# UNIT 5 WELDING

## Structure



## 5.1 INTRODUCTION

Welding is an art of joining metals by heating and then pressing together. The process of joining may also take place by other means of riveting or by fastening nut and bolts. If a joint can be deassembled then joining method is called temporary joining method. If the formed cannot be deassembled without breaking it then the joint is called permanent joint. Normally in welding operation joining of metal pieces is done by raising their temperature to the fusion point so that they form a sort of pool of molten metal at the ends to the joined, sometimes, the pool is supplemented with a filler metal (wire or rod) which normally has almost same compositions as that of the workpieces. This way the pool form a homogeneous mixture. It is allowed to get solidify to have a permanent joint. There is wide diversity in welding technology so its conventional definition can be modified as "welding is a technique of joining similar and dissimilar metals and plastics by adopting ways which do not include adhesives and fasteners."

### Objectives

After studying this unit, you should be able to

- introduction to welding,
- different types of welding processes and their classification,
- welding tools and equipment, and
- welding defects and their remedies.

## 5.2 CLASSIFIATION OF WELDING PROCESSES

Welding process can be classified into different categories depending upon the following criteria :

(a) It can be classified as fussion welding or pressure welding depending upon on the application of heat. If application of heat is not required, it is called pressure welding.

(b) In case of fusion welding it can classified low temperature welding and high temperature welding. When heat is generated to develop low temperature it is called low temperature welding like soldering and brazing. Other fusion welding methods are high temperature welding methods.

(c) Fusion welding can also be classified on the basis of method of heat generation like gas welding, electric arc welding, resistance welding, thermit welding, etc.

(d) On the basis of the type of joint produced it can be categorized as butt welding, seam welding, spot welding, lap joint welding, etc.

Each of the above type of welding can be further classified depending on other micro level characteristics.

### 5.2.1 Gas Welding

It is a fusion welding in which strong gas flame is used to generate heat and raise temperature of metal pieces localized at the place where joint is to be made. In this welding metal pieces to be joined are heated. The metal thus melted starts flowing along the edges where joint is to be made. A filler metal may also be added to the flowing molten metal to fill up the cavity at the edges. The cavity filed with molten metal is allowed to solidify to get the strong joint. Different combinations of gases can be used to obtain a heating flame. The popular gas combinations are oxy-hydrogen mixture, oxygen-acetylene, etc. different mixing proportion of two gases in a mixture can generate different types of flames with different characteristics.

### 5.2.2 Oxy-Acetylene Welding

Oxy-acetylene welding can used for welding of wide range of metals and alloys. Acetylene mixed with oxygen when burnt under a controlled environment produces large amount of heat giving higher temperature rise. This burning also produces carbon dioxide which helps in preventing oxidation of metals being welded. Highest temperature that can be produced by this welding is $3200^{o}C$. The chemical reaction involved in burning of acetylene is

$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O + \text{Heat}$$

on the basis of supply pressure of gases oxy-acetylene welding is categorized as high pressure welding in this system both gases oxygen and acetylene supplied to welding zone are high pressure from their respective high pressure cylinders. The other one is low pressure welding in which oxygen is supplied from high pressure cylinder but acetylene is generated by the action of water on calcium carbide and supplied at low pressure. In this case high pressure supply of oxygen pulls acetylene at the welding zone.

A comparison can be drawn between low pressure and high pressure welding. High pressure welding equipment is handy, supplies pure acetylene at constant pressure, with better control and low expenses as compared to low pressure welding.

## 5.3 FLAME FORMATION AND ITS DIFFERENT TYPES

Flame is established by burning (controlled) of the two gases mixture at the outlet of blow pipe or torch. The proportion of gasses in the mixture is controlled by controlling the flow rate of each of the two gasses. Here, it should be clear that burning of acetylene generates heat and oxygen only supports acetylene in burning. Insufficient supply of oxygen leaves acetylene unburnt in atmosphere creating pollution and adding cost of waste acetylene. A general nomenclature of the flame established in oxy-acetylene welding is given in Figure 5.1. The flame can be divided in to three zones. Zone ‘1’ is very near to the outlet of torch, where oxygen reacts with acetylene and burning of two gases takes place. Zone ‘2’ produces carbon monoxide and hydrogen in ratio 2 : 1 by

volume. This zone gives the highest temperature of the flame. This zone is suppose to consume the oxygen available here and contribute reducing properly to the flame. Zone '3' is the outermost zone of the flame. Temperature of this zone is comparatively low. This zone converts CO to $CO_2$ and $H_2O$ vapours. On the basis of supply proportion of acetylene and oxygen, flames can be divided into three categories, neutral flame, carburizing flame and oxidizing flame. These are described here.

