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MANAV SCHOOL OF POLYTECHNIC VYALA, AKOLA

WORKSHOP PRACTICE

SHOP:- WELDING

2nd sem. [redacted]/ME

Workshop instructor

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WELDING SHOP

INTRODUCTION

Welding, brazing and soldering are the joining processes in which a two pieces of similar or dissimilar metals are united together by heat. The three methods of joining metals given above differ widely from each other, in the manner in which heat is applied and in the type of equipment used. But all of them form permanent joints.

Advantages

1. Welded joints are stronger than any other type of joints.
2. Welded structures are lighter in weight for the same strength.
3. Operation is simple and noiseless.
4. Better material utilization.
5. Lower fabrication cost.
6. Joint efficiency may be as high as 98% to 100%, if the operation is properly controlled.

Now it would be worthwhile to distinguish broadly the welding, brazing and soldering process.

Welding

Welding is a process of joining similar metals by application of heat, with or without the application of pressure and addition of filler material.

Modern methods of welding may be classified under two broad categories. They are :

1. Pressure Welding
2. Fusion or Non-pressure Welding

In the **'Pressure welding process'**, the pieces of metal to be joined are heated to a plastic state and then forced together by external pressure exerted by hammering, rolling or pressing to effect the weld. Forge welding resistance welding and thermal welding are of this type.

In the **'Fusion welding process'** the material at the joint is heated to fusion temperature and a filler metal is added externally. The weld is then allowed to cool down. Electric arc welding, electric resistance welding, gas welding and induction welding are included in this category.

TYPES OF WELDING

1. Arc Welding

In article, general classification of welding processes are given. In this chart electric arc welding is further subdivided into two main categories, namely

(a) Metal Arc Welding and

(b) Carbon Arc Welding

In both processes either the arc is unshielded or shielded by means of a flux or an inert gas environment.

Out of these two processes 'Metal arc welding' with flux coated consumable electrode is by far the most common and cheapest process of welding. We shall first discuss this method in detail.

(a) METAL ARC WELDING (Unshielded)

In this process, heat is obtained from an arc formed between the work and a metal electrode coated with flux. The metal electrode also supplies molten filler metal to the joint. Elec. energy is converted into intense heat in the arc, which attains a temperature around 5,500°C. This intense heat of the arc forms a molten pool in the metal being welded and, at the same time melts the tip of the electrode. As the arc is maintained, molten filler metal from the electrode tip is transferred across the arc, where it fuses with molten base metal, as shown in Figure.

