Manufacturing Process

Module 2

Manufacturing processes are the steps through which raw materials are transformed into a final product.

➢TYPES

Metal Joining process

Metal forming process

Metal machining process

Metal casting process

Metal joining process

Welded joints

- **Welding** is a process of joining two metal pieces as a result of significant diffusion of the atoms of the welded pieces into the joint (weld) region.
- Welding is carried out by heating the pieces to be joined to melting point and fusing them together (with or without filler material) or by applying pressure to the pieces in cold or heated state.

Brazing and soldering

- **It** is a method of joining two metal work pieces by means of a filler material at a temperature above its melting point but below the melting point of either of the materials being joined.

S.No	Welding	Soldering	Brazing
1	**Welding joints are strongest joints used to bear the load. Strength of the welded portion of joint is usually more than the strength of base metal.**	**Soldering joints are weakest joints out of three. Not meant to bear the load. Use to make electrical contacts generally.**	**Brazing joints are weaker than welding joints but stronger than soldering joints. This can be used to bear the load up to some extent.**
2	**Temperature required is 3800°C in welding joints.**	**Temperature requirement is up to 450°C.**	**Temperature may go to 600°C in brazing joints.**
3	**To join work pieces need to be heated till their melting point.**	**Heating of the work pieces is not required.**	**Work pieces are heated but below their melting point.**
4	**Mechanical properties of base metal may change at the joint due to heating and cooling.**	**No change in mechanical properties after joining.**	**May change in mechanical properties of joint but it is almost negligible.**
5	**No preheating of workpiece is required before welding as it is carried out at high temperature.**	**Preheating of work pieces before soldering is good for making good quality joint.**	**Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature**

Welded joints

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Advantages of welding:

1. Strong and tight joining;
2. Cost effectiveness;
3. Simplicity of welded structures design;
4. Welding processes may be mechanized and automated.

Disadvantages of welding:

1. Internal stresses, distortions and changes of micro-structure in the weld region;
2. Harmful effects: light, ultra violate radiation, fumes, high temperature.

Welding Process

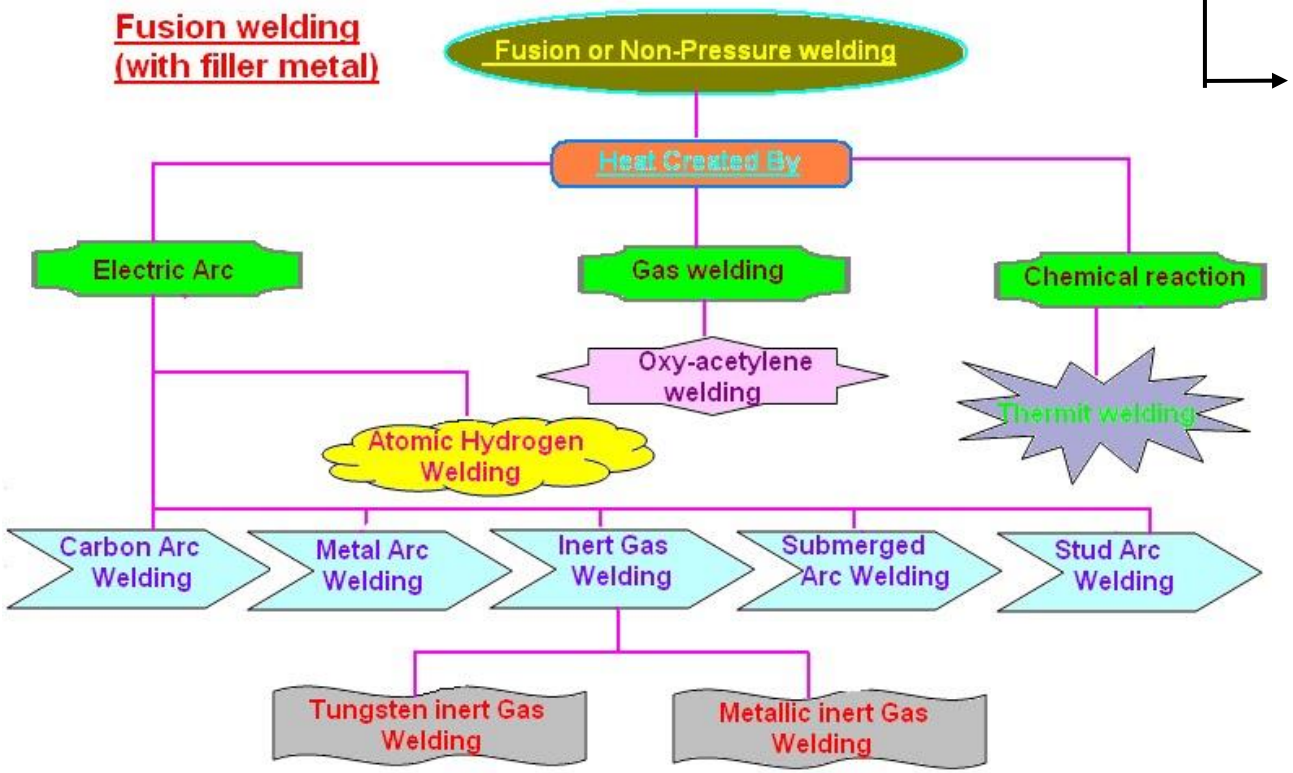
Pressure welding

The piece of metal joined together heated to plastic state and joined together by the application of external pressure

- Forge welding
- Resistance welding

Fusion welding

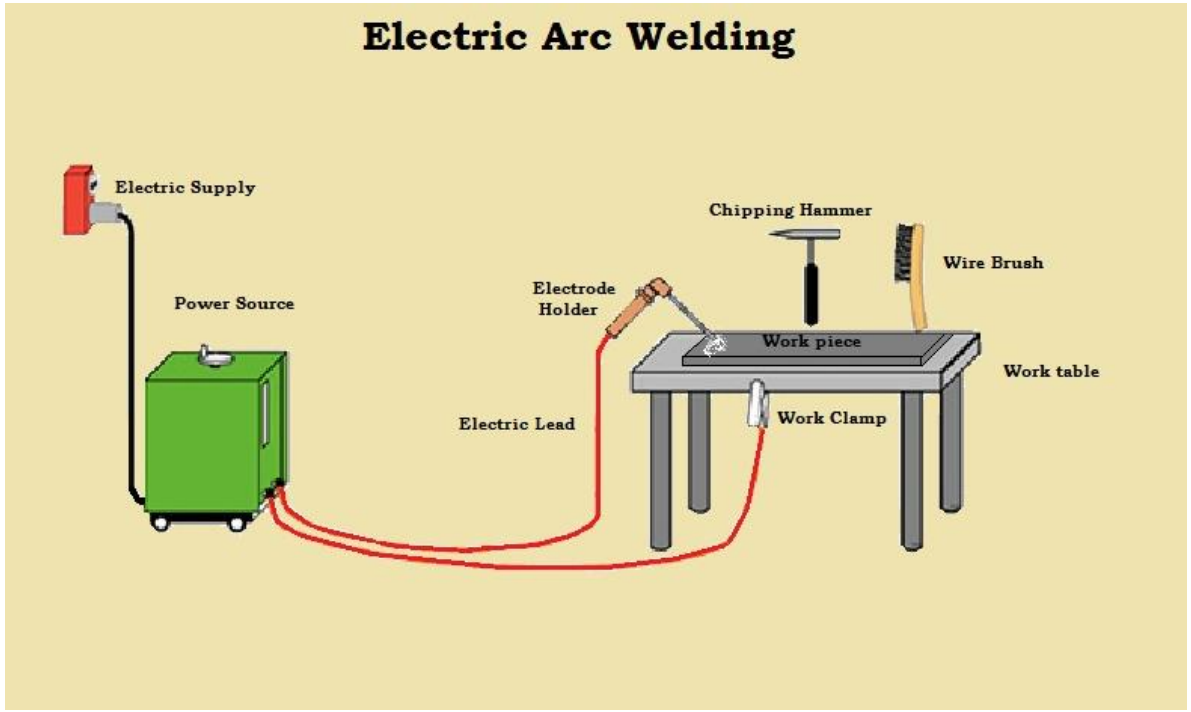
The piece of metal joined together heated to liquid state and allowed to solidify