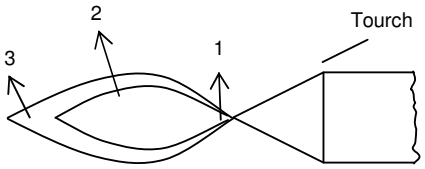


**Figure 5.1 : Establishment of Flame in Oxy-acetylene Welding**

### 5.3.1 Neutral Flame

A neutral flame is obtained when equal amount of $O_2$ and $C_2H_2$ are mixed and burnt at the outlet of welding torch. The flame consists of two sharply defined zones inner white flame cone outer envelope of blue colour as shown in Figure 5.2. In this flame none of two gasses is supplied in excess. This flame is of white cone and has the maximum use for successful welding of many metals.

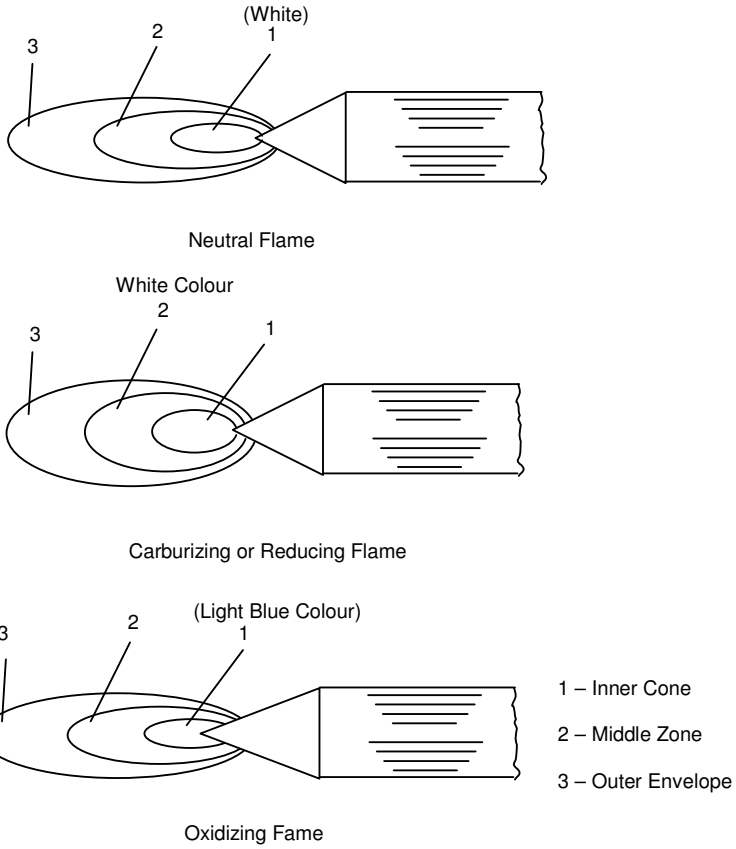


**Figure 5.2 : Three Types of Flames in Oxyacetylene Welding**

### 5.3.2 Carburizing Flame

This flame is obtained when excess of acetylene is supplied than which is theoretically required. This flame is identified by three zones the inner cone which is not sharply defined, an outer envelope as same in case of neutral flamed and middle zone surrounds inner one extended to outer envelope. It is white in colour due to excess acetylene. Larger the excess of acetylene larger will be its length. To get a neutral flame a systematic procedure is to make carburizing flame first and then increase oxygen supply gradually till the excess acetylene zone disappears. The resulting flame will a carburizing flame. Its temperature generation range is 3100°C to 3300°C. It is used for

the welding of metals where risk of oxidation at elevated temperature is more like aluminium, its alloys and lead and its alloys. The metals which have tendency to absorb carbon should not be welded by carburizing flame as they become brittle localized.

### 5.3.3 Oxidizing Flame

This flame as an excess of oxygen over that required for a neutral flame. The ratio $O_2 : C_2H_2 = 1.15$ to 1.50. To have this flame set carburizing flame first convert it to neutral flame and than reduce the supply of acetylene to get oxidizing flame. Its inner cone is relatively shorter and excess oxygen turns the flame to light blue colour. It burns with a harsh sound. It is used for metals which are not oxidized readily like brasses and bronzes.

## 5.4 GAS WELDING TOOLS AND EQUIPMENTS

Equipment for gas welding as well as for gas cutting are almost similar. It consists of two large steel cylinders one containing oxygen at high pressure and other dissolved acetylene also at high pressure. In addition to tools and equipments some consumables are also used in gas welding. Major tools and equipment and consumables are listed below followed by their brief description.

**Tools and Equipment**

(a) Gas cylinders (two)

(b) Hose pipes and valves

(c) Cylinder pressure gauge

(d) Outlet pressure gauge

(e) Pressure regulators

(f) Blow pipe or torch and spark lights

(g) Welding screens

(h) Goggles, screens, gloves and apron

(i) Wire brush, trolley, chipping hammer.

**Consumables**

(a) Oxygen gas

(b) Acetylene gas

(c) Filler metal (rod or wire)

(d) Fluxes.

