WELDING

15·1 Introduction

The welding is a process of joining two similar or dissimilar metals by fusion, with or without the application of pressure and with or without the use of filler metal. The fusion of metal takes place by means of heat. The heat may be obtained from blacksmith's fire, electric arc, electrical resistance or by chemical reaction.

The process of joining similar metals by melting the edges together, without the addition of filler metal, is called *autogenous welding*.

The process of joining similar metals with the help of filler rod of the same metal is called *homogeneous welding*.

The process of joining dissimilar metals using filler rod is called *heterogenous welding*. The filler rod material is such that its melting point is less than the parent metals.

The welding is extensively used in fabrication as an alternative method for casting or forging and as a replacement for bolted and riveted joints. It is also used as a repair medium *e.g.*, to reunite metal at a crack to build up a small part that has broken off such as gear tooth or to repair a worn surface such as bearing surface.

15·2 Weldability

The term 'weldability' may be defined as the property of a metal which indicates the ease with which two similar or dissimilar metals are joined by fusion with or without the application of pressure and with or without the use of filler metal.

Strictly speaking, a metal has good weldability if it can be easily welded in a fabricated structure. The various factors affecting the weldability of a metal are :

1. Composition of the metal.
2. Brittleness and strength of the metal at elevated temperatures.
3. Thermal properties of the metal.
4. Welding techniques, fluxing material and filler material.
5. Proper heat treatment before and after the deposition of the metal.

The common metals having weldability in the descending order are iron, carbon, steel, cast iron, low alloy steels and stainless steel.

5.1 WELDING PROCESS

Welding is a fabrication process in which two or more workpieces, usually metals, are joined permanently to form a single component. Apart from metals, thermoplastics can also be joined together by welding process. Welding is carried out by heating the edges of the workpieces to a suitable temperature and then fused together with or without the application of pressure. Since a slight gap usually exists between the edges of the workpieces, a *filler metal* is used to supply additional material to fill the gap. But, welding can also be carried out without the use of filler metal. The filler metal is melted in the gap, combines with the molten metal of the workpiece, and upon solidification forms an integral part of the weld.

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5.2. PRINCIPLE OF WELDING

An ideal joint between two pieces of metal or plastic can be made by heating the workpieces to a suitable temperature. In other words, on heating, the materials soften sufficiently so that the surfaces fuse together. The bonding force holds the atoms, ions or molecules together in a solid. This *bonding on contact* is achieved only when:

- the contaminated* surface layers on the workpiece are removed,
- recontamination is avoided, and
- the two surfaces are made smooth, flat and fit each other exactly.

In highly deformable materials, the above factors can be achieved by rapidly forcing the two surfaces of the workpiece to come closer together so that plastic deformation makes their shape conform to each another; at the same time, the surface layers are broken up, allowing the intimate contact needed to fuse the materials. This was the principle of the first way known to weld metals; by hammering the pieces together while they are in hot condition.

* *Workpiece surfaces are often chemically contaminated by dirt, grease, oxides etc. Most metals are very reactive; and in air, they become coated with an oxide layer or with adsorbed gas. This layer prevents intimate contact from being made between the two metal surfaces.*

Deformation of the surfaces can be done by rubbing the two surfaces against each other or by heating the metals and pressing them (by applying force) against a suitable material to fuse, But in most of the applications, the size, shape, location, or properties of the material restricts it to be plastically deformed. In such cases, the edges of the parts to be joined are brought together, melted and fused to each other. Coalescence takes place wherein molten metal from one workpiece merge with molten metal of another workpiece. When the coalesced liquid solidifies, the two workpieces join together to form a single component.

15·4 Types of Welding

The welding is broadly divided into the following two groups :

1. *Forge or pressure welding.* In forge or pressure welding (also known as plastic welding), the workpieces are heated to plastic state (except for cold pressure welding) and then the workpieces are joined together by applying pressure on them. In this case no filler material is used. The forge or pressure welding is further classified as follows :

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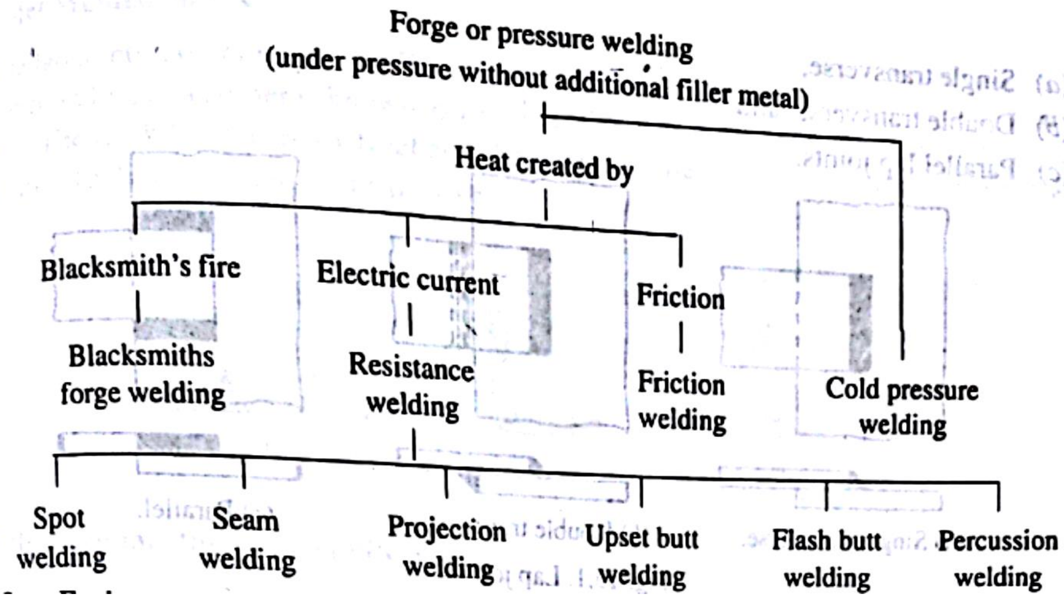
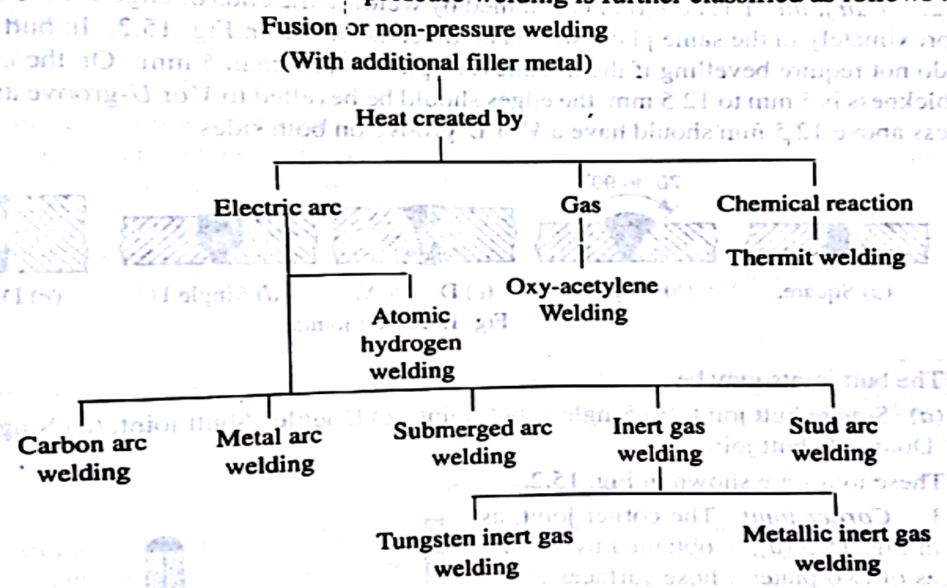


