Elements of Mechanical Engineering [21ME1ESEME/21ME2ESEME]

Module 2

Metal joining processes - Welding, Brazing, Soldering

In practice, various parts of a product/assembly are manufactured individually and are joined together to obtain the final product. Joining methods are widely based upon the application of the product and the type of joint required.

Classification of Joining processes:

- Permanent joints
  - Welding ✓
  - Brazing ✓
  - Soldering ✓
  - Adhesive joint
  - Shrink fits
  - Riveted joints
- Temporary joints
  - Threaded type: Bolt-Nut, Screw joints etc
  - Non-threaded type: Couplings, pins joints, Collar joints etc.

Welding:

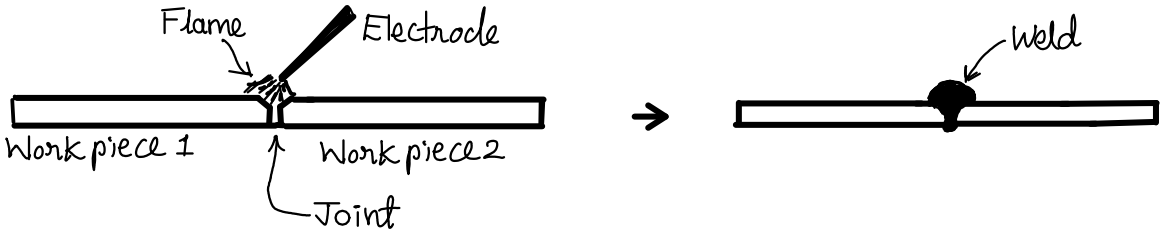
The metallurgical joining of two metal parts together to produce a single part by heating the joint is called Welding.

Classification of welding:

- Arc welding
  - Metal arc welding ✓
  - Plasma arc welding
  - Tungsten Inert Gas (TIG) welding ✓
  - Metal Inert Gas (MIG) welding ✓
- Gas welding
- Resistance welding
- Electron beam welding
- Laser welding
- Ultrasonic welding
- Explosive welding

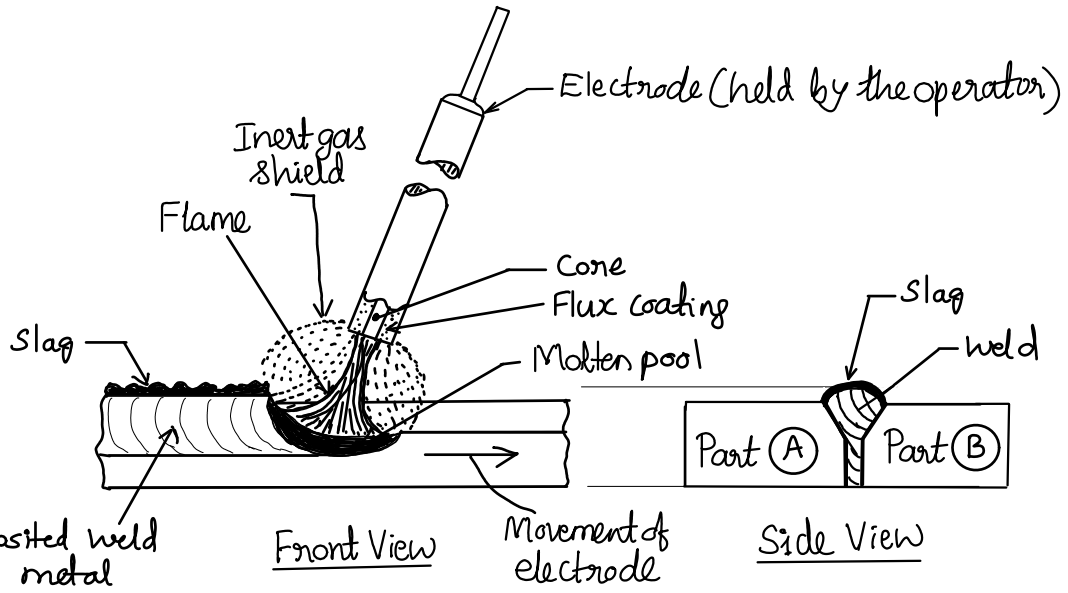
Principle of welding:

In welding, two parts are joined by heating them to the fusion or melting temperature. These parts are then fused with or without the application of pressure. Sometimes filler materials are also added to fuse them. After solidification upon cooling, it forms a homogeneous material of the same composition and characteristic of the parts which are being joined.



Electric arc welding:

Arc welding is the most extensively used welding type. It uses electric power for heating the base metal and filler metal. An electric arc is produced by electrodes which are connected to the power supply.



