



Welding shop

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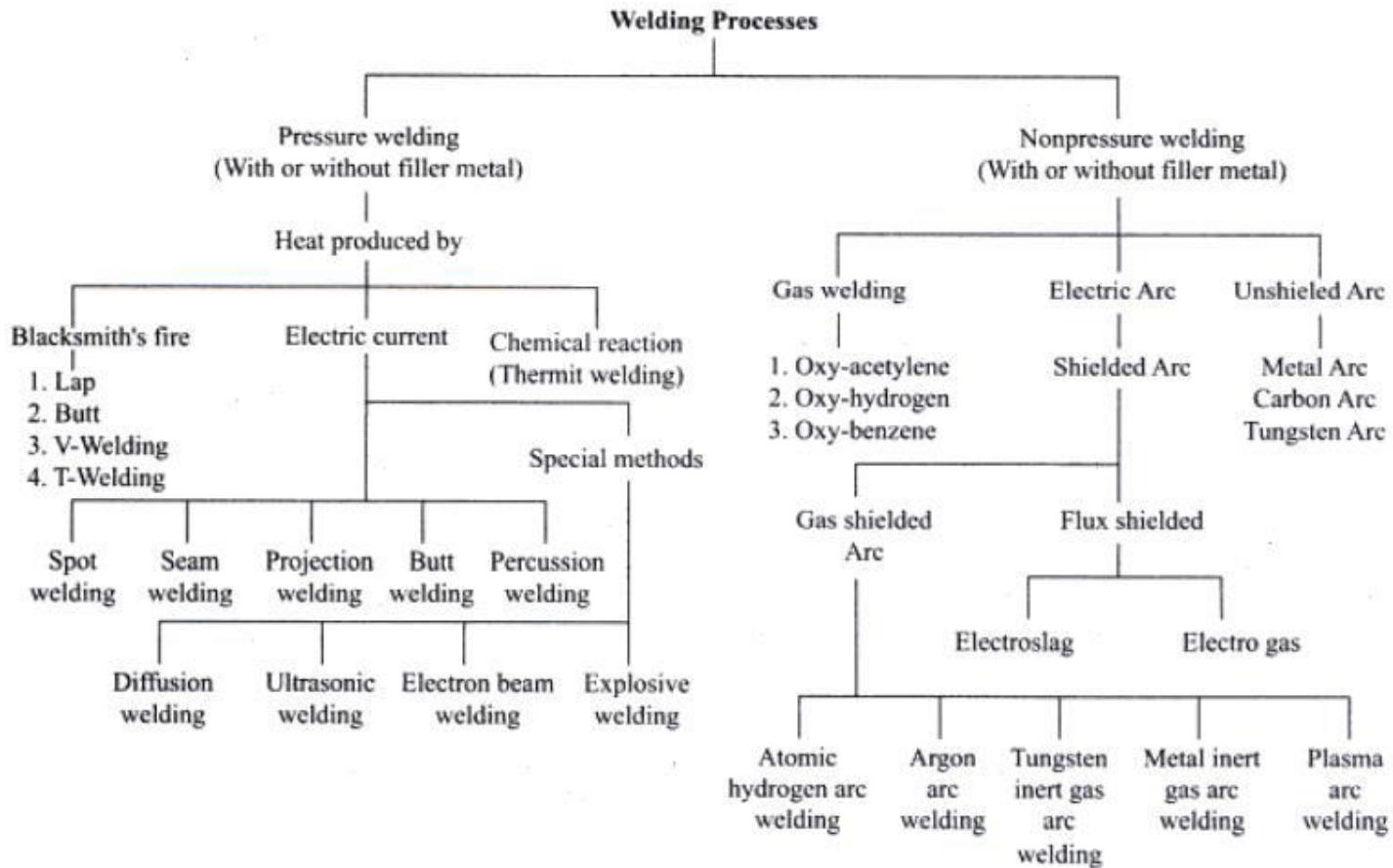
INTRODUCTION

- Welding is a process for joining two similar or dissimilar metals by fusion.
- It joins different metals/alloys, with or without the application of pressure and with or Without the use of filler metal.
- The fusion of metal takes place by means of heat. The heat may be generated either from combustion of gases, electric arc, electric resistance or by chemical reaction.

Types of welding

1. Plastic or Pressure welding: The pieces of metal to be joined are heated to a plastic state and forced together by external pressure.
2. Fusion or non-pressure welding: The material at the joint is heated to molten state and allowed to solidify.

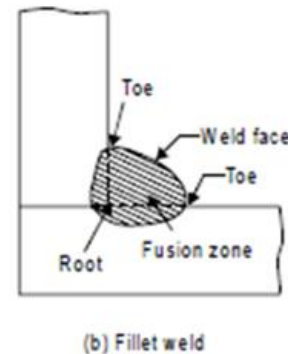
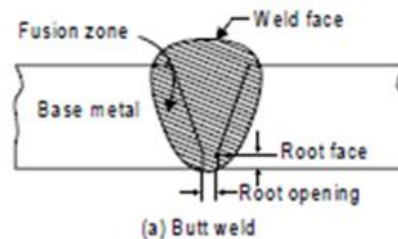
CLASSIFICATION



TERMINOLOGICAL ELEMENTS OF WELDING PROCESS

- 1) **Backing:** It is material support provided at the root side of a weld to aid in the control of penetration.
- 2) **Base metal:** The metal to be joined
- 3) **Bead or weld bead:** It is the metal added during a single pass of welding.
- 4) **Crater:** In arc welding, a crater is the depression in the weld metal pool at the point where the arc strikes the base metal plate.
- 5) **Puddle:** The position of the weld joint that melted by the heat of welding
- 6) **Root:** it is the point at which the two pieces to be joined by welding .