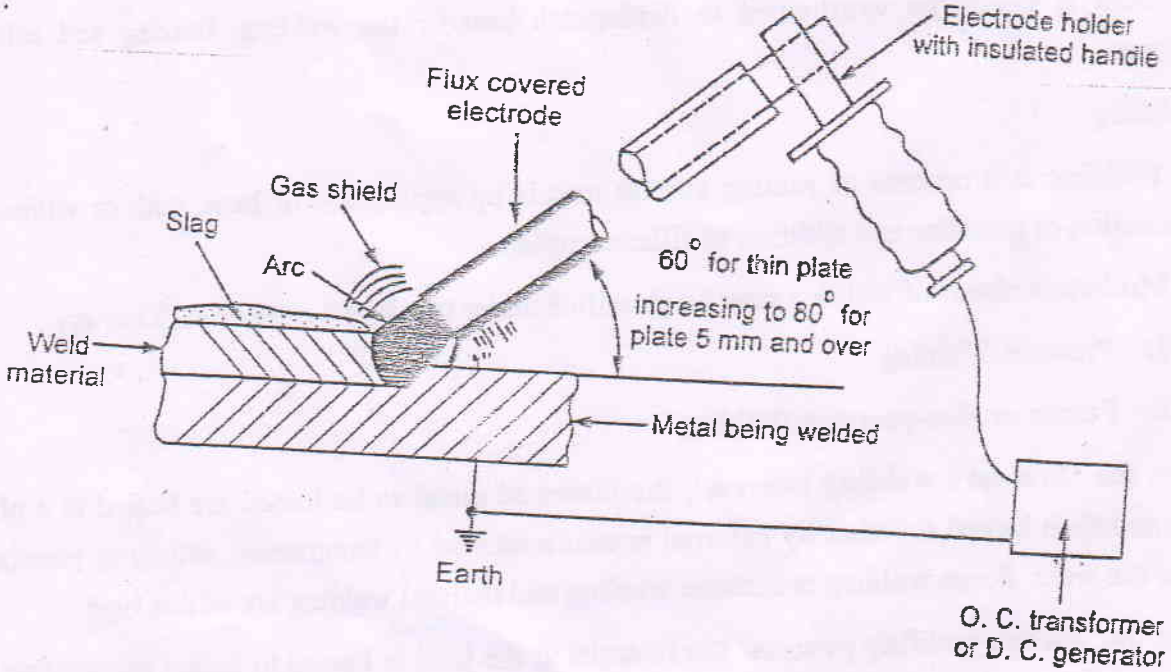


Figure : Electric Arc Welding

PROCEDURE OF GAS WELDING

Following procedure is given for beginners to learn gas welding of plates.

1. Arrange a piece of sheet metal conveniently on the welding table. Light the blow pipe (welding torch) and adjust the flame to neutral.
2. Holding the blow pipe so that the nozzle makes an angle of about : 40° to 50° with the sheet, let the flame play on a point just insider the right edge of the sheet and with the inner cone of flame about 3 mm away from the surface of the sheet, hold the blow pipe until a pool of molten metal about 4 to 6 mm in diameter has been formed. (Refer to Figure).

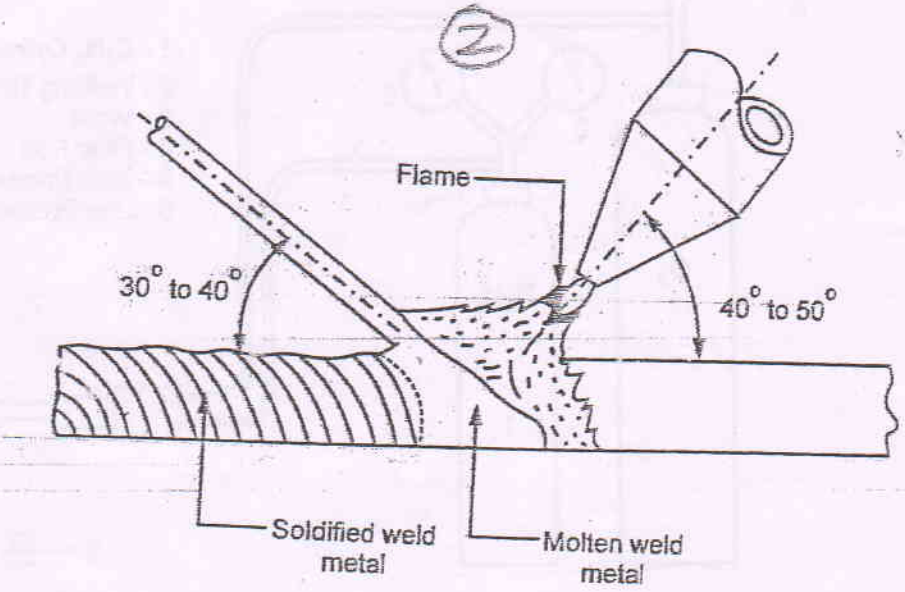


Figure : Process of Gas Welding

Make this pool move across the sheet in the desired direction. To do this the blow pipe should be moved so as to make a series of overlapping ovals.

3. The next step is to deposit a fusion bead using a filler metal rod. The material and size of filler rod will change depending on the base metal and its thickness. (i.e. for welding plain carbon steel plate of 16 gauge, a filler rod of low carbon steel with 3 mm diameter is used).

   The welding blow pipe is held in the right hand (for right handed welder) and the rod in the left hand. The angle of the welding rod with the line of weld should be about 40°.

4. Place the end of the rod in the molten pool, and make the pool travel across the sheet. The motion of the blow-pipe is such that the flame will follow a series of overlapping ovals of molten metal.

