UNIT 3 WELDING WORKSHOP

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3.1 INTRODUCTION

Welding is a process of joining similar metals by application of heat with or without application of pressure and addition of filler material. The result is a continuity of homogeneous material, of the composition and characteristics of two parts which are being joined together. The application of welding is so varied and extensive that it would be no exaggeration to say that there is no metal industry and no branch of engineering that doesn't make use of welding in one form or another.

Objectives

After studying this unit, you should be able to

- describe what is welding,
- know the tools used in welding workshop,
- describe various types of welding processes, and
- perform different types of welding joints.

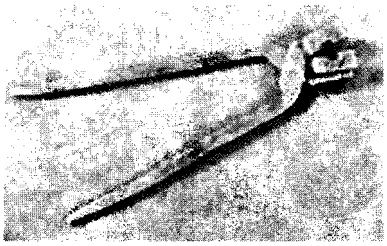
3.2 TOOLS TO BE USED IN THE WELDING WORKSHOP

Bench-Wise

The vice essentially consists of cast iron body, a fixed jaw, a movable joint all made of cast steel, a handle, a square-threaded screw, and a nut all made of mild steel. Separate cast steel plates known as jaw plates are fixed to the joitns by means of set screws and they can be replaced when worn. The holding places of the join plates have teeth for holding the work firmly. The movement of the vice is caused by the movement the screw through the nut fixed under the movable jaw and the screw is provided with a collar inside it to prevent it coming out of the jaw when resolved.

Tong

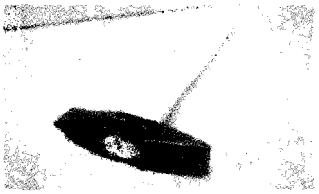
A pair of tongs is used for holding things.



Tong

Chipping Hammer

It is used to remove the iron flakes that are left behind after welding.



Chipping Hammer

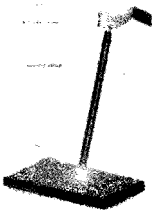
File

A file is used to rub the uneven welding or uneven surfaces. And to finish the final shape of a workpiece.

File

Electrodes

It is a rod used for welding purposes. There are several types of electrode. Non-consumable electrodes, base electrodes and coated electrodes.



Electrodes (Coated)

Welding Shield

It is a shield (screen) used to protect eyes from spark and highly luminous sparks.

Welding Shield

Hand Gloves

It is a thermally insulated pair of gloves used to protect hands from the excessive heat produced by the sparks and related injuries

Hand Gloves

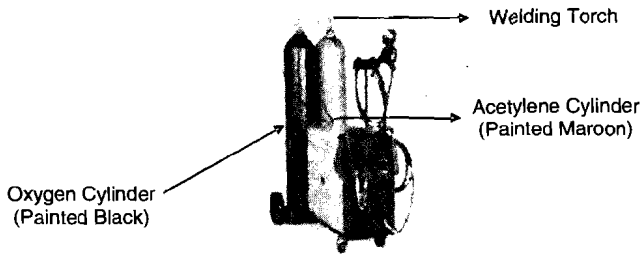
Gas Cylinders

There are two types of gas cylinders :

(a) Acetylene Cylinder (painted maroon), and

(b) Oxygen Cylinder (painted black).

These gases (i.e. cylinders) are used for gas welding (Oxy-Acetylene flame).



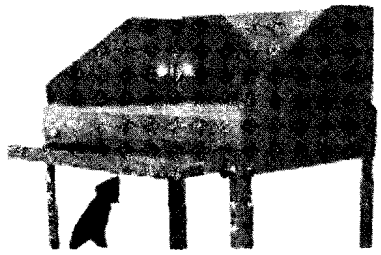
Gas Cylinder

Welding Holder

It is a holder which contains/holds the electrode used for Arc Welding.

Welding Table

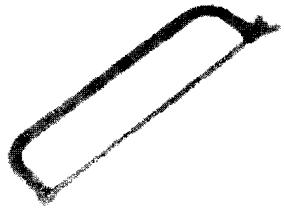
The workpiece to be welded is kept on this table. It is made of metal of very high melting point and the top contains of a perpendicular – rod system.



