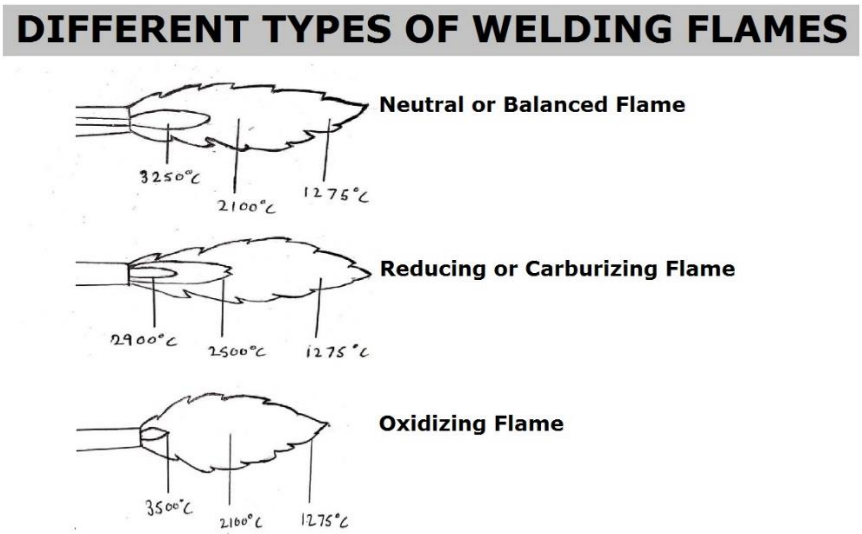
Oxy-acetylene welding (OAW) operation

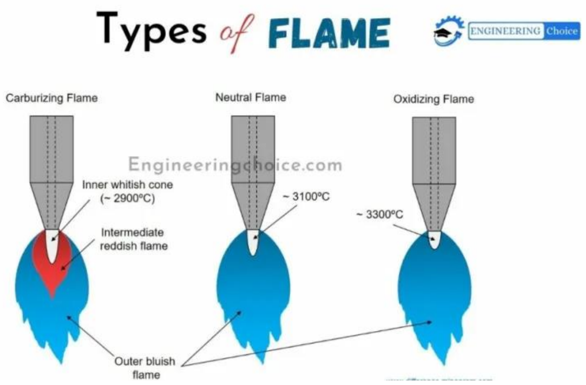


The oxygen and acetylene are supplied to the blow torch separately, where both get mixed and come out through the nozzle of the blow torch. The resultant flame at 3200^{0}C is used to melt the workpieces. To fill up the gap between workpieces and to add strength to the joint, filler rods are added to the molten metal pool. A flux such as borax is used to dissolve and remove metal oxides formed during welding.

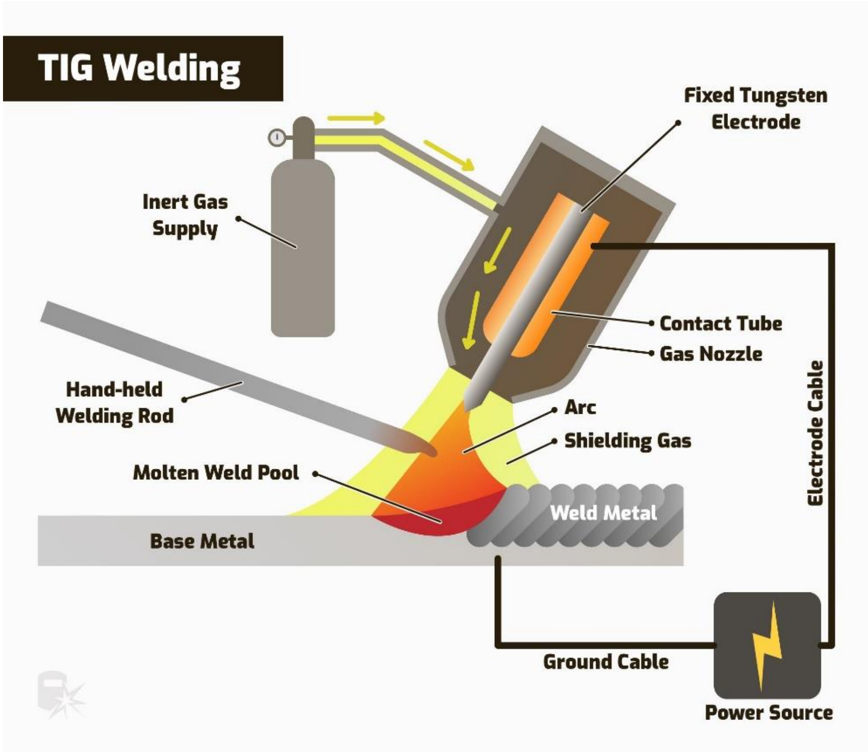
Type of Oxy-acetylene Flames: There are three basic types of oxy-acetylene flames viz., carburising or reducing flame, neutral or balanced flame and an oxidising flame.

