SATHYABAMA UNIVERSITY
SUB-WELDING TECHNOLOGY
SUB CODE-SPRX1009(REG:2010)

UNIT I GAS WELDING 10 hrs.

Welding techniques and terminology -Gas welding -Process variations -Equipment -Generation of acetylene -Types of gases -Flame characteristics -Flash back -Welding torches -Regulators -Welding of ferrous and non ferrous metals -Gas cutting principles and cutting of ferrous and non ferrous metals - Thermit welding process -Characteristic curves of various welding parameters -Welding defects

DEFINITION

Welding is a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone, and with or without the use of filler material.

Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

TYPES

- Plastic Welding or Pressure Welding

  The piece of metal to be joined are heated to a plastic state and forced together by external pressure

  (Ex) Resistance welding

- Fusion Welding or Non-Pressure Welding

  The material at the joint is heated to a molten state and allowed to solidify

  (Ex) Gas welding, Arc welding

Classification of welding processes:

(i). Arc welding

1. Carbon arc
2. Metal arc
3. Metal inert gas
4. Tungsten inert gas
5. Plasma arc
6. Submerged arc
7. Electro-slag

(ii). Gas Welding

1. Oxy-acetylene
2. Air-acetylene
3. Oxy-hydrogen

(iii). Resistance Welding

1. Butt
2. Spot
3. Seam
4. Projection
5. Percussion

(iv) Thermit Welding

(v) Solid State Welding

1. Friction
2. Ultrasonic
3. Diffusion
4. Explosive

(vi) Newer Welding

1. Electron-beam
2. Laser

(vii) Related Process

1. Oxy-acetylene cutting
2. Arc cutting
3. Hard facing
4. Brazing
5. Soldering

Oxy-fuel welding, commonly referred to as oxy welding or gas welding is a process of joining metals by application of heat created by gas flame. The fuel gas commonly acetylene, when mixed with proper proportion of oxygen in a mixing chamber of welding torch, produces a very hot flame of about 5700-5800°F. With this flame it is possible to bring any of the so-called commercial metals, namely: cast iron, steel, copper, and aluminum, to a molten state and cause a fusion of two pieces of like metals in such a manner that the point of fusion will very closely approach the strength of the metal fused. If more metal of like nature is added, the union is made even stronger than the original. This method is called oxy-acetylene welding.

Cutting with the oxy-fuel process is just the opposite from of welding. Oxy-fuel cutting uses acetylene and oxygen to preheat metal to red hot and then uses pure oxygen to burn away the preheated metal. Because this is achieved by oxidation, it is only effective on metals that are easily oxidized at this temperature. Such metals are mild steel and low allow steels. Oxy-fuel cutting can be used to cut thicknesses from 2/8″ to up to 12″.

Traditionally oxy-fuel processes are used for brazing, fusion welding, flame hardening, metalizing, soldering, stress relieving, cutting and bending. The primary uses today are welding, brazing and cutting. This course describes the basic concepts of oxy-fuel welding and cutting including what equipment and safety precautions are needed.

Chemistry of Oxy Acetylene Process

The most common fuel used in welding is acetylene. It has a two stage reaction; the first stage primary reaction involves the acetylene disassociating in the presence of oxygen to produce heat, carbon monoxide, and hydrogen gas.

$2C_2H_2 + 2O_2 = 4CO + 2H_2 + \text{Heat}$ ---------- (1)

A secondary reaction follows where the carbon monoxide and hydrogen combine with more oxygen to produce carbon dioxide and water vapor.

$4CO + 2H_2 + 3O_2 = 4CO_2 + 2H_2O + \text{Heat}$--------- (2)

When you combine equations (1) and (2) you will notice that about 5 parts of oxygen is necessary to consume 2 parts of acetylene

$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O + \text{Heat}$ ----------- (3)

Or we can say about 2.5 parts of oxygen is necessary to achieve complete combustion of acetylene. In operation, one part of oxygen is supplied through the torch and the remaining 1.5 parts is obtained from the surrounding air atmosphere (secondary reaction). When the secondary reaction does not burn all of the reactants from the primary reaction, the welding processes produces large amounts of carbon monoxide, and it often does. Because of the need for supplemental oxygen from the atmosphere, the acetylene oxygen flame cannot be used inside of pipes or structures subjected to oxygen depletion from gas welding. By varying the relative amounts of acetylene and oxygen, a welder can produce different flame atmospheres and temperatures as he requires.

Oxy Fuel welding Gases

Commercial fuel gases have one common property: they all require oxygen to support combustion. To be suitable for welding operations, a fuel gas, when burned with oxygen, must have the following:

a. High flame temperature

b. High rate of flame propagation

c. Adequate heat content

d. Minimum chemical reaction of the flame with base and filler metals

Among the commercially available fuel gases such as propane, liquefied petroleum gas (LPG), natural gas, propylene, hydrogen and MAPP gas, **"Acetylene"** most closely meets all the above requirements.

Acetylene is a hydrocarbon, just as are propane, methane, and virtually all the components which make up gasoline and fuel oils. However, it differs from those hydrocarbons in a way that its molecule is made up of two carbon atoms and two hydrogen atoms, the carbon atoms are joined by what chemists call a "triple bond". When acetylene reaches its kindling* temperature; the bond breaks and releases energy. In other hydrocarbons, the breaking of the bonds between the carbon atoms absorbs energy. The triple bond is the reason that when acetylene and oxygen are mixed and ignited, the flame can reach the temperature of 5700°F to 6300 °F, highest among commonly used gaseous fuels.

The other property of acetylene which you must remember is that acetylene/air mixtures can be ignited when they contain anywhere from 2.5 percent acetylene to 80 percent acetylene. Mixtures of methane (the principal component of natural gas) and air are flammable when they contain as little as 5% methane and not more than 15% methane.

Kindling Temperature – Kindling temperature is the lowest temperature at which a substance bursts into flame.

The other two gases suitable for welding and cutting are:

a) MAPP
b) Hydrogen

MAPP gas is a registered product of the Dow Chemical Company. It is liquefied petroleum gas mixed with methylacetylene-propadiene (acetylene + propane). It has the storage and shipping characteristics of LPG and has a heat value a little less than acetylene.

Hydrogen produces low-temperature flame and is best for aluminum. Hydrogen flame is non-luminous, commonly used for underwater welding (can be used at higher pressure than acetylene).

Gasses suitable for cutting but NOT welding:

a) Propane
b) Methane
c) LPG

Hydrocarbon gases, such as propane, butane, city gas, and natural gas, are NOT suitable for welding ferrous materials due to their oxidizing characteristics. Although propane has a very high number of BTUs per cubic feet in its outer cone, it does not burn as hot as acetylene in its inner cone and therefore not very useful for welding operations. However with a right torch (injector style), propane can make a faster and cleaner cutting and is much more useful for heating and bending applications than acetylene. In some instances, many nonferrous and ferrous metals can be braze welded with care taken in the adjustment of flare and the use of flux.

Advantages of Oxyacetylene Process

1) Does not require electricity;
2) The equipment is portable, easy to transport;
3) Welder has considerable control over the rate of heat input, the temperature of the weld zone, and the oxidizing or reducing potential of the welding atmosphere;
4) Oxyacetylene process is ideally suited to the welding of thin sheet, tubes, and small diameter pipe. It is also used for repair work, maintenance and in body shops;
5) Dissimilar metals can easily be joined;
6) Can also be used for preheating, cutting metal, case hardening, soldering and annealing.

