UTILIZATION ELECTRIC ENERGY

Electric Welding

Chapter 3

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1. INTRODUCTION

Welding is the process of joining two pieces of metal or non-metal together by heating them to their melting point. Filler metal may or may not be used to join two pieces.

The physical and mechanical properties of a material to be welded such as melting temperature, density, thermal conductivity, and tensile strength take an important role in welding. Depending upon how the heat applied is created; we get different types of welding such as thermal welding, gas welding,
and electric welding.

Here in this chapter, we will discuss only about the electric welding and some introduction to other modern welding techniques. Welding is nowadays extensively used in automobile industry, pipe-line fabrication in thermal power plants, machine repair work, machine frames, etc.

2. ADVANTAGES AND DISADVANTAGES OF WELDING

Some of the advantages of welding are:

- Welding is the most economical method to permanently join two metal parts.
- It provides design flexibility.
- Welding equipment is not so costly.
- It joins all the commercial metals.
- Both similar and dissimilar metals can be joined by welding.
- Portable welding equipment are available.

Some of the disadvantages of welding are:

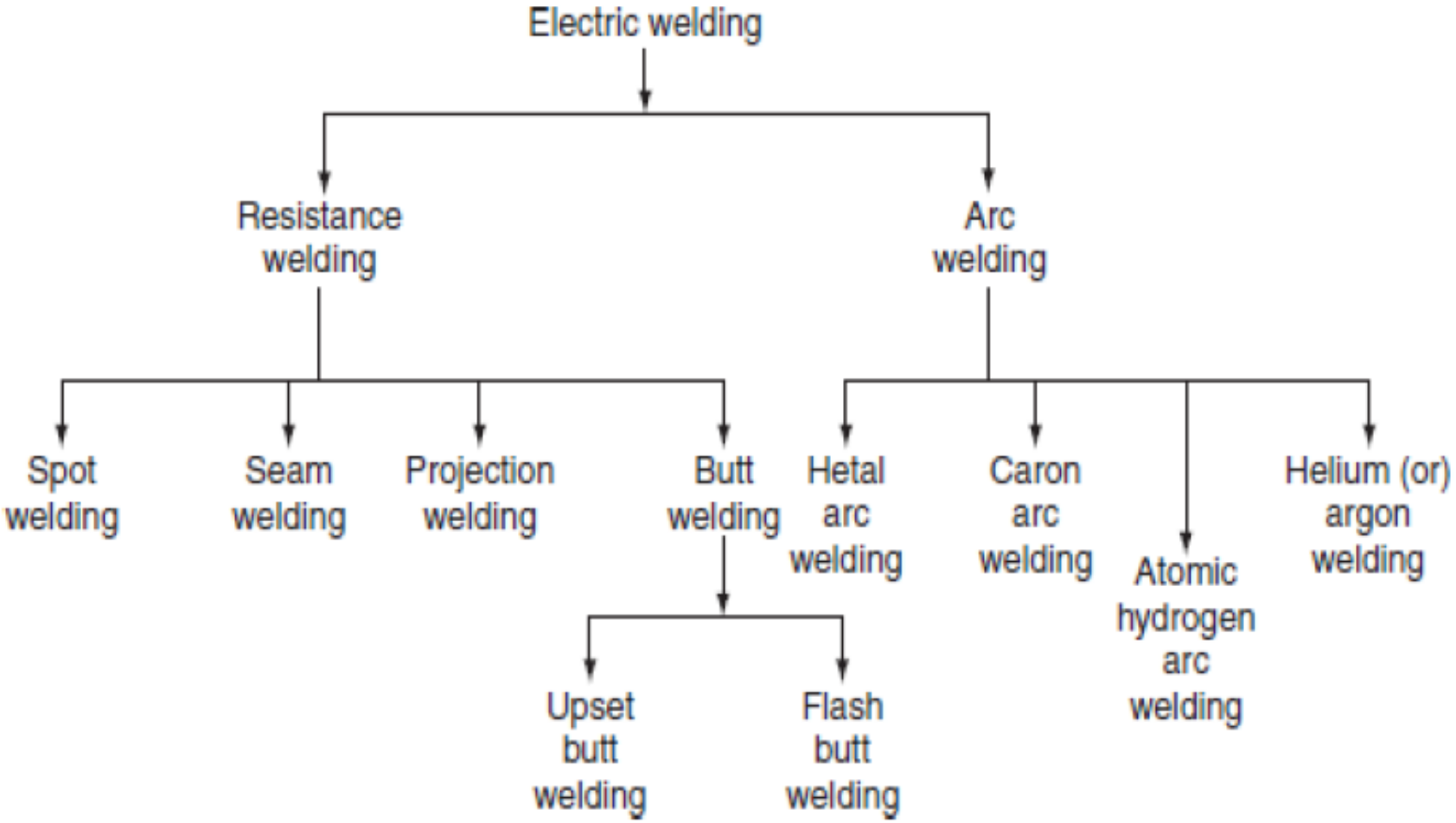
- Welding gives out harmful radiations and fumes.
- Welding needs internal inspection.
- If welding is not done carefully, it may result in the distortion of work-piece.
- Skilled welding is necessary to produce good welding.

ELECTRIC WELDING

It is defined as the process of joining two metal pieces, in which the electrical energy is used to generate heat at the point of welding in order to melt the joint.

3. ELECTRIC WELDING

The classification of electric welding process is shown:



The selection of proper welding process depends on the following factors.

- The type of metal to be joined.
- The techniques of welding adopted.
- The cost of equipment used.
- The nature of products to be fabricated

A. RESISTANCE WELDING

Resistance welding is the process of joining two metals together by **the heat produced due to the resistance offered to the flow of electric current at the junctions of two metals.** The heat produced by the resistance to the flow of current is given by:

$$H = I^2Rt$$

where *I is the current through the electrodes*, *R is the contact resistance of the interface, and t is* the time for which current flows.

