
WELDING

Introduction

Welding is the process for joining different materials.

Welding joins different metals/alloys with the help of number of processes in which heat is supplied either electrically or by means of gas torch.

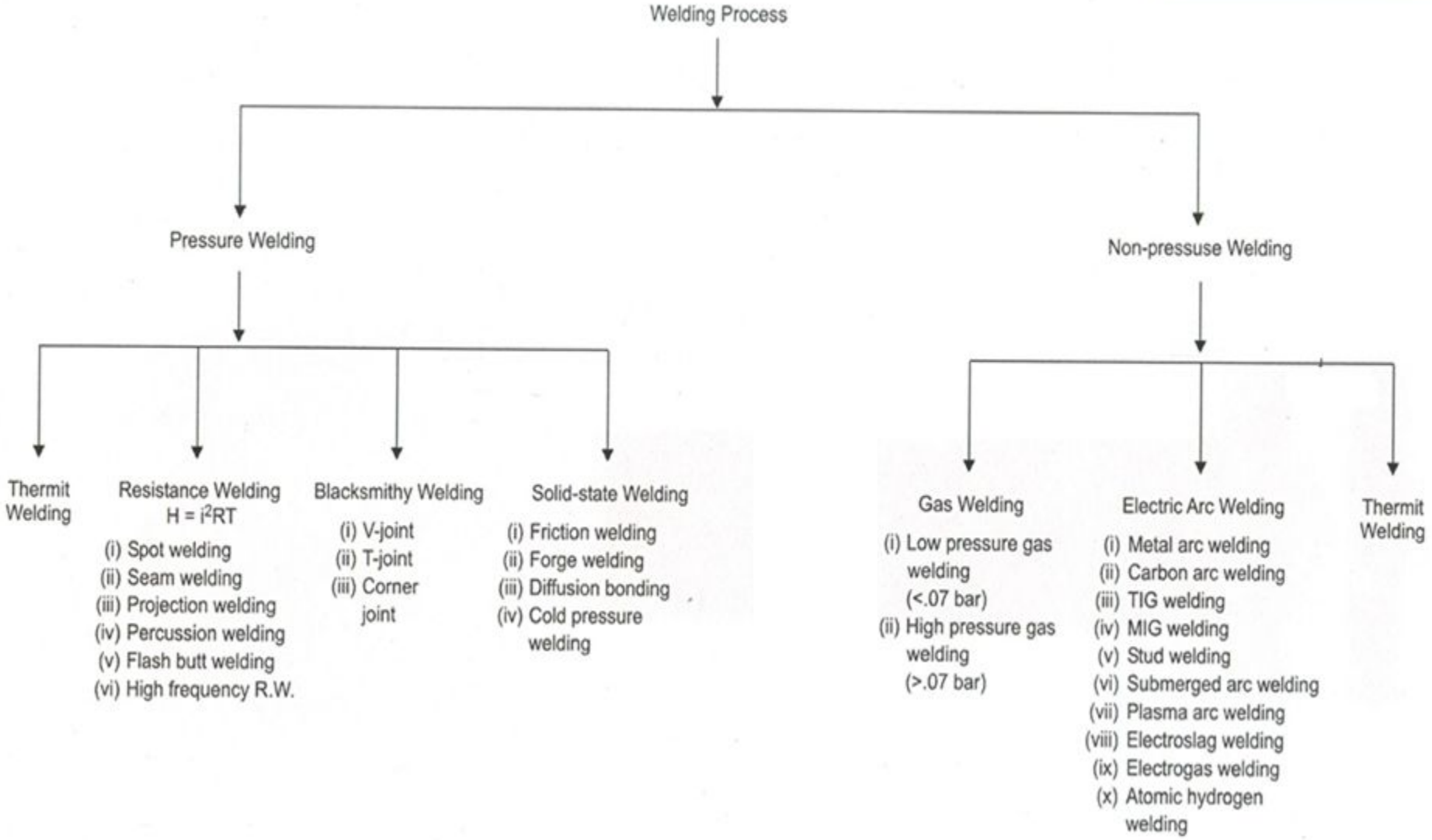
In order to join two or more pieces of metal together by one of the welding processes, the most essential requirement is heat.

Pressure may be employed but in many processes this is not essential.