**Gas Cylinders**

Two large steel cylinders, capable to withstand high pressure are needed to keep oxygen and acetylene separately. Cylinders are painted with different colours : oxygen cylinder in black colour and acetylene cylinder in maroon or red colour. Oxygen is filled at pressure to 2000 pound per square ich (PSI). Large weight of acetylene is kept dissolved in acetone. Acetylene cylinder should not be exposed to higher temperature for safety reasons.

**Pressure Regulators**

Each of the cylinders should be equipped with pressure regulator at the top. Pressure regulator maintains supply pressure at a constant value which have to be much less than the pressure at which gas has been filled in the cylinder. This way supply pressure can be controlled and maintained to different values as per the requirement. Value of supply pressure depends upon inside diameter of outlet nozzle, supply flow rte of gas.

### Pressure Gauge

Pressure gauge measures the pressure with respect to the atmospheric pressure. Two pressure gauges are mounted on each of the cylinders. One for knowing pressure of gas inside the cylinder which is the measure of gas content inside the cylinder. Second gauge is used to know the supply pressure of the gas to below pipe. Former gauge is called cylinder pressure gauge and later one is called outlet pressure gauge.

### Hose Pipes and Values

Hose pipes are used to carry gases from their respective cylinders to blow pipe. Hose pipes are made of rubber with long life. Each value is mounted at the top of each cylinder along with the pressure value is mounted at the top of each cylinder along with the pressure gauge. This value can stop flow of gas from cylinder to hose pipe. One valve is mounted on the each hosepipe where these are connected to blow pipe. These valve can stop the flow and control the flow of oxygen and acetylene independently to get carburizing, oxidizing or neutral flame.

### Blow Pipe and Spark Lighter

Blow pipes are used in welding or cutting. These are made in different design and size to suit the work. Both the gases are mixed in a chamber of blow pipe and then driven out through the orifice of the blow pipe nozzle and burnt by spark lighter. Blow pipes are classified as high pressure torch used in gas cutting and low pressure torch used in gas welding. In case of high pressure blow pipe acetylene is supplied at high pressure as compared to low pressure blow pipe. Construction of a blow pipe is given below in Figure 5.3.

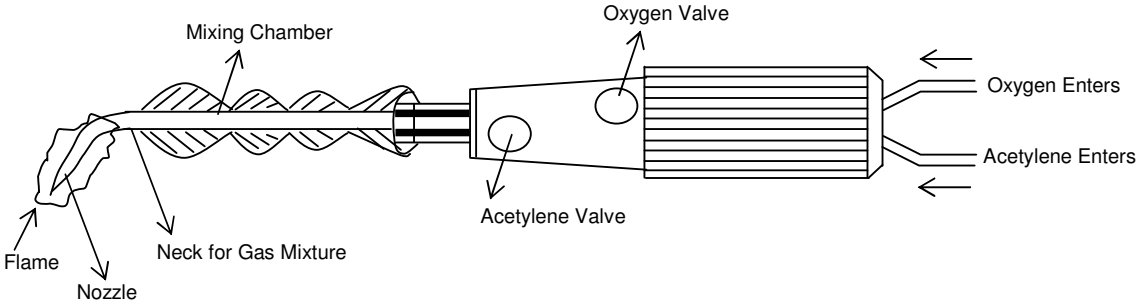


**Figure 5.3 : Blow Pipe Used in Gas Welding**

### Safety Hammer

Goggles, welding screens, gloves and apron are the part of the safety kit used gas welding. Glaze produced by the flame and spirals can damage the hammer beings so safety kit elements are used for protection.

### Chipping Hammer

Chipping hammer is a simple hammer having sharp edge at one of its end and sharp point at its outer end. It is used to remove the adhering layer of slag on the weldment. A brush having hard wires is used for cleaning of weldments after the use of chipping hammer. Trolley is used to carry gas cylinders and other related tools of welding from one place to another.

In addition to the above there are some more material used in gas welding as consumable material, which are describe below.

### Welding Rods

These are also called filler metals. Filler metal is typically in the form of rod, 90 mm long and diameter ranging from 1.6 mm to 9.5 mm. Composition of filler metal must be same as that of base metal. Two types of welding rods are generally available. One is coated welding rods, which have coating of flux. Others are bare welding rods having no coating of flux. Different types of welding rods are used for welding of different metals. Some examples are given below.

*Metal to be Welded*

(a) Iron rich steels

(b) Stainless steel

(c) Copper

(d) Aluminium and its alloy

*Composition of Welding Rod*

(a) More 'C' Si, Mn less 'P' and 'S'

(b) should have 'Cr' and 'V'.

(c) Copper rods with phorphorus.

(d) Rods of same metal containing some silicon.