Limitations of Acetylene

1) Acetylene becomes extremely dangerous if used above 15 pounds pressure. Pure acetylene is self-explosive if stored in the free state under a pressure of 29.4 pounds per square inch (psi);
2) The process is typically slower than the electrical arc-welding processes;

We will learn more about the oxyacetylene process and equipment in this course. The course is divided into 4 sections:

Section -1 Oxy-Acetylene Apparatus

Section -2 Oxy-Acetylene Welding

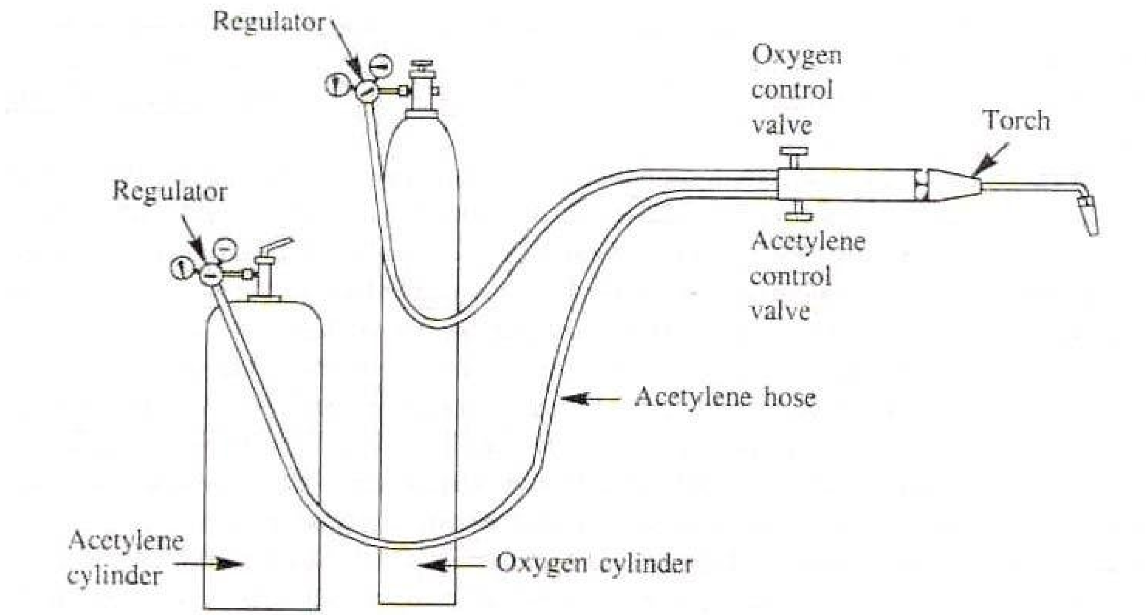
Section -3 Oxy-Acetylene Cutting

Section -4 Oxy-Acetylene Safety & Precautions including case study

SECTION - 1 OXY-ACETYLENE APPARATUS

Before discussing how the system works, it is important to know the name of the components that makes the oxy-fuel apparatus.

Oxy-fuel apparatus consists of two cylinders (one oxygen and one acetylene) equipped with two regulators, pressure gauges, two lengths of hose, and a blow torch. The regulators are attached to cylinders and are used to reduce and maintain a uniform pressure of gases at the torch. The gases at reduced pressure are conveyed to the torch by the hoses. The regulators include high pressure and low pressure gauges to indicate the contents of the cylinder and the working-pressure on each hose. When the gases reach the torch they are there mixed and combustion takes place at the welding tip fitted to the torch.



Oxy-acetylene welding

The basic equipments used to carry out gas welding are:

1. Oxygen gas cylinder (green)
2. Acetylene gas cylinder (maroon/red)
3. Oxygen pressure regulator
4. Acetylene pressure regulator
5. Oxygen gas hose(Blue)

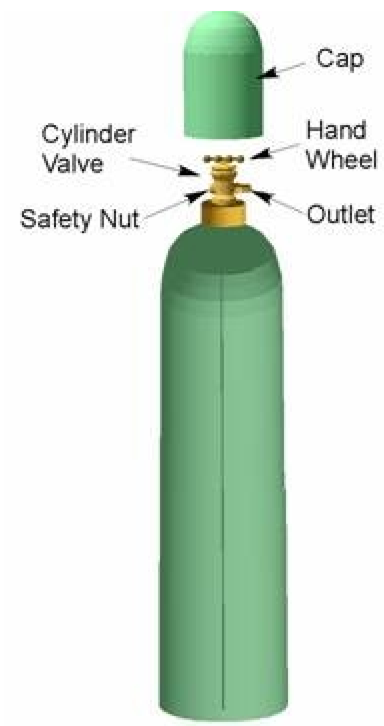
6. Acetylene gas hose(Red)
7. Welding torch or blow pipe with a set of nozzles and gas lighter
8. Trolleys for the transportation of oxygen and acetylene cylinders
9. Set of keys and spanners
10. Filler rods and fluxes
11. Protective clothing for the welder (e.g., asbestos apron, gloves, goggles, etc.)

OXYGEN GAS CYLINDER

Oxygen cylinder is drawn from a piece of high strength steel plate and is available in common sizes of:

- 244 cu ft (for industrial plants);
- 122 cu ft;
- 80 cu ft

Oxygen is stored within cylinders at a pressure of 2200 psi when filled @70°F and is capable of retaining a pressure of almost twice the fill pressure.



The oxygen volume in a cylinder is directly proportional to its pressure. In other words, if the original pressure of a full oxygen cylinder drops by 10% during welding, it means 1/10th of the cylinder contents have been consumed.

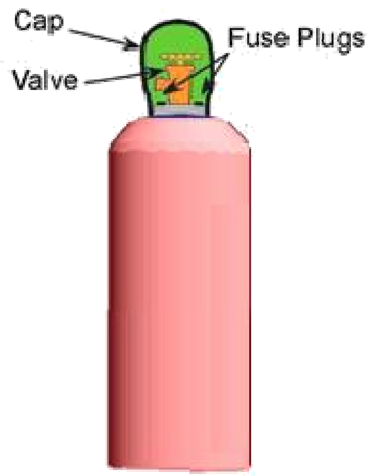
Oxygen cylinders are usually painted green and are screwed right handed.

Oxygen Cylinder Valves

The oxygen cylinder valve is made largely of brass with **right hand** threads. Its outlet is threaded and machined to comply with standards set by the Compressed Gas Association (CGA) and the American National Standards Institute (ANSI). All oxygen regulators sold in the U.S and Canada for use on industrial oxygen cylinders carry a mating inlet nut and nipple. The connection is designated “CGA 540”. Every oxygen cylinder valve is also equipped with *a bursting disk* which will rupture and release the contents of the cylinder if cylinder pressure should approach cylinder test pressure (as it might in case of a fire). In order to protect cylinder valve from getting damaged, a removable steel cap is screwed on the cylinder at all times when the cylinder is not in use. The cylinder valve is kept closed when the cylinder is not in use and even when cylinder is empty.

ACETYLENE GAS CYLINDER

An acetylene cylinder is also a solid drawn steel cylinder and the common sizes are 300, 120 and 75 cubic feet. Cylinder pressure is 250 PSI when filled. An acetylene cylinder is painted maroon and the valves are screwed **left handed** (with grooved hex on nut or shank).



Acetylene is extremely **unstable** in its pure form at pressure above 15 PSI. This instability places special requirements on the storage of acetylene. Acetylene cylinders are packed with porous material (balsa wood, charcoal, corn pith, or portland cement) that is saturated with acetone to allow the safe storage of acetylene. These porous filler materials aid in the prevention of high-pressure gas pockets forming in the cylinder.

Acetone, a colorless, flammable liquid, is than added to the cylinder until about 40 percent of the porous material is saturated. Acetone is a liquid chemical that dissolves large portions of acetylene under pressure without changing the nature of the gas and is a liquid capable of absorbing **25** times its own volume of acetylene gas at normal pressure. Being a liquid, acetone can be drawn from an acetylene cylinder when it is not upright.

Here are two very important things to remember about dissolved acetylene cylinders:

First, acetylene cylinders should always be stored in the upright position to prevent the acetone form escaping thus causing the acetylene to become unstable.

Second, CGA G-1 calls for a withdrawal rate "not to exceed 1/10(one-tenth) of the capacity of the cylinder per hour during intermittent use. For full withdrawal of the contents of the cylinder on a continuous basis, the flow rate should be no more than 1/15 (one-fifteenth) of the capacity of the cylinder per hour." If acetylene is withdrawn too rapidly, quite a lot of acetone may come with it, in vapor or droplet form, and the cylinder may cool down so much that it cannot sustain the high rate. This will affect your torch flame, and will mean that your supplier must replenish the acetone in the cylinder more frequently.

Many acetylene cylinder valves are not equipped with hand wheels, and must be operated by a wrench. The wrench should always be left in place while the cylinder valve is open. Acetylene cylinders should be opened only 1/3 to ¼ of a turn when in use.