Introduction

- Welding provides a permanent joint. The welded parts become a single entity.
- The welded joint can be stronger than the parent materials if a filler metal is used that has strength properties superior to those of the parents, and if proper welding techniques are used.
- Welding is not confined to the manufacturing environment. It can be executed ‘in the field.’’

Classification of welding process



Advantages

1) A good weld is as strong as the base metal.
2) General welding equipment is not very costly.
3) Portable welding equipments are available.
4) Welding permits considerable freedom in design.
5) A large number of metals/alloys both similar and dissimilar can be joined by welding.
6) Welding is usually the most economical way to join components.

Disadvantages

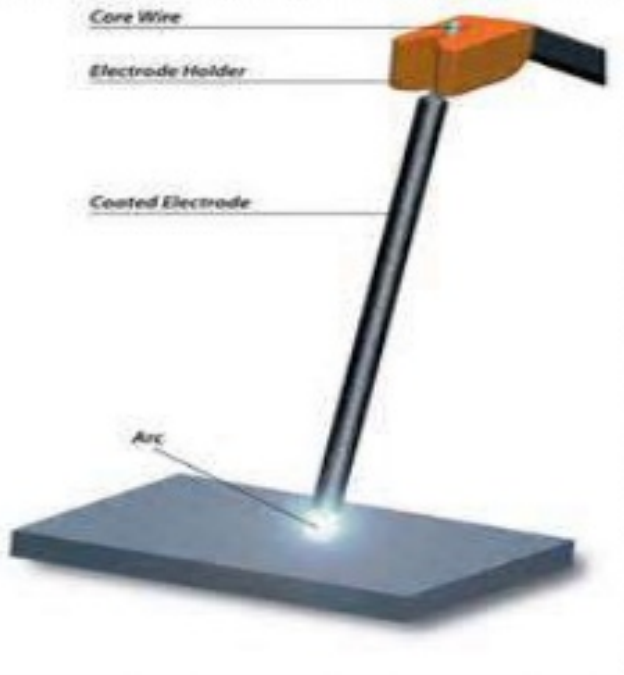
1) Welding gives out harmful radiations, light, fumes and spatter.
2) A skilled welder is required to produce a good welding job.
3) Welding results in residual stresses and distortion of the workpiece.
4) A welded joint for many reasons, needs stress-relief heat treatment.

SHIELDED METAL ARC WELDING

Introduction

- This is one the arc welding processes that is commonly used in construction/fabrication processes. It is also known with several names such as; MMA or MMAW, flux shielded arc welding or informally known as stick welding.
- The electrode used in his process is consumable (a rod covered with flux).
- The flux burns to form the protective layer/cover for the weld.
- The current type used in this process can either be AC or DC depending on the design of the weld which will be stated in the WPS.

- Because of the versatility and simplicity of this process, it is most generally and widely used across the world, it is mostly used for repair and maintenance in the heavy steel industry.



Working principle

- Current flows in through the cables (ground cable and the hot cable) from the power source (AC/DC) which the circuit is completed when the electrode tip comes in contact with the surface of the work piece as will be seen in the diagram that will be displayed in later slide.
- The heat is simply generated at the meeting point between the electrode an d the work pieces (arc).
- The heat input can however be calculated using the formula $H=[(60EI)/(1000S)]$ Kj/in

Working principle cont'd

- Shielded metal-arc welding with the transformer welding machine depends upon this fundamental fact: that when one side of the welding circuit is attached to a piece of steel, a welding electrode connected to the other side and the two brought into contact, an arc will be established.
- If the arc is properly controlled, the metal from the electrode will pass through the arc and be deposited on the steel. When the electrode is moved along the steel at the correct speed, the metal will deposit in a uniform layer called a bead.

Working principle cont'd

- The arc is started by bringing the tip of the electrode into contact with the base metal (work piece) by a very light touch, hence this arc is maintained by keeping the electrode at a relatively close distance from the base metal. This arc length is usually 3mm - 4mm.
- Melting of the base metal and the core wire of the electrode take place to form the weld pool. However, in some cases an external filler rod could be where large weld deposit is required.

Working principle cont'd

- The flux/coating of the electrode melts away to form the shielding layer (slag) that protects the weld pool from atmospheric contaminations as it solidifies. This slag are later chipped off to reveal the actual weld.
- The penetration depth of the weld could either be a full penetration or partial penetration (also referred to as incomplete penetration).
- Incomplete penetration in most cases are considered as defect but could be a requirement as stated in the WPS base on the service condition of the welded joint.

