JOINING OF MATERIAL

1st module

METALLURGICAL AND MATERIAL'S ENGINEERING DEPT. GCE KJR

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DISCLAIMER

INTRODUCTION

Metal joining is defined as the process of joining two metal parts either temporarily or permanently with or without the application of heat and pressure.

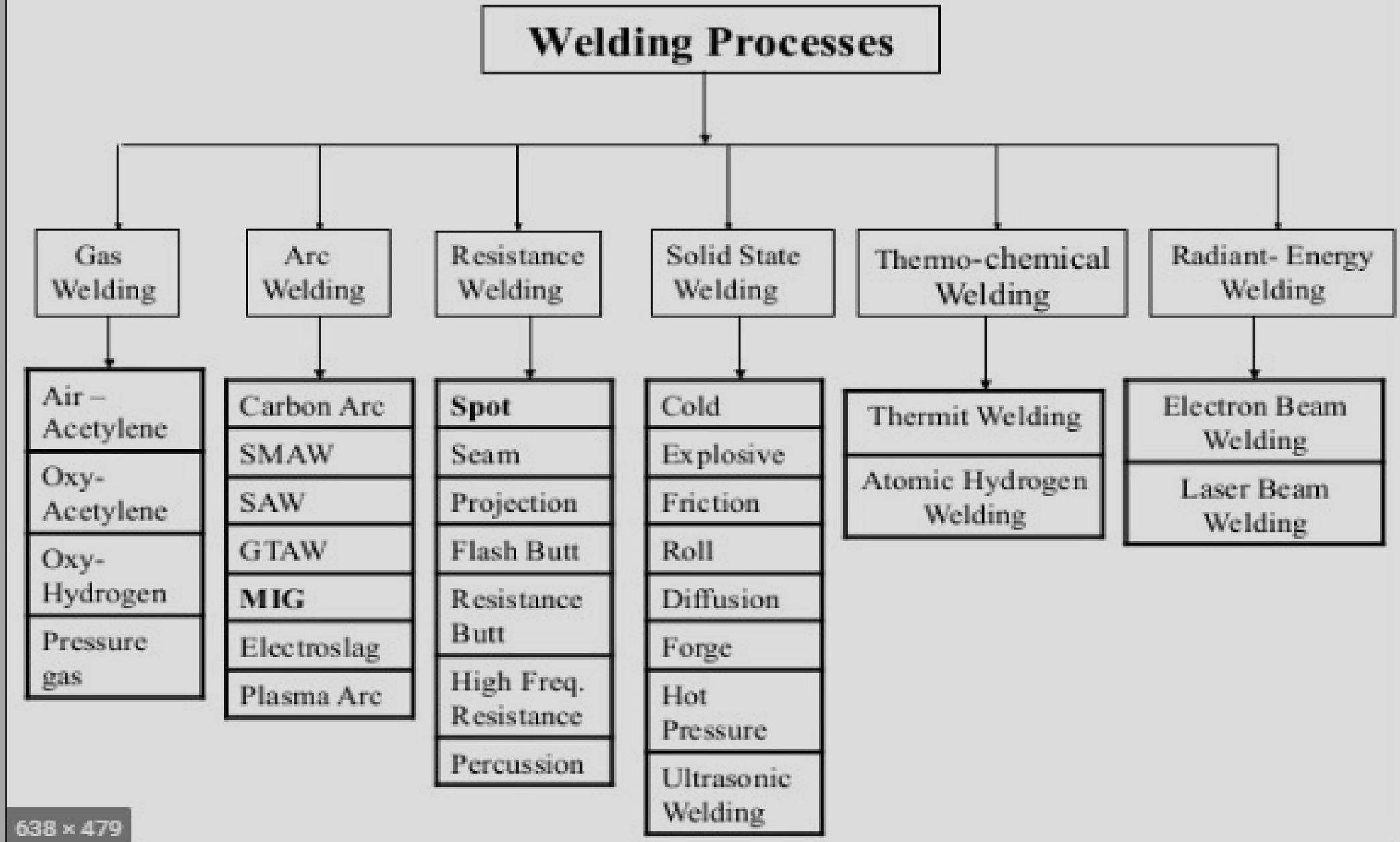
Following are the methods that are used for joining metals:

a. Welding
b. Soldering
c. Brazing
d. Riveting
e. Adhesive bonding
f. Assembling with bolt
g. Seaming

WELDING PROCESS

Welding is a process of joining similar and dissimilar metals or other materials by application of heat, pressure and filler materials.

Classification of Welding Processes



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FUSION WELDING PROCESS

In fusion welding process, coalescence is done by melting two parts to be joined and applying filler metals to the welded joints to provide strength.

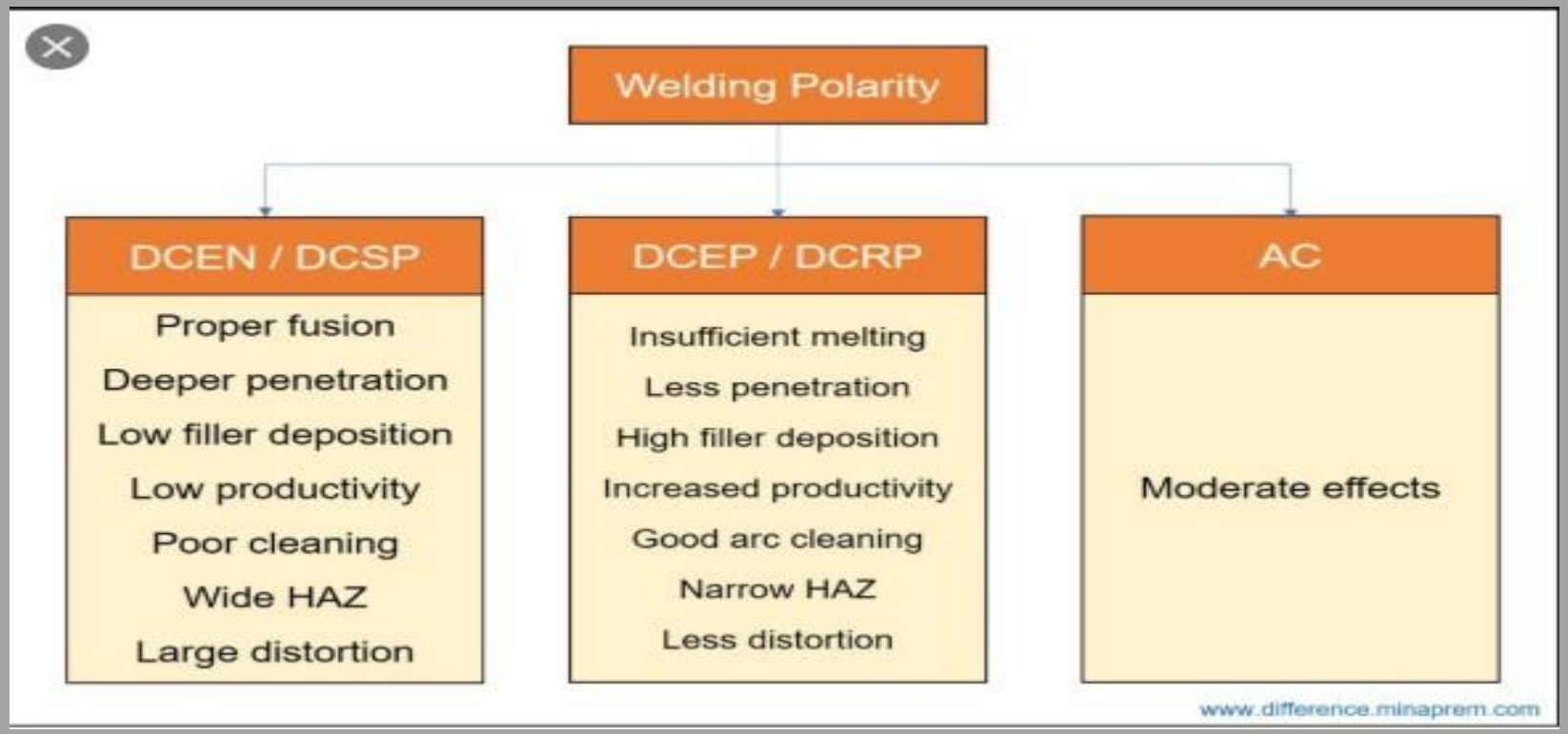
Fusion welding process is classified as:

