Welding Technology

Unit – 2

Resistance Welding Processes

Introduction

- Resistance welding processes are pressure welding processes in which heavy current is passed for short time through the area of interface of metals to be joined.
- These processes differ from other welding processes in the respect that no fluxes are used, and filler metal rarely used. All resistance welding operations are automatic and, therefore, all process variables are pre-set and maintained constant. Heat is generated in localized area which is enough to heat the metal to sufficient temperature, so that the parts can be joined with the application of pressure. Pressure is applied through the electrodes.

Principle

- Heat Generation due to electric resistance.

The heat generated during resistance welding is given by following expression:

$\mathbf{H = I^2 R T}$

Where, **H** is heat generated

I is current in amperes

R is resistance of area being welded

T is time for the flow of current.

Weld Current

- The process employs **currents** of the order of **few KA**, **voltages** range from **2 to 12 volts** and **time** vary from few **ms to few seconds**.

Weld Pressure

- **Force** is normally applied before, during and after the flow of current to avoid arcing between the surfaces and to forge the weld metal during post heating. The necessary **pressure** shall vary from **30 to 60 N /mm^2** depending upon material to be welded and other welding conditions.
- For good quality welds these parameters may be properly selected which shall depend mainly on material of components, their thicknesses, type and size of electrodes.

Cleaning of Surfaces

- Apart from proper setting of welding parameters, component should **be properly cleaned** so that surfaces to be welded are free from rust, dust, oil and grease. For this purpose components may be given **pickling treatment** i.e. dipping in diluted acid bath and then washing in hot water bath and then in the cold water bath. After that components may be dried through the jet of compressed air. If surfaces are rust free then pickling is not required but surface cleaning can be done through some solvent such as acetone to remove oil and grease.

Power Source

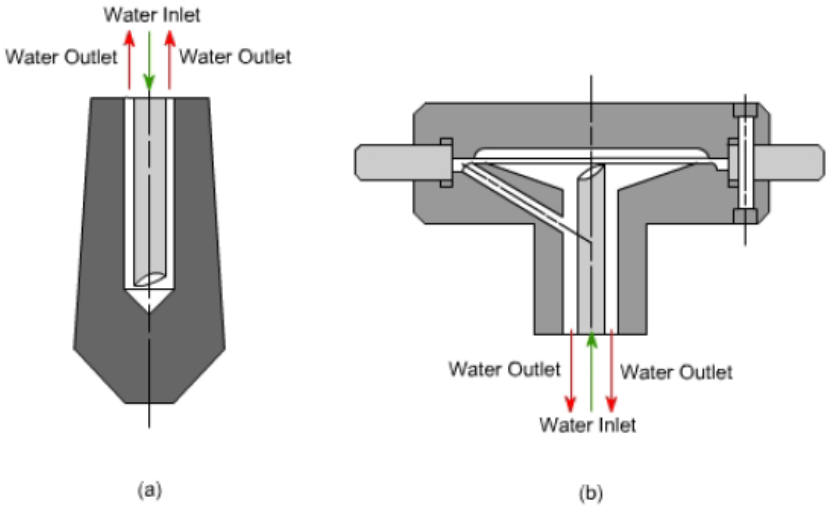
- The **current** may be obtained from a **single phase step down transformer** supplying alternating current. However, when **high amperage** is required then **three phase rectifier** may be used to obtain DC supply and to balance the load on three phase power lines.

Electrode Material

- The material of **electrode** should have **higher electrical and thermal conductivities** with sufficient strength to sustain high pressure at elevated temperatures.
- Commonly used electrode materials are pure copper and copper base alloys.
- Copper base alloys may consist of copper as base and alloying elements such as cadmium or silver or chromium or nickel or beryllium or cobalt or zirconium or tungsten.
- Pure tungsten or tungsten-silver or tungsten-copper or pure molybdenum may also be used as electrode material.

Electrode Cooling

- To reduce wear, tear and deformation of electrodes, cooling through water circulation is required. Figure shows the water cooling system of electrodes.