Welding Table

Hand Hexa

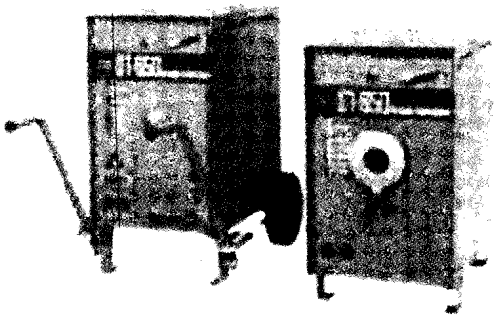
It is device which is used in fitting/bench work to cut the workpiece. The hexa is hung on two slightly hooked pegs projected from pins on a hacksaw which fits into each end of the frame.



Hand Hexa

Arc Welding Machine (Generator and Transformer)

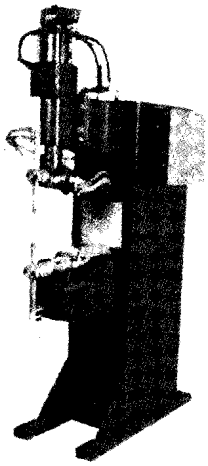
Both direct current and alternating current are used for arc welding, each having its particular application; in some cases either is suitable. DC welding supply is usually obtained from generators driven by electric motor or if no electricity is available, by internal combustion engine. For AC welding supply, transformers are predominantly used for almost all arc welding where mains electricity supply is available.



Arc Welding Machine

Spot Welding Machine

Spot Welding is employed to join overlapping strips, sheets or plates of metal at small areas. The peaces are assembled and places between two electrodes, which must posses high electrical and thermal conductivities and retain the required strength at high temperatures.



Spot Welding Machine

Seam Welding Machine

Seam Welding machine is used for seam welding which is a method of making a continuous joint between two overlapping pieces of metal sheet. The normal procedures to overlapping pieces of metal sheet. The normal procedure to make a seam weld is to place the work between the wheels which serve as conductors for producing continuous welds.

Seam Welding Machine

3.3 PRACTICE SESSION

To cut three pieces of mild steel of dimensions (8 cm × 10 cm) and weld them.

Material Required

(a) Bench-Vice

(b) Workpiece

(c) Hacksaw with hexa

(d) Ruler

(e) File

(f) AC or DC machine

(g) Electrode

(h) Electrode Holder

(i) Chipping Hammer

(j) Wire Brush

(k) Welding Screw

(l) Tong

(m) Hand Gloves

(n) Aprons, sleeves, etc.

Procedure

(a) Take the workpiece and fit it into the bench vice and cut it in dimensions of $8 \times 10\ cm^2$ with the help of a hacksaw.

(b) Rub the uneven edges of the cut-out workpieces in order to give a proper finishing to them.

(c) We now have obtained 3 workpieces of dimensions $80 \times 40\ mm^2$.

(d) Now put the uncoated end of the electrode in the welding holder Switch on the machine and now practice butt and lap joint.

Precautions

(a) Always wear an apron while working.

(b) Wear a full sleeves cotton shirt and shoes with rubber sole.

(c) Use a shield to see the spark.

3.4 EXPERIMENT NO. 1

Aim

To weld 3 pieces of dimensions 40 mm × 80 mm making butt and lap joints.

Apparatus

Welding holder, electrodes, arc-welding machine, arc-welding station, gloves, welding screen, tong and chipping hammer.

Procedures

(a) Keep two pieces side by side and make a small weld joint on the edges of the two sides. See that the pieces are uniformly joint.

(b) Make a clean welding joint by moving the electrode (held in the welding holder slowly along the joint on both sides).

(c) Now hold the pieces with a tong and chip off the flux with a chipping hammer.

(d) Now place the third piece on the other workpieces such that half of the piece lies on it.

(e) Now proceed as earlier.

Precautions

(a) Wear an apron.

(b) Wear a full sleeves cotton shirt so that sparks don't harm.

(c) Wear shoes wear a rubber sole.

(d) Use a shield to protect eyes from spark.

