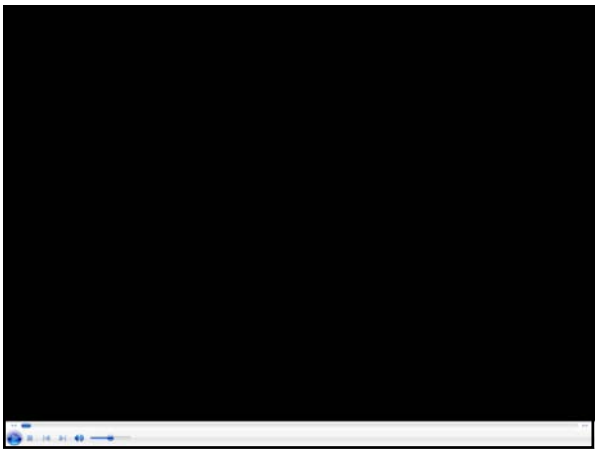


Welding Definition

- Welding is a process by which two materials, usually metals, are permanently joined together by coalescence, which is induced by a combination of temperature, pressure, and metallurgical conditions.
- The particular combination of these variables can range from high temperature with no pressure to high pressure with no increase in temperature.
  - Welding (positive process)
  - Machining (negative process)
  - Forming, casting (zero process)

Requirement for a high quality welding

1. A source of satisfactory heat and/or pressure,
2. A means of protecting or cleaning the metal, and
3. Caution to avoid, or compensate for, harmful metallurgical effects.

Classification of welding processes

- Oxy fuel gas welding (OFW)
- Arc welding (Aw)
- Resistance welding
- Solid state welding (friction welding, ultrasonic welding, forge welding etc.)

- Unique process
  - Thermit welding
  - Laser beam welding
  - Electroslag welding
  - Flash welding
  - Induction welding
  - Electron beam welding

Weldability / Fabrication Processes

- The weldability of a material will depend on the specific welding or joining process being considered.
- For resistance welding of consistent quality, it is usually necessary to remove the oxide immediately before welding.
- Fabrication weldability test is used to determine mechanical properties required for satisfactory performance of welded joint.
- The correct sequence of the given materials in ascending order of their weldability is

Aluminum < copper < cast iron < MS

Contd...

Case of Aluminium

- The oxide coating on aluminum alloys causes some difficulty in relation to its weldability.
- It also has high thermal conductivity and a very short temperature range between liquidus and solidus and when liquid its viscosity is very low.
- Aluminium is poor absorber of laser light.
- During fusion welding, the aluminum would oxidize so readily that special fluxes or protective inert-gas atmospheres must be employed.
- Friction welding and TIG welding is good for aluminium.
- For aluminium AC current plus high frequency is must.

Case of Cast Iron

- Cast iron is more difficult to weld because of its high carbon content and brittleness (poor ductility)
- Massive carbon deposits have a tendency to form in the areas adjacent to the weld, and high-carbon martensite tends to form in the heat-affected zones. These microstructures are very brittle and may crack spontaneously while welding is in progress or later when load is applied to the workpiece.
- Cast iron can be joined by the oxyacetylene brazing process and shielded metal-arc welding (stick) process.
- Some cases preheating and/or post heating is required.

Case of Stainless Steel

- Stainless steel is a difficult metal to weld because it contains both nickel and chromium.
- The best method for welding stainless steel is TIG welding.
- The electric arc is also preferred for welding stainless steels. A heavily coated welding rod, which produce a shielded arc, is employed.
- You must do a better job of pre-cleaning.
- Using a low arc current setting with faster travel speeds is important when welding stainless steel, because some stainless steels are subject to carbide precipitation.

Contd.....

Case of Stainless Steel

- The ferritic stainless steels are generally less weldable than the austenitic stainless steel and require both preheating and postweld heat treatments.
- Welds of ferritic stainless steel can be by
  - (i) autogenously (i.e. without the addition of filler metal)
  - (ii) with an austenitic stainless steel
  - (iii) using a high nickel filler alloy.
  - (iv) Type 405 filler (low 11% Cr, low carbon and small 0.2% Al)
- Welding process: TIG, MIG, Shielded-metal arc welding and Plasma arc welding

IES 2010

Assertion (A): It is generally difficult to weld Aluminum parts by normal arc welding process.