- 7) **Tack weld:** small weld generally used to temporarily hold the two pieces together during actual welding
- 8) **Toe of weld:** it is junction between the weld face and the base metal.
- 9) **Weld face:** it is the exposed surface of the weld
- 10) **weld metal:** the metal that is solidified in the joint
- 11) **Weld pass:** a single movement of the welding torch or electrode along the length of the joint which results in a bead.



Welding joints

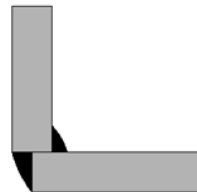
1. Lap joint
2. Butt joint
3. Corner joint
4. Edge joint
5. Tee joint



Butt Joint



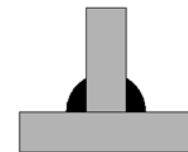
Lap Joint



Corner Joint



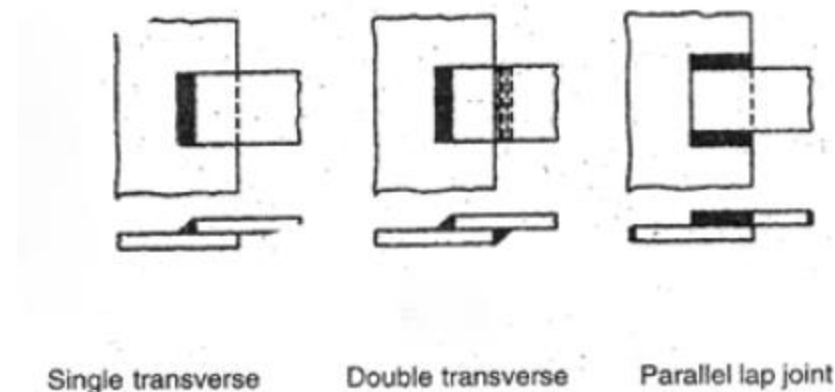
Edge Joint



Tee Joint

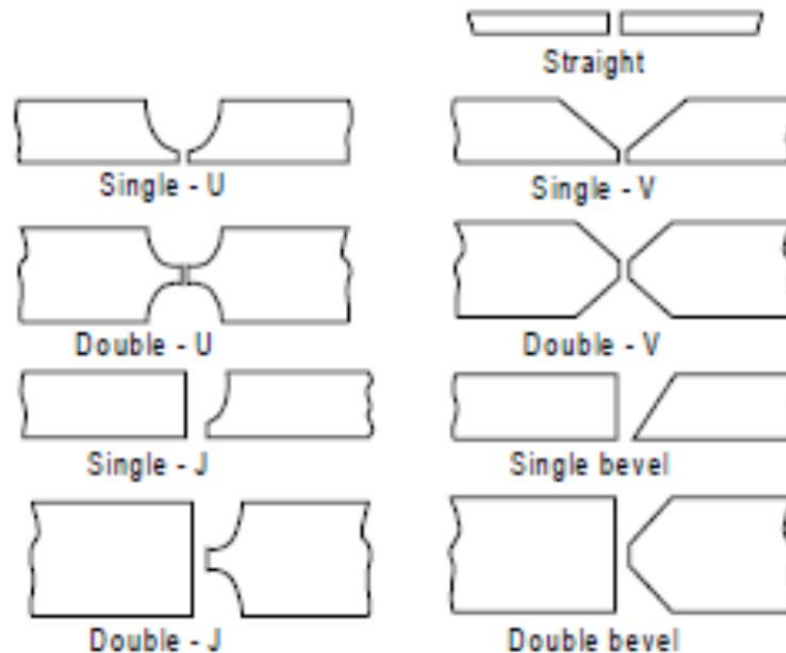
Lap Joint

- It is obtained by overlapping the plates and then welding the edges of the plates.
- These joints are employed on plates having thickness less than 3 mm.
- Types of lap joint shown in fig.



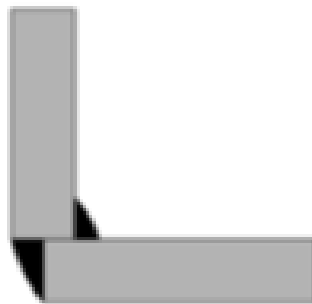
Butt joints

- Butt joint is obtained by welding the ends or edges of the two plates which are in same plane with each other



Corner joint

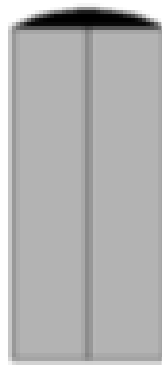
- The corner joint is obtained by joining the edges of two plates whose surface are at an angle of 90^0 to each other.



Corner Joint

Edge Joint

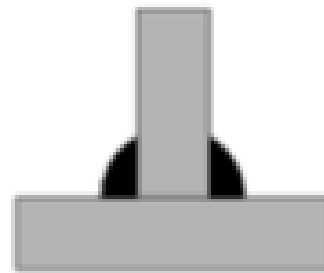
- It is obtained by joining two parallel plates.
- Used for plates having thickness less than 6 mm.



