WELDING WORKSHOP WRITE-UP

By ANEESH PANCHAL (2K20/A6/56)

INTRODUCTION:

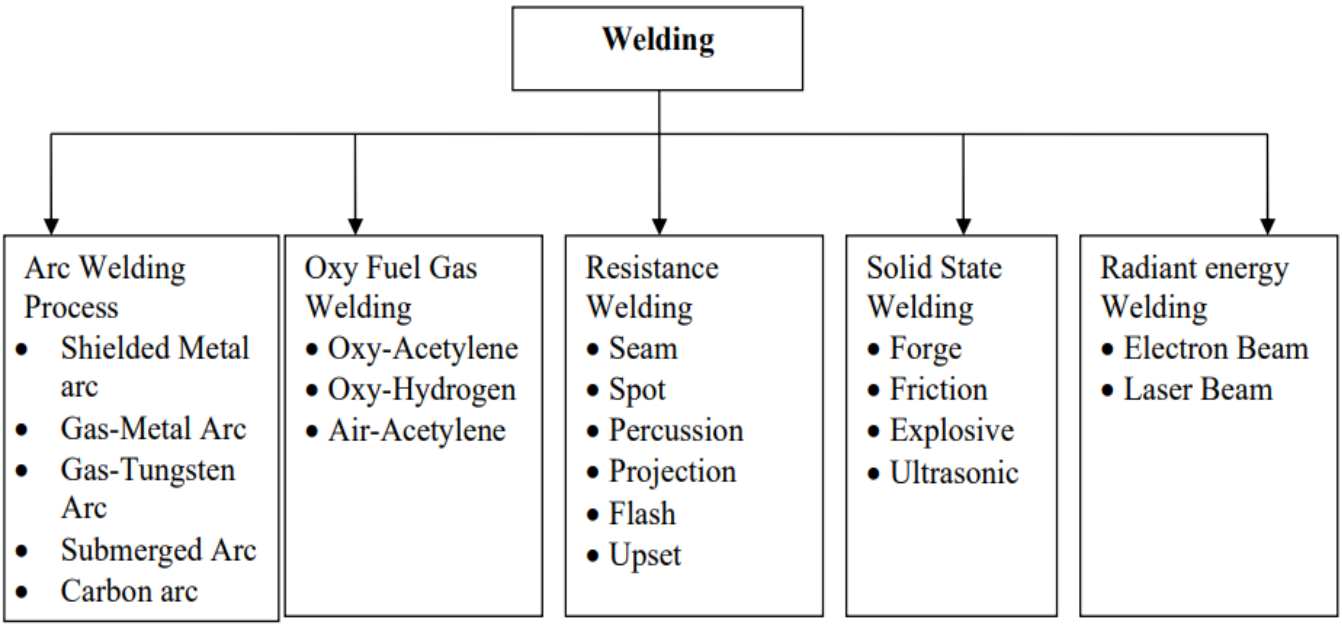
Welding is the metal joining method wherein localized coalescence is produced either by heating the metal to suitable temperatures, with or without use of filler metal or by application of pressure. Welding can be applied to both ferrous (iron based) and non-ferrous (non-iron based) metals and their alloys.

Advantages of Welding:

1. A good weld is as strong as the base metal.
2. Welding equipment is inexpensive and also available in portable form.
3. It facilitates considerable freedom in design.
4. Many metals/ alloys both similar and dissimilar can be joined by welding.

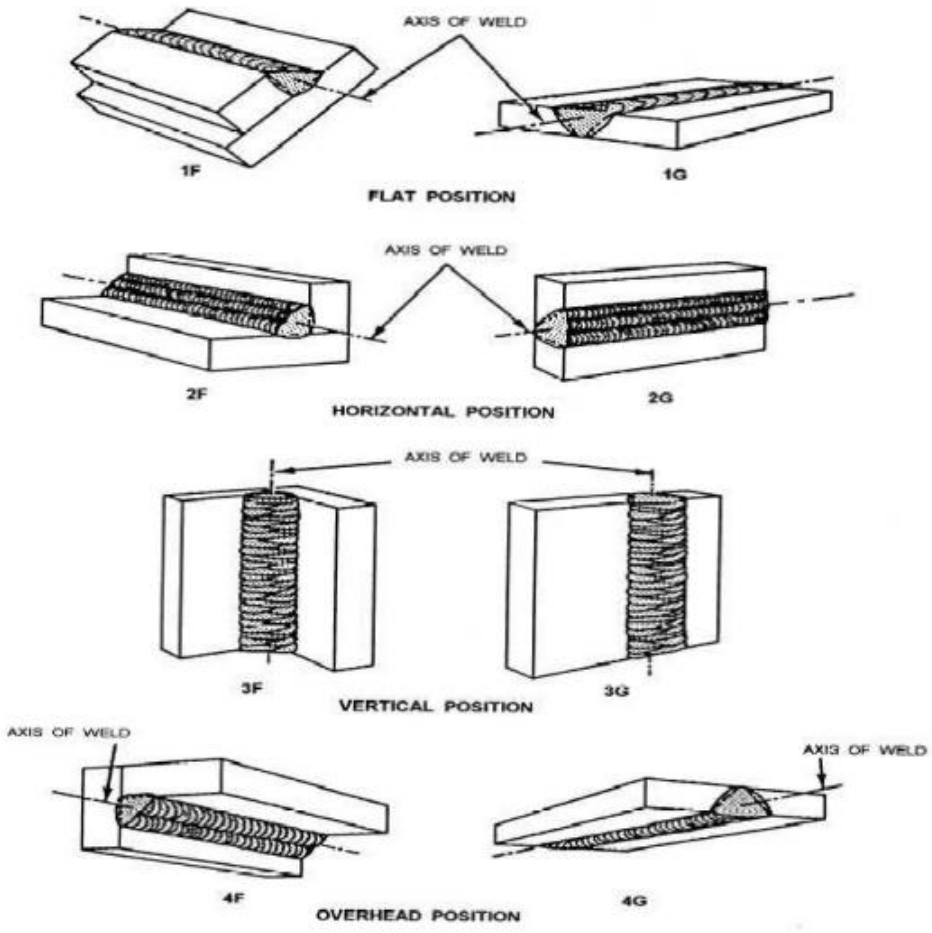
Disadvantages of Welding:

1. Welding gives out harmful radiations and fumes.
2. It results in residual stresses and distortion in work pieces.
3. Edge preparation of work-pieces is required before welding.
4. Structure of welded joint isn't the same as that of parent metal.



Positions of Welding:

1. Flat: Face of the weld is horizontal and the electrode (almost vertical) is above the base metal.
2. Horizontal: Axis of the weld is horizontal.
3. Vertical: Axis of the weld is vertical and welding is done horizontally.
4. Overhead: Face of the weld is nearly horizontal, electrode almost vertical and welding is done from below the base metal.



