Welding

Welding or more generally Joining involves putting two or more pieces together in such a way that they behave as a single piece.

This may involve applying some kind of pressure or heat or both to the pieces to be joined together. Welding provides metallurgical continuity, while mechanical joining process like riveting does not provide metallurgical continuity.

Definition

Localized coalescence of metals produced either by heating the material to the required welding temperature, with or without the application of pressure or by the application of pressure alone, with or without the use of filler materials."

Advantages of Welding

- Welding has proved to be most efficient way of creating new shapes. There is maximum saving of the material.
- It is suitable for single or one off piece or for large numbers of similar jobs.
- Individual components produced by different shaping route such as forging, rolling or casting can joined together by welding.
- Very large to small components can be made by welding.
- Riveting and bolting involves material wastages as it leads to heavier structures.
- Riveted joints are prone to fatigue failures and crevice corrosion attack.
- Welding methods are open for automation and use of ROBOTS.

Classification of Welding

a) **Fusion Welding processes:** Fusion welding is carried out by simultaneous melting of the edges of the pieces to be joined, allowing the molten metal to mix together and solidify as a single piece to bridge the gap between two components, thus melted and solidified metal becomes part of the joint. Additional molten metal can be added either through electrodes or through filler metal.

b) **Solid Phase Welding Process:** Here either the surface to be joined are heated to a temperature below the melting temperature and joined by application of pressure alone or even if molten metal is generated, it is excluded from the joint area by pressure so the molten and solidified metal is not the part of the joint.

Welding Processes

- Oxyacetylene Welding (OAW), gas welding, torch welding
- Shielded Metal Arc Welding (SMAW), MMAW, Stick Welding, Rod Welding
- Submerged Arc Welding (SAW)
- Gas Tungsten Arc Welding (GTAW)
- Gas Metal Arc Welding (GMAW)
- Plasma Arc Welding (PAW)
- Flux Cored Arc Welding (FCAW)
- Torch Brazing (TB)

- **Selection of Welding Processes**
- Availability of equipment – type, capacity and condition
- Number of welds required
- Quality requirements
- Location of work – shop or site
- Material to be welded
- Appearance of the finished product
- Time available for work
- Size of the parts to be joined – parts can be moved or need to be joined in place
- Skill or experience of workers
- Cost of the material and final job – if it is worth to use costly method or equipment
- Code or specification requirement – choice of the welding method may be dictated by the code

Aspects of Welding

In Fusion Welding there are three main aspects as Electric Arc, Electrodes and Fluxes

Electric Arc

In fusion welding processes, electric arc is the main source of the heat, required for melting of the metal. Electric arc forms when electric current is made to pass between two electrodes separated by a gap.Flow of current across the gap is maintained by the presence of ionized gas atmosphere known as “Plasma”. Welding arc is infact a low voltage, high current discharge. Electric arc produces high temperature for melting of metal. Temperature in the region of the arc column may be more than 7000 C.
Electrons come out from the negatively charged electrode known as “Cathode” and flow toward positively charged electrode known as “anode”. About 2/3 of the heat is developed at the anode and rest in the arc column and at the anode Power of the arc and its penetrating power can be increased by increasing the current flowing through the circuit.
flow of current induces magnetic field around the column and constrict it. Arc column is there fore bell shaped, narrow at the electrode end and spreading towards the work piece. Current density is higher at the constricted end. Plasma jet formation takes place which have very high velocities and can propel metal droplets against gravity.

Electrodes

- Consumable & Non-consumable

Fluxes

Aluminum has a layer of aluminum oxide over its surface as it has great affinity for oxygen. Fluxes are used to ensure that oxide formed are minimum and any oxide formed is dissolved or floated off enabling welding to take place easily. Function of Fluxes are as below.

a. Enable the arc to be struck and maintained easily on dc or ac supplies.
b. Provide a shield of gases such as hydrogen or carbon dioxide to shield the molten metal in its transference across the arc and in the molten pool from reacting with the oxygen and nitrogen of the atmosphere.
c. Provide a slag which helps to protect the metal in transit across the arc gap, when gas shield is not voluminous. Further when molten metal is solidifying, it protects hot metal from oxidation and slows the rate of cooling.
d. It controls the chemistry of the weld metal by slag metal reaction when both slag and metal are in molten condition. The slag metal reaction can add alloying elements to the weld metal and absorb the metal oxide which floats off from the molten metal.
e. Surface tension and viscosity of the slag also control the shape of the weld bead and profile of the weld.
f. Welding fluxes contains many oxides such as SiO_2 (A), manganous oxide MnO (B) and magnesium oxide MgO (B), calcium oxide CaO(B), Aluminum oxide Al_2O_3 (Am), BaO(B) and FeO(B)
g. Oxides are f three types Acid, Basic and Amperic
h. In flux coated electrode, CaO combines with SiO_2, with great application of heat to form calcium silicate.

$$CaO + SiO_2 \rightarrow CaSiO_3 \text{ (Slag)}$$
$$Fe_2O_3 + 3\ SiO_2 = Fe_2 (SiO_3) \text{ (Slag)}$$

Different Types of Welding Process