Water Cooling of Electrodes (a) Spot Welding (b) Seam Welding.

Spot Welding

It is simplest type of resistance welding in which the work pieces are held together under pressure of anvil face. The copper electrodes are brought in contact with work piece and current start to flow through it. The work piece material applies some resistance in flow of current which cause local heat generation. At the interface surfaces the resistance is high due to air gap. The current start to flow though it which melt down the interface surface. The amount of current supply and time should be sufficient for proper melting of interface surfaces. Now the current stopped to flow but the pressure applied by electrode maintained for a fraction of second, while the weld rapidly cooled. After it, the electrodes remove and brought to contact at other spot. It will create a circular nugget. The nugget size depends on size of electrode. It is generally about diameter 4-7 mm.

Spot welding is the predominant joining process in automotive industry for assembling the automobile bodies and large components. It is also widely used for manufacturing of furniture and domestic equipment etc

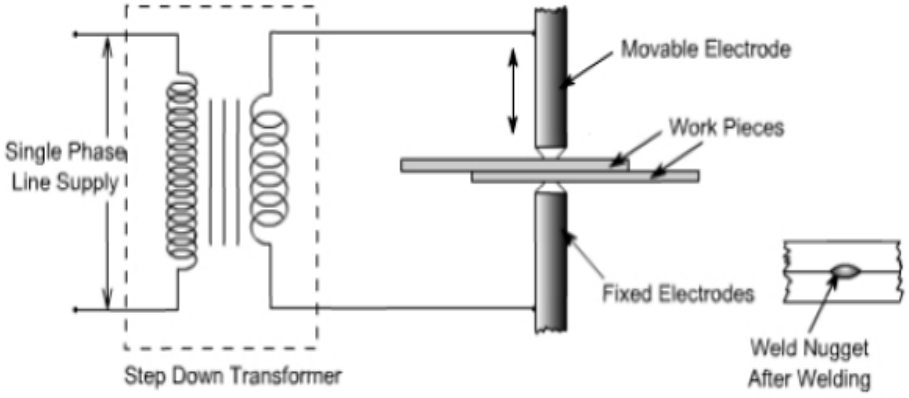


Fig 11.2: Principle of Resistance spot Welding

Resistance Spot Welding Cycle

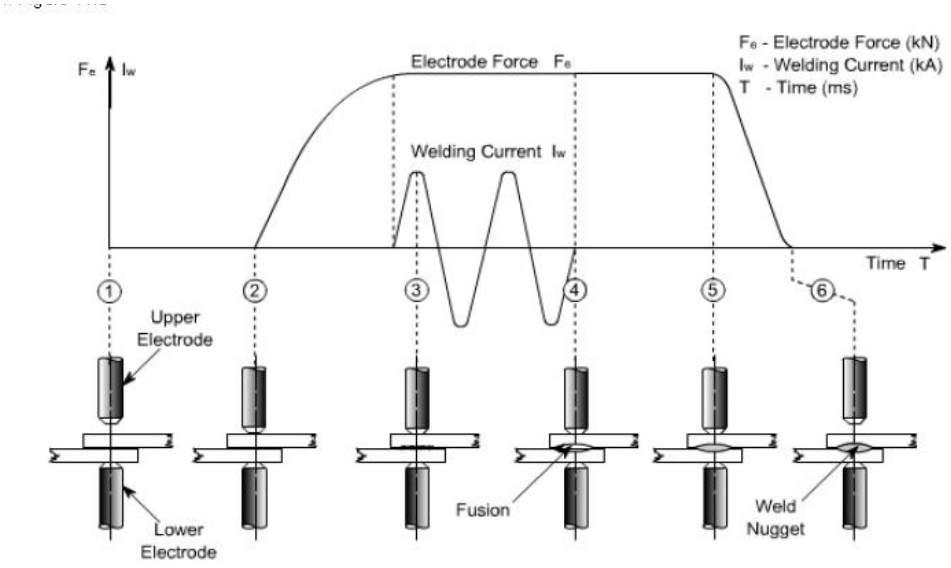
Usually spot welding (as also other ERW machines) are automatic and work on the following weld cycle:

1. Squeeze the two metal pieces together with a light pressure.

2. Pass heavy electric current for a very brief time to obtain coalescence temperature,

3. Apply pressure and hold for some time.

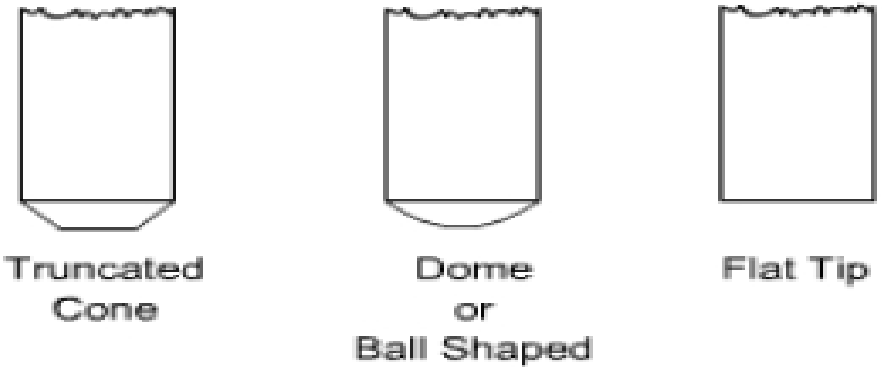
4. Remove pressure.



Spot Welding Cycle

Electrode Shapes

- Pointed tip or truncated cones with an angle of 120° - 140° are used for ferrous metal but with continuous use they may wear at the tip.
- Domed electrodes are capable of withstanding heavier loads and severe heating without damage and are normally useful for welding of nonferrous metals.
- The radius of dome generally varies from 50-100 mm.
- A flat tip electrode is used where minimum indentation or invisible welds are desired.



Electrode shapes

Advantages of Resistance welding

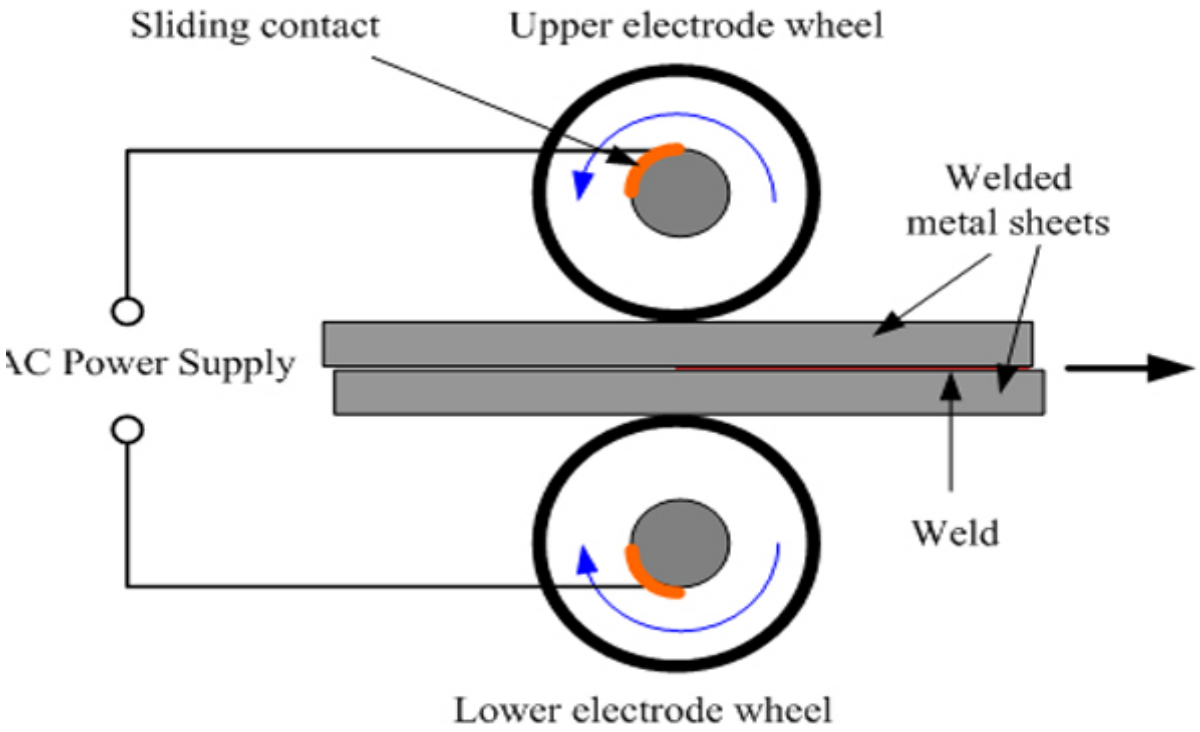
1. Very rapid.
2. Fully automation possible.
3. Conserve material; no filler metal, shielding gases, or flux is required.
4. Skilled operators are not required.
5. Dissimilar metals can be easily joined.