Reason (R): Hard and brittle Aluminum-oxide film is formed at the welded joints.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

IES-2006

Assertion (A): Aluminium has poor weldability.

Reason (R): Aluminium has high thermal conductivity and high affinity to oxygen.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is **not** the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

IES 2011

During plasma arc welding of aluminium, improved removal of the surface oxide from the base metal is obtained with typical polarity of :

(a) DC Straight

(b) DC reverse

(c) AC potential

(d) Reverse polarity of phase of AC potential

IES 2011

Consider the following statements.

Cast iron is difficult to weld, because of

1. Low ductility
2. Poor fusion
3. Tendency to crack on cooling

Which of these statements are correct ?

(a) 1, 2 and 3

(b) 1 and 2 only

(c) 2 and 3 only

(d) 1 and 3 only

IES-2006

Fabrication weldability test is used to determine

(a) Mechanical properties required for satisfactory performance of welded joint

(b) Susceptibility of welded joint for cracking

(c) Suitability for joint design

(d) Appropriate machining process

IES-1999

The correct sequence of the given materials in ascending order of their weldability is

(a) MS, copper, cast iron, aluminium

(b) Cast iron, MS, aluminium copper

(c) Copper, cast iron, MS, aluminium

(d) Aluminium, copper, cast iron, MS

IES 2010

Weldability of ferritic stainless steel used in automotive exhaust system is improved by selecting stainless steel electrode having low content of

(a) Carbon (b) Nitrogen

(c) Chromium (d) Carbon and Nitrogen

IES 2010

Consider the following statements regarding welded joints:

1. It is a permanent type of joint.
2. It is reliable and economical for pressure vessel construction.
3. It is free from fabricational residual stresses.
4. Such joints are suitable for static loading only.
5. Welding is a versatile and flexible metal joining process.

Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 2, 3 and 4 only

(c) 1, 2, 3, 4 and 5 (d) 1, 2 and 5 only

Gas Flame Processes: Welding, Cutting and Straightening

- **Oxy-fuel gas Welding** (OFW): Heat source is the flame produced by the combustion of a fuel gas and oxygen.
- OFW has largely been replaced by other processes but it is still popular because of its portability and the low capital investment.
- Acetylene is the principal fuel gas employed.

- Combustion of oxygen and acetylene (C_2H_2) in a welding torch produces a temp. in a two stage reaction.
- In the first stage

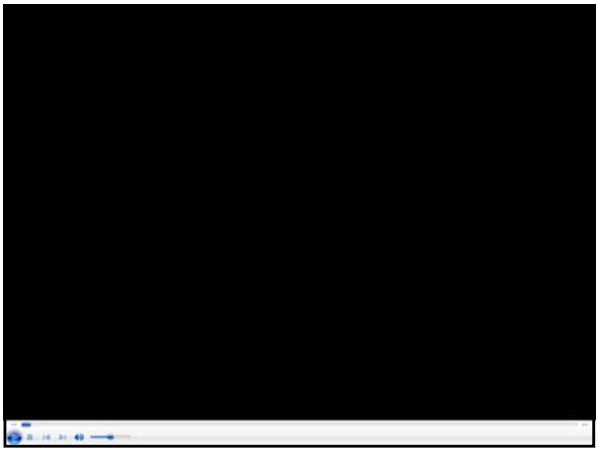
$$C_2H_2 + O_2 \rightarrow 2CO + H_2 \quad + \text{Heat}$$

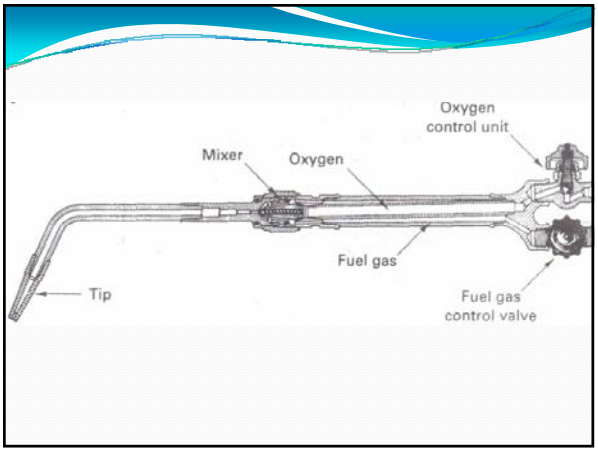
This reaction occurs near the tip of the torch.