Pressure Relationship

In an oxygen cylinder there is a precise relationship between cylinder pressure and cylinder contents. A standard oxygen cylinder that contains 244 cu-ft at 2200 psi @ 700°F will contain 122 cu-ft when the pressure has dropped to 1100 psi at 700°F. In contrast, an acetylene cylinder will not be precisely half-full when its pressure drops to half. Note that the changes in temperature affect the pressure in an acetylene cylinder at a much faster rate than it affects the pressure in an oxygen cylinder. Pressure in an oxygen cylinder will go up or down only about 4 percent for each 20-degree change in temperature (F) from 70 deg. A full acetylene cylinder which has a pressure of 250 psi at 700°F will have a pressure of 315 psi at 900°F and a pressure of 190 psi at 500°F. You must always take temperature into account when estimating how much acetylene the cylinder contains.

OXYGEN & ACETYLENE PRESSURE REGULATORS

The pressure of the gases obtained from cylinders is considerably higher than the gas pressure used to operate the welding torch. The purpose of using a gas pressure regulator is:

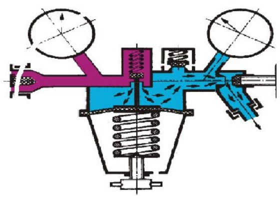
- To reduce the high pressure of the gas in the cylinder to a suitable working pressure, and
- To produce a steady flow of gas under varying cylinder pressures.

A pressure regulator is connected between the cylinder/generator and the hose leading to welding torch. Desired pressure at the welding torch may be somewhere up to 35 psig for oxygen and 15 psig for acetylene.

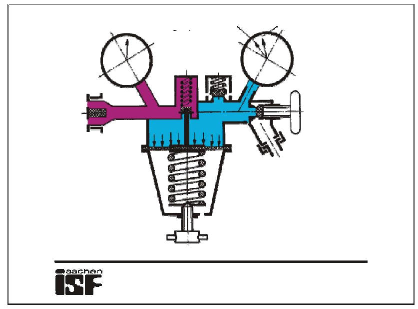
A pressure regulator is fitted with two pressure gauges. One indicates the gas pressure in the cylinder and the other shows the reduced pressure at which the gas is going out.

Gas pressure regulators may be classified as:

a) Single stage Regulator



b)Two stage Regulator



In single stage regulator, reduction of pressure from the cylinder pressure to the welding pressures takes place in single stage. A single stage regulator is all that actually is needed for both oxygen regulation and acetylene regulation for oxyacetylene welding. However, a single stage regulator tends to freeze in cold weather.

The principle of pressure reduction in a two stage regulator is exactly the same as in a single stage regulator, but here the pressure is reduced in two stages instead of one, using two diaphragms and two control valves, so that the pressure reduction ratio is less abrupt.

Backfire: A backfire is caused by the flame going out suddenly on the torch. A backfire may occur when:

- The tip is touched against the work piece;
- If the flame setting is too low;
- If the tip is dirty, damage or loose, or;
- If the tip is overheated.

When a torch backfires, it could cause a flashback.

A flashback is a condition in which the flame burns inside the tip, the torch, or the hose. Flashbacks are caused by the improper mixture of the gases, which increases the rate of flame propagation to such an extent that the flame will flash back to the mixing chamber. If it is not stopped, the flame will ignite the mixture and will travel backwards from the torch, along the hoses, through the regulator and into the cylinder. To prevent such occurrence, a **flash arrestor** shall be installed. Flashback arrestor (not to be confused with a check valve) prevents the shock waves from downstream coming back up the hoses and entering the cylinder (possibly rupturing it), as there are quantities of fuel/oxygen mixtures inside parts of the equipment (specifically within the mixer and blowpipe/nozzle) that may explode, if the equipment is incorrectly shut down; and acetylene decomposes at excessive pressures or temperatures. The flashback arrestor

WELDING TORCH & BLOW PIPE

A welding torch mixes oxygen and acetylene in the desired proportions, burns the mixture at the end of the tip, and provides a means for moving and directing the flame.

There are two types of welding torches, namely:

a) High pressure (or equal pressure) type

b) Low pressure (or injector) type

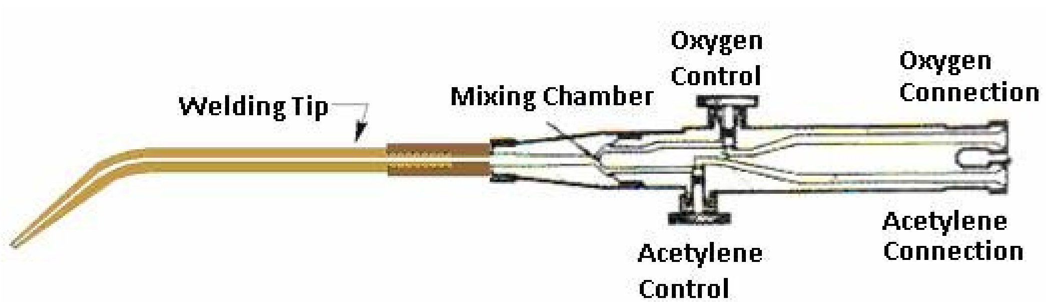
High pressure blowpipes or torches are used with (dissolved) acetylene stored in cylinders at a pressure of 117 psi. Low pressure blowpipes are used with acetylene obtained from an acetylene generator at a pressure of 8 inch - head of water (approximately 0.3 psi).

In high pressure blow torch, both the oxygen and acetylene are fed at equal pressures and the gases are mixed in a mixing chamber prior to being fed to the nozzle tip. The high pressure torch also called the equal pressure torch is most commonly used because:

a) It is lighter and simpler;

b) It does not need an injector;

c) In operation, it is less troublesome since it does not suffer from backfires to the same extent.



To change the power of the welding torch, it is only necessary to change the nozzle tip (size) and increase or decrease the gas pressures appropriately.

Welding Nozzles or Tips

The welding nozzle or tip is that portion of the torch which is located at the end of the torch and contains the opening through which the oxygen and acetylene gas mixture passes prior to ignition and combustion. Depending upon the design of the welding torch, the interchangeable nozzles may consist of:

a) Either, a set of tips which screw onto the head of the blowpipe, or

b) As a set of gooseneck extensions fitting directly onto the mixer portion of the blowpipe.

A welding nozzle enables the welder to guide the flame and direct it with the maximum ease and efficiency. The following factors are important in the selection of appropriate welding nozzle:

a) The position of the weld

b) The type of joint

c) Job thickness and the size of welding flame required for the job

d) The metal/alloy to be welded.

To provide for different amounts of heat, to weld metals of different thicknesses, welding tips are made in various sizes. The size of a welding tip is determined by the diameter of the opening or orifice in the tip. As the orifice size increases, greater amounts of the welding gases pass through and are burnt to supply a greater amount of heat.

The choice of the proper tip size is very important to good welding. For welding thicker material large sized tip is used which will supply more combustible gases and more heat. A chart giving sizes of tips for welding various thicknesses of metal along with oxygen and acetylene pressures used is generally provided by the manufacturers.

Filler Metals:

Filler metals are used to supply additional material to the pool to assist in filling the gap (or groove) and it forms an integral part of the weld. Filler rods have the same or nearly the same chemical composition as the base metal and are available in a variety of compositions (for welding different materials) and sizes. These consumable filler rods may be bare, or they may be coated with flux. The purpose of the flux is to retard oxidation of the surfaces of the parts being welded, by generating gaseous shield around the weld zone. The flux also helps to dissolve and remove oxides and other substances from the work piece and so contributes to the formation of a stronger joint. The slag developed protects the molten metal puddles of metal against oxidation as it cools.

Characteristics of good flux

The melting point of a flux must be lower than that of either the metal or the oxides formed, so that it will be liquid. The ideal flux has exactly the right fluidity when the welding temperature has been reached. The flux will protect the molten metal from atmospheric oxidation. Such a flux will remain close to the weld area instead of flowing all over the base metal for some distance from the weld

2 OXY- ACETYLENE WELDING

The oxyacetylene welding process uses a combination of oxygen and acetylene gas to provide a high temperature flame. The high temperature flame melts the metal faces of the work-pieces to be joined, causing them to flow together. A filler metal alloy is normally added and sometimes used to prevent oxidation and to facilitate the metal union.

The amount of heat applied to the metal is a function of the welding tip size, the speed of travel, and the welding position. The flame size is determined by the welding tip size and the proper tip size is determined by the metal thickness and the joint design.