Here, the total resistance offered to the flow of current is made up of:

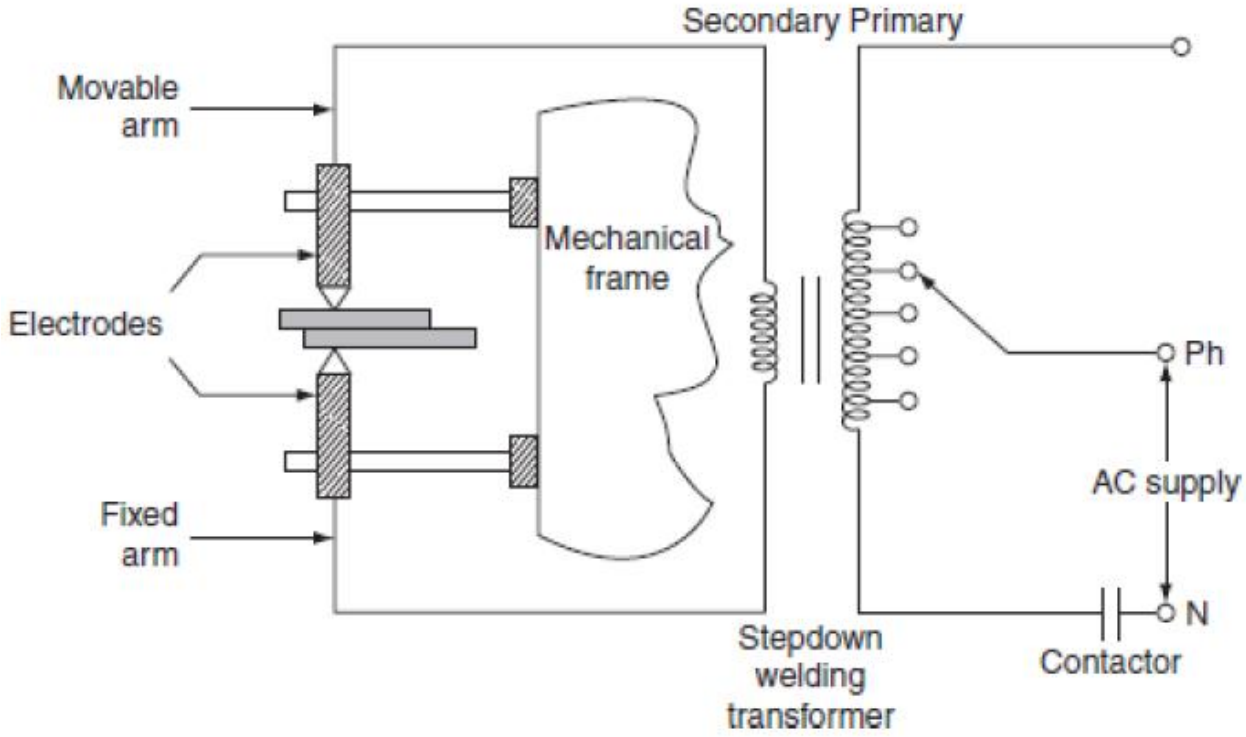
1. The resistance of current path in the work.
2. The resistance between the contact surfaces of the parts being welded.
3. The resistance between electrodes and the surface of parts being welded.

In this process of welding, the heat developed at the contact **area between the pieces to be welded reduces the metal to plastic state or liquid state**, then **the pieces are pressed under high mechanical pressure to complete the weld. The electrical voltage input to the welding varies in between 4 and 12 V depending upon area, thickness, composition, etc. and usually power ranges from about 60 to 180 W for each squre mm of area**.

Any desired combination of voltage and current can be obtained by means of a suitable transformer in AC; hence, AC is found to be most suitable for the resistance welding. The magnitude of current is controlled by changing the primary voltage of the welding transformer, which can be done by using an auto-transformer or a tap-changing transformer.

Automatic arrangements are provided **to switch off the supply after a pre-determined time from applying the pressure, why because the duration of the current flow through the work is very important in the resistance welding.**

The electrical circuit diagram for the resistance welding is shown in Figure. This method of welding consists of a tap-changing transformer, a clamping device for holding the metal pieces, and some sort of mechanical arrangement for forcing the pieces to form a complete weld.



Electric circuit for resistance welding

Advantages

- o Welding process is rapid and simple.
- o Localized heating is possible, if required.
- o No need of using filler metal.
- o Both similar and dissimilar metals can be welded.
- o Comparatively lesser skill is required.
- o Maintenance cost is less.
- o It can be employed for mass production.

However, the resistance welding has got some drawbacks and they are:

- o Initial cost is very high.
- o High maintenance cost.
- o The work-piece with heavier thickness cannot be welded, since it requires high input current.

Applications

- o It is used by many industries manufacturing products made up of thinner gauge metals.
- o It is used for the manufacturing of tubes and smaller structural sections.

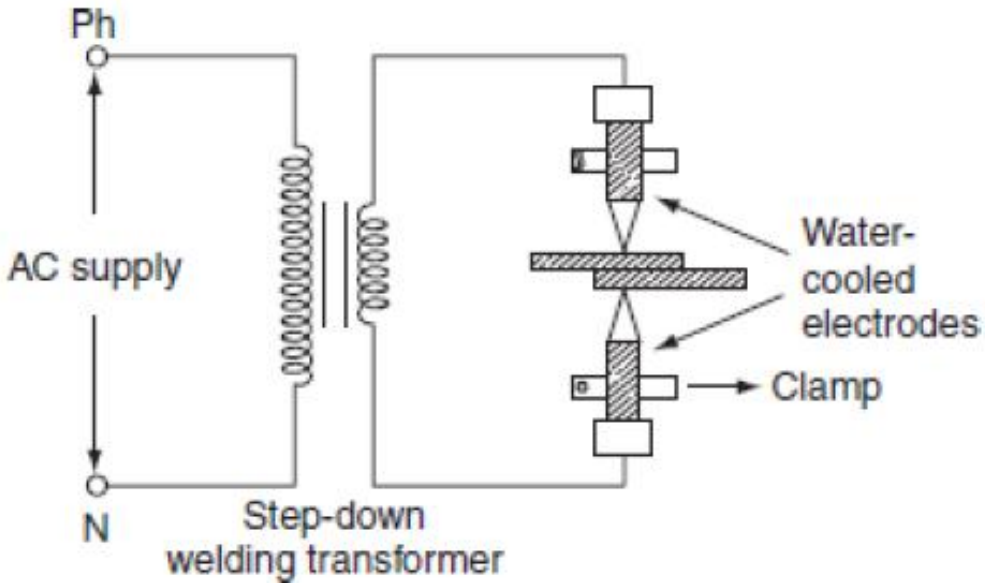
Types of resistance welding

Depending upon the method of weld obtained and the type of electrodes used, the resistance welding is classified as:

1. Spot welding.
2. Seam welding.
3. Projection welding.
4. Butt welding.

(i) Spot welding

Spot welding means the joining of two metal sheets and fusing them together between copper electrode tips at **suitably spaced intervals by means of heavy electric current passed through the electrodes.**



This type of joint formed by the spot welding **provides mechanical strength and not air or water tight,** for such welding it is necessary to localize the welding current and to apply sufficient pressure on the sheet to be welded.

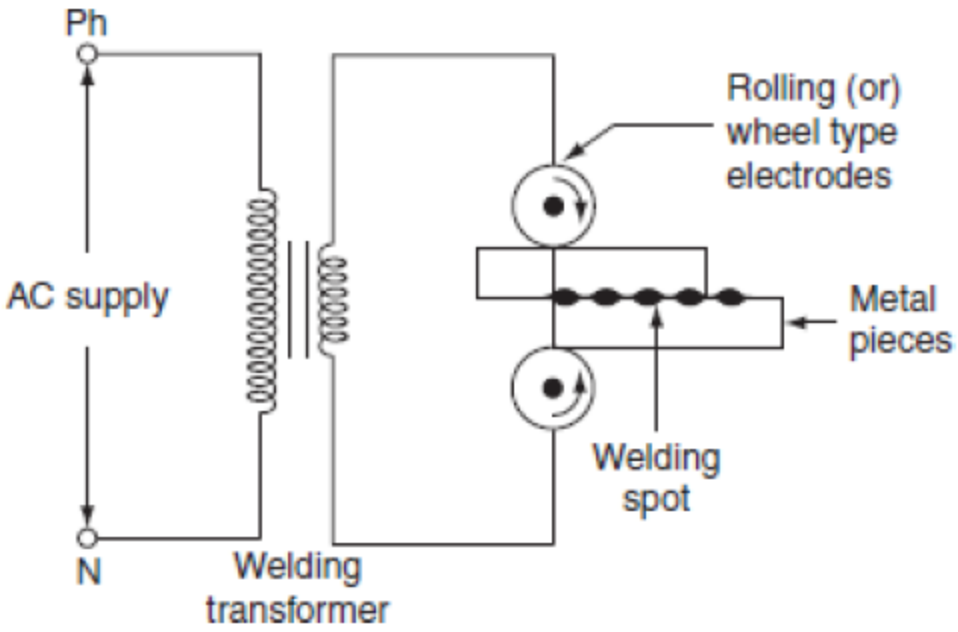
The welding current varies widely depending upon the thickness and composition of the plates. It varies from **1,000 to 10,000 A, and voltage between the electrodes is usually less than 2 V.** The period of the flow of current varies widely depending upon the thickness of sheets to be joined.

Good weld can be obtained by low currents for longer duration and high currents for shorter duration; longer welding time usually produces stronger weld but it involves high energy expenditure, electrode maintenance, and lot of distortion of workpiece.

(ii) Seam welding

Seam welding is nothing but the **series of continuous spot welding. If number spots obtained by spot welding are placed very closely that they can overlap, it gives rise to seam welding.**

In this welding, **continuous spot welds can be formed by using wheel type or roller electrodes instead of tipped electrodes.**

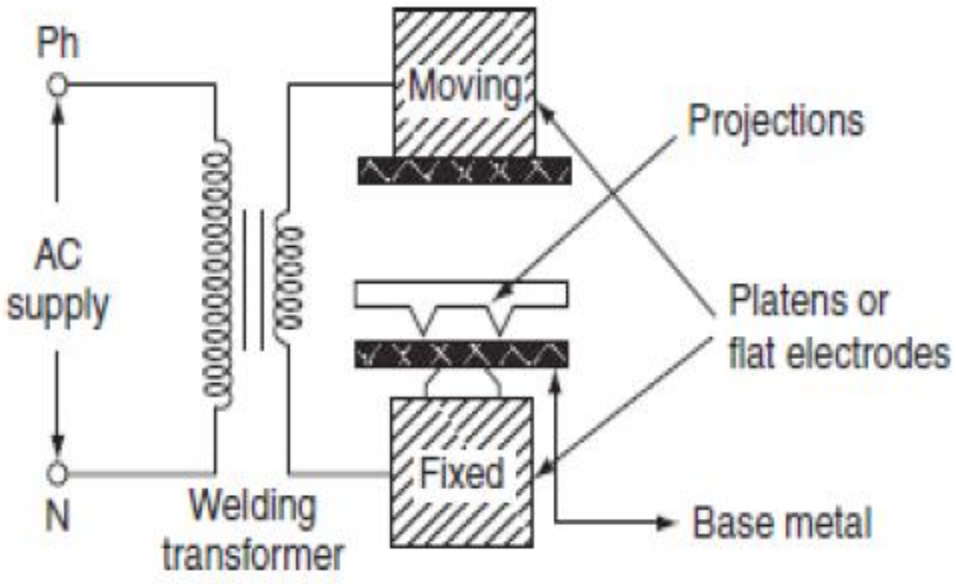


When these wheel type electrodes travel over the metal pieces which are under pressure, **the current passing between them heats the two metal pieces to the plastic state and results into continuous spot welds.**

Seam welding is very important, as it provides leak proof joints. It is usually employed in welding of pressure tanks, transformers, condensers, evaporators, air craft tanks, refrigerators, varnish containers, etc.

