Welding:

Welding may be defined as the metallurgical joining of two metal pieces together to produce essentially a single piece of a metal. Welding is extensively used in fabrication work in which metal plates, rolled steel sections, casting of ferrous materials are joined together. It is also used for repairing broken, worn out, or defective metal parts.

Principle of welding:

A welding is a metallurgical process in which the junction of the two parts to be joined are heated and then fused together with or without application of pressure to produce a continuity of the homogeneous material of the same composition and characteristics of the parts which are being joined.

Types of welding:

Pressure welding: -In this the parts are to be joined are heated only up to the plastic state and then fused together by applying external pressure.

Fusion welding:-In this the joint of two parts is heated to the molten state and allowed to solidify. The different types of fusion welding are

- Arc welding
- Gas welding

Arc welding:

Arc welding is one of several fusion processes for joining metals. By applying intense heat, metal at the joint between two parts is melted and caused to intermix - directly, or more commonly, with an intermediate molten filler metal. Upon cooling and solidification, a metallurgical bond is created. Since the joining is an intermixture of metals, the final weldment potentially has the same strength properties as the

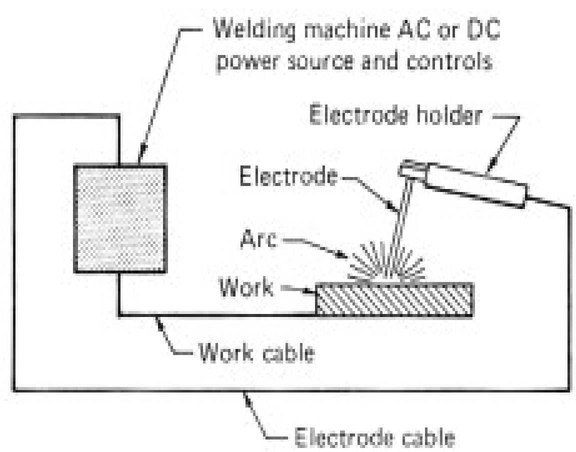


Fig. 1 The basic arc-welding circuit

metal of the parts. This is in sharp contrast to non-fusion processes of joining (i.e. soldering, brazing etc.) in which the mechanical and physical properties of the base materials cannot be duplicated at the joint.

In arc welding, the intense heat needed to melt metal is produced by an electric arc. The arc is formed between the actual work and an electrode (stick or wire) that is manually or mechanically guided along the joint. The electrode can either be a rod with the purpose of simply carrying the current between the tip and the work. Or, it may be a specially prepared rod or wire that not only conducts the current but also melts and supplies filler metal to the joint. Most welding in the manufacture of steel products uses the second type of electrode.

Basic Welding Circuit:

The basic arc-welding circuit is illustrated in Fig. 1. An AC or DC power source, fitted with whatever controls may be needed, is connected by a work cable to the work piece and by a "hot" cable to an electrode holder of some type, which makes an electrical contact with the welding electrode.

An arc is created across the gap when the energized circuit and the electrode tip touches the work piece and is withdrawn, yet still with in close contact.

The arc produces a temperature of about 6500ºF at the tip. This heat melts both the base metal and the electrode, producing a pool of molten metal sometimes called a "crater." The crater solidifies behind the electrode as it is moved along the joint. The result is a fusion bond.

Arc Shielding:

However, joining metals requires more than moving an electrode along a joint. Metals at high temperatures tend to react chemically with elements in the air - oxygen and nitrogen. When metal in the molten pool comes into contact with air, oxides and nitrides form which destroy the strength and toughness of the weld joint. Therefore, many arc-welding processes provide some means of covering the arc and the molten pool with a protective shield of gas, vapor, or slag. This is called arc shielding. This shielding prevents or minimizes contact of the molten metal with air. Shielding also may improve the weld. An example is a granular flux, which actually adds deoxidizers to the

Weld.

Figure 2 illustrates the shielding of the welding arc and molten pool with a Stick electrode. The extruded covering on the filler metal rod, provides a shielding gas at the point of contact while the slag protects the fresh weld from the air.