**Flux**

Flux is used in every welding operation. Mild steel is exceptional to this. Flux is used to prevent oxidation of hot metal. It converts the oxides and nitrides to slag that can be removed from welding zone easily. Formation of oxides and nitrides make weldment weak. Different fluxes are used for welding of different metals. For the welding of copper and its alloy sodium nitrate, sodium carbonates are used as flux. For welding of aluminium or its alloy chloride of sodium, potassium, lithium or barium are used.

**Arc Welding**

Electric arc welding is one of the fusion welding processes in which coalescence of the metal is achieved by the heat from an electric arc between an electrode and workpiece. A line diagram indicating the whole process is shown in Figure 5.4. Electric arc is generated when electrode is brought into contact with the work and is then quickly separated by a short distance approximately 2 mm. The circuit operates at low voltage and high current so arc is established in the gap due to thermoionic emission from electrode (Cathode) to workpiece (Anode). The arc is sustained due to continuous presence of a thermally ionized column of gas. This arc produces at temperature of the order of 5500$^{o}$C or higher. In this way a pool of molten metal consisting of workpiece metal and filler metal is formed in the welding zone. The electrode is moved along the joint with perpendicular zig-zag motion. The solidified molten weld pool makes the strong welded joint. Movement of the electrode relative to workpiece is accomplished by either manually or by mechanical means in case of automatic welding machines. Better uniformity and good quality weldments are possible in case of automatic welding process.

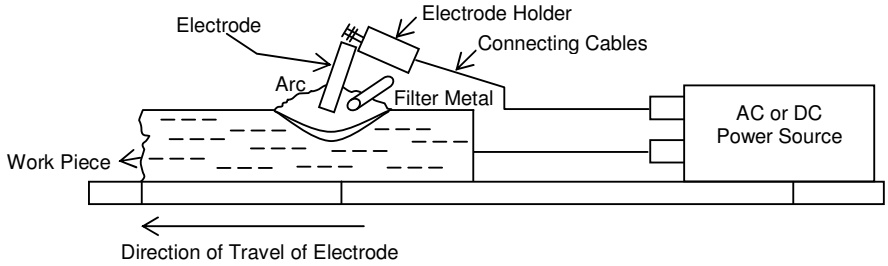


**Figure 5.4 : Process of Electric Arc Welding**

## 5.5 ARC WELDING EQUIPMENT

Arc welding equipment are listed below. The equipments are categorized as facilitator, consumable and protecting equipments. Some of the equipment of arc welding are same as that are used in gas welding like flux, protecting devices and cleaning devices, etc.

**Facilitator Equipment**

(a) Power source (welding machine)

(b) Electrode holder

(c) Work table

(d) Cables (for connection)

(e) Finishing devices like chipping, hammer, wire brush, etc.

**Consumable Equipment**

(a) Electrode

(b) Flux

(c) Workpiece

(d) Filler metal

**Protecting Equipment**

(a) Welding shields

(b) Goggles

(c) Screens

(d) Gloves

(e) Apron

Arc welding equipments are described below.

**Power Source**

Both AC (Alternative Current) and DC (Direct Current) can be used for welding. AC machines are recommended for ferrous metal and DC machines are recommended for other metals for better result. Main constituent of welding machine is transformer which convert the supply to low voltage and high current. For AC welding power is required at 80 to 110 volt and 50 to 80 ampere. For sustaining the established are power factor is kept low. In case of DC welding power is required at 8 to 25 volts and 50 ampere. Polarity is also are significant factor. Two types of polarities are possible in case of DC welding.

*Straight Polarity*

Electrode is made negative pole and workpiece is made positive pole. It is also called as electrode negative.

*Reversed Polarity*

Electrode is made positive pole and workpiece is made negative pole. It is called electrode positive too. As we know that two third of the total heat is generated at positive pole and only one third at negative pole. Polarity is decided according to the requirement of heat at either pole.

**Welding Electrodes**

These are also called welding rods. Two types of welding electrodes are generally used. Consumable electrodes and non-consumable electrodes. Consumable electrodes are the source of filler metal in case of are welding. Consumable electrodes can further be classified into two categories coated and bare electrodes. Bare electrodes are simple rods mode of filler metal with no coating over them. In case of bare electrode flux is required additionally. These electrodes are rarely used. Bare non-consumable electrodes are used in case of gas shielded welding processes (MIG and UIG).

*Non-consumable Electrodes*

They are made of tungsten or carbon. These do not melt in the process of welding and so called non-consumable electrodes. Their depletion rate is very low. In case of non-consumable electrodes metal and flux is supplied additionally. Generally non-consumable electrodes are used in MIG and TIG welding processes.