Arc welding process
Resistance welding process
Radiant welding process
Thermit welding process

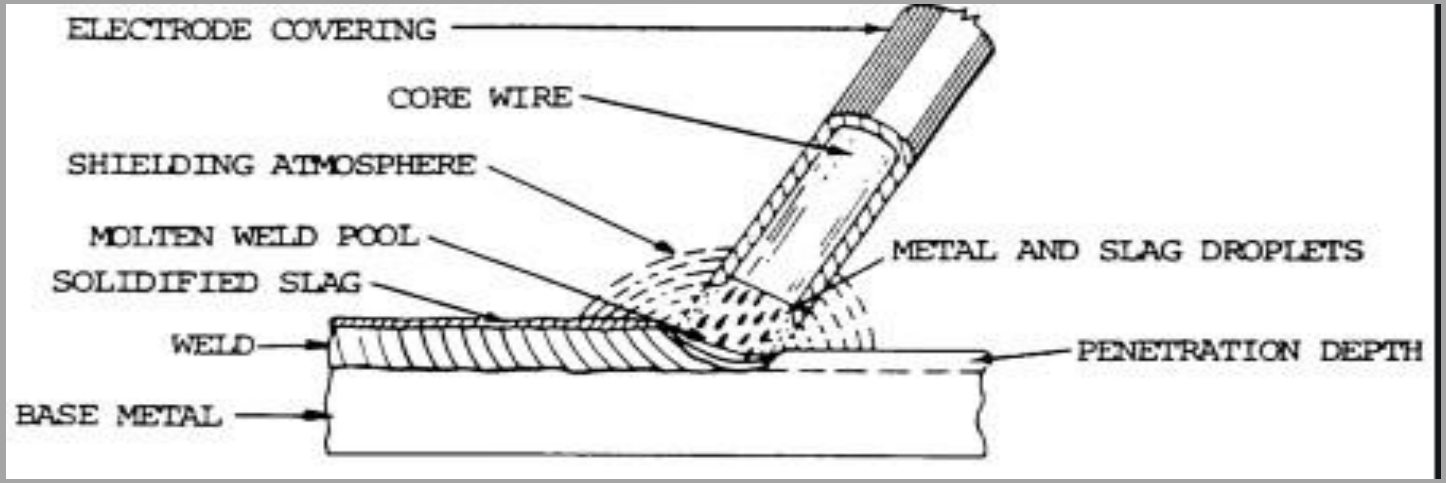
ARC WELDING PROCESS:
It is a fusion process in which coalescence is achieved by the heat formed between an electrode and the work piece. The electrode can be rod or wire which also acts as a filler metal to the joint. The power source for this welding is AC or DC. When the electrode is placed closed to the work piece an arc is created between the gap of electrode and workpiece. It is ionized column of gas develops to complete the circuit. The arc that produced has temperature of about 3600 degree Celsius which helps to melt the metal being welded. This produces a molten pool that solidifies and form the joint.

CONSUMBALE ELECTRODE	NON CONSUMBALE ELECTRODE
electrode itself melts down during welding and deposit at the weld bead. So it acts as a filler metal	It doesnot melts down. So extra supply of filler metal is required
Electrode is chosen based on the base metal composition	Electrode is independent of base metal composition
Does not allow autogenous mode of welding	Allows autogenous welding
SMAW, GMAW, FCAW, SAW, ESW uses consumable electrode	GTAW, TIG USES non consumable electrode

	Alternating Current (from Transformer)	Direct Current (from Generator)
1	More efficiency	Less efficiency
2	Power consumption less	Power consumption more
3	Cost of equipment is less	Cost of equipment is more
4	Higher voltage – hence not safe	Low voltage – safer operation
5	Not suitable for welding non ferrous metals	suitable for both ferrous non ferrous metals
6	Not preferred for welding thin sections	preferred for welding thin sections
7	Any terminal can be connected to the work or electrode	Positive terminal connected to the work Negative terminal connected to the electrode


Welding Polarity
DCEN / DCSP
Proper fusion
Deeper penetration
Low filler deposition
Low productivity
Poor cleaning
Wide HAZ
Large distortion
DCEP / DCRP
Insufficient melting
Less penetration
High filler deposition
Increased productivity
Good arc cleaning
Narrow HAZ
Less distortion
AC
Moderate effects
www.difference.minaprem.com

SHEILDED METAL ARC WELDING



- Uses consumable electrode
- Also known as stick welding
- Both dc or ac can be used