Welded Joints:

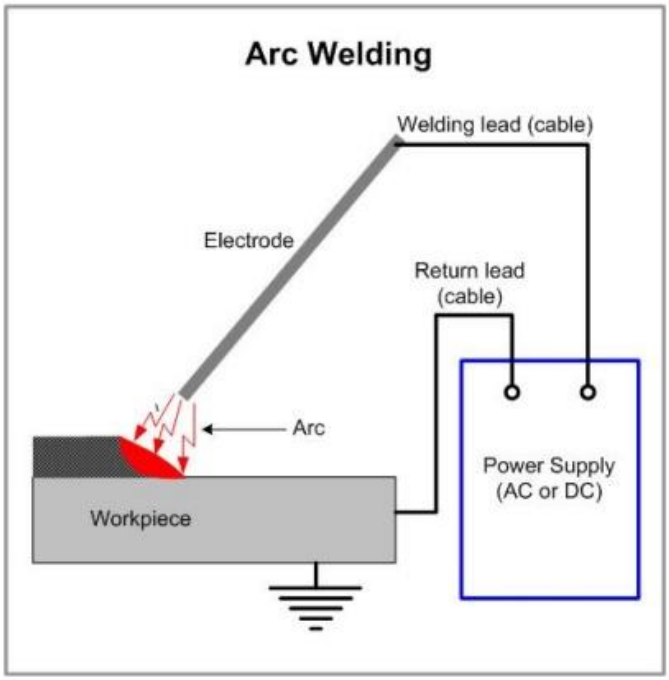
1. Butt Joint: When material thickness does not exceed 5mm, often welded by simply placing the sheared straightened edges close to each other with a gap of 1 to 2 mm. This is "square butt joint".
   Other types of butt joint are single V butt joint and double V butt joint.
2. Lap Joint: Plates overlap each other. The width of the lap is usually between 3 to 5 times the thicknesses of the plate. Welds are made on both sides of the lap.
3. Fillet Joint: It is a T-joint. The purpose of edge preparation is to achieve the required penetration and strength.
   Different types of fillet joints are square, single bevel, double bevel, single J and double J.

Welding Edge Material Specification

Plate Thickness (mm)	Electrode Size (mm)	Type of Joint	Groove Angle	Root Gap (mm)	Root face (mm)
Up to 5-8	3 – 4	Square	Edges are parallel	2 – 4	
4 – 26	4 – 5	Single V	60°	2 – 4	2 – 5
12 – 60	4 – 6	Double V	60°	3 – 4	3 – 5

ARC WELDING

Welding processes in which the source of the heat is electricity i.e. coalescence is brought about by heating the work piece with an electric arc struck between an electrode and the work piece, with or without use of filler metal depending upon the base plate thickness. The electric supply maybe direct current (dc) or alternating current (ac), depending on the characteristics desired of the weld.



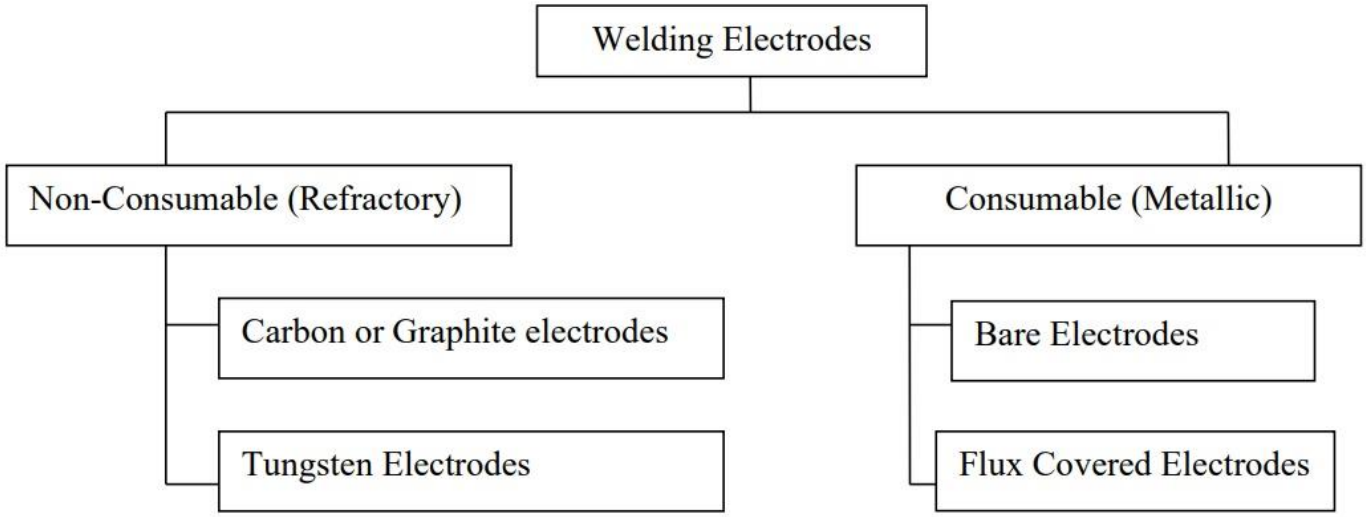
Arc welding

Principle of Operation:

Let us consider dc power supply in which the positive pole (anode) and the negative pole (cathode) remain the same. The arc column is generated between the anode and cathode (of a dc power supply), one of which shall lie on the electrode and the other at the base metal. The cathode and anode are brought in mutual contact for a short while and then drawn apart to establish an air gap. Negatively charged electrons are easily disassociated from the metal at the negative pole or cathode and accelerated towards the anode, striking it with high kinetic energy. Electric charge disrupts electron flow in its orbit, making it to fly off at a tangent from its orbital path to seek another positive nucleus to which it will re-associate itself.

Heat is produced by the 3 ways:

1. On hitting the anode, kinetic energy of electrons is liberated as heat energy.
2. When charge on the electron is received by the anode, an electromotive force (emf) is induced in it, which gets directly transferred into heat energy.
3. When positively charged ions going from anode to cathode, intermingle with electrons heat is produced.



Electrode Classification

Welding Electrode Functions:

1. Initiation and maintenance of welding arc.
2. Protect the molten metal from deleterious effects of oxygen and nitrogen in the air.
3. Provide a slag blanket on the weld
4. Means of introducing alloying elements not contained in the core wire.

