20 GAS WELDING

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20.1 DEFINITION

Gas welding also called an oxy-fuel gas welding, derives the heat from the combustion of a fuel gas such as acetylene in combination with oxygen. The process is a fusion welding process wherein joint is completely melted to obtain the fusion.

The fuel gas generally used is acetylene because of the high temperature generated in the flame. This process is called oxy-acetylene welding. The useful fuel gases used for gas welding are shown in table 20.1.

Table 20.1. Characteristics of fuel gases.

GAS	CHEMICAL FORMULA	HEAT CONTENT (MJ/m^3)	FLAME TEMPERATURE (°C)
Acetylene	C_2H_2	55	3100
Propylene	C_3H_6	88	2500
Propane	C_3H_8	93	2450
Hydrogen	H_2	10	2390
Natural Gas	$CH_4 + H_2$	37	2350

20.2 OXY-ACETYLENE WELDING

20.2.1 Principle of operation

When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited, the flame is produced which is sufficiently hot to melt and join the parent metal. Temperature of flame is about 3100°C. A filler rod is generally added to build up the seam for greater strength.

Oxy-acetylene welding may be classified as:

1. High pressure Oxy-acetylene welding.
2. Low pressure Oxy-acetylene welding.

1. **High Pressure Oxy-acetylene Welding:** In case of high pressure Oxy-acetylene gas welding, the acetylene gas is supplied from the acetylene cylinder in compressed form.
2. **Low Pressure Oxy-acetylene Welding:** In case of low pressure Oxy-acetylene gas welding, the acetylene gas is supplied from the generator at low pressure. In the generator calcium carbide stone is added in the chamber in which water is already present. Calcium carbide stone reacts with the water and produce acetylene gas. This gas can be easily collected from the top of the water and can be used for welding purpose.

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

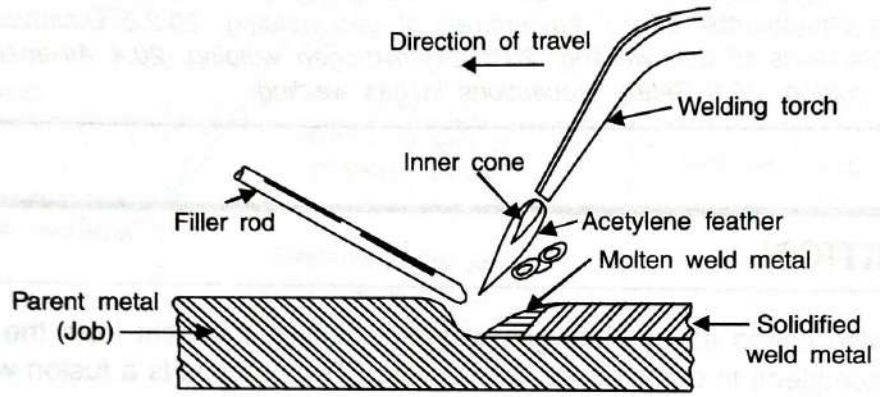


Fig. 20.1. *Oxy-Acetylene Welding.*

20.2.2 Types of Flames

1. Neutral flame

A neutral flame is produced when oxygen to acetylene ratio is 1.1 to 1.

- The temperature is of the order of about 5900°F (3200°C).
- The flame has nicely defined inner cone (light blue in colour) and is surrounded by outer envelope which is dark blue in colour than the inner cone.

