This note is for theoretical topics only. Refer class sessions for numerical and application level questions

Electric welding

Electric welding is the process of joining two metal pieces with the application of electrical energy

Electric Welding can be broadly classified into

1) Resistance Welding
2) Arc Welding

Resistance Welding

Resistance Welding is a welding process, in which work pieces are welded by a combination of pressure applied to them and a localized heat generated by a high electric current flowing through the contact area of the weld.

The electric resistance welding process can be further classified by the geometry of the weld, type of electrode and the method of applying pressure to the joint as:

1. Spot Welding
2. Seam Welding
3. Butt Welding

The key advantage of resistance welding is that no other materials (fillers) are needed to create the bond, which makes this process extremely cost effective.

Resistance welding machines are designed and built for a wide range of automotive, aerospace and industrial applications.

Resistance welding methods are efficient and cause little pollution, but their applications are limited to relatively thin materials.

Resistance Welding Process

Resistance welding is conducted as follows: Apply current through electrodes with the help of a constant current source (AC source via **Step-down transformer**).

The metal parts (workpiece) to be welded is placed as shown in *figure1* and resistance heat is generated at the interface of metal parts due to the heavy current flow resulting in a plastic/liquid form of the metal pieces and makes a nugget. High mechanical pressure is applied thereby resulting in melt joint/weld. Though a large current flows, there is no danger of an electric shock because only low voltage is impressed.

Heat generated 'W' is according to the *Joule's Law*

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The heat produced is $W = I^2 R t$ is used to producing the heat from electrical energy

Here $I = current\ through\ the\ eletrodes$

$R = resistance\ \ offered\ to\ the\ flow\ of\ current$

$t = time\ for\ which\ current\ flows$

$R =$ *Comprises of resistance of current path + resistance between contact surfaces of the parts to be welded + resistance between electrodes and surfaces of the parts to be welded*

Features of Resistance Welding:

1. Any desired combination of voltage and current is obtained using a transformer
2. AC is most preferred for **resistance welding** for the above reason
3. Magnitude of current is controlled using an **autotransformer** or **tap-changing transformer**

Applications:

1. Used for welding of thin Gauge metals. High gauge metals require high current hence this method is not preferred.
2. Used for manufacture of tubes and smaller structural sections
3. Welding of Low carbon steels - the widest application of Resistance Welding
4. Welding of Aluminium alloys
5. Welding of Medium carbon steels, high carbon steels and Alloy steels (may be welded, but the weld is brittle)
6. Resistance Welding (RW) is used for joining vehicle body parts, fuel tanks, and domestic radiators, pipes of gas oil and water pipelines, wire ends, turbine blades, railway tracks.

1. Resistance **Spot Welding**

Spot Welding is a Resistance Welding (RW) process, in which two or more overlapped metal sheets are joined by spot welds. The method uses pointed copper electrodes providing passage of electric current. The electrodes also transmit pressure required for formation of strong weld.

Application:
Spot welding is widely used in automotive industry for joining vehicle body parts and welding/joining of sheet metal structure.

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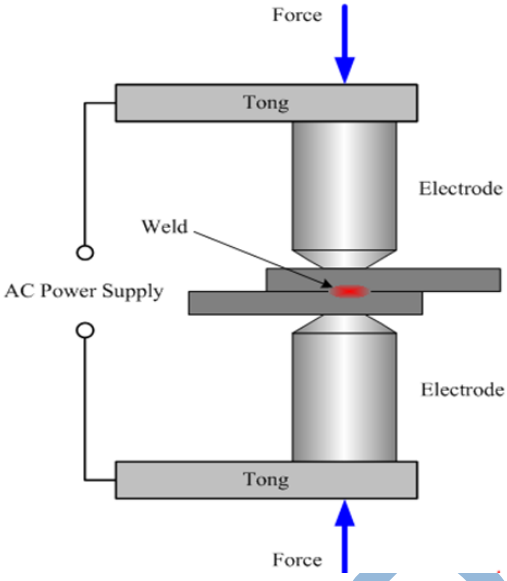

Figure1: Resistance spot welding

2. Resistance **Seam Welding** **

Seam welding is a series of continuous spot welds. Seam welding process is continuous joining of overlapping sheets by passing them between two rotating electrode wheels. Heat generated by the electric current flowing through the contact area and pressure provided by the wheels are sufficient to produce a leak-tight weld.

