WELDING

Welding refers to the process of joining parts by fusing them together. Ideally fusion is brought about by a combination of heat and pressure but normal welding requires no pressure. Pressure welding can be used to carry out special welding.

Ideal conditions for welding

- Smooth joint surfaces that match each other
- Clean joint surfaces. Surfaces free from oxides, grease and dirt.
- The metals to be joined should have the same microstructure
- The metals should be good quality – no internal impurities

Before starting a weld the joint faces should be carefully prepared. When joining large plates this may mean machining the edges to a bevel. Cleaning is very important and is sometimes carried out chemically or by mechanical means.

When metals are heated to high temperatures their surfaces are more easily affected by the oxygen in the atmosphere. This is known as oxidation. Oxidation is a problem with all fusion welding. To prevent this occurring the surfaces are shielded from the atmosphere during the welding operation.

Welding processes differ in the way that they heat the metal, the manner in which the filler metal is added and the method of preventing oxidation.

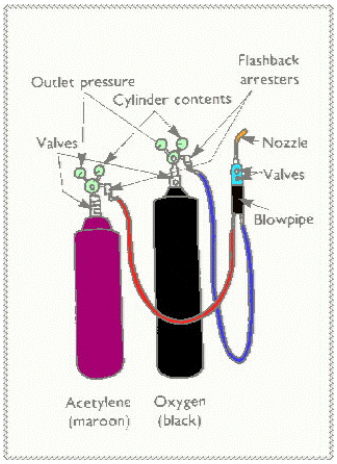
Gas Welding

In gas welding, a flame is used to melt the filler rod and the metal to be joined. This flame is produced by burning a mixture of fuel gas and oxygen.

Fuel gas + Oxygen = Gas welding

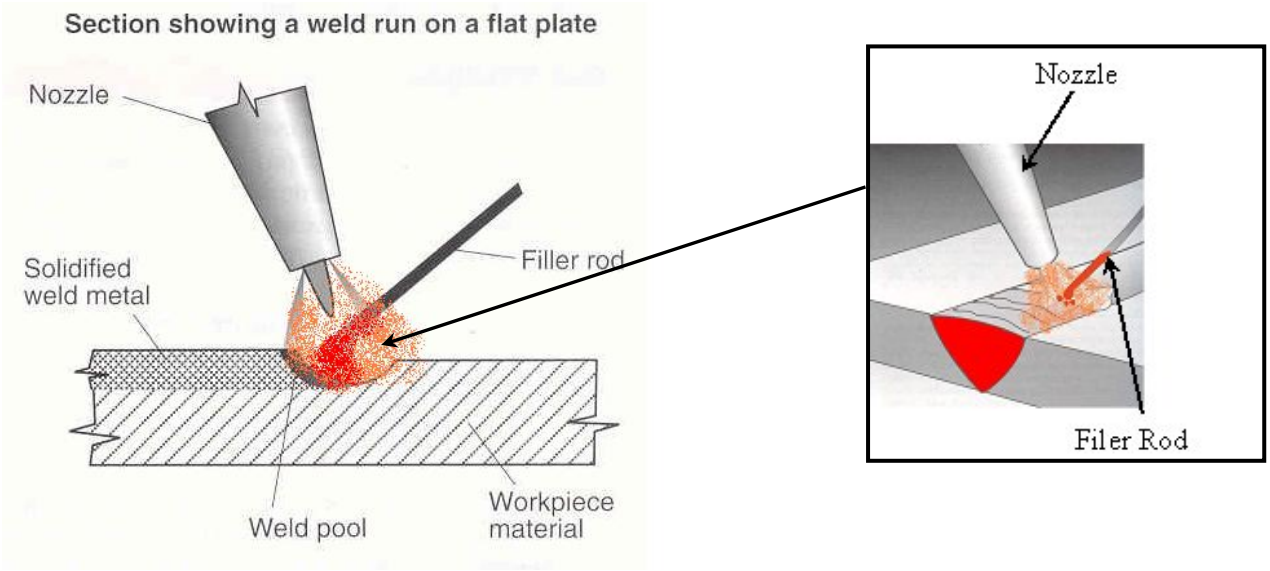
The fuel gas is usually Acetylene but other gases can be used. When Acetylene is used the process is known as oxy-acetylene welding.