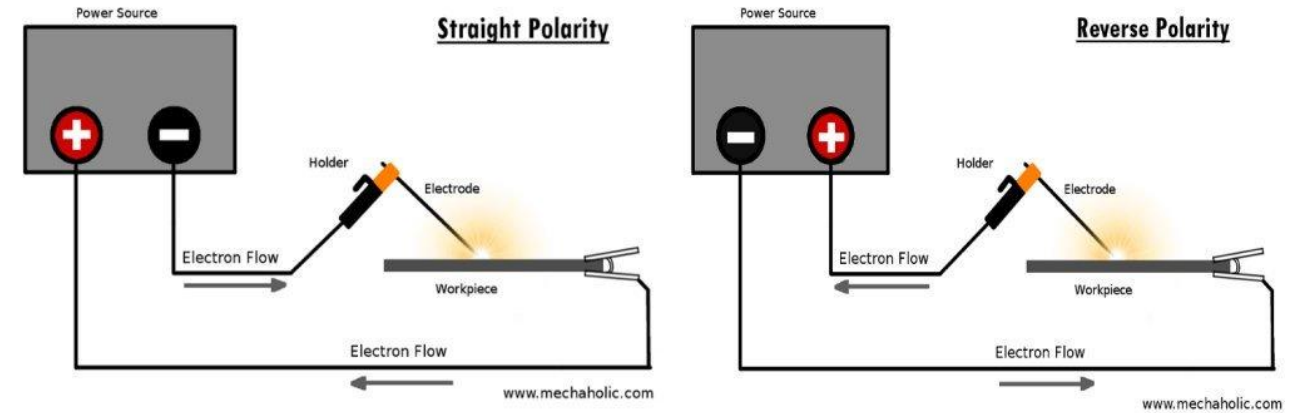


Miscellenious

Welding process other than above two

- Electron beam
- Ultrasonic

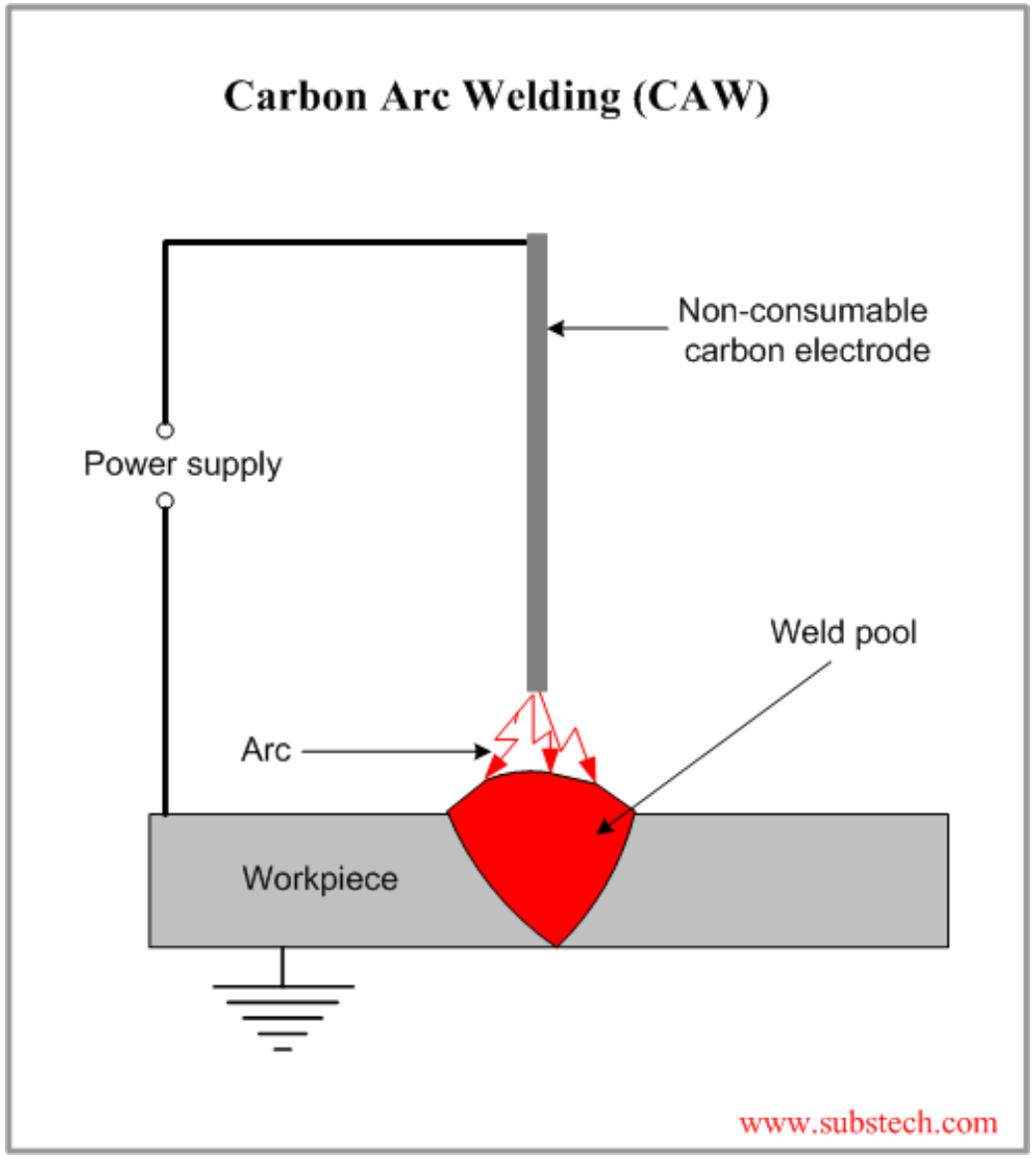




Straight Polarity **Vs** Reverse Polarity

Carbon arc welding

- **Carbon Arc Welding (CAW)** is a welding process, in which heat is generated by an electric arc struck between an carbon electrode and the work piece.
- The arc heats and melts the work pieces edges, forming a joint.
- If required, filler rod may be used in Carbon Arc Welding.
- End of the rod is held in the arc zone.
- The molten rod material is supplied to the weld pool.



Advantages of Carbon Arc Welding:

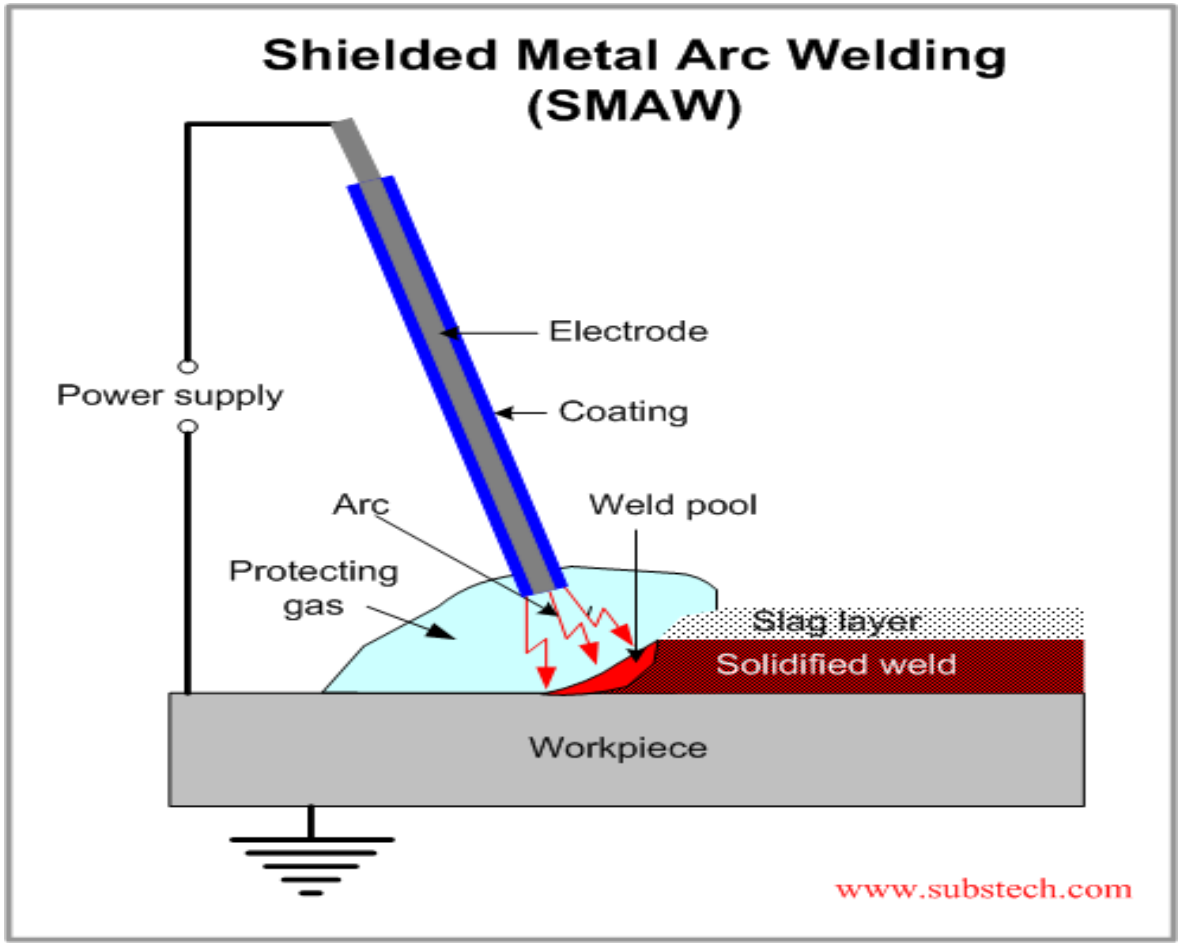
- Low cost of equipment and welding operation;
- High level of operator skill is not required;
- The process is easily automated;
- Low distortion of work piece.

Disadvantages of Carbon Arc Welding:

Unstable quality of the weld (porosity);
Carbon of electrode contaminates weld material with carbides.