The arc itself is a very complex phenomenon. In-depth understanding of the physics of the arc is of little value to the welder, but some knowledge of its general characteristics can be useful.

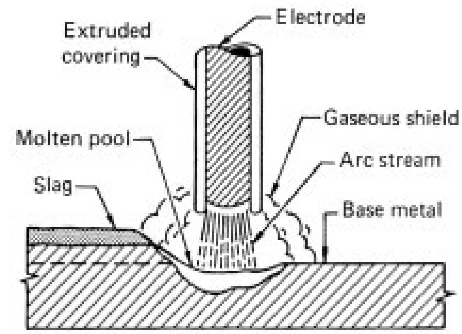
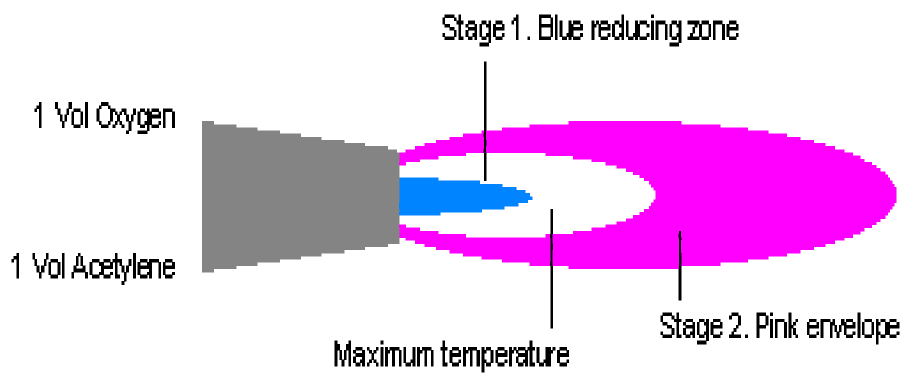


Fig. 2 This shows how the coating on a coated (stick) electrode provides a gaseous shield around the arc and a slag covering on the hot weld deposit.

Gas welding:

Gas welding is a fusion method welding, in which a strong gas flame is used to raise the temperature of the work piece so as to melt them. As in arc welding the filler metal is used to fill the joint. The gases can be used for heating are oxygen and acetylene mixture and oxygen and hydrogen mixture. The most commonly used is the oxy-acetylene mixture.

Oxy-Acetylene Flame Types



Neutral Flame:

As the supply of oxygen to the blowpipe is further increased, the flame contracts and the white cone become clearly defined, assuming a definite rounded shape. At this stage approximately equal quantities of acetylene and oxygen are being used and combustion is complete, all the carbon supplied by the acetylene is being consumed and the maximum heat given out. The flame is now neutral, and this type of flame is the one most extensively used by the welder, who should make himself thoroughly familiar with its appearance and characteristics.

Carburizing Flame:

This is a flame in which an excess of acetylene is burning, i.e. combustion is incomplete and unconsumed carbon is present. When lighting the blowpipe the acetylene is turned on first and ignited, giving a very smoky yellow flame of abnormal size, showing two cones of flame in addition to an outer envelope; this is an exaggerated form of the carburising flame, but gives out comparatively little heat and is of little use for welding. When the oxygen is turned on and the supply is gradually increased, the flame, though still of abnormal size contracts towards the blowpipe tip where an inner white cone of great luminosity commences to make its appearance. If the increase in the supply of oxygen is stopped before the cone becomes clearly defined and while it is still an inch or so long, the result is a carburising flame which is mainly used for hard surfacing and should not be employed for welding steel as unconsumed carbon may be introduced into the weld and produce a hard, brittle, deposit.

Oxidising Flame:

A further increase in the oxygen supply will produce an oxidising flame in which there is more oxygen than is required for complete combustion. The inner cone will become shorter and sharper, the flame will turn a deeper purple color and emit a characteristic slight "hiss", while the molten metal will be less fluid and tranquil during welding and excessive sparking will occur. An oxidising flame is only used for special applications, and should never be used for welding.