(iii) Projection welding

In the projection welding, both current and pressure are localized to the welding points as in the spot welding. **But the only difference in the projection welding is the high mechanical pressure applied on the metal pieces to be welded, after the formation of weld. The electrodes used for such welding are flat metal plates known as *platens*.**



One of the two pieces of metal is run through a machine that makes the bumps or projections of required shape and size in the metal. As current flows through the two metal parts to be welded, which heat up and melt. These weld points soon reach the plastic state, and the projection touches the metal then force applied by the two flat electrodes forms the complete weld.

The projection welding has the following advantages over the spot welding.

- o Simplicity in welding process.
- o It is easy to weld some of the parts where the spot welding is not possible.
- o It is possible to join several welding points.
- o Welds are located automatically by the position of projection.
- o As the electrodes used in the projection welding are flat type, the contact area over the projection is sufficient.

This type of welding is usually employed on punched, formed, or stamped parts where the projection automatically exists. The projection welding is particularly employed for mass production work, i.e., welding of refrigerators, condensers, crossed wire welding, refrigerator racks, grills, etc.

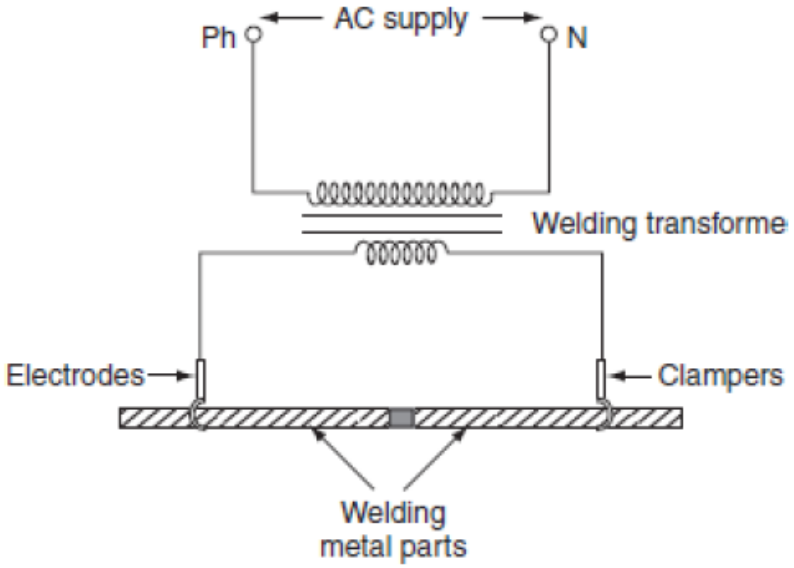
(iv) Butt welding

Butt welding is similar to the spot welding; however, the only difference is, in butt welding, instead of electrodes the metal parts that are to be joined or butted together are connected to the supply. **The three basic types of the butt welding process are:**

1. Upset butt welding.
2. Flash butt welding.
3. Percussion butt welding.

(a) Upset butt welding

In upset welding, the two metal parts to be welded are joined end to end and are connected across the secondary of a welding transformer. **Due to the contact resistance of the metals to be welded, heating effect is generated in this welding.**

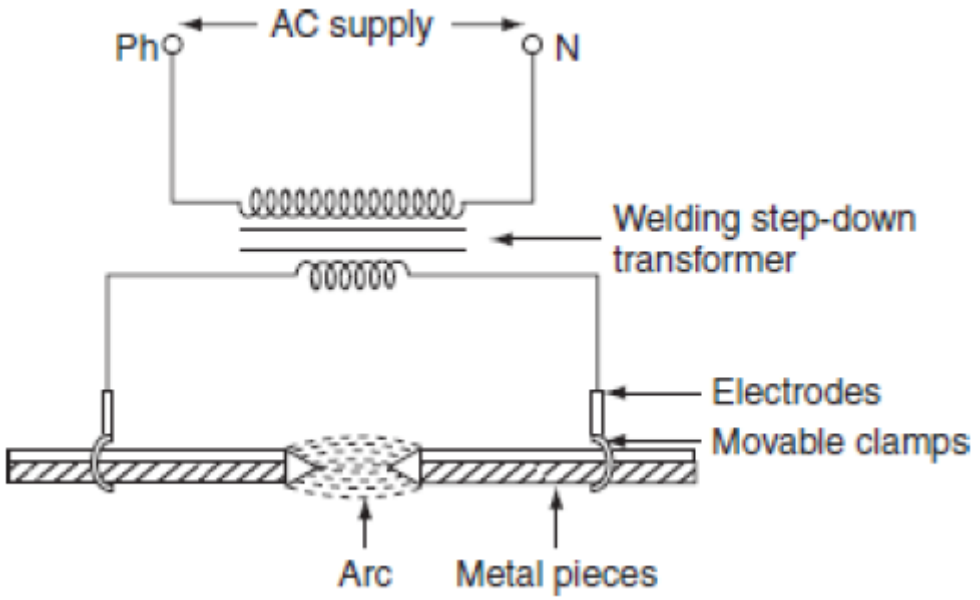


When current is made to flow through the two electrodes, heat will develop **due to the contact resistance of the two pieces and then melts**. By applying high mechanical pressure either manually or by toggle mechanism, the two metal pieces are pressed. **When jaw-type electrodes are used that introduce the high currents without treating any hot spot on the job**.

This type of welding is usually employed for welding of rods, pipes, and wires and for joining metal parts end to end.

(b) Flash butt welding

Flash butt welding is a combination of resistance, arc, and pressure welding. This method of welding is mainly used in the production welding. In this method of welding, the two pieces to be welded are brought very nearer to each other under light mechanical pressure.