Functions of electrode coatings

1.To stablize the arc.

2. To provide the gasesous atmosphere for protection from atmospheric gases like O,H,N etc.

3. To reduce spattering of weld metal .

4. To insulate the electrode.

5. To slow down the fast cooling rate of the weld.

6. To include or add the alloying elements.

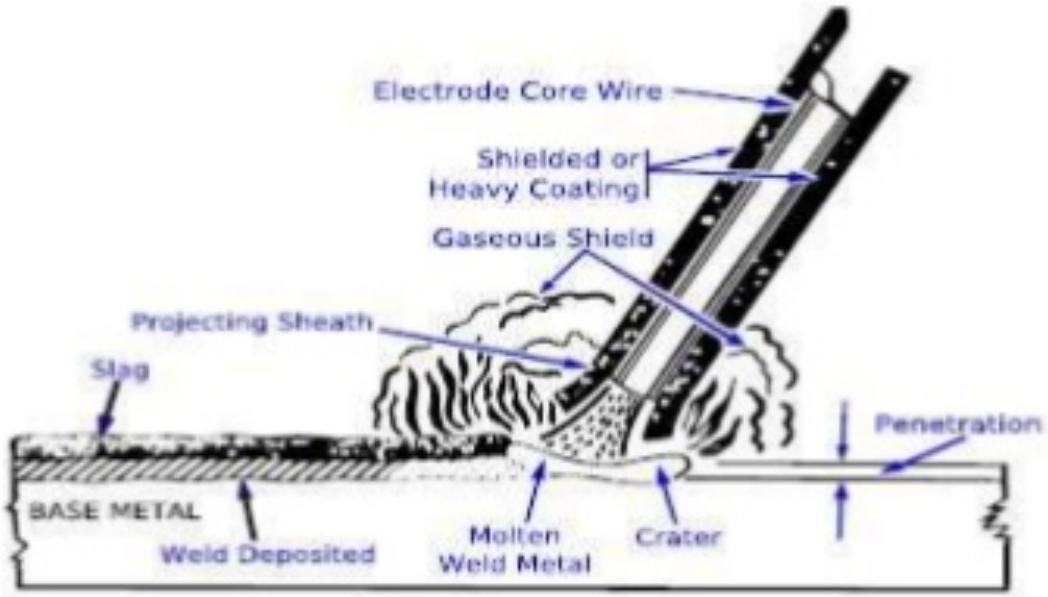
7. To remove impurity in the form of slag.

- Sticks of electrodes are available in the sizes of 3.2,4,5,6,8,9 and 12 mm diameter and 350 mm or 450 mm in length.

Selection of electrodes

1. Composition of the base metal.
2. Thickness of base metal.
3. Depth of penetration required.
4. Welding position.
5. Use of AC or DC.
6. Mechanical strength required for the joint.

- Below is a detail diagram that describes the operation of SMAW process.



Shielded Metal Arc Welding (SMAW)

Advantages

- Versatility - readily applied to a variety of applications

and a wide choice of electrodes

- Relative simplicity and portability of equipment
- Low cost
- Adaptable to confined spaces and remote locations
- Suitable for almost all welding positions like Flat, Horizontal, Vertical & Overhead

Disadvantages

- Not as productive as continuous wire processes (MIG)
- Likely to be more costly to deposit a given quantity of metal
- Frequent stop/starts to change electrode
- Relatively high metal wastage (electrode stubs)
- Current limits are lower than for continuous or automatic processes (reduces deposition rate)

Gas Welding

- Gas welding is a process in which oxy –fuel flame is used to weld the work piece. Oxy-fuel welding is fusion welding process.
- The intensity of the heat generated in the flame depends upon the oxy-fuel gas mixture and relative pressures of the gases.
- Some times compressed air is also utilised instead of oxygen.
- Generally used fuel gases is C_2H_2.
- H_2,C_3H_8,C_4H_{10} and Natural gas. But oxy-acetylene mixture gives highest flame temperature compared to other mixtures.

Oxyacetylene Welding (OAW)

The oxyacetylene welding process uses a combination of oxygen and acetylene gas to provide a high temperature flame.

Oxyacetylene Welding (OAW)

OAW is a manual process in which the welder must personally control the the torch movement and filler rod application

The term oxyfuel gas welding outfit refers to all the equipment needed to weld.