Welding defects:

Common weld defects include:

- i. Lack of fusion
- ii. Lack of penetration or excess penetration
- iii. Porosity
- iv. Inclusions
- v. Cracking
- vi. Undercut
- vii. Lamellar tearing

Any of these defects are potentially disastrous as they can all give rise to high stress intensities which may result in sudden unexpected failure below the design load or in the case of cyclic loading, failure after fewer load cycles than predicted.

2. Types of Defects

i and ii. - To achieve a good quality join it is essential that the fusion zone extends the full thickness of the sheets being joined. Thin sheet material can be joined with a single pass and a clean square edge will be a satisfactory basis for a join. However thicker material will normally need edges cut at a V angle and may need several passes to fill the V with weld metal. Where both sides are accessible one or more passes may be made along the reverse side to ensure the joint extends the full thickness of the metal.

Lack of fusion results from too little heat input and / or too rapid traverse of the welding torch (gas or electric).

Excess penetration arises from to high a heat input and / or too slow transverse of the welding torch (gas or electric). Excess penetration - burning through - is more of a problem with thin sheet as a higher level of skill is needed to balance heat input and torch traverse when welding thin metal.

ii. Porosity - This occurs when gases are trapped in the solidifying weld metal. These may arise from damp consumables or metal or, from dirt, particularly oil or grease, on the metal in the vicinity of the weld. This can be avoided by ensuring all consumables are stored in dry conditions and work is carefully cleaned and degreased prior to welding.

iv. Inclusions - These can occur when several runs are made along a V join when joining thick plate using flux cored or flux coated rods and the slag covering a run is not totally removed after every run before the following run.

v. Cracking - This can occur due just to thermal shrinkage or due to a combination of strain accompanying phase change and thermal shrinkage.

In the case of welded stiff frames, a combination of poor design and inappropriate procedure may result in high residual stresses and cracking.

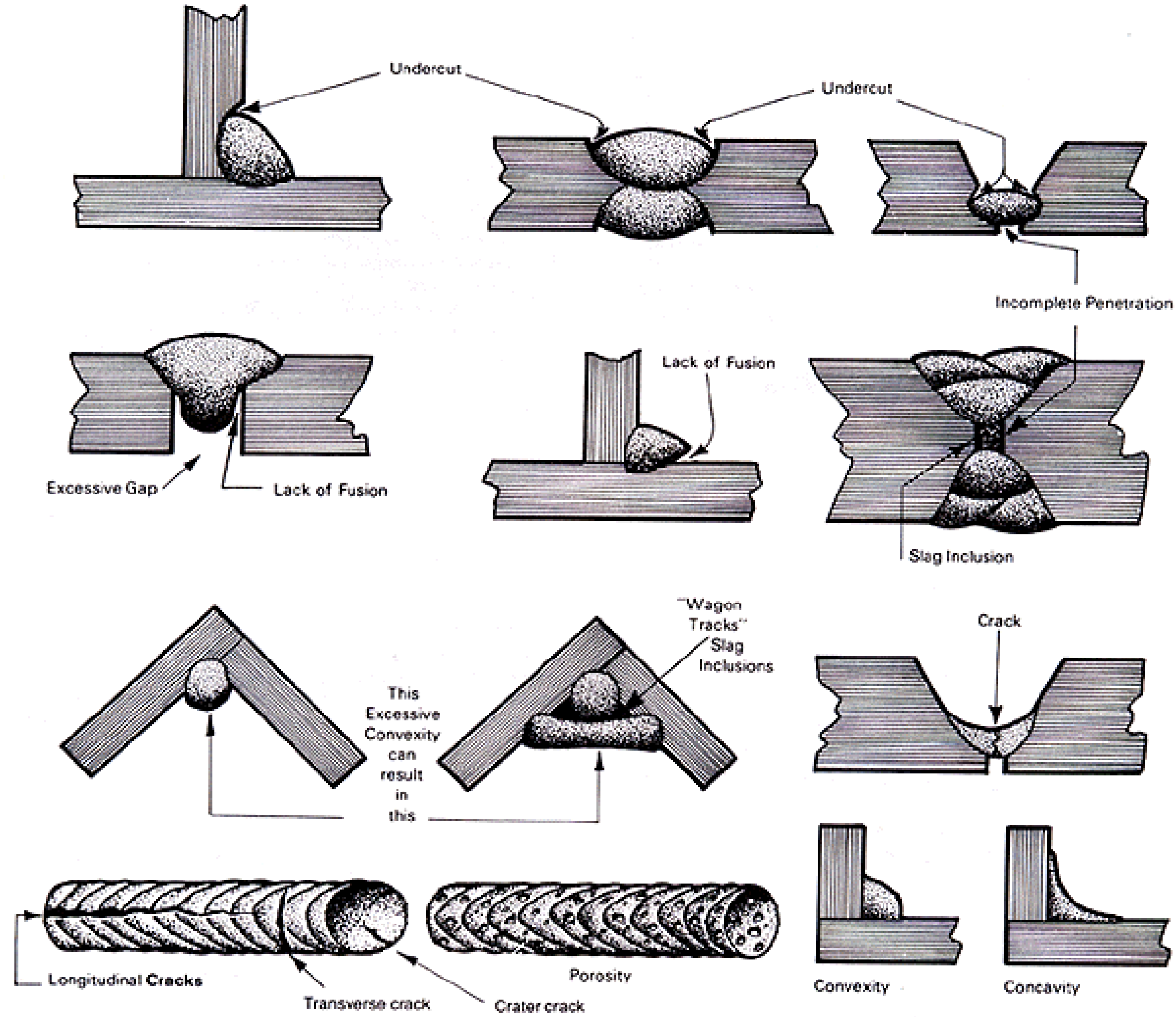
Where alloy steels or steels with carbon content greater than about 0.2% are being welded, self cooling may be rapid enough to cause some (brittle) marten site to form. This will easily develop cracks.