Core Wire composition for Welding Electrodes (IS:2680-1964)

Element	Low Carbon Steel (%)	Medium Carbon Steel (%)
Carbon (max)	0.15	0.25-0.30
Silicon	0.3-0.7	0.30-0.50
Manganese	0.9-1.5	0.30-1.60
Sulphur (max)	0.03	0.03
Phosphorous (max.)	0.03	0.03

Constituents of the Arc:

The arc stream comprises of 3 areas of heat:

1. Anode Area: Area of high heat attributed to electrons striking the anode and current capacity of electrons.
2. Plasma Area: Area of low heat resulting from the atomic collision of some electrons with positive ions.
3. Cathode Area: Area of medium heat, attributed to positive ions striking the cathode.

In DC Supply, 2/3 energy released is at the anode.
Here positive and negative terminals can be located in 2 ways

i) Positive Ground/ Straight Polarity: The base metal is the positive pole or anode and the electrode, the cathode.

ii) Negative Ground/ Reverse Polarity: The base metal becomes the cathode and electrode becomes the anode.

In AC Supply, energy equalized between anode and cathode, plasma area is the area of medium heat part.

Here terminals continuously interchange between the base metal and the electrode.

Electrode Polarity and Effects

AC current Effects:

1. Currents higher than those in Direct Current Reverse Polarity (DCRP) can be employed (400 to 500 amps for 6mm diameter electrode)
2. Arc cleaning of base metal.
3. Normal penetration.
4. Equal heat distribution at electrode and job.
5. Electrode tip is colder as compared to DCRP.

Direct Current Reverse Polarity (DCRP) Effects:

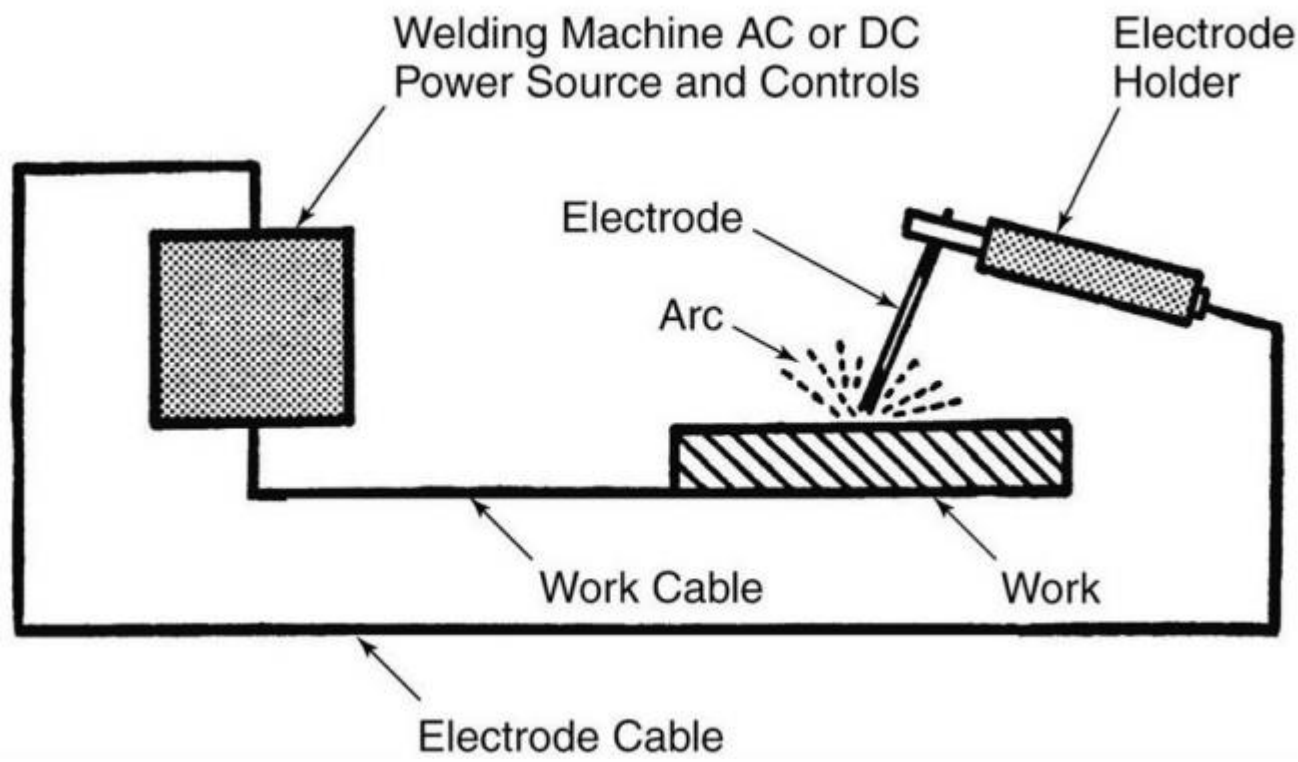
1. Currents employed are less than 125 amperes.
2. 66.66% heat is generated at the electrode and 33.33% is at the job.
3. Least penetration.
4. Better arc cleaning action.
5. Chances of electrode overheating.

Direct Current Straight Polarity (DCSP) Effects:

1. Welding current up to 1000 amperes can be employed.
2. 33.33% heat is generated at the electrode and 66.66% is at the job.
3. Deep penetration.
4. No arc cleaning for the base metal.
5. Electrode runs colder as compared to DCRP or AC.

SHIELDED METAL ARC WELDING (SMAW)

In SMAW, coalescence is brought about by heating the work piece with an electric arc set up between a flux coated electrode and the work piece. The flux covering decomposes due to arc heat and performs a variety of functions. The electrode melts to supply the necessary filler metal.



Operation of SMAW:

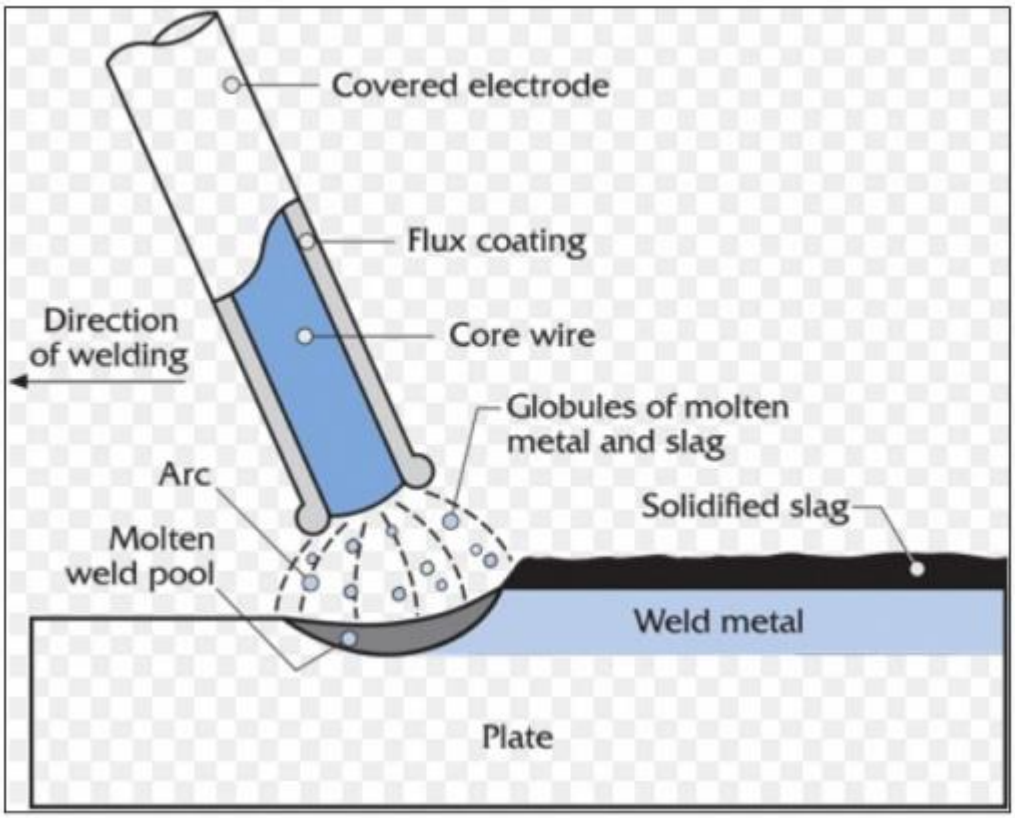
(i) Work piece Preparation:

1. Make work piece free of any foreign matter.
2. Work pieces to be welded are positioned and spaced relative to each other.
3. Welding leads are connected to the power supply and the work piece.
4. Power is switched on and an optimum current is set. Electrode is gripped in the holder.

(ii) Striking the Arc

(iii) Welding the Joint:

1. Once the arc is struck, electrode is tilted to a suitable angle depending on the penetration of weld bead desired.
2. The electrode is then progressed along the joint at a constant speed and also lowered at the rate at which it melts.
3. A crater is generally formed at the end of the weld due to magnetic arc blow, and is a weak point in any weld.



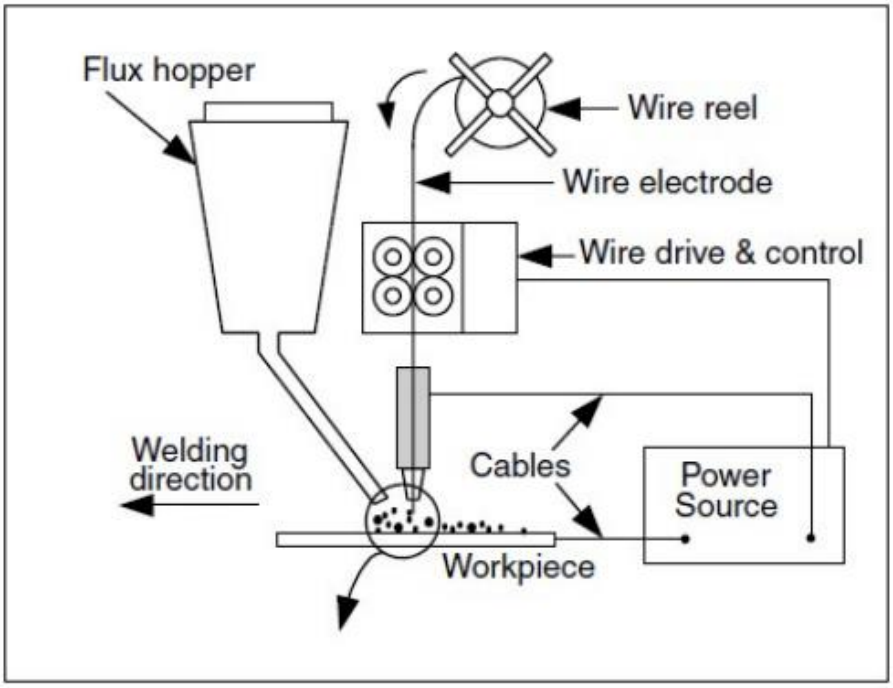
SMAW process

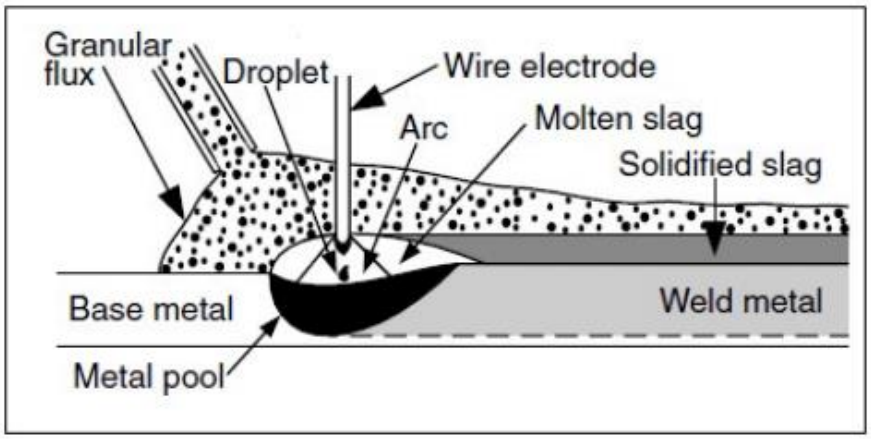
Welding Equipment's:

1. AC or DC welding supply.
2. Welding electrodes.
3. Electrode holder.
4. Welding leads.
5. Ground connection.
6. Hand and face shields.

SUBMERGED ARC WELDING (SAW)

An appropriate quantity of the powder is continuously spread in form of a mound (sufficiently deep to completely submerge the arc column) in front of the electrode along the line of weld by a hopper carried by the welding head. Flux adjacent to the arc column melts and floats to the surface of molten pool, then solidifies to form slag on top of the weld which can easily be removed. Rest of the flux can be reclaimed easily as it is only an insulator. Heat of the arc causes the electrode and base metal to melt and adjacent flux accomplishes tasks of penetration, filling the crater and fusion of the joint.