'Oxygen' is produced by electrolysis and liquifying air. Most of the commercial oxygen is made by liquifying air and separating oxygen from the nitrogen. It is stored in steel cylinders at a pressure of about 14 N/mm^2. Acetylene is generated from the reaction of calcium carbide with water, in an acetylene generator.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

(Calcium Carbide) (Water) (Slaked Lime) (Acetylene Gas)

Normally, acetylene cylinders are used. Acetylene cylinders are filled with a porous filter, saturated with acetone, in which the acetylene gas can be compressed safely. These cylinders hold about $9m^3$ of gas at pressures upto 1.8 N/mm^2.

These cylinders are shown in Figure.

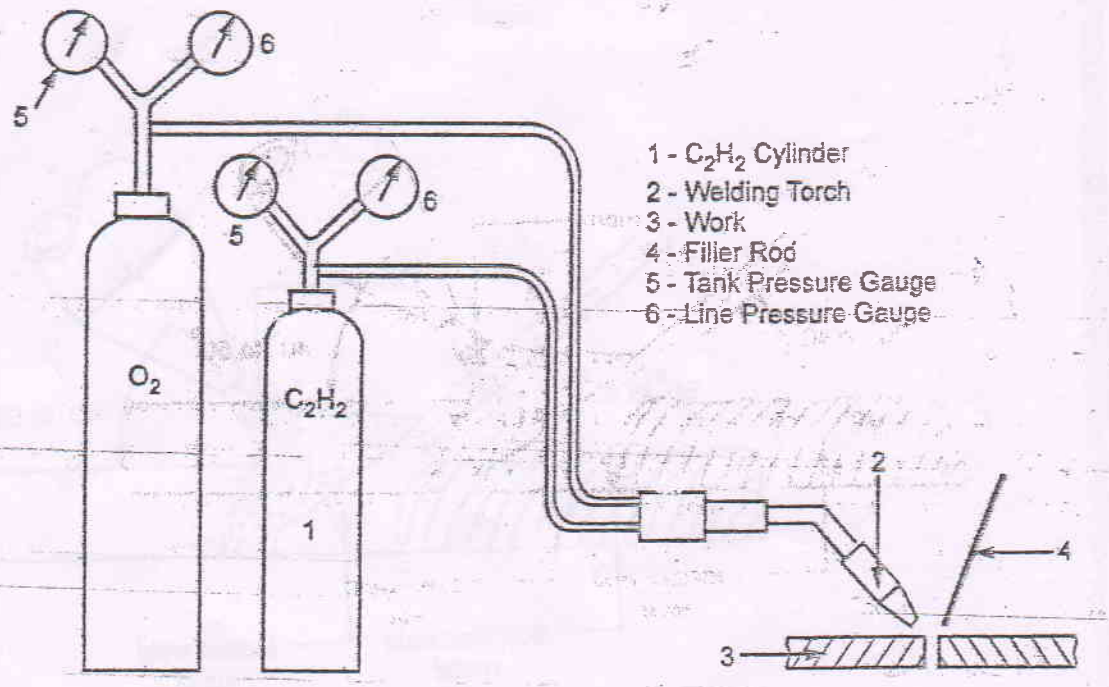


Figure : Oxy-acetylene Welding

For identification of cylinders from each other they are of different sizes and colours. Acetylene cylinders are painted 'maroon' and oxygen painted with 'black'.

Precautions to be observed when using Oxygen and Acetylene Cylinders

1. All valves must be closed when work is finished.
2. There should be no leaks at the gland round the valve spindle.
3. If a cylinder catches fire at the valve or regulator, shut the valve and tighten the joint properly before further use.
4. If the cylinder becomes hot or fires internally, close the valve, disconnect the regulator, remove cylinder into open, then open the valve fully to allow gas to escape freely, and immerse cylinder into water.
5. Store cylinders in upright position.
6. Use trolley for handling cylinders to avoid damage to the valves.

3. OXY-ACETYLENE GAS CUTTING [GAS CUTTING]

It is a chemical process in the sense that the metal, at the portion where it is to be cut, is actually made to oxidise under the action of the flame. All ferrous metals can be cut by means of an oxy-acetylene name. The metal to be cut is heated up to red heat by means of the flame and then a sharp stream of oxygen is made to impinge on to the hot surface to form iron oxide and thus remove the metal from there. This process is a very efficient one which enables a fairly quick and clean cutting of ferrous metals.