Oxy-acetylene Welding

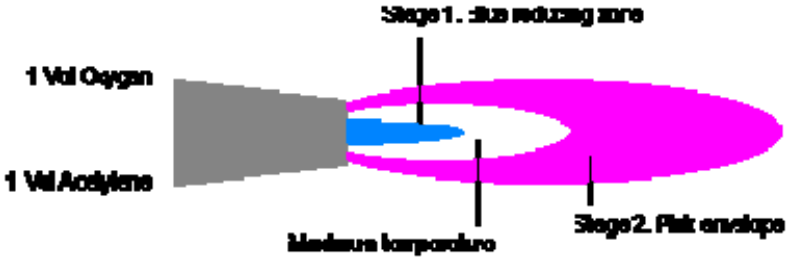


- A fusion welding process
- Oxygen stored in a black cylinder and acetylene stored in a red cylinder
- Gasses are transported to the torch in two separate coloured hoses, blue for oxygen and red for acetylene.
- The mixture of gasses can be adjusted at the torch
- Gas burns to a temperature of 3100^{o}C, this is capable of melting the metal
- As the molten metal on both joint faces meet, it fuses. This forms a permanent joint when allowed to cool.
- A filler metal is sometimes required and is fed by hand into the weld pool where it is kept at melting point. This is fed in at a regular pace to get a uniform weld

- There are many different types of filler rod that can be used to suit various metals to be joined. The rod is not the same composition as the metals to be joined; elements such as silicon are often added to improve the quality of the weld.



Oxy-acetylene Welding Flame



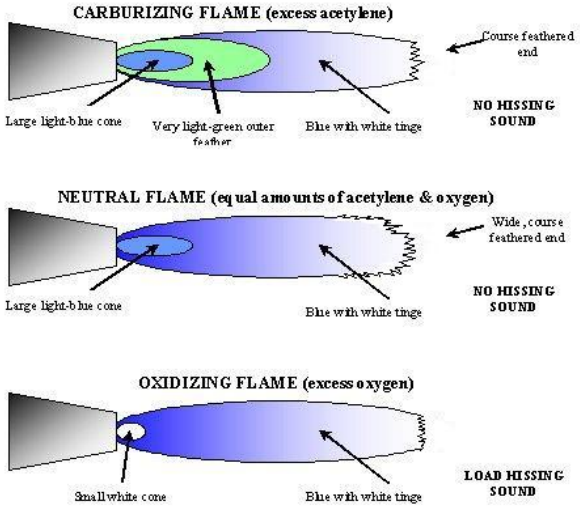
This has two distinct zones, the inner and outer. The inner zone is the hottest part of the flame. The welding should be carried out with the point of the inner cone at the joint faces.

The outer zone or the secondary combustion envelope is not as hot but has two functions

1. To preheat the joint faces
2. To prevent oxidation by using up some of the excess surrounding oxygen through combustion

Flame Adjustment

The oxygen and acetylene mixture can exit the torch in three different ways. These can be easily identified by the appearance of the flame.



1. A **neutral flame** – this has an inner cone and a secondary combustion envelope. Most welding is done with this flame.
2. An **oxidising flame –** this has excess oxygen and is used in welding brass. It can also be used as a decarburising flame for steels (the oxygen reacts with the carbon in the steel)
3. A **carburising** flame – this has excess acetylene and is used for special welding to

ensure that the metal is well protected from oxidation.

Equipment used in gas welding

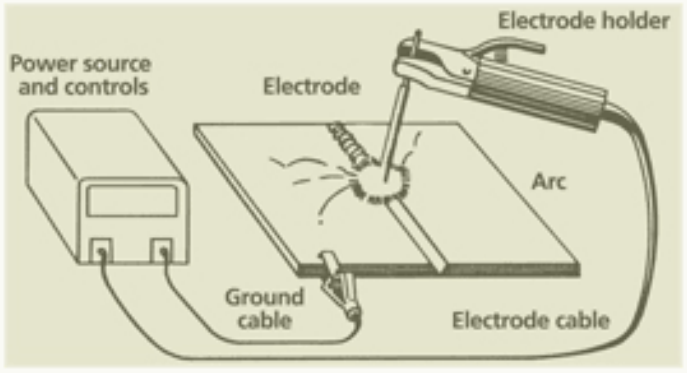
- Pressurised cylinders of oxygen and acetylene – oxygen is in gas form but acetylene is stored or dissolved in a porous material called acetone inside of the cylinder *(dissolved acetylene).*
- Gas pressure regulators – two gauges on each tank, one to indicate the pressure in the tank and the other to indicate the pressure in the supply pipe
- Welding torch – gases supplied through separate colour coded hoses. Separate controls for each gas on torch
- Gas Hose pipes – reinforced rubber hoses. Fittings for acetylene are left-hand threads. Those for oxygen are right-hand.
- Flashback arrestors – these are located on both pipes, close to the torch. They prevent the flame returning from the torch to the cylinders