Edge Joint

Tee Joint

- Obtained by joining two plates whose surfaces are at right angles to each other.
- These joints are suitable up to 3mm thickness

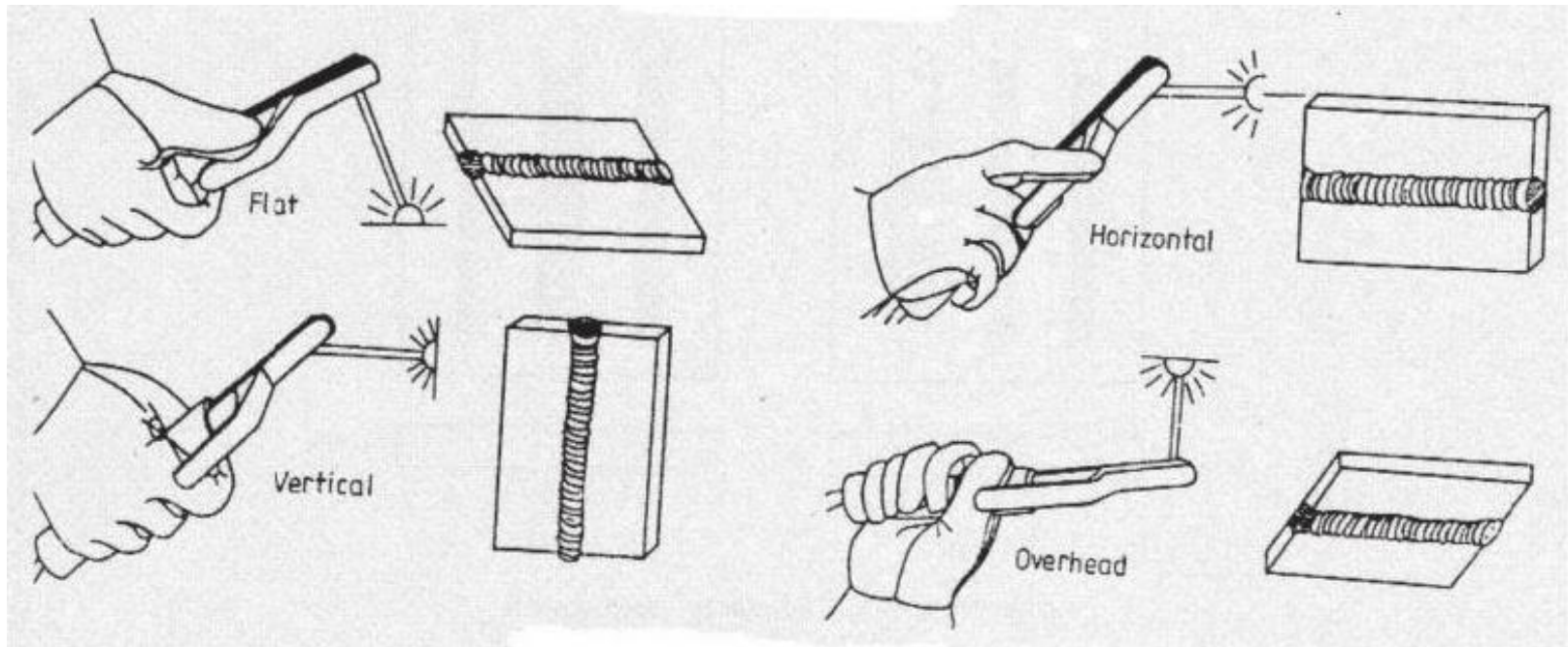


Tee Joint

Welding Positions

- **Flat or down hand position:** In which the welding is performed from the upper side of the joint and the face of the weld is approximately horizontal.
- **Horizontal position:** The plane of the workpiece is vertical and the deposited weld head is horizontal.
- **Vertical position:** The plane of the workpiece is vertical and the weld is deposited upon a vertical surface
- **Overhead position:** the plane of the workpiece is horizontal. But the welding is carried out from the underside

Welding Positions



Advantages of welding

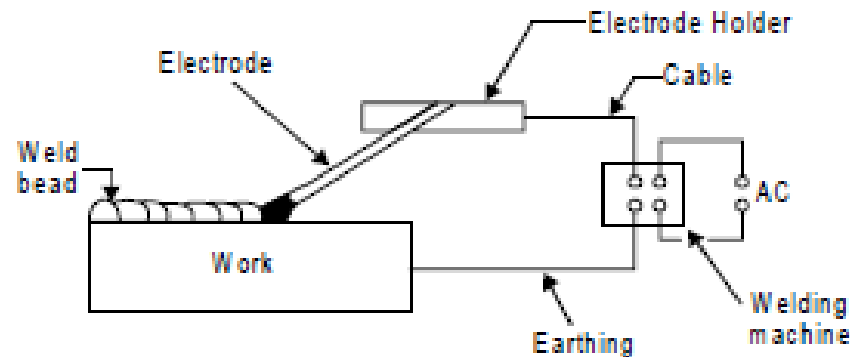
- 1) A properly made weld can be stronger than the part on which it is used.
- 2) It is a permanent joint.
- 3) The equipment is inexpensive.
- 4) The equipment can be portable.
- 5) The process allows considerable freedom in design.

Disadvantages of welding

- 1) A good welding job require skilled operator.
- 2) Fixtures are often needed to hold parts in position for welding.
- 3) Each part of weldment must be cut to size and shape before it can be welded.
- 4) Presence of residual stresses and distortion in the welded joints.

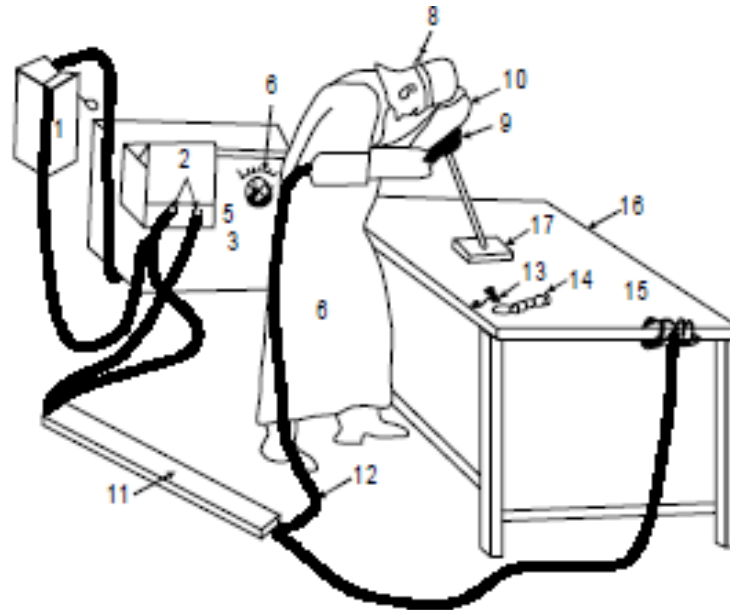
Arc Welding processes

- The process, in which an electric arc between an electrode and a workpiece or between two electrodes is utilized to weld base metals, is called an arc welding process.



