2 Gas welding

Gas welding is one of the oldest methods of welding and, for many years, was the most widely used method of metal-melting; however, its use is a lot less common today. Nevertheless, it is a versatile method, using simple and relatively cheap equipment. It is suitable for repair and erection work, for welding pipes/tubes and structures with a wall thickness of 0.5–6 mm in materials particularly prone to cracking, such as cast iron and non-ferrous metals. It is also widely used for cladding and hardfacing. The heat is generated by the combustion of acetylene in oxygen, which gives a flame temperature of about 3100 °C. This is lower than the temperature of an electric arc, and the heat is also less concentrated. The flame is directed onto the surfaces of the joint, which melt, after which filler material can be added as necessary. The melt pool is protected from air by the reducing zone and the outer zone of the flame. The flame should therefore be removed slowly when the weld is completed.

The less concentrated flame results in slower cooling, which is an advantage when welding steels that have a tendency to harden, although it does make the method relatively slow, with higher heat input and the added risk of thermal stresses and distortion.

In addition to welding, gas flames are also often used for cutting, and are very useful for heating and flame straightening.

2.1 Equipment

A set of equipment (Figure 2.1) consists essentially of gas bottles, pressure regulators, gas hoses, flashback arresters and welding torches.

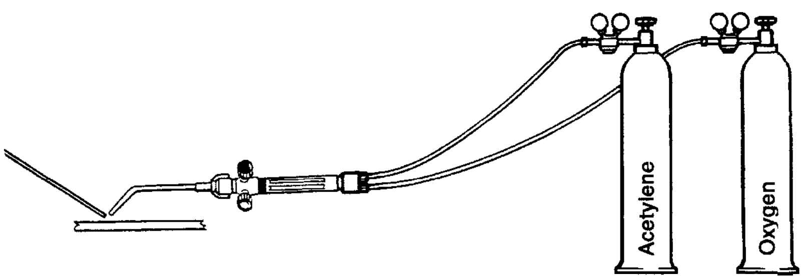

Figure 2.1 A gas welding set.

Welding gases and their storage

Gas bottles for combustible gases must be stored outdoors or in a well-ventilated area. Special warning signs must be displayed on the outside of the storage area. Acetylene and oxygen bottles must be kept well apart.

Acetylene

Acetylene (C_2H_2) is the fuel gas for gas welding. It consists of 92.3 % of carbon by weight, and 7.7 % of hydrogen. Its combustion in oxygen produces a higher combustion temperature than that of any other hydrocarbon gas. In addition, its flame is the most concentrated in comparison with other gases.

Acetylene ignites very easily, and produces an explosive mixture in air over a wide range of concentrations (2.3–82 %). Check carefully that there are no leaks.

Acetylene is chemically unstable under pressure, even without the presence of air and, under certain conditions, it can explosively decompose to its constituents (carbon and hydrogen). To enable the gas to be stored, the bottles are filled with a porous mass, saturated with acetone, which absorbs the gas when it is filled. The pressure in the bottles is 2 MPa. However, explosive decomposition can occur in the pipes from the bottle if the pressure exceeds 1.5 MPa.

TABLE 2.1 Important characteristics of fuel gases.

Gas	Density, kg/m^3	Calorific value. MJ/kg	Flame temperature. °C	Combustion velocity, m/s
Acetylene	1.07	48.2	3 100	13.1
Propane	2.00	46.4	2 825	3.7
Hydrogen	0.08	120	2 525	8.9

Oxygen

Oxygen is stored as a compressed gas or liquid. In bottles, it is usually stored at a pressure of 20 MPa. Large users usually receive the gas in liquid form.

Make sure that all connections are clean and tight, in order to avoid leakage. Never apply oil or grease to connections.

Pressure regulators

The purpose of the pressure regulator is to reduce the high and variable pressure in the bottle to a suitable working pressure. It keeps the gas flow rate constant throughout the life of the bottle charge, despite any variations in back pressure caused by the heating of the welding torch.

Gas hoses

Gas hoses are colour-coded: red for acetylene and blue for oxygen. In addition, in order to protect against mistakes, the acetylene connection has a left-hand thread, while the oxygen connection has a right-hand thread.

Flashback arrester

A flashback means that the flame burns backwards into the torch with a popping sound. It occurs if the combustion speed of the flame exceeds the speed at which the gas is being supplied, so that the flame front moves backwards.

A flashback arrester fitted at the regulator prevents a flashback from going any further back.

The reason for a flashback occurring is that a mixture of oxygen and acetylene has occurred in the hoses, e.g. by oxygen having entered the acetylene hose and formed an explosive mixture. The flashback arrester prevents the flame from reaching the acetylene bottle and triggering an explosive decomposition.

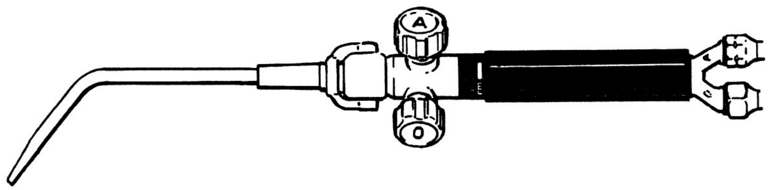

Figure 2.2 Gas welding torch.

Welding torches

One can distinguish between two types of welding torches: ***injector torches*** for low pressure acetylene and ***high pressure torches.***

In high pressure torches, the acetylene and oxygen flows are self-powered by the pressure in their storage bottles, and mix in the mixing chamber section of the torch.

In low-pressure torches, the oxygen flows into the torch through a central jet, producing an injection effect that draws in acetylene from the surrounding peripheral connection. From here, the gases continue to the mixing section prior to combustion.

Gas flames

The basic requirement for a good weld is that the size and type of the flame should be suited to the type of work.