2. *Fusion or non-pressure welding*. In fusion or non-pressure welding, the edge of workpieces to be joined and the filler material are heatd to a temperature above the melting point of the metal and then allowed to solidify. The fusion or non pressure welding is further classified as follows :



15·5 Cold Pressure Welding

This is a modern process and has been developed during recent years. In this process certain similar and dissimilar metals are joined without any source of heat. The two parts to be welded are subjected to high pressure which results in inter-surface molecular fusion of the parts to be joined. This process is mainly used for welding non-ferrous metals particularly aluminium and copper.

15·6 Types of Welded Joints

The relative positions of the two pieces being joined determine the type of joint. The following are the five basic types of joints commonly used in fusion welding.

1. *Lap joint*. The lap joint is obtained by over lapping the plates and then welding the edges of the plates. These joints are employed on plates having thickness less than 3 mm. The lap joints may be

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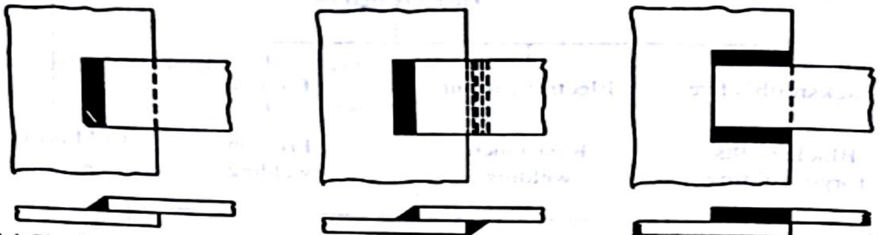
(*a*) **Single transverse,**
(*b*) **Double transverse, and**
(*c*) **Parallel lap joints.**



(*a*) Single transverse. (*b*) Double transverse. (*c*) Parallel.

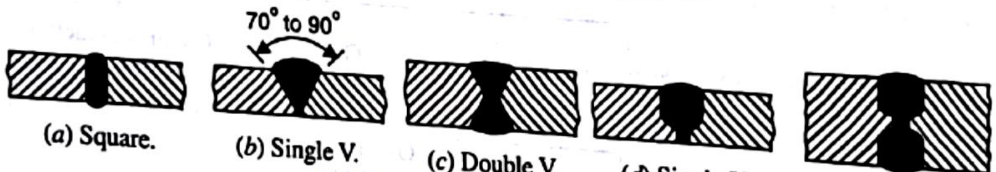
Fig. 15.1. Lap joints.

The lap j...

Fig. 15.1. Lap joints.

The lap joints are shown in Fig. 15.1. A single transverse lap joint has the disadvantage that the edge of the plate which is not welded can buckle or warp out of shape.

2. *Butt joint*. The butt joint is obtained by welding the ends or edges of the two plates which are approximately in the same plane with each other as shown in Fig. 15.2. In butt welds, the plate edges do not require bevelling if the thickness of plate is less than 5 mm. On the other hand, if the plate thickness is 5 mm to 12.5 mm, the edges should be bevelled to *V* or *U*-groove and plates having thickness above 12.5 mm should have a *V* or *U*-groove on both sides.



(*a*) Square. (*b*) Single V. (*c*) Double V. (*d*) Single U. (*e*) Double U.

Fig. 15.2. Butt joints.

The butt joints may be

(*a*) Square butt joint, (*b*) Single *V*-butt joint, (*c*) Double *V*-butt joint, (*d*) Single *U*-butt joint, and (*e*) Double *U*-butt joint.

These joints are shown in Fig. 15.2.

3. *Corner joint*. The corner joint, as shown in Fig. 15.3 (*a*), is obtained by joining the edges of two plates whose surfaces are at an angle of approximately 90° to each other. It is used for both light and heavy gauge sheet metal. In some cases corner joint can be welded, without any filler metal, by melting off the edges of the parent metal.

(*a*) Corner joint. (*b*) Edge joint. (*c*) T- joint.

Fig. 15.3

4. *Edge joint*. The edge joint, as shown in Fig. 15.3 (*b*), is obtained by joining two parallel plates. It is economical for plates having thickness less than 6 mm. This joint is unsuitable for members subjected to direct tension or bending.

5. *T-joint*. The T-joint, as shown in Fig. 15.3 (*c*) is obtained by joining two plates whose surfaces are approximately at right angles to each other. It is widely used to weld stiffeners in air craft and other thin walled structures. These joints are suitable upto 3 mm thickness.

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15·18 Arc Welding

The arc welding is a fusion welding process in which the welding heat is obtained from an electric arc between the work (or base metal) and an electrode. The electric arc is produced when two conductors of an electric circuit are touched together and then separated by a small distance, such that there is sufficient voltage in the circuit to maintain the flow of current through the gaseous medium (air). The temperature of heat produced by the electric arc is of the order of 6000°C to 7000°C.