*Coated Consumable Electrodes*

These are the most popular arc welding electrodes. No additional filler metal and flux are required with them. In general these electrodes have core of mild steel and coating over them of flux material. Coating on the electrode performs many functions. It develops a reducing atmosphere and prevents oxidation, forms separable slag from metal impurities, establishes ac providing necessary alloying elements to the weld pool. The common ingredients act as flux which help in slag formation are asbestos, mica, silica, fluorspar, stealite, titanium dioxide, iron oxide, metal carbonates, etc. Ingredients used to produce reducing atmosphere are cellulose, dalomine, wood flour, starch. Iron powder provides higher deposition rate. Manganese oxide and potassium silicate and titanate are the alloying elements and stabilizers.

**Electrode Classification and Coding**

According to ISI coding system an electrode is specified six digits with a prefix letter 'M' which is indicative of its suitability for metal arc welding. Explanation of six digits is given below.

*First Digit*

First digit stands for particular type of coating on the electrode. This digit can be any from 1 to 8.

*Second Digit*

It can be any from 1 to 6. Each digit is an indicative of a particular position of welding by the respective electrode.

*Third Digit*

This includes digit 0 to 7. Each digit representing a particular current condition corresponding to an electrode.

*Fourth Digit*

Any digit out of 1 to 8 is used for this purpose. Electrode of a particular number indicates minimum tensile strength of the wledment made by the electrode.

*Fifth Digit*

It indicates the percentage elongation of deposited weldment in tensile testing. Different percentages are represented by number 1 to 5.

*Sixth Digit*

It signified the minimum impact strength of the weldment. Different strength values are categorized in five categories ranging from 1 to 5.

**Electrode Holder**

Electrode holder is a device to hold the electrode. Electric current flows in to the welding zone through electrode holder so it should be perfectly insulated. Electrode is held into its jaws. Jaws of holder should be made of metal with high conductivity and heat resistant. In some cases if its jaws are subjected to very high temperature, the holder is made equipped with water cooling facility.

**Connecting Cables**

Circuit of arc welding set up is completed with the help of connecting cables. The cable used to connect electrode holder with power source should be enough flexible to facilitate easy movement of electrode. The cable should also be well insulated and capable to carry high current.

**Work Table**

Work table is a table where workpieces to be welded are placed. Work table is also connected with the power source to give a particular polarity to the workpiece. Electric circuit forms when electrode is brought in contact of workpiece through work table and electrode holder.

**Welding Shield**

Like gas welding arc welding also requires welding shield for the protection of eyes of the welder (operator). Additionally, electric arc welding generates ultraviolet radiations which may cause permanent damage to eyes. Welding shield to be used in case of arch welding should be opaque to ultraviolet radiations. Other safety devices goggle, gloves, apron are also used in arc welding as discussed in gas welding.

**Chipping Hammer**

Like gas welding chipping hammer is also used in case of arc welding to clean the joint.

**Filler Metal**

In case of use of non-consumable electrode separate filler metal is used to improve properties of weldment. Selection of a filler metal depends on the metal to be welded. Some common types of filler metal are discussed below.

**Coated Filler Metal**

Rods of this type of filler metal consists the coating of flux material.

**Bare Filler Metal**

No coating of flux is there, it is supplied additionally as per the requirement. For stainless steel and alloy steel filler metal should be alloy of chromium and vanadium. For the welding of copper filler metal should be phosphorous mixed copper. Filler metal composition should be same as that of the material to be welded. Sometimes additional alloying elements are added to them to improve mechanical properties of weldment.

**Flux Material**

Like gas welding flux is also used in arc welding to prevent oxidation of hot element. As oxidation of hot metal imparts poor mechanical properties of joint. Some flux material as discussed in gas welding are used in arc welding. Flux can be supplied through coating of electrode or coating on filler metal or separately. Some times spray of inert gas is used to prevent oxidation and no flux is required in such cases.

**Resistance Welding**

Resistant welding is also one of the fusion welding technique that utilize heat and pressure to make the welded joint. Required heat is generated at the junction due to flowing current through it and resistance offered. The amount of heat generated is $H = i^2 Rt$ where $H$ is the heat generated w-sec, $i$ is the current flowing $R$ resistance of junction, $t$ is the time for which current flows. Principle of resistance welding can be explained with the help of diagram shown in Figure 5.5. It consists of workpiece to be welded, two opposing electrodes a mechanism to apply pressure to squeeze the workpieces, AC power supply to maintain the current, a circuit breaker with times to stop the flowing current after a preset time.