i. Carburising flame: it is obtained by supplying excess acetylene in the ratio of between 0.95 to 1. it has 3 cones; an inner white cone, surrounded by intermediate whitish cone and bluish envelope flame. Used for welding alloy steels, cast iron and aluminium.
ii. Neutral flame: it is obtained by supplying equal volumes of oxygen and acetylene. It consists of an inner whitish cone surrounded by blue flame. Most of the welding done with this flame.
iii. Oxidising flame: it is obtained when there is excess oxygen in the range of 1.15 to 1.5. its appearance resembles a neutral flame with the exception that inner white flame is somewhat shorter. This is generally used for cutting as it is not suitable for welding.



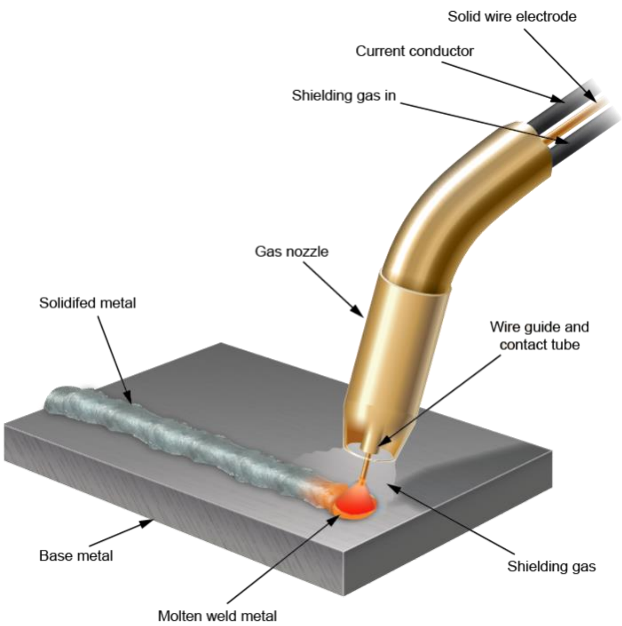


Tungsten Inert Gas (TIG) Welding:



TIG welding, sometimes referred to Gas Tungsten Arc Welding (GTAW) is the process of using an electric arc with an electrode made of tungsten which do not dissolve or burn off when welding. The most important applications for TIG welding are pipeline and pipe welding. It is, however, used in many industries, such as aviation and aerospace and sheet metal industries when welding particularly thin materials and special materials such as titanium.

Metal Inert Gas (MIG) Welding:



Referred to Gas Tungsten Arc Metal Inert Gas (MIG) welding is an arc welding process that uses a continuous solid wire electrode heated and fed into the weld pool from a welding gun. MIG welding is generally used for large and thick materials. It employs a consumable wire that acts as both the electrode and the filler material. Compared to TIG welding, it is much faster, resulting in shorter lead times and lower production costs.

Difference between soldering and brazing:

Soldering	Brazing
Melting temperature is 450^0C	Melting temperature is between 450^0C and 1000^0C.
Weaker joints compared to brazing	Stronger joints
Filler materials are alloy of tin	Filler materials are Aluminium, Silver, Copper, Nickel and Gold.
The flux usually used is Resin	The flux usually used is Borax
Economical process	Not as economical as soldering
Suitable process to join metals with small thickness.	Suitable process to join metals with larger thickness.

