WELDING

Welding is **a fabrication process whereby two or more parts are fused together by means of heat, pressure or both forming a join as the parts cool**.
In general, it is a process in which two metal pieces similar (or) dissimilar may be joined by heating them to a temperature high enough to fuse the metals with (or) without the application of pressure and with (or) without the aid of filler material.

Weldability

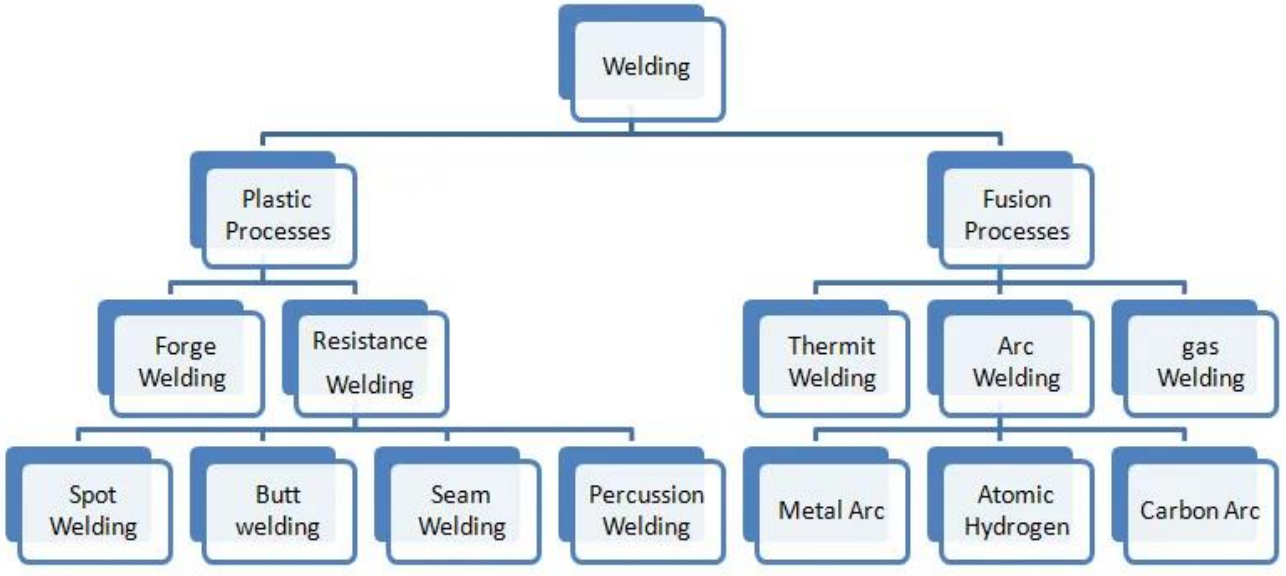
- The ease with which welding of a given material can be done without producing any defect is called **Weldability**.
- Weldability can also be defined as the capability of metal to be welded under the fabrication conditions imposed satisfactorily on the intended surface.
- The metal should not require expensive or complicated or extracting procedures to produce a
- sound joint.

Factors affecting Weldability:

Melting point, thermal conductivity, reactivity, the coefficient of thermal expansion, electrical resistance and surface condition of material are the factor that affects weldability.

1. **Melting point of metal**: Materials with a medium melting point can be welded very easily.
2. **Thermal conductivity**: Material with high thermal conductivity (K) are treated as difficult to weld materials.
3. **Reactivity**: If the material reacts with air, water or surroundings it becomes difficult to weld.
4. **The coefficient of thermal expansion of metals**: Material with high thermal expansion coefficient, it becomes difficult to weld.
5. **Electrical resistance**: Higher the electrical resistance of the material, it becomes difficult because it requires a lot of heat energy.
6. **Surface condition**: The material with the dirty surface it becomes difficult to weld.

CLASSSIFICATION OF WELDING



Electric Arc Welding

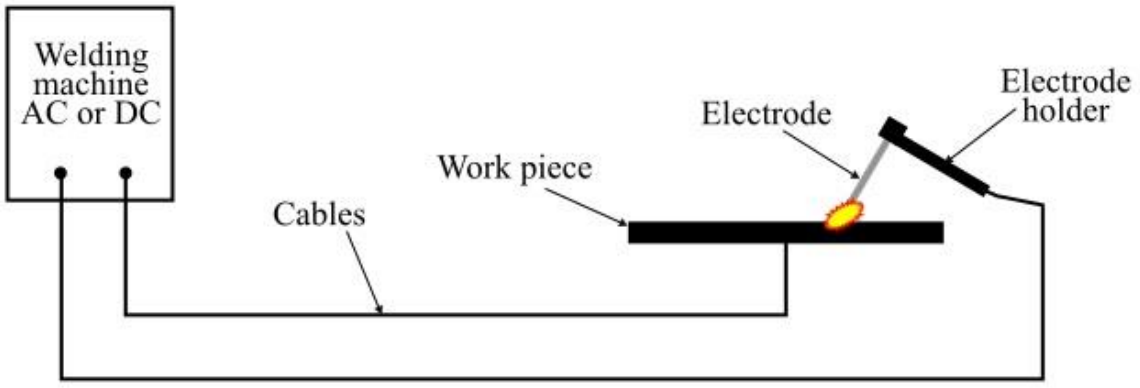
The **electric arc welding** is the welding process which uses electric arc to create heat to melt and join the metals. In the electric arc welding, the electric power supply creates an electric arc between the electrode and the base material.

Depending upon the type of power supply used, the electric arc welding equipment is classified into two sections as −

- Direct Current (DC) Arc Welding
- Alternating Current (AC) Arc Welding

Equipment Required for Electric Arc Welding

The various equipment required for the electric arc welding (AC and DC) are shown in the figure and described below.



Welding Machine

The welding machine used for electric arc welding can either be an AC or DC welding machine.