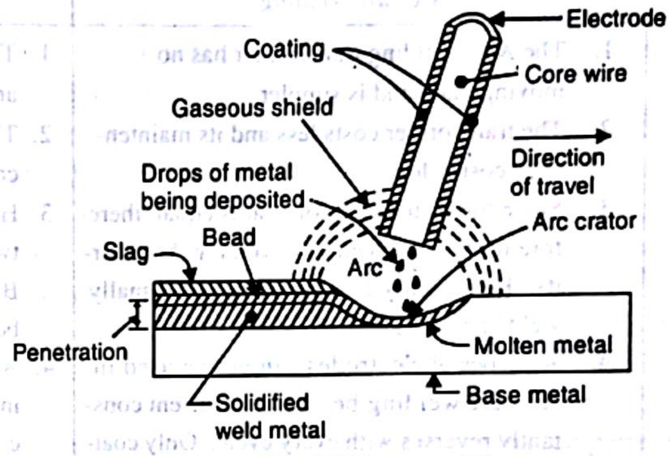


Fig. 15.14. Arc welding.

The most common method of arc welding is with the use of a metal electrode which supplies filler metal. The welding is done by first making contact of the electrode with the work* and then separating the electrode to a proper distance to produce an arc. When the arc is obtained, intense heat so produced quickly melts the work under the arc forming a pool of molten metal which seems to be forced out of the pool by the blast from the arc, as shown in Fig. 15.14. A small depression is formed in the work and the molten metal is deposited around the edge of this depression, which is called the *arc crator*. The slag is brushed off after the joint has cooled. The arc, once started, should be advanced at a uniform speed along the desired line of welding. The melting should reach to a sufficient depth below the original surfaces of the metal pieces to be joined to obtain the desired weld. This is known as obtaining *proper penetration*.

Both the direct current (D.C.) and alternating current (A.C.) arc used for arc welding. The direct current supply for arc welding is usually obtained from a generator driven by either an electric motor or a petrol or diesel engine. The alternating current supply for arc welding is obtained from a step down transformer which receives current from the supply mains at 200 to 440 volts and transforms it to the voltage actually required (*i.e.*, 80 to 100 volts) for striking the arc only. In order to maintain the arc, a still lower voltage say about 30 to 40 volts is required. The voltage required in case of D.C. welding is 60 to 80 volts for striking the arc and 15 to 25 volts for maintaining the arc.

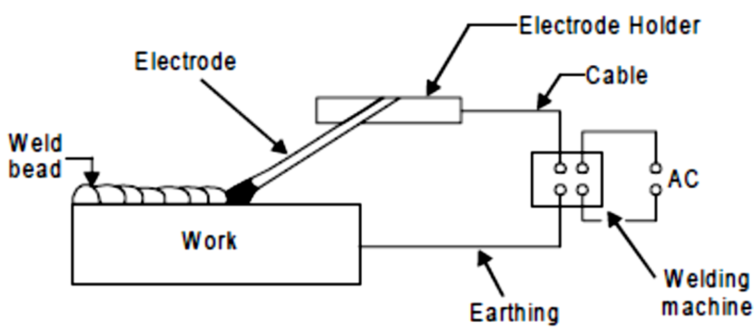
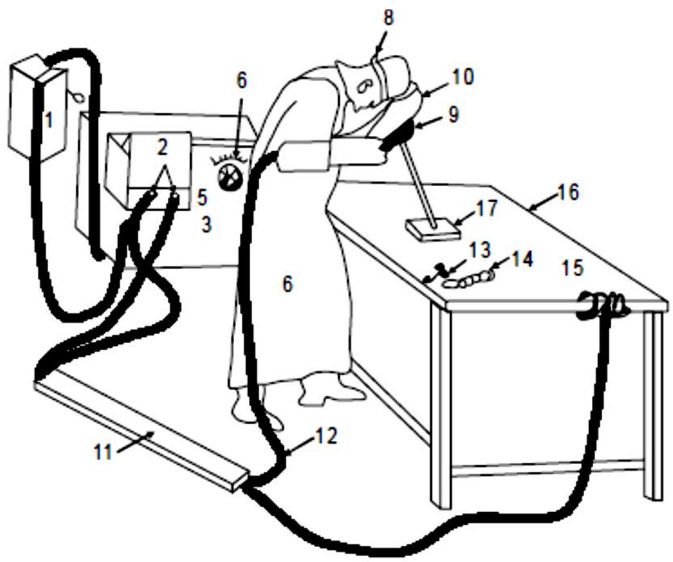


Fig. 17.9(a) Principle of arc welding



(1) Switch box.
(2) Secondary terminals.
(3) Welding machine.
(4) Current reading scale.
(5) Current regulating hand wheel.
(6) Leather apron.
(7) Asbestos hand gloves.
(8) Protective glasses strap.
(9) Electrode holder.
(10) Hand shield.
(11) Channel for cable protection.
(12) Welding cable.
(13) Chipping hammer.
(14) Wire brush.
(15) Earth clamp.
(16) Welding table (metallic).
(17) Job.

Fig. 17.9(b) Arc welding process setup

17.6.1 Arc Welding Equipment

Arc welding equipment, setup and related tools and accessories are shown in Fig. 17.9. However some common tools of arc welding are shown separately through Fig. 17.10-17.17. Few of the important components of arc welding setup are described as under.

1. Arc welding power source

Both direct current (DC) and alternating current (AC) are used for electric arc welding, each having its particular applications. DC welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines. For AC welding supply, transformers are predominantly used for almost all arc welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normal open circuit welding voltage (50-90 volts). The following factors influence the selection of a power source:

1. Type of electrodes to be used and metals to be welded
2. Available power source (AC or DC)
3. Required output
4. Duty cycle
5. Efficiency
6. Initial costs and running costs
7. Available floor space
8. Versatility of equipment

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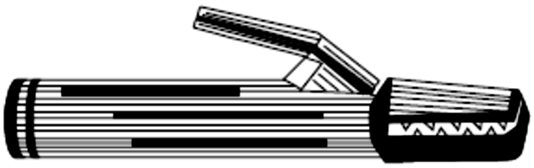