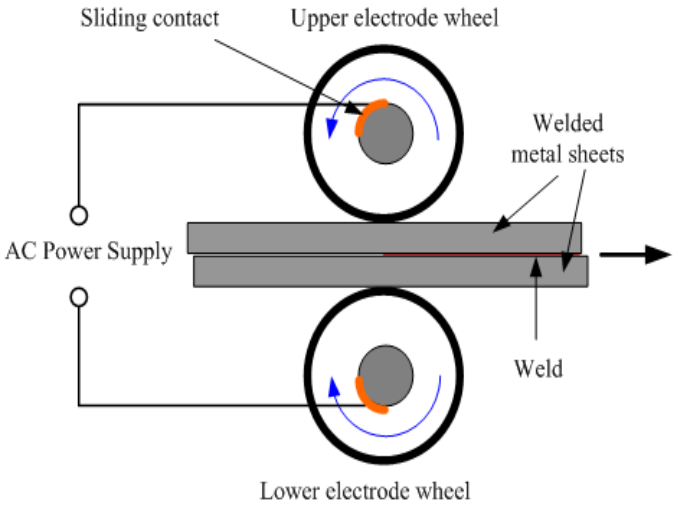

Figure2: Resistance seam welding

Application:

Seam welding is widely used to provide **leak proof joints**. Used in welding of pressure tanks, transformers, condensers, fuel tanks, aircraft tanks

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3. **Butt Welding** Butt welding is similar to spot welding with the only difference that in butt welding, instead of separate electrodes, the metal parts to be welded are directly connected to the supply.

There are two types of Butt welding 1) Flash welding 2) Resistance Butt welding

3.1 Flash Butt Welding: is a Resistance Welding (RW) process which is a combination of resistance, arc and pressure welding.

In Flash welding, electric current is followed by forging pressure application. Flash butt welding is used with machinery and connects multiple pieces of metal together that are miss-matched in size and shape.

Application:
Steels, Aluminium alloys, Copper alloys, Magnesium alloys, Copper alloys and Nickel alloys may be welded by Flash Welding.
Thick pipes, ends of band saws, frames, and aircraft landing gears are produced by Flash Welding.

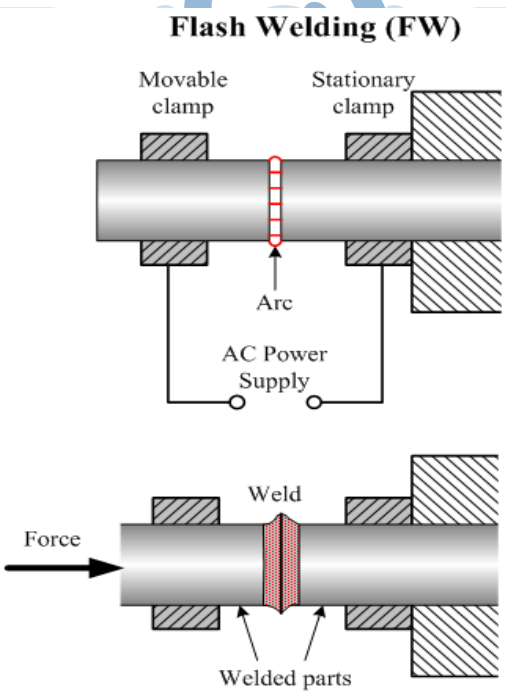
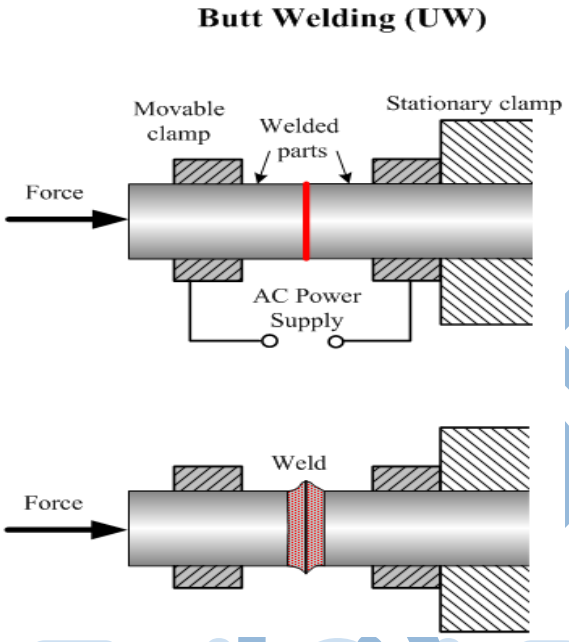