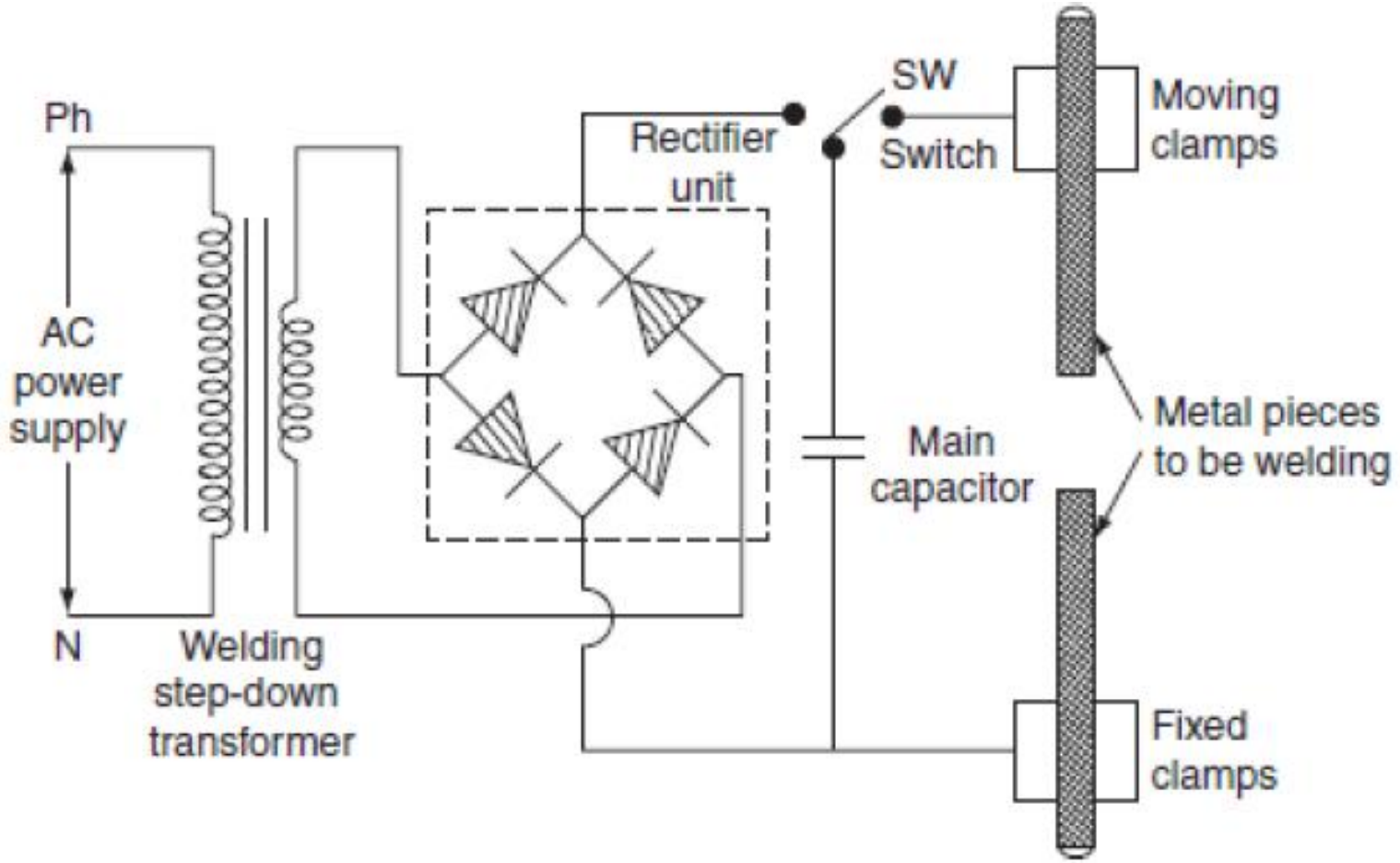
These two pieces are placed in a conducting movable clamps. When high current is passed through the two metal pieces and they are separated by some distance, then arc established between them. This arc or flashing is allowed till the ends of the work-pieces reach melting temperature, the supply will be switched off and the pieces are rapidly brought together under light pressure. **As the pieces are moved together, the fused metal and slag come out of the joint making a good solid joint.**

Following are the advantages of the flash butt welding over the upset welding.

- Less requirement of power.
- When the surfaces being joined, it requires only less attention.
- Weld obtained is so clean and pure; due to the foreign metals appearing on the surfaces will burn due to flash or arc.

(c) Percussion welding

It is a form of the flash butt welding, **where high current of short duration is employed using stored energy principle. This is a self-timing spot welding method.**



Percussion welding arrangement consists of one fixed holder and the other one is movable. The pieces to be welded are held apart, with the help of two holders, when the movable clamp is released, it moves rapidly carrying the piece to be welded. There is a sudden discharge of electrical energy, which establishes an arc between the two surfaces and heating them to their melting temperature, when the two pieces are separated by a distance of 1.5 mm apart. As the pieces come in contact with each other under heavy pressure, the arc is extinguished due to the percussion blow of the two parts and the force between them affects the weld. The percussion welding can be obtained in two methods; one is capacitor energy storage system and the other is magnetic energy storage system.

The capacitor ‘C’ is charged to about 3,000 V from a controlled rectifier. The capacitor is connected to the primary of welding transformer through the switch and will discharge. This discharge will produce high transient current in the secondary to join the two metal pieces. Percussion welding is difficult to obtain uniform flashing of the metal part areas of the cross-section grater than 3 sq. cm. Advantage of this welding is so fast, extremely shallow of heating is obtained with a span of about 0.1 sec. It can be used for welding a large number of dissimilar metals.