Safety Notes

Never use oxygen as compressed air in the workshop.
Special care is always needed when using pressurised gases and flammable gases.
Instruction is needed in the safe handling and operation of gas welding equipment.
Always wear the correct protective clothing when welding.
Welding goggles protect your eyes from harmful light rays that are emitted by the welding process.
When welding in confined spaces, ensure that there is sufficient ventilation.
Ensure that there are no flammable liquids, gases or other materials in or around the welding area.

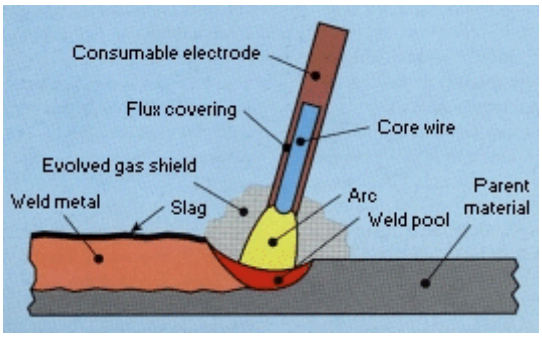
Electric Arc Welding

- Electric arc welding is a fusion welding process.
- An arc is produced when a high current jumps from the electrode to the work-piece in order to complete a circuit.
- Temperatures up to 7000^{o}C are possible.
- All arc-welding processes require an electric circuit.
- Some arc-welding processes use consumable electrodes (electrode used up in the process), others do not (they use non-consumable electrodes). The electrodes in these processes are used to maintain an arc.



Manual Metal Arc Welding Process (MMA)

An electric arc is formed and maintained between the work and the electrode. The heat from the arc melts the metal at the joint edges. The molten metal forms a pool called the 'weld pool', when this cools or solidifies the parts become permanently joined.



The electrode is a metal wire covered by a coating, often called a stick electrode. During welding the coating melts and performs many functions.

- To produce a gas which shields the weld pool from oxidisation
- Contains flux which helps the weld to form
- Produces slag, which combines all of the unwanted impurities. This slag floats to the top and during cooling it protects the weld from oxidising or cooling too rapidly (preventing brittleness)
- Can contain powdered metals, which melt and are added to the weld pool. This is sometimes used to add alloying elements in order to strengthen the weld
- Helps to maintain the arc, especially in AC welding

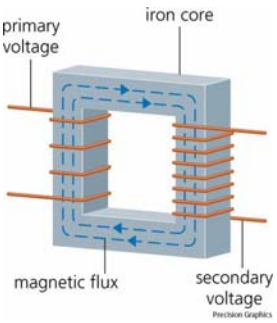
Electrical terms used in welding

- Direct current – DC
- Alternating current – AC
- Current – I – measured in amps
- Voltage – V – measured in volts
- Resistance – R – measured in Ohms
- Ohms Law – current, voltage and resistance are related to each other

Voltage = Current **X** *Resistance* **V = IR**

The Transformer

This is a device for transforming an alternating current at a particular voltage to an alternating current at a higher or lower voltage. A simple transformer consists of an iron core on which two coils of wire are wound. When the primary coil is connected to the electricity supply, the AC current causes an alternating magnetic field within the iron core. This magnetic field in turn produces an alternating current in the second coil. If the secondary coil has a smaller number of coils than the primary coil, the output voltage will be lower than the input voltage but the output current will be higher than the input current.



Equipment used in MMA welding

- Welding power source
- Cables
- Electrode holder
- Ground clamp (earth clamp)

AC Power Source

- Takes its power directly from the main supply of electricity
- It uses a transformer to supply the correct voltage to suit the welding conditions
- The current in the secondary coil can be adjusted
- The primary coil is connected to the electricity supply and the secondary coil is connected to the electrode holder and the earth clamp.