Principle of operation:

An arc is produced when the current-carrying conductors are brought together momentarily and then separated by a small gap. If there is sufficient voltage between conductors to flow electric current through the air gap, an arc is produced. This arc is associated with a bright glow and intense heat and has the temperature of the order of 5000-6000°C, which is enough to melt the base metals. In arc welding, usually, the parts to be welded are wired as one pole of the circuit and the electrode held by the operator, forming the other pole. Heat generated by the arc quickly melts the workpiece which is directly under the arc, forming a small pool of molten metal. Tip of the electrode also melts and gets mixed with the base metal. A solid joint is formed when the molten metal cools and solidifies.

The flux coating(oxides, carbonates, flourides etc.) over the electrode produces an inert gas shield surrounding the arc and protects the molten metal from oxidizing by coming in contact with the atmosphere. The formation of slag prevents sudden cooling of the joint which is required to reduce the brittleness.

Welding process (procedure):

1. Preparation of base parts: Clean the area of the parts where welding is needed, by removing paint, rust etc. This is generally done with the help of wire brush, or a grinder with wire wheel. Removing contaminates such as rust or paint will drastically increase the quality of welds. Some parts may need edge preparation which is normally done using filing.

2. Use of safety devices: Arc produced in arc welding is extremely hot. It also generates dangerous Ultra Violet (UV) light that can easily harm the eyes, if operator looks directly at it. Hence, personal protection equipment (PPE) is needed. This includes safety glasses, leather welding jacket, welding gloves, welding mask (welding hood), Safety shoes etc. Lots of sparks can be generated during welding, that can easily burn any unprotected areas of the body. These sparks can also easily start a fire, so any flammable material should be kept at a reasonable distance from the welding area.

3. Setting up the machine: Fix the electrode to electrode holder. Turn ON the welder (welding machine) and adjust the settings.

4. Carrying out welding: Fix the workpiece using any suitable work holding device. Carry out welding by moving the welding electrode at the joint at a controlled speed and by maintaing the gap.

5. Cleaning: Slag and spatter are removed by using chipping hammer and wire brush. Grinding can be used for getting good finish.

Advantages

1. Welds produced are faster and Stronger
2. Can weld thick and thin materials
3. Can weld variety of materials
4. Low operating and maintenance cost
5. Noiseless operation

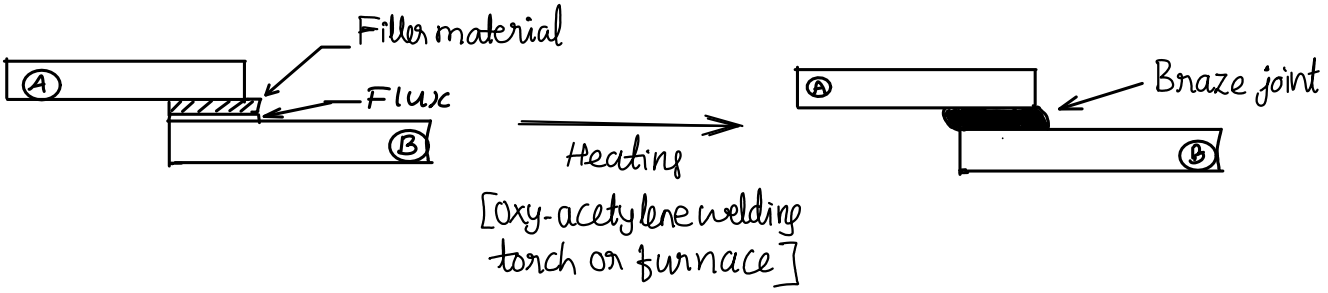
Disadvantages

1. Required a source of electric power.
2. Produces radiation
3. Produces sparks and spatter
4. Electric current can be dangerous particularly when moisture is present.
5. Safety devices are needed.

*Spatter = Droplets of molten metal generated at or near the welding arc.

Brazing:

Brazing is the process of joining two metal surfaces by the addition of non-ferrous filler material (a special fusible alloy) to produce joints stronger than Soldering. Two metal surfaces may be similar or dissimilar.



Principle of operation:

Generally, Copper alloys, Silver alloys and Aluminium alloys are used as filler materials. Before brazing, the surfaces of the parts to be joined are cleaned to remove the oxide layer and grease. After cleaning, a flux is applied at the place of the joint. Borax and mixture of Borax and Boric acid are used as flux. After applying flux, filler material is kept at the joint. Joint is then heated by using oxy-acetylene welding torch or by placing it in furnace to the temperature above the melting temperature of the filler material (500°C to 1000°C). The molten filler material flows by capillary action into the joint space and after cooling produces a strong joint.