Shielded metal arc

- **Arc welding** is a welding process, in which heat is generated by an electric arc struck between an electrode and the work piece.
- Fig shows schematic diagram of SMAW
- In SMAW electrodes are coated with a shielding flux of a suitable composition.
- The flux cleans the metal surface, supplies some alloying elements to the weld, protects the molten metal from oxidation and stabilizes the arc
- The intense of heat of arc forms a molten pool in the metal being welded and at the same time melts the electrode tip .
- As the arc column is moved the molten metal solidifies and forms the weldement
- The impurities and oxides get deposited as slag
- The slag is removed after Solidification.



Advantages

1. Simple, portable and inexpensive equipment;
2. Wide variety of metals, welding positions and electrodes are applicable;
3. Suitable for outdoor applications.

Disadvantages

1. The process is discontinuous due to limited length of the electrodes;
2. Weld may contain slag inclusions;
3. Fumes make difficult the process control

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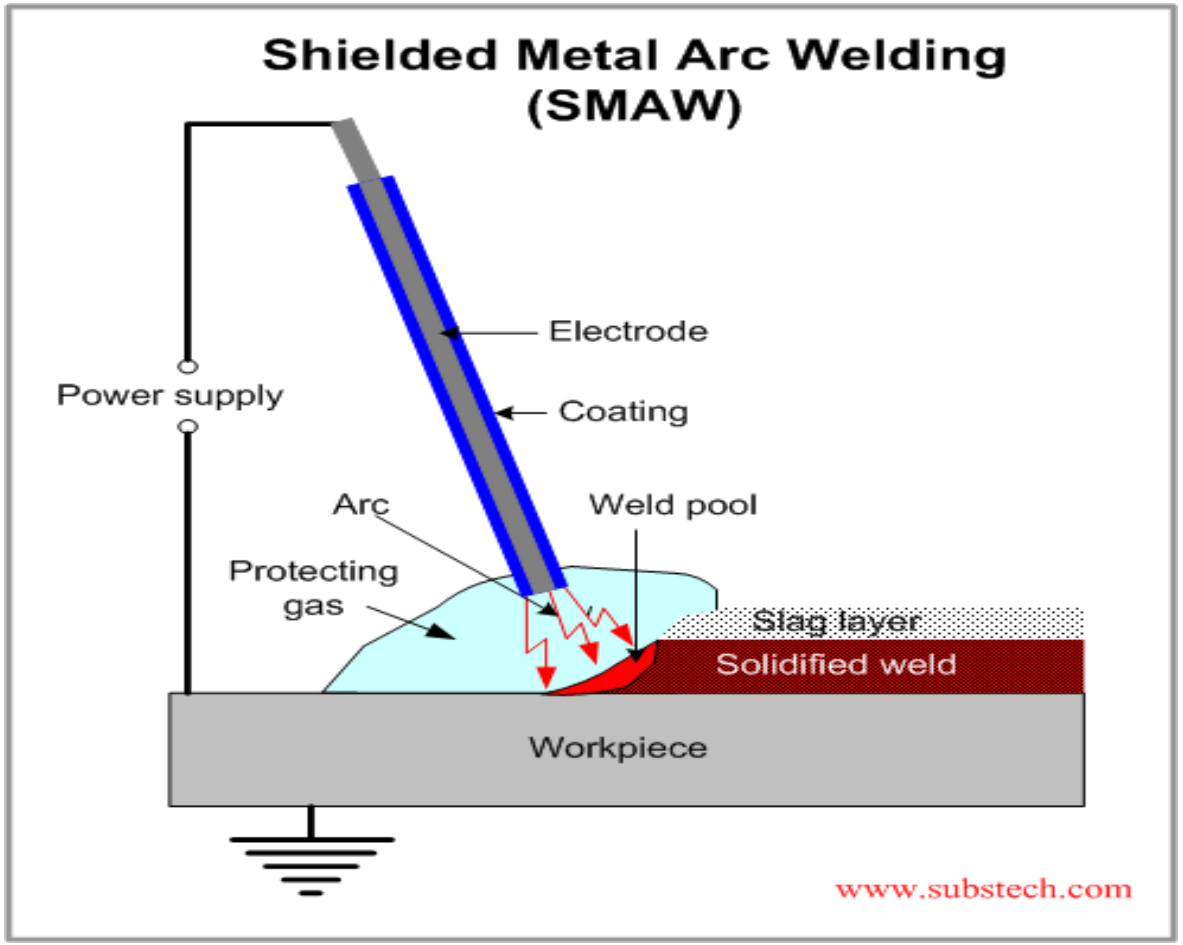

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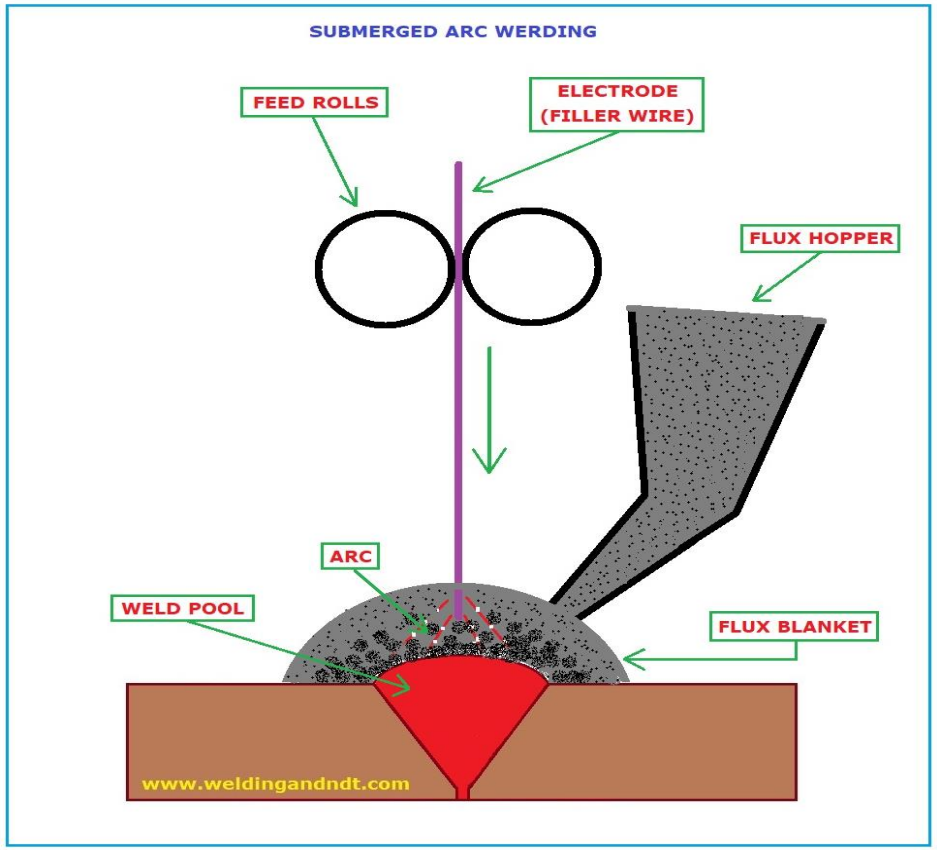
3. Fumes make difficult the process control

Submerged arc welding(SAW)

- **SAW** is a welding process, in which heat is generated by an electric arc struck between an electrode and the work piece
- **Submerged Arc Welding** which utilizes a bare consumable metallic electrode producing an arc between itself and the work piece within a granular shielding flux applied around the weld.
- The arc heats and melts both the work pieces edges and the electrode wire. The molten electrode material is supplied to the surfaces of the welded pieces, fills the weld pool and joins the work pieces.
- Since the electrode is submerged into the flux, the arc is invisible. The flux is partially melts and forms a slag protecting the weld pool from oxidation and other atmospheric contaminations.



Advantages of Submerged Arc Welding (SAW):

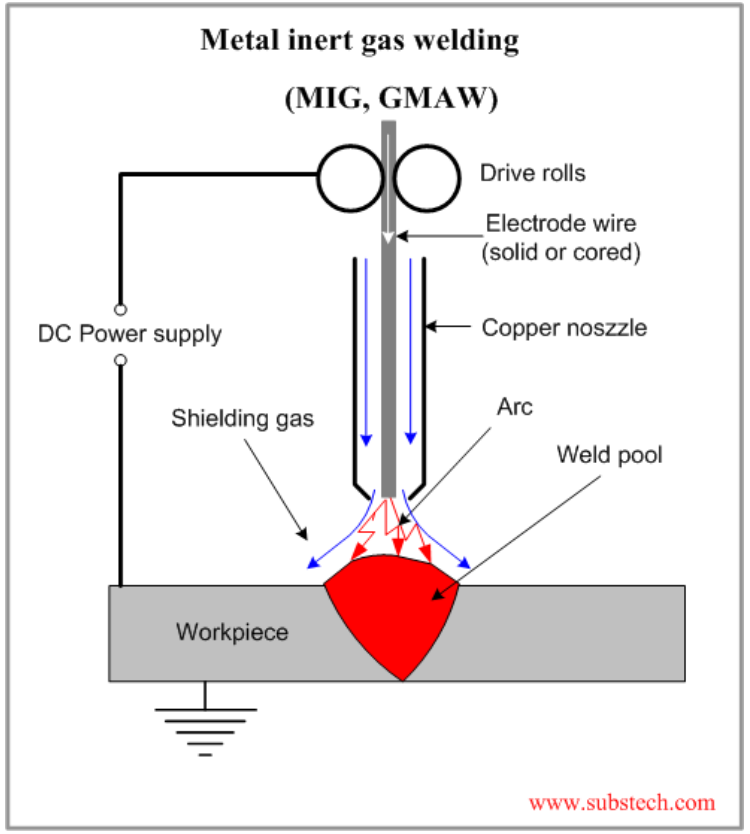
- Very high welding rate;
- The process is suitable for automation;
- High quality weld structure.

