

## UNIT II RESISTANCE WELDING PROCESSES

**Resistance Welding** is a welding process, in which work pieces are welded due to a combination of a pressure applied to them and a localized heat generated by a high electric current flowing through the contact area of the weld. **Resistance Welding Processes and Equipments** - Resistance welding is a group of welding processes wherein coalescence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part and by the applications of pressure. No filler metal is needed.

Heat produced by the current is sufficient for local melting of the work piece at the contact point and formation of small weld pool ("nugget"). The molten metal is then solidifies under a pressure and joins the pieces. Time of the process and values of the pressure and flowing current, required for formation of reliable joint, are determined by dimensions of the electrodes and the work piece metal type.

AC electric current (up to 100 000 A) is supplied through copper electrodes connected to the secondary coil of a welding transformer.

The following metals may be welded by Resistance Welding:

- Low carbon steels - the widest application of Resistance Welding Aluminum alloys
- Medium carbon steels, high carbon steels and Alloy steels (may be welded, but the weld is brittle)

### **Advantages of Resistance Welding -**

- (i) Fast rate of production.
- (ii) No filler rod is needed.
- (iii) Semi automatic equipments.
- (iv) Less skilled workers can do the job.
- (v) Both similar and dissimilar metals can be welded.
- (vi) High reliability and reproducibility are obtained.
- (vii) More general elimination of warping or distortion of parts.

### **Disadvantages of Resistance Welding -**

- (i) The initial cost of equipment is high.
- (ii) Skilled persons are needed for the maintenance of equipment and its controls.
- (iii) In some materials, special surface preparation is required.
- (iv) Bigger job thicknesses cannot be welded.

### **Applications of Resistance Welding**

Resistance welding is used for

- (i) Joining sheets, bars, rods and tubes.
- (ii) Making tubes and metal furniture.
- (iii) Welding aircraft and automobile parts.
- (iv) Making cutting tools.
- (v) Making fuel tanks of cars, tractors etc.
- (vi) Making wire fabric, grids, grills, mash weld, containers etc.

**The most popular methods of Resistance Welding are:**

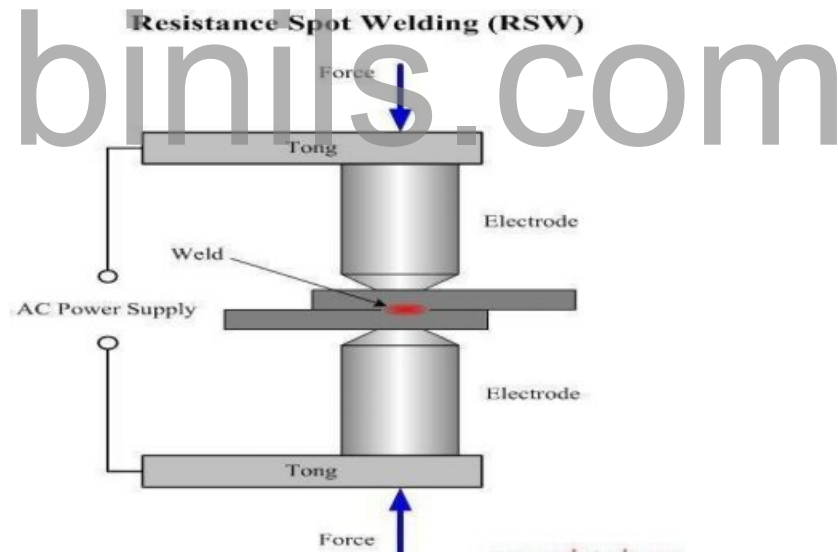
- Spot Welding (RSW)
- Projection welding (PW)
- Seam Welding (RSEW)
- Flash Welding (FW)
- Resistance Butt Welding (UW)
- Percussion welding and High frequency resistance welding processes

**Spot Welding (RSW)**

Spot welding came into use in the period 1900-1905. It is now the most widely used of resistance welding processes. Spot welding is employed for joining sheet to sheet, sheets to rolled sections or extrusions, wire to wire, etc. Spot welding is used for joining relatively light gauge parts (up to about 3 mm thick) superimposed on one another (as a lap joint).

**Definition**

Spot welding is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat generated, by resistance to the flow of electric current through workpieces that are held together under force by two electrodes, one above and the other below the two overlapping sheets.