Brazing process (procedure):

1. Cleaning
2. Application of flux
3. Placing the filler metal
4. Heating
5. Cooling and inspection

Advantages

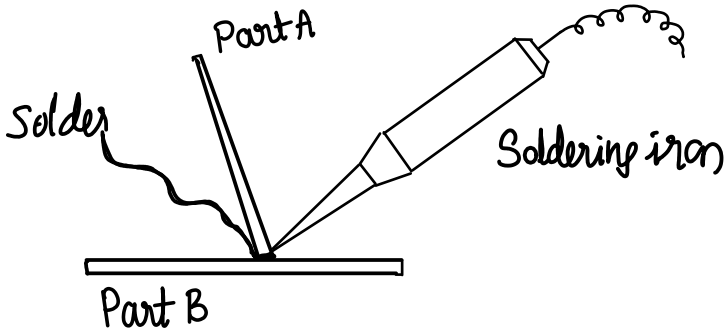
1. Easy process. Can be carried out by an unskilled labour.
2. Dissimilar metals can be joined
3. More joint strength than Soldering
4. Pressure-tight, leak-proof joints
5. Quicker and economical
6. Less heat energy is needed compared to welding
7. Neat joint, No metallurgical damage to the base metal.

Disadvantages

1. Large sections are difficult to braze.
2. Less joint strength compared to welding
3. Can not withstand very high service temperature
4. Requires high degree of cleanliness.
5. Colour of the joint is often discarded from that of base metals.

Soldering:

Soldering is a process of joining two metal pieces by the addition of filler material whose melting temperature is significantly lower than 450°C.



Principle of operation:

Normally Zinc chloride is used as flux, whose main functions are to remove non-metallic oxide films from the metal surface and to wet the surfaces to ease the flow of metal. Heat is applied on the solder by electric soldering iron or ordinary flame such that the solder is melted and fills up the gap between two metals completely. The joint is formed once the solder solidifies. Alloys of Lead-Tin or Lead-Silver are used as solder materials.

Soldering process (procedure):

1. Cleaning
2. Application of flux
3. Tinning (rubbing the tip of soldering iron for cleaning)
4. Heating the soldering iron
5. Soldering by keeping the solder at the joint
6. Cleaning and inspection

Advantages

1. Simple and economical process
2. Joints can be easily repaired (reworked)
3. Less energy required
4. Life of solder is high
5. High repeatability
6. No metallurgical damage to the base parts

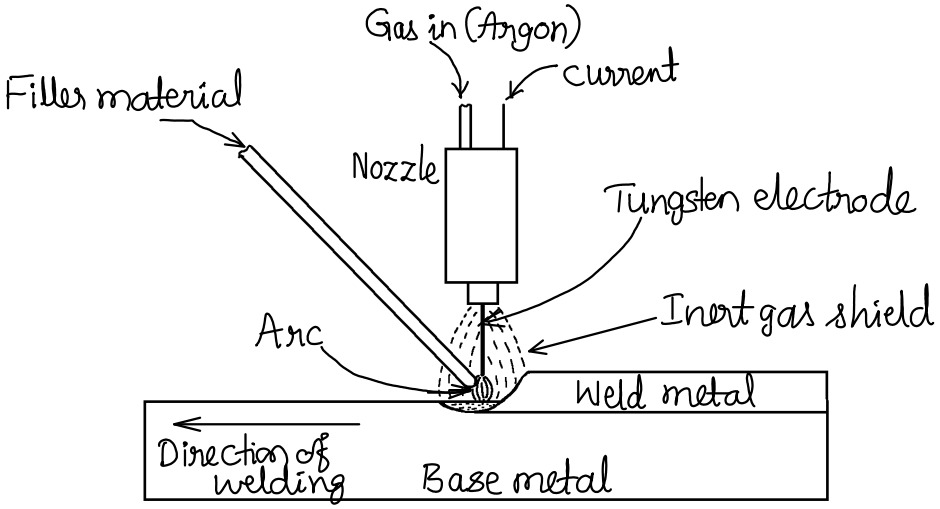
Disadvantages

1. Joint strength is very low
2. Can not withstand high temperatures
3. Cleaning is very essential to avoid any corrosion on the soldered surfaces

Comparison of Welding, Brazing and Soldering processes

Sl No.	Description	Welding	Brazing	Soldering
1	Joint strength	Strongest	Medium	Lowest
2	Melting of base metal	Melting and fusing	Hardly any metallurgical effect	No metallurgical change
3	Composition of filler metal	Similar to base metal	Dissimilar	Dissimilar
4	Use of filler material	Optional	Needed always	Always necessary
5	Joining surfaces	Similar surfaces	May be dissimilar	May be dissimilar
6	Flow of filler material	Mostly deposited into the joint	Mostly capillary action	Mostly capillary action
7	Heat affected zone	High	Less	Negligible
8	Surface finish	Requires finishing operation	Good	Good
9	Joining temperature	Very high of the order of 5000°C	450 to 1000°C	Less than 450°C
10	Flux used	Oxides,Carbonates and Fluorides etc.	Borax, Boric acid	Zinc chloride
11	Application	Cast iron, Alloy steels, Non-ferrous metal parts	Cast irdon, ceramics	Sheet metal work, plumbing, electric circuit

Introduction to TIG welding: TIG – Tungsten Inert Gas



It is a welding process, in which heat is produced by an electric arc ignited between a base metal and the non-consumable tungsten electrode. Tungsten has a high melting point hence doesn't melt during welding.