Characteristics of the oxy-acetylene welding process include:

- The use dual oxygen and acetylene gases stored under pressure in steel cylinders;
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip;
- The high temperature the gas mixture attains (~5800°F);
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks;
- The use of double line rubber hoses to conduct the gas from the tanks to the torch;

- Melting the materials to be welded together;
- The ability to regulate temperature by adjusting gas flow.

Types of Welding Flames

In oxyacetylene welding, flame is the most important tool. All the welding equipment simply serves to maintain and control the flame. The flame must be of the proper size, shape and condition in order to operate with maximum efficiency. Three distinct types of flames are possible on adjusting the proportions of acetylene and oxygen:

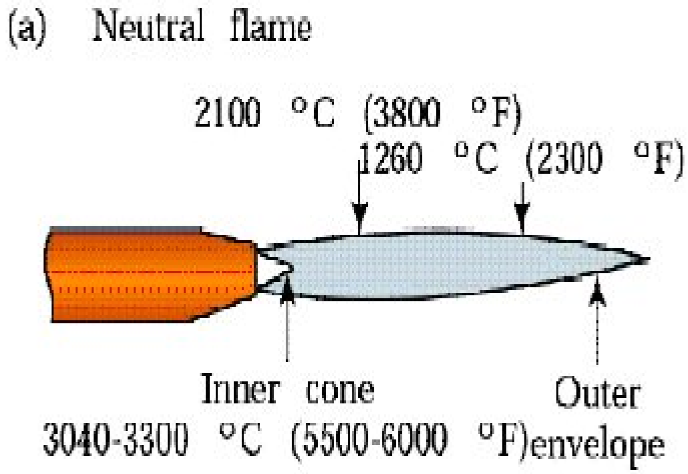
1. Neutral Flame (Acetylene oxygen in equal proportions)
2. Oxidizing Flame (Excess of oxygen)
3. Reducing Flame (Excess of acetylene)

Neutral Flame

A neutral flame is produced when the ratio of oxygen to acetylene, in the mixture leaving the torch, is almost exactly one-to-one. The temperature of the neutral flame is of the order of about 5900ºF.

Neutral Flame (5850°F).

For Fusion welding of steel and cast iron



Characteristics of Neutral flame:

a) The neutral flame is obtained when approximately one volume of oxygen and one volume of acetylene are mixed. It's termed "neutral" because it will usually have no chemical effect on the metal being welded. It will not oxidize the weld metal; it will not cause an increase in the carbon content of the weld metal.

b) Neutral flame is obtained by gradually opening the oxygen valve to shorten the acetylene flame until a clearly defined inner cone is visible. For a strictly neutral flame, no whitish streamers or feathers should be present at the end of the cone.

c) Neutral flame is used for most welding operations and for preheating during cutting operations. When welding steel with neutral flame, the molten metal puddle is quiet and clear; the metal flows easily without boiling, foaming, or sparking.

d) There are two clearly defined zones in the neutral flame. The inner zone consists of a luminous cone that is bluish-white. The inner cone is where the acetylene and the oxygen combine. Surrounding this is a light blue flame envelope or sheath. This neutral flame is obtained by starting with an excess acetylene flame in which there is a "feather" extension of the inner cone. When the flow of acetylene is decreased or the flow of oxygen increased the feather will tend to disappear. The neutral flame begins when the feather disappears.

e) The tip of the inner is the hottest part of the flame and is approximately 5850ºF, while at the end of the outer sheath or envelope the temperature drops to approximately 2300ºF. This variation within the flame permits some temperature control when making a weld. The position of the flame to the molten puddle can be changed, and the heat controlled in this manner.

f) The neutral flame is commonly used for the welding of:

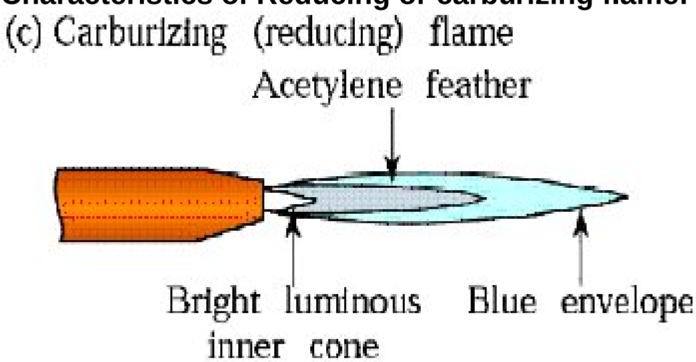
   - Mild steel
   - Stainless steel
   - Cast Iron
   - Copper
   - Aluminum

Carburizing or Reducing Flame:

If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburizing or reducing flame, i.e. rich in acetylene. A reducing flame can be recognized by acetylene feather which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in color.

Carburizing Flame (Excess acetylene with oxygen, 5700°F) Used for hard facing and welding white metal.

Characteristics of Reducing or carburizing flame:



An excess of acetylene creates a carburizing flame. The reducing or carburizing flame is obtained when slightly less than one volume of oxygen is mixed with one volume of acetylene. This flame is obtained by first adjusting to neutral and then slowly opening the acetylene valve until an acetylene streamer or "feather" is at the end of the inner cone. The length of this excess streamer indicates the degree of flame carburization. For most welding operations, this streamer should be no more than half the length of the inner cone.

a) The carburizing flame is characterized by three flame zones; the hot inner cone, a white-hot "acetylene feather", and the blue-colored outer cone. This is the type of flame observed when oxygen is first added to the burning acetylene. The feather is adjusted and made ever smaller by adding increasing amounts of oxygen to the flame. A welding feather is measured as 2X or 3X, with X being the length of the inner flame cone. This type of flare burns with a coarse rushing sound. It has a temperature of approximately 5700ºF (3149ºC) at the inner cone tips.

The feather is caused by incomplete combustion of the acetylene to cause an excess of carbon in the flame.

c) The carburizing flame may add carbon to the weld metal and will tend to remove the oxygen from iron oxides which may be present, a fact which has caused the flame to be known as a "reducing flame". With iron and steel it produces very hard, brittle substance known as iron carbide. This chemical change makes the metal unfit for many applications in which the weld may need to be bent or stretched. Metals that tend to absorb carbon should NOT be welded with reducing flame.

d) The reducing flame is typically used for welding high carbon steel and hard facing operations or backhand pipe welding techniques. When used in silver solder and soft solder operations, only the intermediate and outer flame cones are used. They impart a low temperature soaking heat to the parts being soldered.

e) Since this flame provides a strong reducing atmosphere in the welding zone, it is useful for those materials which are readily oxidized like oxygen free copper alloys. It is also used for high carbon steels, cast iron and hard surfacing with high speed steel and cement carbides. A reducing flame has an approximate temperature of 5500°F (which is lowest among all the three flames). A reducing flame may be distinguished from a carburizing flame by the fact that a carburizing flame contains more acetylene than a reducing flame. A carburizing flame is used in the welding of lead and for carburizing (surface hardening) purposes. A reducing flame, on the other hand, does not carburize the metal; rather it ensures the absence of the oxidizing condition. It is used for welding with low alloy steel rods and for welding those metals, (e.g. non ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

Oxidizing Flame:

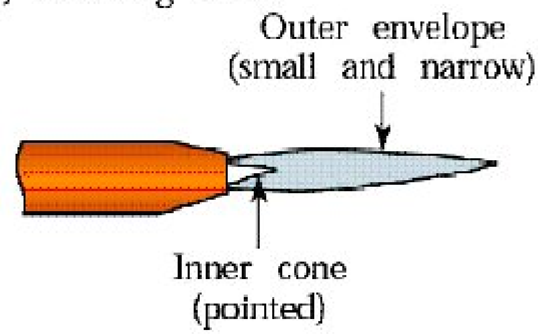
The oxidizing flame is the third possible flame adjustment. It occurs when the ratio of oxygen to acetylene required for a neutral flame is changed to give an excess of oxygen. This flame type is observed when welders add more oxygen to the neutral flame.

Oxidizing Flame (Acetylene and excess oxygen, 6300°F)

For braze welding with Bronze rod.

The presence of excess oxygen in this flame creates undesirable oxides to the structural and mechanical detriment of most metals. It is useful for welding copper base alloys, zinc base alloys, cast iron, manganese steel etc.