Figure3: Flash Welding

3.2 Resistance Butt welding: The process is similar to Flash Welding, however in Butt Welding pressure and electric current are applied simultaneously in contrast to Flash Welding where

electric current is followed by forging pressure application. Resistance butt welding is used on joints that are of similar shape and size

Figure4: Resistance Butt Welding



Application:
Butt welding is used for welding small parts. The process is highly productive and clean. In contrast to Flash Welding, Butt Welding provides joining with no loss of the welded materials.

Welding Transformer

Working Principle and Applications & characteristics of welding transformer

Welding transformers acts as a source of constant current required for welding process.

The winding which is connected to power supply is called primary winding and the winding to which the electrodes or metal parts or workpiece is connected is called secondary winding.

Construction of welding transformer:

1. Welding transformer is a step down transformer $(N_1 >> N_2)$

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2. It has a magnetic core with primary winding which is thin and has large number of turns $(V_1 >> V_2)$

3. A secondary winding with less number of turns and high cross-sectional area $(I_2 >> I_1)$

4. Thus we get **Low voltage** and **high current** from the secondary winding output.

Working of welding transformer:

1. As it is a step down transformer we have less voltage at secondary which is nearly 15 to 45 volts and has high current values which is nearly 200 A to 600 A or even thousands of amperes.

2. For adjusting the voltage on secondary side there are tappings on secondary winding to obtain the required amount of secondary current for welding.

3. These tappings are connected to several high current switches.

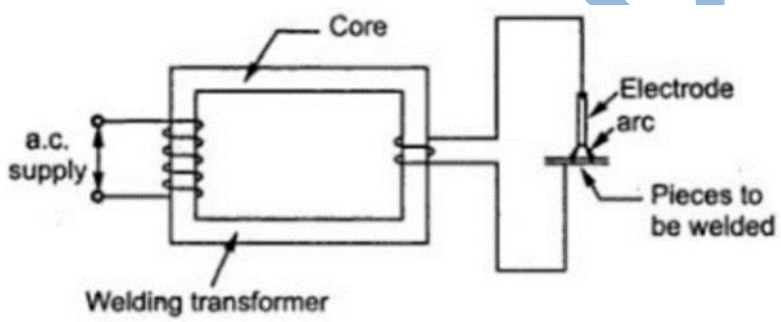

Figure 5: How a welding transformer works

4. Now one end of secondary winding is connected to the welding electrode and the other end is connected to the welding pieces as shown in *Figure 5*

5. When a high current flows, a large amount of heat $W = I^2 R t$ is produced due to contact resistance between welding pieces and electrode.