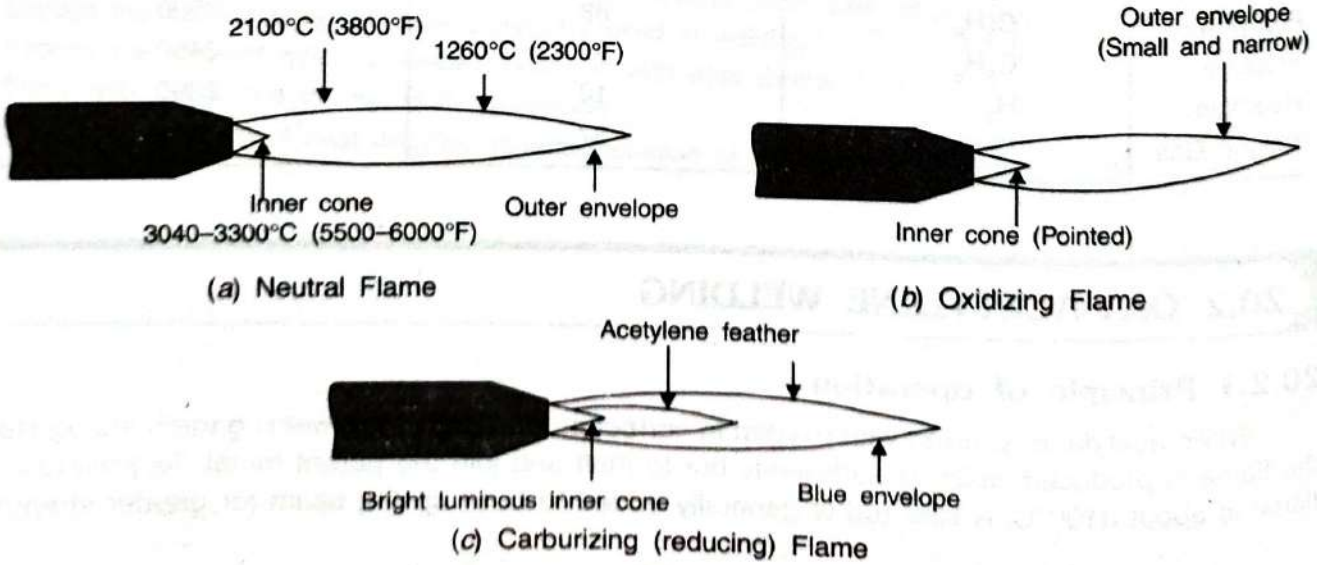


Fig. 20.2. *Types of Flames.*

- It is called neutral because it will not oxidize or carburise the metal.
- It is used for welding of :
  - ❖ Mild steel
  - ❖ Stainless steel
  - ❖ Copper
  - ❖ Cast iron
  - ❖ Aluminium

2. Oxidizing flame

- ❖ After the neutral flame, if the supply of oxygen is further increased, the result will be an oxidizing flame.
- ❖ Its inner cone is more pointed, outer flame envelope is much shorter.
- ❖ It burns with a loud roar.
- ❖ The temperature is of the order of about 6300°F (because of exess O_2 so complete combustion takes place).
- ❖ This flame is harmful for steels, because it oxidizes the steels.
- ❖ Only in the welding of copper and copper based alloys, oxidizing flame is desirable, because in those cases a thin protective layer of slag forms over the molten metal.

3. Reducing flame

If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburising or reducing flame *i.e.* rich in acetylene.

- ❖ In this flame, acetylene feather exists between the inner cone and outer envelope.
- ❖ Temperature is of the order of about 5500 °F (less because it does not completely consume the available carbon).
- ❖ Metals that tend to absorb carbon should not be welded with reducing flame.
- ❖ Carburizing flame contains more acetylene than a reducing flame.
- ❖ Carburizing flame is used for the welding of lead and for carburizing (surface hardening) purposes.
- ❖ Reducing flame is used with low alloy steel rod for welding high carbon steel.

20.2.3 Chemistry of Oxy-Acetylene Flame

Combustion of gas mixture takes place in two main stages :

Stage 1. Oxygen and acetylene in equal proportions by volume burn in the inner white cone and forms carbon monoxide, while the hydrogen is liberated.

$$2C_2H_2 + 2O_2 \longrightarrow 4CO + 2H_2 \quad \ldots (i)$$

Stage 2. The carbon monoxide produced in stage 1 (inner cone) uses the oxygen from the air and results in carbon dioxide and water vapours

$$4CO + 2H_2 + 3O_2 \longrightarrow 4CO_2 + 2H_2O \quad \ldots (ii)$$

Combining equations (*i*) and (*ii*)

$$2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O \quad \ldots (iii)$$

So it can be seen that about two fifth of the oxygen necessary for the complete combustion of acetylene is received from the cylinders and rest from the surrounding air atmosphere.

20.2.4 Welding Operation

To ignite a flame

- Open the acetylene control valve of the welding torch and after the system has been flushed clean of air, the gas is ignited. At this stage, enough of oxygen is drawn in from the atmosphere to burn acetylene partially.
- The acetylene control valve of the welding torch is then opened in order to adjust the proportions in which acetylene and oxygen are required to mix and burn.
- Flame adjustment will be done according to our requirement of flame as discussed in 20.2.2.