Limitations

1. Joints in spots only.
2. Thick plates cannot be welded easily
3. Only lap joint welding is possible

Seam Welding

- Weld is made between overlapping sheets of metal. The seam is a series of overlapping spot welds.
- The basic equipment is the same as for spot welding. except that the electrodes are now in the form of rotating disks (As shown below).
- Timed pulses of current pass to form the overlapping welds.
- As the metal passes between the electrodes, timed pulses of current pass through it to form the overlapping welds.
- Weld is made between overlapping sheets of metal, and the process is used to produce liquid- or gastight sheet metal vessels, such as gasoline tanks, automobile mufflers, and heat exchangers. The seam is actually a series of overlapping spot welds such as those in Figure below.
- The welding current is usually a bit higher than conventional spot welding, to compensate for the short circuit of the adjacent weld, and external cooling of the work, by air or water, is often employed.
- Overlapping of weld nuggets may vary from 10 to 50 %. When it is approaching around 50 % then it is termed as continuous weld.
- In a variation of the process, a continuous seam is produced by passing a continuous current through the rotating electrodes. A typical welding speed is about 1.5 m/min for thin sheet.



Seam Welding

Electrode Shapes

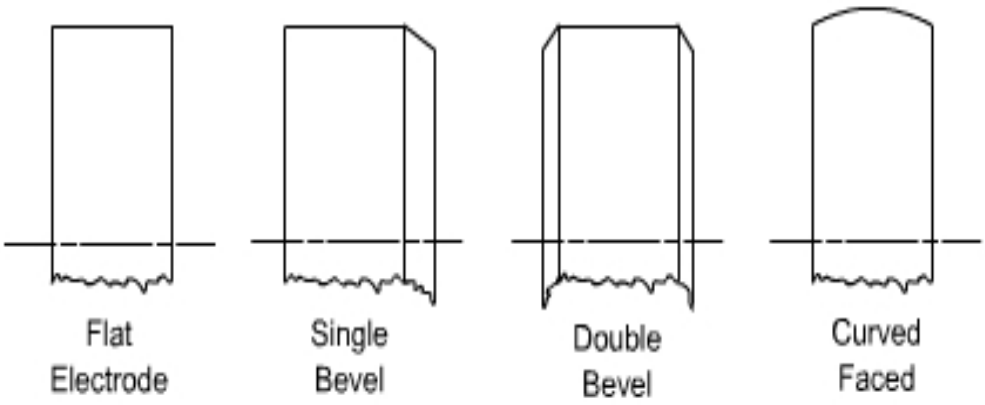


Fig 11.7: Electrode Shapes of Seam Welding

Advantages

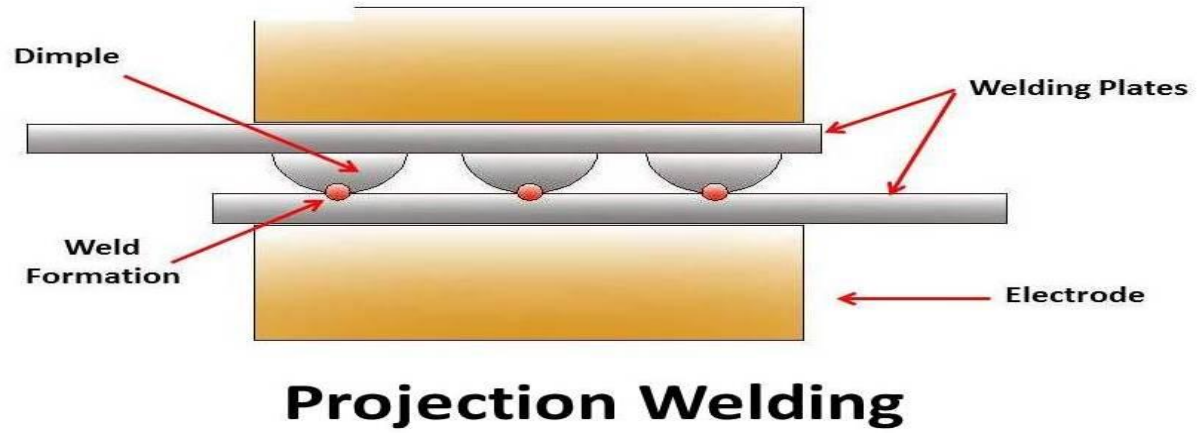
1. Faster than spot welding.
2. Continuous spots can be generated
3. Gastight joints are produced.

Applications

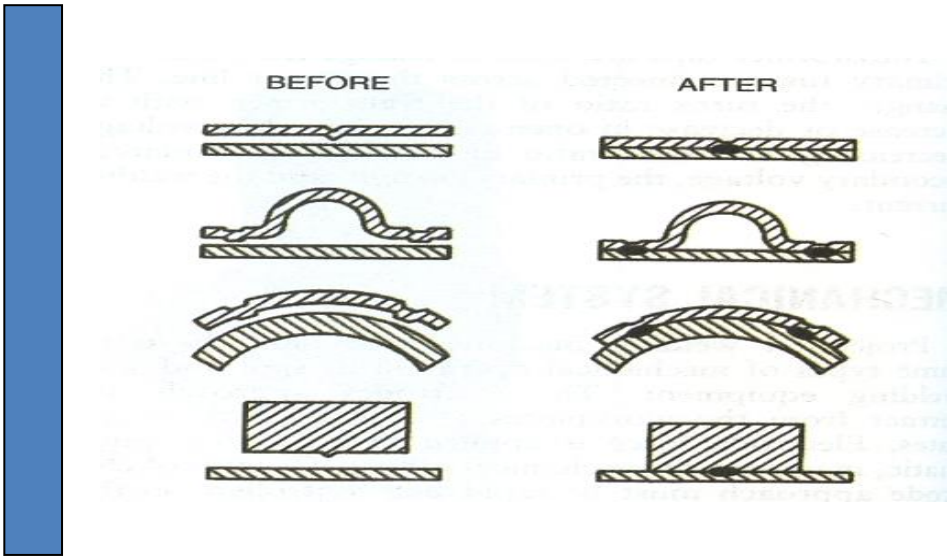
- Used for making petrol tanks for automobiles, seam welded tubes, drums and other components of domestic applications.