(e) Handle the equipments carefully.

3.5 RESISTANCE WELDING WORKSHOP

Welding

It is a process of joining similar metals by application of heat with or with out application of pressure and addition of filler material.

Resistance Welding

Metal parts to be joined can also be heated by developing the contact resistance to the flow of electric current. It is based on the well known and very well documented principle that when the electric current experiences resistance, the heat is generated.

Principle and Working of Resistance Welding

The amount of heat (H) generated is related to magnitude of electric current (I), the resistance (R) to the electric current, and the time for which the current is allowed to flow, i.e.

$$H = RT\,I^2$$

where H = Heat generated in watt hours,

T = Time in hours,

R = resistance in sums, and

I = Current in amperes.

This process utilises the contact resistance between the two metallic surfaces. When two metallic surfaces are brought into contact, only a small fraction of the apparent area is in actual metal to metal contact. When a current is passed through such an interface, all of it is carried by these tiny metallic bridges and the oxide layer in contact does not carry any current. As a result, the current flow is restricted thus resistance to flow is experienced. The resistance to current flow can be calculated with the following assumptions :

(a) All bridges are of uniform size having spherical shape of radius (r_1).

(b) All the bridges are uniform spaced (Zr_2 apart).

Assuming n bridges per unit area, then the contact resistance per unit area can be estimated from each spherical construction and considering n such paths in parallel. Each constriction (compressed local area) consists of two identical hemispheres in area. The resistance (R) to each hemisphere is given by

$$R = \frac{p\,(r_2 - r_1)}{S}$$

where p = Resistively of material,

$r_2 - r_1$ = Length of current path, and

S = Geometric mean-area of hemisphere of radii r_2 and r_1, respectively.

i.e. $$S = [(2\pi r_2^2)\,(2\pi r_1^2)]^{\frac{1}{2}} = 2\pi r_2 r_1$$

So $$R \approx \frac{P}{2\pi r_1}$$

Since, $r_2 > r_1$, hence the total contact resistance per unit area is given by

$$R_c = \left(\frac{2}{n}\right)\left(\frac{p}{2\pi r_2}\right) = \frac{p}{\pi n r_1}$$

Experiments reveal that the total contact resistance (R_c), obtained by this equation lies within ± 15% error. So the actual value of R_c can be taken as:

$$R_c = \frac{(0.85\,p)}{(\pi n r_1)}$$

So, the heat generated by the contact resistance with an applied voltage (V) is given as $\frac{V_2}{R_c}$ per unit area. Further, after a very short time (say 0.001 sec), the contact resistance drops to about $\frac{1}{10}$ of its original value because of softening of material, thereby the value (πr_1) increases.

Resistance welding can be explained on the above basis, where the metal parts are heated to a plastic state over a limited area by their resistance to the flow of current and then mechanical pressure is applied to accomplish the weld. Obviously, the current must be higher. The interface between the two surfaces of work-piece offers the greatest resistance to current flow in comparison to the compete circuit and therefore, the interface area become the area of greatest heat.

The main types of resistance welding are :

(a) Spot welding

(b) Butt welding

(c) Seam welding

(d) Projection welding

(e) High Frequency welding

(f) Percussion welding

The temperature is controlled by controlling the magnitude of welding current and timing. Current of the order of 3000-100000 amps is required to heat the metal pieces to their plastic state. Such a magnitude of current can be obtained from a step down transformer. As current density is increased, welding time can be decreased. Rest continued in applications of resistance welding under point 1, 2, 3 and 4.

Advantages of Resistance Welding

(a) It is faster.

(b) It permits more accurately, regulated application of heat.

(c) Mechanical pressure is used to forge the weld, resulting in a fine grain structure and good mechanical properties comparable to parent metal.

(d) No filler material and flues are used.