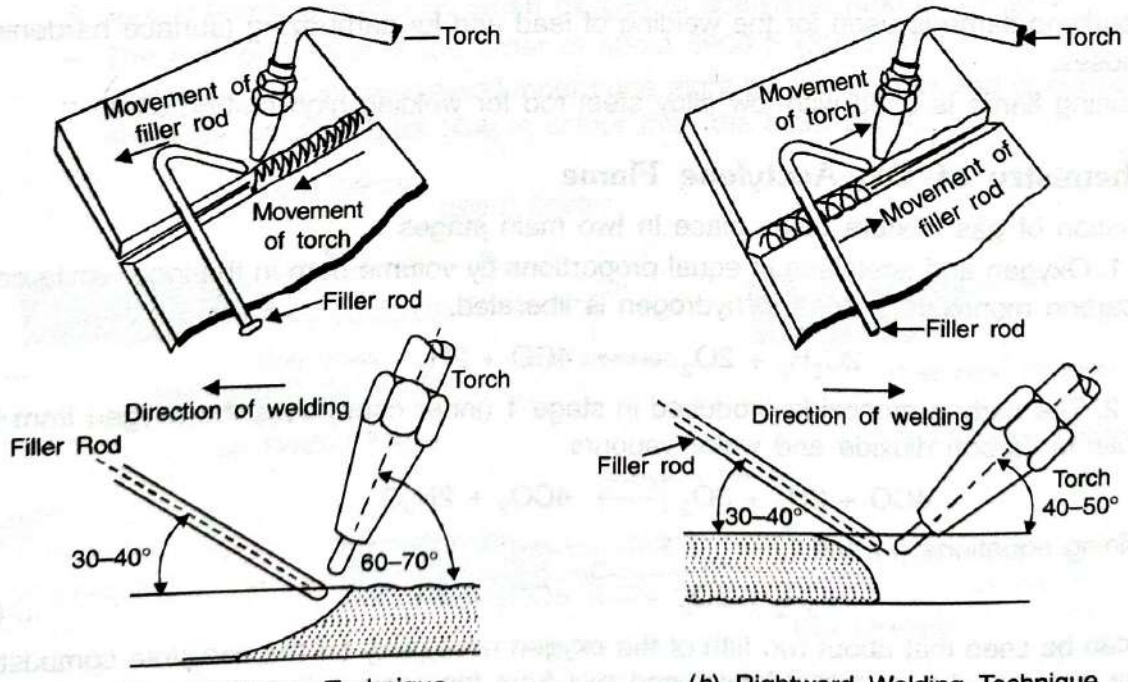
To extinguish the flame and stop welding

- When the welding or cutting operation is finished, close the torch acetylene valve first and then turn off the torch oxygen valve.
- Then close the oxygen cylinder valve.
- Release the pressure in the hose and regulator by opening the oxygen control valve on the torch.
- Release the pressure on the oxygen regulator by turning the regulator to the minimum pressure positions.
- Close the oxygen control valve on the torch.
- Repeat the same procedure for purging acetylene.

20.2.5 Welding Techniques

Depending upon the ways in which welding rod and the welding torch can be used, there are two usual techniques used in gas welding namely :

1. Leftward technique or fore-hand welding method.
2. Rightward technique or back-hand welding method.



(*a*) Leftward Welding Technique (*b*) Rightward Welding Technique

Fig. 20.3. *Welding Techniques.*

1. Leftward Technique

- ❖ The welder starts welding at the right hand end of the joint and proceeds towards the left.
- ❖ The welding flame is directed away from the finished weld.
- ❖ Welding torch is given small sideways movements, while the filler rod is moved steadily across the seam.
- ❖ Good control and neat appearances are obtained.
- ❖ It preheats the joint.
- ❖ If workpiece thickness is more than 3 mm, bevel of plates is necessary and included angle of V joint is 80-90 degrees, so it is not economical.
- ❖ When the weld is recommenced, the tip of the rod causes weld contamination.

2. Rightward Technique

- ❖ Welding begins at the left-hand end of the joint and proceeds towards the right, hence the name rightward technique.
- ❖ The torch flame is directed towards the completed weld.
- ❖ Since the flame is constantly directed on the edges of the V ahead of the weld puddle, no sidewise motion of the torch is necessary, which results narrower V-groove (30 degree bevel).
- ❖ The ripples are heavier and spaced further apart.

Rightward technique has got certain advantages over the leftward :

- ❖ Upto 8 mm plate thickness, no bevel is necessary. This reduces the cost of preparation of edges and consumption of filler rod.
- ❖ For bigger thickness, included angle of V need be only 60 degrees against 80 degrees in leftward technique.
- ❖ The welder's view of the weld pool and the sides and bottom of the V groove is unobstructed so better control is possible.
- ❖ The weld quality is better.
- ❖ Smaller total volume of deposited metal reduces shrinkage and distortion.
- ❖ Because of less consumption of filler rod, cost of welding is less.

20.2.6 Gas Welding Equipments

1. Oxygen Gas Cylinder

Oxygen cylinders are painted black and valve outlets are screwed right handed.