(b) Oxidizing flame



Characteristics of an Oxidizing flame:

a) The oxidizing flame is produced when slightly more than one volume of oxygen is mixed with one volume of acetylene. To obtain this type of flame, the torch should first be adjusted to a neutral flame. The flow of oxygen is then increased until the inner cone is shortened to about one-tenth of its original length. When the flame is properly adjusted, the inner cone is pointed and slightly purple. An oxidizing flame can also be recognized by its distinct hissing sound. The temperature of this flame is approximately 6300ºF (3482ºC) at the inner cone tip.

b) An oxidizing flame can be recognized by the small white cone which is shorter, much bluer in color and more pointed than that of the neutral flame. The outer flame envelope is much shorter and tends to fan out at the end on the other hand the neutral and carburizing envelopes tend to come to a sharp point.

c) An oxidizing flame burns with a decided loud roar. An oxidizing flame tends to be hotter than the other two flames. This is because of excess oxygen which causes the temperature to rise as high as 6300°F and not heat up as much thermally inert carbon.

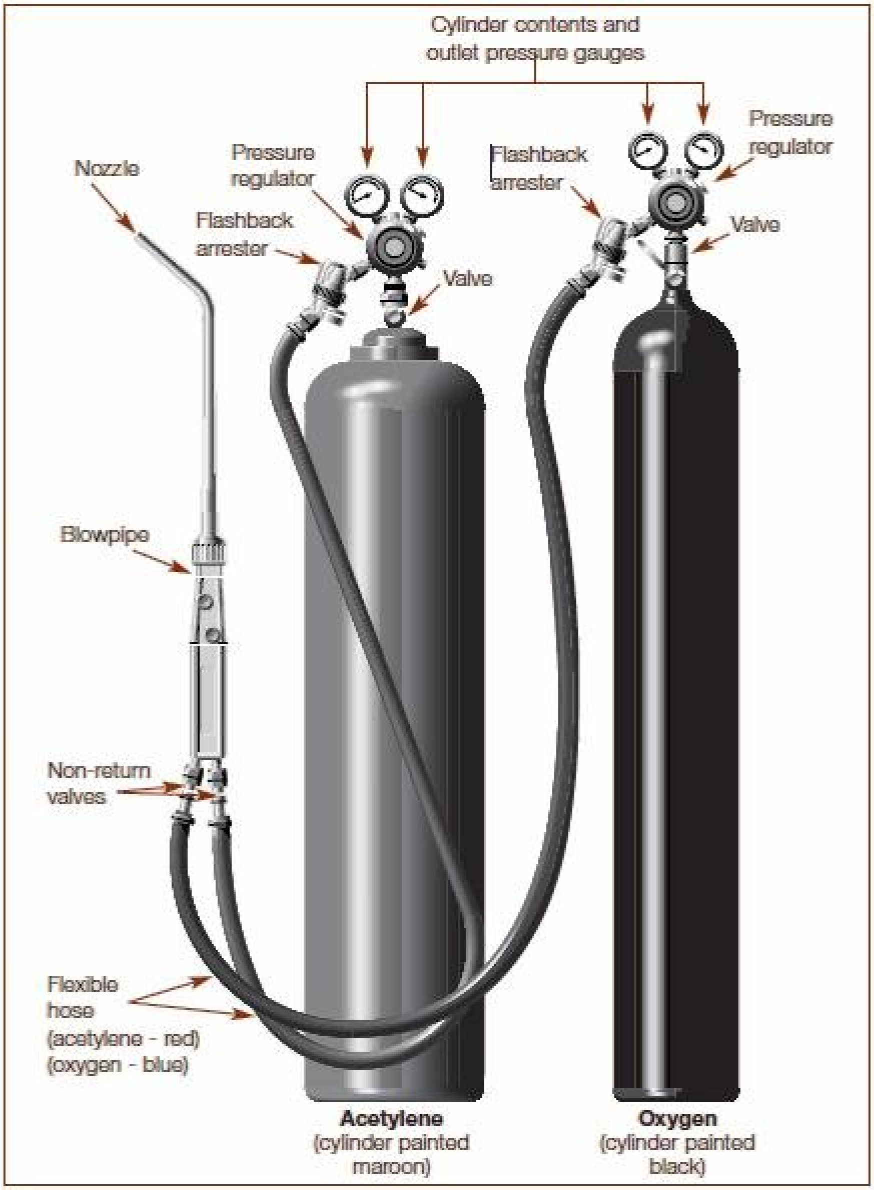
d) When applied to steel, an oxidizing flame especially at high temperatures tends to combine with many metals to form hard, brittle, low strength oxides. This indicates that the excess oxygen is combining with the steel and burning it. Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance. This flame will ruin most metals and should be avoided, except as noted below.

e) An oxidizing flame is of limited use in welding. It is not used in the welding of steel. A slightly oxidizing flame is helpful when welding most

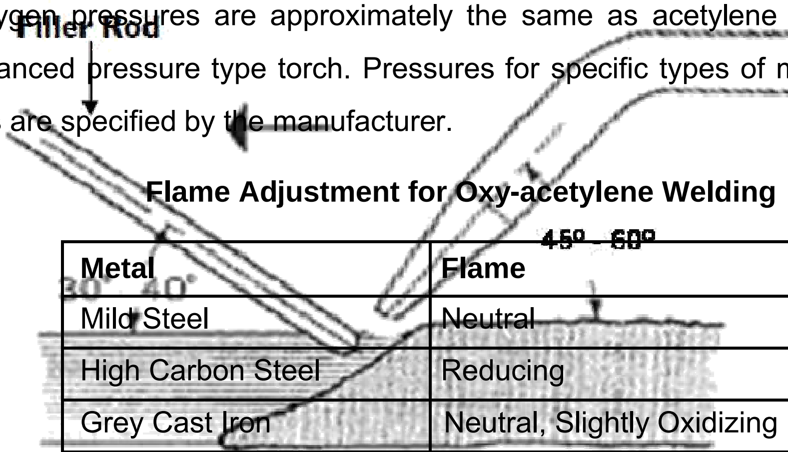
   - Copper base metals
   - Zinc base metals, and
   - A few types of ferrous metals, such as manganese steel and cast iron

A stronger oxidizing flame is used in the welding of brass or bronze. The oxidizing atmosphere, in these cases, creates a base metal oxide that protects the base metal. For example, in welding brass, the zinc has a tendency to separate and fume away. The formation of a covering copper oxide prevents the zinc from dissipating.

SETTING UP AN OXYACETYLENE TORCH



2. Oxygen pressures are approximately the same as acetylene pressures in the balanced pressure type torch. Pressures for specific types of mixing heads and tips are specified by the manufacturer.



Flame Adjustment for Oxy-acetylene Welding

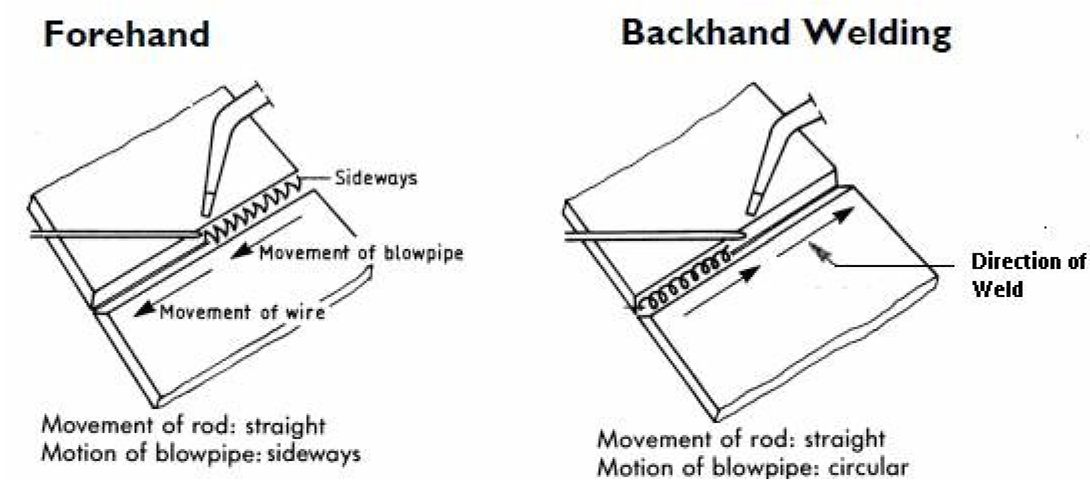
Metal	Flame
Mild Steel	Neutral
High Carbon Steel	Reducing
Grey Cast Iron	Neutral, Slightly Oxidizing
Alloy Steel	Neutral
Lead	Neutral
Aluminum	Slightly Carburizing
Brass	Slightly Oxidizing
Copper, Bronze	Neutral, Slightly Oxidizing
Nickel Alloy	Slightly Carburizing

Using the Torch

The torch tip should be positioned above the metal plate so that the white cone is at a distance of 1.5 to 3.0 mm from the plate. The torch should be held at an angle of 45 to 60° from the horizontal plane.