AC Welding Machine

The AC arc welding machine has a step-down transformer to reduce the input supply voltage of 220 V to 80 V. The AC arc welding machine works with the power supply of frequency 50 Hz or 60 Hz. The efficiency of the AC welding transformer varies from 80% to 85% and the energy consumed per kg of deposit is about 3 to 4 kWh. Although the AC welding machine has low power factor about 0.3 to 0.4.

DC Welding Machine

The DC arc welding machine commonly consists of a motor-generator set. Where, the motor is a squirrel cage induction motor and the generator is the differential compound DC generator to give drooping characteristics. The source of DC power may also be an engine driven generator or transformer-rectifier welding set. In case of DC arc welding machine, the energy consumed per kg of deposit is about 6 to 10 kWh and the output voltage of the DC arc welding machine may be varied between 40 to 80 Volts and the current from 30 A to 300 A. The motor used in the DC arc welding has a power factor of 0.6 to 0.7.

Electrode Holder

The electrode holder is the equipment used for holding the electrode at a desired angle. The electrode holders for arc welding come in different sizes depending upon the current rating from 50 A to 500 A.

Leads or Cables

The cables or leads carry the electric current from the welding machine to the work-piece. The cable used for welding process are made of copper or aluminium and are flexible. The cables used for electric arc welding are made of 1000 to 2000 very fine wires twisted together so that the cables have flexibility and greater mechanical strength. The cable wires are insulated by a rubber covering.

Lugs or Cable Connectors

The cable connectors are used for making the connection between machine switches and welding electrode holder. Generally, the mechanical type connectors are used because they can be assembled or removed easily. The cable connector for welding processes are designed according to the current rating of the cable used.

What is Electric Arc Welding?

The process of welding in which heat is produced by creating an electric arc to join metal workpieces is known as **electric arc welding**.

Electric arc welding is a type of welding that uses a welding power supply to create an electric arc between a metal stick, called electrode, and the workpiece to melt the metals at the point of contact.

Electric arc welding can use either DC supply or AC supply and a consumable or non-consumable electrode.

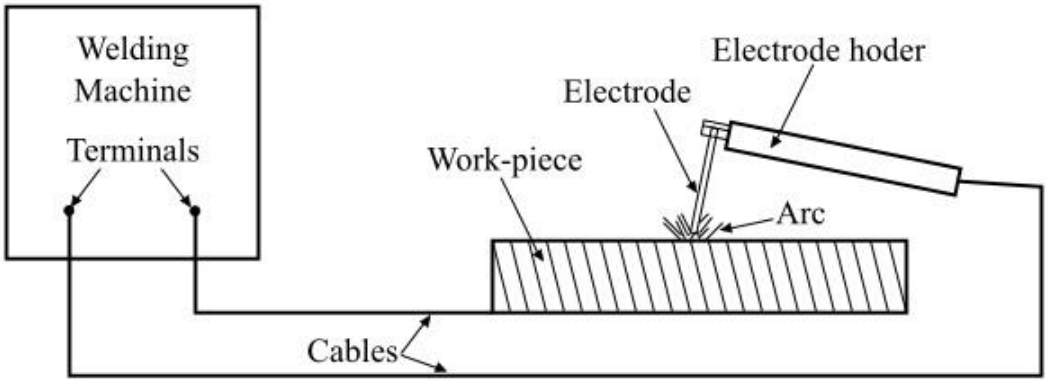
Working Principle of Electric Arc Welding

The process of electric arc welding is based on the principle that, when electric current is passed through an air gap from one electric conductor to another, then an electric arc is produced which generates a very intense and concentrated heat.

The temperature of the arc between two conductors is approximately 3500 °C to 4000 °C. This high temperature generates intense heat in the arc at the point of welding, which melts a small portion of metal in the work-piece.

The electric arc keeps this molten metal pool agitated and the base metal is thoroughly mixed with melted electrode metal, after that the metal pool cools down under a protective cover of slag left by the electrode. On cooling, a strong weld join is formed between the two metal pieces.

A simplified circuit of electric arc welding is shown in the figure.



Electric Arc Welding

In electric arc welding, either AC or DC current is obtained from a welding power supply. Here, one terminal is connected to the electrode mounted on an electrode holder, which is held by the welder, while the other terminal is connected to the workpiece and the circuit is completed through an air gap between the electrode and the work-piece.

The length of the air gap (i.e., distance between electrode tip and the surface of the work-piece) is about 3 mm to 6 mm. The welding is done by creating an electric arc between the electrode and the workpiece. The temperature of the arc is very high (about 3500 °C to 4000 °C) and the metal in contact with the arc becomes molten which enables a weld to be melt. The electrode is then moved slowly in the desired direction to complete the weld.

Types of Electric Arc Welding

The electric arc welding is mainly classified into following types −

- DC Metallic Arc Welding
- AC Metallic Arc Welding
- Carbon Arc Welding
- Atomic Hydrogen Arc Welding
- Shielded Arc Welding

Advantages of Arc Welding

Some of the chief advantages of the electric arc welding are given as follows −

- The electric arc welding is the suitable welding process for high speed welds.
- Apparatus required for arc welding is very simple and portable.
- The electric arc welding gives superior temperature at the point of welding.
- Electric arc welding can work on both AC and DC supply.
- It is inexpensive to install.

Disadvantages of Electric Arc Welding

The disadvantages of electric arc welding are as follows −

- The welding process with electric arc welding requires skilled operators.
- Electric arc welding cannot be used for welding of reactive metals such as aluminium, titanium, etc.
- Electric arc welding is not suitable for welding thin metals.

Applications of Electric Arc Welding

The important applications of electric arc welding are as follows −

- Electric arc welding is used in repairing of broken parts of machines.
- It is used for welding of cast iron or steel housings and frames.
- Electric arc welding is used in various industries such as automotive industries, construction industries, mechanical industries, etc.
- Electric welding is also used for welding process in shipbuilding.