Inert gas shield keeps the contaminates away from the weld. Filler metal is added separately.

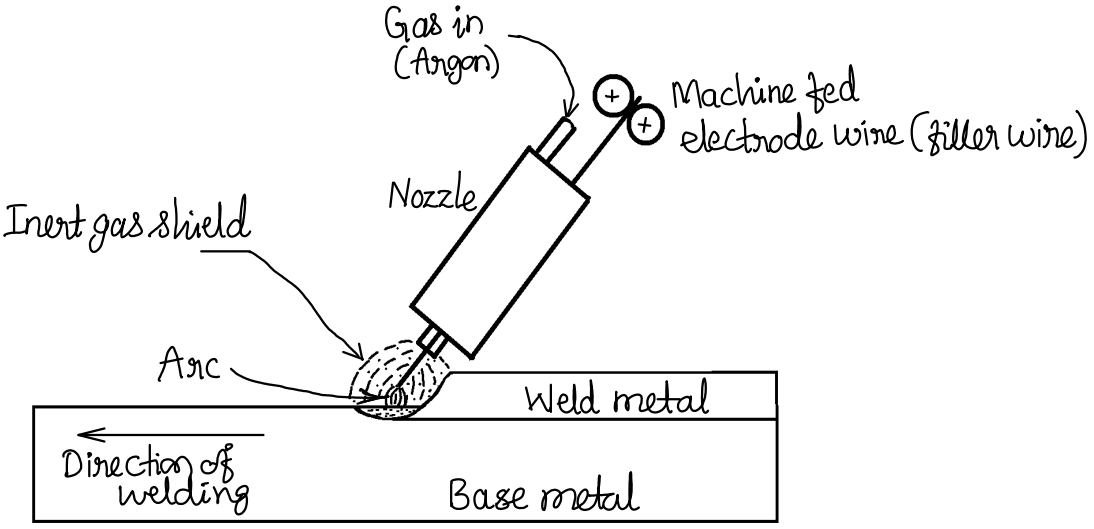
Advantages

1. Slag free operation due to absence of flux.
2. Different materials can be welded.
3. No cleaning is required
4. Weld composition is very close to that of base metal
5. Weld structure is of high quality
6. Concentration of heat in the small zone reduces thermal distortions.

Disadvantages

1. High cost equipment
2. Slow process
3. Filler material is required
4. Skilled operator is needed
5. Outdoor application is limited as wind can disturb the inert gas shield

Introduction to MIG welding: MIG – Metal Inert Gas



In MIG welding, a thin wire acts as the electrode which is fed from a spool mounted on a gun through a flexible tube and it comes out of the nozzle on the welding gun or torch. The wire is fed continuously when the trigger on the welding gun is pulled. Electric arc generated heats the joint. metals melt and mix together and solidify to join the workpieces into a single part.

Advantages

1. No slag formation
2. Faster process
3. Less skilled operator can do the process
4. Thick sheets / Large sections can be welded.
5. Lower production cost
6. No cleaning / finishing required

Disadvantages

1. Welds are not as precise, strong or clean as obtained in TIG.
2. Expensive and non-portable equipment
3. Outdoor application is limited as wind can disturb the inert gas shield

Sample questions

1. Classify welding processes and explain the principle of working of electric arc welding with a neat sketch. [10 Marks]
2. Sketch and briefly explain electric arc welding process. [06 Marks]
3. Discuss with a neat sketch metal joining process where electricity is necessary and temperature of the order of 5000 degree C could be achieved. [07 Marks]
4. Differentiate between soldering and brazing. [04 Marks]
5. Define welding and soldering and compare them. [06 Marks]
6. Differentiate welding and soldering in terms of; the process temperature, filler and flux materials used, joint strength, heat affected zone and applications. [06 Marks]
7. If a processor is to be connected to a printed circuit board, which joining process would be ideal? Describe the process. [04 Marks]
8. List the advantages and disadvantages of TIG welding. [04 Marks]
9. Briefly explain the MIG welding with sketch. [06 Marks]
10. Compare TIG and MIG welding. [04 Marks]