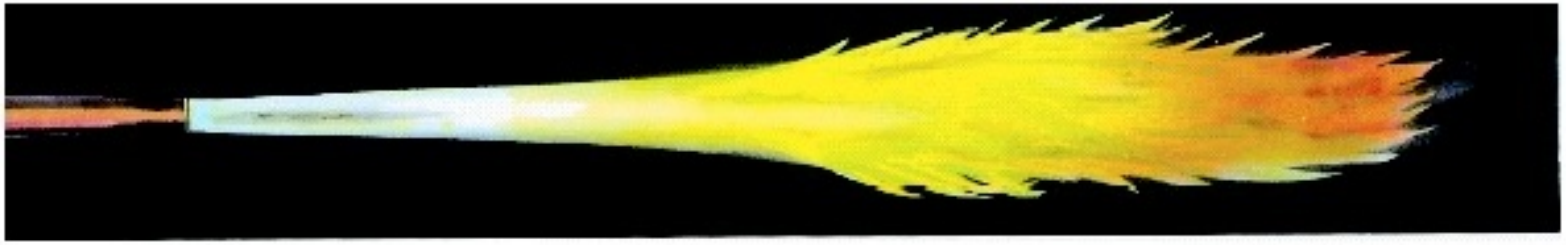
Cylinders contain oxygen and acetylene gas at extremely high pressure.

- Oxy –acetylene flame
- This combustion takes place in two stages i.e primary stage of combustion. In primary stage of combustion inner cone is developed.
- $2C_2H_2+2O_2$ ------ $4CO+ 2H_2+$ 448KJ/Mol
- In secondary stage of combustion CO and H2 ignite and burn at a low temperature than the primary stage.
- $3O2+ 4CO+2H2$ ----- $4CO2+ 2H2O+$ 812KJ/Mol

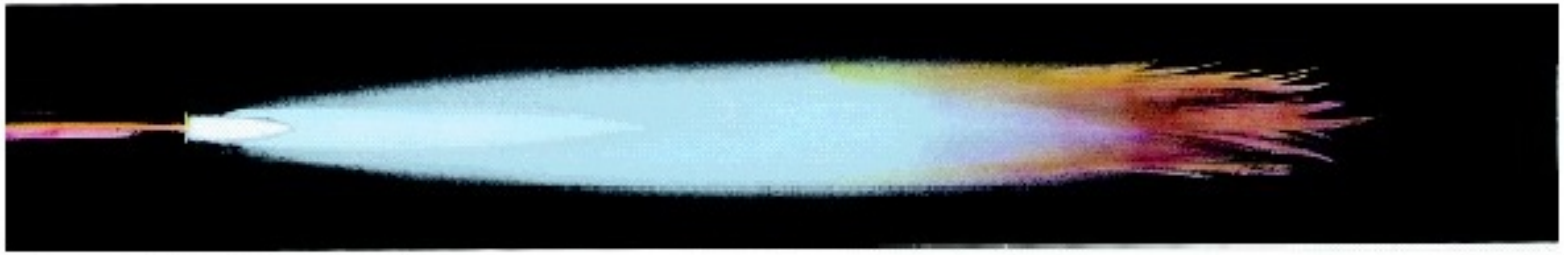
- **Neutral flame-** Two sharply defined zones are inner white cone and outer blue envelop.
- The maximum temperature occurs at a distance of 3-5 mm from the inner cone.
- Used for C.I, Mild steel, stainless steel, Al, Cu etc.
- **Oxidising flame** -The flame is similar to Neutral flame but inner cone is shorter than that of neutral flame, outer flame is light blue. This is oxidizing in nature.
- Used for brass,zinc,bronze,gold etc.

- **Reducing or Carburizing Flame-** The three zones are there, inner cone which is not sharply defined,outer envelope is similar to neutral flame, the third zone surrounding the inner cone extends up to outer envelope. It is whitish colour and shows the excess of acetylene used. It is used for low carbon steel, Al, non ferrous metals like Monel metal,nickel etc.

Pure Acetylene and Carburizing Flame profiles



Acetylene Burning in Atmosphere
Open fuel gas valve until smoke clears from flame.