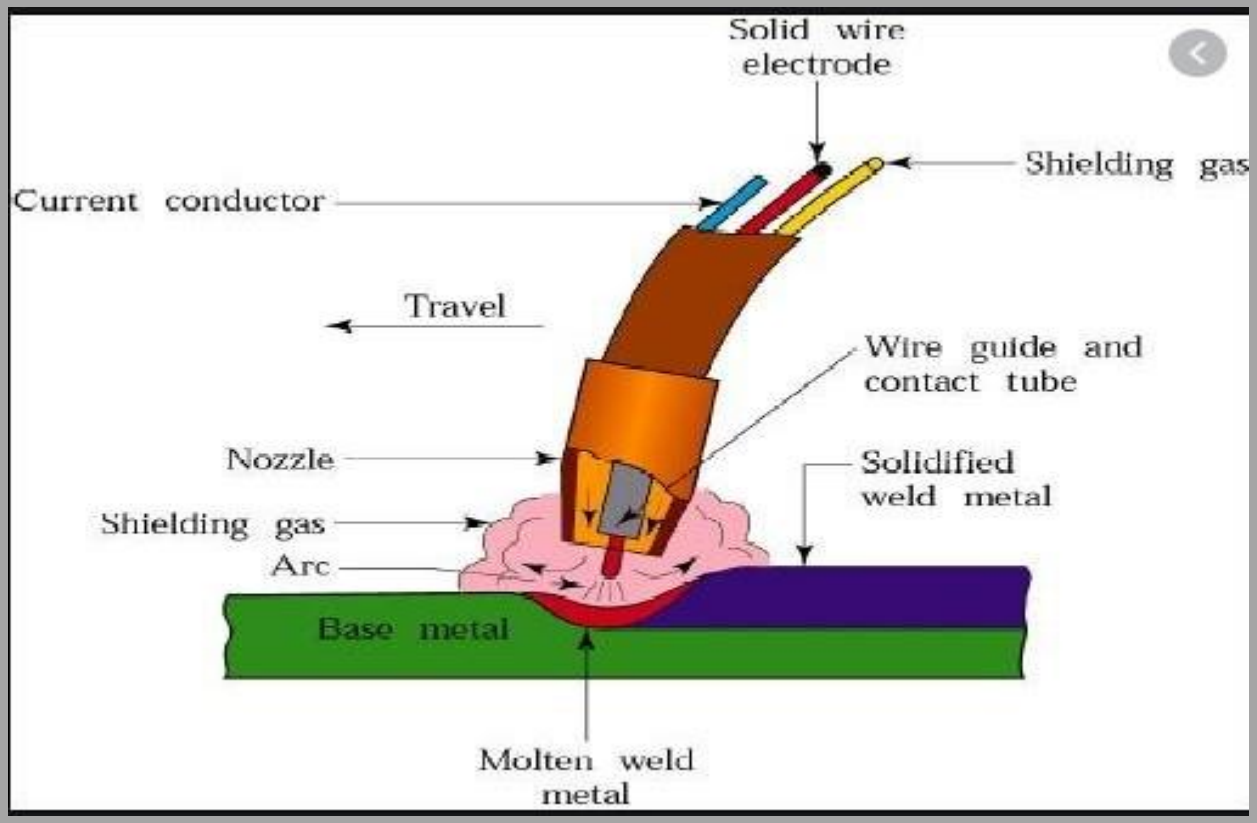
limitation of SMAW

- Electrodes need to be periodically changed
- High current levels may melt the coating periodically

Functions of flux:

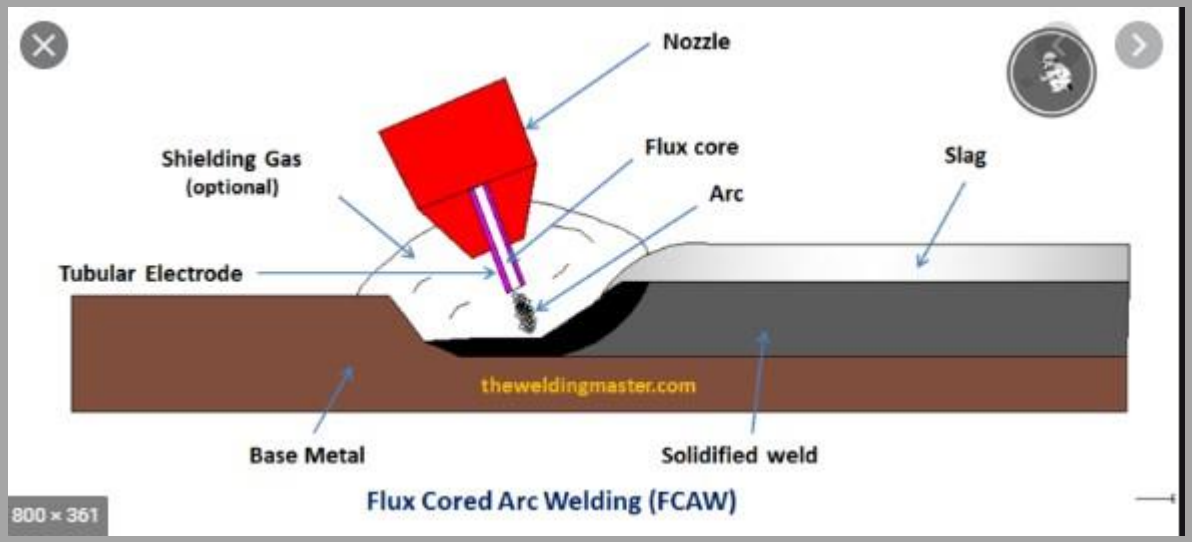
- Provide protective atmosphere to welding
- Stabilizes the arc
- Spattering is reduced
- Remove impurities from the weld in the form of slag

GAS METAL ARC WELDING



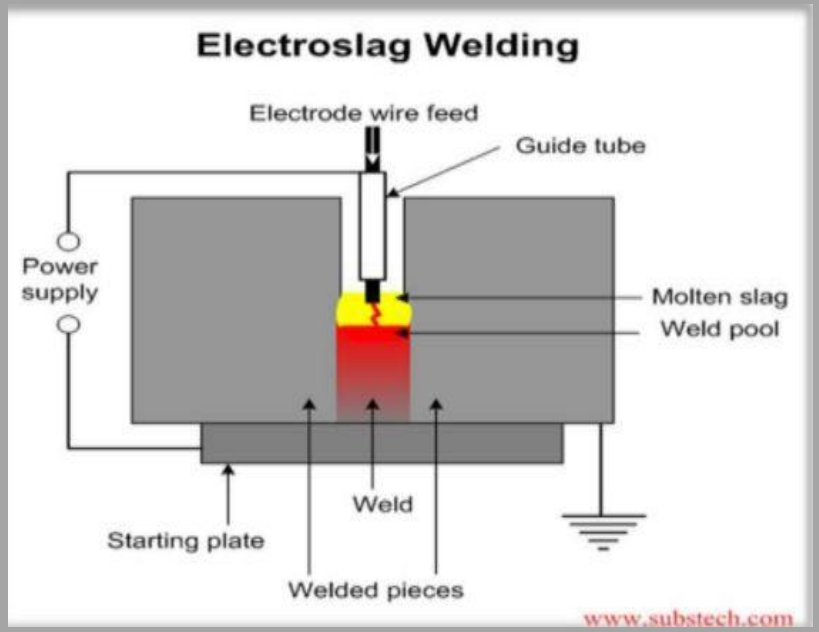
- Shielding gas is supplied externally to protect from contamination of weld
- The electrode fed is solid wire fed continuously through the arc into the weld pool, which ultimately becomes the filler metal at the weld.
- Inert gas such as helium and argon, is used to shield and protect the arc, weld pool and the base metal.
- Bare electrodes are used because the combination of shielding gas and electrode clean the slag automatically.

