

6<sup>th</sup> Sem Metallurgical Engg.

Industrial Metallurgy

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## Classification of welding process:-

Pressure welding :- Pressure welding uses friction or explosion to heat the joining section of metal workpieces and join them under pressure.

Non pressure welding :- In non pressure welding process, the material at the joint is heated to a molten state and allow to solidify.

## Gas welding process:-

Gas welding is a fusion welding process. It joins metals, using the heat of combustion of an oxygen and fuel gas (i.e acetylene, hydrogen, propane etc) mixture.

### Types of flames:-

- 1) Neutral flame (Acetelene oxygen in equal proportion)
- 2) Oxidising flame (Excess of oxygen)
- 3) Reducing flame (Excess of acetelene)

## Gas welding equipments:-

The apparatus used in gas welding consist of an oxygen source, fuel gas source, two pressure regulators and two flexible hoses and a torch.

## Gas welding process.

The oxygen cylinder as well as acetylene cylinder are set up on the site where gas welding is to be done.

Both the cylinders are provided with the pressure regulator valves that need to be turned off initially.

Before starting the gas welding process, the welder must take safety precautions.

In order to ignite the gas welding torch, the pressure valves are opened slightly and the hand valves are adjusted for supply of gas.

Flame is produced by burning of the gas mixture at the tip of the torch.

Filler material is added to the weld groove and it forms the integral part of the weld after its solidification.

Adding flux is to avoid the contamination of atmospheric oxygen.

After the welding process is completed allow the welded part to cool down.

## Advantages of gas welding.

- 1) Ability to weld ferrous and nonferrous metals together.
- 2) A neutral flame is used for welding and cutting both ferrous and nonferrous metals.

- 3) Equipments and tools are inexpensive.
- 4) It does not require specialised labor.

### Disadvantages :-

- 1) A slow rate of cooling, leading to slow production.
- 2) Not suitable for welding high strength steel.
- 3) Not suitable for welding thick sections.

### Applications of gas welding :-

Gas welding includes welding of hot water pipes, gas bottles, nuclear heat exchangers and boilers.

Arc welding :-

Metallic arc welding :-

The type of electric welding in which an arc is established between the workpiece and the filler metal electrode is known as metallic arc welding.

In metallic arc welding, the intense heat of the arc forms a molten pool in the metal being welded and at the same time melts the tip of the electrode. As the electric arc is maintained, filler metal from the tip of the electrode is transferred across the arc and it fuses with the molten base metal.

This type of welding is applicable in welding of carbon steel, and welding of high alloy austenitic stainless steel.

## submerged arc welding :-

It is a welding process where the tubular electrode is fed continuously to join two metals by generating heat between electrode and metal.

In submerged arc welding process, instead of flux covered electrode, granular flux and a bare electrode is used. Arc between the electrode and job is the heat source and remains buried under the flux serves as a shield and protects the molten ~~metal~~ weld pool from atmospheric contamination. The process may be semi-automatic or automatic.

### Equipments :-

- a) Welding head
- b) Flux hopper
- c) Welding power source
- d) Flux
- e) Electrodes

### Advantages :-

- 1) Molten flux provides very suitable conditions for high current to flow.
- 2) Considerably higher welding speeds.
- 3) High metal deposition rates can be achieved.
- 4) Welding is carried out without sparks, smoke, flash and spatter.

### Disadvantages:-

- 1) Since the operator can not see the welding being carried out, he cannot judge accurately the progress of welding.
- 2) The process is limited to welding in flat position and metal more than 4.8 mm thick.

### Applications:-

- 1) Fabrication of pipes, penstocks, pressure vessels, boilers, rail road, locomotive etc.

## TIG welding :- (Tungsten Inert Gas welding) -

It is an arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a tungsten electrode and the job. A shielding gas (argon/helium, etc.) is used to avoid atmospheric contamination of the molten weld pool. A filler metal may be added if required.

### Equipments :-

- a) welding torch, Tungsten electrode and filler metal.
- b) welding power source, high frequency unit, DC suppressor unit and cable.
- c) inlet gas cylinder, pressure regulator and flow meter.