6. This high heat, melts the tip of electrode and fills the gap between the welding pieces.

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7. *Figure 6* shows the volt – ampere characteristics of welding transformer

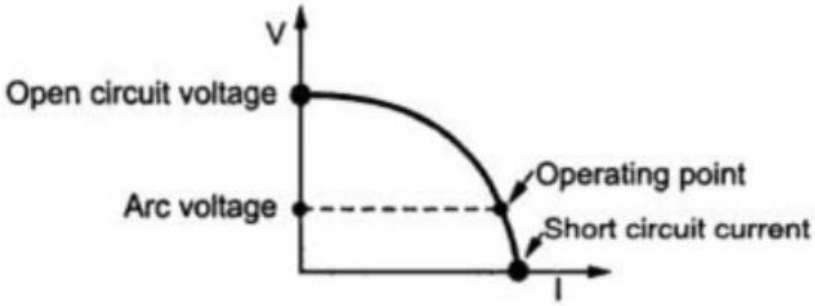

Figure 6: Volt – Ampere (VI) characteristics of welding transformer

Arc control of welding transformer: (extra reading)

The impedance of welding transformer must be higher than the normal transformer to control arc and also to control current.

We can use different reactors for controlling the arc. They are

1. Tapped reactor.
2. Moving coil reactor.
3. Magnetic shunt reactor.
4. Continuously variable reactor.
5. Saturable Reactor.

Electric Arc Welding *(only Brief study required)*

Arc welding is a fusion welding process in which the heat required to fuse the metal is obtained from an electric arc between the base metal and an electrode.

Arc welding process:

The electric arc is produced when two conductors touches together and then separates by a small gap of 2 to 4 mm, such that the current continues to flow, through the ionized air. The temperature produced by the electric arc is about 4000°C to 6000°C. A metal electrode is used which supplies the filler metal. The electrode may be flux coated or bare. In case of bare electrode, extra flux material is supplied. Both direct current (D.C.) and alternating current (A.C.) are used for arc welding. No external pressure is required and hence this method is called **non-pressure welding**.

The alternating current for arc is obtained from a step down transformer. The transformer receives current from the main supply at 220 to 440 volts and step down to required voltage i.e., 80 to 100 volts. The direct current for arc is usually obtained from a generator driven by either an electric motor, or petrol or diesel engine. *(Features& characteristics of welding generator will be discussed in Electrical Machines)*

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Note: *DC welding generator used is* ***DIFFERENTIAL DC Generator * **** *(one of very few applications of differential DC generator)*

An open circuit voltage (for striking of arc) in case of D.C. welding is 60 to 80 volts while a closed circuit voltage (for maintaining the arc) is 15 to 25 volts

In electric arc welding metal pieces to be joined are heated to melting point by creating an electric arc between them to form a pool of molten metal and then allowing it solidify to form welded joint. Sometimes additional material is added to form the weld by melting the wire known as filler metal.

Due to melting of electrode material droplets are transferred to the work piece through the arc and deposited along the joint.

Metal Arc welding:

In metal arc welding, arc is maintained between electrode and work piece which form the two terminals. In this welding, electrode used may be bare or coated. Bare electrode has same composition as that of parent metal whereas coated electrode have some material or flux that prevents the oxidation of surface.

Features:

1. In this type of welding, the electrodes used must be of the same metal as that of work-piece to be welded
2. Requires low temperature compared to other arc welding methods (~ 2400°C to 2600°C)
3. Both AC & DC can be applied.
4. Presence of flux is must to prevent the oxidation of metal weld.