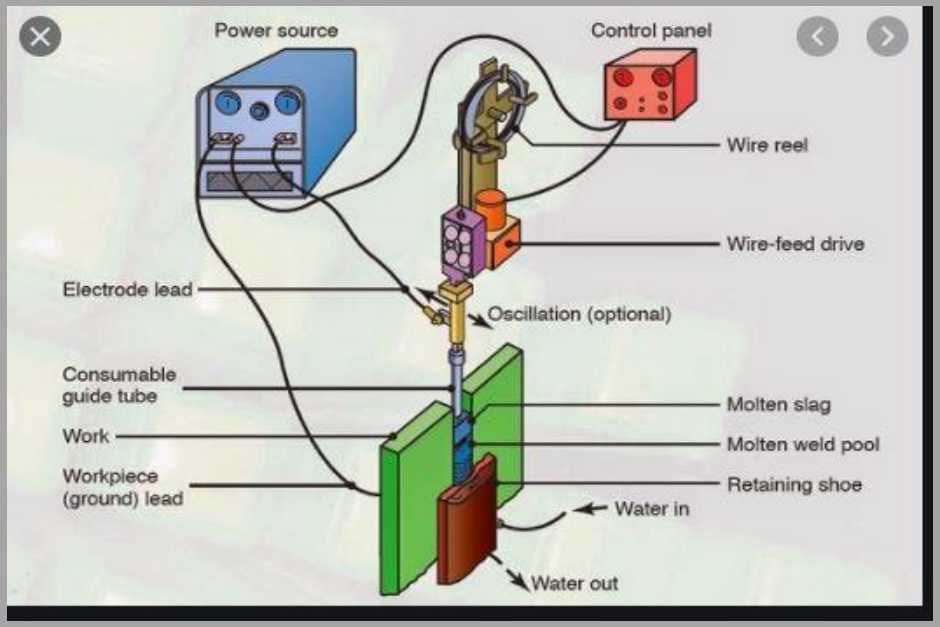
FLUX CORED ARC WELDING



- In this type of welding, shielding is provided from a flux contained within the tubular electrode with or without additional shielding from an externally supplied gas.
- A constant current or voltage power is given.
- The welding is costly and complex
- Heavy cost requires exhaust equipment
- Slag removal is required between passes

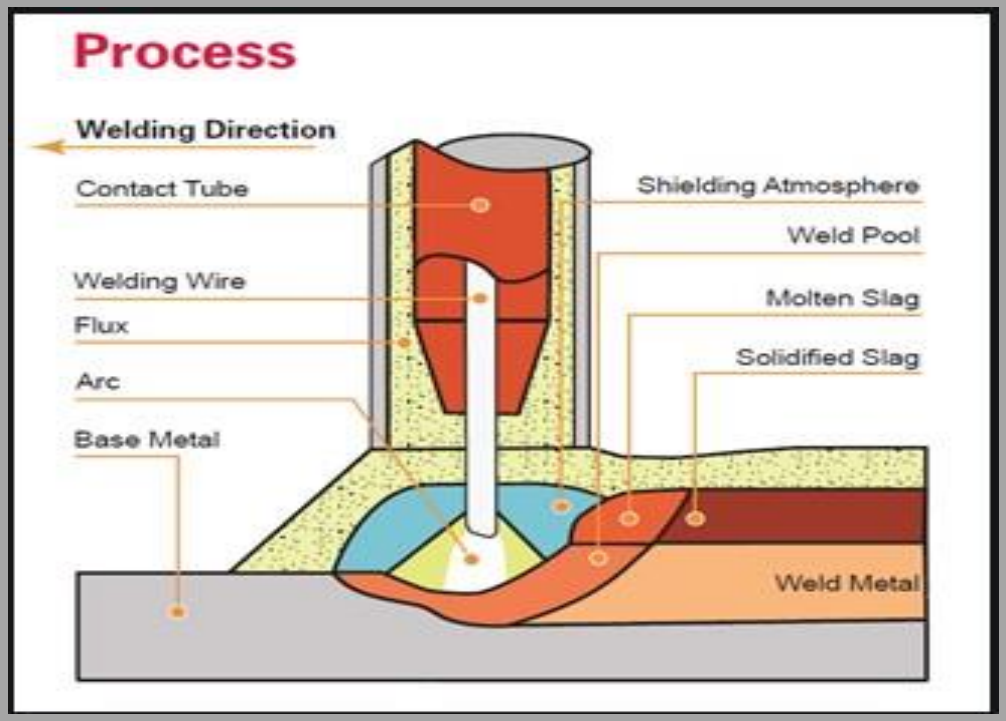
ELECTRO-SLAG WELDING





ADVANTAGES	LIMIATION	APPLICATION
low cooling rate so no cold cracking	Too high input	Plate thickness upto 80 mm can be joined
Semi automatic and faster	High temperature of welding needs cooling arrangement	Can be used for large casting
High productivity and low cost	Slow cooling gives columnar grains	Welding of thick walled large diameter pips, pressure vessels etc
No problem for slag inclusion or porosity		

SUBMERGED ARC WELDING



- Welding is shielded by a cover of granular flux
- In this process, the welding arc and the work piece are completely submerged under cover of granular flux
- During welding, granular flux is melted using heat generated by arc and forms cover of molten flux layer which in turn avoids spatter tendency and prevents accessibility of atmospheric gases to the arc zone and the weld pool
- The molten flux reacts with the impurities in the molten weld to form slag which floats over the surface of the weld metal

ADVANTAGES

- HIGH QUALITY
- NO SPATTER
- HIGH DEPOSITION RATE
- LOW DISTORTION

LIMITATION

- Precise joint preparation
- Solidification cracking
- High operational cost
- Irregular wire feed
- Flux is subjected to contamination and absorption of moisture