### Advantages :-

- 1) No flux is used, hence there is no danger of flux entrapment when welding refrigerator and air conditioner.
- 2) Because of the clear visibility of the arc and the job, the operator can exercise a better control on the welding process.

### Disadvantages :-

- 1) TIG welding requires a separate filler rod.
- 2) Equipment costs are higher than that for flux shielded metal arc welding.

## Applications:-

- 1) Welding aluminium, magnesium, copper, nickel and their alloys, carbon, alloy or stainless steels, mneonel, hightemperature and hard surfacing alloys like zirconium, titaniums etc.
- 2) Welding sheet metal and thinner sections.
- 3) Rocket motor chamber fabrications in launch vehicles.

## Metal Inert Gas (MIG) welding :-

It is an arc welding process where coalescence is produced by heating the job with an electric arc established between a continuously fed metal electrode and the job. No flux is used but the arc and the molten metal are shielded by an inert gas, which may be argon, helium, carbon dioxide or a gas mixture.

### Equipments:-

- a) Welding power source and cables.
- b) Welding torch and wire electrode coiled on a spool.
- c) Wire feed mechanism and controls consist of a pair of driving rolls, electric motor etc.
- d) Shielding gas cylinder, pressure regulator and flow meter.
- e) Controls for switching on and off the current electrode wire and inert gas.

### Advantages:-

- 1) MIG is much faster than TIG.
- 2) It can produce joints with deep penetration.
- 3) The process can be easily mechanized.
- 4) Thick and thin both types of work pieces can be welded effectively.

### Disadvantages:-

- 1) More complex than TIG.
- 2) May not work well in outdoor welding application.

### Applications

- 1) The process can be used for the welding of carbon, silicon and low alloy steels, stainless steel, aluminium, magnesium, copper, nickel and their alloys etc.
- 2) For welding tool steels and dies.
- 3) For the manufacture of refrigeration parts.

## Thermite Welding :-

It is a process that uses heat from exothermic reaction to produce coalescence between metals. The name is derived from "thermite", which is the generic name given to a reaction between metal oxides and reducing agents.

### Procedure :-

- 1) Clean the joint.
- 2) Allow for contraction.
- 3) Construct the mold.
- 4) Preheating the mold.
- 5) Crucible and its charging.
- 6) Ignite the thermite mixture.
- 7) Opening the the mold.
- 8) Finishing the weld.
- 9) Advantages:-

The heat necessary for welding is obtained from a chemical reaction and thus no costly power supply is required therefore broken parts can be welded on the site itself.

### Limitation :-

Thermite welding is applicable only to ferrous metal parts of heavy sections.

The process is uneconomical if used to weld cheap metal or light parts.

### Applications :-

- 1) For repairing fractured rails.
- 2) For butt welding pipes end to end.

## Resistance Welding :-

Resistance welding is a group of welding processes wherein coalescence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part and by the application of pressure. No filler metal is needed.

## Advantages of Resistance welding :-

- 1) Fast rate of production
- 2) No filler rod is needed
- 3) Semi automatic equipments
- 4) Less skilled worker needed
- 5) High reliability

## Disadvantages :-

- 1) Initial cost of equipment is high.
- 2) In some materials special surface preparation is required.
- 3) Bigger job thickness cannot be welded.

## Application :-

- 1) Joining sheets, bars, rods and tubes.
- 2) Making tubes and metal furniture.
- 3) Welding aircraft and automobile parts.

## Welding of stainless steels:-

When 11.5% or more chromium is added to iron, a fine film of chromium oxide forms spontaneously on the surfaces exposed to air. The film acts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainless steel.

All stainless steel can be grouped into three metallurgical classes :-

- a) Austenitic      ⑥ Ferritic
- c) Martensitic

## Welding of Cast Iron:-

Cast iron is a brittle, cheap and thrown in the flesh to fix but used everywhere from the workshops to kitchen.

A family of iron-carbon alloys with 2-4% carbon makes them a hard cast iron metal. It is less malleable, less ductile and does not stretch or deform when heated. Instead they ~~get~~ crack and making the process of welding enormously difficult.