2. Acetylene Gas Cylinder

Acetylene cylinder is painted maroon and the valves are screwed left-handed, to make this easily recognizable, they are chamfered or grooved.

3. Oxygen and Acetylene Pressure Regulators

- ❖ The pressure of the gases obtained from cylinders/generators is considerably higher than the gas pressure used to operate the welding torch. The purpose of using a gas pressure regulator is, therefore :
- ❖ To reduce the high pressure of the gas in the cylinder to a suitable working pressure.

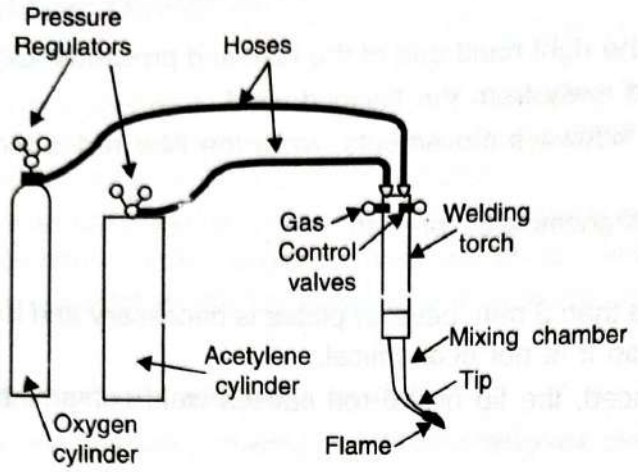


Fig. 20.4. *Gas Welding Equipment.*

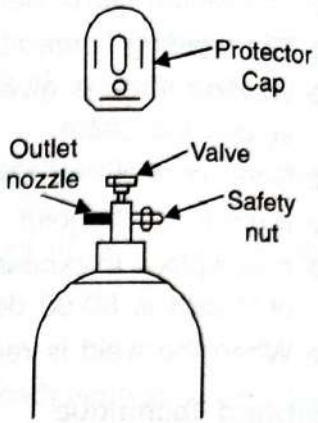


Fig. 20.5. *Oxygen Cylinder.*

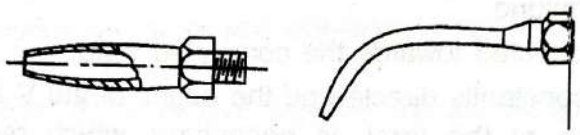


Fig. 20.6. *Welding Nozzles.*

- To produce a steady flow of gas under varying cylinder pressures.
- A pressure regulator is fitted with two pressure gauges one for gas pressure in the cylinder and the other shows the reduced pressure at which the gas is coming out.
- A pressure regulator is connected between the cylinder/generator and the hose leading to welding torch.

4. Oxygen and Acetylene Gas Hoses and Hose Connections

Hoses : The hose for the supply of oxygen to the welding torch is coloured blue and has right handed thread connections, whereas the acetylene hose is coloured red and has left handed connections with chamfers or grooves on the nuts.

Hose Clamps : A metal clamp is used to attach the welding hose to a nipple. The clamp squeezes the hose around the nipple to prevent it from working loose.

Hose Couplers : These are used to join two pieces of welding hoses.