The blowpipe used for this purpose is of special type which, in addition to the usual passages of oxygen and acetylene of a welding blowpipe, carries an additional provision for supplying a strong jet of oxygen through the nozzle after the metal has been sufficiently heated to red heat Thus, this blowpipe carries two separate passages of oxygen; one for supplying oxygen to burn with acetylene to form the heating flame and the other, placed centrally in the nozzle, to provide the required jet for oxidation. These passages are respectively known as preheating oxygen passage and cutting oxygen passage and the gas passing through them is also termed accordingly i.e., preheating oxygen and cutting oxygen respectively (See Figure). Since this blowpipe can be moved in any desired direction it is possible to cut the metal in any shape we like.

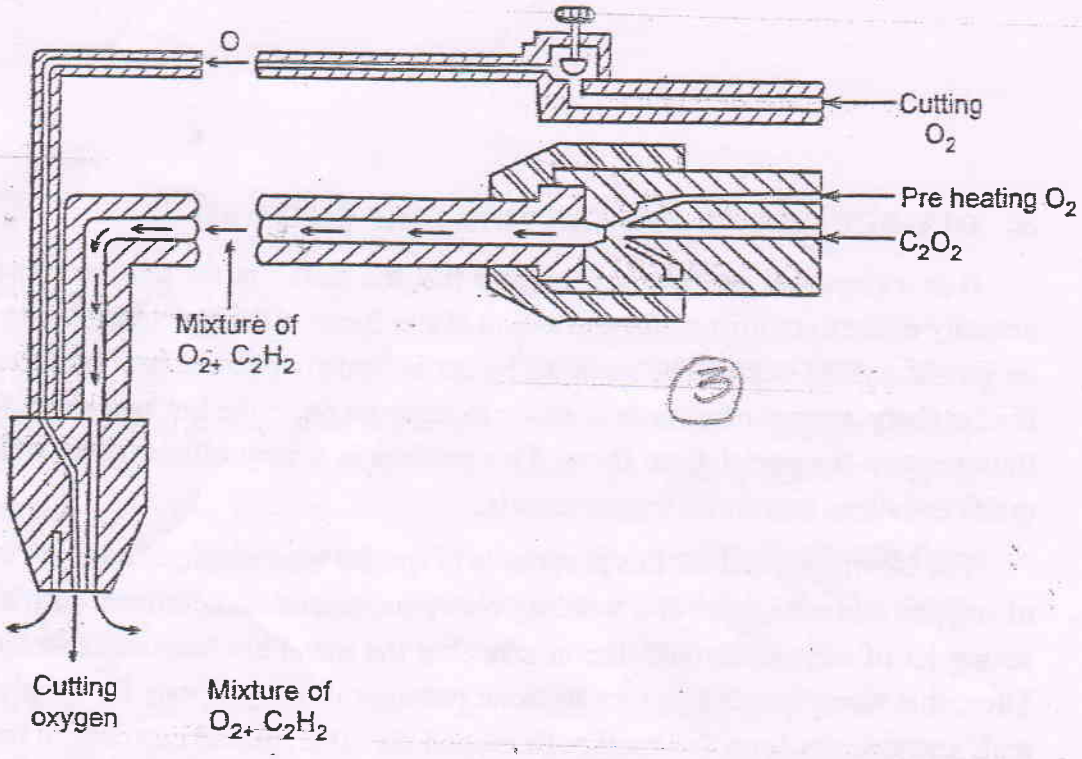


Figure : Cross-section through an oxy-acetylene cutting blowpipe

For starting the operation, acetylene and the preheating oxygen are turned on and the flame adjusted to netural. After the metal has been heated to red heat or a little whitish the cutting oxygen valve is operated to make a sharp oxygen jet to strike against the hot metal. This forms the iron oxide there and the same gets melted immediately. It is then blown off by the oxygen jet; thus providing a narrow slit along the cutting line.1t is necessary to maintain a proper distance (usually about 6 mm) between the nozzle tip and the top surface of tile metal plate. This is accomplished by fixing the blowpipe on a guide which slides on the metal surface during the operation and facilitates the above requirement. The movement of tile blowpipe should neither be too fast nor too slow. It should be so controlled that it enables the cut to penetrate fully through the metal thickness, which will be evident from tile sparks coming out of the slit on tile other side of the metal. A too slow movement will spoil the edge of the cut as the preheating flame will start melting them. In the same way, a too fast movement will prevent the cut from penetrating fully through tile metal thickness.