Disadvantages of Submerged Arc Welding (SAW):

- Weld may contain slag inclusions;
- Limited applications of the process - mostly for welding horizontally located plates.

Metal inert gas arc welding(MIG)

- **Metal Inert Gas Welding (Gas Metal Arc Welding)** is a arc welding process, in which the weld is shielded by an external gas (Argon, helium)
- Consumable electrode wire, having chemical composition similar to that of the parent material, is continuously fed from a spool to the arc zone
- The arc heats and melts both the work pieces edges and the electrode wire. The fused electrode material is supplied to the surfaces of the work pieces, fills the weld pool and forms joint.
- Due to automatic feeding of the filling wire (electrode) the process is referred to as a semi-automatic. The operator controls only the torch positioning and speed.



Advantages of Metal Inert Gas Welding (MIG, GMAW):

- Continuous weld may be produced (no interruptions);
- High level of operators skill is not required;
- Slag removal is not required (no slag)

Disadvantages of Metal Inert Gas Welding (MIG, GMAW):

- Expensive and non-portable equipment is required;
- Outdoor application are limited because of effect of wind, dispersing the shielding gas.

Tungsten Inert Gas Arc Welding (TIG, GTAW)

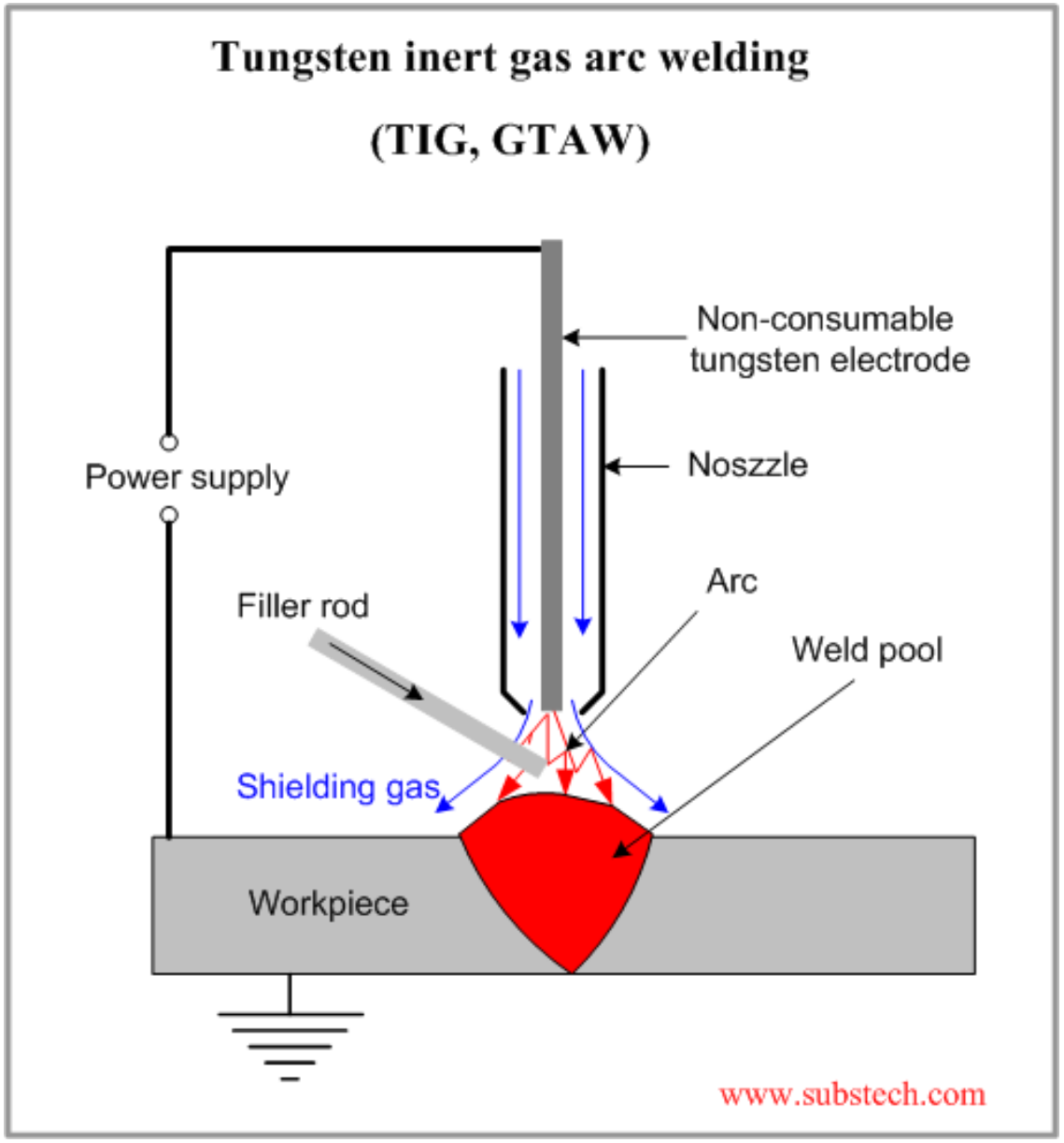
- **Tungsten Inert Gas Arc Welding (Gas Tungsten Arc Welding)** is a welding process, in which heat is generated by an electric arc struck between a tungsten non-consumable electrode and the work piece.
- The weld pool is shielded by an inert gas (Argon, helium, Nitrogen) protecting the molten metal from atmospheric contamination.
- The heat produced by the arc melts the work pieces edges and joins them. Filler rod may be used, if required.
- Tungsten Inert Gas Arc Welding produces a high quality weld of most of metals. Flux is not used in the process.

Advantages of Tungsten Inert Gas Arc Welding (TIG)

- Weld composition is close to that of the parent metal;
- High quality weld structure
- Slag removal is not required (no slag);
- Thermal distortions of work pieces are minimal due to concentration of heat in small zone.

Disadvantages

- Low welding rate;
- Relatively expensive;
- Requres high level of operators skill.



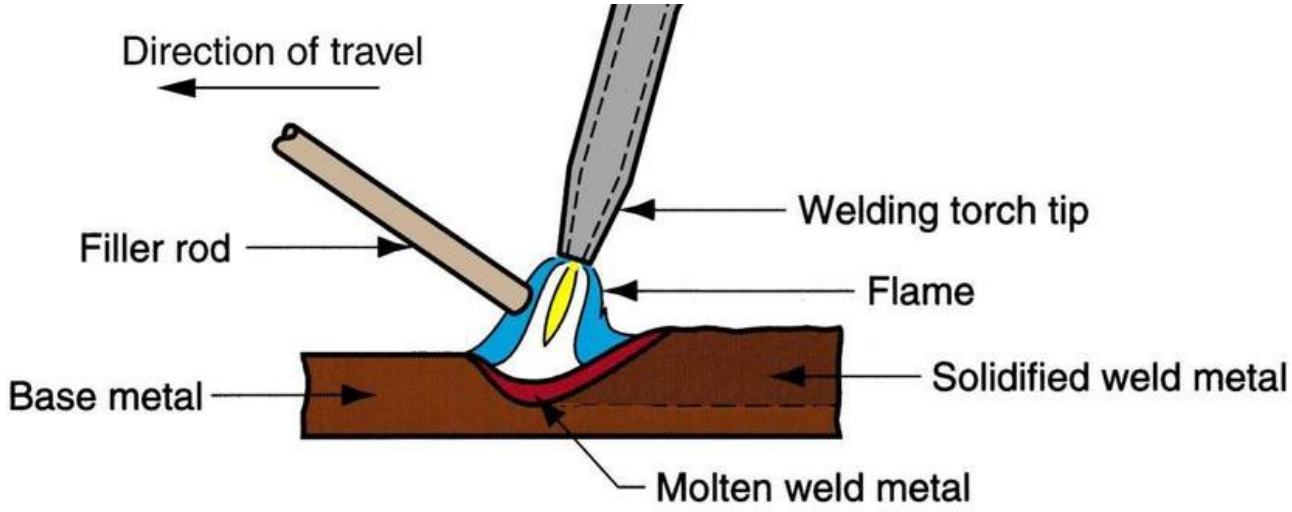
Oxy-acetylene gas welding

- **Gas Welding** is a welding process utilizing heat of the flame from a welding torch.
- The torch mixes a fuel gas with Oxygen in the proper ratio and flow rate providing combustion process at a required temperature.
- The hot flame fuses the edges of the welded parts, which are joined together forming a weld after Solidification.
- **Oxyacetylene Welding** is a Gas Welding process using a combustion mixture of acetylene (C_2H_2) and oxygen (O_2) for producing gas welding flame.
- Filler rod is used when an additional supply of metal to weld is required. Shielding flux may be used if protection of weld pool is necessary.