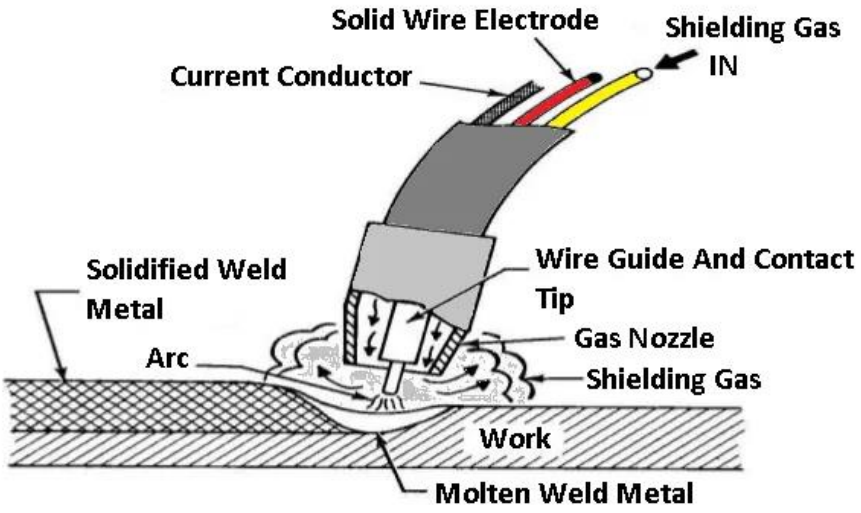
METAL INERT GAS WELDING

MIG welding holds for metal inert gas welding. This MIG welding process is also identified as gas metal arc welding (GMAW), which you can also call wire welding.

In this types of welding, a thin wire works as the electrode, which is fed from a spool attached to a gun through a flexible tube and comes out of the nozzle on the welding gun or torch. The wire is fed continuously when the trigger is pulled on the welding gun

In gas metal arc welding, the heat is produced by an electric arc incorporating a continuous feed consumable electrode that is shielded by an externally supplied gas. The process of GMAW requires a welding gun, a source of electric power supply, an electrode wire feed unit, and a source of shielding gas. The welding gun guides the electrode wire, current wire and shielding gas tube. In GMAW, the self-regulation of the arc length is maintained by a constant voltage power supply with a constant wire feed speed unit.

Today, the gas metal arc welding is the most common industrial welding process, preferred for its versatility, speed and automation.



METAL INERT GAS WELDING

Advantages of Gas Metal Arc Welding

The chief advantages of gas metal arc welding are given as follows −

- Gas metal arc welding process requires no flux.
- GMAW can be adapted for manual and automatic operations.
- It requires no cleaning after the welding is done.
- Gas metal arc welding requires much less skilled welder for it operation.
- GMAW is suitable for horizontal, vertical and overhead welding positions.
- It provides complete protection to weld from atmospheric contamination.
- Gas metal arc welding can be used for both ferrous and non-ferrous metals.

Applications of Gas Metal Arc Welding

Some of the applications of the gas metal arc welding are given as follows −

- It is used in the semi-automated or automated industrial applications.
- Gas metal arc welding can be used to weld the all commercially available metals.
- GMAW can be used for deep groove welding of plates and castings.
- GMAW is also used for welding of light gauge metals, where high speeds are possible.

TUNGSTEN INERT GAS (TIG) OR GAS TUNGSTEN ARC WELDING (GMAW)

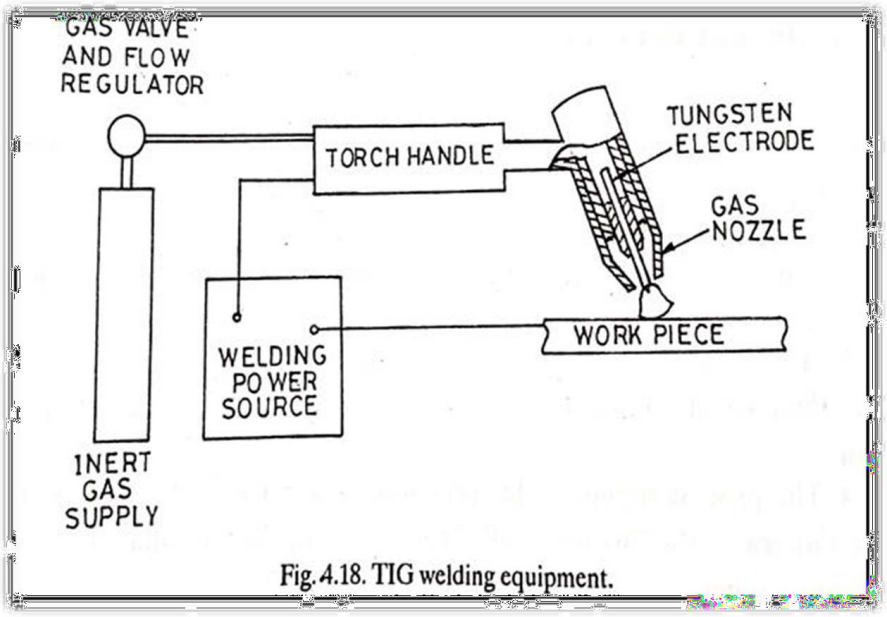


Fig. 4.18. TIG welding equipment.

DEFINITION

It is an arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a tungsten electrode and the job. A shielding gas (argon helium, nitrogen, etc.) is usedto avoid
atmospheric contamination of the molten weld pool. A filler metal may beaded , if required.