Fig. 17.10 Electrode holder

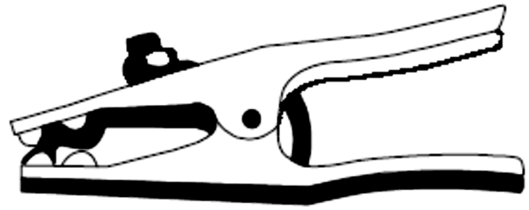


Fig. 17.11 Earth clamp

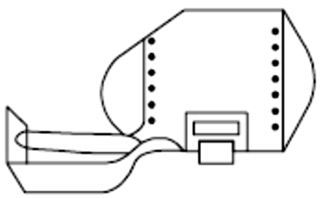


Fig. 17.12 Hand screen

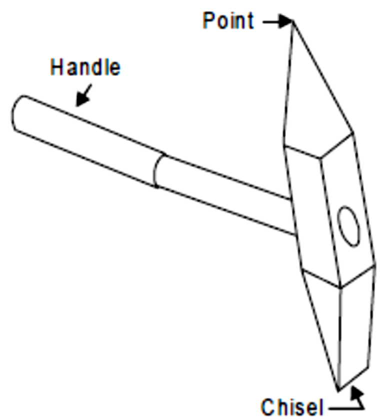


Fig. 17.13 Chipping and hammer

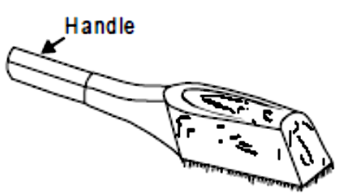


Fig. 17.14 Wire brush

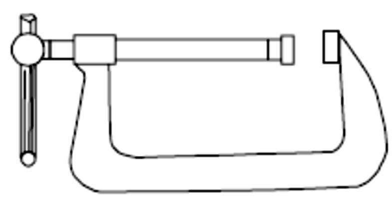


Fig. 17.15 C-clamp

2. Welding cables

Welding cables are required for conduction of current from the power source through the electrode holder, the arc, the workpiece and back to the welding power source. These are insulated copper or aluminium cables.

3. Electrode holder

Electrode holder is used for holding the electrode mannually and conducting current to it. These are usually matched to the size of the lead, which in turn matched to the amperage output of the arc welder. Electrode holders are available in sizes that range from 150 to 500 Amps.

5. Hand Screen

Hand screen (Fig. 17.12) used for protection of eyes and supervision of weld bead.

6. Chipping hammer

Chipping Hammer (Fig. 17.13) is used to remove the slag by striking.

7. Wire brush

Wire brush (Fi. 17.14) is used to clean the surface to be weld.

8. Protective clothing

Operator wears the protective clothing such as apron to keep away the exposure of direct heat to the body.

17.5 GAS WELDING PROCESSES

A fusion welding process which joins metals, using the heat of combustion of an oxygen /air and fuel gas (i.e. acetylene, hydrogen propane or butane) mixture is usually referred as 'gas welding'. The intense heat (flame) thus produced melts and fuses together the edges of the parts to be welded, generally with the addition of a filler metal. Operation of gas welding is shown in Fig. 17.5. The fuel gas generally employed is acetylene; however gases other than acetylene can also be used though with lower flame temperature. Oxy-acetylene flame is the most versatile and hottest of all the flames produced by the combination of oxygen and other fuel gases. Other gases such as Hydrogen, Propane, Butane, Natural gas etc., may be used for some welding and brazing applications.

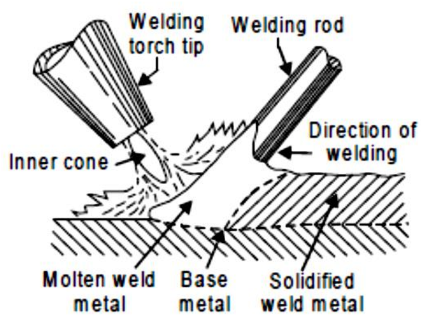


Fig. 17.5 Gas welding operation

17.5.1 Oxy-Acetylent Welding

In this process, acetylene is mixed with oxygen in correct proportions in the welding torch and ignited. The flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal. The oxy-acetylene flame reaches a temperature of about 3300°C and thus can melt most of the ferrous and non-ferrous metals in common use. A filler metal rod or welding rod is generally added to the molten metal pool to build up the seam slightly for greater strength.

17.5.1.1 Types of Welding Flames

In oxy-acetylene welding, flame is the most important means to control the welding joint and the welding process. The correct type of flame is essential for the production of satisfactory welds. The flame must be of the proper size, shape and condition in order to operate with maximum efficiency. There are three basic types of oxy-acetylene flames.

1. Neutral welding flame (Acetylene and oxygen in equal proportions).

2. Carburizing welding flame or reducing (excess of acetylene).
3. Oxidizing welding flame (excess of oxygen).

The gas welding flames are shown in Fig 17.6.

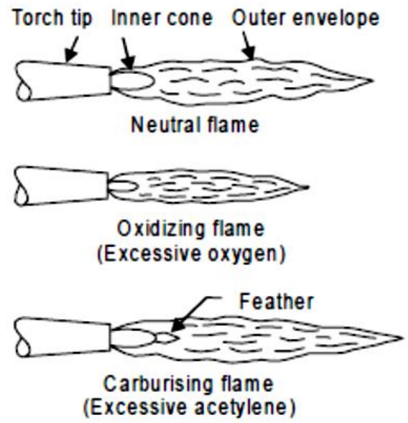


Fig. 17.6 Gas welding flames

Neutral Welding Flame

A neutral flame results when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip. The temperature of the neutral flame is of the order of about 5900°F (3260°C). It has a clear, well defined inner cone, indicating that the combustion is complete. The inner cone is light blue in color. It is surrounded by an outer flame envelope, produced by the combination of oxygen in the air and superheated carbon monoxide and hydrogen gases from the inner cone. This envelope is Usually a much darker blue than the inner cone. A neutral flame is named so because it affects no chemical change on the molten metal and, therefore will not oxidize or carburize the metal. The neutral flame is commonly used for the welding of mild steel, stainless steel, cast Iron, copper, and aluminium.