DC Power Source

There are two types of DC welding plant in use

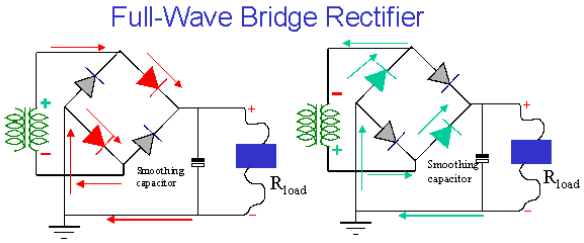
- DC generator
- Transformer – rectifier

DC generator

A motor drives an electrical generator. This motor can be electric, diesel or petrol powered. It provides DC current for the arc.

Transformer – rectifier

This has a built-in device to change alternating current into direct current. This built-in device is called a bridge rectifier. The transformer- rectifier has the advantage that it can supply AC or DC current for welding.



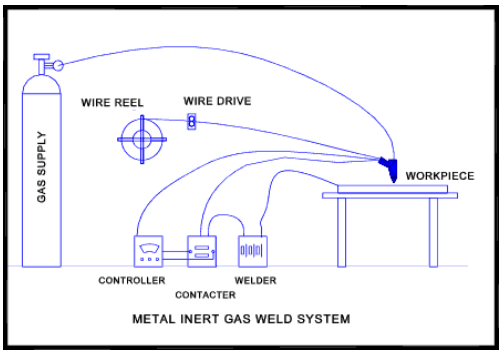
On part of the cycle when the top of the secondary is positive, current flows through the two red diodes, with current flowing 'down' through the load. On part of the cycle when the top of the secondary is negative, current flows through the two green diodes, with current still flowing 'down' through the load. The drop across the load is two diode drops less than the voltage on the secondary coil.

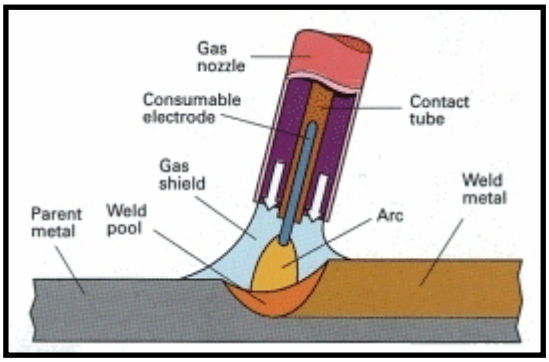
The rectifier converts AC current to DC current using a single phase bridge converter. It uses four diodes to conduct the power supply. During one half cycle of the AC supply diodes D1 and D3 are conducting. During the next half cycle diodes D2 and D4 are conducting. The current is then passed through a smoothing capacitor to give a DC output.

<u>The Cables</u>

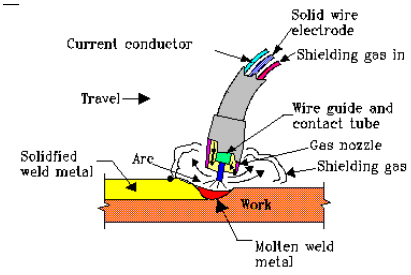
It is important that the diameter of the cables is not too small as this could increase resistance and cause them to heat up during the welding process. They usually contain many strands of thin copper wire, which allows them to carry the electric current and still remain flexible.

Metal Arc Gas Shielded Welding (MAGS)