Basic principle of arc welding

Arc Welding setup



- | | | |
|------------------------------------|------------------------------------|--------------------------------|
| (1) Switch box. | (7) Asbestos hand gloves. | (13) Chipping hammer. |
| (2) Secondary terminals. | (8) Protective glasses strap. | (14) Wire brush. |
| (3) Welding machine. | (9) Electrode holder. | (15) Earth clamp. |
| (4) Current reading scale. | (10) Hand shield. | (16) Welding table (metallic). |
| (5) Current regulating hand wheel. | (11) Channel for cable protection. | (17) Job. |
| (6) Leather apron. | (12) Welding cable. | |

Arc Welding Equipment's

1. Power source
2. Welding electrodes
3. Electrode holder
4. Face shield
5. Chipping hammer
6. Wire brush
7. Welding cables
8. Earthing clamp
9. Tongs
10. Hand gloves
11. Apron
12. Anvil etc.

1) Arc welding power source:

Both direct current (DC) and alternating current (AC) are used for electric arc welding, each having its particular applications.

- DC welding supply is usually obtained from generators driven by electric motor or if no electricity is available by internal combustion engines.
- For AC welding supply, transformers are predominantly used for almost all Arc-welding where mains electricity supply is available. They have to step down the usual supply voltage (200-400 volts) to the normal open circuit welding voltage (50-90 volts).
- **Current requirements**
 - 20-200 amperes for thin materials
 - 20-300 amperes for general work
 - Up to 600 amperes for heavy work.

Comparison Between A.C. and D.C. Arc Welding

A.C. welding	D.C. welding
1.Low no load voltage	1. High no load voltage
2. High efficiency	2. Low efficiency
3. Low cost and simpler	3. Two to three times costlier
4. Maintenance is easier and economical	4. Maintenance cost is high
5. Less suitable for use at low current with small dia. electrode	5. Better suited for use at low current with small dia. Electrode.

Polarity In Arc welding

When DC is used there is a choice of polarity and this choice is affected by the fact that the positive pole of the arc becomes hottest

- If the electrode is connected to negative side of generator this is called straight polarity or direct current electrode negative(DCEN). it is used for welding of heavy materials
- If the electrode is connected to the positive side it termed as reverse polarity or direct current electrode positive (DCEP). It is used for welding of thin materials.

2) Welding Electrode

An electrode is a piece of wire or a rod of a metal or alloy, with or without coatings. An arc is set up between electrode and workpiece.

Welding electrodes are classified into following types-

(1) Consumable Electrodes

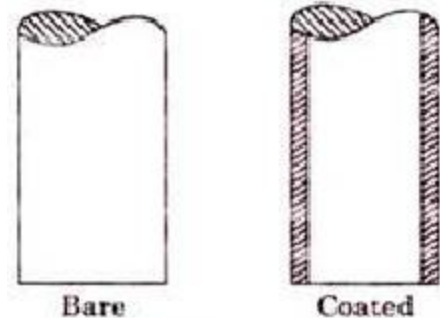
(a) Bare Electrodes

(b) Coated Electrodes

(2) Non-consumable Electrodes

(a) Carbon or Graphite Electrodes

(b) Tungsten Electrodes



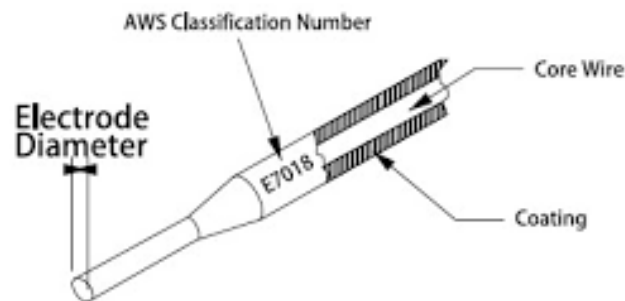
Bare electrode

- which consist of metal or alloy wire without any flux coating.



Coated Electrode

- Obtained by applying a light coating of flux on the rods with a dusting or washing process.
- The flux coating assists both in eliminating undesirable oxides and preventing their formation.
- Types of flux coating depends on the weld metal composition.



Electrode Size

- Metal electrodes are available in 1.5 to 9.5 mm diameter and 35 to 45 cm of length.
- Carbon electrodes are available in 4.5 to 12.5 mm diameter and length about 25 cm.
- Diameter of electrode is selected depending on the thickness of the parent metal and the welding current to be used.
- Diameter of electrode controls the penetration.

electrode current Vs electrode size Vs plate thickness

Plate thickness, mm	Electrode size, mm	Electrode current range,amp
1.6	1.6	40-60
2.5	2.5	50-80
4.0	3.2	90-130
6.0	4.0	120-170
8.0	5.0	180-270
25.0	6.0	300-400

Classification of Coating

- Cellulose coating: provide gas shield, deeply penetrating arc and rapid burning rate.
- Rutile coating: (a) viscous for butt and fillet weld
(b) fluid type for flat and horizontal position.
- Iron oxide coating: used for deep groove in flat position.
- Lime fluorspar: used for heavy section and restrained joints.