To prevent these problems a process of pre-heating in stages may be needed and after welding a slow controlled post cooling in stages will be required. This can greatly increase the cost of welded joins, but for high strength steels, such as those used in petrochemical plant and piping, there may well be no alternative.

VI Undercutting - In this case the thickness of one (or both) of the sheets is reduced at the toe of the weld. This is due to incorrect settings / procedure. There is already a stress concentration at the toe of the weld and any undercut will reduce the strength of the join.

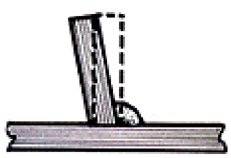
Vii Lamellar tearing - This is mainly a problem with low quality steels. It occurs in plate that has a low ductility in the through thickness direction, which is caused by non metallic inclusions, such as suphides and oxides that have been elongated

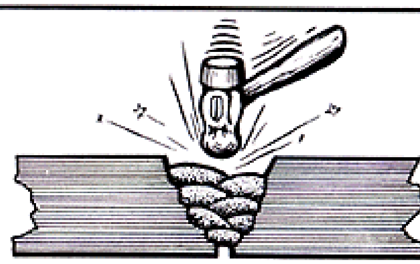
during the rolling process. These inclusions mean that the plate can not tolerate the contraction stresses in the short transverse direction.
Lamellar tearing can occur in both fillet and butt welds, but the most vulnerable joints are 'T' and corner joints, where the fusion boundary is parallel to the rolling plane. These problems can be overcome by using better quality steel, 'buttering' the weld area with a ductile material and possibly by redesigning the joint.



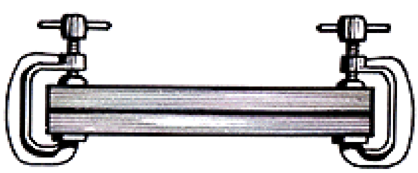
COMBATTING DISTORTION

Pre Setting
(weld pulls parts into line)

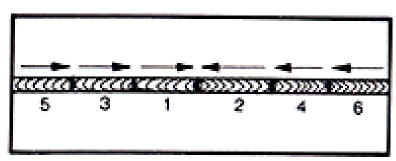




"Peening" To counteract shrinkage pull in heavy welds from one side



Clamp back to back or on to "Strong Backs"



Balance pull of shrinking (cooling) welds by techniques such as "Step back"