For cutting cast iron, a carburising preheating flame should be adjusted and the nozzle kept at a comparatively greater distance. Also, cast iron needs a relatively longer preheating than steel before actual cutting starts, so much so that the metal gets melted by preheating. After this the slag and molten mass are blown off by means of the cutting oxygen jet and tile cut then proceeds further in the same way. The blowpipe in both the cases i.e. for cast iron as well as steel, is drawn towards tile operator during cutting.

TYPES OF FLAMES

WELDING FLAME

The oxyacetylene produces hottest flame with temperature in the range of 3000°C to 3500°C. The reaction is as follows

$$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O \quad \text{... (For complete combustion)}$$

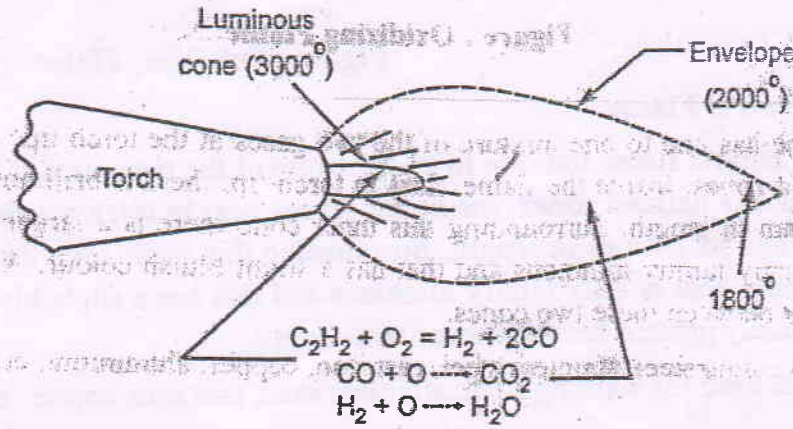


Figure : Reactions in Welding Name

For complete combustion ratio of oxygen to acetylene is 2.5 : 1. The flame temperature produced is dependant upon the relative proportion of these two gases. In commercial oxyacetylene welding and heating, most popular proportion of oxygen and acetylene is 1 : 1, which produces more or less 'neutral flame', as its effort is neither oxidising nor carburising.

Type of Flames

The three types of flame required in the oxy-acetylene welding are as follows (Refer Figure).

1. The oxidizing flame, i.e., a flame burning with an excess of oxygen.
2. The neutral flame, which is obtained when equal quantities of oxygen and acetylene are burning.
3. The carburizing flame, i.e., a flame burning with an excessive acetylene.

1. Oxidizing Flame

An oxidizing flame resembles a neutral flame, but the inner luminous cone is shorter and not sharply defined. It has a purple tinge. An oxidizing flame will produce a boiling, burning condition, the top of the bead will be covered with scale, with small pin holes underneath, and the steel in the neighbourhood of the melted area will become very hard.

This flame is used for welding brasses in order to reduce the volatilization of the zinc. Th temperature of the flame is also reduced.

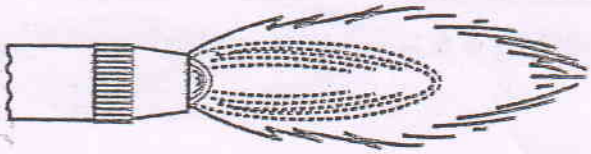


Figure : Oxidizing Flame

2. Neutral Flame

A neutral flame has one to one mixture of the two gases at the torch tip. The flame has two sharply defined zones. Inside the flame, next to torch tip, there is brilliant white cone a u 2 mm to 18 mm in length. Surrounding this inner cone there is a larger cone, or envelope flame, that is only faintly luminous and that has a slight bluish colour. A colourless cone is usually present between these two cones.