3) Electrode holder

- A metal electrode is the device used for holding the electrode mechanically. It conveys electric current from welding machine to the electrode; it has an insulated handle to protect the operator's from heat and electric shock.



4) Face shield

- A face shield is used to protect the eyes and face from the rays of the arc and from spatter or flying particles of hot metal. It is available either in hand or helmet type. The hand type is convenient to use wherever the work can be done with one hand. The helmet type though not comfortable to wear, leaves both hands free for the work.



5)Chipping hammer

- A chipping hammer is used for removing slag formation on welds. One end of the head is sharpened like a cold chisel and the other, to a blunt, round point.
- It is generally made of tool steel. Molten metal dispersed around the welding heads, in the form of small drops, is known as spatter. When a flux coated electrode is used in welding process, then a layer of flux material is formed over the welding bead which contains the impurities of weld material. This layer is known as slag.
- Removing the spatter and slag formed on and around the welding beads on the metal surface is known as chipping.



Chipping hammer

6) Wire brush

- A wire brush is used for cleaning and preparing the work for welding.
- The bristles are made from steel or stainless steel.



7) Welding cables

- Two welding cables are required, one from the machine to the electrode holder and the other from the machine to the ground clamp
- Flexible cables are usually preferred because of the ease of using and coiling the cables.
- Cables are specified by their current capacity say 300A, 400 A etc.



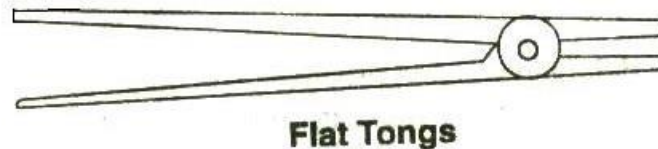
8) Earthing clamp

- It is connected to the end of the ground cable. It is normally clamped to the welding table or the job itself to complete the electric current.
- It should be strong and durable and give low resistance connection.



9) Tongs

- When welding smaller pieces together, for moving the pieces to different welding angles and shifting of pieces for chipping. It is advisable to use a flat tongs.



10) Hand gloves

These are used to protect the hands from electric shocks and hot spatters



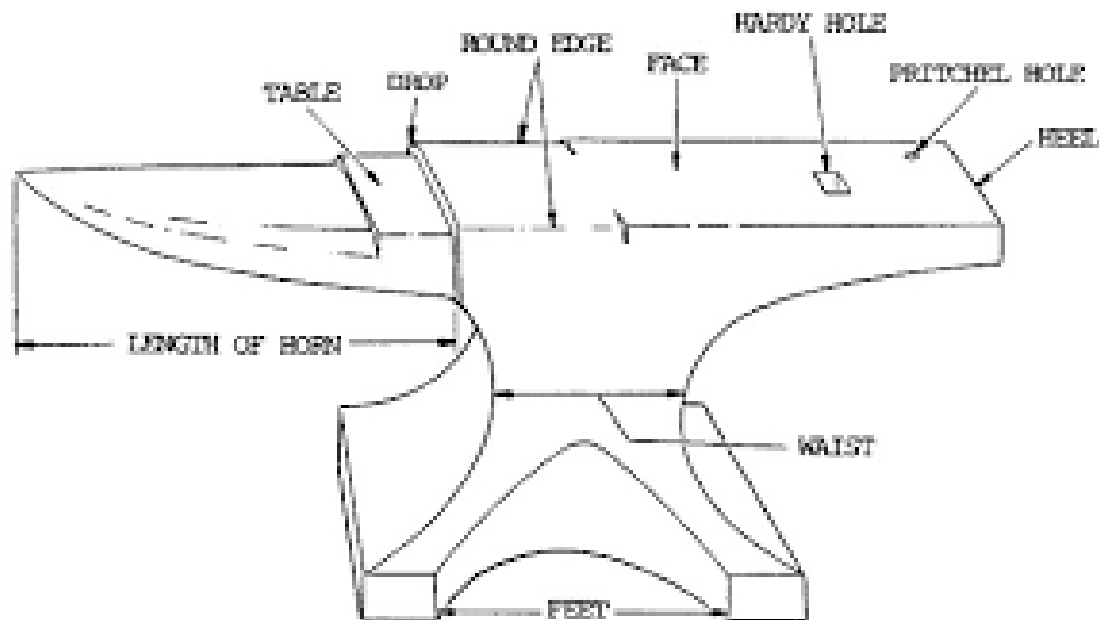
11) Apron

- Operator wears the protective clothing such as apron to keep away the exposure of direct heat to the body.



12) Anvil

- It is a solid casting of mild steel. Used for supporting the work for hammering, punch marking, chipping of welded parts etc.



Safety Recommendations for ARC Welding

- 1) The body or the frame of the welding machine shall be efficiently earthed. Pipe lines containing gases or inflammable liquids or conduits carrying electrical conductors shall not be used for a ground return circuit All earth connections shall be mechanically strong and electrically adequate for the required current.
- 2) Welding arc in addition to being very is a source of infra-red and ultra-violet light also; consequently the operator must use either helmet or a hand-shield fitted with a special filter glass to protect eyes
- 3) Excess ultra-violet light can cause an effect similar to sunburn on the skin of the welder