The torch movement along the joint should be either oscillating or circular. In forehand welding, the torch is moved in the direction of the tip. This tends to preheat before the white cone of the tip melts it. In backhand welding the torch moves backwards. The outer blue flames are directed on the already welded joint. This allows the joint to be continuously annealed relieving the welding stresses. This welding allows a better penetration as well as form bigger weld. Backhand welding is generally used for thicker materials.

When the welding rod is used to provide filler material, it is necessary to hold it at a distance of 10 mm from the flame and 1.5 to 3.0 mm from the surface of the weld metal pool or puddle. This way the rod gets preheated and when dipped into the puddle would readily get melted.



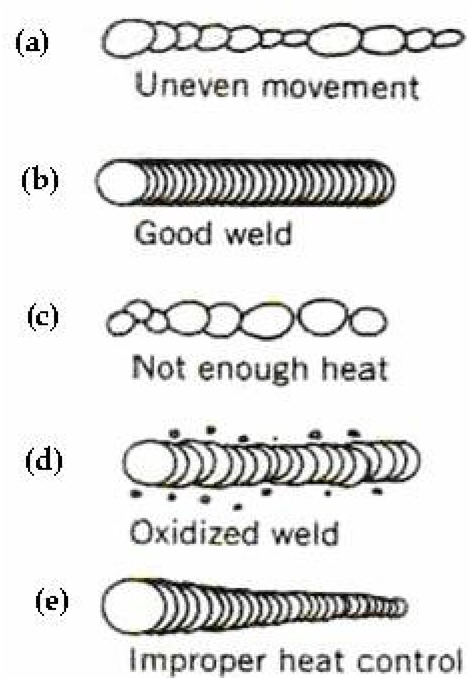
Oxy-fuel welding can be used for all the types of joints in all positions. Overhead usage requires additional skill to safeguard the welder. The various butt joint edge preparations are shown in the adjacent figure.

Thicker plates require more than one pass of the gas torch along the length to complete the joint. In multi pass welding, the first pass (root pass) is very critical in any welding operation.

Weld Appearances

Welding gas pressures are set in accordance with the manufacturer's recommendations. The welder will modify the speed of welding travel to maintain a uniform bead width. Trained welders are taught to keep the bead the same size at the beginning of the weld as at the end. If the bead gets too wide, the welder increases the speed of welding travel. If the bead gets too narrow or if the weld puddle is lost, the welder slows down the speed of travel. Welding in the vertical or overhead positions is typically slower than welding in the flat or horizontal positions.

The welder must add the filler rod to the molten puddle. The welder must also keep the filler metal in the hot outer flame zone when not adding it to the puddle to protect filler metal from oxidation. Do not let the welding flame burn off the filler metal. The metal will not wet into the base metal and will look like a series of cold dots on the base metal. There is very little strength in a cold weld. When the filler metal is properly added to the molten puddle, the resulting weld will be stronger than the original base metal.



Tip and rod size

You need to select the proper tip size for the job to get the correct heat for the metal being welded. Some general guidelines include:

- Tips need to be selected to match the size of filler rod used and the thickness of the gauge metal being welded. The larger the filler rod, the thicker the metal, the higher the number of tip to be used.
- As a basic rule of thumb, choose a rod size that is the same thickness as the metal that you are welding.
- Tip sizes 3, 5 and 7 are common sizes to use for steel between 1/16" and 1/8" thick.

Flame Size

If the puddle is not moving properly, it may be because of incorrect tip size or it may mean you need to adjust your torch valve setting slightly. Remember that you also need to have the torch set for the correct flame type – usually neutral.

Preparation of Metal

Metal should be free of rust, grease, oil and paint. Use a grinder or wire brush to remove rust or paint. Anything that has had oil or grease on it should be avoided as it is potentially toxic and flammable when heated.

Torch or Rod Angle

The angle between the torch flame and the steel helps you to move the weld puddle where you want it. Change the angle that you are working until you find the angle that works best, usually 45 to 60 degrees.

Distance between torch and work

The close you hold the torch to your work, the more heat is created. The greater heat increases the depth of penetration of the weld and makes the weld puddle narrower.

Speed and method of torch movement

Slower speed will make a wider weld with a deeper penetration. The object is to get a flat weld. To achieve that you may need some slight back and forth or oval motions with the torch. A steady, even speed and movement is important to achieving a quality weld.

Advantages of Gas Welding –

1) Welder has considerable control over the rate of heat input, the temperature of the weld zone, and the oxidizing or reducing potential of the welding atmosphere;
2) As the source of heat and filler metal are separated, the metal deposition can be easily controlled and heat properly adjusted giving rise to a satisfactory weld;
3) Welding equipment is portable and can be operated at remote places. Besides gas welding, the equipment can be used for preheating, post heating, braze welding, torch brazing and it is readily converted to oxygen cutting;
4) Weld bead size and shape and weld puddle viscosity are also controlled in the welding process because the filler metal is added independently of the welding heat source;
5) Gas welding is ideally suited to the welding of thin sheet, tubes, and small diameter pipe. It is also used for repair welding. Thick section welds, except for repair work, are not economical.

Limitations of gas welding:

1) Gas flame takes a long time to heat up the metal than an arc;
2) Flame temperature is less than the temperature of the arc;
3) Slower speed of welding compared electric arc welding;
4) Heavy sections cannot be joined efficiently;
5) For heavy sections proper penetration may not be achieved;
6) Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g., titanium and zirconium) cannot be gas welded;
7) Flux used in the filler metal provides fumes which are irritating to the eyes, nose, throat and lungs;
8) More safety is recommended in gas welding;
9) Acetylene and oxygen are expensive gases;

Applications of Gas Welding –

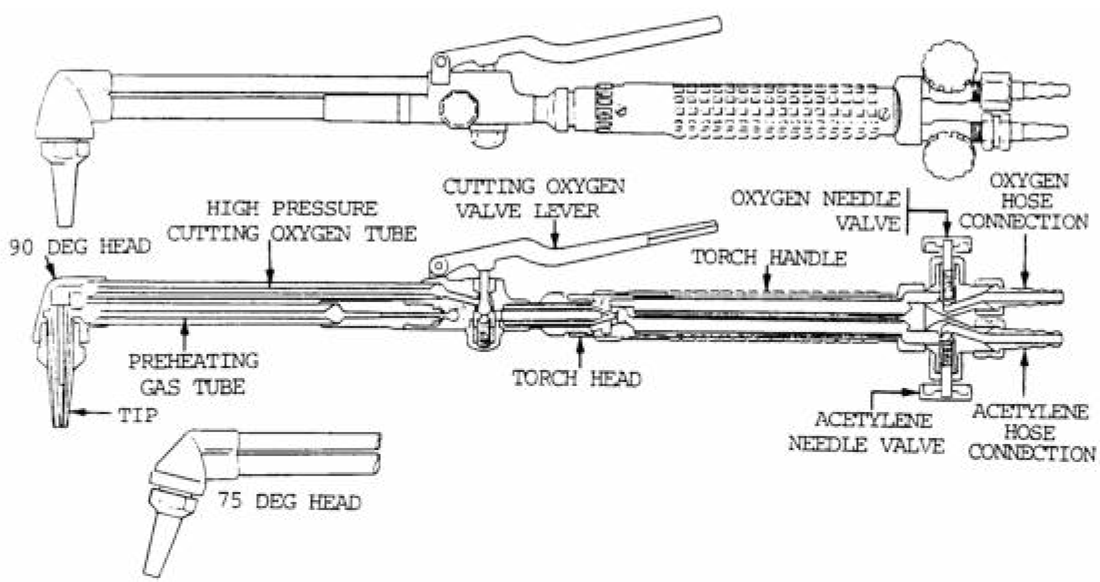
1) For joining of thin materials. The process is used extensively for soldering copper tubing;
2) For joining materials in whose case excessively high temperatures or rapid heating and cooling of the job would produce unwanted or harmful changes in

the metal;

3) For joining materials in whose case extremely high temperatures would cause certain elements in the metal to escape into the atmosphere;
4) For joining most ferrous and nonferrous metals, e.g., carbon steels, alloy steels, cast iron, aluminum, copper, nickel, magnesium and its alloys, etc;
5) In automotive and aircraft industries. In sheet metal fabricating plants, etc.