Resistance spot welding is a process in which faying surfaces are joined in one or more spots by resistance to the flow of electric current through workpieces that are held together under force by electrodes. The contacting surfaces in the region of current concentration are heated by a short-time pulse of low-voltage, high-amperage current to form a fused nugget of weld metal. When the flow of current ceases, the electrode force is maintained while the weld metal rapidly cools and solidifies. The electrodes are retracted after each weld, which usually is completed in a fraction of a second.

The size and shape of the individually formed welds are limited primarily by the size and contour of the electrode faces. The weld nugget forms at the faying surfaces, as shown in Figure 1,

but does not extend completely to the outer surfaces. In section, the nugget in a properly formed spot weld is round or oval in shape; in plan view, it has the same shape as the electrode face (which is usually round) and approximately the same size. Spacing between adjacent spot welds or rows of spot welds must be enough to prevent shunting or to limit it to an acceptable amount.

#### **Spot Weldable Metals -**

Low carbon steel (mild steel).

(ii) Hardenable steels, which, after getting spot welded are treated in an annealing furnace.

(iii) High speed steel bits are spot welded to tool shanks for use in lathes, shapers, etc. The tool, after A. Unequal thickness; Band C Multiple thickness getting welded, is annealed before final hardening.

(iv) Stainless steels: Ferritic stainless steels behave very much as mild steel, however, the pressure should be kept a little longer after welding. Martensitic (cutlery and similar qualities) stainless steel can be treated as hardenable steel as it has pronounced air hardening qualities.

#### **Non-ferrous Metals**

(i) Aluminium

(ii) Aluminium Magnesium Alloys

(iii) Aluminium Manganese Alloys

(i), (ii) and (iii) may be spot welded satisfactorily. Oxide film on them is removed and a high capacity machine is used as aluminium is a good conductor.

(iv) Copper. For welding copper upto 1.5 mm thick, hard faced or pure tungsten (welding) electrodes are necessary.

(v) Nickel, Nickel alloys and Monel Metal require machine capacity and settings rather similar to those employed for spot welding stainless steels.

#### **5. Special alloy electrodes**

They are made up of copper-zirconium and copper-cadmium zirconium. They find applications similar to alloy (1) but where resistance to softening of the electrode face is a must.

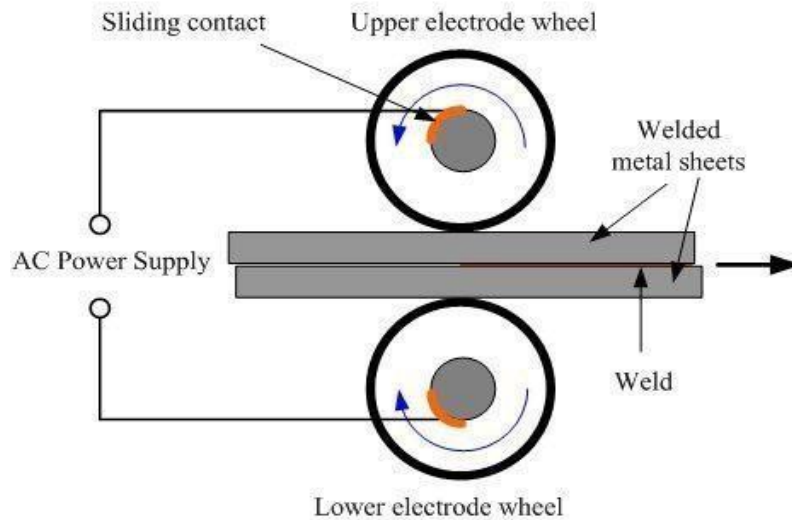
#### **RESISTANCE-SEAM WELDING (RSEW)**

**Seam Welding** is a Resistance Welding (RW) process of 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.

Resistance seam welding (RSEW) is a resistance welding process which produces coalescence at the faying surfaces the heat obtained from resistance to electric current through the work parts held together under pressure by electrodes.

The resulting weld is a series of overlapping resistance spot welds made progressively along a joint rotating the electrodes. When the spots are not overlapped enough to produce gaslight welds it is a variation known as roll resistance spot welding. This process differs from spot welding since the electrodes are wheels. Both the upper and lower electrode wheels are powered. Pressure is applied in the same manner as a press type welder. The wheels can be either in line with the throat of the machine or transverse. If they are in line it is normally called a longitudinal seam welding machine. Welding current is transferred through the bearing of the roller electrode wheels. Water cooling is not provided internally and therefore the weld area is flooded with cooling water to keep the electrode wheels cool.