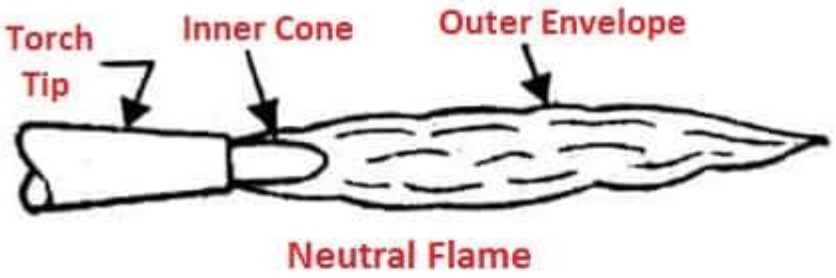
- Oxyacetylene flame has a temperature of about 6000°F (3300°C). Combustion of acetylene proceeds in two stages:

  1. Inner core of the flame. $C_2H_2 + O_2 = 2CO + H_2$

  2. Outer envelope of the flame: $CO + H_2 + O_2 = CO_2 + H_2O$



Types of welding flames



Neutral flame

- Equal amount of oxygen and acetylene .
- Used for welding of ferrous materials such as low carbon steel, mild steel etc.

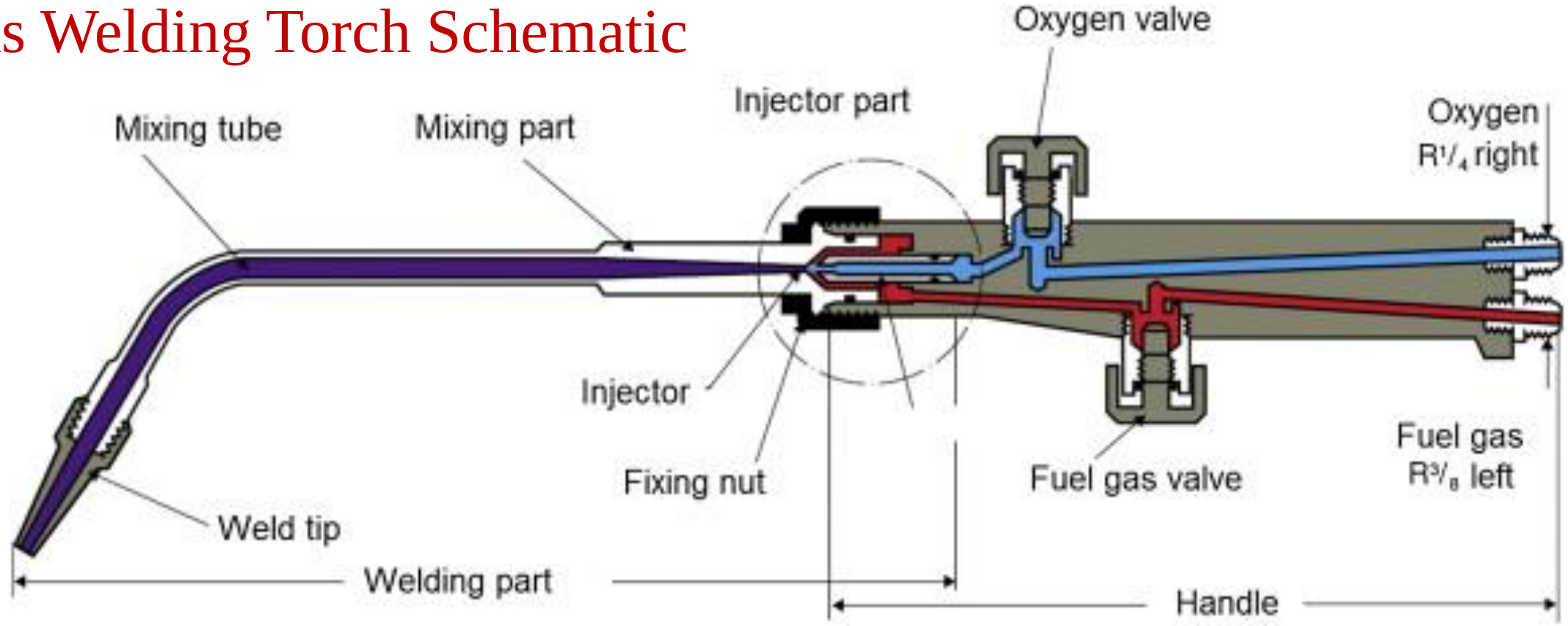
Carburizing flame

- Here the amount of acetylene is more than that of oxygen.
- Oxygen to acetylene ratio : 0.9:1
- Used for welding aluminum.

Oxidizing flame

- Here amount of oxygen is more than acetylene
- Oxygen to acetylene ratio : 1.5:1
- Used for welding non ferrous material such as barzz, bronze ,copper etc.

Gas Welding Torch Schematic



Advantages of gas Welding:

- Versatile process;
- Low cost, portable equipment;
- Electricity supply is not required.

Disadvantages Of Gas Welding:

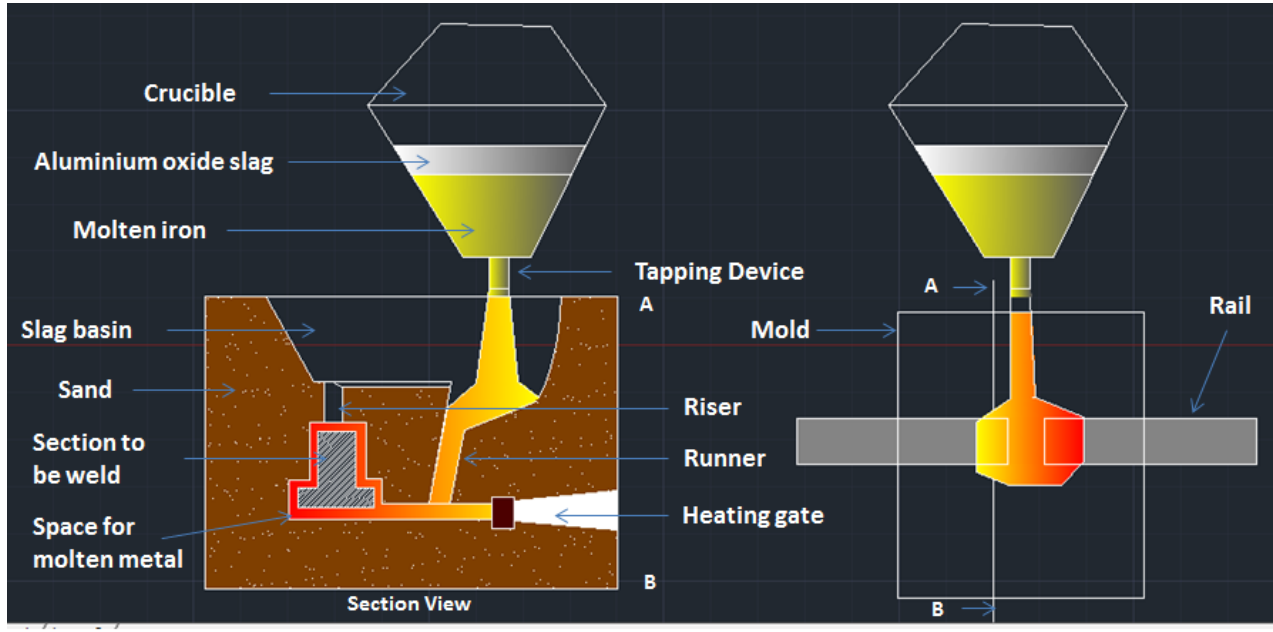
- High skill operator is required;
- Flame temperature is lower, than in arc welding;
- Fumes evolved by shielding fluxes;
- Some metals cannot be welded (reactive and refractory metals).

Thermite welding process

- **Thermit Welding** is a welding process utilizing heat generated by exothermic chemical reaction between a mixture of a metal oxide and aluminum powder.
- The proportion of Aluminium oxide to iron powder is 3:1
- The combustion reaction products (iron and aluminum oxide) heat up to 4500°F (2500°C). Liquid iron fills the sand (or ceramic) mold built around the welded parts, the slag (aluminum oxide), floating up , is then removed from the weld surface.

$$8Al + Fe_3O_4 = 9Fe + 4Al_2O_3 + heat$$

- Thermit Welding is used for repair of steel casings and forgings,for joining railroad rails, steel wires and steel pipes, for joining large cast and forged parts.