- In the second stage combustion of the CO and H_2 and occurs just beyond the first combustion zone.

$$2CO + O_2 \rightarrow 2CO_2 + \text{Heat}$$
$$H_2 + \tfrac{1}{2}O_2 \rightarrow H_2O + \text{Heat}$$

Oxygen for secondary reactions is obtained from the atmosphere.



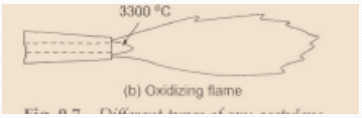


Three types of flames can be obtained by varying the oxygen/acetylene (or oxygen/fuel gas) ratio.

- If the ratio is about 1 : 1 to 1.15 : 1, all reactions are carried to completion and a neutral flame is produced.
- Most welding is done with a neutral flame, since it will have the least chemical effect on the heated metal.

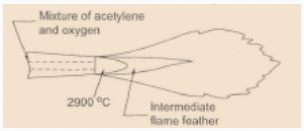
Oxy-acetylene gas welding neutral flame

- A higher ratio, such as 1.5 : 1, produces an oxidizing flame, hotter than the neutral flame (about 3300°C) but similar in appearance.
- Used when welding copper and copper alloys but harmful when welding steel because the excess oxygen reacts with the carbon, decarburizing the region around the weld.



Oxy-acetylene gas welding Oxidising flame

- Excess fuel, on the other hand, produces a carburizing flame.
- The excess fuel decomposes to carbon and hydrogen, and the flame temperature is not as great (about 3000°C).
- Flames of this type are used in welding Monel (a nickel-copper alloy), high-carbon steels, and some alloy steels, and for applying some types of hard-facing material.



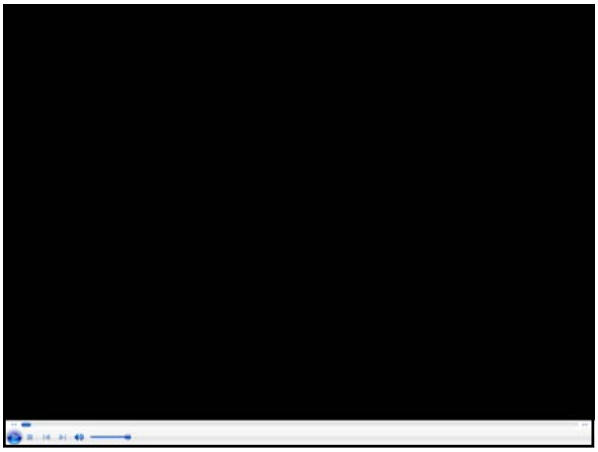
Oxy-acetylene gas welding Carburizing flame

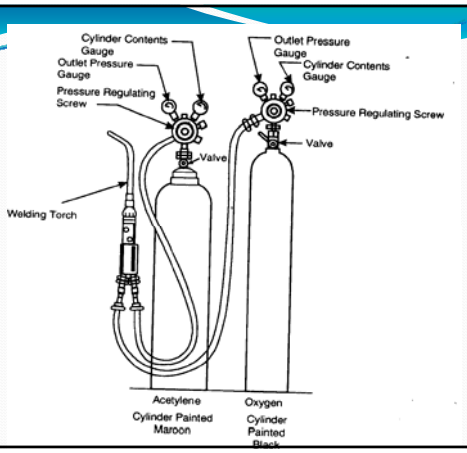
Metal	Flame
M S	N
High carbon steel	R
Grey cast iron	N, slightly oxidizing
Alloy steel	N
Aluminium	Slightly carburizing
Brass	Slightly oxidizing
Copper, Bronze	N, slightly oxidizing
Nickel alloys	Slightly carburizing
Lead	N

IES 2009 Conventional

Explain the three types of oxy-acetylene flames. Indicate with the help of sketches the various zones, respective temperature ranges and applications of each type of flame.