It is used for welding steel, stainless steel, cast iron, copper, aluminium, etc.

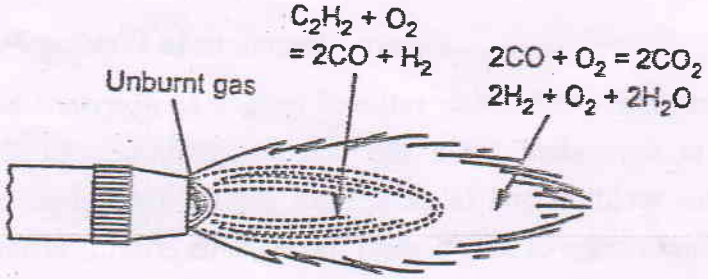


Figure : Neutral Flame

3. Carburizing Flame

A carburizing flame consists of three zones. As in the neutral flame, there is a sharply defined inner cone and a bluish outer envelope, but between these surroundings the inner cone, there is an intermediate cone of whitish colour. The finished bead will have spongy appearance.

It is used for welding cast iron.

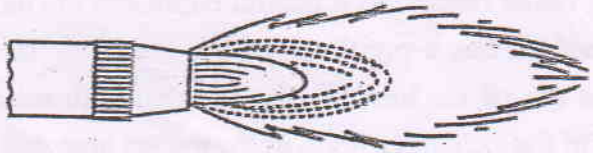


Figure : Carburizing Flame

TYPES OF WELDS

There are four basic types of welds illustrated in Figure. They are

1. Bed Type
2. Fillet Type
3. Groove Type
4. Plug Type

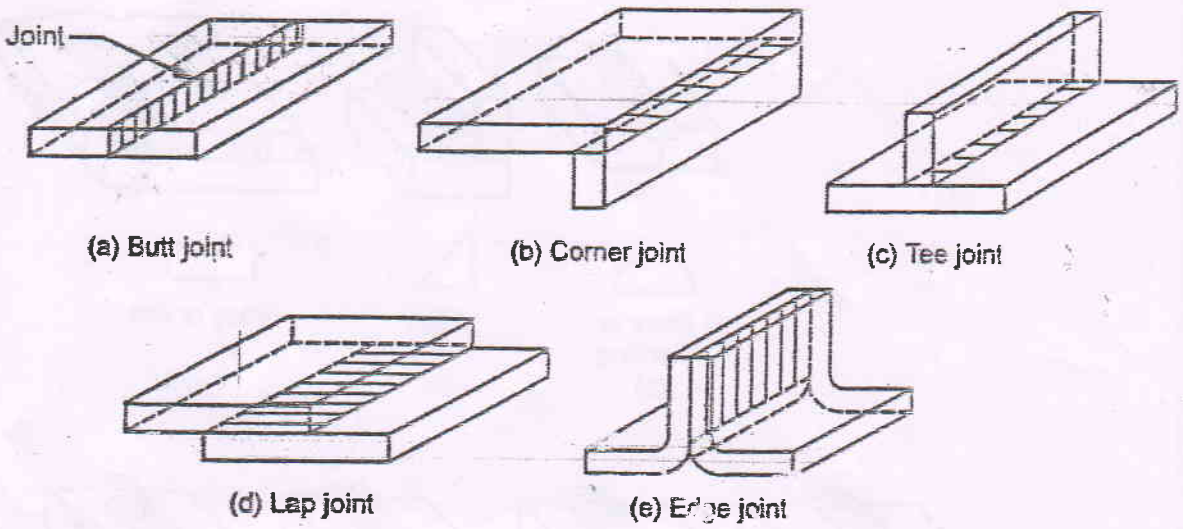


Figure : The Basic Types of Welds

1. Bead Welds

These are used for making edge joints in thin materials and for building up surfaces. The latter, known as hard surfacing or hard facing consists of the overlaying, by welding, of a more wear-resisting material upon a basic metal blank. This may consist of a high alloy steel on a mild steel blank or a non-ferrous alloy on a tool steel blank.

2. Fillet Welds

These are used for tee joints, lap joints and corner joints. The size of the fillet weld is measured by the 'leg length' of the largest 45° right angle triangle that can be inscribed within the contour of the cross section of the weld, as shown in figure.