Features of SAW:

1. SAW is done with bare wire electrodes.
2. Can be done manually or automatically.
3. SAW welds have high strength and ductility.
4. Weld bead formed in SAW is smooth due to unique protection.
5. Voltage Rating for SAW: 20 – 40V
6. Current Rating for SAW: 1000 amp (max)

Classification of SAW Fluxes

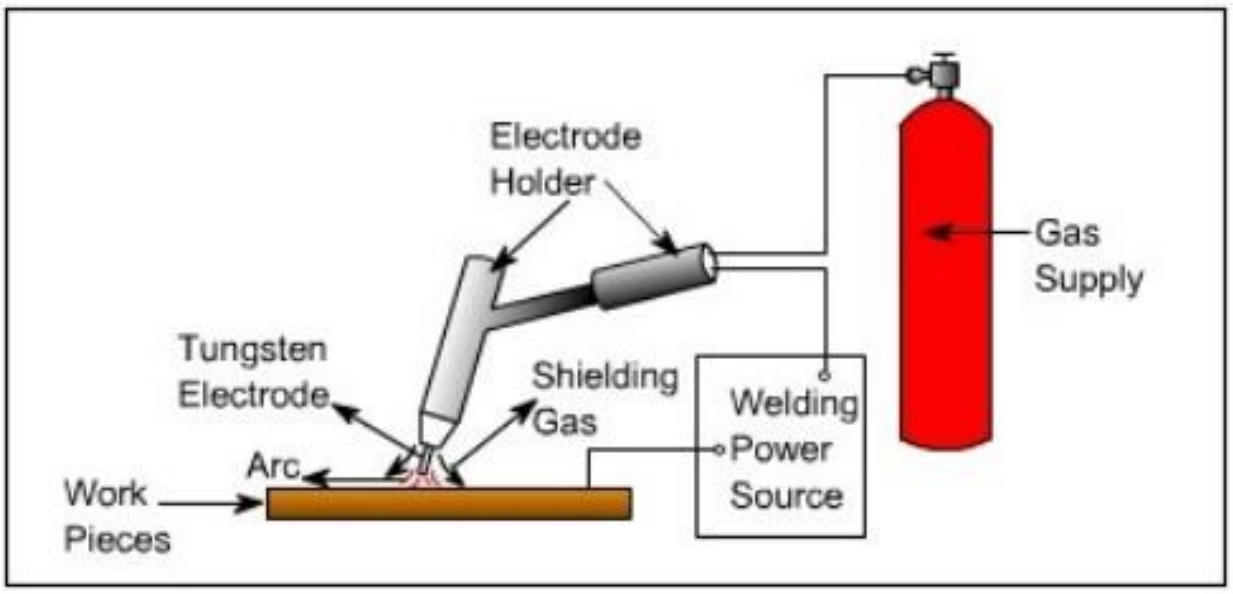
Type	Character	Role of Major Constituents				
		SiO_2	$Al2O_3$	MnO	CaO	CaF_2
Mn-SiO_2	Acidic	Provides Viscosity and Current Carrying capacity. Decreases Stability and width to penetration ratio. In flux, silica varies from 25 to55% by weight.	Improves impact properties due to grain refining and formation of acicular ferrite. Decreases stability and viscosity. Flux contain 5-10% by weight of alumina.	Alloying of manganese in the weld. Favours higher welding speeds. Lowers current carrying capacity. % by weight in flux: 30-45%	Removes phosphorous and sulphur. Improves impact strength.	Increases the fluidity of molten metal. Helps in removal of dissolved hydrogen by forming hydrogen fluoride.
Ca-SiO_2	Acidic					
Ca-SiO_2	Neutral					
Ca-SiO_2	Basic					
Al_2O_3-TiO_2	Neutral					
Al_2O_3	Basic					
CaF_2	Basic					

Purposes of Welding Fluxes in SAW:

1. Molten flux floats as a liquid blanket over molten metal protecting it from the affect of oxygen and nitrogen.
2. Acts as a good insulator and concentrates heat within a small welding zone, thus improves fusion.
3. Absorbs impurities and adds alloying elements.
4. Improves the process efficiency by reducing spatter and burning losses.

GAS TUNGSTEN ARC WELDING (GTAW) or, TUNGSTEN INERT GAS (TIG) WELDING

In GTAW, coalescence is brought about by heating the job with an electric arc struck between a tungsten electrode and the job. A shielding gas (Ar or He or mixture of the two) is used to avoid atmospheric contamination of the molten weld pool.
The tungsten electrode is non-consumable, so a filler material may or may not be added depending on the thickness of the work piece.



GTAW setup

GTAW Operation Sequence:

1. Welding current, water and inert gas supply are turned on.
2. After striking the arc, it is allowed to impinge on the job and a molten weld pool is created.
3. The welding torch is then moved along the joint, and at the far end the arc is extinguished by increasing the arc length. The solidifying weld pool is protected by the shielding gas for a few seconds even after the arc is extinguished.

Welding Equipment's:

1. Welding torch
2. Tungsten electrode
3. Filler material
4. Power source
5. Inert gas cylinder
6. Pressure regulator and flow meter
7. Cooling water supply

Electrode:

3 materials are used for electrode in TIG Welding:
1. Pure Tungsten
2. Zirconiated Tungsten
3. Thoriated Tungsten

Melting point of pure tungsten is approximately 3400 degree celcius and boiling point 6000 degree celcius, which ensure electrode's long life.
Thorium or Zirconium is added to tungsten in small amount ranging from 0.001 – 2%. Their electron emitting capabilities are better which enhances the arc.

Material:

GTAW is generally applied to carbon steels, stainless steels, refractory metals, heat resisting alloys, aluminium alloys, copper alloys, magnesium and nickel alloys.

GAS METAL ARC WELDING (GMAW) or, METAL INERT GAS (MIG) WELDING

In GMAW, coalescence is brought about by heating the job with an electric arc established between a continuously fed metal electrode and the job. The arc and molten metal are shielded by an inert gas (argon, helium, carbon dioxide or a mixture of gases) and no flux is used. MIG welding is a refinement of TIG welding.

GMAW Operation Sequence:

1. Gas and water flow is checked.
2. Current and wire feed speed are set and electrical connections secured.
3. The arc is struck. Arc length is maintained constant by using principles of self adjusted arc in manually operated process and self-controlled arc in semiautomatic processes.

Self-adjusted arc: If the arc length decreases, the voltage also decreases and arc current increases. The increased current melts electrode at a faster rate, arc length increases and becomes normal.

Self-controlled arc: If the arc length decreases, voltage will decrease, which in turn reduces the speed of electric motor and electrode feed rate. This will increase and bring the arc length to normal value.

