Unit -2 Electric Welding

Introduction of Electric Welding

The process of joining materials together through the use of heat that is produced by an electric current is known as **electric welding**.

Electric welding is often done by melting the workpieces by the heat produced by electric current and adding a filler material to form a pool of molten material that cools to become a strong joint.

In other words, the branch of welding in which electric current is used to produce the large heat required for joining of pieces of metals together is called the **electric welding**.

The electric welding is gaining acknowledgement, because of its machinery is inexpensive and easy manipulation becoming known.

➢ Types of Electric Welding

The electric welding process is classified into two categories, viz −

- Arc Welding
- Resistance Welding

Arc Welding

Arc welding is the type of electric welding process in which two metals are joined through the heat that is produced by an electric arc.

Electric arc welding can be further classified into following types −

- DC Metallic Arc Welding
- AC Metallic Arc Welding
- Carbon Arc Welding
- Atomic Hydrogen Arc Welding
- Shielded Arc Welding

Resistance Welding

Resistance welding is the process of joining two metal work pieces together by passing an electric current for a length of time through the metals to be joined and a mechanical pressure is also applied for joining the metal workpieces.

The resistance welding is also classified into following types −

1. Butt Welding
2. Flash Welding

3. Spot Welding
4. Seam Welding
5. Projection Welding

Advantages of Electric Welding

Some of the advantages of the electric welding processes are given as follows −

- Electric welding is suitable for high speed welds.
- Electric welding apparatus are simple and portable.
- Electric welding can produce superior temperature as compared other types of welding processes.
- Automatic welding is possible with the electric welding.
- Welds obtained are very clean.
- Electric welding creates strong welds.

➢ Electric Arc Welding

The process of welding in which heat is produced by creating an electric arc to join metal workpieces is known as **electric arc welding**.

Electric arc welding is a type of welding that uses a welding power supply to create an electric arc between a metal stick, called electrode, and the workpiece to melt the metals at the point of contact.

Electric arc welding can use either DC supply or AC supply and a consumable or non-consumable electrode.

Working Principle of Electric Arc Welding

The process of electric arc welding is based on the principle that, when electric current is passed through an air gap from one electric conductor to another, then an electric arc is produced whichgenerates a very intense and concentrated heat.

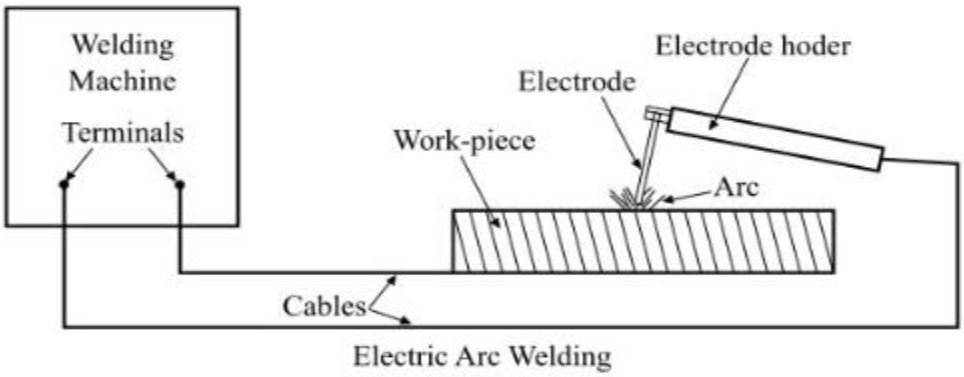

Figure 2.1- Detailed diagram of Electric Arc welding

The temperature of the arc between two conductors is approximately 3500 °C to 4000 °C. This high temperature generates intense heat in the arc at the point of welding, which melts a small portion of metal in the work-piece.

The electric arc keeps this molten metal pool agitated and the base metal is thoroughly mixed with melted electrode metal, after that the metal pool cools down under a protective cover of slag left by the electrode. On cooling, a strong weld join is formed between the two metal pieces.

In electric arc welding, either AC or DC current is obtained from a welding power supply. Here, one terminal is connected to the electrode mounted on an electrode holder, which is held by the welder, while the other terminal is connected to the workpiece and the circuit is completed through an air gap between the electrode and the work-piece.