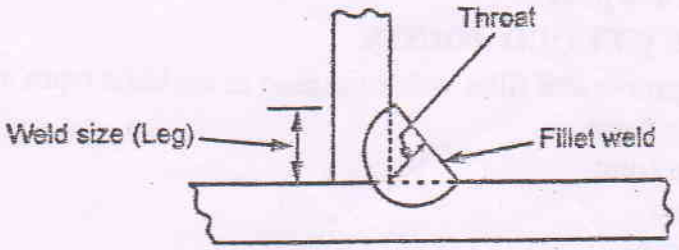


Figure : Tee Joint

3. Groove Welds

The cross sections of groove welds are illustrated in figure. The size of such welds is the depth of the groove, which may be usually taken as the thickness of the plates to be joined (say 't'). welding from both sides with a double – groove preparation [Figure (b), (d), (f)] is to be preferred where accessibility and shop facilities permit, because less weld metal is required and a saving in time and materials is effected. The choice of the groove type depends on the type of joint to be welded and the thickness of the parts.

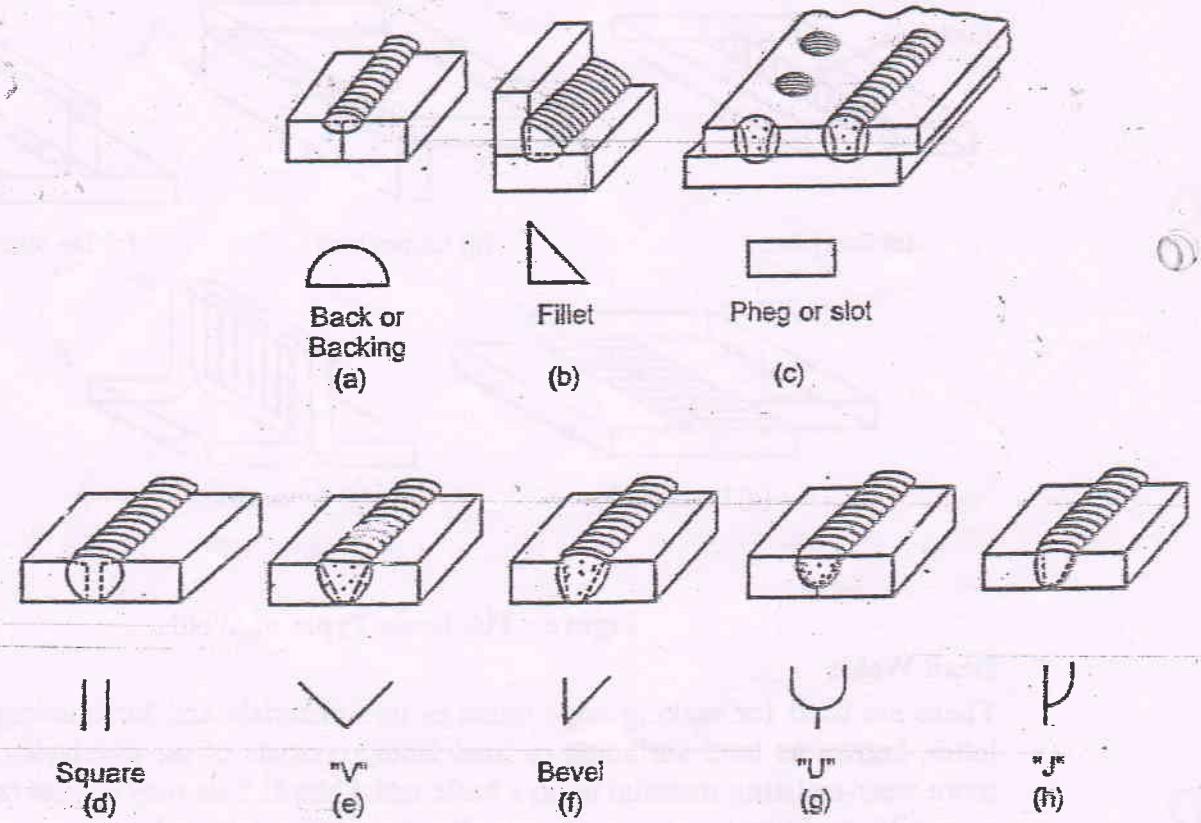


Figure : Arc and Gas Welds and Symbols

4. Plug Welds

These are used to connect two parts of welding through a round hole or a slot in either one of the parts as shown in figure (The Basic Types of Welded - 4). Plug welds are used for welding stay bolts to thick plates and for strengthening the support of a fixture, bolted or welded to a plate.

