

## Module-I

### 1. Overview of fabrication processes

The fabrication of engineering systems frequently needs joining of two or more components and parts. Three types of joining methods namely mechanical joining (nuts & bolts, clamps, rivets), adhesive joining (epoxy resins, fevicol), welding (welding, brazing and soldering) are commonly used for manufacturing variety of engineering product/component. Each type of joint offers different load carrying capacity, reliability, compatibility in joining of similar or dissimilar materials besides their fitness for use in different environments and cost. It will be appropriate to consider following aspects while selecting type of joints for an application:

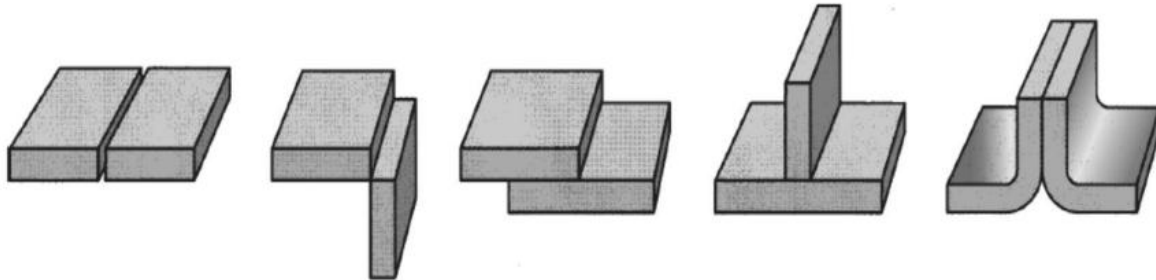
- a) type of joint required for an application is temporary or permanent
- b) Whether similar or dissimilar materials are to be joined in order to take care of the compatibility aspect as metallurgical incompatibility can be disastrous for performance of the joints
- c) Physical, chemical metallurgical properties of materials to be joined
- d) requirements of the service from the joint under special conditions of temperature, corrosion, environment, and reliability
- e) type and nature of loading conditions (static and dynamic loading under tension, shear, compression, bending etc.)
- f) economy or cost effectiveness is one most important factors influencing the selection of joint for manufacturing an engineering component

Depending on the application the fabrication processes are broadly three types;

- i. Temporary joining: Temporary joints allow easy dismantling of assembled components without breaking any parts. Nuts & bolts, clamps joints are temporary joining.
- ii. Semi-permanent joining: Semi permanent joints look like permanent joint but allow dismantling of assembled components without rupturing or breaking parent body. Riveted joint is a semi-permanent joint as it can be dismantle only by rupturing rivet.

- iii. Permanent joining: Permanent joints don't allow dismantling of assembled components without rupturing or breaking the parent metals or parts. Welding, brazing and soldering are permanent type joint.

Types that are predominately used in the joining of parts are the butt, corner, lap, tee and edge joints.



Butt joint

Corner joint

Lap joint

Tee joint

Edge joint

## **Welding:**

Welding is a metal joining process in which two or more parts are joined or coalesced at their contacting surfaces by suitable application of heat or/and pressure. Sometime a filler material is added to facilitate coalescence.

Although most of the welding processes at the time of their developments could not get their place in the production except for repair welding, however, at the later stage these found proper place in manufacturing/production. Presently welding is widely being used in fabrication of pressure vessels, bridges, building structures, aircraft and space crafts, railway coaches and general applications. It is also being used in shipbuilding, automobile, electrical, electronic and defense industries, laying of pipe lines and railway tracks and nuclear installations etc.

## **General Applications:**

Welding is vastly being used for construction of transport tankers for transporting oil, water, milk and fabrication of welded tubes and pipes, chains, LPG cylinders and other items. Steel furniture, gates, doors and door frames, body and other parts of white goods items such as refrigerators, washing machines, microwave ovens and many other items of general applications are fabricated by welding.

**Pressure Vessels:**

One of the first major uses of welding was in the fabrication of pressure vessels. Welding made considerable increases in the operating temperatures and pressures possible as compared to riveted pressure vessels.

**Bridges:**

Early use of welding in bridge construction took place in Australia . This was due to problems in transporting complete riveted spans or heavy riveting machines necessary for fabrication on site to remote areas. The first all welded bridge was erected in UK in 1934. Since then all welded bridges are erected very commonly and successfully.

**Ship Building :**

Ships were produced earlier by riveting. Over ten million rivets were used in 'Queen Mary' ship which required skills and massive organization for riveting but welding would have allowed the semiskilled/unskilled labor and the principle of pre-fabrication. Welding found its place in ship building around 1920 and presently all welded ships are widely used. Similarly submarines are also produced by welding.

**Building Structures:**

Arc welding is used for construction of steel building leading to considerable savings in steel and money. In addition to building, huge structures such as steel towers etc also require welding for fabrication.

**Aircraft and Spacecraft:**

Similar to ships, aircrafts were produced by riveting in early days but with the introduction of jet engines welding is widely used for aircraft structure and for joining of skin sheet to body.

Space vehicles which have to encounter frictional heat as well as low temperatures require outer skin and other parts of special materials. These materials are welded with full success achieving safety and reliability.

**Railways:**

Railways use welding extensively for fabrication of coaches and wagons, wheel tyres laying of new railway tracks by mobile flash butt welding machines and repair of cracked/damaged tracks by thermit welding.

**Automobiles:**

Production of automobile components like chassis, body and its structure, fuel tanks and joining of door hinges require welding.