### Seam Welding (RSEW)



In seam welding a rather complex control system is required. This involves the travel speed as well as the sequence of current flow to provide for overlapping welds. The welding speed, the spots per inch, and the timing schedule are dependent on each other. Welding schedules provide the pressure, the current, the speed, and the size of the electrode wheels.

This process is quite common for making flange welds, for making watertight joints for tanks, etc. Another variation is the so-called mash seam welding where the lap is fairly narrow and the electrode wheel is at least twice as wide as used for standard seam welding. The pressure is increased to approximately 300 times normal pressure. The final weld mash seam thickness is only 25% greater than the original single sheet.

Seam Welding is high speed and clean process, which is used when continuous tight weld is required (fuel tanks, drums, domestic radiators).

#### Advantages

- Gas tight as well as liquid tight joints can be made.
- The Overlap is less than spot or projection welding.
- The production of single seam weld and parallel seams can be got simultaneously.

#### Disadvantages

- The welding process is restricted to a straight line or uniformly curved line.
- The metals sheets having thickness more than 3mm can cause problems while welding.
- The design of the electrodes may be needed to change to weld metal sheets having obstructions.

#### Applications of RSEW

- Girth weld is possible in rectangular or square or even in circular shapes.

- Most of the metals can be welded (Except copper and some high percentage copper alloys)
- Butt welding can be done.

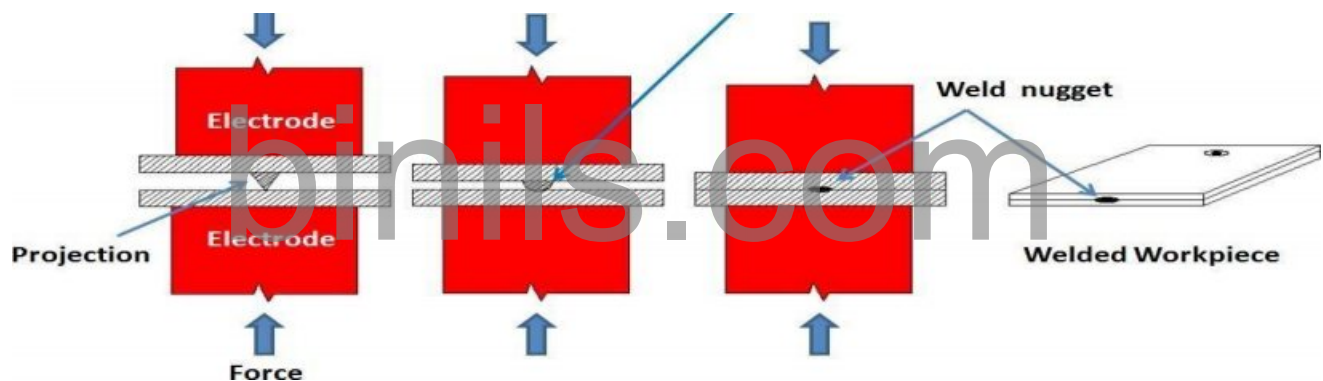
## PROJECTION WELDING

In the projection welding, as per the name, different projections are formed for effective welding. Projection Welding is one of the types of resistance welding and its working principle is quite the same as the resistance welding. The only difference here is that projection or embossed joints are used for the welding purpose.

### Working Principle

As per the definition, different projections are formed in this welding technique. Here, the metal pieces that are to be joined are kept in between the two electrodes. A larger pressure force is applied to the electrodes. As current is passed through the system, the heat formation takes place due to the internal resistance of the metal workpieces. One point that you must note down here, is that the heat generation takes place due to the internal resistance of the metal workpieces rather than an electric arc. Those projections concentrate the heat. As the pressure applied to the electrodes increases, this projection collapses and the formation of the fused weld nugget takes place. Thus, a quality weld is formed.

The exact working of the projection welding can be understood by referring the below image.



You can see in the above image that the projection means the embossed joints are formed on one of the base metals and then, these base metals are kept in between the two electrodes and force is applied perpendicular to the electrodes.

But as the applied force increases those sharp projections collapse and the formation of the weld takes place at the weld surface. The above image illustrates the formation of the weld nuggets as well as the collapsing of the sharp projections.

### Advantages

- ┆ As the above stated, this welding requires a very small supply of current and thus, it saves the electricity usage. So, less electricity requirement and a longer electrode life are the two most prominent benefits of this welding process.
- ┆ While doing spot welding there is a limitation on the thickness of the metal that has to be welded. But in this welding, almost metals of all thickness are welded.
- ┆ It can be used effectively for welding of the joints which are on the complicated locations.