Thermit Welding Process

Advantages :

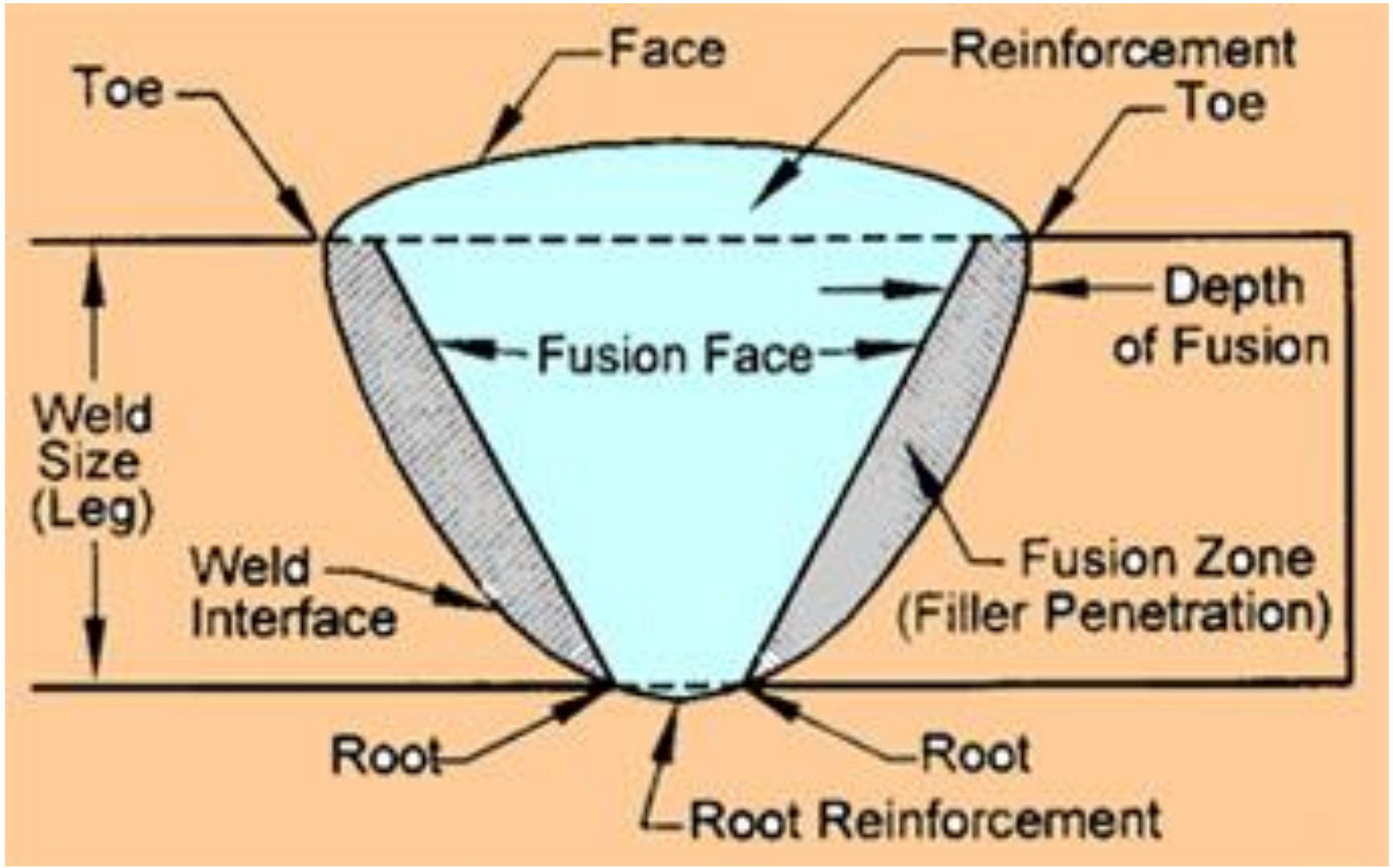
No external power source is required (heat of chemical reaction is utilized);

Very large heavy section parts may be joined

Disadvantages

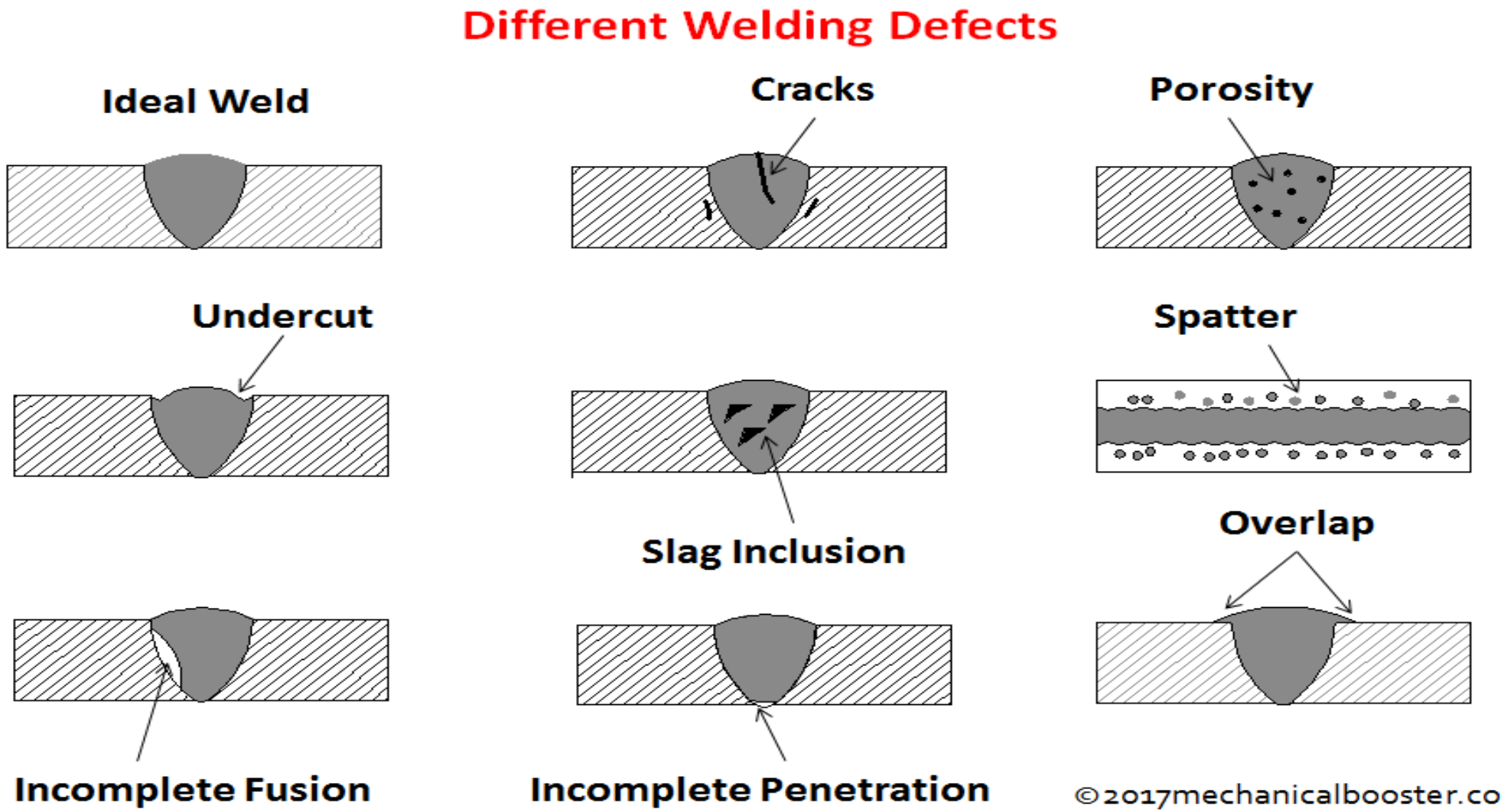
- Only ferrous (steel, chromium, nickel) parts may be welded;
- Slow welding rate;
- High temperature process may cause distortions and changes in Grain structure in the weld region.
- Weld may contain gas (Hydrogen) and slag contaminations.

Welding Zone



WELDING DEFECTS

- Welding Defects can be defined as the irregularities formed in the given weld metal due to wrong welding process or incorrect welding patterns, etc



1. Weld Crack

This is the most unwanted defect of all the other welding defects. Welding cracks can be present at the surface, inside of the weld material or at the heat affected zones

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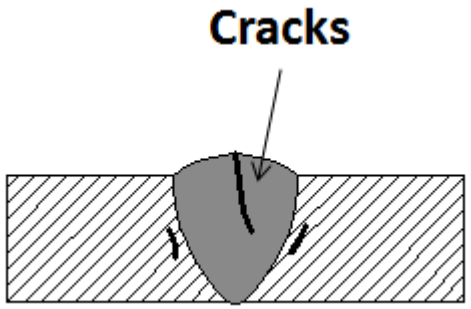


Causes Of Weld Crack:

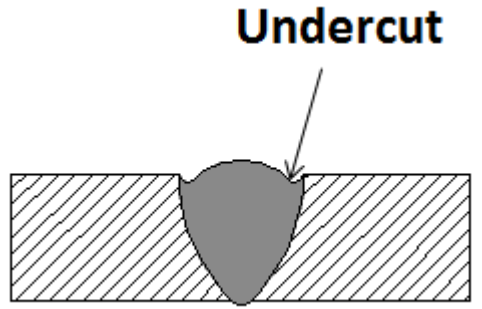
1. Poor ductility of the given base metal.
2. The presence of residual stress can cause a crack on the weld metal.

Remedies for Weld crack:

1. Using appropriate materials may decrease the chances of crack.
2. Preheating the weld and reducing the cooling speed joint helps in reducing crack.

2.Under cut

- **A groove or depression adjacent to the sides of the weld, reducing the cross-sectional thickness of the base metal**. .