Shielding gases for GMAW Process

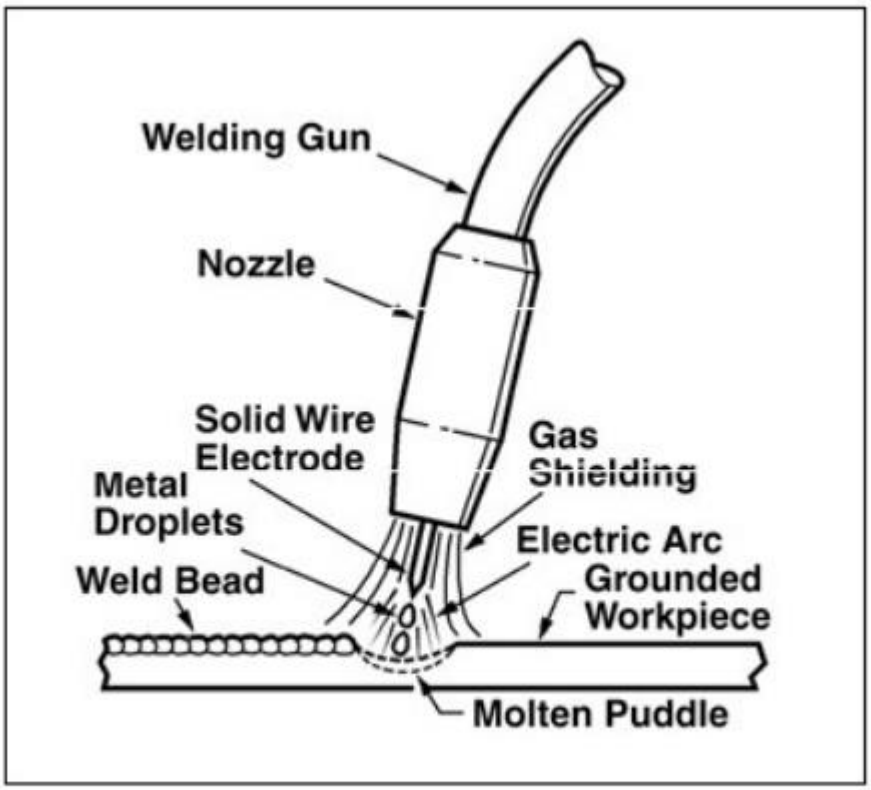
Material	Shielding Gas	Gas Effect
Mild Steel	CO_2	Low Spatter
	$CO_2 + O_2$	Avoids lack of fusion
	Argon + O_2	Better Bead Shape
	Argon + CO_2	No Spatter
Low Alloy Steel	Argon + O_2	Eliminates Undercutting
	Argon + CO_2	Lower Cost
Stainless Steels	Argon + O2	Stable arc
	Argon + H_2	Hotter running arc
	Helium + Ar + CO_2	Improved bead shape
Aluminium	Argon	Removes Surface Oxides
	Helium+ Argon	Porosity Control
Magnesium	Agron	Removes Surface Oxide
	Argon + Helium	Hotter Arc
Nickel	Argon	Control on base metal
	Argon + Helium	Fluidity
	Argon + H_2	Hotter running arc
Copper	Nitrogen	Counteracts high thermal conductivity
Titanium	Argon	Good Metal Transfer

Metal Transfer in MIG Welding:

1. Short Circuit Transfer: End of the electrode, gets heated and distorts due to capillary attraction, magnetic influences and gravitational force. The metal touches the work piece there is short circuiting for an instant. An magnetic field, which sets up perpendicular to the current, necks down the metal (touching the base metal). This necking down is called the pinch effect, which eventually separates the metal (from the electrode).

2. Globular Transfer: Metal transfer where the tip of the wire forms globules or large droplets that melt and are forced across the Arc into the weld puddle in all positions and the arc makes a hissing sound.

3. Spray Transfer: The ion flow creates bubbles in the molten mass in the electrode tip, on which the electrons also impinge. The potential voltage disrupts the molten mass to fly off the electrode in metallic particles, creating a spray arc effect.



GMAW operation

Materials:

MIG is generally applied to carbon steels, stainless steels, heat resistant alloys, aluminium and copper alloys.

Shielding Gas:

Major shielding gases used for both TIG non-consumable electrode and the MIG consumable electrode processes are Argon, Helium, Carbon dioxide and combinations of these gases to optimize the characteristics of each of them.
Shielding gases can be classified as

Inert Gases:

Features of Argon as shielding gas:
1. It is denser than Helium hence lesser volume per second of it is required.
2. Suitable for short arc processes involving lower voltages.
3. Suited for welding of thin metals.
4. Doesn't affect heat much during manual operation in which arc length varies.

Features of He as shielding gas:
1. It can be used for processes involving higher voltages.
2. Often used in MIG welding operation.
3. Greater weld speed is obtained due to larger volume per second.

Chemically Reactive Gases:

Features of Carbon Dioxide as shielding gas
Advantages:
1. Inexpensive and used for welding of ferrous metals.
2. Electrical resistant qualities are better than argon and helium, hence can withstand amperage up to 20 – 30% higher.

Disadvantages:
1. It should be made free from moisture otherwise hydrogen is released during welding which introduce porosity in the weld.
2. A small amount of oxygen is formed in metal due to heat in arc column which causes
   (i) Slight reduction in strength of the metal.
   (ii) Formation of toxic carbon monoxide gas.
3. Due to high electrical resistance of carbon dioxide, arc length is very sensitive.

Other gases:

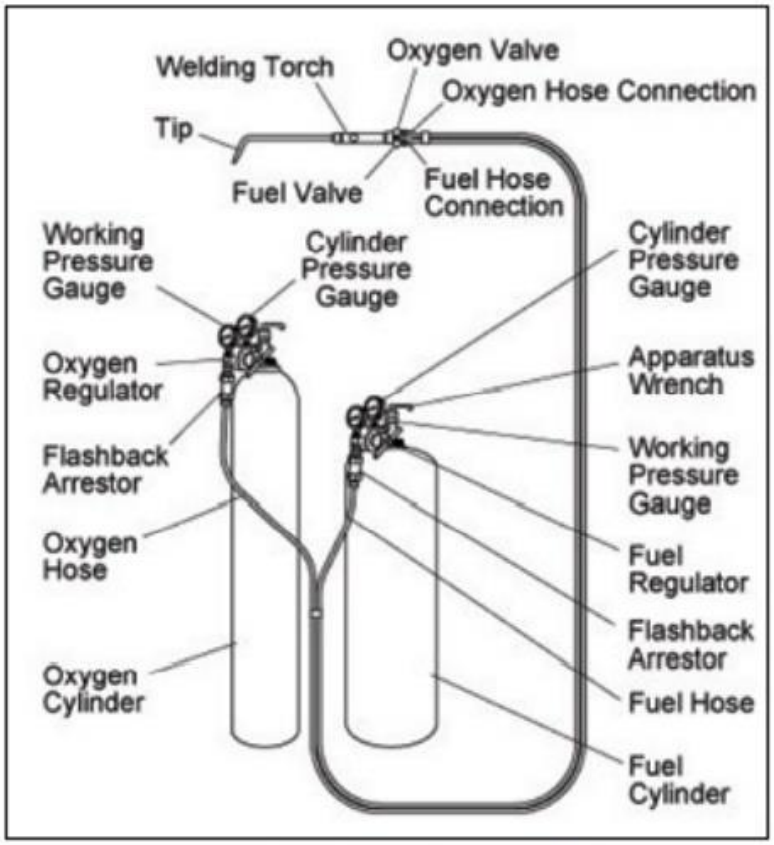
Other gases used for gas shielding are Nitrogen, Oxygen and Hydrogen.
These can only be used in small quantities for mixing or as carriers.