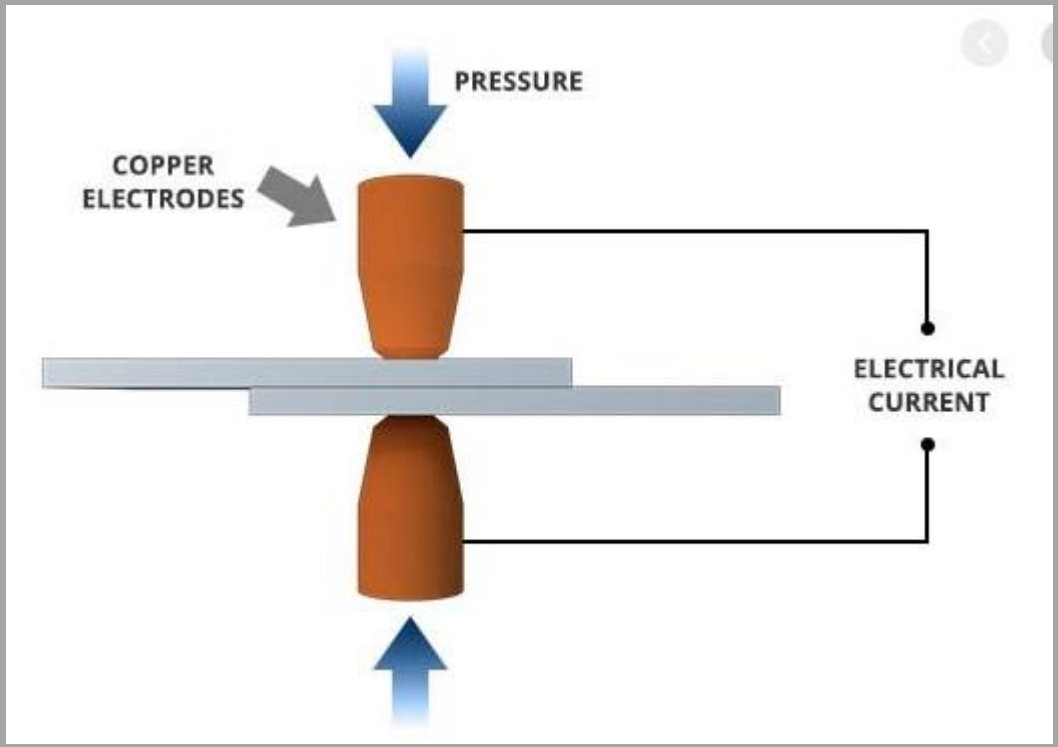
RESISTANCE WELDING

- Welding is done by the application of heat generated by resistance of the material
- These are pressure welding processes in which heavy current is passed for a short time through the area of interface of metals to be joined
- No flux and filler metals are added
- Heat is generated in localized are which is enough to heat the metal to sufficient temperature, so that the parts to be joined with the application of pressure, pressure is applied through the electrode
- The heat generated during resistance welding is given by the expression
  $H = I^2Rt$
  Where H = heat generated
  I = current
  R = resistance
  t = time for the flow of current

TYPES OF RESISTANCE WELDING

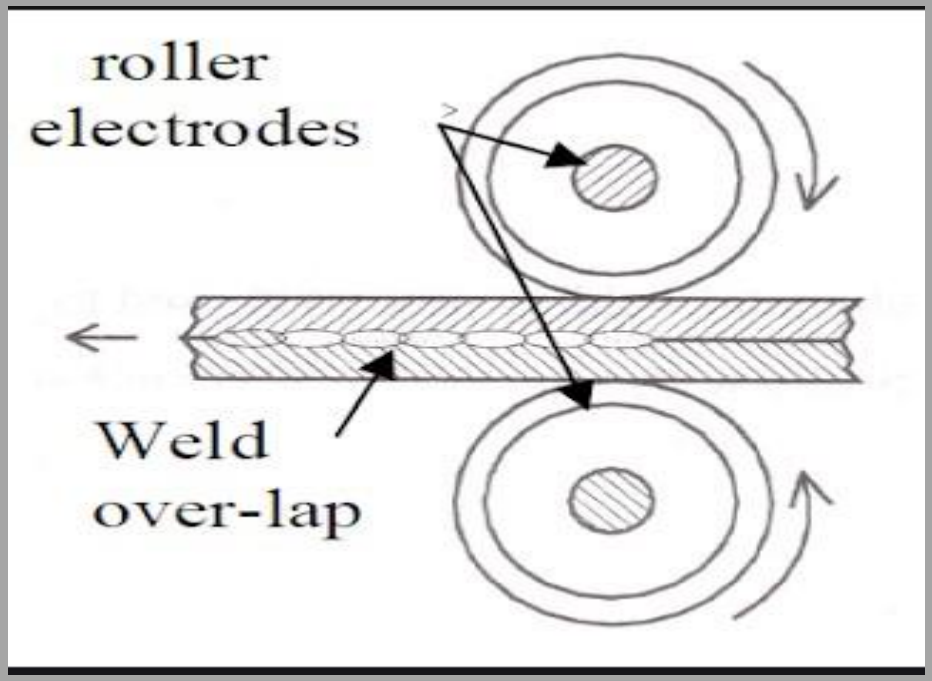
- RESISTANCE SPOT WELDING
- RESISTANCE SEAM WELDING
- PROJECTION WELDING

RESISTANCE SPOT WELDING



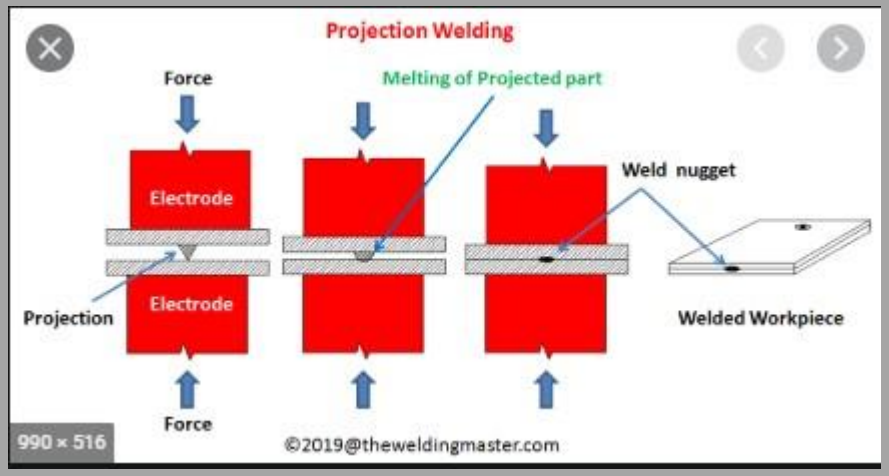
- In this process, fusion of faying surfaces of a lap joint is achieved at one location by opposing cylindrical electrodes
- The electrodes are a pair of copper rods between which the sheets are to be welded are positioned
- It is used for components such as flat sheets, panels as in car bodies

RESISTANCE SEAM WELDING



- Overlapping sheets are gripped between two wheels or roller disc electrodes and current is passed to obtain the intermittent seam i.e., weld nuggets are equally spaced or continuous seam
- The electrodes used in seam welding are a pair of rotating copper rolls between which sheets to be welded are passed
- The joints are continuous
- It is used to weld components such as fuel tank shells and other application which require the joint to be leak proof