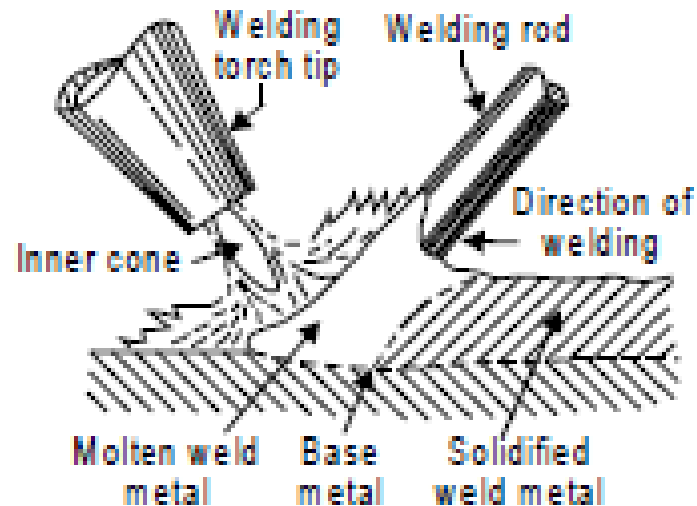
- 4) The welder's body and clothing are protected from radiation and burns caused by sparks and flying globules of molten metal with the help of the following:
- 5) Gloves protect the hands of a welder.
- 6) Leather or asbestos apron is very useful to protect welder's clothes and his trunk and thighs while seated he is doing welding.
- 7) For overhead welding, some form of protection for the head is required
- 8) Leather skull cap or peaked cap will do the needful.
- 9) Leather jackets and leather leggings are also available as clothes for body protection.
- 10) Welding equipment shall be inspected periodically and maintained in safe working order at all times.
- 11) Arc welding machines should be of suitable quality.
- 12) All parts of welding set shall be suitably enclosed and protected to meet the usual service conditions.

Gas Welding

- Oldest methods of fusion welding process
- Most widely used method of metal melting
- The equipment is relatively simple and cheap
- Heat is generated by the combustion of combustible gas with oxygen
- Combustion takes place at the nozzle or the outlet of the torch
- This process of welding is generally known as Oxygen – Fuel Gas welding
- Commercial gases used for gas welding: acetylene, hydrogen, propane, butane and commercial LPG.

GAS WELDING PROCESSES

- A fusion welding process which joins metals, using the heat of combustion of an oxygen /air and fuel gas (i.e. acetylene, hydrogen propane or butane) mixture is usually referred as 'gas welding'.



TYPES OF GAS WELDING

Fuel Gas	Flame Temperature
1. OXY-ACETYLENE	3500 ⁰ C
2. OXY-HYDROGEN	2500 ⁰ C
3. OXY-PROPANE	2500 ⁰ C
4. NATURAL GAS	2000 ⁰ C

Oxy- Acetylene Gas Welding

- In this process, 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.
- Acetylene is the fuel gas used, produce high heat content in the range of 3200°C
- Complete combustion of acetylene is represented by the equation

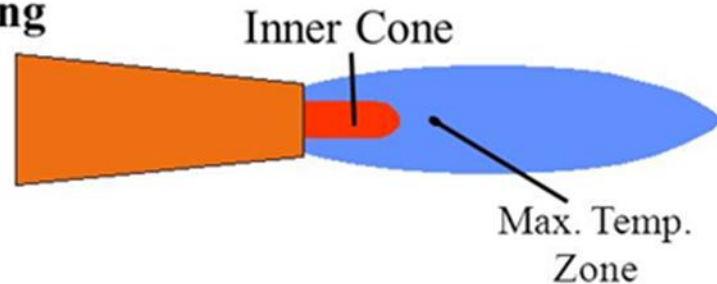


Types of gas flames

The Oxy-acetylene welding Flame

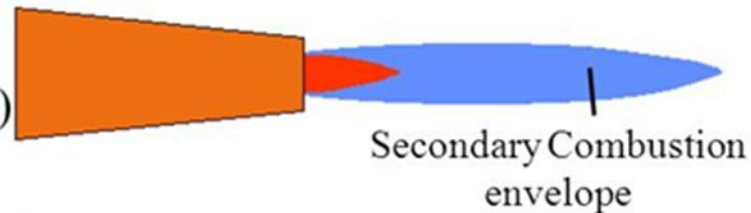
Reducing or Carburizing

Excess acetylene (0.9:1)
(Alloy steels and
aluminium alloys)



Oxidizing

Excess oxygen (1.5:1)
(Brasses, Bronzes, copper)

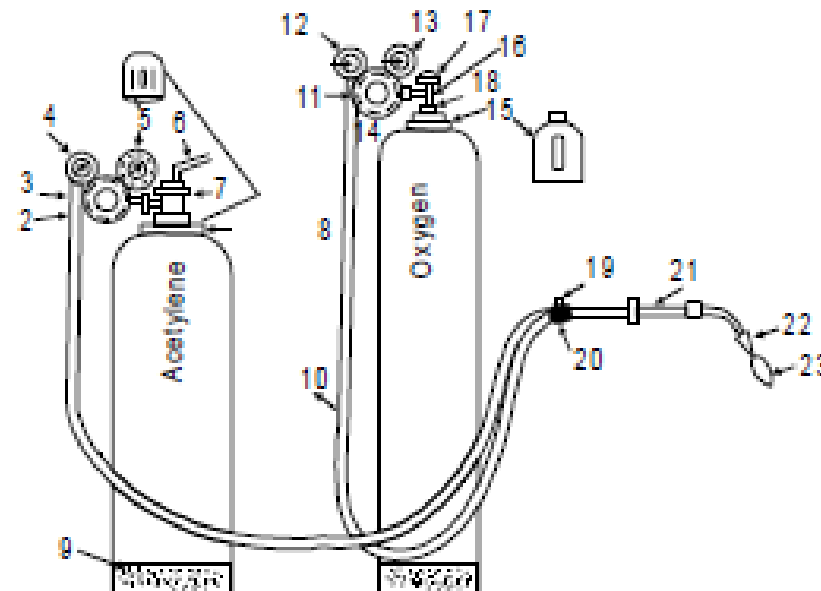


Neutral

Equal acetylene & oxygen
(low carbon steel, mild
steels).