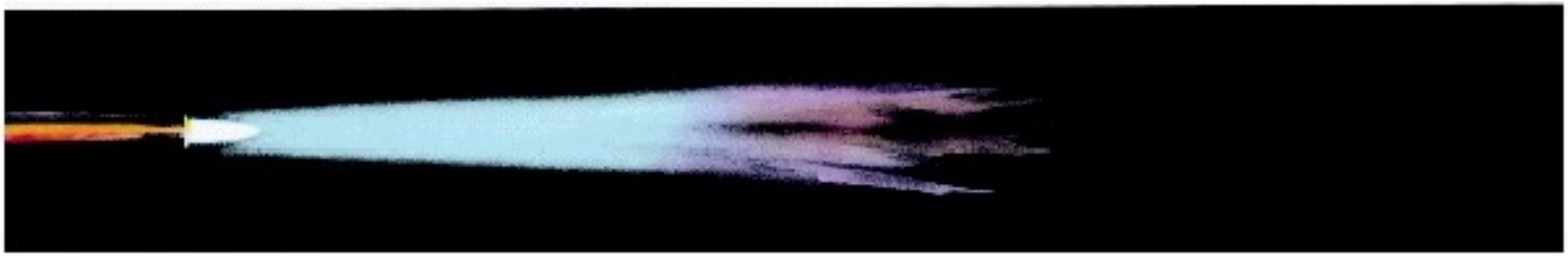


Carburizing Flame
(Excess acetylene with oxygen.) Used for hard-facing and welding white metal.

Neutral and Oxidizing Flame Profiles

Neutral Flame

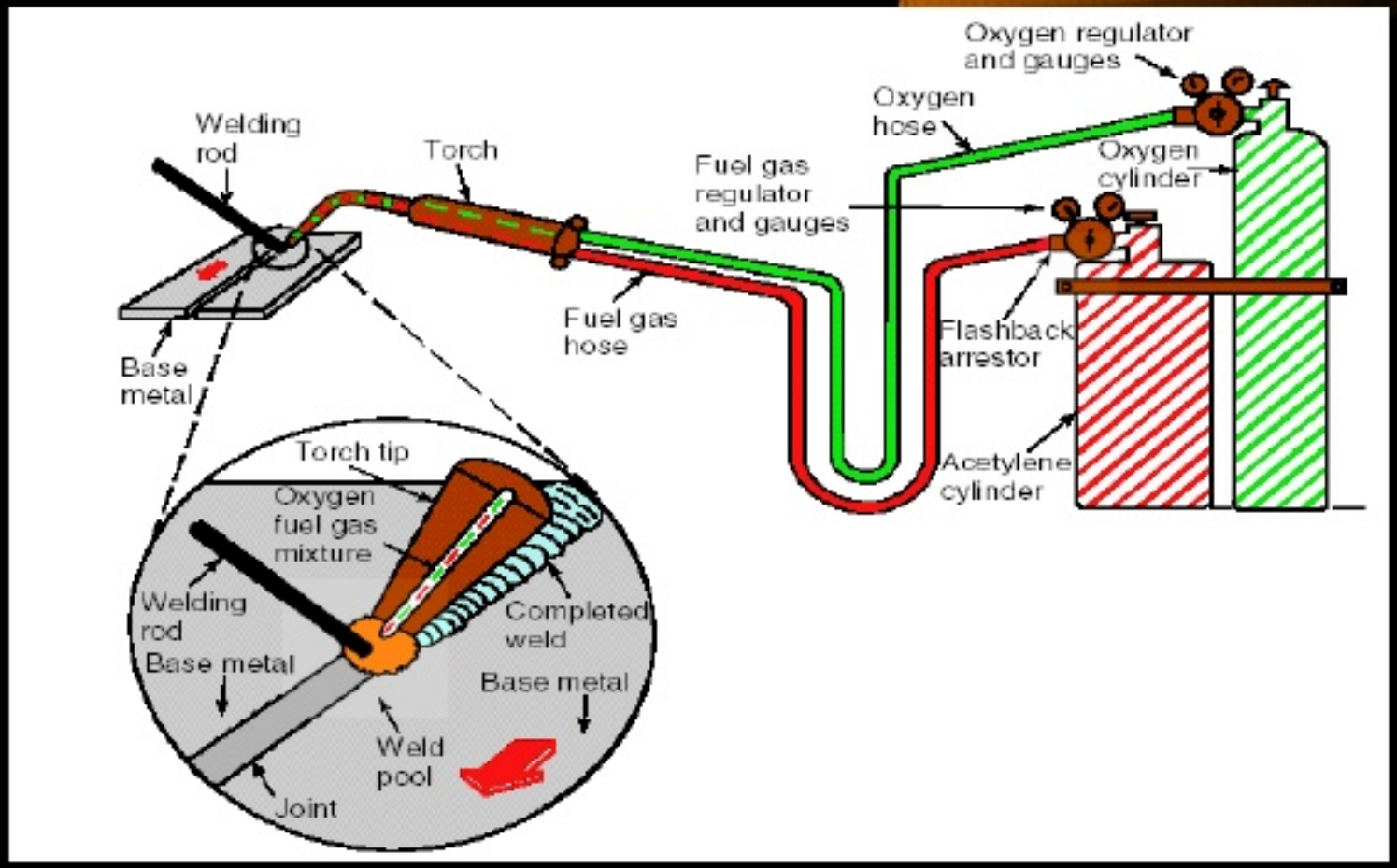
(Acetylene and oxygen.) Temperature 5589˚F (3087˚C). For fusion welding of steel and cast iron.