- The heat balance is an important part of any welding process and this welding gives a good heat balance while welding.

### Disadvantages

- This welding process is not applicable for some types of the coppers and brasses.
- Projection formation is a quite complicated process and it takes time to form the projections. It is very difficult to form the spherical projection and a skilled person is required to form such projections. While making those projections, a height of the projection has to be maintained properly.
- This process is not applicable to all types of workpieces. The composition of the metal workpieces has to be considered while this process and it has some limitations.

### Application

As Projection welding is mostly used for the mass production. It has many applications such as:

- Automobile industry uses projection welding to a very large extent.
- This welding process is also used for the fan covers and hollow metal doors.
- It is also used for producing the compressor parts and for the semi-conductors.
- Have you heard about the diamond segment welding? In the diamond segment welding, projection welding finds its applications.

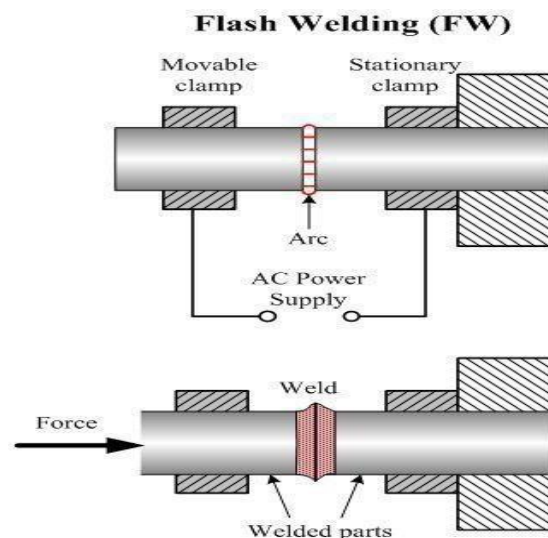
## BUTT WELDING

Welding of two pieces of metal together with a butt weld can be carried out by different resistance welding processes. The butt weld consists of joining of two pieces of metal together either on face or on edge.

It is of two types namely upset butt welding and flash butt welding.

### Flash Welding (FW)

Flash Welding is a Resistance Welding (RW) process, in which ends of rods (tubes, sheets) are heated and fused by an arc struck between them and then forged (brought into a contact under a pressure) producing a weld.





### **Construction and working of Flash Butt Welding:**

The welded parts are held in electrode clamps, one of which is stationary and the second is movable. Flash Welding method permits fast (about 1 min.) joining of large and complex parts. Welded part are often annealed for improvement of toughness of the weld. Steels, Aluminum alloys, Copper alloys, Magnesium alloys, Copper alloys and Nickel alloys may be welded by Flash Welding.

It is another type of resistance welding which is used to weld tubes and rods in steel industries. In this process, two work pieces which are to be welded will be clamped in the electrode holders and a high pulsed current in the range of 100000 ampere is supplied to the work piece material. In this two electrode holders are used in which one is fixed and other is movable. Initially the current is supplied and movable clamp is forced against the fixed clamp due to contact of these two work pieces at high current, flash will be produced. When the interface surface comes into plastic form, the current is stopped and axial pressure is increased to make joint. In this process weld is formed due to plastic deformation.

### **Application:**

1. Resistance welding is widely used in automotive industries.
2. Projection welding is widely used in production of nut and bolt.
3. Seam welding is used to produce leak prove joint required in small tanks, [boilers](#) etc.
4. Flash welding is used to welding pipes and tubes.