PRINCIPLE OF OPERATION

Welding current, water and inert gas supply are turned on. The arc is struck either by touching the electrode with a scrap metal tungsten piece or using a high frequency unit. In the first method arc is initially struck on a scrap metal piece (or a tungsten piece) and then broken by increasing the arc length. This procedure repeated twice or thrice warms up the tungsten electrode. The arc is then struck between the electrode and pre cleaned job to be welded. This method avoids breaking electrode tip, job contamination and tungsten loss. In the second method, a high frequency current is super-imposed on the welding current. The weldingtorch (holding the electrode) is brought nearer to the job. When electrode tip reaches within a distance of 3to 2 mm

from the job, a spark jumps across the air gap between the electrode and the job. The air path gets ionizedand arc is established.

ADVANTAGES

1. No flux is used, hence there is no danger of flux entrapment when welding refrigerator and airconditioner components.
2. Because of clear visibility of the arc and the job, the operator can exercise a better control on thewelding process.
3. This process can weld in all positions and produces smooth and sound welds with less spatter.
4. TIG welding is very much suitable for high quality welding of thin materials (as thin as 0.125 mm).
5. It is a very good process for welding nonferrous metals (aluminium etc.) and stainless steel.

DISADVANATAGES

1. Tig welding requires a separate filler rod.
2. Tungsten if it transfer to molten weld pool can contaminate the same. Tungsten inclusion is hardand brittle.

. APPLICATIONS

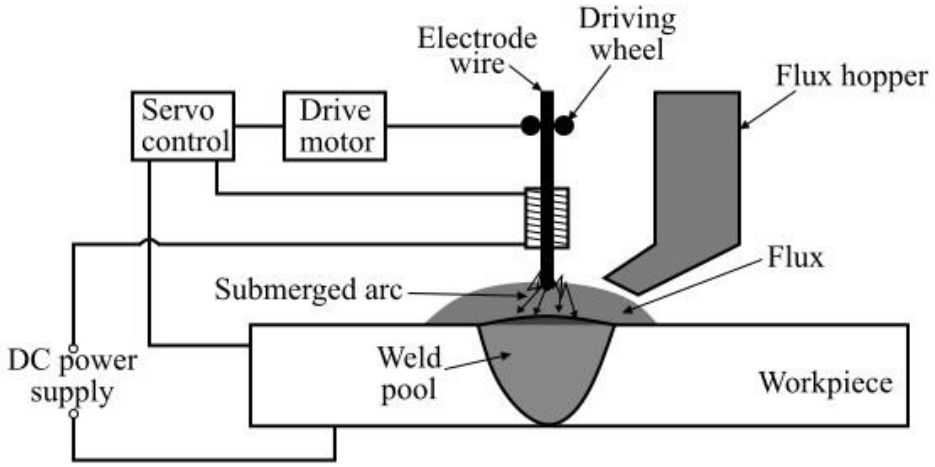
1. Welding aluminium, magnesium, copper, nickel and their alloys,carbon, alloy or stainless steels, inconel,high temperature and hard sur-facing alloys like zirconium, titanium etc.
2. Welding sheet metal and thinner sections.
3. Welding of expansion bellows, transistor cases, instrument dia-phragms, and can-sealing joints.
4. Precision welding in atomic energy, aircraft, chemical and instru-ment industries.
5. Rocket motor chamber fabrications in launch vehicles.

What is Submerged Arc Welding?

Submerged arc welding (SAW) is a welding process that involves the formation of an electric arc between a continuously fed electrode and the workpiece to be welded. The process of submerged arc welding was developed by the Linde-Union Carbide Company.

SAW requires a continuous fed of consumable solid or flux cored tubular electrode. In case of submerged arc welding, the molten weld and the arc are protected from the atmospheric contamination by being submerged under a blanket of granular fusible flux consisting of lime, silica, manganese oxide, calcium fluoride and other compounds.

A simplified schematic diagram of submerged arc welding is shown in the figure below.



Submerged Arc Welding

The flux in molten state becomes conductive and provides a path for the current flow between the electrode and the workpiece. Also, the layer of the flux completely covers the molten metal and hence preventing the spatter and sparks. This layer also suppresses the intense ultraviolet radiation and fumes.

Submerged arc welding can be operated in either manual mode or automatic mode or semi-automatic mode (handheld welding gun). Normally, SAW is limited to the horizontal welding position, however, horizontal groove position weld has been done with a special arrangement to support the flux. In case of SAW, the deposit rate is about 45 kg/h. The welding current for the submerged arc welding varies from 300 A to 2000 A.

With SAW, single or multiple electrode wire variations of the welding process exist. In this welding process, constant voltage welding power supplies (AC or DC) are most commonly used, although, a constant current power supply in combination with a voltage sensing wire feeder may also be used.

Advantages of Submerged Arc Welding

Some of the primary advantages of submerged arc welding are given as follows −

- In case of SAW, the rate of deposition of material is very high, about 45 kg/h.
- With submerged arc welding, strong welds are readily made with good process design and control.
- SAW gives deep weld penetration.
- Practically, edge penetration is not necessary with the submerged arc welding process.
- SAW produces minimal welding fume and arc light.
- With submerged arc welding process, high speed welding of thin sheet steels up to 5 m/min. is possible.
- In mechanized applications, SAW gives high operation factor.
- Submerged arc welding process is suitable for both indoor and outdoor applications.
- In case of SAW, 50 % to 90 % of the flux is recoverable.
- Distortion is much less with the submerged welding process.
- The welds produced by the submerged arc welding are strong, uniform, ductile, and corrosion resistant.
- There is no chance of spatter of the weld because the arc is always covered by a blanket of flux.

Limitations of Submerged Arc Welding

Following are the limitation of the submerged arc welding as −

- SAW can only be used for welding of ferrous materials like steel or stainless steel and some nickel based alloys.
- Submerged arc welding process requires relatively troublesome flux handling systems.
- Submerged arc welding process requires inter-pass and post weld slag removal.
- The residues of flux and slag can present the health and safety concerns.
- SAW is limited to the 1F, 2F and 1G welding positions only.