There are many types of weldability of cast iron.

gray cast iron - weldability with difficulty  
white cast iron - Unweldable  
Ductile cast iron - Rarely weldable, slow and extensive process.

## Welding of Copper alloys :-

Copper and copper alloys offer a unique combination of material properties that makes them advantageous for many manufacturing environments. They are widely used because of their excellent electrical and thermal conductivity, outstanding resistance to corrosion, ease of fabrication, and good strength and fatigue resistance. Other useful characteristics include spark resistance, metal to metal wear resistance, low permeability properties and distinctive color.

Copper and most copper alloys can be joined by arc welding, welding processes that use gas shielding are generally preferred although SMAW can be used for many noncritical applications.

## Temperature distribution in Welding :-

In this work, a three dimensional model has been proposed to predict temperature distribution and weld pool shape during dissimilar arc welding of low carbon steel and ferritic stainless steel. The model has been developed using the finite element

software ANSYS, while in the analysis, the effects of process parameters as well as dilution, in the weld pool have been considered. To verify the predictions, welding experiments were conducted under different welding conditions and the model results were then compared with the measured weld pool geometry, a reasonable consistency was observed.

### Weldability :-

The weldability also known as joinability, of a material refers to its ability to be welded.

### Welding defects :-

In a metal working, a welding defect is any flaw that compromises the usefulness of a weldment.

### Testing of welding joints :-

- 1) Visual inspection
- 2) Magnetic particle inspection
- 3) Liquid penetration inspection
- 4) Eddy current inspection
- 5) Radio graphic inspection
- 6) Failure analysis
- 7) Ultrasonic inspection
- 8) Metallurgical testing

## Brazing :-

Brazing is a metal joining process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, with the filler metal having a lower melting-point than the adjoining metal. Brazing differs from welding in that it does not involve melting the workpiece.

## Soldering :-

Soldering is a joining process used to join different types of metal together by melting solder. Solder is a metal alloy usually made ~~is~~ of tin and lead which is melted using a hot iron. The iron is heated to a temperature above 600 degree fahrenheit which then cools to create a strong electrical bond.

## Powder Metallurgy :-

Powder metallurgy is a term covering a wide range of ways in which materials or components are made from metal powders. P/M processes can reduce or eliminate the need for subtractive processes in manufacturing, lowering material losses and reducing the cost of the final product.

### Advantages of powder metallurgy :-

- 1) Powder metallurgy generally do not require further finishing.
- 2) There is no wastage of raw material.
- 3) Reasonably complex shapes can be made.
- 4) Automation of P/M process is easy as compared to other manufacturing process.

### Disadvantages of P/M :-

- 1) Tooling cost is generally high and can only be justified in mass production.
- 2) Raw material cost is generally very high.
- 3) Mechanical properties of the parts are of low quality as compared to cast or machined parts.

## Application of P/M :-

Components that are difficult to manufacture by any other method, such as those made from tungsten, molybdenum or tungsten carbide. In addition porous bearings, filters, and many types of hard and soft magnetic components are made ~~exactly~~ exclusively using powder metallurgy.

## Making of metal powder :-

There are four main processes used in powder production are solid state reduction, atomization, electrolysis and chemical.

## Metal Powder Compaction :-

- ① To consolidate the powder into desired shape
- ② To impart to as high a degree as possible the desired final dimensions with due consideration to any dimension changes resulting from sintering.
- ③ To impart the desired level any type of porosity
- ④ To impart adequate strength for subsequent handling.

## Isostatic pressing :-

Isostatic pressing is a powder metallurgy (P.M) forming process that applies equal pressure in all directions on a powder compact thus achieving maximum uniformity of density and microstructure without the geometrical limitation of uniaxial pressing. It is of two types "cold" or "hot".

Cold isostatic pressing :- is used to compact green parts at ambient temperature.

Hot isostatic pressing :- is used to fully consolidate parts at elevated temperature by solid state diffusion.

## Sintering of metal powder :-

Sintering of powder metals is a process in which particles under pressure chemically bond to themselves in order to form a coherent shape when exposed to a high temperature.