Oxidizing Flame

(Acetylene and excess oxygen.) For braze welding with bronze rod.

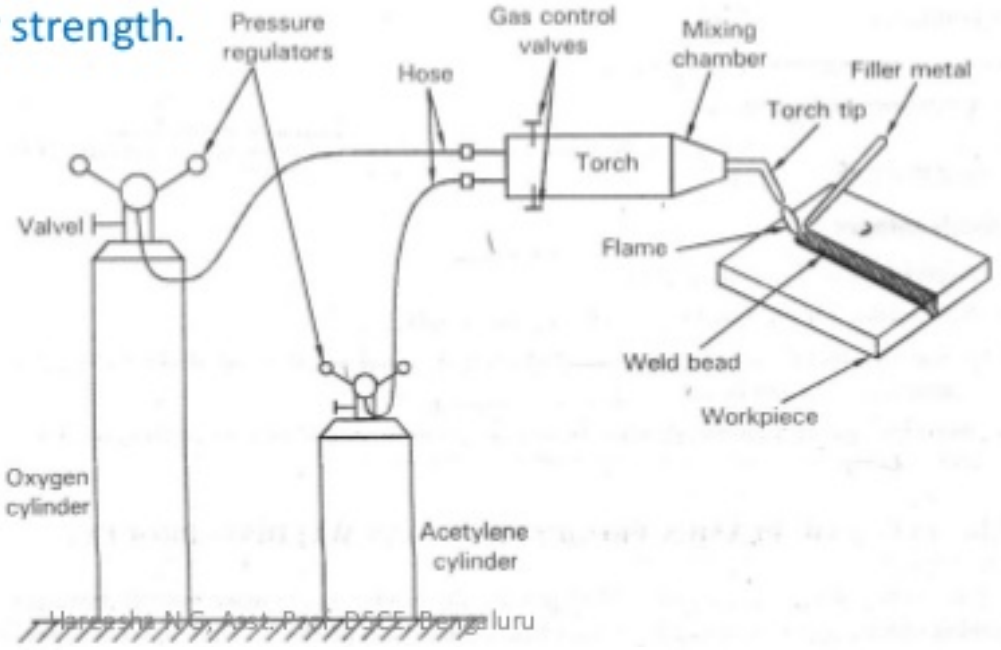
Typical Oxyacetylene Welding (OAW) Station



- In gas welding the most commonly used equipments are welding torch, welding tip, pressure regulators, gas cylinders, hose and hose fittings, goggles, spark lighter etc.
- Welding torch is mixing chamber for oxygen and acetylene.
- Welding tip is that part through which the mixed gases pass just before ignition.
- Pressure regulator is to reduce the cylinder pressure and to provide a steady flow of gas.

PRINCIPLE

- When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited, the flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal.
- The oxy-acetylene flame reaches a temperature of about 3200°C and thus can melt all commercial metals which, during welding, actually flow together to form a complete bond.
- A filler metal rod is generally added to the molten metal pool to build up the seam slightly for greater strength.



Disadvantages of Gas Welding

- Heavy sections cannot be joined economically.
- Flame temperature is less than the temperature of the arc.
- Fluxes used in certain welding and brazing operations produce fumes that are irritating to the eyes, nose, throat and lungs.
- Gas flame takes a long time to heat up the metal than an arc.
- More safety problems are associated with the handling and storing of gases.
- Acetylene and oxygen gases are rather expensive.
- Flux shielding in gas welding is not so effective as an inert gas shielding in TIG or MIG welding.