Applications of Submerged Arc Welding

The submerged arc welding process is used for following −

- SAW is suitable for welding of carbon steels, as in structure and vessel construction.
- Submerged welding process is used for welding of low alloy steels.
- It is also used for stainless steels and nickel based alloys.
- SAW can also be used for surfacing applications such as wear-facing, corrosion overlay of steels, etc.

Differences between MIG Welding and TIG Welding

The following table highlights the differences between MIG welding and TIG welding −

MIG Welding	TIG Welding
Stands for Metal Inert Gas Welding.	It stands for Tungsten Inert Gas Welding.
A consumable electrode is used in the metal inert gas (MIG) welding process.	TIG welding uses a non-consumable tungsten electrode.
The electrodes itself acts as the filler material in MIG welding.	TIG welding requires additional filler material rod, as the tungsten electrode does not melt during welding process.
In case of MIG welding, the composition of the electrode metal is selected according to the base metal, i.e., the electrode material is usually similar to	TIG Welding always uses an electrode made of tungsten.

MIG Welding	TIG Welding
that of the base metal.	
MIG welding is a gas shielded metal arc welding, where, the shielding gas protects the weld pool from the atmospheric contamination.	TIG welding is a gas shielded tungsten arc welding.
MIG welding is suitable for homogeneous welding process.	TIG welding is suitable for autogenous welding process. Although, it can also be used for homogeneous welding by supplying additional filler.
In case of MIG welding, DC supply with reverse polarity is used.	TIG welding can used both AC and DC supply.
MIG welding process is comparatively faster than TIG Welding.	TIG welding is a slow welding process.
The filler deposition rate is very high in the case of MIG welding.	In TIG welding, the rate of filler deposition is low.
In MIG welding process, the electrode-cum-filler is fed continuously from a wire reel.	TIG welding does not require electrode feed, as it uses a non-consumable tungsten electrode.
MIG welding can be used for welding of metal sheets of thickness up to 40 mm.	TIG welding is limited to the metal sheet thickness about 5 mm.
Spatters are usually produced with the MIG welding.	TIG welding is free from spatters.
MIG welding is free from tungsten inclusion defects.	In TIG welding process, the tungsten inclusion defect may occur when a broken part of the tungsten electrode gets embedded into the weld bead.
The quality and appearance of the joint or weld made by the MIG welding is not very good.	TIG welding produces the weld bead of good quality and appearance.

GAS WELDING AND CUTTING

GAS WELDING

Gas welding is a most important **type of welding** process. It is done by burning of fuel gases with the help of oxygen which forms a concentrated flame of high temperature. This flame directly strikes the weld area and melts the weld surface and filler material. The melted part of welding plates diffused in one another and create a weld joint after cooling

GAS CUTTING

. Cutting with the oxy-fuel process is just the opposite from of welding. Oxy-fuel cutting uses acetylene and oxygen to preheat metal to red hot and then uses pure oxygen to burn away the preheated metal. Because this is achieved by oxidation, it is only effective on metals that are easily oxidized at this temperature. Such metals are mild steel and low allow steels. Oxy-fuel cutting can be used to cut thicknesses from 2/8″ to up to 12″.

OXY-ACETYLENE WELDING

Oxy-fuel welding, commonly referred to as oxy welding or gas welding is a process of joining metals by application of heat created by gas flame. The fuel gas commonly acetylene, when mixed with proper proportion of oxygen in a mixing chamber of welding torch, produces a very hot flame of about 5700-5800°F. With this flame it is possible to bring any of the so-called commercial metals, namely: cast iron, steel, copper, and aluminum, to a molten state and cause a fusion of two pieces of like metals in such a manner that the point of fusion will very closely approach the strength of the metal fused. If more metal of like nature is added, the union is made even stronger than the original. This method is called oxy-acetylene welding

Oxy-acetylene welding is a fusion welding process.it joins metals ,using the heat of combustion of an oxygen and acetylene gas mixture. The intense of heat (flame) thus produced melts and fuses together theedges of the parts to be welded, generally with the addition of a filler metal.

PRINCIPLE OF OPERATION

-When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited, the flameresulting at the tip of the torch is sufficiently hot to melt and join the parent metal.
-The oxy-acetylene flame reaches a temperature of about 3200°Cand thus can melt all commercial metalswhich, during welding, actually flow together to form a complete bond. A filler metal rodis generally added to the molten metal pool to build up the seams lightly for greater strength
- Oxy-acetylene welding does not require the components to be forced together under pressure until theweld forms and solidifies.

GAS WELDING EQUIPMENT

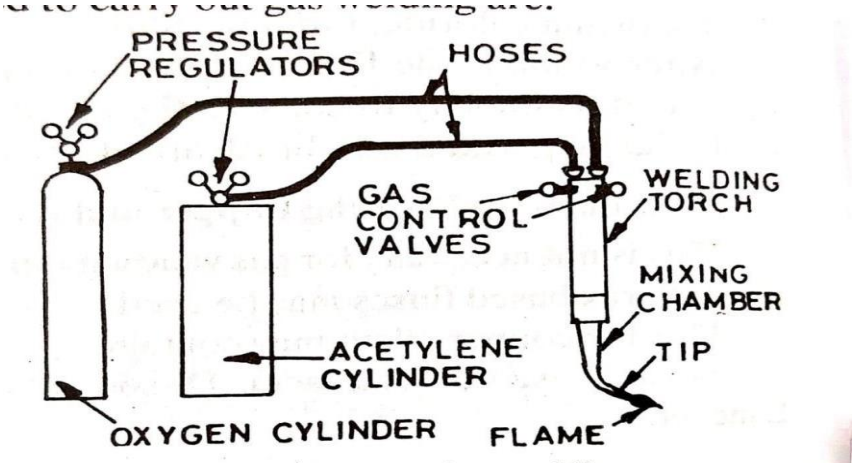


Fig. 3.5. Oxy-acetylene welding equipment.