The length of the air gap (i.e., distance between electrode tip and the surface of the work-piece) is about 3 mm to 6 mm. The welding is done by creating an electric arc between the electrode and the workpiece. The temperature of the arc is very high (about 3500 °C to 4000 °C) and the metal in contact with the arc becomes molten which enables a weld to be melt. The electrode is then moved slowly in the desired direction to complete the weld.

Types of Electric Arc Welding

The electric arc welding is mainly classified into following types −

1. DC Metallic Arc Welding
2. AC Metallic Arc Welding
3. Carbon Arc Welding
4. Atomic Hydrogen Arc Welding
5. Shielded Arc Welding

Advantages of Arc Welding

Some of the chief advantages of the electric arc welding are given as follows −

- The electric arc welding is the suitable welding process for high speed welds.
- Apparatus required for arc welding is very simple and portable.
- The electric arc welding gives superior temperature at the point of welding.
- Electric arc welding can work on both AC and DC supply.
- It is inexpensive to install.

Disadvantages of Electric Arc Welding

The disadvantages of electric arc welding are as follows −

- The welding process with electric arc welding requires skilled operators.

- Electric arc welding cannot be used for welding of reactive metals such as aluminium, titanium, etc.
- Electric arc welding is not suitable for welding thin metals.

Applications of Electric Arc Welding

The important applications of electric arc welding are as follows −

- Electric arc welding is used in repairing of broken parts of machines.
- It is used for welding of cast iron or steel housings and frames.
- Electric arc welding is used in various industries such as automotive industries, construction industries, mechanical industries, etc.
- Electric welding is also used for welding process in shipbuilding.

➢ 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** or simply **metal arc welding.**

The figure shows the simplified circuit diagram of metallic arc welding.

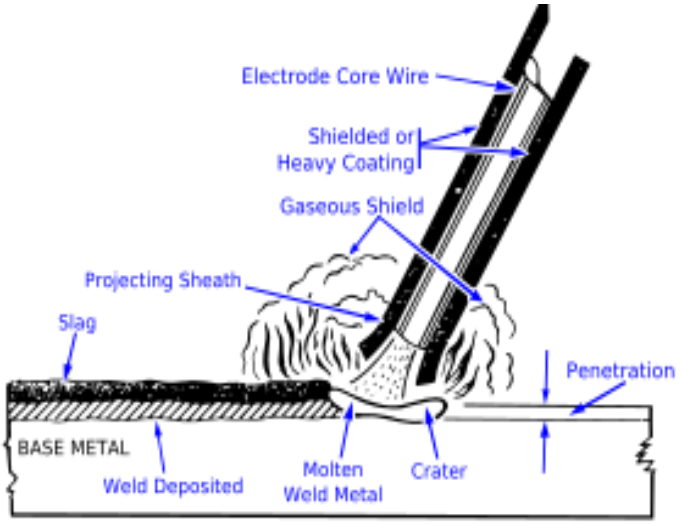

Figure 2.2 Detailed diagram of mattalic aec welding

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.

The electric arc in this method of welding may be created by direct current *or* alternating current. In the places, where normal electricity supply is not present, diesel driven generators are used for welding. The DC supply can be obtained from the electricity mains with the help of transformer and rectifier unit.

Although a transformer is widely used for AC arc welding as it is inexpensive and simple having no maintenance cost due to absence of moving parts. With AC system, the coated electrodes are used while with the DC system, bare electrodes can be used.

In metallic arc welding, to strike the electric arc, an open circuit voltage of between 60 to 80 volts is required and for maintaining the short arc 15 to 25 volts is necessary. Depending upon the class of the work to be welded, the electric current required for metallic arc welding varies from 10 to 500 Amperes.

With the DC system, the main disadvantage of the metallic arc welding is the presence of arc blow, i.e. distortion of the arc stream from the intended path due to magnetic forces of a non-uniform magnetic field. However, with the AC system, the problem of arc blow is considerably reduced.

Electrodes for Metallic Arc Welding

The electrodes which are used for metal arc welding are of three types viz −

- Bare Electrodes
- Dipped or Light Covered Electrodes
- Heavy Coated Electrodes

Bare Electrodes

- Bare electrodes have no coating of flux on them. The bare electrodes are not used in these days because; it was found that the weld made by the bare electrodes was considerably poor in ductility, resistance to impact and fatigue. The appearance of the weld made by the bare electrode was also not good. This poor performance of the bare electrodes is due to vaporization of important elements of the weld metal during welding process and also due to the presence of oxides and nitrides resulting from the atmospheric contamination of weld metal.
- Bare electrodes are mainly used at a lower welding voltage. For the bare electrodes, the welding current ranges from 150 to 300 A, depending upon the size of the electrode used. However, with the bare electrodes, more difficulty is experienced in the stating of the arc.