Projection welding

"Projection welding is an electric resistance welding process that produces welds by the heat obtained from the resistance to the flow of the welding current. The resulting welds are localized at predetermined points by projections, embossments, or intersections"

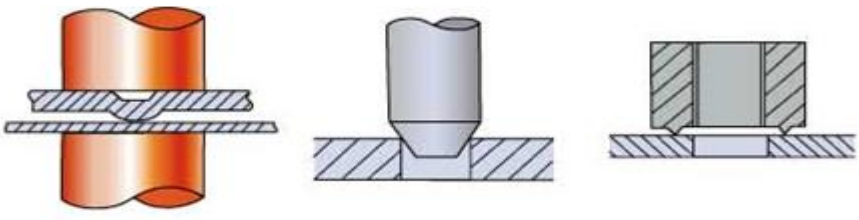


A dimple is embossed into one of the work pieces at the locations where the weld is desired as shown in the Figure. The work-pieces are then placed between large area electrodes. Pressure and current are applied as in the spot welding process. Since the current must flow through the points of contact, namely the dimples, the heating is concentrated where the weld is desired. As the metal heats and becomes plastic, pressure causes the dimple to flatten and form a weld. Since the projections are press formed, they can often be produced during other blanking and forming operations with virtually no additional cost.



Various Projection Designs Before and After Welding

Typical Projection Designs



a. Embossed b. Stud-to-Plate c. Annular

Materials Suitable for Projection Welding

- Low carbon steel
- Hardenable steels
- Stainless steels-ferritic, martensitic, and austenitic types
- Nickel-base alloys
- Copper alloys
- Aluminum and magnesium alloys
- Titanium alloys
- Coated and plated steels

Advantages

- Simultaneous operation can be done i.e. more than one welds can be made.
- Projection welding has this advantage that it can weld metals of thickness which is not suitable for spot welding.
- Projection welding electrodes have a longer life when compared to spot welding electrodes. It's because projection welding electrodes have to withstand less wear and less heating.
- Resistance projection welding is not limited to sheet to sheet joints.
- Projection welding can be done in specific points which are desired to be welded.
- In difficult welding work projection welding gives a better heat balance.
- Projection welding saves electricity because it needs less current to produce heat. So it reduces the shrinkage and distortion defects.

Disadvantages

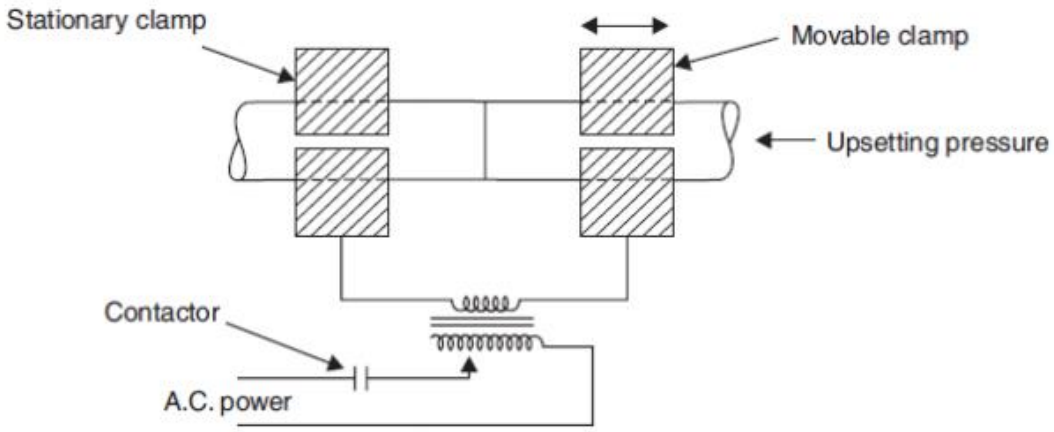
- All types of metals cannot be welded using projection method. Metal thickness and composition is a big question.
- All the metals are not strong enough to support the projections. Some brasses and coppers cannot be welded satisfactorily using projection welding.
- There is an extra operation which is called forming of projection.
- Projections need to have same heights for a appropriate welding.

Applications

- Tubular connections
- Attaching nuts and stud
- Sheet metal assemblies
- Tank fittings and ferrules
- Projection welding is used in refrigeration works (mass production of condensers, gratings, racks etc.)