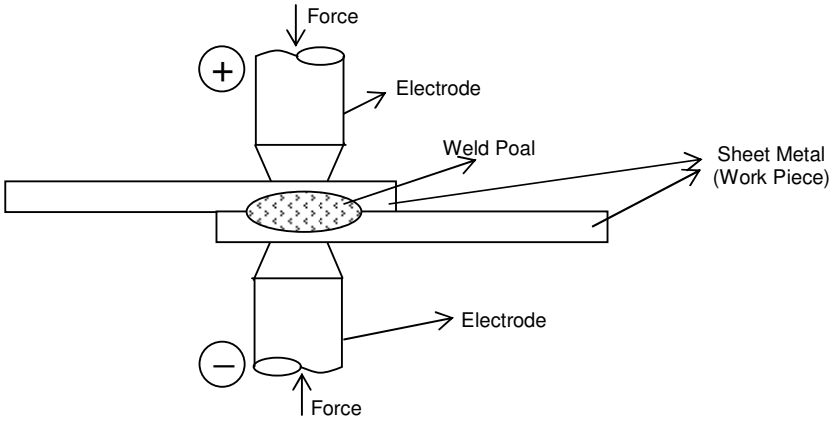


**Figure 5.5 : Resistance Welding**

Depending upon the joint to be make resistance welding can be divided into different categories :

(a) Spot welding,

(b) Seam welding,

(c) Projection welding, and

(d) Precision welding.

These welding techniques are explained below :

**Spot Welding**

It is widely used in mass production of automobiles, appliances, metal furniture and other products made of sheet metal. There are approximately 10,000 individual spot welds in a single car body. In this welding fusion of the faying surfaces of a lap joint is achieved at one location by opposing electrodes. Thickness of workpiece should be up to 3 mm. The joint made so is not air tight or waterproof. Size and shape of spot weld depends upon the size and shape of electrode tips. Shape can be circular, hexagonal, square or any other. Strength of a spot weld is equal to the strength of metal of workpiece.

**Resistance Seam Welding**

In this case rotating wheels are used as welding electrodes. It is like making a continuous series of spot welds along the lap joint. This process produces air tight and leak proof joint. The lap joint to be made is allowed to pass through between rotating electrodes. These electrodes press the workpiece and fuse it to make a continuous lap joint. This welding is used in production of gasoline tanks, automobile, welding procedure is shown in Figure 5.6.

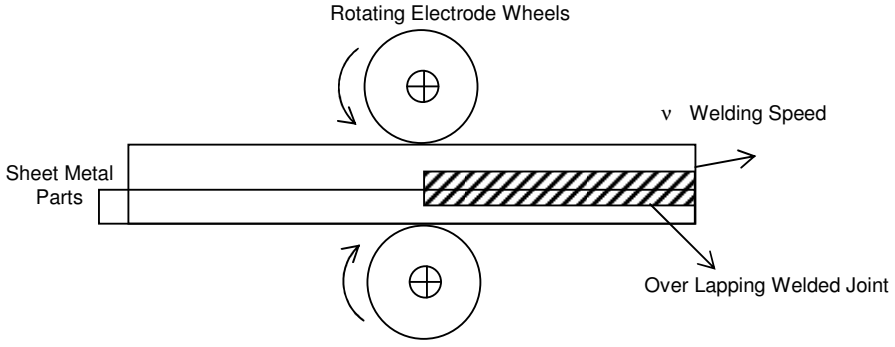


**Figure 5.6 : Resistance Seam Welding**

**Resistance Projection Welding**

In this welding coalescence occurs at one or more relatively small contact points on the parts. The contact points are identified by the design of the parts to be welded. These parts may consist of projections, embossment, or localized

interactions of the parts. This method is precise, quick and cheaper. Electrodes are designed specifically for a particular type of workpiece. So it is advisable to use this method in case of mass production only. The basic working of projection welding is shown in Figure 5.7.

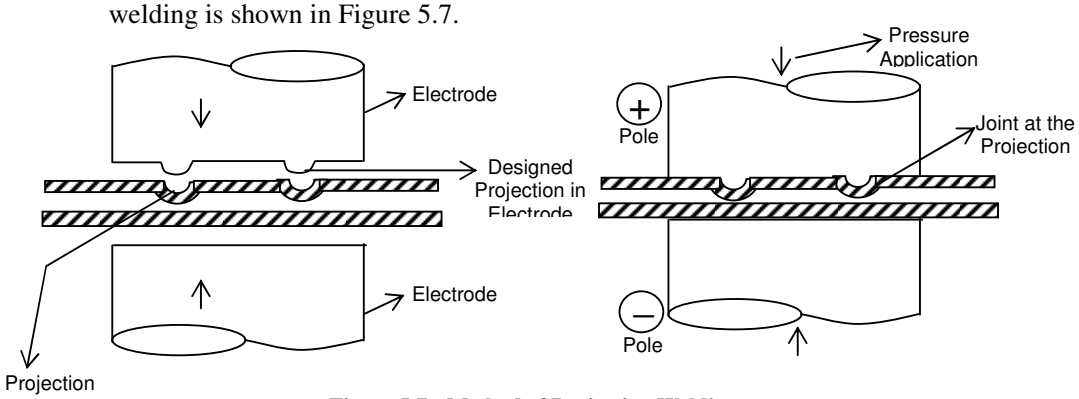


**Figure 5.7 : Method of Projection Welding**

### Resistance Percussion Welding

Percussion welding is just like a flash welding. In case of flash welding butt joints are formed. Two surfaces to be joined are brought into contact, electric current is passed through to heat them till melting point. Then surfaces are pressed together to form the welded joint. In this case heating occurs due to resistance of the joint and arc occurs between them up to some extent. This is the basic principle of flash welding. Percussion welding is similar to flash welding but duration of welding cycle is very short. It is of the order of upto 10 m. sec. Fast heating is accomplished by rapid discharge between the two surfaces to be joined followed immediately by percussion of one part against the other to form the weld. The heating is very localized. It is used in case of electronic circuit making where ultra accuracy in heat application is required.