Dipped or Light Covered Electrodes

- Dipped or light covered electrodes are considered an improved version of the bare electrodes. In case of dipped electrodes, the electrode is lightly covered with the flux material. The dipped electrodes provide better protection against the oxidation of the weld. These electrodes require a higher welding voltage and lower welding current as compared to the bare electrode.

Heavy Coated Electrodes

- In heavy coated electrodes, the electrode is heavily covered with a flux material. The flux is a material of substantial thickness and solidity that is calculated to provide protection to the electrode. In case of heavy coated electrodes, the flux coated on the core wire is composed of special element which protects both the arc and the weld metal. The appearance and the physical properties of the weld are also improved considerably.

Applications of Metallic Arc Welding

The field of application of metallic arc welding includes –

1. Welding of carbon steel.
2. Welding of high-alloy austenitic stainless steel.
3. With many precautions, this welding process can also be used for low and medium steels.

➢ Atomic Hydrogen Arc Welding

The **atomic hydrogen arc welding** is an arc welding process which uses an arc between two tungsten electrodes in a shielding atmosphere of hydrogen. The atomic hydrogen arc welding was invented by **Irving Langmuir.**

The essentials of the atomic hydrogen arc welding are as follows –

1. The electrical energy is supplied to create an arc between two tungsten electrodes where it is transformed into heat.
2. The source of electrical energy could be either DC or AC, but in practice, AC supply should be chosen as it is commonly available.

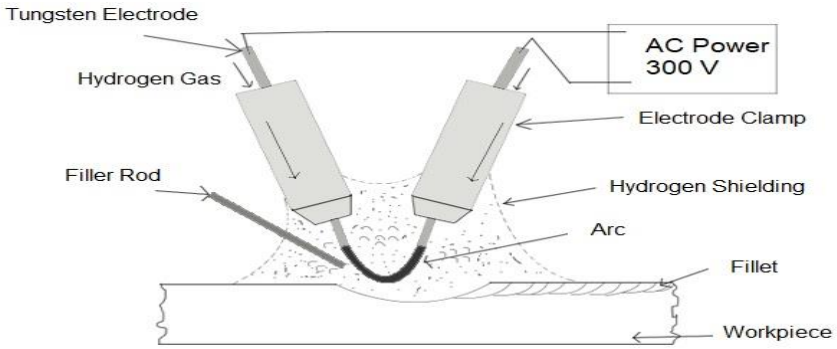

Figure 2.3 -Detailed diagram of Atomic arc welding

3. Molecular hydrogen is blown through the arc and transformed catalytically into the atomic form which acts as a carrier for transfer of energy from the arc to the work-piece.
4. In the direction away from the arc, a sudden decrease of temperature causes the rapid decrease in the concentration of atomic hydrogen and a release of the heat of recombination.

Working of Atomic Hydrogen Arc Welding

In the atomic hydrogen arc welding, to strike and maintain the arc, an open circuit voltage of 300 Volts is necessary and a current range up to 50A is required. This power is obtained from a transformer which is having a number of primary tappings to allow for various supply voltages and a tapped reactor to allow the adjustment of the current.

1. In the atomic hydrogen arc welding process, the arc is created between two tungsten electrodes and molecular hydrogen passes through this arc.
2. The molecular hydrogen changes to its atomic form due to the high temperature (about 4000 °C) of the arc.
3. When the atomic hydrogen travels to the cooler regions in the vicinity of the arc, it regains its molecular form.
4. In this process, the hydrogen gives up the energy which it had received from the arc.
5. Consequently, a very intense heat is produced which is used to melt the work-piece to be welded.
6. After cooling, the two parts of the work-piece are welded together. Also, a filler rod may be used if extra metal is required for making the joint.

The atomic hydrogen arc welding is mainly used for welding stainless steel and most non-ferrous metals, etc.

Advantages of Atomic Hydrogen Arc Welding

The advantages of the atomic hydrogen arc welding are given as follows –

1. With the atomic hydrogen arc welding quite thick sections can be welded.
2. The atomic hydrogen arc welding gives strong, ductile and sound welds.
3. Atomic hydrogen arc welding can be used for materials which are too thin for gas welding.
4. In the atomic hydrogen arc welding, the arc and the weld zone are surrounded by burning hydrogen which protects them from atmospheric contamination.
5. The tungsten electrodes remain cool because of the flow of hydrogen gas. It increases the life of the electrodes.