### **Advantages:**

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

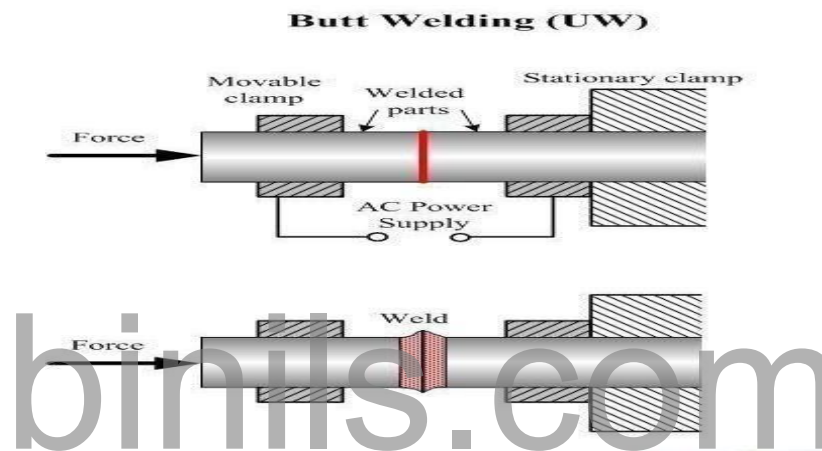
### **Disadvantages:**

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

## Resistance Butt Welding (UW)

### Construction and working:

Resistance Butt Welding is a Resistance Welding (RW) process, in which ends of wires or rods are held under a pressure and heated by an electric current passing through the contact area and producing a weld. 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. 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.



It is a resistance welding process that produces coalescence over the entire area of faying surfaces or progressively along a butt joint by the heat obtained from the resistance to the flow of welding current through the area where those surfaces are in contact. It can be used only if the parts to be welded are equal in cross-sectional area.

End to end welds, lap welds, and butt welds are included. The faces of the metal pieces to be joined are prepared for even contact. The metal pieces to be joined are fixed in clamps and butted squarely against each other and heavy current is passed through them. In this case heating is obtained by the contact resistance of the metals to be welded. When sufficient heat is developed, the pieces are rammed by force to complete the weld.

Pressure is applied either manually or with toggle mechanism. The pressure applied upsets or forges the parts together. The joint is cooled under pressure. After cooling, the force is released and the weld is completed. Upset butt welding, which has the advantage of creating no flash spatter and a smooth and symmetrical upset, is used principally on non-ferrous materials for welding bars, rods, wire, tubing, formed parts etc.

The voltage required for welding is 2-8 volts and current varies from 50 A to several hundred amperes, depending upon the material and the area to be welded at a time. The current, pressure and time may be manual or automatic controlled. The latter method is preferred in production machines. If intimate contact is not obtained because of improper joint preparation, the weld will be defective.



### Advantages

- ┆ This method is simple and does not necessary high expert labor.
- ┆ The resistance welding metal thickness is 20mm, & thinness is 0.1 mm
- ┆ Automated simply
- ┆ The rate of production is high
- ┆ Both related, & different metals can be weld.
- ┆ Welding speed will be high
- ┆ It does not need any flux, filler metal & protecting gases.

### Disadvantages

- ┆ Tools cost will be high.
- ┆ The work section thickness is limited because of the current requirement.
- ┆ It is less proficient for high-conductive equipment.
- ┆ It consumes high electric-power.
- ┆ Weld joints contain small tensile & fatigue power.

### Application

- ┆ It is used for welding metal sheets, bars, rods fittings etc.
- ┆ (ii) Flash welding finds applications in automotive and air craft products.
- ┆ (iii) It is also employed in household appliances, refrigerators and farmimplements.

### PERCUSSION WELDING:

Percussion welding (PEW) is a type of resistance welding that blends dissimilar metals together. Percussion welding creates a high temperature arc that is formed from a short quick electrical discharge. Immediately following the electrical discharge, pressure is applied which forges the materials together.

### PRINCIPLE

The pieces to be welded are held in two clamps as for flash welding. One of the clamps is stationary while the other is mounted in a slide and backed up against a heavy spring. When the movable clamps is released it advances rapidly towards the fixed clamp carrying the work piece. As the distance between the ends of the work pieces reduces to less than about 1.5 mm, then the stored electric energy causes intense arcing over the surfaces raising the temperature. As the two parts come together the arc is extinguished due to the percussion blow.

The energy required for causing the discharge may be built up either by the electrostatic method using a capacitor or by the electromagnetic method using a collapsing magnetic field linking the primary and secondary windings of an inductive device or transformer. A Protective gas shield around the weld may be provided when welds of very high quality are desired. The process is used in the butt welding of bars, rods, tubes and pipes.

These welding machines are built for automatic operation and have pre-set controlled parameters at each stage of the cycle.

### **Welding Force:**

Welding force may be applied by: Pneumatic, Electromagnetic, Spring force or Gravity (falling weights).

### **Advantages of Percussion Welding:**

- ▢ The action takes place in a very little time, usually less than 0.1 Seconds
- ▢ It causes very little damage to material close to the weld.
- ▢ Hardened surfaces may be welded without any danger of annealing.
- ▢ As the heat is concentrated at the ends of the work pieces heat balance is not much of a problem.
- ▢ Parts with different thermal conductivities or different masses can be easily welded.