Upset Welding

- In upset welding (UW), the pieces to be joined are brought together to mate with each other in a butt joint compared to lap joint.
- The two pieces are held tightly together and current is applied, so that the heat is generated through the contact area between the two plates.
- Because of the joint being under pressure, the ends of the two pieces get slightly upset and hence its name.
- This is useful for joining the two ends of rods or similar pieces.



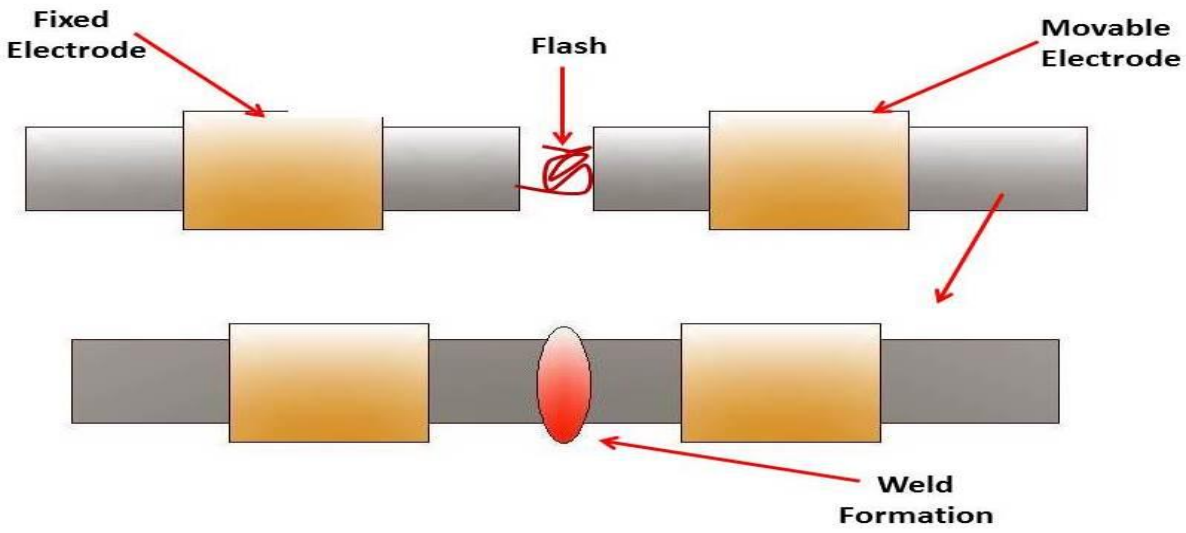
Upset Welding

Flash Butt welding

- Flash welding (FW) is similar to upset welding except that the heat required for melting is obtained by means of an arc rather than the simple resistance heating.
- The flash-welding equipment consists of essentially two platens to which the two pieces to be joined are clamped. One of the platens is fixed while the other is movable, the movement being controlled by means of a cam.
- The ends of the two pieces need not be parallel and as prepared as in the case of upset welding.

Working

- The two pieces are brought together and the power supply is switched on. A current of the range of 1000 A is supplied from the power supply to work piece material .Momentarily the two pieces are separated to create the arc to melt the ends of the two pieces. Then again the pieces are brought together and the power switched off while the two ends are fused under force. Most of the metal melted would flash out through the joint and forms like a fin around the joint.
- It is generally a faster operation compared to that of upset welding and would be automatically controlled by a cam arrangement.