SPOT Welding

Conventionally, spot welding is employed to weld over lapping work pieces up to the thickness of 5 mm. Spot welding can be done in overlapping strips, sheets, wires, plates, etc. Spot welding process consists of clamping two or more metallic pieces over lapping each other between the two water-cooled copper electrodes, since copper has high electrical and thermal conductivity. The pressure is being applied for a very shot period through these electrodes with the help of mechanically operated air pressure or hydraulic of cylinder, and then a high current (40 amps or more) obtained with the help of transformer for a very short duration (fraction of a second). At the place of pressure and high current, a local fusion takes place at the interface. The interfaces to be joined must be initially cleaned (mechanically as well as chemically). A spot weld so obtained normally contains more porosity at the weld center, which is harmless if not in excess.

Obviously, the electrodes should be sufficiently strong to retain their shape, strength at high temperature and pressure, since the electrodes are subjected to service conditions of temperature and pressure during its operation. So, depending on its use, the electrode may be made of pure copper (for limited service life), copper alloys, copper + tungsten + chromium alloy (good for continuous working). Water is circulated through electrodes to avoid overheating, and to cool weld. Pressure, Welding time, hold time are the basic factors controlling the success of spot welding.

Before any pressure is applied, one must ensure that there is no contamination between the pieces of metal to be lapped. Now place the pieces between the pieces of metal to be lapped. Now place the pieces between the copper electrodes of the spot welder. The pressure time or squeeze time helps the two work pieces to bring together in intimate contact just prior to current flow. The surfaces of the contact area mist be uniform to have intimate contact on the application of pressure. The resistance (R) at the joint interface is inversely proportional to applied pressure P (R proportional to $\frac{1}{p}$) i.e. heat is proportional to resistance. It means if the pressure is too high, the required resistance will be too low and similarly the high amount of heat spot will be generated, owing to high resistance for effective welding, high heat and pressure are required so the equipment is usually massive. If a series of spot welds are to be made, obviously then a higher current is necessarily to each subsequent spot in view of the shot circulation provided by the preceding welds. Weld time is the time period through which the current flows during welding completion. This is usually in fraction of second, i.e. spot weld can be made in two 1.6 mm thick plates of mild steel in 0.3 sec.

Low carbon steels offer no metallurgical problems during spot welding. Once the weld nugget is formed, the metal passes austenite back to pearlite. But high carbon steels when spot welded the rapid cooling of weld nuggets may become brittle, so proper treatment should be given to ensure success.

Hold Time is basically cooling period i.e. interval from the end of current flow to the electrode lift water cooled electrodes serve to transfer the heat rapidly. Power supply is an important component forth success of spot welding.

There are two basic types of power source required for spot welding, i.e. stored and direct energy. The stored energy machines draw low currents at relatively constant rate and store it (bank of capacitors), so it can be discharged instantaneously when needed to make a weld variation in the line voltage has almost on the efficiency of machines.

Table 3.1

Sheet Thickness (mm)	Tip-dia O_1D_1	Electrode Force (M Pa)	Weld Cycles Needed (Number)	Amperes	Dia of Fused Zone (mm)	Min Spacing (mm)
0.5	9.5	2.00	6	6500	3.3	9.5
0.875	9.5	2.45	8	9500	4.32	12.7
1.2	12.7	4.48	10	10500	4.82	19.00
1.5	12.7	5.5	14	12000	6.35	25.4
1.88	15.8	7.6	17	14000	7.1	31.75
2.25	15.8	8.96	20	15000	7.6	30.1
2.65	15.8	11.00	23	17500	7.87	41.28
3.00	22.2	12.4	26	19000	8.13	44.5

Direct Energy Machines have the advantage of both lower initial cost and lower maintenance cost. The current which is use for spot welding, may be make to build up gradually (up slope) and after a very short interval, decreases gradually (down slope) up slope gives the electrodes a few impulse of time to sink into the metal and seat before they got the full current to weld. Incase of soft materials, over heating occurs at the electrode tip and thus a small amount of metal is transferred from parent material to the tip surface. The down slope controls the cooling action and ensures proper temperature. During this period, if the applied pressure is high, forging action will take place.

The spots should not be so close that current is shunted to the previous weld, thus reducing the size of weld being made. A general rule is to allow 16 t distance between the welds (t = thickness of metallic plate).

Advantage

(a) Low cost

(b) High speed of welding

(c) Dependability

(d) Less skilled worker needed

(e) No distortion

(f) No edge preparation except cleaning

Applications

(a) As a replacement of riveting.