Disadvantages of Atomic Hydrogen Arc Welding

The disadvantage of the atomic hydrogen arc welding is as follows –

1. The atomic hydrogen arc welding process is expensive than the other types of welding processes.
2. Atomic hydrogen arc welding requires skilled operator.
3. Atomic hydrogen arc welding can be used in flat position only.
4. As the hydrogen is highly inflammable, hence this welding process is riskier.

Applications of Atomic Hydrogen Arc Welding

The atomic hydrogen arc welding is used in following applications –

1. Atomic hydrogen arc welding is used in the applications where fast welding process is required such as for welding the stainless steel, etc.
2. This welding process can be used for welding most of the ferrous and non-ferrous metals.
3. It is used for very precision welding.
4. It is also used for welding thin sheets of metal

➢ Resistance Welding

Resistance welding is the process of joining two metal work pieces together by passing an electric current for a length of time through the metals to be joined and a mechanical pressure is also applied for joining the metal workpieces.

➢ Types of Resistance welding

Butt Welding-- Butt welding is one of the simplest and versatile resistance welding process. In the butt welding process, heat is produced by the contact resistance between two metal workpieces. The faces of the workpieces should be machined or edge prepared.

The circuit diagram for butt welding process is shown in the figure.

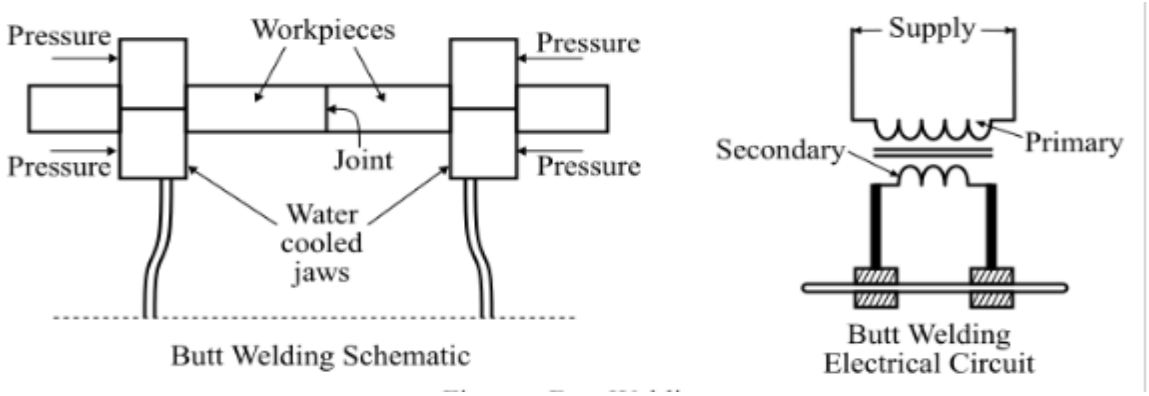

Figure 2.4 -- BUTT Welding

1. In butt welding, the two workpieces are brought together and mechanical pressure is applied along the axial direction by a spring.
2. A welding transformer is used that is having larger number of turns in the primary winding and smaller number of turns in secondary winding.
3. A heavy current is passed from the welding transformer, which creates the required heat at the joint due to comparatively high resistance of the contact area.
4. This heat melts the metal at the joint and the two workpieces fuse together producing a weld joint.

Advantages of Butt Welding

The primary advantages of the butt welding process are given as follows −

1. Butt welding process is easy to machine.
2. It provides distortion control
3. It produces welds of high strength with complete fusion.

Disadvantages of Butt Welding

There are some disadvantages of butt welding such as −

1. For butt welding, the welding geometry can limit its applications.
2. Welds made by butt welding are sensitive to faying surface conditions.
3. Butt welding process may require fixturing or backing.

Applications of Butt Welding

The main applications of butt welding are as follows −

- Butt welding is used, where the metal pieces are joined end to end or edge to edge.
- Butt welding is used for welding such articles whose cross-sectional area is as much as 6.25 cm^2 such as steel rails.
- Butt welding is also used for welding pipes, wires and rods, etc.