Advantages of Gas Welding

- It is probably the most versatile process. It can be applied to a wide variety of manufacturing and maintenance situations.
- Welder has considerable control over the temperature of the metal in the weld zone.
- The rate of heating and cooling is relatively slow. In some cases, this is an advantage.
- Since the sources of heat and of filler metal are separate, the welder has control over filler-metal deposition rates.
- The equipment is versatile, low cost, and usually portable.
- The cost and maintenance of the gas welding equipment is low when compared to that of some other welding processes.

BRAZING

Brazing the joining of two metal pieces by the addition of a special filler metal is known as brazing.

During brazing, the base metal of the two pieces to be joined is not melted.

An important requirement is that the filler metal must wet the base metal surfaces to which it is applied.

- Strong joints may be obtained.
- The filler metal having a melting temperature above 427°C but below the melting temperature of base metal, is distributed between the surface by capillary attraction.
- In brazing, special fluxes are required to remove surface oxide and give the filler metal the fluidity to wet the surfaces.
- Alloys of copper, silver, and aluminium are the most common brazing filler metals.
- In brazing, generally lap , butt and scarf joints are used. Out of all three, lap joint is the strongest because of large contact area.

- Joint clearance is important because sufficient space must be allowed for capillary attraction.

Application of brazing:

1. Applied to join materials, which is difficult to weld.
2. Possible in dissimilar metals.
3. Thin sections of metals can be joined.

Advantages:

1. Process is rapid
2. Neat appearance of the joint with minimum finishing.
3. Used for assembly of pipes to fitting, carbide tips to tools, radiators, heat exchangers, electrical parts and repair of castings.

Soldering

- Similar to brazing but a filler metal introduced into the joint in a liquid state at a temperature below 427°c and allowed to solidy to unite with the parent metal.
- Solders are mainly tin-lead alloys having a melting range of 180°c-370°c.
- The steps involved in making a soldered joint includes pre cleaning, fitting the parts, Applying flux, heating the desired section of the parts, applying the solder, cooling the soldered joint, and post cleaning.

- In a process, a little alloying with the base metal takes place and additional strength is obtained by mechanical bonding. The strength of the joint is largely depends on the adhensive quality of the alloy, which never reach the strength of the materials being joined.
- The flux helps clean the base metal to allow compound to take place.
- Commonly used fluxes with soldering includes zinc chloride, ammonium chloride.

- Most metals such as iron, steel, copper alloys, silver and gold and nickel alloys can be joined by soldering.
- **Applications**
- 1. joining automobile radiator core and plumbing.
- 2. electronic industry including radio, TV and computers.
- 3. for tight seal joints
- 4. electrical industries for joining wires cables.

- **Advantages**
- 1. it adds rigidity and improves electrical conductivity.
- 2. Solders are more ductile in nature.
- 3. used for sealing fabricated joint.
- 4. Low heat input as compared to brazing and welding.
- 5. It is easy to make a rejoint by soldering.

welding	brazing	soldering
TEMPERATURE OF JOINING IS GREATER THAN MELTING POINT OF METAL TO BE JOINED.	TEMPERATURE OF JOINING IS MORE THAN 427°C	TEMPERATURE OF JOINING IS LESS THAN 427°C
STRENGTH OF JOINT IS HIGH	STRENGTH IS LOW	STRENGTH IS POOR
USED FOR WELDING OF MACHINE PARTS AND HEAVY STRUCTURAL COMPONENTS	USED FOR JOINING ALUMINIUM, MAGNESIUM AND THEIR ALLOYS	USED IN ELECTRICAL CIRCUITS, DOMESTIC AND PLUMBING APPLICATION.
IT IS A PROCESS OF JOINING TWO SIMILAR OR DISSIMILAR METALS BY APPLICATION OF HEAT, PRESSURE OR BOTH AND WITH OR WITHOUT THE USE OF FILLER METAL	IT IS A PROCESS OF JOINING TWO METAL PIECES BY ADDITION OF SPECIAL FILLER METAL	JOINING BY MEANS OF FUSIBLE ALLY CALLED SOLDER.
THE BASE METALS TO BE JOINED ARE MELTED	THE BASE METALS TO BE JOINED ARE NOT MELTED	THE BASE METALS TO BE JOINED ARE NOT MELTED