[20 – Marks]





Uses, Advantages, and Limitations

- OFW is **fusion welding**.
- **No pressure is involved**.
- Filler metal can be added in the form of a wire or rod.
- Fluxes may be used to clean the surfaces and remove contaminating oxide. The gaseous shield produced by vaporizing flux can prevent oxidation during welding, and the slag produced by solidifying flux can protect the weld pool. Flux can be added as a powder, the welding rod can be dipped in a flux paste, or the rods can be pre-coated.

Contd...

- Exposer of the heated and molten metal to the various gases in the flame and atmosphere makes it difficult to prevent contamination.
- Heat source is not concentrated, a large area of the metal is heated and distortion is likely to occur.
- Flame welding is still quite common in field work, in maintenance and repairs, and in fabricating small quantities of specialized products.

Oxy acetylene welding equipment

- Oxygen is stored in a cylinder at a pressure ranging from 13.8 MPa to 18.2 MPa .
- Due to high explosiveness of free acetylene it is stored in a cylinder with 80-85% porous calcium silicate and then filled with acetone which absorb upto 420 times by its volume at a pressure 1.75 MPa .
- At the time of acetylene release if acetone comes with acetylene the flame would give a purple colour.
- Another option is acetylene generator.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

Pressure Gas Welding

- Pressure gas welding (PGW) or Oxyacetylene Pressure Welding is a process used to make butt joints between the ends of objects such as pipe and-railroad rail.
- The ends are heated with a gas flame to a temperature below the melting point, and the soft metal is then forced together under considerable pressure.
- This process, therefore, is actually a 'form of solid-state welding.

IES 2010

The ratio between Oxygen and Acetylene gases for neutral flame in gas welding is

(a) 2 : 1 (b) 1 : 2

(c) 1 : 1 (d) 4 : 1

GATE-1994

The ratio of acetylene to oxygen is approximately..... for a neutral flames used in gas welding.

(a) 1 : 1

(b) 1 : 2

(c) 1 : 3

(d) 1.5 : 1

GATE-2003

In Oxyacetylene gas welding, temperature at the inner cone of the flame is around

(a) 3500°C

(b) 3200°C

(c) 2900°C

(d) 2550°C

IES 2010

Assertion (A): Oxidizing flame is used in gas welding to join medium carbon steels having high melting point.

Reason (R): In gas welding, oxidizing flame produces the maximum temperature compared to neutral and reducing flame.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

GATE-2002

The temperature of a carburising flame in gas welding is that of a neutral or an oxidising flame.

(a) Lower than

(b) Higher than

(c) Equal to

(d) Unrelated to

IES-2009

By which one of the following methods gray cast iron is usually welded?

(a) TIG welding (b) MIG welding

(c) Gas welding (d) Arc welding

IES-1998

In oxy-acetylene gas welding, for complete combustion, the volume of oxygen required per unit of acetylene is

(a) 1

(b) 1.5

(c) 2

(d) 2.5

IAS 1994

In gas welding of mild steel using an oxy-acetylene flame. the total amount of acetylene consumed was 10 litre. The oxygen consumption from the cylinder is

(a) 5 litre

(b) 10 litre

(c) 15litre

(d) 20 litre

IAS-1995

Assertion (A): If neutral flame is used in oxy-acetylene welding, both oxygen and acetylene cylinders of same capacity will be emptied at the same time.

Reason (R): Neutral flame uses equal amounts of oxygen and acetylene.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is **not** the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Oxygen Torch Cutting (Gas Cutting)

- Iron and steel oxidize (burn) when heated to a temperature between 800°C to 1000°C.
- High-pressure oxygen jet (300 KPa) is directed against a heated steel plate, the oxygen jet burns the metal and blows it away causing the cut (kerf).
- For cutting metallic plates shears are used. These are useful for straight-line cuts and also for cuts up to 40 mm thickness.

Contd...