GAS WELDING

Gas welding process is a fusion welding process. It joins metals using the heat of combustion of oxygen/air and a fuel gas mixture. The intense heat produced melts and fuses together the edges of the parts to be welded.

Oxy – Acetylene Welding:

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.



Oxy-Acetylene welding set-up

Different Types of Flames:

Neutral Flame:

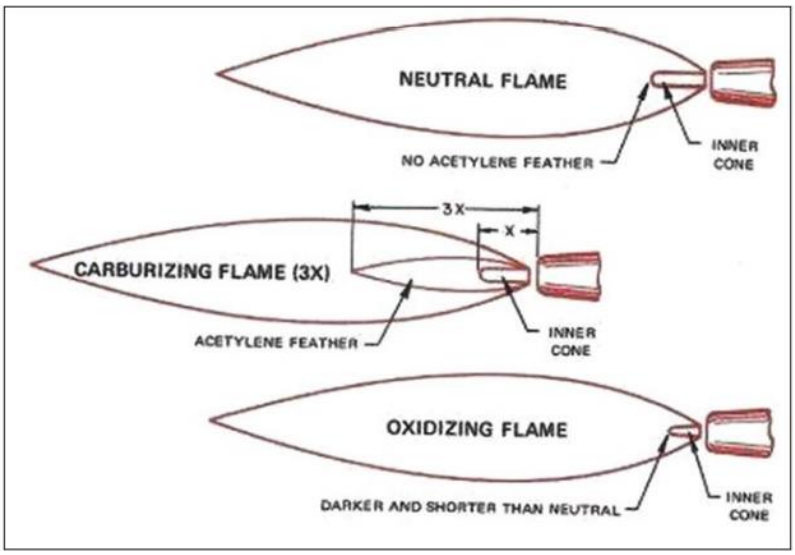
1. Equal volumes of oxygen and acetylene are mixed.
2. Temperature of flame is about 3260 degree celcius.
3. Flame has inner cone with light blue colour surrounded by cover of dark blue colour.
4. Suitable for: Mild steel, Stainless steel, Cast iron, Copper, Aluminium.

Oxidising Flame:

1. Oxygen is supplied to neutral flame.
2. Burns with a loud roar.
3. Hotter than neutral flame and temperature rise as high as 3500 degree celcius.
4. suitable for: Copper and Zinc base metals, Cast iron, Manganese steel.

Reducing Flame:

1. Volume of oxygen supplied to neutral flame is reduced. It is rich in Acetylene.
2. Flame has an approximate temperature of 3038 degree celcius.
3. Suitable for welding high carbon steel.



Oxy – Acetylene Equipment's:

1. Oxygen cylinder (Black in colour)
2. Acetylene cylinder (Maroon in colour)
3. Cylinder valves
4. Gas hoses
5. Welding torch and Torch tip.

Advantages of Gas Welding:

1. Probably the most versatile welding process.
2. Welder has considerable control over the temperature of the metal in the weld zone.
3. Rate of heating and cooling is relatively slow.
4. Since the source of heat and filler metal are separate, the welder has control over filler metal deposition.
5. Equipment is low cost, self sufficient and usually portable.

Disadvantages of Gas Welding:

1. Heavy sections cannot be joined economically.
2. Flame temperature is less than the temperature of the arc.
3. Refractory metals and reactive metals cannot be welded by this process.
4. More safety problems are associated with it.
5. Flux shielding gases are not so effective.

RESISTANCE WELDING

Resistance welding is a group of welding processes wherein coalescence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which work is a part and by application of pressure.

Variables of Resistance Welding:

1. Heat: (i) Current
   (ii) Resistance
   (iii) Time
   (iv) Squeeze Time: Time between initial application of the electrode pressure on the work and the initial application of current to make the weld.
   (v) Off Time: Interval from the end of the hold time to the beginning of the squeeze time for the next welding cycle.

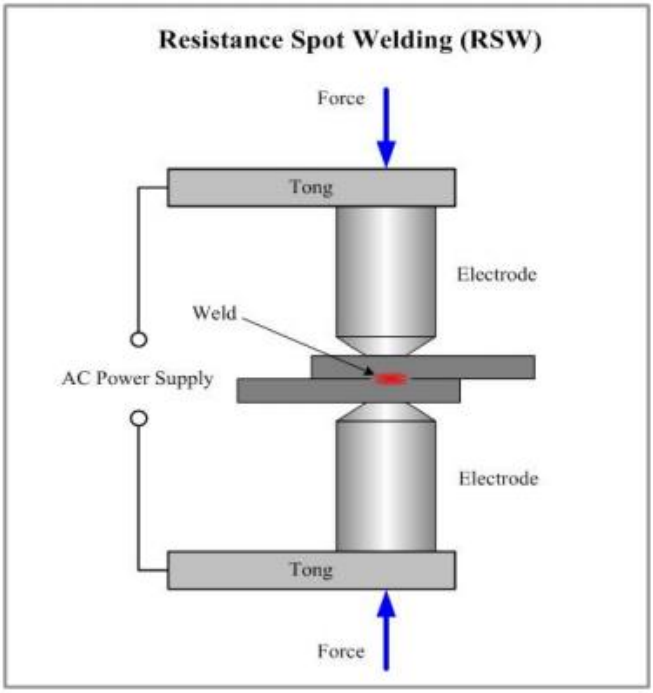
2. Pressure: Electrode force has the following effects
   (i) Brings intimate contact between the work pieces.
   (ii) Ensures completion of electric circuit.
   (iii) Provides forging action and thus reduces weld porosity.

Resistance Spot Welding:

It is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat generated by resistance to the flow of electric current through the work pieces.

Procedure of Operation:

1. Electrodes are brought together against the overlapping work pieces and pressure applied so that the surfaces of the two work pieces under the electrodes come in physical contact.
2. Welding current is switched on for a definite period of time. As the current passes through the electrode and the work pieces to the other electrode, a small area where work pieces are in contact is heated.
3. The welding current is cut off. Extra electrode force is then applied so that the pressure forges the weld and holds it together while metal cools down and gains strength.
4. Electrode pressure is released to remove the spot-welded work piece.