Applications

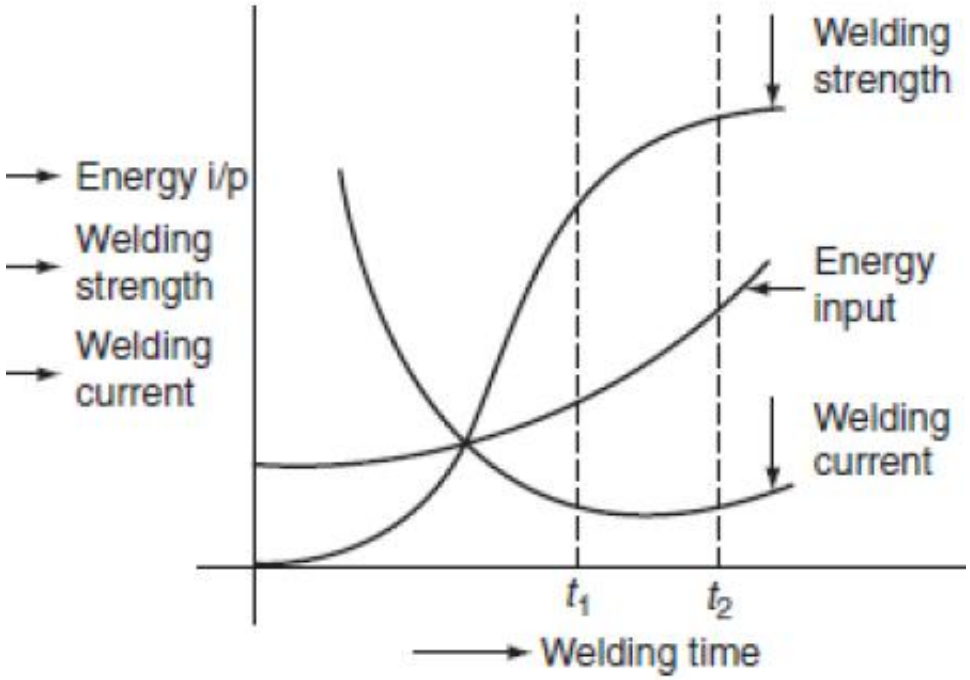
- It is useful for welding satellite tips to tools, sliver contact tips to copper, cast iron to steel, etc.
- Commonly used for electrical contacts.
- The metals such as copper alloys, aluminum alloys, and nickel alloys are percussion welded.

CHOICE OF WELDING TIME

The successful welding operation mainly depends upon three factors and they are:

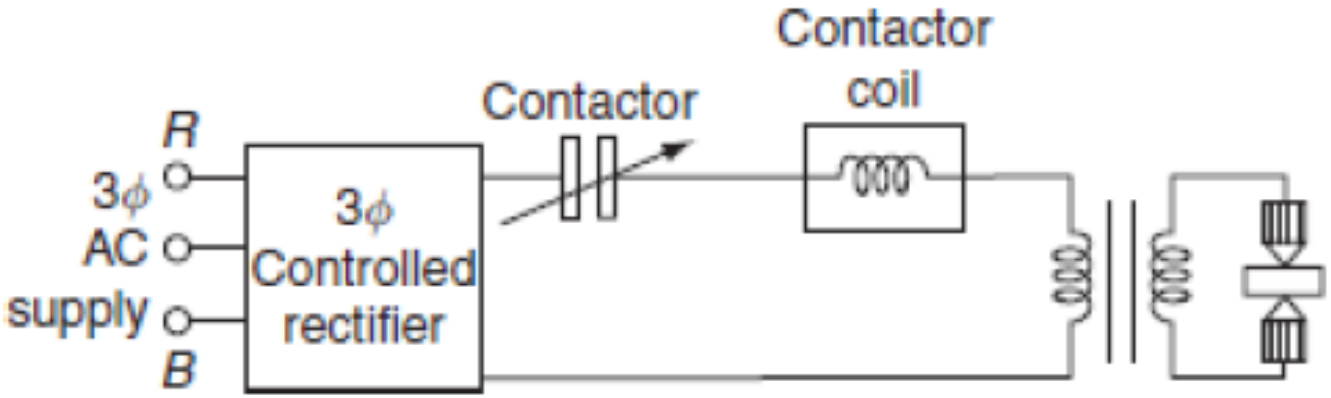
1. Welding time.
2. Welding current.
3. Welding pressure.

Figure shows how the energy input to the welding process, welding strength, and welding current vary with welding time.



Electromagnetic storage welding circuit is shown in Figure. In this type of welding, the energy stored in the magnetic circuit is used in the welding operation.

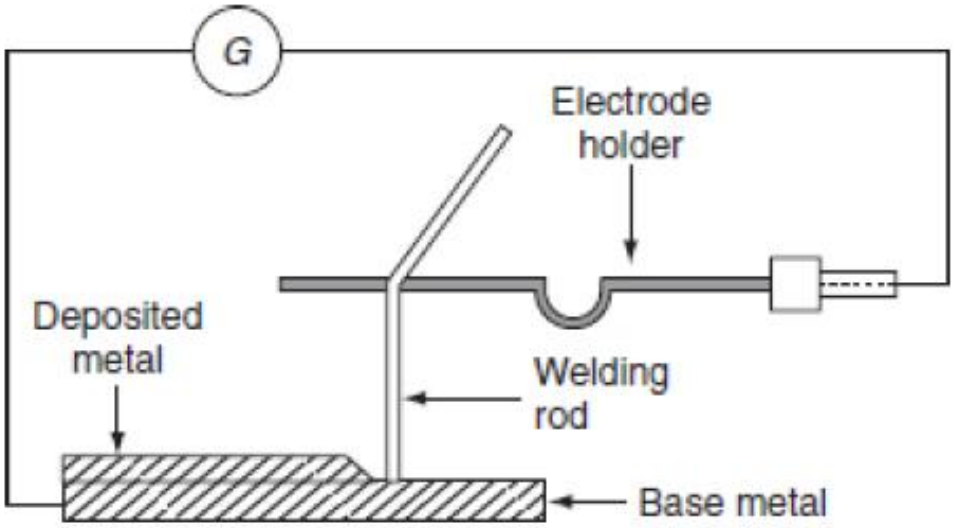
In this system, rectifier is fed from AC supply, which is converted to DC, **the DC voltage of rectifier is controlled in such a way that**, **voltage induced in the primary without causing large current in the secondary of transformer on opening the contactor switch,** DC on longer flows, there is rapid collapse of magnetic field, which induces very high current in the secondary of a transformer. Induced currents in the secondary of the transformer flow through the electrodes that develop heat at the surface of the metal and so forming the complete weld.