Flash Welding

Flash welding, also called flash butt welding, is a resistance welding process, in which the ends of the workpieces are pressed together and a heavy electric current is passed through the joint during the welding process.

In flash welding, the electrical current is applied to the workpieces before they are brought together so that when they meet arcing (or flashing) takes place.

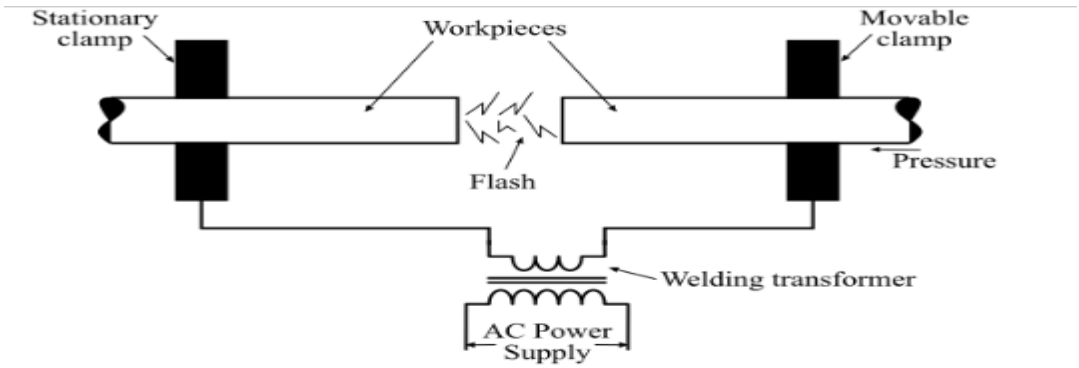

Figure 2.5- Diagram of flash welding

1. In flash welding process, the two workpieces to be welded are clamped strongly in a flash welding machine.
2. The two workpieces are brought together, and the flash created and the resistance to the current flow heats the contacting surfaces.
3. As soon as the workpieces have been brought to their melting temperature, the supply of current is cut off and the workpieces are rapidly brought together under high mechanical pressure which forces the fused metal and slag out of the joint and making a good solid weld.
4. When the ends of the workpieces collide, the squeezed molten metal flashes out in the outward direction and this outward direction of the metal causes a flashing effect. Due to this flashing effect, this welding process is called as flash welding.

Advantages of Flash Welding

Following are the main advantages of the flash butt welding process –

1. In flash welding, the power consumed is less as the arc is also produces some heat required for welding process.
2. Flash welding is very cheap.
3. Flash welding can be used for welding metals having different melting temperatures.
4. Flash welding produces neat, clean and strong welds.

Disadvantages of Flash Welding

Following are some of the disadvantages of flash welding –

1. The welding machine used for flash welding is bulky.
2. Chance of fire hazards is high.
3. In flash welding, metal is lost during flashing.

Applications of Flash Welding

Some applications of the flash welding are given as follows –

1. Flash welding is used extensively in production work, particularly in welding rods and pipes together.
2. Flash welding is widely used in automobile construction on the body, axis, wheels, frames and other parts.
3. Flash welding is also used in welding motor frames, transformer tanks and many other types of steel containers.

Projection Welding-- Projection welding is the resistance welding process which joins the metal pieces together by using the heat generated by an electric current. In this welding process, different

projections are formed on the workpieces for effective welding, which is why the name "projection welding."

Projection welding does not use electrodes for concentration of heat; instead the projection on the workpiece is used for this purpose. Actually, projection welding is a modified version of spot welding. It consists of forming slight projections on one of metal.