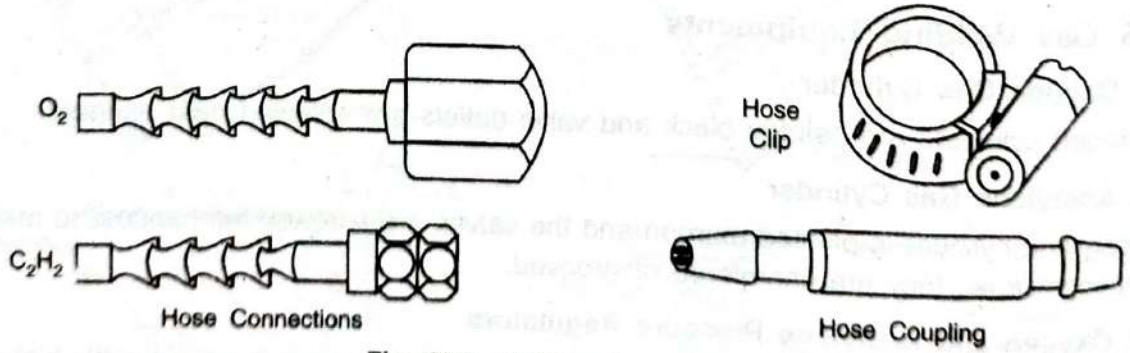


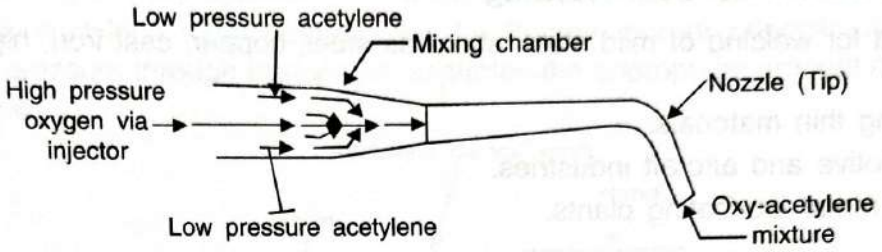
Fig. 20.7. *Welding Hose Fittings.*

5. Welding Torch or Blowpipe

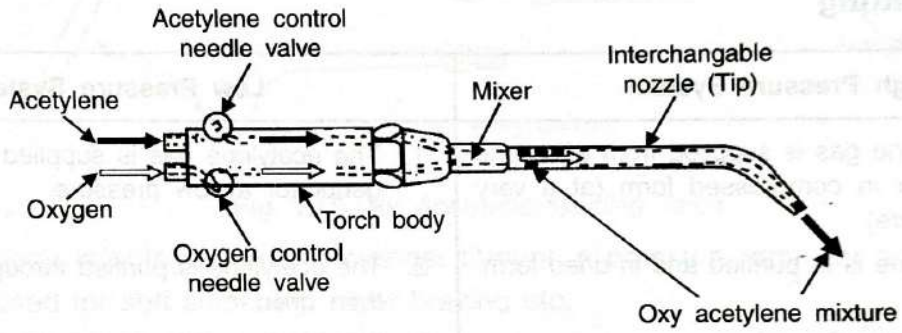
Oxygen and the fuel gas having been reduced in pressure by the gas regulators are fed through suitable hoses to a welding torch which mixes and controls the flow of gases to the

welding nozzle or tip where the gas mixture is burnt to produce a flame for carrying out gas welding operation. There are two types of welding torches namely :

- ❖ High pessure (or equal pressure) type.
- ❖ Low pressure (or injector) type.



(*a*) Low Pressure Welding Torch



(*b*) High Pressure Welding Torch

Fig. 20.8. *Welding Torches.*

6. **Trolleys for the transportation of oxygen and acetylene cylinders.**
7. **Set of keys and spanners.**
8. **Filler rods and fluxes.**
9. **Gas lighter.**
10. **Protective clothing for the welder (*e.g.* asbestos apron, gloves, goggles etc.)**

20.2.7 Advantages of Gas Welding

1. It can be applied to a wide variety of manufacturing and maintenance situations.
2. Rate of heating and cooling of weld deposit and job is slow.
3. No electric current is required.
4. Equipment is having less cost.
5. Operator is having better control because sources of heat and filler metals are separate.
6. Cost and maintenance of the welding equipment is low.

20.2.8 Disadvantages of Gas Welding

- ❖ Flame temperature is less than the temperature of the arc.
- ❖ Refractory metals (*e.g.* tungsten, molybdenum, tantalum etc.) and reactive metals (titanium and zirconium) cannot be gas welded.
- ❖ Gas flame takes a long time to heat up the metal than an arc.
- ❖ Heat affected zone is wider.

- ❖ Acetylene oxygen gases are rather expensive.
- ❖ Storage of gases is not safe. More safety is needed.
- ❖ More skilled operators are needed.

20.2.9 Applications of Gas Welding

- ❖ It is used for welding of mild steel, stainless steel, copper, cast iron, high carbon steels etc.
- ❖ For joining thin materials.
- ❖ In automotive and aircraft industries.
- ❖ In sheet metal fabricating plants.

20.2.10. Comparison between high pressure and low pressure oxy-acetylene welding

High Pressure System	Low Pressure System
1. The acetylene gas is supplied from acetylene gas cylinder in compressed form (at a very high pressure)	1. The acetylene gas is supplied from acetylene generator at low pressure.
2. The acetylene is in purified and in dried form.	2. The acetylene is purified through purifiers and then dried.
3. Plant is more safer.	3. Plant is less safe as the chances of leakage are always there in generator connections.
4. Plant is neat and clean.	4. Lot of cleanliness is needed in generating the acetylene gas.
5. Hydraulic back pressure valve is not required.	5. Hydraulic back pressure valve is a must.
6. High working efficiency.	6. Less working efficiency.
7. Plant is portable and easy to assemble and dismental.	7. Generator is difficult to move and lot of space is needed.
8. Two reducing valves are used one for oxygen and other for acetylene.	8. Only one reducing valve is used *i.e.*, for oxygen only.