Magnetic energy storage welding circuit

ELECTRIC ARC WELDING

Electric arc welding is the process of joining two metallic pieces or melting of metal is obtained due to the heat developed by an arc struck between an electrode and the metal to be welded or between the two electrodes as shown



In this process, **an electric arc is produced by bringing two conductors (electrode and metal-piece) connected to a suitable source of electric current, momentarily in contact and then separated by a small gap, arc blows due to the ionization and give intense heat.**

The heat so developed is utilized to melt the part of work-piece and filler metal and thus forms the weld.

In this method of welding, **no mechanical pressure is employed; therefore, this type of welding is also known as *'non-pressure welding'*.**

The length of the arc required for welding depends upon the following factors:

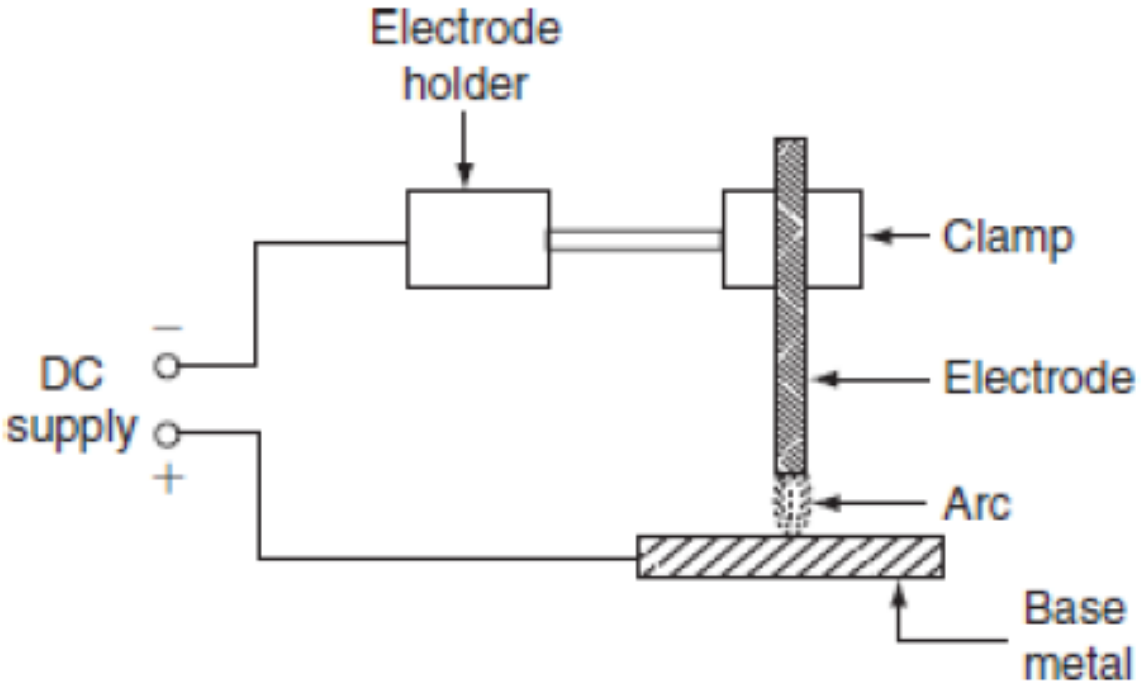
- The surface coating and the type of electrodes used.
- The position of welding.
- The amount of current used.

Various types of electric arc welding are:

1. Carbon arc welding.
2. Metal arc welding.
3. Atomic hydrogen arc welding.
4. Inert gas metal arc welding.
5. Submerged arc welding.

A. Carbon arc welding

It is one of the processes of arc welding in which arc is struck between two carbon electrodes or the carbon electrode and the base metal. The simple arrangement of the carbon arc welding is shown in Figure.



In this process of welding, **the electrodes are placed in an electrode holder used as negative electrode and the base metal being welded as positive. Unless, the electrode is negative relative to the work,** due to high temperature, there is a tendency of the particles of carbon will fuse and mix up with the base metal, which causes brittleness; DC is preferred for carbon arc welding since there is no fixed polarity maintained in case of AC.

In the carbon arc welding, carbon or graphite rods are used as electrode. **Due to longer life and low resistance, graphite electrodes are used, and thus capable of conducting more current.** The arc produced between electrode and base metal; heat the metal to the melting temperature, on the negative electrode is 3,200°C and on the positive electrode is 3,900°C.

This process of welding is normally employed where addition of filler metal is not required. The carbon arc is easy to maintain, and also the length of the arc can be easily varied. One major problem with carbon arc is its instability which can be overcome by using an inductor in the electrode of 2.5-cm diameter and with the current of about of 500–800 A employed to deposit large amount of filler metal on the base metal.
Filler metal and flux may not be used depending upon the type of joint and material to be welded.

Advantages

- The heat developed during the welding can be easily controlled by adjusting the length of the arc.
- It is quite clean, simple, and less expensive when compared to other welding process.
- Easily adoptable for automation.
- Both the ferrous and the non-ferrous metals can be welded.