Carburising or Reducing Welding Flame

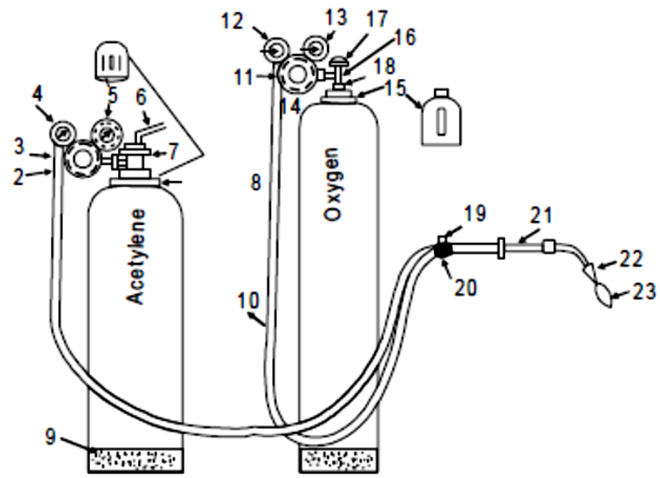
The carburizing or reducing flame has excess of acetylene and can be recognized by acetylene feather, which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in color. With iron and steel, carburizing flame produces very hard, brittle substance known as iron carbide. A reducing flame may be distinguished from carburizing flame by the fact that a carburizing flame contains more acetylene than a reducing flame. A reducing flame has an approximate temperature of 3038°C. A carburizing-flame is used in the welding of lead and for carburizing (surface hardening) purpose. A reducing flame, on the other hand, does not carburize the metal; rather it ensures the absence of the oxidizing condition. It is used for welding with low alloy steel rods and for welding those metals, (e.g., non-ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

Oxidising Welding flame

The oxidizing flame has an excess of oxygen over the acetylene. An oxidizing flame can be recognized by the small cone, which is shorter, much bluer in color and more pointed than that of the neutral flame. The outer flame envelope is much shorter and tends to fan out at the end. Such a flame makes a loud roaring sound. It is the hottest flame (temperature as high as 6300°F) produced by any oxy-fuel gas source. But the excess oxygen especially at high temperatures tends to combine with many metals to form hard, brittle, low strength oxides. Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance. For these reasons, an oxidizing flame is of limited use in welding. It is not used in the welding of steel. A slightly oxidizing flame is helpful when welding (*i*) Copper-base metals (*ii*) Zinc-base metals and (*iii*) A few types of ferrous metals such as manganese steel and cast iron. The oxidizing atmosphere in these cases, create a base-metal oxide that protects the base metal.

17.5.1.2 Gas Welding Equipments

An arrangement of oxy acetylene welding set up is shown in Fig.17.7. The basic tools and equipments used for oxy-acetylene welding are following:



1. Acetylene hose
2. Adjusting screw
3. Acetylene regulator
4. Regulator outlet pressure gauge
5. Cylinder pressure gauge
6. Valve wrench
7. Acetylene cylinder valve
8. Cylinder cap
9. Fusible plugs
10. Oxygen hose
11. Oxygen regulator
12. Regulator outlet pressure gauge
13. Cylinder pressure gauge
14. Cylinder cap
15. Oxygen cylinder valve
16. Oxygen cylinder valve
17. Hand wheel
18. Bursting disc
19. Acetylene valve
20. Oxygen valve
21. Welding torch
22. Torch tip
23. Flame

Fig. 17.7 Oxy acetylene welding set up

Acetylene and oxygen gas is stored in compressed gas cylinders. These gas cylinders differ widely in capacity, design and colour code. However, in most of the countries, the standard size of these cylinders is 6 to 7 m^3 and is painted black for oxygen and maroon for acetylene. An acetylene cylinder is filled with some absorptive material, which is saturated with a chemical solvent acetone. Acetone has the ability to absorb a large volume of acetylene and release it as the pressure falls. If large quantities of acetylene gas are being consumed, it is much cheaper to generate the gas at the place of use with the help of acetylene gas generators. Acetylene gas is generated by carbide-to-water method.

Oxygen gas cylinders are usually equipped with about 40 litres of oxygen at a pressure of about 154 Kgf/cm^2 at 21°C. To provide against dangerously excessive pressure, such as could occur if the cylinders were exposed to fire, every valve has a safety device to release the oxygen before there is any danger of rupturing the cylinders. Fragile discs and fusible plugs are usually provided in the cylinders valves in case it is subjected to danger.

Gas pressure regulators

Gas pressure regulators are employed for regulating the supply of acetylene and oxygen gas from cylinders. A pressure regulator is connected between the cylinder and hose leading to welding torch. The cylinder and hose connections have left-handed threads on the acetylene regulator while these are right handed on the oxygen regulator. A pressure regulator is fitted with two pressure gauges, one for indication of the gas pressure in the cylinder and the other for indication of the reduced pressure at which the gas is going out.

Welding torch

Fig 17.8 shows the construction of the welding torch. It is a tool for mixing oxygen and acetylene in correct proportion and burning the mixture at the end of a tip. Gas flow to the torch is controlled with the help of two needle valves in the handle of the torch. There are two basic types of gas welding torches:

(1) Positive pressure (also known as medium or equal pressure), and

(2) Low pressure or injector type

The positive pressure type welding torch is the more common of the two types of oxy-acetylene torches.

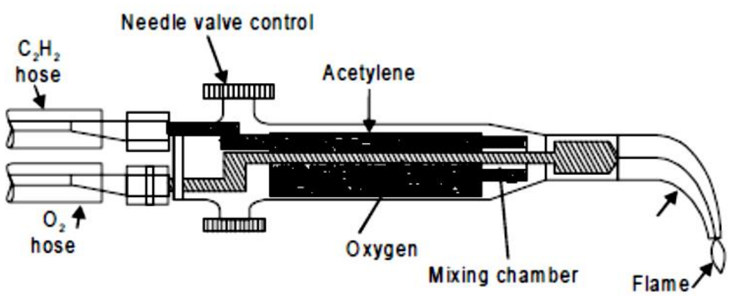


Fig. 17.8 Welding torch

Torch tips

It is the portion of the welding apparatus through which the gases pass just prior to their ignition and burning. A great variety of interchangeable welding tips differing in size, shape and construction are available commercially. The tip sizes are identified by the diameter of the opening. The diameter of the tip opening used for welding depends upon the type of metal to be welded.

Hose pipes

The hose pipes are used for the supply of gases from the pressure regulators. The most common method of hose pipe fitting both oxygen and acetylene gas is the reinforced rubber hose pipe. Green is the standard color for oxygen hose, red for acetylene, and black hose for other industrially available welding gases.

Goggles

These are fitted with colored lenses and are used to protect the eyes from harmful heat and ultraviolet and infrared rays.

Gloves

These are required to protect the hands from any injury due to the heat of welding process.

Spark-lighter

It is used for frequent igniting the welding torch.

Filler rods

Gas welding can be done with or without using filler rod. When welding with the filler rod, it should be held at approximately 900 to the welding tip. Filler rods have the same or nearly the same chemical composition as the base metal. Metallurgical properties of the weld deposit can be controlled by the optimum choice of filler rod. Most of the filler rods for gas welding also contain deoxidizers to control the oxygen content of weld pool.