Flash Butt Welding

Percussion Welding

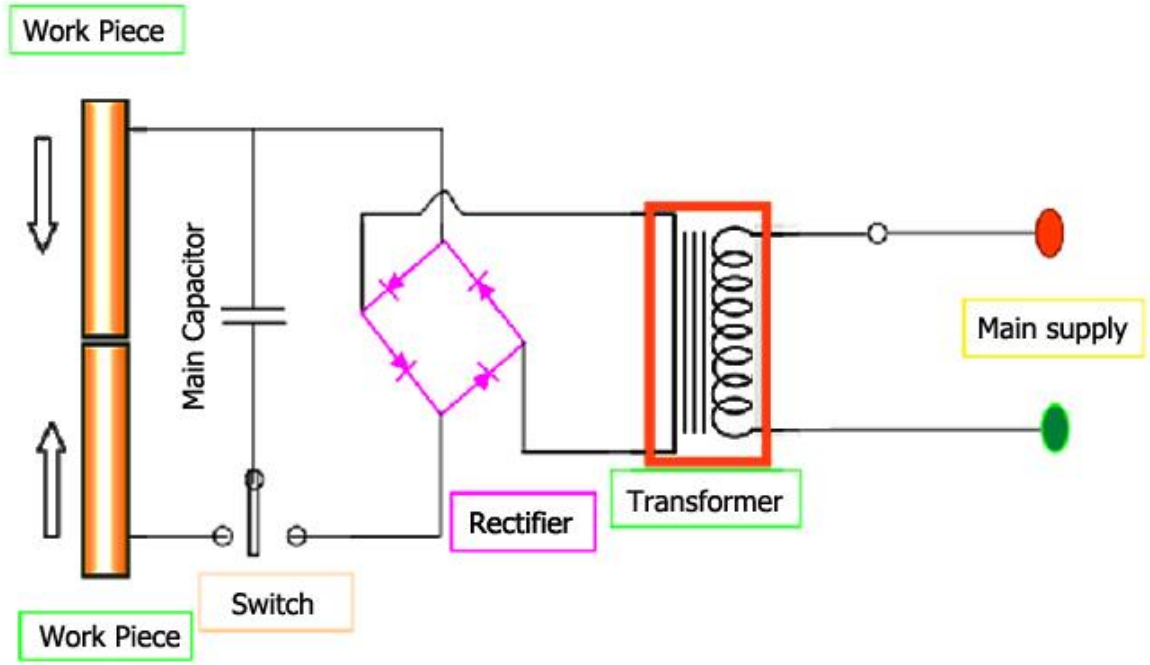
- Percussion welding is a similar process where the, heating is obtained by an arc produced by a rapid discharge of stored electrical energy, which is followed by a rapid application of force to expel the metal and produce the joint.
- In percussion welding, the arc duration is only 1 to 10 ms. while the heat is intense, it is also highly concentrated.
- Only a small amount of weld metal is produced, little or no upsetting occurs at the joint, and the heat-affected zone is quite small.
- Application is generally restricted to the butt welding of bar or tubing where heat damage is a major concern.

Working

The welding process the one part is fixed and another one clamped in slide motion. The sliding operation of work piece for using backed up with a heavy spring. During the welding process, the movable clamp is released rapidly the welding parts are 1.5 mm apart and electrical energy is discharged suddenly. In this reason intense arc generated between the surface. The sudden pressure is applied immediate following electric discharge. When the process is completed within a second time period. It welding process limited to smaller surface.

Application of percussion welding:

- It is used joining of aluminium rod, tube or bar to copper metal.
- Satellite tips to steel or non-ferrous metals.
- It used in telephone industry for connecting leaded components to terminally
- Steels or non-ferrous alloys to corrosion resistance alloy.
- Threaded steel studs to aluminium.
- Silver contact finger to copper studs



Percussion Welding

Advantages and Disadvantages of Resistance Welding:

Advantages:

- It can weld thin (0.1 mm) as well as thick (20mm) metals.
- High welding speed.
- Easily automated.
- Both similar and dissimilar metals can be weld.
- The process is simple and fully automated so does not required high skilled labor.
- High production rate.
- It is environment friendly process.
- It does not require any filler metal, flux and shielding gases.

Disadvantages:

- High equipment cost.
- The thickness of work piece is limited due to current requirement.
- It is less efficient for high conductive materials.
- High electric power required.
- Weld joints have low tensile and fatigue strength