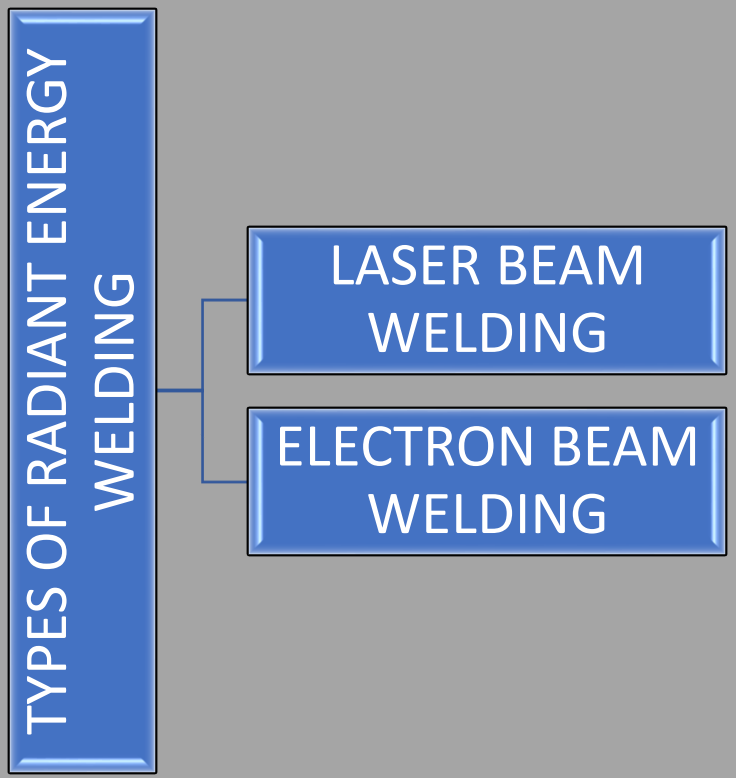
PROJECTION WELDING



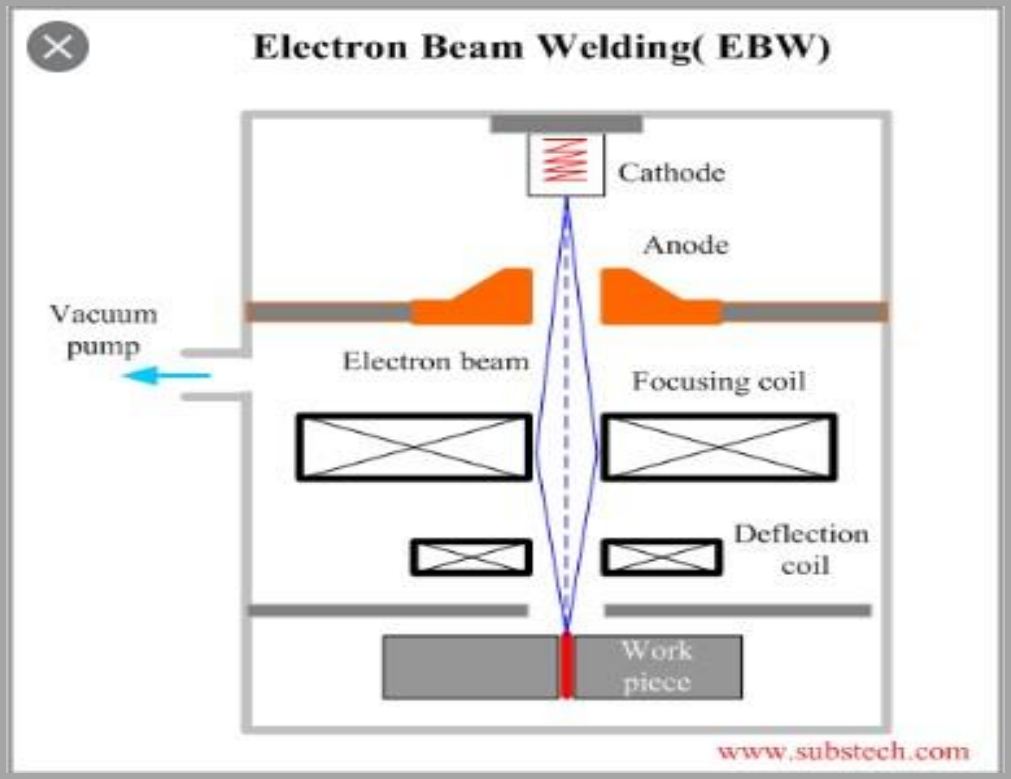
- In this type, one of the sheets to be joined is provided with a number of projections to help localize the current at a spot
- By providing a projection on the surface of one of the workpiece weld current and force can be focussed into the small area of the projection to produce heat at the desired weld location
- It extend the electrode lie by increasing the electrode contact area and decreasing the current density at the surface of the electrode
- Projection welding is effective even if the weldment is thick

RADIANT ENERGY WELDING

- In radiant energy welding processes, heat is produced at the point of welding when a stream of electrons or a beam of electro-magnetic radiations strikes on the work piece
- This welding can be carried out in vacuum or at low pressures