Causes of Undercut:

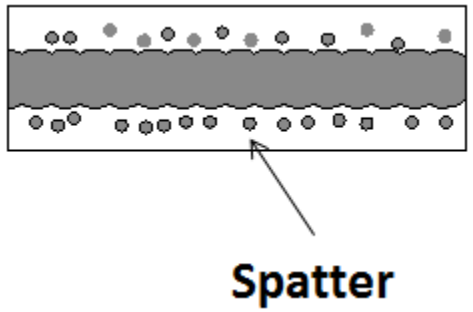
1. If the arc voltage is very high then this defect may occur.
2. High electrode speed is also one of the reasons for this defect.

Remedies for Undercut:

1. Reduce the arc length or lower the arc voltage.
2. The diameter of the electrode should be small.
3. Reduce the travel speed of the electrode.

SPATTER

- When some metal drops are expelled from the weld and remain stuck to the surface, then this defect is known as Spatter.



CAUSES OF SPATTER:

1. High Welding current can cause this defect.
2. The longer the arc the more chances of getting this defect.
3. Incorrect polarity.
4. Improper gas shielded may also cause this defect.

REMEDIES FOR SPATTER:

1. Reducing the arc length and welding current
2. Using the right polarity and according to the conditions of the welding.

BLOW HOLES

- Small holes in the weld joint caused by the presence of moisture.

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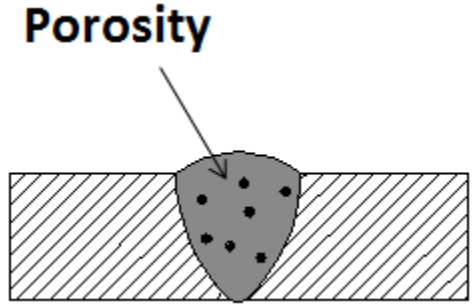


CAUSES OF POROSITY:

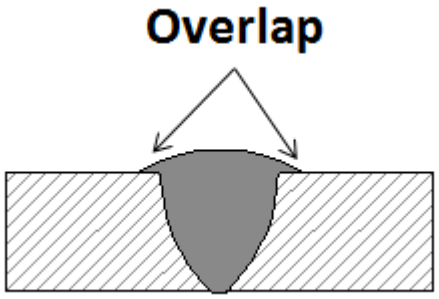
1. It occurs when the electrode is not coated properly.
2. Using a longer arc may also increase its chances.
3. Increased welding currents.
4. Rust or oil on the welding surface.

REMEDIES FOR POROSITY:

1. Proper selection of the electrode.
2. Decreasing the welding current.
3. Using smaller arc and slowing the process to allow the gases to escape.
4. Remove rust or oil from the surface and use a proper technique

5.OVERLAP

- When the weld face extends beyond the weld toe, then this defect occurs. In this condition the weld metal rolls and forms an angle less than 90 degrees.



Causes of Overlap:

1. Improper welding technique.
2. By using large electrodes this defect may occur.
3. High welding current

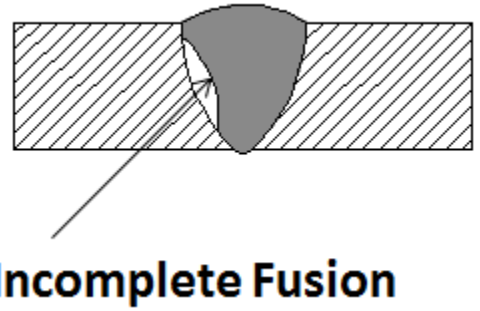
Remedies for Overlap:

1. Using a proper technique for welding.
2. Use small electrode.
3. Less welding current.

6. Incomplete fusion

It occurs when the groove of the metal is not filled Completely

Causes:



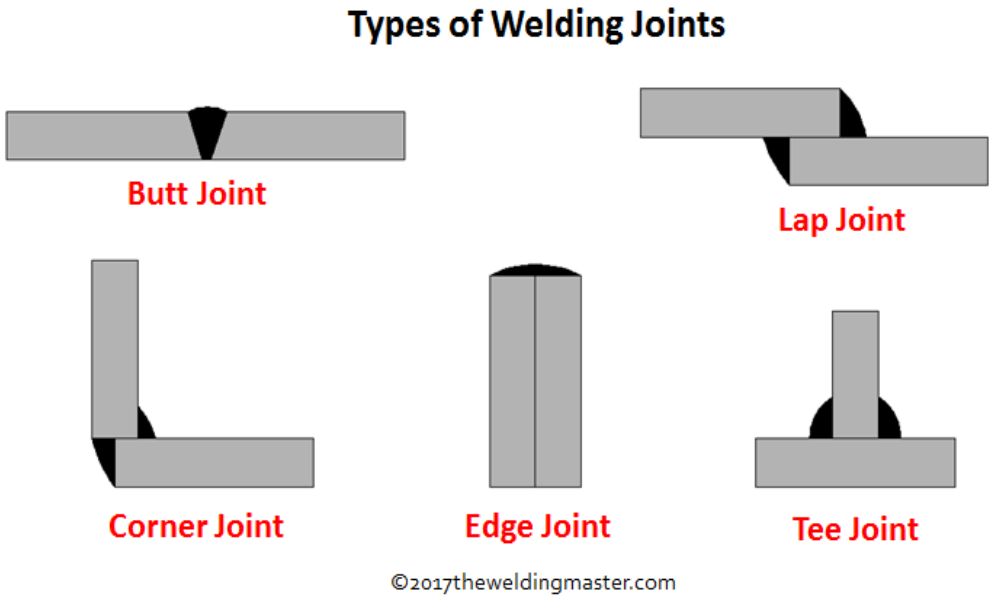
Causes of Incomplete fusion:

1. Too rapid speed of travel of electrode,
2. Insuffcient current to properly melt the parent metal

Remedies for Incomplete Fusion:

1. Increasing the welding current and decreasing the travel speed helps in removing the chances of incomplete fusion.
2. Reducing the deposition rate.

TYPES OF WELDING JOINT



Butt Joint

- The joint which is formed by placing the ends of two parts together is called butt joint

Corner Joint

- The joint formed by placing the corner of two parts at right angle is called corner joint (see fig above). Two parts which is going to be weld with corner joint forms the shape of L

T-Joint

- The joint which is made by intersecting two parts at right angle (i.e at 90 degree) and one part lie at the centre of the other.

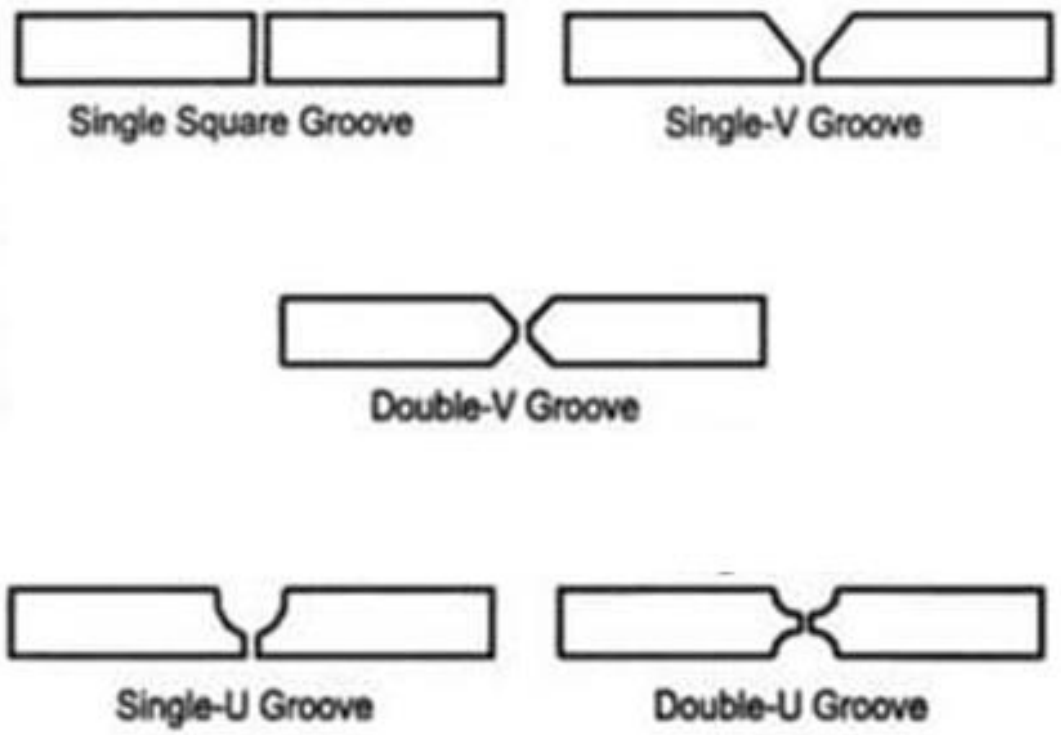
Lap Joint

- The lap joint is formed when the two parts are placed one over another and than welded (see fig above). It may one sided or double sided.
- This types of welding joints are mostly used to join two pieces with different thickness.