Fluxes

Fluxes are used in gas welding to remove the oxide film and to maintain a clean surface. These are usually employed for gas welding of aluminium, stainless steel, cast iron, brass and silicon bronze. They are available in the market in the form of dry powder, paste, or thick solutions.

Advantages

- Process is simple and inexpensive.
- Eliminates skilled operator.
- Temperature of the flame can be controlled depending on the thickness and type of the material being welded.

Disadvantages

- Acetylene gas is slightly costlier.
- Not suitable for thick and high melting point metals.
- Refractory metal like tungsten, molybdenum etc., and reactive metals like zirconium, titanium etc., cannot be gas welded.
- Acetylene gas is highly explosive. Hence, precautions should be taken during its storage and welding.

15·49 Gas Welding Technique

In a gas welding (or oxy-acetylene welding), the acetylene is, first of all, turned on by using the control valve on the torch and then it is ignited with a friction spark lighter. The flame is adjusted by supplying the oxygen with the oxygen control valve on the torch. The pieces to be welded are properly prepared and positioned. The weld is started by preheating and melting a small puddle of molten base metal. In case a welding rod is used to provide filler metal, it should be held in the flames so that its end melts at about the same time as the base metal. In order to obtain proper penetration and to produce a good weld, the tip of the torch should be moved with a side-to-side motion, slowly and uniformly. The usual techniques in oxy-acetylene welding are as follows :

1. *Left ward*

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...niques in oxy-acetylene welding are as follows :

1. *Left-ward or fore-hand welding*. In this method, the welding torch is held in the operator's right hand, the tip pointing towards the left and the weld is made from right to left. The torch makes an angle of 60°–70° with the plate and the welding rod makes an angle of 30°– 40°, as shown in Fig. 15.31. The flame is given a circular, rotational or side-to-side motion to obtain uniform fusion on each side of the plate. This method is more efficient for butt welding on plates upto 2 mm thickness. When plates over 3 mm thickness are to be butt welded, then the plate edges are bevelled to produce a 'V' of 80° to 90°. The larger volume of this 'V' requires sufficient quantity of filler material. If the 'V' is reduced, the welding torch flame pushes the molten metal from the pool towards the unmelted sides of the 'V'.

Note : The plates above 6 mm thickness are not economical to weld with this method.

2. *Right-ward or back-hand welding*. In this method, the welding torch is held in the right hand and the filler rod in the left hand. The welding begins at the left hand end of the joint and proceeds towards the right. The filler rod is given circular motion while the welding torch moves in straight line. In this case, the torch makes an angle of 40°–50° with the plate and the welding rod makes an angle of 30°– 40°, as shown in Fig. 15.32. This method is better and economical for plates

over 6 mm thickness. A good fusion can be obtained with this method without preparing 'V' upto 8 mm thick plates. The plate edges are bevelled to produce 'V' of 60° for plates above 8 mm thick.

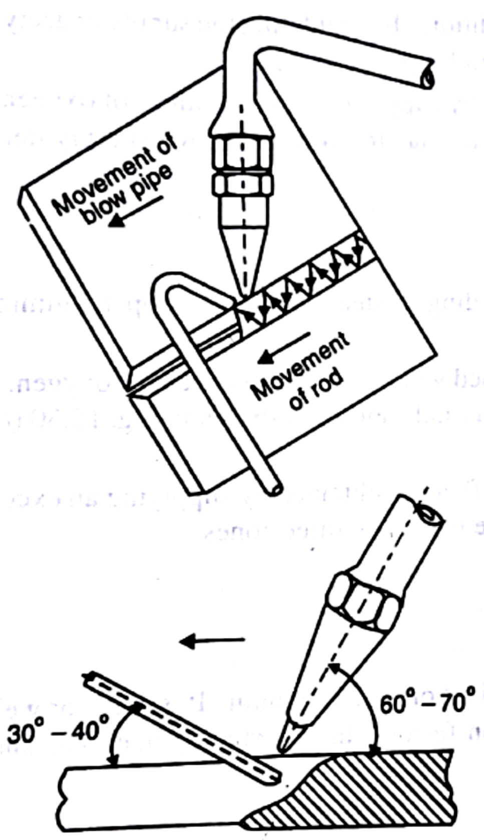

Fig. 15.31. Left-ward or fore-hand welding.

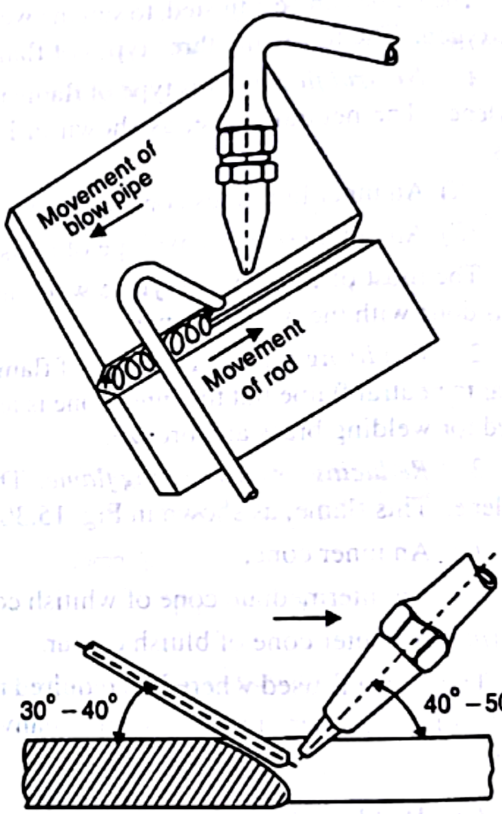

Fig. 15.32. Right-ward or back-hand welding.

This process uses a larger flame for a given plate thickness. This larger flame gives greater welding speed and less filler rod consumption. Since the welding torch moves in a straight line, the molten metal is agitated very little and excess oxidation is prevented. The plates upto 15 mm thick may be welded in one pass and above 16 mm thickness more runs must be deposited but the number is kept to a minimum.

6.1 RESISTANCE WELDING

Resistance welding is a welding process in which the workpieces are joined by the heat generated due to the resistance offered by the workpieces to the flow of electric current through them. A certain amount of pressure is applied to the workpieces to complete the weld.