### **Disadvantages of Percussion Welding:**

- ▢ The process cannot be used for welding heavy sections larger than 600 mm<sup>2</sup>.
- ▢ The process is limited to butt welded joint only

### **Applications of Percussion Welding:**

- ▢ Welding of satellite tips to tools
- ▢ Welding of Steel to Cast Iron
- ▢ Welding of Zinc to Steel
- ▢ Welding of Copper to Aluminium etc.,
- ▢ Welding of Studs
- ▢ Join a stranded wire directly to a component pin on axis

### **High Frequency Resistance Welding (HFRW)**

High frequency resistance welding (HFRW) is a resistance welding process which produces coalescence of metals with the heat generated from the resistance of the work pieces to a high-frequency alternating current in the 10,000 to 500,000 hertz range and the rapid application of an upsetting force after heating is substantially completed. The path of the current in the work piece is controlled by the proximity effect.

### **Working:**

In high frequency welding the phenomenon of 'skin effect' by which the current flows near the surface of the conductor and not through its entire thickness is utilised to weld materials at unusually high speed of upto 300 m/min. The ac with a frequency range of 100 to 500 KHz is commonly employed.

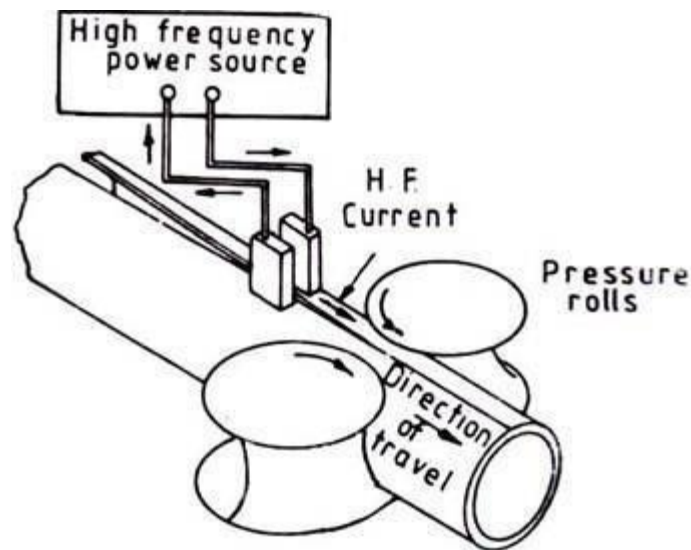


Figure shows a high frequency resistance welding setup for tube production. As shown, the two contact blocks are placed on opposite sides of the V- shaped gap and the current flows through the shortest path between the contacts and concentrates entirely at the edges of the metal. As the process employs a high voltage of about 100 volts, no difficulty is encountered in achieving good electrical contact between the contact blocks and the metal even when the material has oxide scale on it.

This process is ideally suited for making pipe, tubing, and structural shapes. It is used for other manufactured items made from continuous strips of material. In this process the high frequency welding current is introduced into the metal at the surfaces to be welded but prior to their contact with each other.

Current is introduced by means of sliding contacts at the edge of the joint. The high-frequency welding current flows along one edge of the seam to the welding point between the pressure rolls and back along the opposite edge to the other sliding contact.

The current is of such high frequency that it flows along the metal surface to a depth of several thousandths of an inch. Each edge of the joint is the conductor of the current and the heating is concentrated on the surface of these edges. At the area between the closing rolls the material is at the plastic temperature, and with the pressure applied, coalescence occurs.

#### **Applications:**

- 1) The predominant application of High-Frequency Resistance Welding is for continuous manufacturing of pipe and tubing.
- 2) These are generally prepared for welding in a continuous roll forming strip mill where the flat strip is gradually shaped to a round form.
- 3) They are used for many special joining applications of both similar and dissimilar metals and such structural shapes as I beams, H beams and T sections.

#### **Advantages:**

- 1) less effective splinting;
- 2) High current density and high efficiency due to the proximity of the contact head;
- 3) Small thermal influence range;
- 4) Small influence of pipe diameter, weldable pipes with a diameter of about 8 to 1270 mm;
- 5) Welding speeds of up to 100 to 120 m/min.

**Disadvantages :**

- 1) Consumption of the contact head;
- 2) Erosion defects;
- 3) Small heating range, rapid burning, which is unfavorable to the inner surface of the tube.

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