- For thicker plates with specified contour, shearing cannot be used and oxy-fuel gas cutting (OFC) is useful.
- Gas-cutting is similar to gas welding except torch tip.

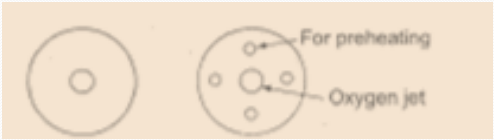
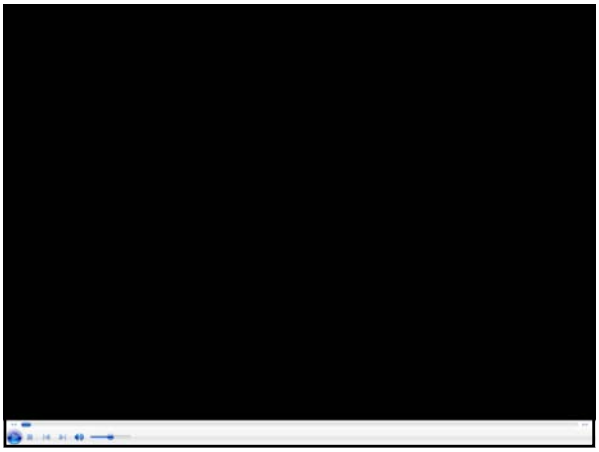


Fig- differences in torch tips for gas welding and gas cutting

Contd...



- Larger size orifice produces kerf width wider and larger oxygen consumed.
- At kindling temperature (about 870°C), iron form iron oxide.
- Reaction:

$$3Fe + 2O_2 \rightarrow Fe_3O_4 + 6.67 \text{ MJ/kg of iron}$$

The other reactions:

$$2Fe + O_2 \rightarrow 2FeO + 3.18 \text{ MJ/kg of iron}$$

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3 + 4.9 \text{ MJ/kg of iron}$$

- All exothermic reactions preheat the steel.

Contd...

- For complete oxidation 0.287 m^3 oxygen/kg of iron is required
- Due to unoxidized metal blown away the actual requirement is much less.
- Torch tip held vertically or slightly inclined in the direction of travel.
- Torch position is about 1.5 to 3 mm vertical from plate.

Contd...

- The drag lines shows the characteristics of the movement of the oxygen stream.

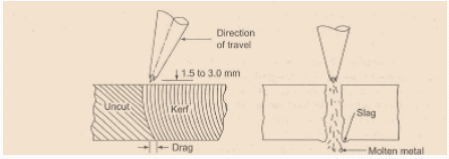


Fig- positioning of cutting torch in oxy- fuel gas cutting

- Drag is the amount by which the lower edge of the drag line trails from the top edge.
- Good cut means negligible drag.

Contd...

- If torch moved **too rapidly**, the bottom does not get sufficient heat and produces large drag so very rough and irregular-shaped-cut edges.
- If torch **moved slowly** a large amount of slag is generated and produces irregular cut.

Contd...

- Gas cutting is more useful with thick plates.
- For thin sheets (less than 3 mm thick) tip size should be small. If small tips are not available then the tip is inclined at an angle of 15 to 20 degrees.

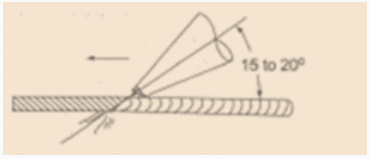
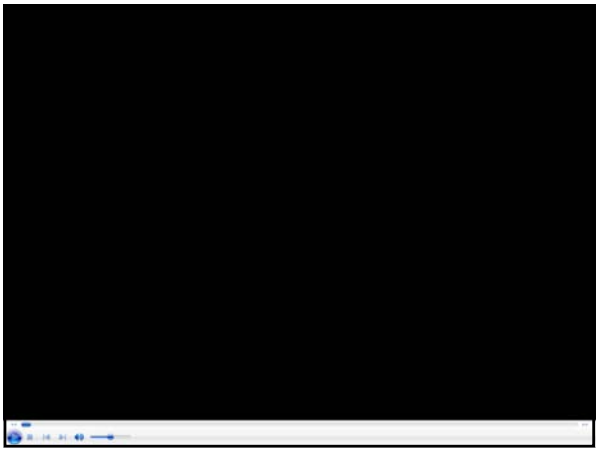