Principle

When electric current flows through a material, it offers resistance to the flow of current resulting in heating of the material. The heat generated is used to make a weld between two or more workpieces. Resistance welding is based on the above principle. The heat generated in the material is given by Joules law:

$$H \alpha\ I^2RT$$

or $H = k\,I^2RT$ where H = heat generated in the material in *Joules*,
I = Flow of current through the material in *Amperes*,
R = Electrical resistance of the material in *Ohms*,
T = time for which the electric current flows through the material in *seconds*,
k = a constant, usually < 1 to account for heat loss through conduction and radiation.

High current is the primary requirement to produce a resistance weld. A step down transformer that converts the high voltage, low current power line to a high current (upto 100,000 A) and low voltage (0.5 – 10 V) power is used for the purpose.

There are atleast seven important resistance welding processes, but from the syllabus point of view, *spot welding, seam welding, butt welding*, and *projection welding* only have been discussed in this chapter.

6.1.1 Spot Welding

Spot welding is a resistance welding process in which the two overlapping workpieces held under pressure are joined together at one spot (location), Hence the name *spot welding*.

WELDING

Figure 6.1(a) shows the details of a resistance spot welding process.

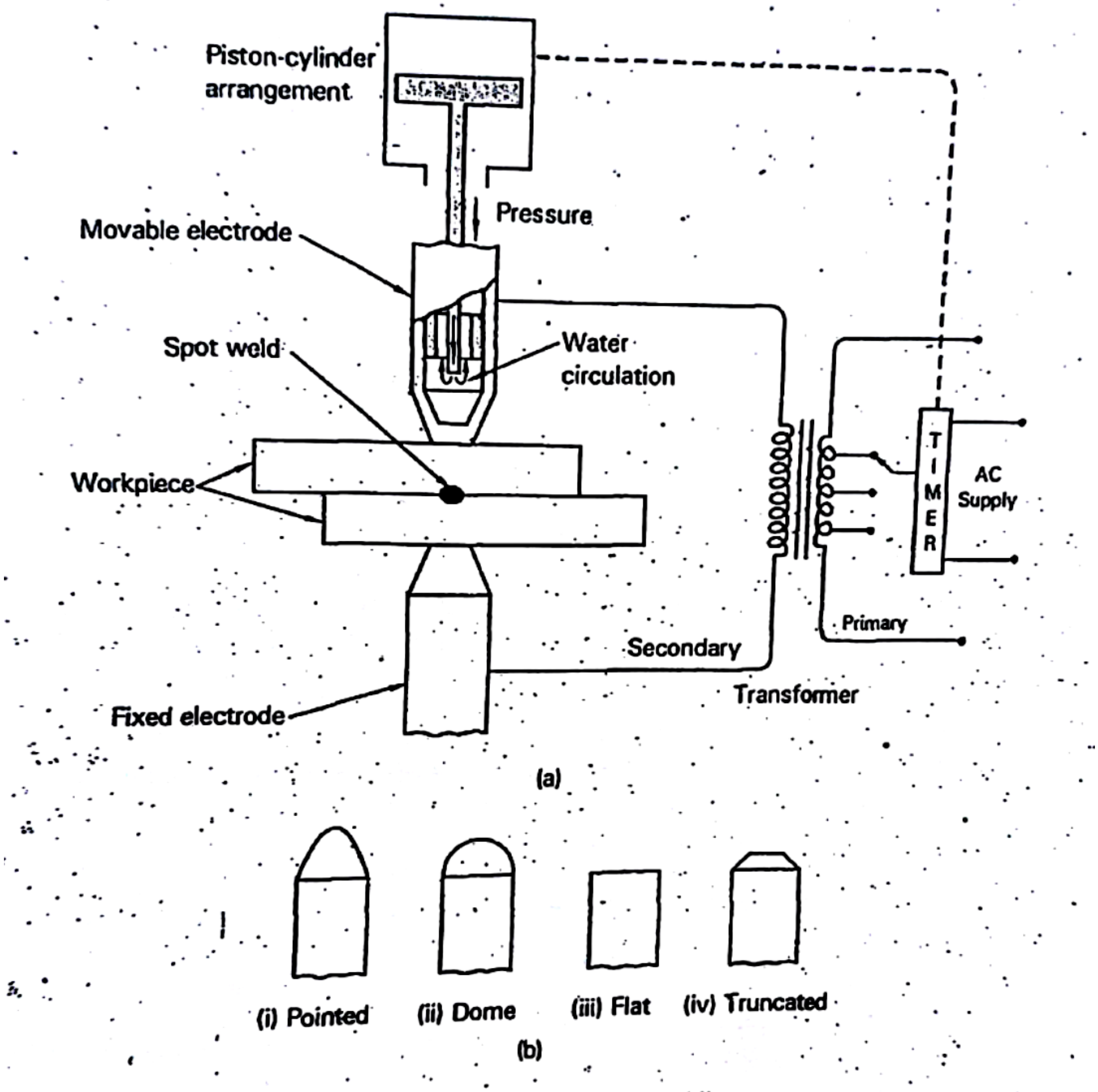

Figure 6.1 Resistance spot welding

Description and Operation

a) The two workpieces to be joined are cleaned to remove dirt, grease and other oxides either chemically or mechanically to obtain a sound weld.

b) The workpieces are then overlapped and placed firmly between two water cooled cylindrically shaped copper alloy electrodes, which in turn are connected to a secondary circuit of a step-down transformer. The electrodes carry high currents, and also transmit the force/pressure to the workpieces to complete the weld.

c) In operation, the welding current is switched ON. As the current passes through the electrodes, to the workpiece, heat is generated in the air gap at the point of contact of the two workpieces.

d) The heat at this contact point is maximum, with temperature varying from 815 – 930°C, and as a result melts the workpieces locally at the contact point to form a spot weld.

e) In order to obtain a strong bond, external pressure is applied to the workpiece, through the electrode, by means of a piston-cylinder arrangement. The current is switched OFF.

In some cases, external pressure is not required, and the holding pressure of the two electrodes is just sufficient to create a good joint.

f) Heat dissipates throughout the workpiece, which cools the spot weld causing the metal to solidify. The pressure is released and the workpiece is moved to the next location to make another spot weld.

In some spot welding machines, the workpiece remains stationary while the electrode moves to the next location to make a weld.

... difficult to weld because of their high thermal conductivity.

Applications

Spot welding is extensively used for welding steels, and especially in the automotive industry for cars that requires several hundred spot welds made by industrial robots.