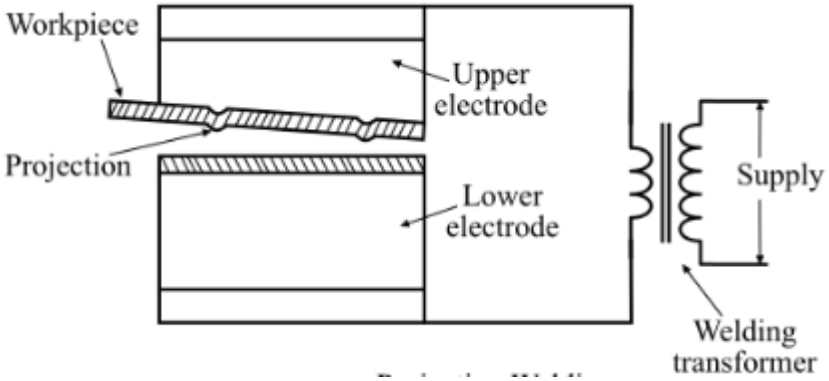

Figure 2.6- Projection welding

1. The set up used for projection welding consists of two copper electrodes.
2. The metal pieces to be welded are kept between these two electrodes as shown in the above figure.
3. After that, the projections are accurately formed in precise locations on the metal workpieces by using a special set of dies.
4. Once the projections are formed, the raised portions on one workpiece are pressed into contact with another workpiece.
5. At the same time, a high electric current is passed through the workpieces.
6. When the raised portions touch the second workpiece of metal, the electric current flows through the contact points, which heats and fuses the two metal workpieces together.

Advantages of Projection Welding

Projection welding has the following advantages –

1. There is no limitation on the metal thickness, i.e., metal of any thickness can be welded with the projection welding.
2. With projection welding, more than one welds are done at a time. Hence, more output is obtained.
3. In the projection welding, less current is passed through the electrodes and low pressure is applied. Thus, the electrode life is increased.
4. Projection welding gives good heat balance while welding process.
5. The weld with good furnished appearance is obtained in the projection welding.

Disadvantages of Projection Welding

The disadvantages of projection welding are as –

1. The process of projection formation is complicated and time consuming.
2. It requires highly skilled welders.
3. Projection welding cannot be applied to all types of workpieces.
4. Equipment used for projection welding are expensive.

Applications of Projection Welding

Some applications of projection welding are as follows –

1. Projection welding is used for welding studs, nuts to plates, etc.
2. Projection welding is also used in automobile industries, ship building works and sheet metal works, etc.
3. It is also used for welding the parts of refrigerator, grills, condensers, etc.

Seam Welding--- The welding process in which two similar or dissimilar materials are joined at the seam by the application of heat generated from electrical resistance is known as **seam welding**. The seam welding is a types of resistance welding, in which weld is produced by roller electrodes instead of tipped electrodes.

Most seam welding processes produce a continuous or intermittent seam weld near the edge of two overlapped metals by using two machine driven roller electrodes. As in the seam welding process, the roller electrodes move over the metal workpieces, the workpieces are under pressure and the current passing through them heats the two workpieces of the metal to the melting point. Thus, this process, sometimes, also called the seam **spot welding**.

Resistance seam welding is one of the most common welding processes used to join metal sheets with a continuous weld. In seam welding process, when two similar or dissimilar materials are pressed together, there will be a small gap between them because of irregularities in the metal surface. This gap causes an electrical resistance between the two materials and results them to heat up at the seam.

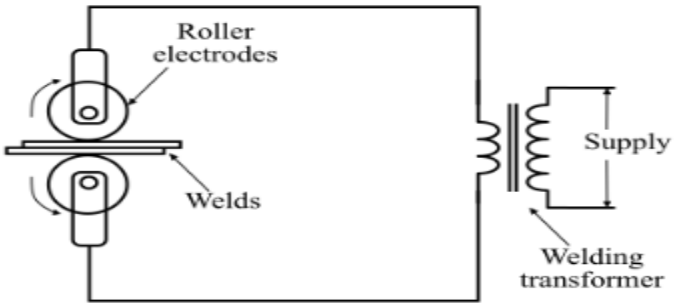

Figure 2.7 Seam welding diagram

In seam welding process, the welding current is the main parameter, i.e., the amount of heat generated at the seams depends upon the magnitude of welding current flowing through it.

Types of Seam Welding

The resistance seam welding is broadly classified into two types, viz. –

1. **Intermittent Seam Welding** – In case of intermittent welding, the weld occurs at specific spots rather than as a continuous line. This type of seam welding is useful for welding thick metals where a continuous weld is not possible.
2. **Continuous Seam Welding** – In continuous seam welding, uninterrupted current flows through the electrodes and the metals to be joined are passed through the electrodes at a constant speed. As the workpieces remain under constant pressure, thus, it produces a uniform overlapping weld.

Advantages of Seam Welding

The chief advantages of resistance seam welding are listed below –

1. The welds produced by the seam welding are air-tight and water-tight.
2. Seam welding is a fast welding process and it can be automated using robotic machines.
3. It does not require any flux and filler materials.