Fig. Recommended torch position for cutting thin steel



Application

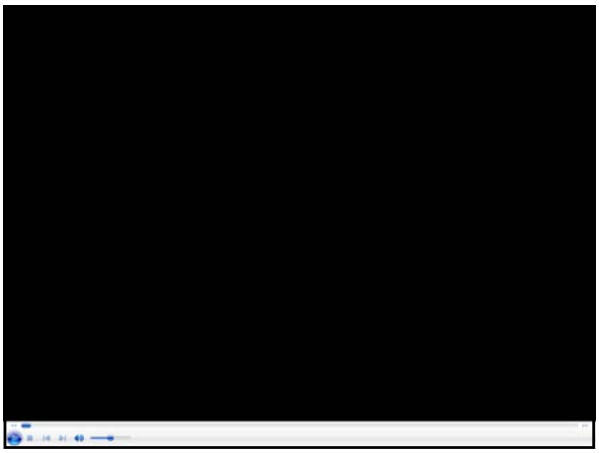
- Useful only for materials which readily get oxidized and the oxides have lower melting points than the metals.
- Widely used for ferrous materials.
- Cannot be used for aluminum, bronze, stainless steel and like metals since they resist oxidation.

Difficulties

- Metal temperature goes beyond lower critical temperature and structural transformations occur.
- Final microstructure depends on cooling rate.
- Steels with less than 0.3 % carbon cause no problem.

Contd...

- For high carbon steel material around the cut should be preheated (about 250 to 300°C) and may post heat also necessary.
- Cutting CI is difficult, since its melting temp. is lower than iron oxide.
- If chromium and nickel etc are present in ferrous alloys oxidation and cutting is difficult.



IES-1992

The edge of a steel plate cut by oxygen cutting will get hardened when the carbon content is

(a) Less than 0.1 percent
(b) Less than 0.3 percent
(c) More than 0.3 percent
(d) Anywhere between 0.1 to 1.0 percent

IES 2007

Consider the following statements in respect of oxy-acetylene welding:

1. The joint is not heated to a state of fusion.
2. No pressure is used.
3. Oxygen is stored in steel cylinder at a pressure of 14 MPa.
4. When there is an excess of acetylene used, there is a decided change in the appearance of flame.

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1, 2 and 4

IES-2001

Oxyacetylene reducing flame is used while carrying out the welding on

(a) Mild steel (b) High carbon steel
(c) Grey cast iron (d) Alloy steels

IES-1992

Thick steel plate cut with oxygen normally shows signs of cracking. This tendency for cracking can be minimised by

(a) Slow speed cutting
(b) Cutting in two or more stages
(c) Preheating the plate
(d) Using oxy-acetylene flame

IES-2005

Consider the following statements:

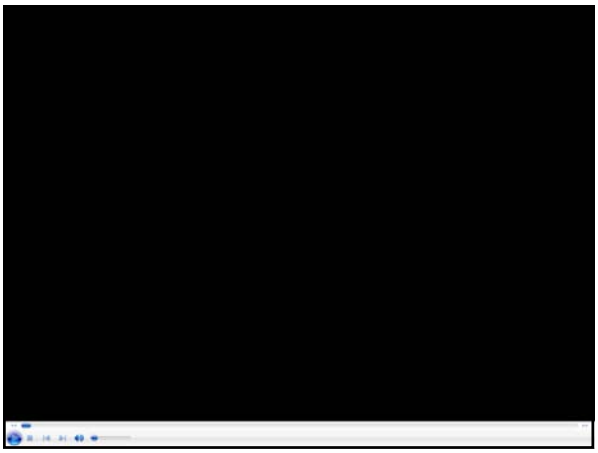
1. In gas welding, the torch should be held at an angle of 30° to 45° from the horizontal plane.
2. In gas welding, the Size of the torch depends upon the thickness of metal to be formed.
3. Drag in gas cutting is the time difference between heating of the plate and starting the oxygen gas for cutting.