(b) In automobile body, and

(c) Aircraft, etc.

3.6 SEAM WELDING

Basically, it is a continuous type of spot welding over two overlapping pieces of sheet metal. Instead of using pointed electrodes, the work is allowed to pass between the copper alloy wheels or rollers which act as electrodes. These rollers also apply the desired pressure and the seam of welds is prepared by making high intensity current off

and on continuously i.e. the gas filled electronic tubes are used to make and break the circuit. Thus series of overlapping spot welding joints are obtained, this resembles to stitches. Seam welding can be produced such that even water and gas tight joints can be developed. Intermitted spots or overlap spots can be controlled by rolls. Steel plates of 10 mm thick have been seam welded to hold about 200 kg/sq. cm pressure. Pressure tight and leak proof tanks or pressure vessels can be easily fabricated. Sometimes cooling water is used to cool down the welded plates.

Applications of Resistance Welding

(a) In resistance welding electrical pressure or voltage from either 120 or 240 V is reduced down to 4 to 12 volts, depending on the composition, area, thickness, etc. of the metal being welded. The amount of power supplied to the weld usually ranges from about 6 to 18 kW for each cm^2 of area. Alternating current has been found most convenient for this purpose as it is possible to obtain any desired combination of current and voltage be using a suitable transformer.

(b) The machine used for making resistance welds contains a transformer, a clamping device for holding the pieces, and a mechanical means for forcing the pieces together to complete the weld. In machines which are operated continuously the electrodes are cooled by water circulating through hallow electrodes.

(c) Resistance welding, which is used with sheet metal from 0.5 to 3.2 mm thick and with steel pipe and tubing is employed mainly for mass production, because of the type of equipment required for its application. Metals of medium and high resistance, such as steel, stainless steel, monel metal and silicon bronze, are easy to weld.

(d) High frequency resistance welding is done with 400 to 450 kV current readily breaks through oxide film barriers and produces an thin heat affected zone because it travels on the surface of the material.

(e) Spot welding method is used for fabricating all types of sheet metal structures where mechanical strength rather than water or air tightness is required. This may be applied to all types of boxes cans, enclosing cases, etc.

(f) Spot welding machines are made in capacities from 10 to 150 kVA.

(g) Steel plates 10 mm thick are usually seam welded to hold about 200 kg/cm^2 (20000 Kn/m^2) pressure.

(h) Seam welding is used on many types of pressure tight or leak proof tanks for various purposes and numerous other products.

Precautions needed in Welding Shop (Resistance Welding Shop)

(a) To obtain good welds, the sheet metal should be free of foreign matter and scale. Films of any type have a tendency to cause variations in surface resistance and also increase the heating effect of the metal in contact with the electrodes.

(b) Thoroughly check the circuit of electric welding before use. Check polarity, earth, etc.

(c) Use of proper current etc is essential for proper welding and also for safety of the operator.

(d) Use of shield is essential for eye production. Hand gloves should be used for hand protection. Use of leather apron for body protection is also essential.

(e) Cables must be protected against mechanical damage and loose connections.

(f) Use of defective electrode holder should be avoided.

Welding Parameters

(a) Electrode diameter to be used $= 5\sqrt{t}$

$\therefore$ For 1.5 mm mild steel plate, electrode diameter $= 5 \times 1.22 = 6.1$ mm.

(b) Weld nugget to be employed $= 6\sqrt{t}$

$\therefore$ For 1.5 mm mild steel plate, nugget diameter $= 6 \times 1.22 = 7.32$ mm.

(c) Current density employed in welding

(Voltage use for mild steel = 480 V)

$$J = 192 + Ve^{-t}$$

$\therefore$ For 1.5 mm mild steel plate, the current density $= 192 + 480 \times e^{-1.5} = 234$.

(d) Overlap

$$= 2.5 + 2t$$

$\therefore$ For 1.5 mm thick mild steel plate, overlap = 5.5 mm.

(e) Weld spacing

$$= 48t$$

$\therefore$ For 1.5 mm thick mild steel plate weld spacing = 72 mm.