Disadvantages

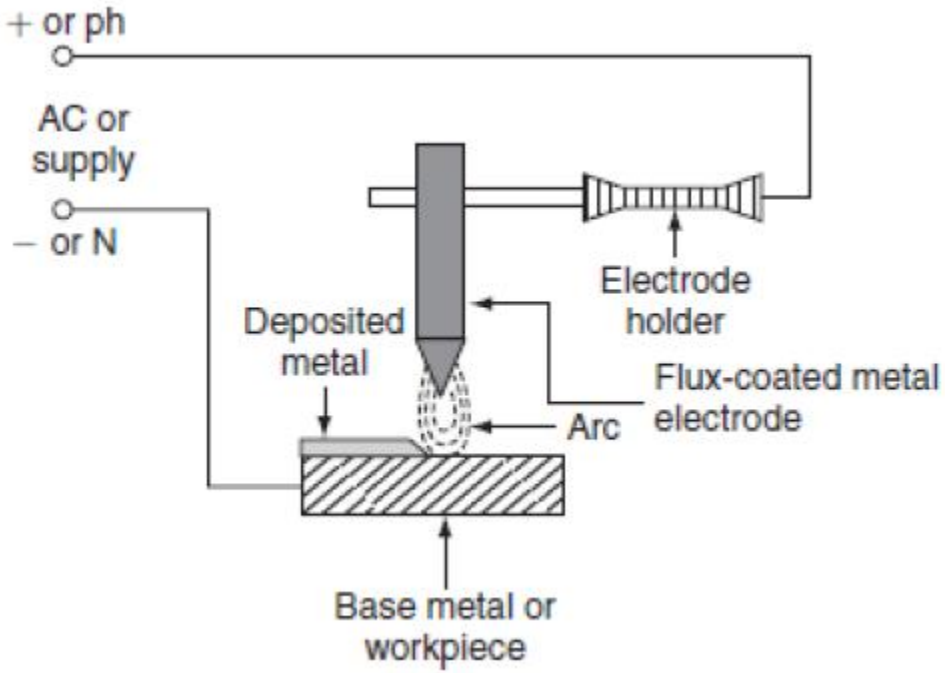
- Input current required in this welding, for the work-piece to rise its temperature to melting/welding temperature, is approximately double the metal arc welding.
- In case of the ferrous metal, there is a chance of disintegrating the carbon at high temperature and transfer to the weld, which causes harder weld deposit and brittlement.
- A separate filler rod has to be used if any filler metal is required.

Applications

- It can be employed for the welding of stainless steel with thinner gauges.
- Useful for the welding of thin high-grade nickel alloys and for galvanized sheets using copper silicon manganese alloy filler metal.

B. Metal arc welding

In metal arc welding, **the electrodes used must be of the same metal as that of the work-piece to be welded**. **The electrode itself forms the filler metal**. An electric arc is stuck by bringing the electrode connected to a suitable source of electric current, momentarily in contract with the work-pieces to be welded and withdrawn apart. The circuit diagram for the metal arc welding is shown in Figure.



Write about:

1. **Atomic hydrogen arc welding.**
2. **Inert gas metal arc welding.**
3. **SUBMERGED ARC WELDING.**
4. **ELECTRON BEAM WELDING.**
5. **LASER BEAM WELDING.**
6. **TYPES OF WELDING ELECTRODES.**

The arc produced between the work-piece and the electrode results high temperature of the order of about 2,400°C at negative metal electrode and 2,600°C at positive base metal or work-piece.

This high temperature of the arc melts the metal as well as the tip of the electrode, then the electrode melts and deposited over the surface of the work-piece, forms complete weld.

Both AC and DC can be used for the metal arc welding. The voltage required for the DC metal arc welding is about 50–60 V and for the AC metal arc welding is about 80–90 V.

In order to maintain the voltage drop across the arc less than 13 V, the arc length should be kept as small as possible, otherwise the weld will be brittle. The current required for the welding varies from 10 to 500 A depending upon the type of work to be welded.

The main disadvantage in the DC metal arc welding is the presence of arc blow, i.e., distortion of arc stream from the intended path due to the magnetic forces of the non-uniform magnetic

field with AC arc blow is considerably reduced. For obtaining good weld, the flux-coated electrodes must be used, so the metal which is melted is covered with slag produces a non-oxidizing gas or a molten slag to cover the weld, and also stabilizes the arc.

COMPARISON BETWEEN RESISTANCE AND ARC WELDING

Resistance welding	*Arc welding*
1 The source of supply is AC only.	The source of supply is either AC (1-φ or 3-φ) or DC.
2 The head developed is mainly due to the flow of contact resistance.	The heat developed is mainly due to the striking of arc between electrodes or an electrode and the workpiece.
3 The temperature attained by the workpiece is not so high.	The temperature of the arc is so high, so proper care should be taken during the welding.
4 External pressure is required.	No external pressure is required hence the welding equipment is more simple and easy to control.
5 Filler metal is not required to join two metal pieces.	Suitable filler electrodes are necessary to get proper welding strength.
6 It cannot be used for repair work; it is suitable for mass production.	It is not suitable for mass production. It is most suitable for repair works and where more metal is to be deposited.
7 The power consumption is low.	The power consumption is high.
8 The operating power factor is low.	The operating power factor is high.
9 Bar, roller, or flat type electrodes are used (not consumable).	Bare or coated electrodes are used (consumable or non-consumable).

COMPARISON BETWEEN AC AND DC WELDING

AC welding	*DC welding*
1 Motor generator set or rectifier is required in case of the availability of AC supply.	Only transformer is required.
2 The cost of the equipment is high.	The cost of the equipment is cheap.
3 Arc stability is more.	Arc stability is less.
4 The heat produced is uniform.	The heat produced is not uniform.
5 Both bare and coated electrodes can be used.	Only coated electrodes should be used.
6 The operating power factor is high.	The power factor is low. So, the capacitors are necessary to improve the power factor.
7 It is safer since no load voltage is low.	It is dangerous since no load voltage is high.
8 The electric energy consumption is 5–10 kWh/kg of deposited metal.	The electrical energy consumption is 3–4 kWh/kg of deposited metal
9 Arc blow occurs due to the presence of non-uniform magnetic field.	Arc blow will not occur due to the uniform magnetic field.
10 The efficiency is low due to the rotating parts.	The efficiency is high due to the absence of rotating parts.

ELECTRIC WELDING EEQUIPMENT

Electric welding accessories required to carry out proper welding operation are:

1. Electric welding power sets.
2. Electrode holder to hold the electrodes.
3. Welding cable for connecting electrode and workpiece to the supply.
4. Face screen with colored glass.
5. Chipping hammers to remove slag from molten weld.
6. Wire brush to clean the weld.
7. Earth clamp and protective clothing.