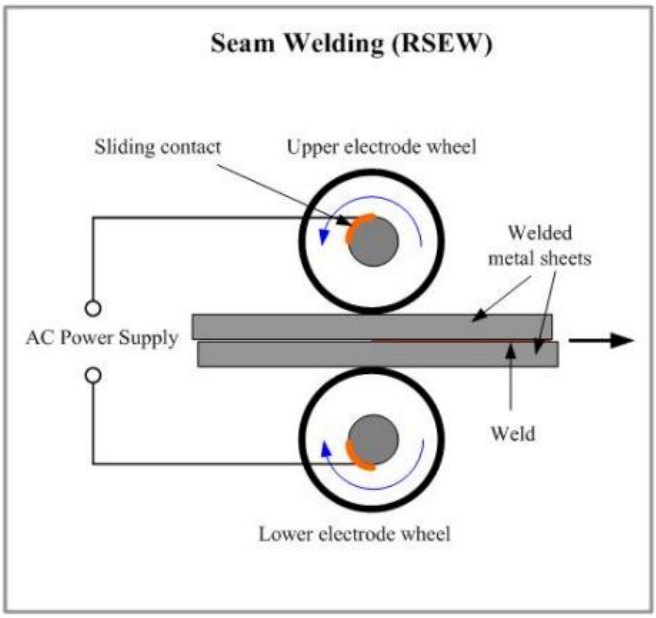
Resistance Seam Welding:

The result of seam welding is a series of overlapping resistance spot welds made progressively along a joint by rotating the circular electrodes.

Procedure of Operation:

Seam welding is similar to spot welding, except that circular rolling electrodes are used to produce continuous air-tight seam of overlapping welds. There are two seam welding methods. One involves continuous motion and the other intermitted motion during welding operation.

In continuous motion method, electrodes rotate at a constant speed and the current flows continuously or is interrupted. In intermittent motion welding, the electrodes travel the distance necessary for each successive weld and then stop.



Resistance Projection welding:

The result of projection welds is localized at predetermined points by projections, embossments or intersections.

Procedure of Operation:

1. The electrodes, instead of being tips as in spot welding, are flat and relatively large in surface area.
2. The projection in the upper piece is held firmly in contact with the lower piece under electrode pressure.
3. The current flows and being localized to the region around the projection, heats the metal in that area to the plastic state.
4. The heated and softened projection collapse under the pressure of the electrodes thereby forming the weld.

COMMON DEFECTS IN WELDING

1. Cracks: due to poor ductility of base metal, concave weld bead, fast arc travel speed.
2. Distortion: due to slow arc travel speed, residual stresses in plates to be weld.
3. Incomplete Penetration: due to low arc current, high arc travel speed.
4. Inclusion: maybe in form of slag or any other foreign material. Caused by long arcs, large electrode diameter, under cutting, wrongly placed tack welds.
5. Porosity and Blow Holes: occur due to entrapped gases.
6. Spatter: small metal particles which are thrown out of the arc during welding. It is caused by excessive arc current, longer arcs, damp electrodes.
7. Undercutting: a groove gets formed along the side of the weld bead on the parent metal caused on rusty and scaly job surfaces by longer arc with larger diameter.

WRITE UP / EXPERIMENT-V

AIM:

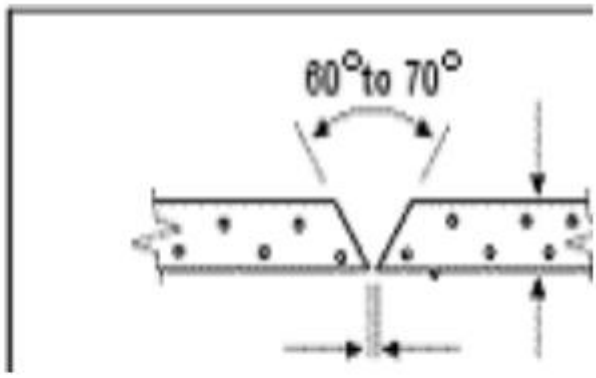
To weld two pieces (100mm x 50mm x 6mm each) of metal in a single V Butt Joint by Shielded Metal Arc Welding (SMAW).

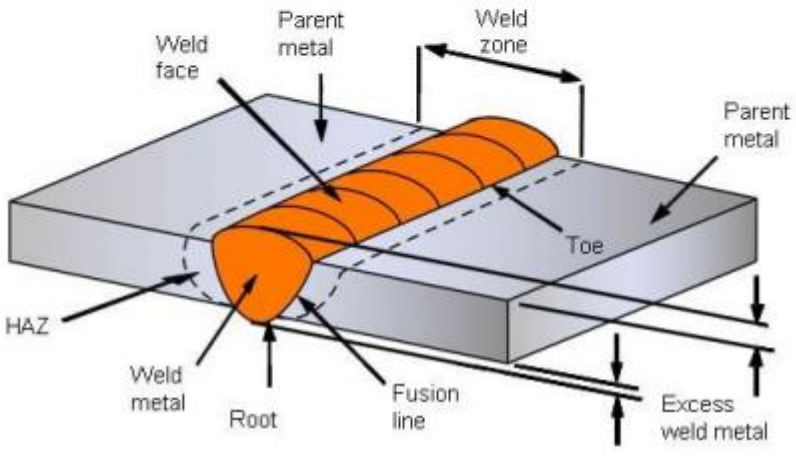
WELDING EQUIPMENT'S:

1. AC or DC welding supply.
2. Welding electrodes.
3. Electrode holder.
4. Welding leads.
5. Ground connection.
6. Hand and face shields.

OPERATION OF SMAW:

(i) Work piece Preparation
(ii) Striking the Arc
(iii) Welding the Joint





PROCEDURE (IN OWN WORDS):

1. First of all the work piece must be thoroughly cleaned to remove rust, scale and other foreign materials.
2. The Butt joint is one of the most frequently used weld joints. A Butt joint consists of placing the edges of two pieces together.
3. The given work piece are placed on the table in such a way that two work piece are brought close to each other so that it forms a 'V-shape' when the plates butt each other.
4. The angle contained by the v- groove must be between 60 to 70 degrees to accommodate the electrode and ensure strength of the joint.
5. Now the welding current output may be adjusted.
6. When current is passed, arc is produced between the electrode and the work pieces.
7. Now set the two work pieces in correct position and maintain the gap 3 mm and tack at both ends of the work pieces.
8. Then the welding is carried out throughout the length.
9. If welding not done properly then break the weld and start from step 7 again.
10. As soon as the welding process is finished, switch off the current supply and drop the work piece into water for cooling using tongs.
11. Slags are removed by chipping process with the help of chipping hammer.
12. Finally using wire brush, welded portions are cleaned.

RESULT:

We have successfully welded two pieces of metal in a single V Butt Joint by Shielded Metal Arc Welding (SMAW).

THANKS FOR READING !!!!!