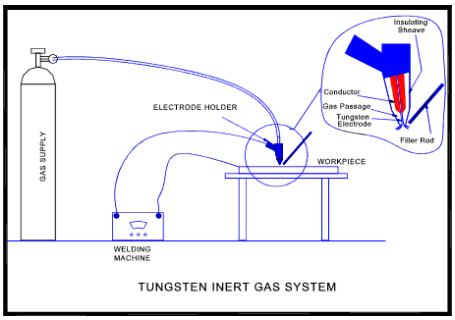


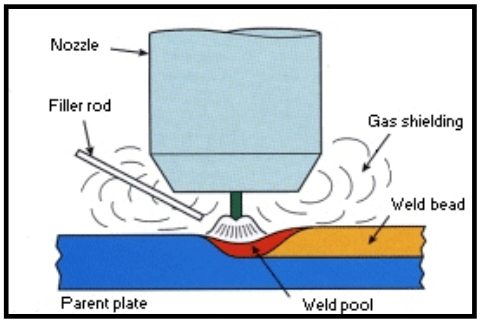
- Previously known as MIG welding (metal inert gas)
- The electrode is a bare wire that is fed continuously from a spool through the welding gun. This wire electrode is consumed during the welding process and also acts as the filler metal.
- Shielding of the weld pool is carried out by a continuous supply of inert gas.
- This gas is also fed through the welding gun. Argon (Ar), Nitrogen (N), Carbon dioxide (CO_2) or Helium (He) can be used.



- DC power is used in MAGS welding and is supplied by a transformer-rectifier.
- MAGS welding can be used on light sheet metal as well as heavy plate.
- It uses a continuous wire electrode feed; therefore no slag is formed on the weld.
- Often used in car manufacture and can be carried out by robots.

Tungsten Arc Gas Shielded Welding (TAGS)

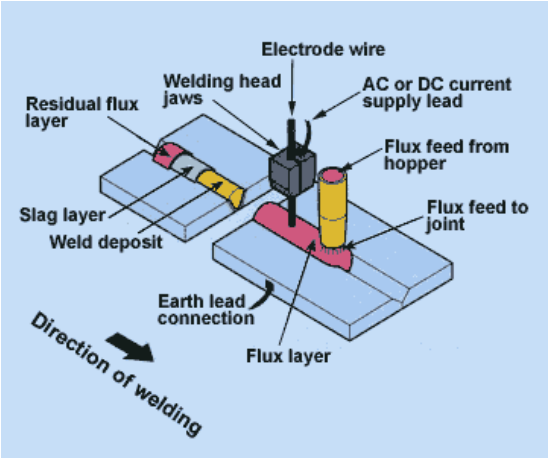




- Previously known as TIG welding (tungsten inert gas)
- This welding process does not consume the electrode. The electrode is made of tungsten and is referred to as a non-consumable electrode.
- This process also uses an inert gas fed from a cylinder to shield the weld pool.
- If filler metal is required a filler wire is fed manually into the weld area, similar to oxy-acetylene welding.
- The arc in this process is started differently than in previous welding processes. The operator starts it when the electrode is held close to the work and a foot pedal pressed. This foot pedal operates a separate electric circuit, which is high frequency and is specifically for starting and maintaining the arc.
- TAGS' welding normally uses DC current but can also supply the required AC current to weld Aluminium and Stainless Steel.

Submerged Arc Welding (SAW)

- In this process a bare wire consumable electrode is used and fed automatically into the weld pool.
- The flux is in powder form and it too is fed automatically onto the weld area from a hopper.
- The flux completely covers the weld area and the arc; hence the name 'submerged arc welding'.
- This process is suitable for long, un-interrupted weld runs. E.g. reinforcing beams for construction and fabrication.
- Can use AC or DC current.

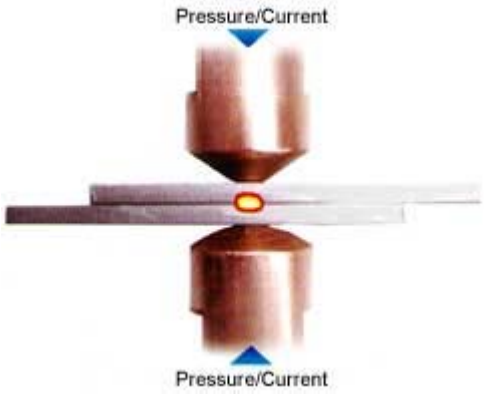


Resistance Welding

There are many forms of resistance welding. The resistance to the flow of an electric current causes the heat in the joint area. The greatest resistance to the current and hottest area is where the joint faces meet. Once the melting point of the metal is reached the joint is made through fusion.