The size of the flame depends on the size of the torch nozzle and on the pressure of the gases flowing through it. This pressure should be maintained within certain limits. If it exceeds the normal pressure, there will be a considerable jet effect and the flame will become 'hard'. Below the correct pressure, the jet effect will be reduced and the flame will be 'soft'.

We distinguish between three different types of flames, depending on their chemical effect on the melt pool: carburising, neutral, and oxidising.

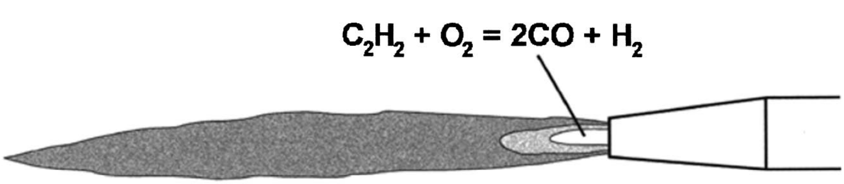

Figure 2.3 A normal weldingflame. Carbon monoxide and hydrogen are formed in the innermost reaction zone. They produce a reducing zone (in the middle), with combustion continuing in the outer zone with oxygen from the surrounding air.

Neutral flame

The normal flame is that which is used most. It (Figure 2.3) is easily recognised by the three clearly distinguished combustion zones. The innermost zone, the cone, is a mixing zone and glows white. Acetylene is burning here, to form carbon monoxide and hydrogen which produce a colourless tongue around the cone. This second zone is chemically reducing, and so it reduces any metal oxides and keeps the melt pool clean. The outer, blue zone of the flame is where carbon monoxide and hydrogen are burning with oxygen from the air, forming the final combustion products of carbon dioxide and water vapour. It prevents oxygen in the air from coming into contact with the molten metal, and so acts as a shielding gas.

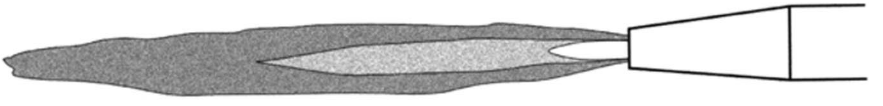

Figure 2.4 Carburisingjlame.

The carburising flame

If the proportion of acetylene in a neutral flame is increased, there is insufficient oxygen to burn the surplus acetylene in the core zone. The acetylene therefore continues to the second zone, where it appears as a highly luminous yellow-white flame. To some extent, the length of second zone indicates the amount of excess acetylene.

Figure 2.5 Oxidising flame.

The oxidising flame

If the quantity of oxygen in the weakly reducing flame is further increased, the flame changes to an oxidising flame. The core length is reduced, and the flame takes on a violet tinge with low luminosity.

Forehand and backhand welding

Two different methods of welding are used when gas welding: forehand and backhand. The flame in forehand welding is directed away from the finished weld, while in backhand welding it is directed towards it (Figure 2.6).

Thin sheet metal (less than 3 mm) is normally carried out using forehand welding. This method is generally used for ***non-ferrous metals,*** although thicker materials can also be backhand welded.

Steel over 3 ***mm*** thick should be backhand welded, as the size of the melt pool is so large, when welding thick materials, that the gases and slag cannot escape from the pool without assistance. Backhand welding is faster than forehand welding, and so the workpiece is subjected to high temperature for a shorter time. As a result, backhand welding thick materials have a finer crystalline structure and retain their toughness better than would have been the case if they had been forehand welded.

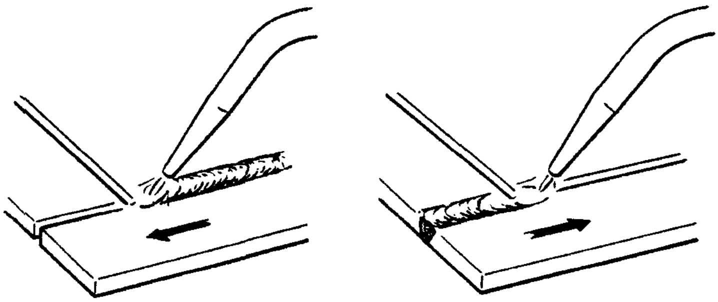

Figure 2.6 Forehand welding (left) and backhand welding (right).

Flux is used when welding easily oxidised materials, where the welding flame itself is insufficient to prevent oxides forming. This is likely to be the case when welding stainless steels and non-ferrous metals. The flux is brushed onto the joint surfaces before welding, and must be thoroughly removed after welding in order to prevent corrosion.

The benefits of gas welding

Gas welding is very suitable for welding pipes and tubes, it is both effective and economic for applications such as HVAC systems, for the following reasons:

- The ability to even out the temperature in the weld at low temperatures. Slow heating and cooling can avoid the risk of hardening.
- Metal thicknesses up to about 6 mm can be welded with an I-joint.
- Speed, as only one pass is needed. Filler wires can be changed without having to pause for grinding.
- Good control of melting, as the welder can see at all times that he has the desired pear-shaped opening in the bottom of the melt pool.
- Root defects are avoided by taking care to ensure good burn-through.
- Pipes and tubes often have to be welded in very confined spaces. In such cases, gas welding is often preferable, bearing in mind the less bulky protective equipment required (goggles, as against a normal arc welding helmet or visor, and compact torch) to perform the work.
- The equipment is easy to transport and requires no electricity supply.
- It is possible to use the light from the flame to locate the joint before welding starts.
- The size of the HAZ can be reduced by surrounding the weld area with damp (fire-proof!) material.

Other applications for gas welding include welding of hot water pipes, gas bottles, nuclear heat exchangers and boilers.

Warning: Note the risk of fire when carrying out temporary welding or cutting work in the vicinity of flammable materials or parts of buildings.