### Advanced Welding Techniques

There are some more advanced welding techniques which are efficient and gives better quality. Some of these techniques are being discussed below.

### Submerged Arc Welding

This is first arc welding technique to be automated. Submerged arc welding uses continuous consumable electrode of the shape of a bare wire. The established arc is shielded by a cover of granular flux. The electrode wire is fed continuously and automatically from a roll into the welding zone. The flux is introduced in to the joint slightly ahead of the weld arch by gravity from a hopper as shown in Figure 5.8. blanket of granular flux completely submerges the welding zone preventing sparks, spatter and radiations. The portion of the flux near to the arc is melted, forming slag, after mixing with molten metal. Slag can be removed from the weldment. Cover of granular flux not only provides protection from the environment but also provides good thermal insulation resulting in slow cooling imparting toughness and ductility to the joint.

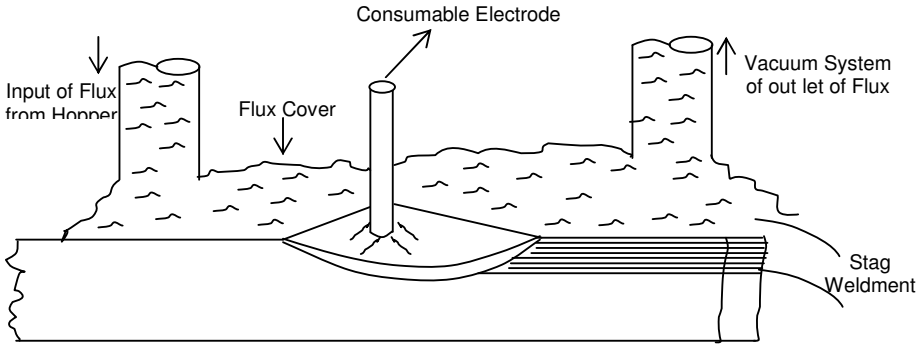


**Figure 5.8 : Setup of Submerged Arc Welding**

### Applications of Submerged Arc Welding

It is widely used in steel fabrication, structural shapes, longitudinal and circumferential seams of large diameter pipes, welding pressure vessels, welding of heavy machinery, etc.

Steel plates of 25 mm thickness or more are routinely welded by this process. Submerged arc welding is not used to weld high carbon steel, tool steel and non-ferrous metal. There is one more limitation that due to gravity feed of flux, the parts must always be in a horizontal orientation and a backup plate is required beneath the joint during the welding operation.

### Machine of Saw

Submerged arc welding is carried out with the help of submerged arc welding machine. It consists of fixture, work table, transformer. Electrode holder, flux tube or hopper, wire coil are mounted over the machine. Both AC and DC can be used in this process. In case of AC voltage varied from 65 to 100 volts and current may go upto 80 amperes. A remote control is always incorporated in the power supply source with a switch near the welding lead. It is used to regulate the power supply. Power can be switched off and switches on with the help of remote control unit.

## 5.6 INERT GAS SHIELDED WELDING (TIG AND MIG)

In any type of welding we require flux to avoid oxidation of weldment to maintain proper strength of the joint. In this regard, to keep the atmospheric air away from the welding pool, inert gases like argon, helium, carbon dioxide, are used for surrounding the arc to keep atmosphere away. It not only results in production of sound weld but also enables welding of such metals which are otherwise difficult to weld. Important techniques of this type of welding are Tungsten Inert gas and Metal inert gas welding.

### TIG Welding

This is similar to arc welding. Additionally it requires a cylinder of inert gas, valve, pressure regulator and hose pipe with sprayer to spray inert gas in the welding pool. A non-consumable tungsten electrode is used to establish arc. Sometimes inert gas sprayer is also mounted in the electrode holder. As per the requirement additional filler metal can be provided from the outside to make up the joint. This is suitable for welding of most of the metal and alloys except lead and zinc due to their very low melting point. It is also observed as WIG welding.

### MIG Welding

This is similar to TIG welding. At the place of non-consumable tungsten electrode, a consumable metal electrode is used in the form of continuously fed metal wire. The electrode wire and inert gas are fed through welding gun. Only DC is recommended for this type of welding giving positive polarity to electrode wire. Feeding speed of electrode wire is adjusted according to the welding speed. This is used for the welding of carbon steel, low alloys steel, stainless steel and alloys of the metal exhibiting resistance to heat.