Disadvantages of Seam Welding

Some disadvantages of resistance seam welding process given as –

1. As it has of roller electrodes, thus, only straight line or uniformly curved line welds can be made with the resistance seam welding.
2. It is not suitable for metal sheets of thickness more than 3 mm per sheet.

Applications of Seam Welding

The resistance seam welding is used in various applications, some of them are –

1. It is used for making lap joints.
2. It is used in manufacturing process of various types of pressure tight or leak proof tanks such as fuel tanks, oil switches, transformer tanks, aircraft tanks, etc.
3. Used for welding parts of vessels that need to be air tight and water tight.
4. For welding of pipes and tubes.

Seam Welding--The welding process which is used for welding two or more metal sheets together by applying pressure and heat from an electric current to the weld area is known as **spot welding**.

Spot welding is a type of resistance welding process, which is why it is also known as the *resistance spot welding*.

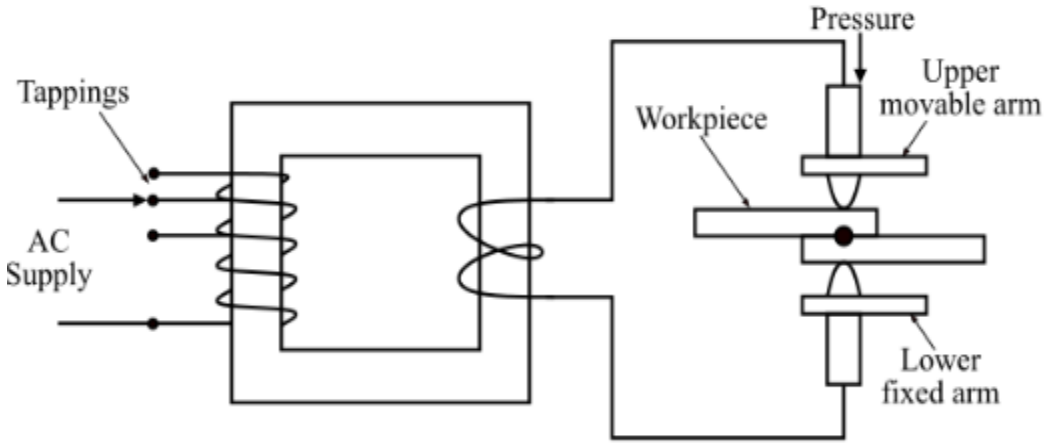

Figure2.8 Spot welding diagram

Spot welding is the simplest and most universally adopted method of making lap joints in thin sheet up to a maximum thickness of 12.7 mm.

A typical spot welding machine consists of a transformer to produce high current at low voltage and the electrodes are connected to the ends of the secondary winding for leading the current to the work.

There is also an arrangement to bring the electrodes in contact with the work and to apply the necessary mechanical pressure.

Spot Welding Process

In the spot welding process, the materials to be welded are overlapped and pressed between two water-cooled electrodes and a high electric current is passed through the assembly. The metals in the zone of pressure gets heated up to their melting temperature and the joint so made gets cooled under pressure.

For spot welding process, the required welding current is about 5000 A and the voltage between the electrodes is usually less than 3 V. Also, the open circuit voltage is less than 12 V. To regulate the secondary voltage and current, tapings are provided on the primary winding of the transformer.

The main factors affecting the quality of the spot weld are –

1. Value of welding current
2. Time for which the current flows
3. Pressure between the electrode tips

Advantages of Spot Welding

The main advantages of spot welding are as follows –

1. Spot welding has high compatibility with efficiency and uniformity.
2. Spot welding is economical, i.e., it is relatively cheap to operate.
3. Spot welding provides a much more efficient way of utilizing electrical energy for welding process.
4. Spot welding is a fast welding process.

Disadvantages of Spot Welding

The disadvantages of spot welding are as follows –

1. Spot welding requires a large working area.
2. The welding gun used in the spot welding is heavy and require great strength when using it. Therefore, spot welding may be very dangerous to the aged welders.
3. Spot welding is not suitable for the thicker materials.

Applications of Spot Welding

Some of the applications of spot welding are given as follows –

1. Spot welding is used in various industries such as automotive, aerospace, metal furniture, electronics, building construction, etc.
2. Spot welding is used in high volume production applications.
3. It is applied for welding of thin sheets.
4. Spot welding is also used for fabricating all types of sheet metal structures where high mechanical strength is required.
5. Spot welding can also be applied to all types of boxes, cores and enclosing cases, etc.