The basic equipments used to carry out gas welding are:

1. Oxygen gas cylinder. (Black in colour)
2. Acetylene gas cylinder. (Maroon in colour)
3. Oxygen pressure regulator.
4. Acetylene pressure regulator.
5. Oxygen gas(Blue/Black).
6. Acetylene gas hose (Red).
7. Welding torch or blow-pipe with a set of nozzles and gas lighter.
8. Trolleys for the transportation of oxygen and acetylene cylinders.
9. A set of keys and spanners.
10. Filler rods and fluxes.
11. Protective clothing for the welder (e.g., asbestos apron, gloves,goggles etc.)

TYPES OF FLAMES

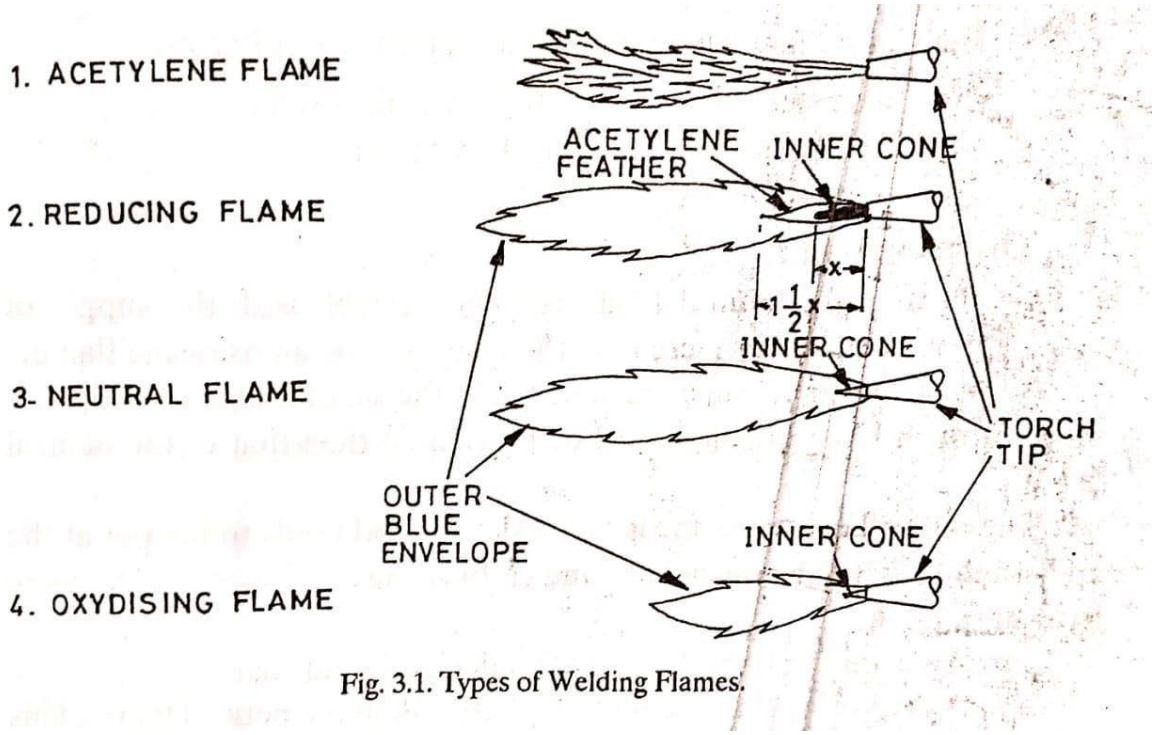


Fig. 3.1. Types of Welding Flames.

TYPES OF FLAMES (Fig. 3.1)

1. Neutral Flame (Acetylene oxygen in equal proportions)
2. Oxidising Flame (Excess of oxygen)
3. Reducing Flame (Excess of.acetylene)

NEUTRAL FLAME

The Neutral Flame is one in which equal amounts of oxygen and acetylene combine. The inner cone is light blue in colour. it is surrounded by an outer flame envelop, produced by combination of
oxygen in the air and superheated carbon monoxide and hydro-gen gases from inner cone. Temperature3200°C.

OXYDISING FLAME

The Oxidizing Flame has an excess of oxygen. (Fig.7.8). The inner cone is shorter, much bluer in colour, and usually more pointed than a neutral flame. The outer flame envelop is much shorter and tends to fan- out at the end temperature 3330°C.

REDUCING FLAME

- If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburisingor reducing flame, i.e. rich in acetylene.
- A reducing flame can be recognized by acetylene feather which exists between the inner cone and theouter envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in colour.approximate temperature of reducing flame is 3038°C.

RESISTANCE WELDING

DEFINITION

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 the work is a part and by theapplications of pressure. No filler metal is needed.