**Electrical Industry:**

Starting from generation to distribution and utilization of electrical energy, welding plays important role. Components of both hydro and steam power generation system, such as penstocks, water control gates, condensers, electrical transmission towers and distribution system equipment are fabricated by welding. Turbine blades and cooling fins are also joined by welding.

**Electronic Industry:**

Electronic industry uses welding to limited extent such as for joining leads of special transistors but other joining processes such as brazing and soldering are widely being used. Soldering is used for joining electronic components to printed circuit boards. Robotic soldering is very common for joining of parts to printed circuit boards of computers, television, communication equipment and other control equipment etc.

**Nuclear Installations:**

Spheres for nuclear reactor, pipe line bends joining two pipes carrying heavy water and other components require welding for safe and reliable operations.

**Defense Industry:**

Defence industry requires welding for joining of many components of war equipment. Tank bodies fabrication, joining of turret mounting to main body of tanks are typical examples of applications of welding.

**Disadvantage:** Expensive manual Labor, high energy and dangerous, does not allow disassemble and defects.

### Two Types of Welding

- Fusion Welding – melting base metals
  - Arc Welding (AW) – heating with electric arc
  - Resistance welding (RW) – heating with resistance to an electrical current
  - Oxyfuel Welding (OFW) – heating with a mixture of oxygen and acetylene (oxyfuel gas)
  - Other fusion welding – electron beam welding and laser beam welding
  
- Solid State Welding – No melting, No fillers
  - Diffusion welding (DFW) – solid-state fusion at an elevated temperature
  - Friction welding (FRW) – heating by friction
  - Ultrasonic welding (USW) – moderate pressure with ultrasonic oscillating motion

### Welding Operation

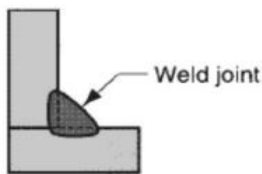
- 50 types processes are available (American Welding Society)
- Applications: Constructions, Piping, pressure vessels, boilers and storage tanks, Shipbuilding, Aerospace, Automobile and Railroad.
- Welder - manually controls placement of welding gun
- Fitter assists by arranging the parts prior to welding
- Welding is inherently dangerous to human workers
  - High temperatures of molten metals,
  - Fire hazard fuels in gas welding,
  - Electrical shock in electric welding
  - Ultraviolet radiation emitted in arc welding (a special helmet with a dark viewing window)

➤ Sparks, spatters of molten metal, smoke, and fumes (good ventilation).

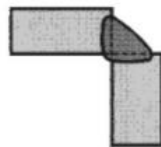
• Automation - Machine, Automatic and Robotic welding

• Types of Welds

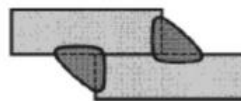
- Fillet weld
- Groove weld
- Plug and slot welds
- Spot and Seam welds
- Flange and Surfacing welds



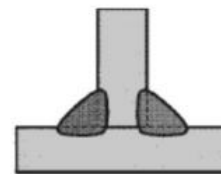
Inside single fillet corner joint



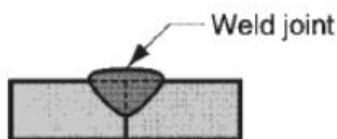
Outside single fillet corner joint



Double fillet lap joint



Double fillet Tee joint



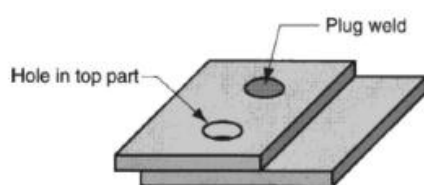
square groove weld one side



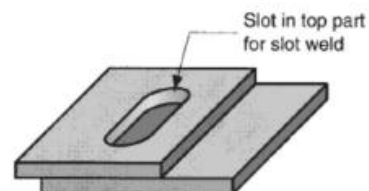
single bevel groove weld



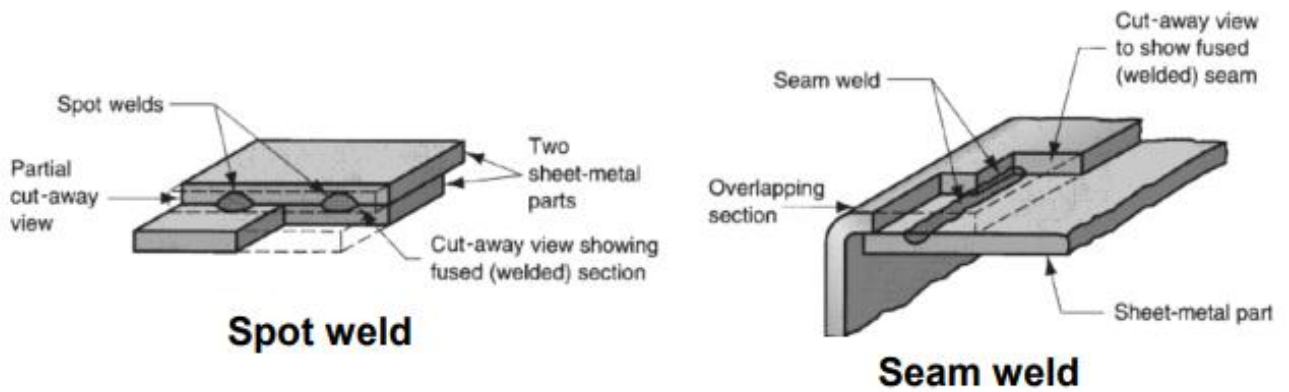
single V-groove weld



Plug weld



Slot weld



There are four basic welding positions, which are flat, horizontal, vertical and overhead are shown below;