6.1.2 Seam Welding

Seam welding is a resistance welding process in which the overlapping workpieces held under pressure are joined together by a *series of spot welds* made progressively along the joint utilizing the heat generated by the electrical resistance of the workpieces.

Seam welding is similar to spot welding process, but, instead of pointed electrodes, mechanically driven wheel shaped electrodes are used to produce a continuous weld. Figure 6.2 shows the two principal views of a seam welding process.

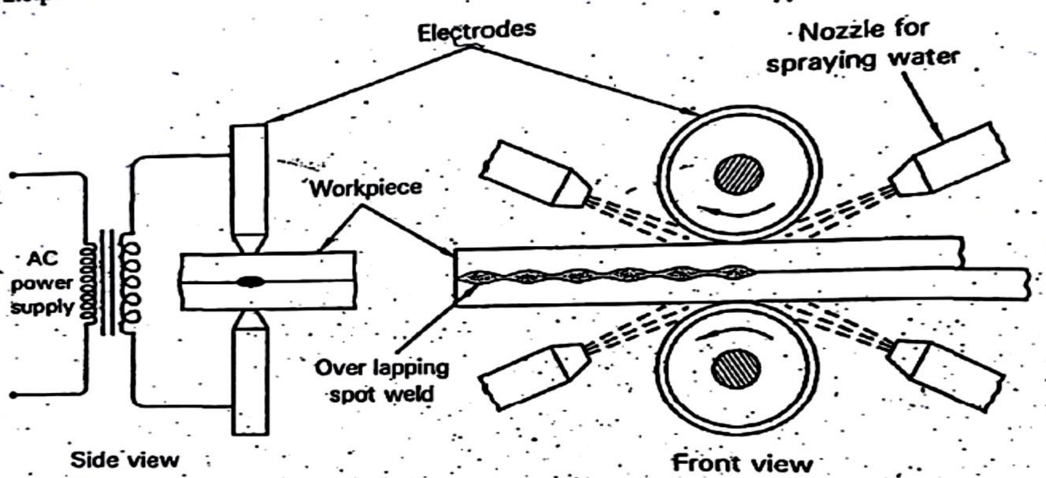

Figure 6.2 Seam welding process

WELDING

Description and Operation

a). The two workpieces to be joined are cleaned to remove dirt, grease and other oxides either chemically or mechanically to obtain a sound weld.

b) The workpieces are overlapped and placed firmly between two wheel shaped copper alloy electrodes, which in turn are connected to a secondary circuit of a step-down transformer.

c) The electrode wheels are driven mechanically in opposite directions with the workpieces passing between them, while at the same time the pressure* on the joint is maintained.

d) Welding current is passed in series of pulses at proper intervals through the bearing of the roller electrode wheels (not shown in figure).

e) As the current passes through the electrodes, to the workpiece, heat is generated in the air gap at the point of contact (spot) of the two workpieces. This heat melts the workpieces locally at the contact point to form a spot weld.

** Pressure is applied by air, spring or by hydraulic means.*

f) Under the pressure of continuously rotating electrodes and the current flowing through them, a series of overlapping spot welds are made progressively along the joint as shown in the figure.

g) The weld area is flooded with water to keep the electrode wheels cool during welding.

Advantages

- A contin

g thickness greater than 3 mm.

Applications

Used to fabricate liquid or gas tight sheet metal vessels such as gasoline tanks, automobile muffers, and heat exchangers.

ELECTRODES FOR ARC WELDING

Both nonconsumable and consumable electrodes are used for arc welding.

Nonconsumable electrodes may be made of carbon, graphite or tungsten which do not consume during the welding operation. *Consumable electrodes* may be made of various metals depending upon their purpose and the chemical composition of the metals to be welded. These consumable electrodes may be classed into bare and coated.

WELDING

In using the *plain or bare electrodes*, as the globules of the metal pass from the electrode to the work, they (globules) are exposed to the oxygen and nitrogen in the surrounding air. This causes the formation of some nonmetallic constituents which are trapped in the rapidly solidifying weld metal and thereby decreases the strength and ductility of the metal.

Coated electrodes, on the other hand, serve several purposes;. (1) to facilitate the establishment and maintenance of the arc ; (2) to protect the molten metal from the oxygen and nitrogen of the air by producing a shield of gas around the arc and weld pool ; (3) to provide the formation of slag so as to protect the welding seam from rapid cooling ; and (4) to provide a means of introducing alloying elements not contained in the core wire.

Coated electrodes can be divided into two general groups : (1) lightly coated (or washed) electrodes with a coating layer several tenths of a millimetre thick, and (2) heavily coated electrodes (Fig. 9.12) with relatively thick high quality covering applied in a layer of 1 to 3 mm. The primary purpose of a light coating is to increase arc stability, so they are also called *ionizing coatings*. For this reason, lightly coated electrodes may only be used for welding non-essential jobs. The welds produced have poor mechanical properties due to the lack of protection of the molten metal. Heavily coated electrodes, sometimes referred to as shielded-arc electrodes, serve all the four purposes described above, and are used to obtain a weld metal of high quality, comparable with, and even superior to the parent metal in terms of mechanical properties. Heavy coatings used are composed of ionising (chalk), deoxidising (aluminium, ferro-manganese, etc.), gas generating (starch), slag-forming (kaolin), alloying and binding materials.

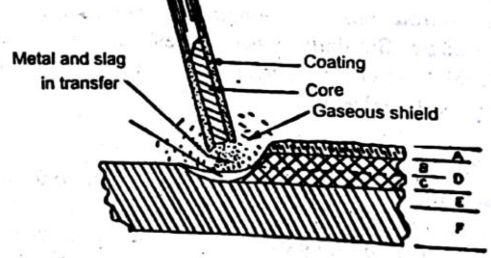

Figure 9.12 Shielded arc welding
1. slag layer, 2. Weld reinforcement, 3. penetration, 4. wled deposit, 5. base metal heat afected zone, 6. uneffected base metal.

WELDING

Both bare and coated electrodes , for hand arc welding are made in the shape of rods unto 12 mm in diameter and 450 mm long. Semi-automatic and automatic welding use electrode wire in coils. Soft steel wire containing 0.1 to 0.18 per cent carbon, and 0.0025 to 0.04 per cent phosphorus and sulphur is used for electrodes in welding carbon steel. Electrodes for alloy steel are made of low-alloy steel wire containing upto 0.25 per cent carbon.