GAS CUTTING

The equipment and accessories for oxy-gas cutting are the same as for oxy-gas welding except that you use a cutting torch or a cutting attachment instead of a welding torch. The main difference between the cutting torch and the welding torch is that the cutting torch has an additional tube for high-pressure oxygen, along with a cutting tip or nozzle. The tip is provided with a center hole through which a jet of pure oxygen passes. Mixed oxygen and acetylene pass through holes surrounding the center holes for the preheating flames. The number of orifices for oxyacetylene flames ranges from 2 to 6, depending on the purpose for which the tip is used. The cutting torch is controlled by a trigger or lever operated valve. The cutting torch is furnished with interchangeable tips for cutting steel from less than ¼” to more than 12.0” in thickness.



OPERATION OF CUTTING EQUIPMENT

Setting up the oxyacetylene equipment and preparing for cutting must be done carefully and systematically to avoid costly mistakes. Refer below the Step-by-Step instructions before any attempt is made to light the torch:

1) Secure the cylinders so they cannot be accidently knocked over. A good way to do this is to either put them in a corner or next to a vertical column and then secure them with a piece of line. After securing the cylinders, remove the protective caps.
2) Standing to one side, crack each cylinder valve slightly and then immediately close the valve again. This blows any dirt or other foreign matter out of the cylinder valve nozzle. Do not bleed fuel gas into a confined area because it may ignite. Ensure the valves are closed and wipe the connections with a clean cloth.
3) Connect the fuel-gas regulator to the fuel-gas cylinder and the oxygen regulator to the oxygen cylinder. Using a gang wrench, snug the connection nuts sufficiently to avoid leaks.
4) Back off the regulator screws to prevent damage to the regulators and gauges and open the cylinder valves slowly. Open the fuel-gas valve only one-half turn and the oxygen valve all the way. Some fuel-gas cylinders have a hand-wheel for opening the fuel-gas valve while others require the use of a gang wrench or T-handle wrench. Leave the wrench in place while the cylinder is in use so the fuel-gas bottle can be turned off quickly in an emergency. Read the high-pressure gauge to check the contents in each cylinder.
5) Connect the RED hose to the fuel-gas regulator and the GREEN hose to the oxygen regulator. Notice the left-hand threads on the fuel-gas connection.
6) To blow out the oxygen hose, turn the regulator screw in (clockwise) and adjust the pressure between 2 and 5 psig. After the hose has been purged, turn the screw back out again (counterclockwise) to shutoff the oxygen. Do the same for the fuel-gas hose, but do it ONLY in a well-ventilated place that is free from sparks, flames, or other possible sources of ignition.
7) Connect the hoses to the torch. The RED (fuel-gas) hose is connected to the connection gland with the needle valve marked “FUEL.” The GREEN (oxygen) hose is connected to the connection gland with the needle valve marked “OXY.”
8) With the torch valves closed, turn both regulator screws clockwise to test the hose connections for leaks. If none are found, turn the regulator screws counterclockwise

and drain the hose by opening the torch valves.

9) Select the correct cutting tip and install it in the cutting torch head. Tighten the assembly by hand, and then tighten with your gang wrench.

10) Adjust the working pressures. The fuel-gas pressure is adjusted by opening the torch needle valve and turning the fuel-gas regulator screw clockwise. Adjust the regulator to the working pressure needed for the particular tip size, and then close the torch needle valve. To adjust acetylene gas, you should set the gauge pressure with the torch valves closed. To adjust the oxygen working pressure, you should open the oxygen torch needle valve and proceed in the same manner as in adjusting the fuel-gas pressure.

11) In lighting the torch and adjusting the flame, always follow the manufacturer's directions for the particular model of torch being used. This is necessary because the procedure varies somewhat with different types of torches and, in some cases, even with different models made by the same manufacturer. In general, the procedure used for lighting a torch is to first open the torch oxygen needle valve a small amount and the torch fuel-gas needle valve slightly more, depending upon the type of torch. The mixture of oxygen and fuel gas coming from the torch tip is then lighted by means of a spark igniter or stationary pilot flame. Adjust the preheating flame to neutral.

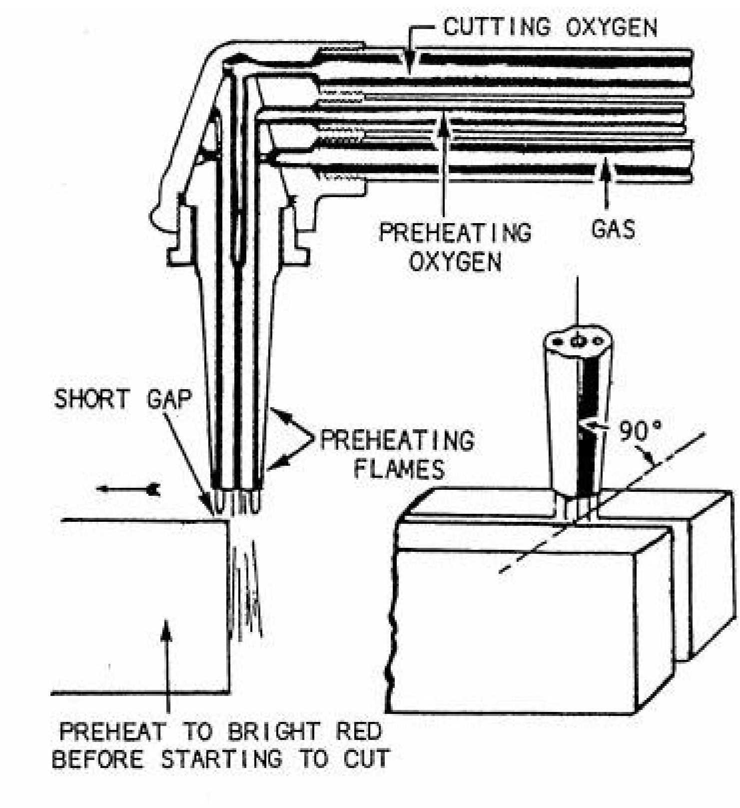
12) Hold the torch so that the cutting oxygen lever or trigger can be operated with one hand. Use the other hand to steady and maintain the position of the torch head to the work. Keep the flame at a 90 degree angle to work in the direction of travel. The inner cones of the preheating flames should be about 1/16 in. (1.6 mm) above the end of the line to be cut. Hold this position until the spot has been raised to a bright red heat, and then slowly open the cutting oxygen valve.

13) Cutting is initiated by heating the edge or leading face (as in cutting shapes such as round rod) of the steel to the ignition temperature (approximately bright red heat) using the pre-heat jets only, then using the separate cutting oxygen valve to release the oxygen from the central jet. The oxygen chemically combines with the iron in the ferrous material to instantly oxidize the iron into molten iron oxide, producing the cut. If the cut has been started properly, a shower of sparks will fall from the opposite side of the work. Move the torch at a speed which will allow the cut to continue penetrating the work. A good cut will be clean and narrow.

14) When cutting billets, round bars, or heavy sections, time and gas are saved if a burr is raised with a chisel at the point where the cut is to start. This small portion will heat quickly and cutting will start immediately. A welding rod can be used to start a cut on heavy sections. When used, it is called a starting rod.

CUTTING MILD-CARBON STEEL

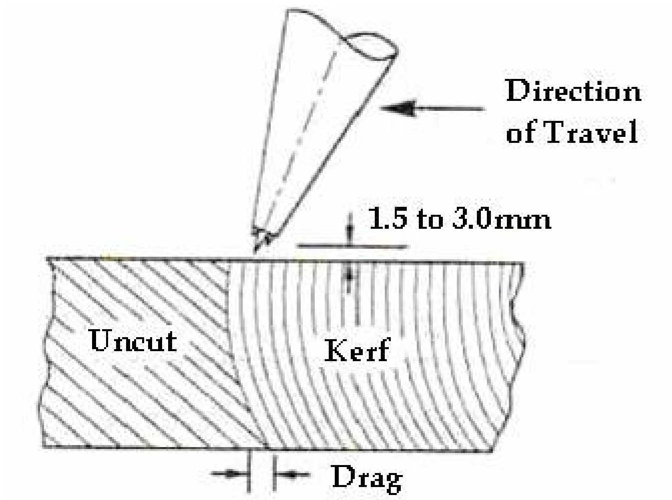
To cut mild-carbon steel with the oxyacetylene cutting torch, you should adjust the preheating flames to **neutral**. Hold the torch perpendicular to the work, with the inner cones of the preheating flames about 1/16 inches above the end of the line to be cut (refer figure below). Hold the torch in this position until the spot you are heating is a bright red. Open the cutting oxygen valve slowly but steadily by pressing down on the cutting valve lever.