3.7 EXPERIMENT NO. 2

Aim

To join two metal sheets of 1.5 mm thickness through the spot welding.

Apparatus

Two metal sheets of thickness 1.5 mm and length 100 mm, sand paper, spot welding machine.

Procedure

(a) Initially cut two mild steel sheets of length 100 mm each using a hammer and chisel.

(b) Clean using a hammer and chisel.

(c) The face surface of the sheets are being finally rubbed with a sand paper.

(d) Then the welding parameters according to the thickness of the sheet are calculated.

(e) Then the two sheets are made to overlap up to correct length and finally the overlap region is placed between the electrodes.

(f) As the electrodes are being pressed with the help of paddle the circuit gets completed & a nugget is ground due to heat offered due to resistance between the sheets.

Precautions

(a) Welding parameters play an important role in deciding the quality of weld, so must be calculated properly.

(b) The paddle faces at the sheet must be properly cleaned with the help of sand paper.

(c) The paddle must be kept pressed until whole of the nugget formation takes place.

Result

The mild steel sheets have been perfectly joined by the spot welding process.

3.8 EXPERIMENT NO. 3

Aim

To join two metal sheets of 1.5 mm thickness through seam welding process.

Apparatus

Two metal sheets of thickness 1.5 mm and length 100 mm; sand paper; seam welding machine.

Procedure

(a) Initially cut two mild steel sheets of lengths 100 mm each using a hammer and a chisel.

(b) The edges of the sheet are made smoothly by a file.

(c) Then the welding parameters according to the thickness of the sheet are calculated and set in the welding machine.

(d) Then the two sheets are made to overlap.

(e) As the electrodes get passed through paddle, the circuit gets completed and a continuous seam joint is sustained.

Precautions

(a) Welding parameters play an important role in deciding the quality of weld; so it must be calculated properly.

(b) The paddle must be kept pressed while whole of the nugget formation takes place.

(c) The paddle faces of the sheet must be properly cleaned with the help of a sand paper.

Result

The two mild steel sheets have been perfectly joined through seam welding process.

3.9 SEAM WELDING ELECTRODES

Seam welding electrodes are generally in the form of wheels and are some times referred to a seam welding wheels. An exception to this is when a flat anvil or mandrel is used on one side with a wheel on the other. In either case however the actual application is essential the same as spot welding and the electrode materials are generally the same. Only the shape is changed.

Seam welding wheels are at two types one for knurl or friction roll driven machines and other for gear or idling applications. The essential difference between the two types is their thickness and welding face contour or shape. Knurl or friction roll driven wheel must fit the knurl contour or shape knurl driven wheels are used principally on coated stock, because during the welding operation, the coating sticks or alloys to the roll breaks up this coating. The friction drive rolls are the same as the knurled roll hot with the knurling omitted. Both however are so constructed as to continually dress the sides of the wheel thus preventing mushrooming and maintaining uniform face width. Gear driven or idling wheels are sometimes provided with an idling knurling tool to perform this same function.

Role of Electronic in welding Technology

Control of Automated Machines

The factors that usually need to be controlled are the sequence of movements the speed of movement and in some cases the path followed by the mechanisms. The control of the sequence of movements can be ob-

by sending trigger signals from a microprocessor system such as a computer or a programmable logic controller to the control values or motors at the machine. However the speed and path control is more complex and usually involves control of electric current to a motor for electronically powdered systems or to a value which subsequently regulates. The flow of fluid in systems that are fluid powdered.

Feedback devices

These devices used widely in soft automation systems provide feedback information on displacement and speed of the controller.

A potentiometer is used to provide information an angular displacement. A tact generator operates as a motor in reverse, i.e. it generates a current when its coils are rotated in a magnetic field.

A microprocessor based controller is used mainly with these devices. Encoders are of two types, the incremental encoder and the absolute encoder. Bar coding is the most widely used and familiar method due to its versatility. In this type of system numeric or alpha numeric information is represented as a series at bars at varying thickness and separations. They are quiet ubiquitous and you will see them on sweet wrappers, newspapers, pre-packed food, etc.