TYPES OF RESISTANCE WELDING

- SPOT WELDING
- SEAM WELDING
- PROJECTION WELDING

SPOT WELDING

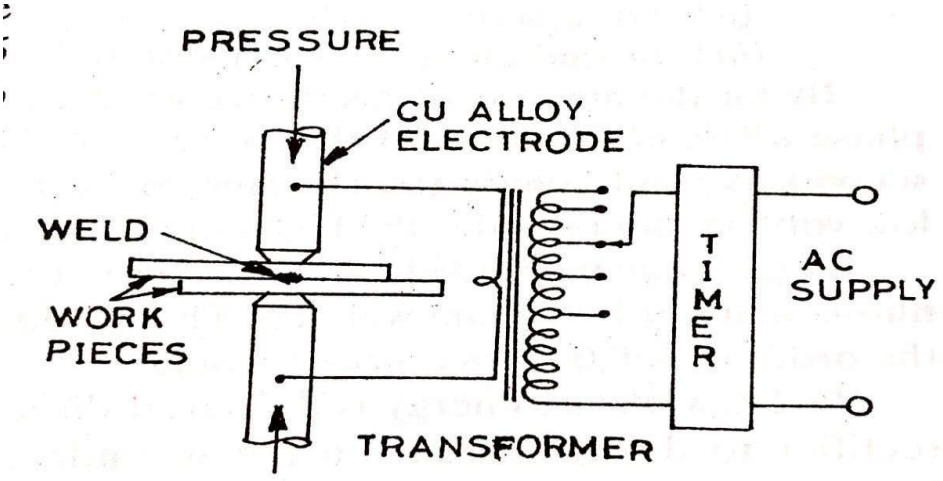


Fig. 5.1. Principle of resistance spot welding.

Spot welding is a form of resistance welding in which a weld is produced at a spot in the work piece between current-carrying electrodes, the weld being of approximately the same area as the electrode tips, oras the smaller of tips of differing size. The two pieces which are to be welded are laid be-tween two rod shaped electrodes and pressed together. The pressure exerted by the electrodes must be great enough to bring the two work pieces into contact at the point to be welded. Only then is the current switched on. The electrical resistance is the greatest at the inter-face where the plates are in contact, and if a large current at low voltage is passed between the electrodes through the plates, heat is evolved at the interface, the heat evolved being equal to $I^2 Rt$ joules, where I is current in amperes, R is the resistance in ohms and t
is the time in seconds.

OPERATION

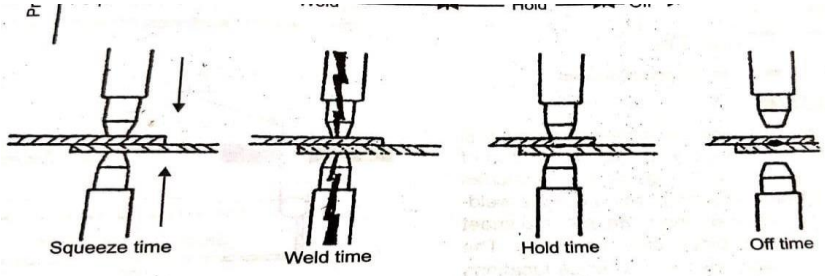


Fig. 11.4. Standard four event sequence for spot welding

1. **Squeeze time** . It is the time between the initial application of the electrode pressure on the work and theinitial application of current to make the weld. During this period the upper electrode comes in contact with the work piece and develops full electrode force. At the end of the squeeze time, the welding current is applied.
2. **Weld time** . During this period the welding current flows through the circuit, i.e., it enters from oneelectrode, passes through the work-pieces and goes out from the second electrode.
3. **Hold time** . It is the time during which force acts at the point of welding after the last impulse of weldingcurrent ceases. The electrode pressure is maintained until the metal has somewhat cooled.
4. **Off time** . It is the interval from the end of the hold time to the beginning of the squeeze time for the next(resistance) welding cycle.

DVANTAGES OF SPOT WELDING

(i) Low cost,
(ii) High speed of welding,
(iii) Dependability,
(iv) Less skilled worker will do,
(v) More general elimination of warping or distortion of parts,
(vi) High uniformity of products,
(vii) Operation may be made automatic or semi-automatic, and
(viii) No edge preparation is needed.

SEAM WELDING

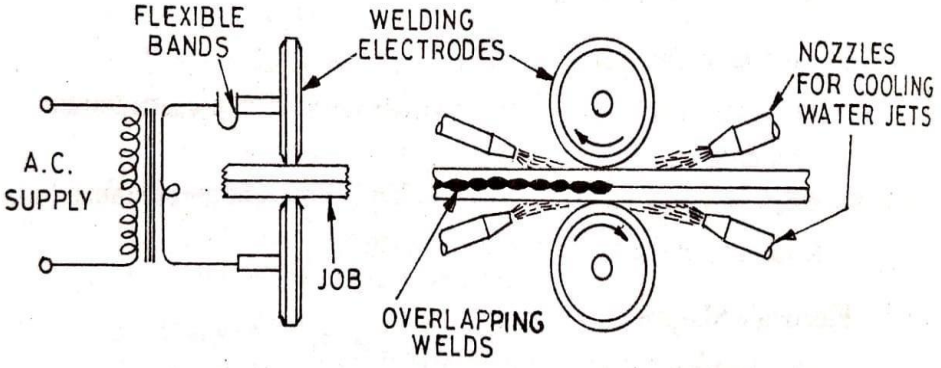


Fig. 5.17. Principle of seam welding.

Seam welding is a resistance welding process wherein coalescence at the faying surfaces is produced by the heat obtained from resistance to electric current (flow) through the work parts held together under pressure by electrodes. The resulting weld is a series of overlapping resistance-spot welds made progressively along a joint by rotating the circular electrodes .

Advantages of Seam Welding

(i) It can produce gas tight or liquid-tight joints.
(ii) Overlap can be less than for spot or projection welds.
(iii) A single seam weld or several parallel seams may be produced simultaneously.

Disadvantages of Seam Welding

(i) Welding can be done only along a straight or uniformly curved line.
(ii) It is difficult to weld thicknesses greater than 3 mm.
(iii) A change in the design of electrode wheels is required to avoidobstructions along the path of the wheels during welding.

Applications of Seam Welding

(i) Girth welds can be made in round, square or rectangular parts.
(ii) Except for copper and high copper alloys, most other metals of common industrial use can be seam welded.
(iii) Besides lap welds, seam-welding can be used for making butt seam welds too.