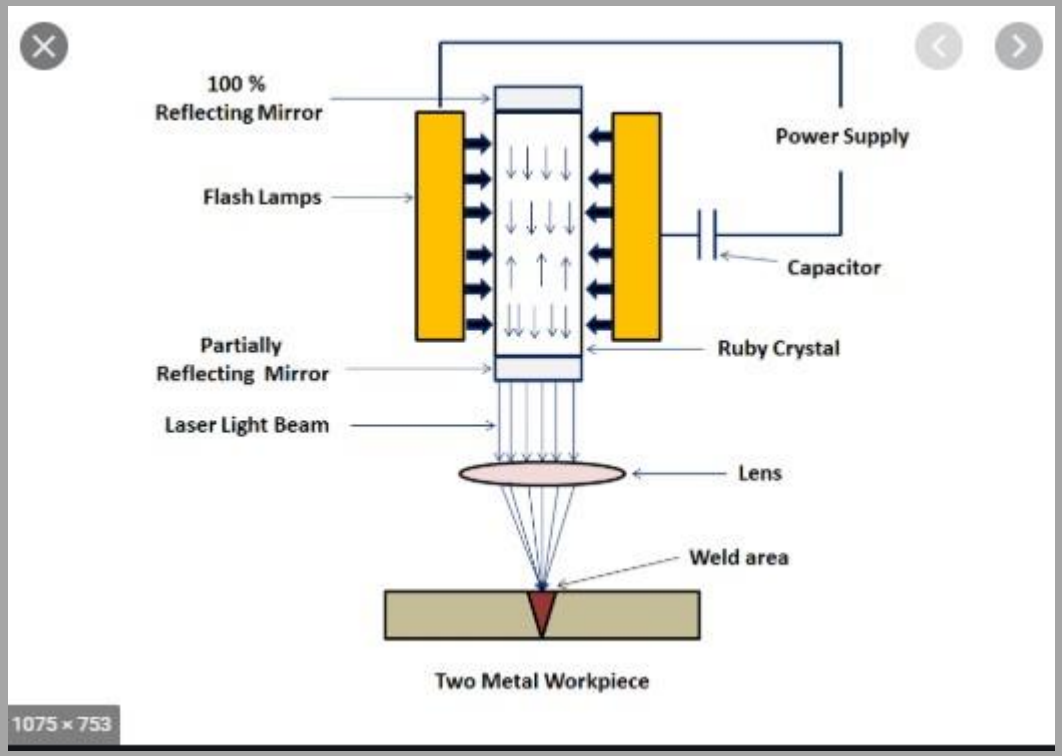


ELECTRON BEAM WELDING



- Welding is done by electron that is generated by an electron gun and accelerated to high speeds using electrical fields. This high speed stream of electrons is tightly focused using magnetic fields and applied to the materials to be joined. The beam of electrons create kinetic energy which when strikes the workpiece melt the metal and joins them
- It requires an vacuum atmosphere
- It has deep penetration

LASER BEAM WELDING

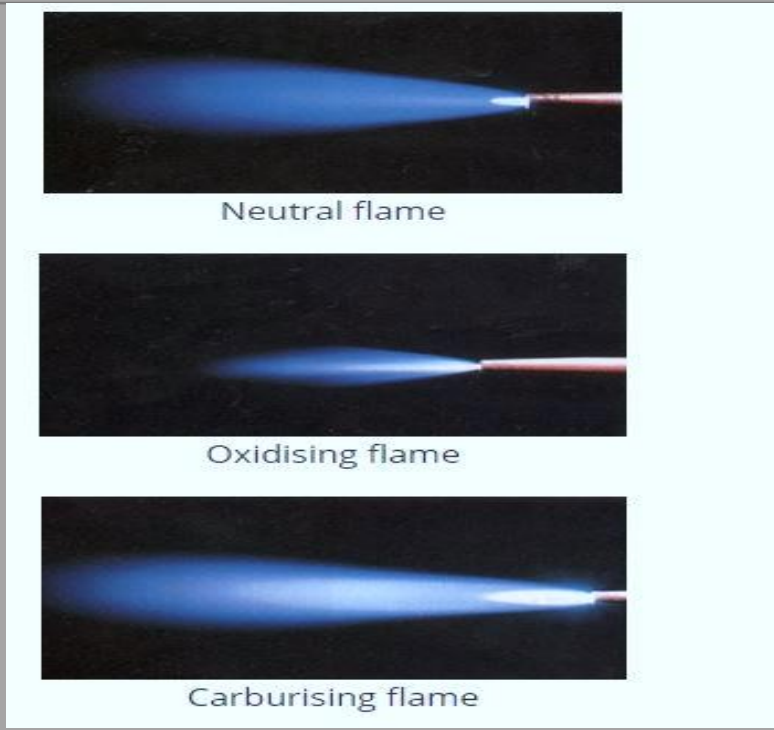


- Welding is done by the use of laser. The laser beam are focussed between the two metal pieces to be joined. The beam has enough energy and its melt the metal pieces and fill the cavity.
- It works on the principle that when electrons of an atom get excited by absorbing some energy. And then after some time when it returns back to its ground state, it emits a photon of light. The concentration of this emitted photon increased by stimulated emission of radiation and we get a high energy concentrated laser beam

GAS WELDING

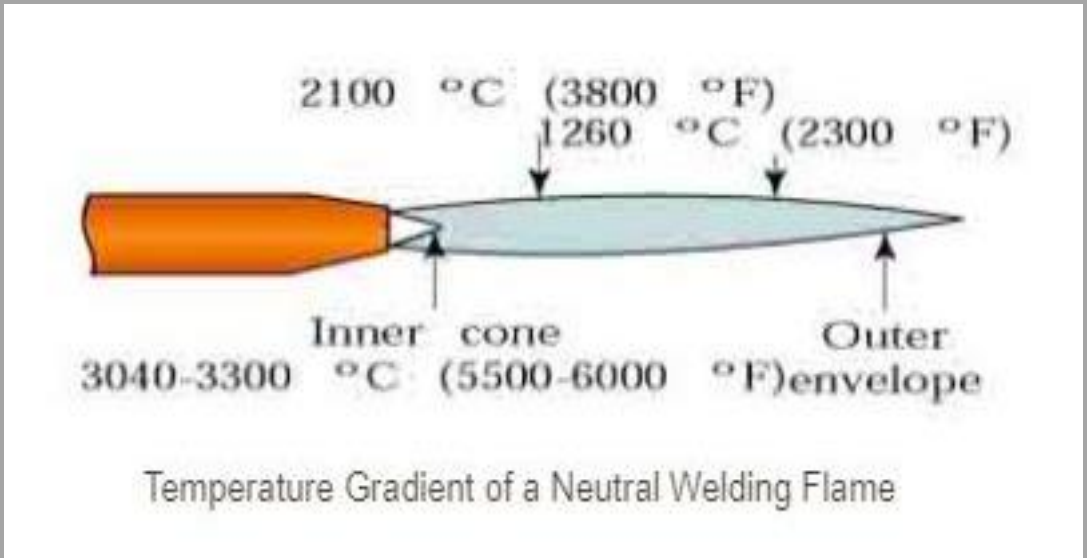
It is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200 deg.C. The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene.

THREE DISNTICT FLAME ARE USED



NEUTRAL FLAME

- IT HAS A ONE TO ONE RATIO OF ACETYLENE AND OXYGEN
- IT HAS A SHORT INNER CONE WHICH IS BLUISH WHITE AND A LONGER OTER ENVELOPE CHRACTERIZES A NEUTRAL FLAME
- INSIDE THE INNER CONE THE PRIMARY COMBUSTION TAKES PLACE BETWEEN O2 AND C2H2 AND GIVES RISE TO CO AND H2, AND IT WILL REACT WITH SURROUNDING AIR TO FORM CO2 AND H2O.THIS IS THE SECONDARY REACTION WHICH ACCOUNT FOR ONE-THIRD OF THE TOTAL HEAT GENERATED
- THE AREA WHERE SECONDARY COMBUSTION TAKES PLACE IS CALLED THE PROTECTION ENVELOPE SINCE CO AHD H2 CONSUME THE O2 ENTERING FROM THE SURROUNDING AIR, THEREBY PROTECTING THE WELD METAL FROM OXIDATION
- NEUTRAL FLAME ARE COMMONLY USED TO WELD MILD STEEL STAINLESS STEEL CAST IRON COPPER ALUMINIUM