### Laser Beam Welding

Laser beam welding (LBM) is a fusion welding process in which coalescence is achieved by the energy of a highly concentrated coherent light beam focused on the joint to be welded. LASER stands for *Light Amplification by Stimulated Emission of Radiation*. In this case spray of inert gas is used for shielding the weld pool. LBW is used for deeply penetrated narrow joint. The weldment formation is very accurate, highly focused and very precise so it is recommends to join the small parts.

**Thermit Welding (TW)**

Thermit is a trade name for thermite. A mixture of Aluminium powder and iron oxide that produces an exothermic reaction when ignited. In case of thermit welding heat is produced by superheated molten metal form the chemical reaction of thermit. Filler metal is obtained from liquid (molten) metal. Heat is generated when finely mixed powders of aluminium and iron oxide in the ratio of 1 : 3 is ignited to a temperature of around 1300°C. Following reaction takes place :

$$8AL + 3F3_3O_4 \rightarrow \underset{\text{Molten Filler Metal}}{9Fe} + 4Al_2O_3(\text{slag}) + \text{heat}$$

Thermit welding has applications in joining of rail road rails, repair of cracks in castings and forgings in ship building industries.

**Atomic Hydrogen Welding**

In this case, workpieces are kept out of circuit. At a place of single electrode, two non-consumable tungsten electrodes are used forming terminals of a AC circuit. These electrodes establish an arc between them. Hydrogen gas drawn from a cylinder is blown into the arc. Thus, arc flame is produced carrying a very high intensity of heat. When hydrogen is forced through the arc, its molecules break up into atoms to form that is known as atomic hydrogen when this atomic hydrogen goes out of the arc to the joint the atoms combine again to form molecules and release huge energy. This energy (heat) is utilized in making the joint.

## 5.7 WELDING DEFECTS

In case of welding, we apply heat to the workpieces to join them together then these are allowed to coal down till room temperature. This process may incorporate some defects to the weldment. These defects are described below.

**Residual Stresses and Warpage**

Rapid heating and then uncontrolled cooling result in uneven expansion and contraction in the workpiece and weldment. This causes development of residual stresses in the weldment. Distortion and warpage may also be there. Sometimes wrong selection of filler metal and welding technique may also be the cause of residual stress and warpage.

**Cracks**

This is a serious welding defect appears as fracture type interruptions in the weld. Crack works as a point of stress concentration so reduce the strength of the joint.

**Cavities or Porosity**

Porosity consists of small voids in weld metal formed by gases entrapped during solidification. Shape of the voids may be spherical holes or elongated holes. There can be another type of voids named as shrinkage voids formed due to shrinkage of metal during solidification.

**Solid Inclusions**

This is the entrapped non-metallic solid material. It may be the inclusion of slag generated in a welding process.

**Incomplete Fusion**

It is also called lack of fusion. Some examples of this defect are shown in Figure 5.9. It is a weld bead in which fusion has not occurred throughout the entire cross-section of the joint. In other words it is a lack of penetration. That is molten metal has not penetrated upto root of the joint.

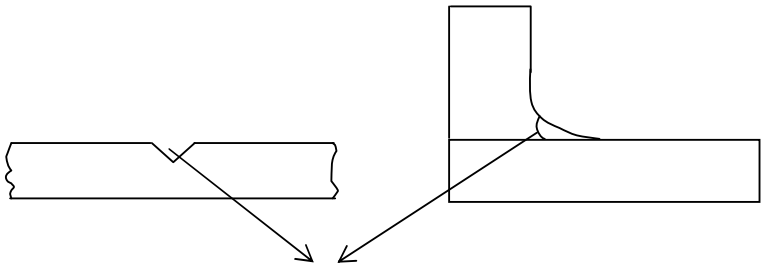


**Figure 5.9 : Incomplete Fusion**

### Imperfaction in Shape

For a particular type of edge preparation the weldment should acquire a predefined shape for maximum strength. If actual shape of weldment different from the predefined one it is called imperfect shape. It contributes to poor strength to the welded joint.

### Other Common Defects

There are some minor defects like *arc strikes*. In this cause, electrode touches the workpiece near the joint. Mark developed so is called arc strike. Dropping of excess molten metal on the work surface which splashes on to the surface of the part is called *excessive spatter*.

## 5.8 SUMMARY

Process of welding is described as a way of joining similar or desimilar metals with the application of heat and slight pressure. Categorization of welding is done on the basis of the heat generation mechanism. The operations used to do different type of welding are also discussed in this unit. Their tools and equipment are described. The major problem identified in welding is the oxidation of weldment. This problem can be solved in so many ways, these ways are different in different methods of welding. Some of the metals which are very much sensitive to oxidation TIG and MIG welding operations are recommended. Different type of welding defects and care to be taken to avoid them are also included in this unit.