Edge Joint

- The joint formed by welding the edges of two parts together are called edge joint. This joint is used where the edges of two sheets are adjacent and are approximately parallel planes at the point of welding

BUTT JOINT EDGE PREPARATION



i) Square Butt:

It is used when the thickness of the plate is from 3 to 5 mm. Both the edges to be weld should be spaced about 2 to 3mm apart . That means no edge preparation is required if thickness of work piece is less than 5 mm

(ii) Single- V-Butt:

It is used when the thickness of the plates is from 8 to 16 mm. Both the edges are bevelled to form an angle of about 70° to 90°

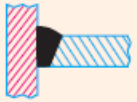
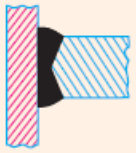
(iii) Double-V-Butt:

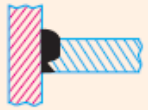
It is used when the thickness of the plates is more than 16mm and where welding can be performed on both sides of the plate. Both the edges are beveled to form a double-V.

(iv) Single and Double-U Butt:

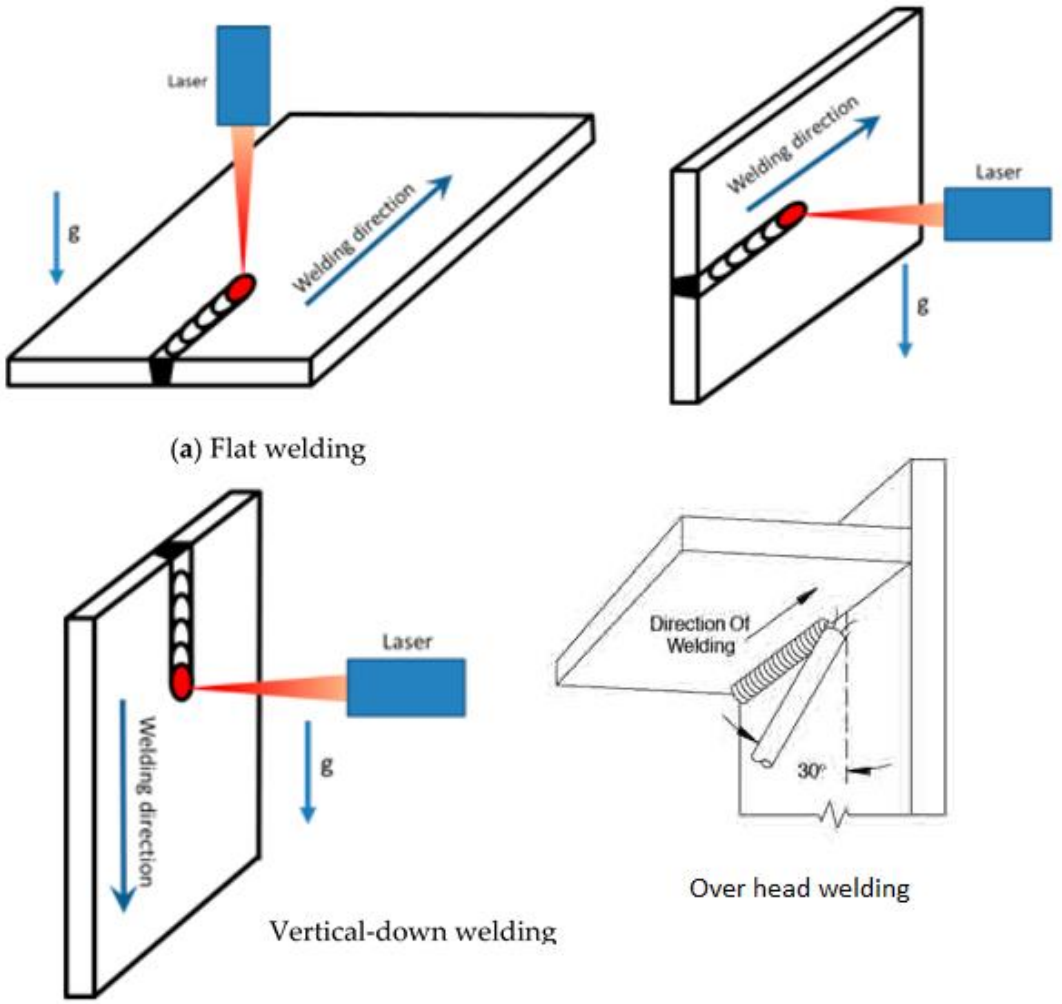
It is used when the thickness of the plate is more than 20mm. The edge preparation is difficult but the joints are more satisfactory. It requires less filler metal.

Welding symbol

S. No.	Form of weld	Sectional representation	Symbol
1.	Fillet		
2.	Square butt		
3.	Single-*V* butt		
4.	Double-*V* butt		
5.	Single-*U* butt		
6.	Double-*U* butt		
7.	Single bevel butt		
8.	Double bevel butt		

S. No.	Form of weld	Sectional representation	Symbol
9.	Single-*J* butt		
10.	Double-*J* butt		
11.	Bead (edge or seal)		
12.	Stud		
13.	Sealing run		
14.	Spot		

Welding Position



Flat welding

- This type of welding is performed from the upper side of the joint. The face of the weld is approximately horizontal.

Horizontal welding

- In horizontal welding, the weld axis is approximately horizontal

Vertical Welding

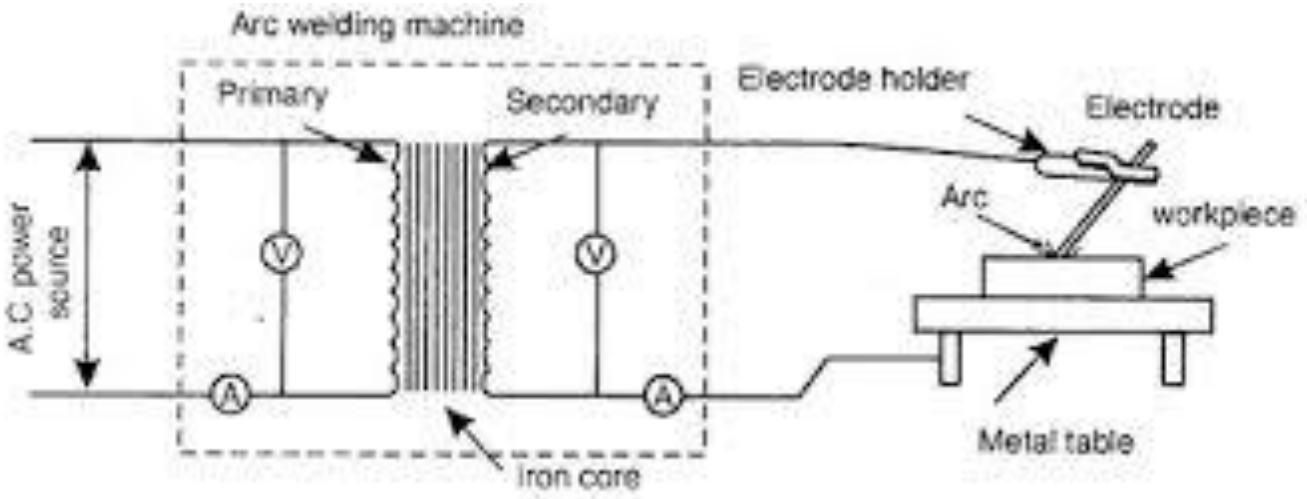
- In vertical position welding, the axis of the weld is approximately vertical.
- When welding is done on a vertical surface, the molten metal has a tendency to run downward and pile up.
- To avoid molten metal pile up normally vertical welding is carried out in down ward direction

Over head welding

- Overhead welding is performed from the underside of a joint.
- In overhead welding, the metal deposited tends to drop or sag on the plate, causing the bead to have a high crown

ARC WELDING MACHINES

AC WELDING



It is used to step down the voltage supply and increase the ampre rate It consist of primary and secondary circuits. The input is given to primary windings. By electromagnetic induction the current flows through the secondary coil. The output can be controlled as per requirement.

DC WELDING

1. AC MOTOR GENERATOR

- In this generator is driven by suitable AC motor. The average voltage of the generator is 25V. the current ranges from 25-100A, the voltage in the generator is variable. The voltage can be set to the desired value with the help of rheostat.

2 DIESEL ENGINE GENERATOR SET

- In this set, the drive is given by a diesel engine. Rest of the system is same as in case of AC motor generator. Diesel engine generator sets are used in the area's where electricity is not available.

3.TRANSFORMER RECTIFIER SET

- It allows the current to flow through it only in one direction because it has a one way valve or solid rectifier installed on the electrode side of the secondary coil. The set can supply straight polarity and reverse polarity power supply.

Comparison between AC and DC welding

AC welding	*DC welding*
• Equipment is cheaper and simpler.	• Equipment is costlier and complicated.
• In AC transformer there is no moving part, therefore it is easy to maintain.	• DC generator set has many parts moving and its maintenance cost is higher than AC transformer.
• It can be operated at large distances from power sources as the voltage drop is negligible.	• In DC the voltage drop is very high. Therefore shorter cables are used.
• Only coated electrodes can be used in AC welding.	• Both coated and bare electrodes can be used.
• Less problem in arc blow.	• More problem of arc blow.
• It cannot be used for welding non-ferrous materials.	• Almost all the metals can be welded.
• It can be used only when AC current is available.	• An engine generator can be used in case of non-availability of AC power.