Figure 7: Electric Metal arc welding

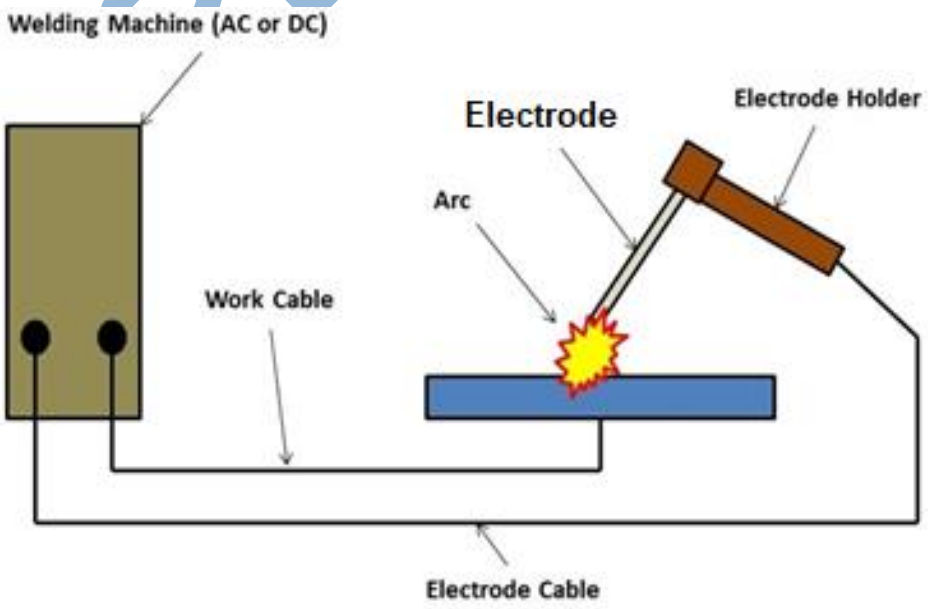

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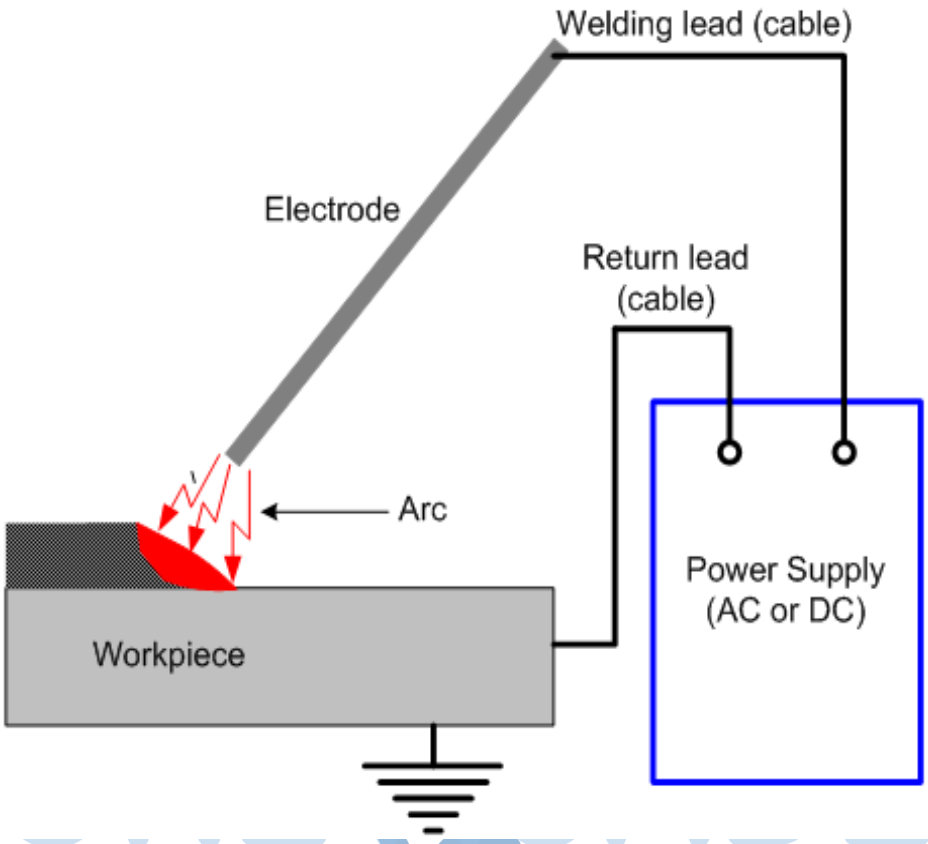
Figure8: Arc welding arrangement (for reference)