PROJECTION WELDING

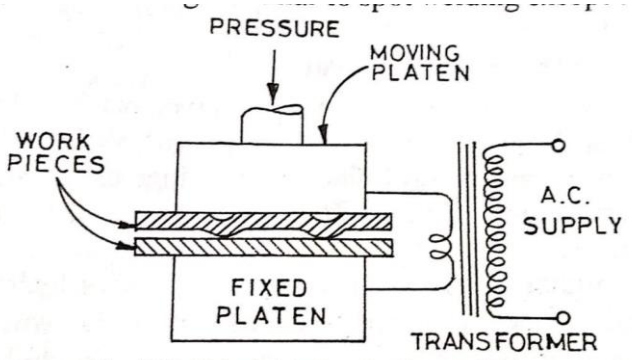


Fig. 5.21. Principle of projection welding.

Projection welding is a resistance welding process wherein coalescence is produced by the heat obtained from resistance to electric current flow through the work parts held together under pressure by electrodes. The resulting welds are localized at predetermined points by projections, embossments or intersections.

OPERATION

— Fig. 5.22 shows the stages in projection welding :

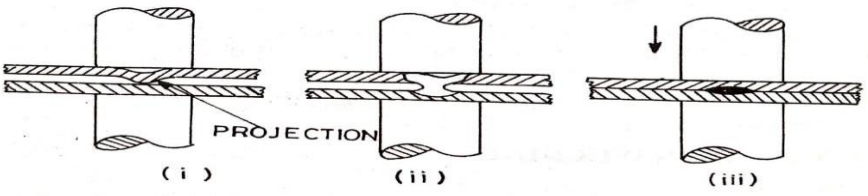


Fig. 5.22. Stages in projection welding.

These projections serve to concentrate(localize) the welding heat at these areas and facilitate fusion without the necessity of employing a large current.

(i) The projection in the upper piece is held in contact with the lower piece under electrode pressure.
(ii) The current flows and being localized to the region around the projection, heats the metal in that area to the plastic state.
(iii) The heated and softened projection collapses under the pressure of the electrodes thereby forming the weld.

Advantages of Projection Welding

- A number of welds can be made simultaneously.
- Projection welds can be made in metals that are too thick to be joined by spot welding.
- Scale, rust, oil and work-metal coatings interfere less with projection welding than with spot welding.

Applications of projection welding

- Automobiles have many areas that are projection welded.
- Small fasteners, nuts, etc. can be welded to larger components.
- Projection welding is particularly applicable to mass production work, e.g., the welding of refrigerator condensers, crossed wire welding, (refrigerator racks, gratings, grills) etc.

BRAZING & SOLDERING

BRAZING

Brazing is defined as a group of joining processes wherein coalescence is produced by heating to a suitable temperature and by using a filler metal having a liquidus above 800°F (470°C) and below the solidus of the base metals. In brazing, metallic parts are joined by a non-ferrous filler metal or alloy. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.

SOLDERING

Soldering is defined ás a group of welding processes that will produce a solid bond between two metal surfaces by heating them to a suitable temperature.(Fig. 10.19). The filler metal (solder) in this process must have a melting temperature below 427°C and below the melting point of the metal being joined.

Soldering vs **Brazing**

Comparison Chart

Soldering	Brazing
It is a low-temperature analog to brazing.	It is used to join a wide variety of similar or dissimilar metals.
It uses filler alloys with melting temperatures below 450 °C (840 °F).	It is done at temperatures above 450 °C but below the critical temperature of metal.
It is mainly used in electronic industries to form a permanent connection between the electronic components.	It is mainly used to join all kinds of metals used in electronic circuitry, pipe fittings, automotive
Base metal does not require preheating.	Base metal requires preheating.
Soldering creates stronger joints.	The joints are relatively weaker than with soldering.
The soldering process is comparatively cheaper than other metal-joining methods.	The brazing process is a bit pricey than soldering.

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Differences between Arc Welding and Gas Welding

The following table highlights several differences between arc welding and gas welding −

Arc Welding	Gas Welding
In the arc welding process, an electric arc is created to produce the required heat for fusing the base metal for coalescence formation.	In gas welding process, combustion of gaseous fuel with oxygen is employed to generate the required heat.
Arc welding can only be used for the metals which are electrically conductive.	Gas welding is equally applicable for both electrically conductive and non-conductive metals.
Electric arc welding requires availability of electric power supply for its operation.	No electric power supply is required in case of gas welding.
In case of arc welding, no cylinder containing fuel and oxygen is required.	In case of gas welding, two cylinders are employed, one for gaseous fuel such as acetylene, propylene, etc. While another is required for containing oxygen.
Arc welding process requires shielding of the arc and the weld bead which is provided either by flux coating of the electrode or some inert gas.	No shielding is provided in case of gas welding process.
As the arc temperature is very high, the temperature of the core is about more than 6000 °C. Therefore, arc welding can be used for joining of metals having high melting point.	Temperature of the gas flame is comparatively low, about 3500 °C. Therefore, gas welding cannot be used for welding of the metals having very melting point.
The electric arc has a narrow cross-sectional area. Therefore, it reduces the width of weld bead and heat affected zone.	The area of cross-section of the gas flame is relatively wider. Therefore, it results in wider weld bead and heat affected zone.
The high temperature and narrow electric arc increases the heat density, which results in quick fusion of metals.	The lower temperature and wider gas flame result in less heat density. Thus, gas welding requires more for the welding process, which makes it uneconomical.
Arc welding can be used for joining thicker components.	Gas welding is suitable only for thin plates and sheet metals.
Arc welding has inherent arc cleaning, due to flow of avalanche of electrons.	In gas welding process, no arc cleaning takes place. Hence, the base metal requires cleaning prior to welding.
Arc welding is not suitable for heating, cleaning, cutting, etc.	In addition to the joining of metals, the gas welding can be used for heating, gas cutting, brazing, soldering and cleaning, etc.