Temperature Gradient of a Neutral Welding Flame

CARBURIZING FLAME

- WHEN EXCESS ACETYLENE IS USED THE RESULTING FLAME IS CALLED A REDUCING FLAME
- THE COMBUSTION OF ACETYLENE IS INCOMPLETE
- A GREENISH ACETLYNE FEATHER BETWEEN THE INERT CONE AND THE OUTER ENVELOPE CHRACTERIZES A REDUCING FLAME
- IT IS GOOD FOR WELDING ALUMINUM ALLOYS, HIGH CARBON STEEL

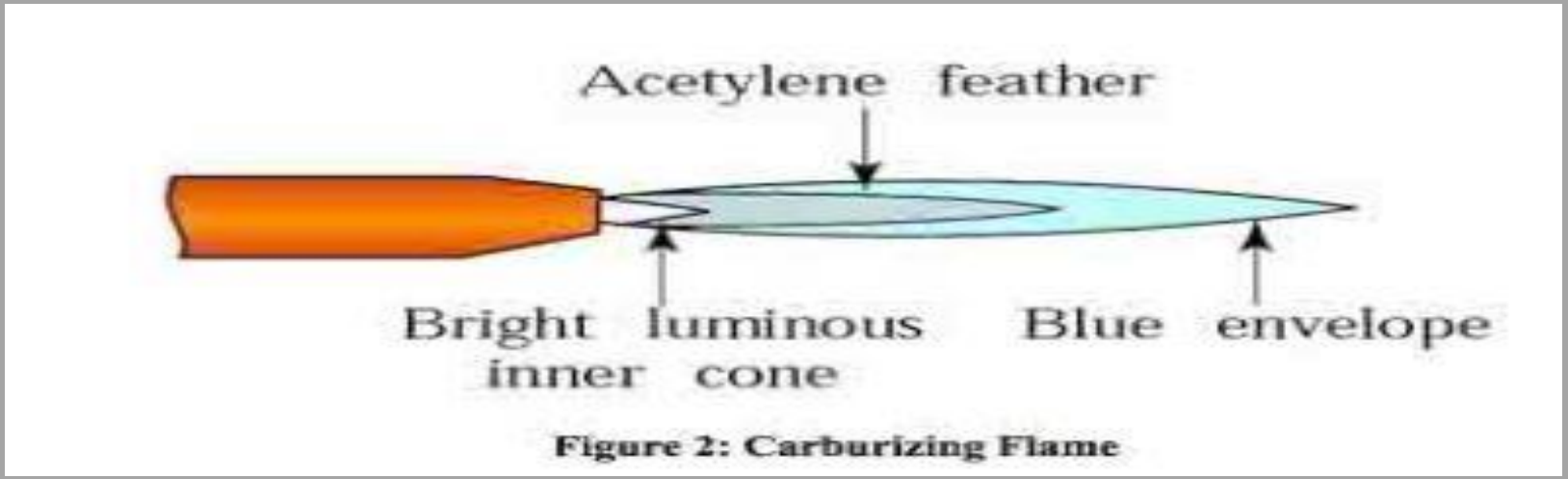
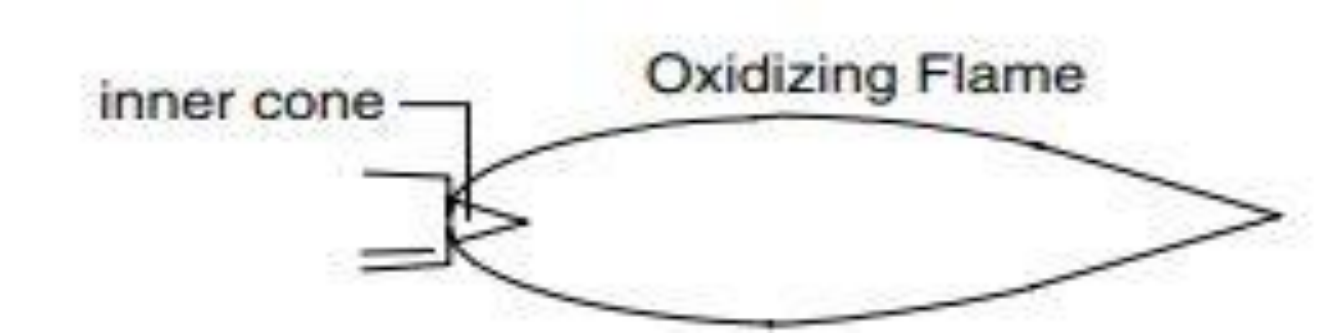


Figure 2: Carburizing Flame

OXIDIZING FLAME

- When excess oxygen is used, the flame becomes oxidizing because of the presence of unconsumed oxygen. A short white inner cone characterizes an oxidizing flame. This flame is preferred when welding brass because copper oxide covers the weld pool and thus prevents zinc from evaporating from the weld pool.



Differences between reducing flame and oxidizing flame	
Carburizing or Reducing Flame	Oxidizing Flame
1. Carburizing flame is obtained when less oxygen than that is required stoichiometrically is supplied.	1. Oxidizing flame is obtained when excess oxygen than that is required stoichiometrically is supplied.
2. Incomplete combustion of gaseous fuel (like acetylene, propylene, propane, natural gas, etc.) takes place within the flame.	2. Complete combustion of gaseous fuel occurs within the flame. Even after the entire fuel burns out, oxygen remains in excess.
3. A carburizing flame consists of three distinct layers (i) inner white cone, (ii) intermediate reddish flame feather, (iii) outer bluish flame.	3. An oxidizing flame typically consists of two layers (i) inner white cone, and (ii) outer bluish flame.
4. Comparatively larger inner cone is obtained.	4. Inner cone in the flame is smaller.
5. The average temperature at the inner cone is comparatively less (around 2900°C).	5. The heat intensity and the temperature are more at the inner cone (3300°C).
6. The weld bead formed with carburizing flame can be somewhat hard and brittle than the corresponding parent components.	6. The weld bead formed with carburizing flame can be comparatively softer and ductile than the corresponding parent components.
7. Less noisy.	7. More noisy.

ADVANTAGES AND DISADVANTAGES

The main advantage of the oxyacetylene welding process is that the equipment is simple, portable, and inexpensive. Therefore, it is convenient for maintenance and repair applications. However, due to its limited power density, welding speed is very low and the total heat input per unit length of the weld is rather high, resulting in large heat-affected zones and severe distortion. The oxyacetylene welding process is not recommended for welding reactive metals such as titanium and zirconium because of its limited protection power

REFERENCES

1. Welding and Welding Technology by R.L.Little, TMH
2. Manufacturing process by Sandy Khippal