Gas Welding Equipment's



1. Acetylene hose
2. Adjusting screw
3. Acetylene regulator
4. Regulator outlet pressure gauge
5. Cylinder pressure gauge
6. Valve wrench
7. Acetylene cylinder valve
8. Cylinder cap

9. Fusible plugs
10. Oxygen hose
11. Oxygen regulator
12. Regulator outlet pressure gauge
13. Cylinder pressure gauge
14. Cylinder cap
15. Oxygen cylinder valve
16. Oxygen cylinder valve

17. Hand wheel
18. Bursting disc
19. Acetylene valve
20. Oxygen valve
21. Welding torch
22. Torch tip
23. Flame

Gas Welding Equipment

- 1) Cylinders
- 2) Pressure Regulator
- 3) Hoses
- 4) Welding Torch
- 5) Goggles
- 6) Gloves

1) Cylinders

- Gas cylinders are colour-coded
- Oxygen cylinders: oxygen cylinder is black with a white/grey shoulder.
- Acetylene cylinder is maroon.
- Cylinders should also carry a label that gives details of the type of gas.



2) Pressure regulator

- Both oxygen and fuel gases are filled in cylinder at high pressure.
- These gases cannot use at this high pressure for welding work so a pressure regulator is used between flow.
- It supplies oxygen at pressure about 70 – 130 KN / M² and gas at 7 – 103 KN / M² to the welding torch.



3) Hoses (tubing)

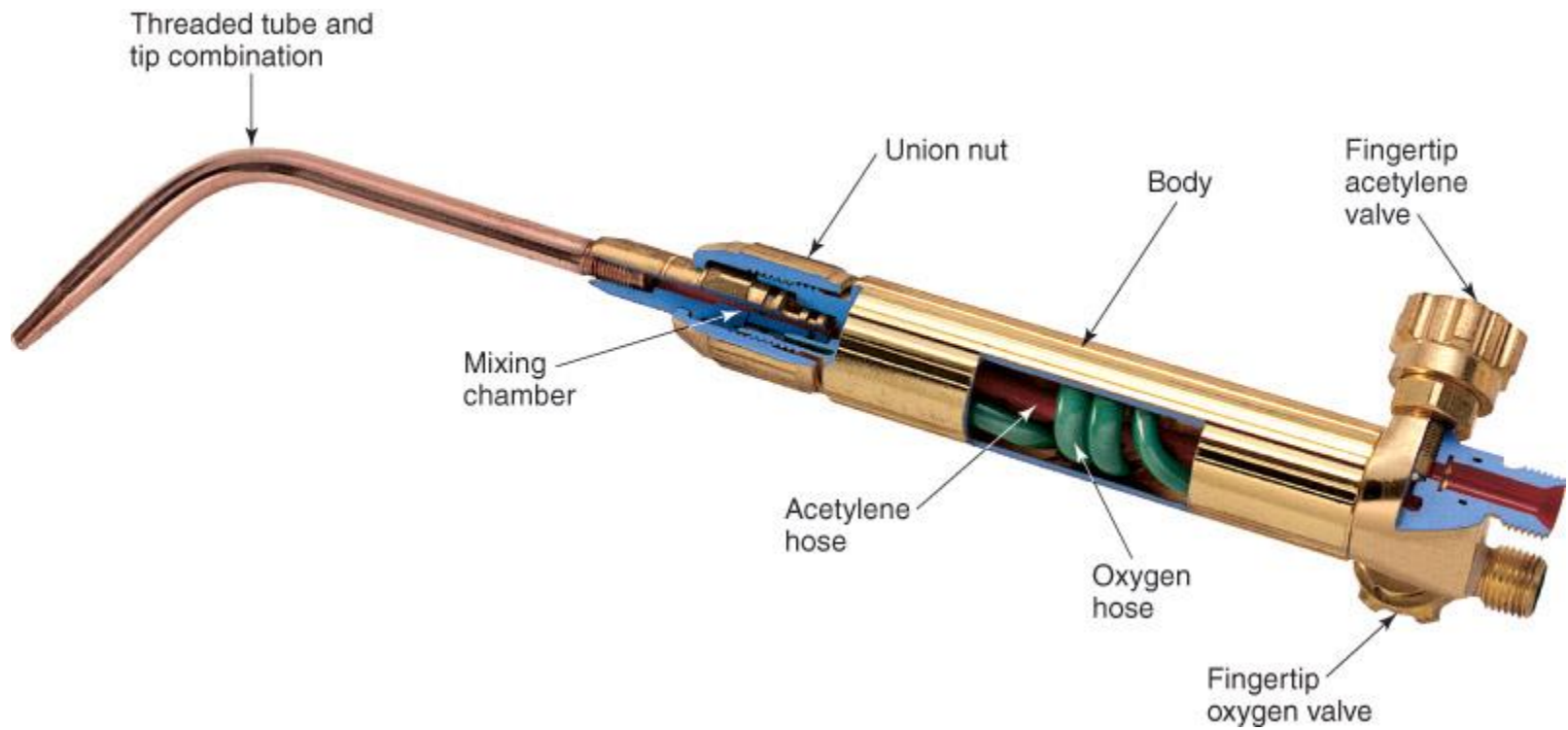
- Hoses are generally constructed of synthetic rubber and reinforcing material, and are designed to withstand high pressures, while providing flexibility to give the operator freedom of movement.
- Oxygen hoses are black /blue and the fittings at each end of the hose have right-hand threads.
- Fuel gas hoses are red or maroon and the fittings have left-hand threads.



4) WELDING TORCH

- Welding torches are most important part of gas welding. Both the fuel gas and oxygen at suitable pressure fed through hoses to the welding torch.
- There are valves for each gas with control the flow of gases inside the torch. Both gases mixed there and form a flammable mixture.
- These gases ignite to burn at the nozzle. The fire flame flow through nozzle and strikes at welding plates.
- The nozzle thickness depends on the size of the welding plates and material to be welded.