Position of torch tip for starting a cut

When the cut is started correctly, a shower of sparks will fall from the opposite side of the work, indicating that the flame has pierced the metal. Move the cutting torch forward along the line just fast enough for the flame to continue to penetrate the work completely. If you have made the cut properly, you will get a clean, narrow cut that looks almost like it was made by a saw.

A good cut is characterized by very small or negligible drag. When the torch is moved too rapidly, the metal at the bottom does not get sufficient heat to get oxidized and cut and hence there is a large drag. When the torch is moved slowly, all the preheated metal is burnt away by the oxygen jet and a large amount of slag is generated.

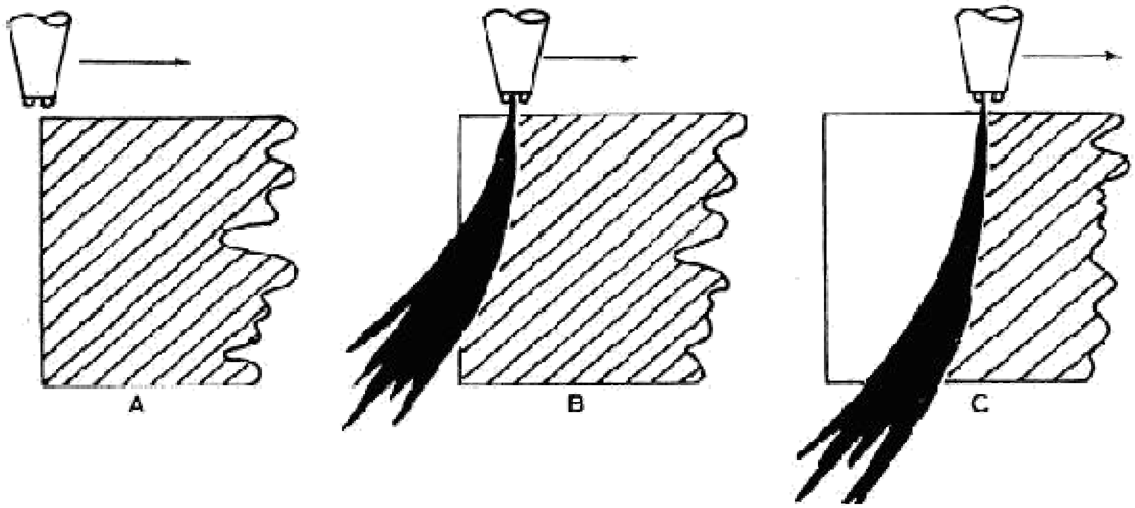


Drag Figure

***Kerf -** The narrow slit formed in metal as cutting progresses. The ideal kerf is a narrow gap with a sharp edge on either side of the work piece; overheating the work piece and thus melting through it causes a rounded edge.

Cutting Thick Steel

Steel, that is greater than 1/8 inch thick, can be cut by holding the torch so the tip is almost vertical to the surface of the metal. If you are right-handed, one method to cut steel is to start at the edge of the plate and move from right to left. Left-handed people tend to cut left to right. Both directions are correct and you may cut in the direction that is most comfortable for you. Figure below shows the progress of a cut in thick steel.



Progress of a cut in thick steel

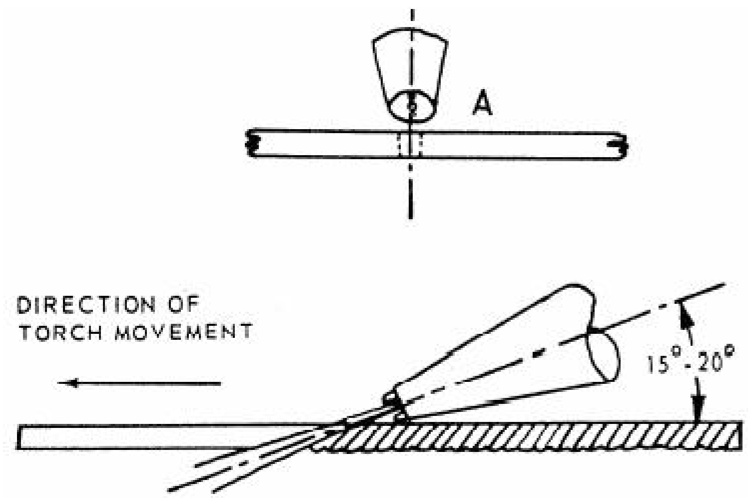
After heating the edge of the steel to a dull cherry red, open the oxygen jet all the way by pressing on the cutting lever. As soon as the cutting action starts, move the torch tip at an even rate. Avoid unsteady movement of the torch to prevent irregular cuts and premature stopping of the cutting action.

To start a cut quicker in thick plate, you should start at the edge of the metal with the torch angled in the opposite direction of travel. When the edge starts to cut, bring the torch to a vertical position to complete the cut through the total thickness of the metal. As soon as the cut is through the metal, start moving the torch in the direction of travel.

Two other methods for starting cuts are used. In the **first** method, you nick the edge of the metal with a cold chisel at the point where the cut is to start. The sharp edges of the metal upset by the chisel will preheat and oxidize rapidly under the cutting torch, allowing you to start the cut without preheating the entire edge of the plate. In the **second** method, you place an iron filler rod at the edge of a thick plate. As you apply the preheat flames to the edge of the plate, the filler rod rapidly reaches the cherry red temperature. At this point, turn the cutting oxygen on and the rod will oxidize and cause the thicker plate to start oxidizing.

Cutting Thin Steel

Though the gas cutting is more useful with thick plates, thin sheets (1/8 inch or less) can also be cut by this process taking special precautions. Tip size chosen should be as small as possible. If small tips are not available, then the tip is inclined at an angle of 15 to 20 degrees and point the tip in the direction the torch is traveling. By tilting the tip, you give the preheating flames a chance to heat the metal ahead of the oxygen jet, as shown in figure below. If you hold the tip perpendicular to the surface, you decrease the amount of preheated metal and the adjacent metal could cool the cut enough to prevent smooth cutting action.



Torch position for cutting thin sheets

Common gauge settings for cutting

- 1/4” material - Oxygen: 30-35psi; Acetylene: 3-9 psi
- 1/2” material - Oxygen: 55-85psi; Acetylene: 6-12 psi
- 1” material - Oxygen: 110-160psi; Acetylene: 7-15 psi

Applications

Oxygen cutting would be useful only for those materials which readily get oxidized and the oxides have lower melting points than the metals. So it is most widely used for ferrous materials.

Oxygen cutting is NOT used for materials like aluminum, bronze, stainless steel which resist oxidation.

Cutting of high carbon steels and cast irons require special attention due to formation of heat affected zone (HAZ) where structural transformation occurs.

Flashback and its causes

A flashback is a burning back of the flame into the tip, or into or through the torch. It is also called a sustained burning in tip or torch. A flashback can be caused by faulty or misused equipment. If it doesn't cause fire or hose rupture, then it may produce a hissing or squealing due to burning inside torch or tip (usually at the mixer). Examples of faulty or misused equipment are:

- Failure to purge.
- Incorrect pressures.
- Distorted or loose tips or adapter seats.
- Kinked hoses.
- Clogged tip or torch orifices.
- Overheated tip or torch.

To stop a flashback:

When squealing sound is heard: the internal combustion must be extinguished immediately by shutting off torch fuel gas and oxygen valves in that order;

Wait a MOMENT, OR UNTIL NO SQUEALING is heard on reopening fuel gas valve, then relight;

When squealing is not heard (and flashback is indicated by flow of hot gases from tip): flame is inside the torch. Immediately shut off cylinder valves and wait. After five minutes, if torch, regulator, and cylinder are cool, disconnect equipment and inspect torch and regulator for inner damage.