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

Plasma Cutting

- Uses ionized gas jet (plasma) to cut materials resistant to oxy-fuel cutting,
- High velocity electrons generated by the arc impact gas molecules, and ionize them.
- The ionized gas is forced through nozzle (upto 500 m/s), and the jet heats the metal, and blasts the molten metal away.
- More economical, more versatile and much faster (5 to 8 times) than oxyfuel cutting, produces narrow kerfs and smooth surfaces.
- HAZ is 1/3 to ¼ th than oxyfuel cutting.
- Maximum plate thickness = 200 mm



Electric Arc Welding

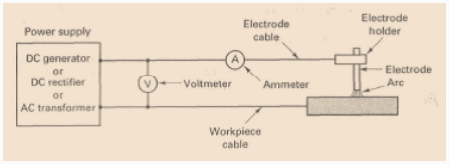


Fig. Basic circuit for arc welding

Principle of Arc

- An arc is generated between cathode and anode when they are touched to establish the flow of current and then separated by a small distance.
- 65% to 75% heat is generated at the anode.
- If DC is used and the work is positive (the anode of the circuit), the condition is known as **straight polarity** (SPDC).

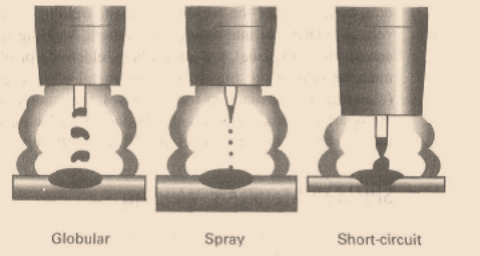
Contd...

- Work is negative and electrode is positive is reverse polarity (RPDC).
- SPDC conditions are preferred.
- DC arc-welding maintain a stable arc and preferred for difficult tasks such as overhead welding.
- For a stable arc, the gap should be maintained.

Contd...

- Manual arc welding is done with shielded (covered) electrodes
- Bare-metal wire used in automatic or semiautomatic machines.
- Non consumable electrodes (e.g tungsten) is not consumed by the arc and a separate metal wire is used as filler.
- There are three modes of metal transfer (globular, spray and short-circuit).

Three modes of metal transfer during arc welding



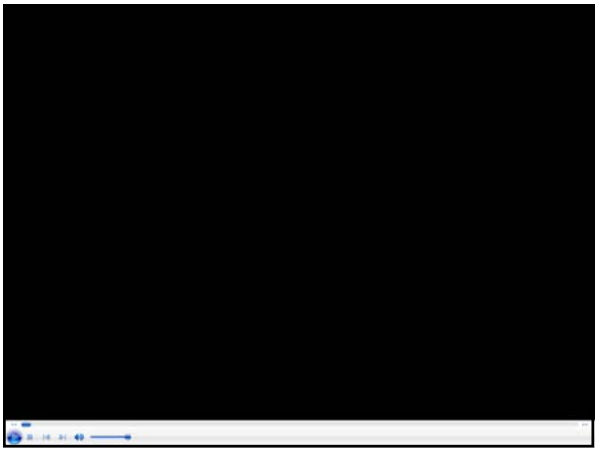
Major Forces take part in Metal Transfer

(i) gravity force

(ii) Surface tension

(iii) electromagnetic interaction

(iv) hydrodynamic action of plasma



JWM 2010

Assertion (A) : Bead is the metal added during single pass of welding.

Reason (R) : Bead material is same as base metal.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

GATE-1993

In d.c. welding, the straight polarity (electrode negative) results in

(a) Lower penetration

(b) Lower deposition rate

(c) Less heating of work piece

(d) Smaller weld pod

Arc welding equipments

1. Droopers: Constant current welding machines
   - Good for manual welding
2. Constant voltage machines
   - Good for automatic welding

Contd...