Resistance Spot Welding

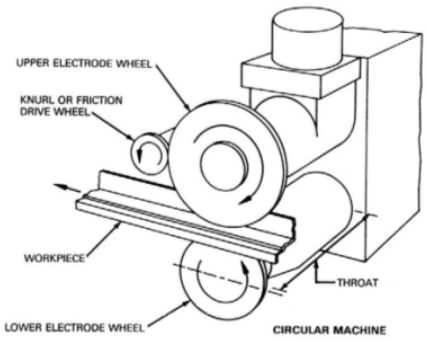
- Used to join light gauge sheet metal
- Electrodes are made from brass, copper or some other low resistance metal
- A combination of pressure and electric current at the electrodes causes rapid heating and fusing of a small globule of metal from both faces



- This process can be carried out on both fixed and portable machines
- Often carried out by robotic control in the car manufacturing industry

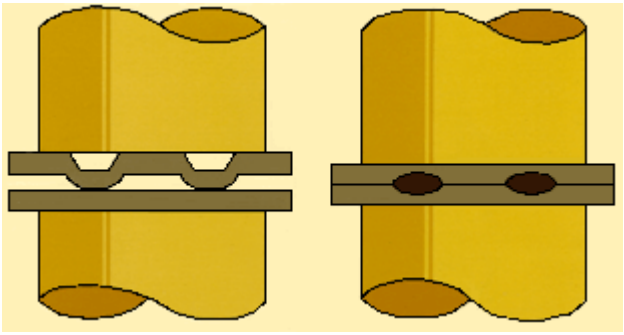
Resistance Seam Welding

- Used for continuous seams, two methods in general use
- Stitch welding is one method, which uses a series of overlapping spots to create the welded seam
- Roller welding is another method, which uses rollers. These rollers have electrical pulses passing through them to create the weld.
- Water jets are often used to cool the work piece on exiting the rollers



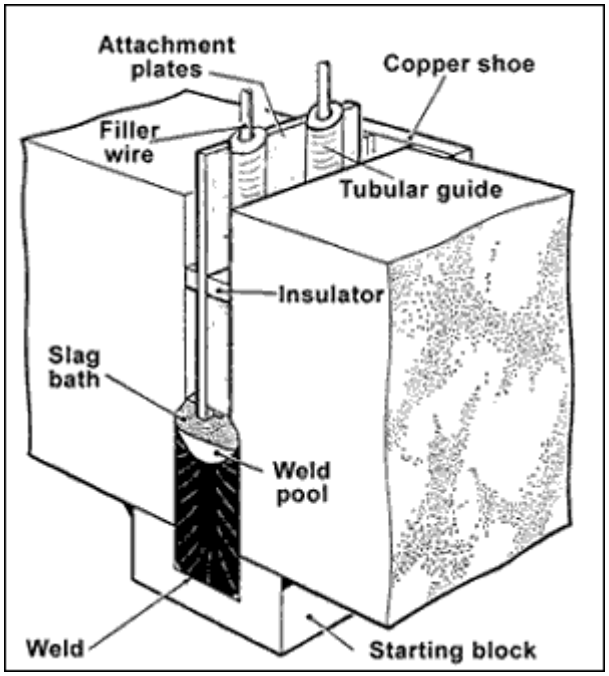
Projection Welding

- Used for resistance welding of relatively large objects
- The contact area between the two parts needs to be reduced. This is achieved by forming points on one of the surfaces.
- The electric current is concentrated to these new contact areas and the weld is formed.
- This allows several spots to be carried out simultaneously
- Often used in mass production



<u>Electroslag Welding</u>

- This is a very effective process for welding thick sections of steel plate, usually 50mm plus.
- It is totally automatic
- The heat required for welding is achieved from the passage of electrical current through a liquid slag
- There is an arc involved but the process is totally different to submerged arc welding. The arc in this process is only used to produce molten slag
- The resistance of the metal to be welded plays no part in the welding process, it is the molten slag that melts the joint faces and the filler metal
- The molten slag and the molten metal is contained between two copper dams which travel upwards as the weld metal solidifies
- The bare metal electrode is continuously fed into the weld pool
- The weld is assisted to solidify by the water cooling of the copper plates
- This process is ideal for the welding of large plates ranging from 13mm to 900mm



- The edges need to be square and approximately 25 – 30 mm apart prior to welding
- Applications include building construction, machine manufacture, heavy pressure vessels, and the joining of large castings.

Multi-run Welds

This is when multiple layers of weld are laid on the weld joint. This adds to the penetration of the weld thus strengthening the finished joint. Each new run post-heats the previous one resulting in more refinement in the materials structure.