TYPES OF WELDED JOINTS

Bead, groove and fillet welds are used in six basic types of joints, namely,

1. Butt Joint
2. Lap Joint
3. Edge
4. Corner
5. Tree
6. Plug Joint

Each of these joints and the types of weld normally used with it are illustrated in Figure.

Lap and butt joints are most commonly used in resistance welding, gas welding and electric arc welding processes.

In selecting the type of joint and its weld preparation, the main factors to be considered are :

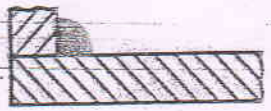
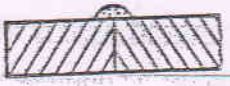
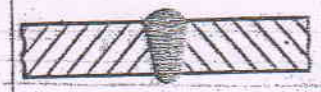
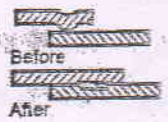
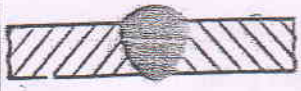
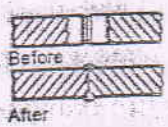
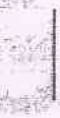
1. The nature of the load
2. The cost of the edge preparation and welding;
3. The accessibility for welding.

After understanding the basic principles about the type of welds, type of welded joints and general classification of welding processes, we shall proceed ahead to discuss 'non-pressure or fusion welding' processes in details.

In non-pressure welding, we shall limit our discussion to more common welding methods, namely Arc Welding and Gas Welding.

In each method of welding the following points are considered for better understanding:

1. Basic Process Description,
2. Equipment Used,
3. Applications,
4. Maintenance
5. Hints for Safe Working.

Form of Weld	Sectional Representation	Welding symbol	Form of Weld	Sectional Representation	Welding symbol
Fillet			Bead or Edge Weld		
Square Butt			Spot Weld		
Single-V-butt			Seam Weld		
Double-V-Butt			Projection Weld		
Single U-Butt			Butt Resistance or Pressure Weld		

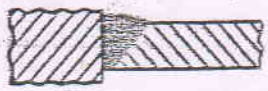
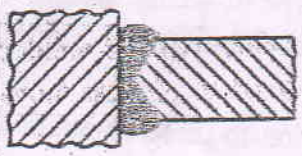
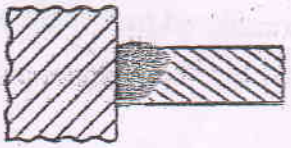
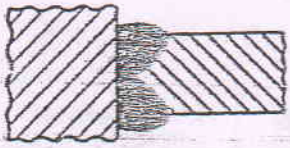
Double-U-Butt			Supplementary Welding symbols	
Single-Bevel Butt			Weld All Round	
Double-Bevel Butt			Field Weld	
Single-J-Butt			Flush Contour	
Double-J-Butt			Convex Contour	

Figure : Types of Welded Joints and the Corresponding Standard Symbols

SAFETY PRECAUTIONS

Arc Welding

1. Earthing must be done properly with metal plate.
2. Hand gloves, screen must be used.
3. Regulator for voltage and ampere must be proper.
4. Welding rod should not be made wet condition.
5. Electrical connections must be in series (may be single phase or three phase)
6. The distance between welding rod in the welding holder and the workpiece must be 3 to 5 mm.

Gas Welding

1. Oxygen and acetylene gas cylinder must be regulated properly and regulator must be in serviceable condition.
2. The hose pipes should be sufficient in length and in different colours.
3. The nozzle of tourch ignitors must be fully cleaned.
4. No necked flame with in 10 meters from the gas plant.
5. Serviceable fire extinguisher must be kept.