- WELDING TORCH



5) Goggles

- Used to protect eyes from radiation while welding.



6) Gloves

- Protect the hands of welders from the hazards of welding.



Advantages

- Portable and most versatile process
- Better control over temperature
- Suitable to weld dissimilar metals
- Low cost and maintenance

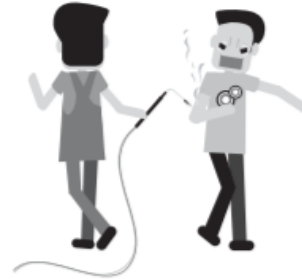
Disadvantages

- Not suitable for heavy section
- Less working temperature
- Slow rate of heating

Safety in oxy-acetylene welding



Clear the welding area



Be careful of other people



Do not use heat on any container that may have contained fuel



Keep hoses clear of the floor.
Wear gloves



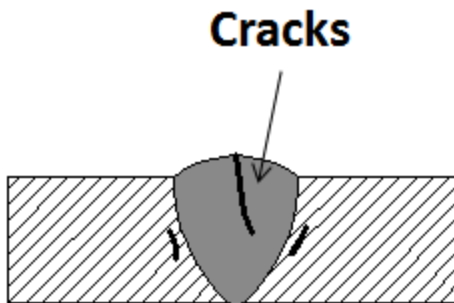
Mark work that is hot

Welding Defects

- 1) Weld crack
- 2) Porosity**
- 3) Undercut**
- 4) Incomplete Fusion**
- 5) Incomplete Penetration**
- 6) Slag Inclusion**
- 7) Spatter**

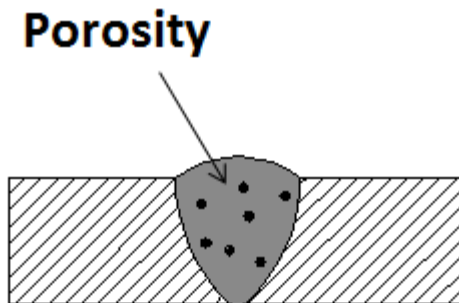
1) Weld Cracks

The most serious type of welding defect is a weld crack and it's not accepted almost by all standards in the industry. It can appear on the surface, in the weld metal or the area affected by the intense heat.



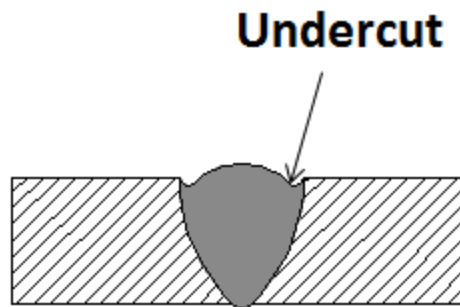
2) Porosity

Porosity occurs as a result of weld metal contamination. The trapped gases create a bubble-filled weld that becomes weak and can with time collapse.



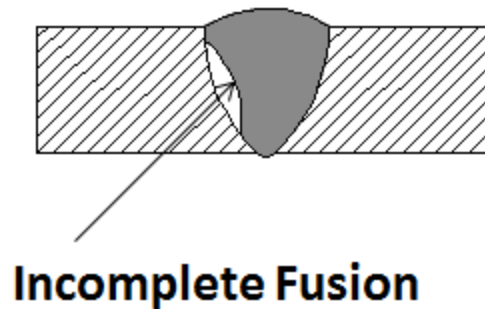
3) Undercut

This welding imperfection is the groove formation at the weld toe, reducing the cross-sectional thickness of the base metal. The result is the weakened weld and workpiece.



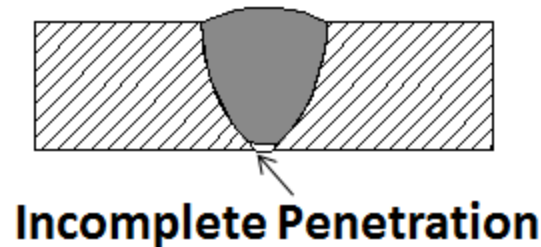
4) Incomplete Fusion

This type of welding defect occurs when there's a lack of proper fusion between the base metal and the weld metal. It can also appear between adjoining weld beads. This creates a gap in the joint that is not filled with molten metal.



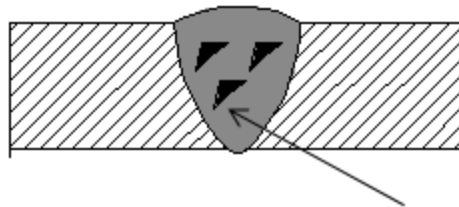
5) Incomplete Penetration

Incomplete penetration occurs when the groove of the metal is not filled completely, meaning the weld metal doesn't fully extend through the joint thickness.



6) Slag Inclusion

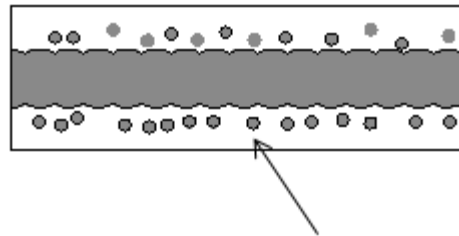
Slag inclusion is one of the welding defects that are usually easily visible in the weld. Slag is a vitreous material that occurs as a byproduct of stick welding, flux-cored arc welding and submerged arc welding. It can occur when the flux, which is the solid shielding material used when welding, melts in the weld or on the surface of the weld zone.



Slag inclusion

7) Spatter

Spatter occurs when small particles from the weld attach themselves to the surrounding surface. It's an especially common occurrence in gas metal arc welding. No matter how hard you try, it can't be completely eliminated. However, there are a few ways you can keep it to a minimum.



Spatter