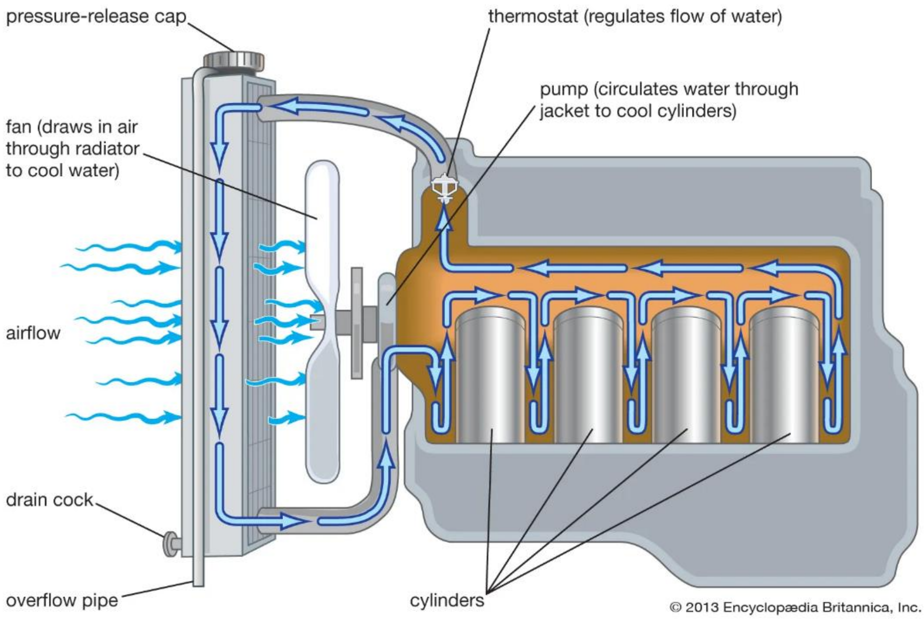
Difference between Brazing and Welding:

Brazing	Welding
Metal to be joined are not melted. Joint is produced by the solidification and adhesion of a thin layer of molten filler metal.	The surfaces to be joined are melted.
There is no penetration into the base metal.	There is penetration into the base metal.
The molten Brazing filler alloy spreads along the joint.	The molten filler alloy does not spread along the joint and solidifies where it melts.
Relatively weaker joints are produced.	Relatively stronger joints are produced.
Average operator skill is required.	High operator skill is required.
Not as economical as welding.	Economical compared to brazing.

Heat Transfer Applications:

Modes of heat transfer:
Heat is defined as the form of energy that is transferred across a boundary by virtue of a temperature difference. There are 3 modes of heat transfer.
Conduction: The transfer of heat between two bodies in direct contact is called conduction.
Radiation: Heat may be transferred between two bodies separated by empty space or gases by the mechanism of radiation through electromagnetic waves.
Convection: A third method of heat transfer is convection which refers to the transfer of heat between a wall and a fluid system in motion.

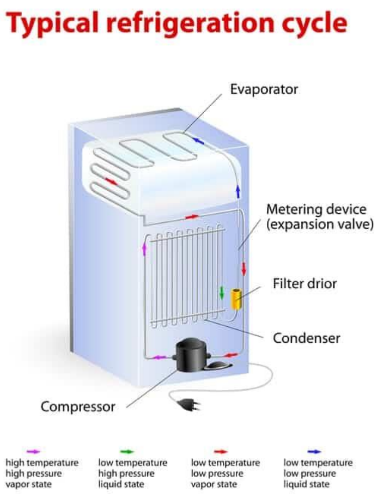
Automobile radiator:



A radiator helps to eliminate excess heat from the engine. It is part of the engine's cooling system, which also includes a liquid coolant, hoses to circulate the coolant, a fan, and a thermostat that monitors the coolant temperature.
The hot cooling water flows from the engine the radiator coils, where it gives heat to the air blown using a fan.

Condenser of refrigerator:
A refrigerator's condenser is part of the system that removes heat from its interior. Combined with the evaporator unit within the fridge, the condenser removes heat from inside the refrigerator and transfers it to the outside of the unit. The high temperature and high-pressure refrigerant carrying heat from the cabin to be cooled is given to atmospheric air in the condenser coils.

Evaporator of refrigerator:



The basic function of an evaporator in the refrigerator system is to remove the heat from the water, air, and other substances present in the refrigerator. The evaporators of refrigerator systems act as a heat exchanger which helps in transferring the heat from the substance and make it cool. The low temperature, low pressure refrigerant flowing through the evaporator coils absorbs heat from the space to be cooled.

Cooling of electric and electronic devices:
There are several techniques for cooling including various styles of heat sinks, thermoelectric coolers, forced air systems and fans, heat pipes, and others.
All electronic components have a thermal limit or a maximum operating temperature. When they reach or exceed this certain temperature, they will breakdown and potentially destroy the circuit board.
In cases of extreme low environmental temperatures, it may be necessary to heat the electronic components to achieve satisfactory operation.

Active cooling is the use of fans to reduce the heat of computer components. Active cooling contrasts with passive cooling, which involves reducing the speed at which a component is running to reduce its heat. Active cooling requires the use of energy specifically dedicated to cooling the component.
Passive cooling utilizes natural conduction, convection, and radiation to cool a component. Passive cooling is an approach to cooling computer components through slowing the speed at which the component, such as the processor, is operating.