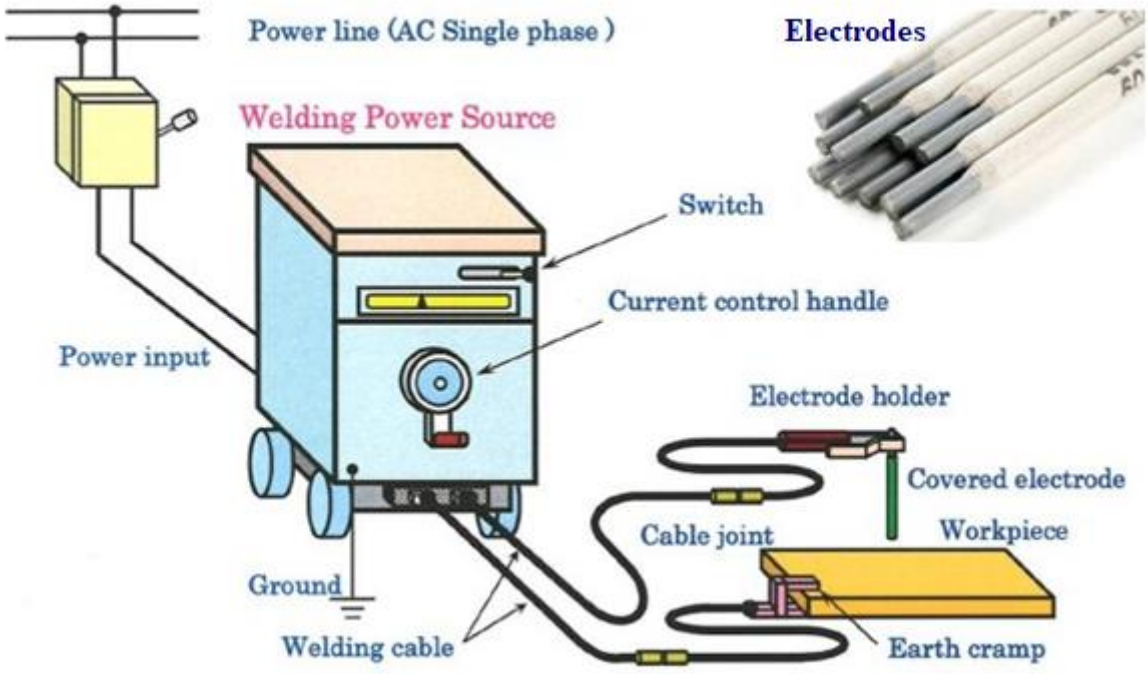


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Figure9: Metal Arc Welding arrangement (for reference)

Comparison of Resistance & Arc Welding

Resistance Welding	Arc Welding
1. AC supply is preferred	AC & DC source can be used
2. Heat is produced due to flow of current through the contact resistance	Heat is produced due to formation arc between electrode and work piece
3. External Pressure needs to be applied for weld	No external pressure is required
4. The working temperature is not very high	The working temperature in the arc formation is very high
5. Power consumption is low	High power consumption
6. Filler materials are not required for the weld	Filler electrodes are must
7. The welding equipment is complex and bulky	Relatively simple construction and portable
8. Power factor is low (~ 0.3-0.5 range)	Power factor is good (~ 0.5-0.7 range)

***NOTE**: This note is prepared on the topic Electrical Welding for **SSC JE / KPSC, KSEB Sub Engineer/ AE level exams**, (Please refer to course outline shared in class).*

*The relevance of Electrical Welding for competitive exams / number of questions from this topic is **very less** and an overall idea of the topic with emphasis on applications and the type of electrical equipment (type of transformers/ DC generators etc. used) for the same should be the ideal approach.*
Electrical Welding as such is a very vast topic and most areas are irrelevant for competitive exams.

Additional exam specific points will be discussed in class / Q&A sessions
(Additional MCQs on welding will follow in Short Note-8 & QCards)

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