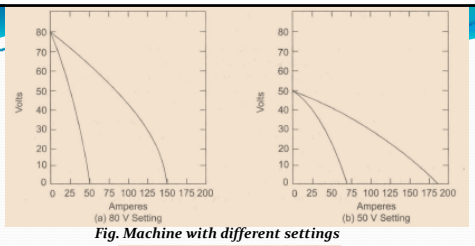


Fig. Machine with different settings

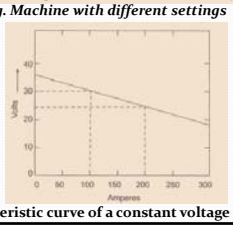
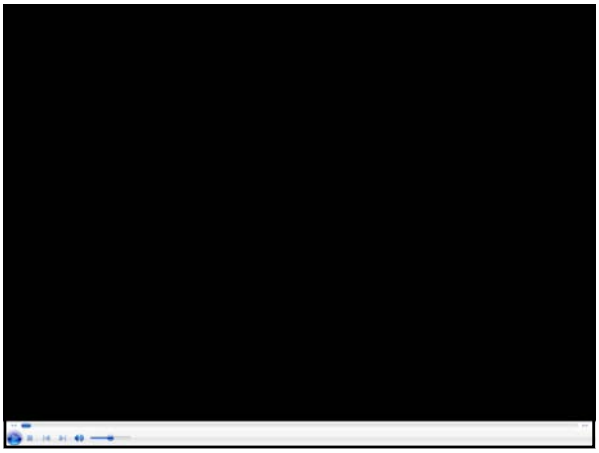


Fig. Characteristic curve of a constant voltage arc-welding machine

Formula

$$\frac{V}{OCV}+\frac{I}{SCC}=1$$

- Requires a large current (150 to **1000** A), voltage is between 30 and 40 V, actual voltage across the arc varying from 12 to 30 V.
- To initiate a weld, the operator strike the electrode and start arc.



IES 2010

In arc welding, the arc length should be equal to

(a) 4.5 times the rod diameter
(b) 3 times the rod diameter
(c) 1.5 times the rod diameter
(d) Rod diameter

IES-2005

Consider the following statements:

1. In arc welding, 65% to 75% heat is generated at the anode.
2. Duty cycle in case of arc welding is the cycle of complete welding of work piece from the beginning.
3. Arc blow is more common with DC welding.

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1 and 3

IES-2001

In manual arc welding, the equipment should have drooping characteristics in order to maintain

(a) Voltage constant when arc length changes
(b) Current constant when arc length changes
(c) Temperature in the are constant
(d) Weld pool red-hot

IES-2001

In arc welding, d.c. reverse polarity is used to bear greater advantage in

(a) Overhead welding
(b) Flat welding of lap joints
(c) Edge welding
(d) Flat welding of butt joints

IES-1998

The voltage-current characteristics of a dc generator for arc welding is a straight line between an open-circuit voltage of 80 V and short-circuit current of 300 A. The generator settings for maximum arc power will be

(a) 0 V and 150 A (b) 40 V and 300 A
(c) 40 V and 150 A (d) 80 V and 300 A

IAS-1999

Open-circuit voltage of 60 V and current of 160A were the welding conditions for arc welding of a certain class of steel strip of thickness 10 mm. For arc welding of 5mm thick strip of the same steel, the welding voltage and current would be

(a) 60 V and 80 A
(b) 120 V and 160 A
(c) 60 V and 40 A
(d) 120 V and 40 A

IAS-1998

Assuming a straight line V-I characteristics for a dc welding generator, short circuit current as 400A and open circuit voltage as 400 which one of the following is the correct voltage and current setting for maximum arc power?

(a) 400 A and 100 V (b) 200 A and 200 V
(c) 400 A and 50 V (d) 200 A and 50 V

Duty Cycle

- The percentage of time in a 5 min period that a welding machine can be used at its rated output without overloading.
- Time is spent in setting up, metal chipping, cleaning and inspection.
- For manual welding a 60% duty cycle is suggested and for automatic welding 100% duty cycle.

Contd...

Required duty cycle, $T_a = \left(\frac{I}{I_a}\right)^2 T$

Where ,T = rated duty cycle

I = rated current at the rated duty cycle

I_o = Maximum current at the rated duty cycle

Electrode

1. Non-consumable Electrodes
2. Consumable Electrodes

Non-consumable Electrodes

- Made of carbon, Graphite or Tungsten.
- Carbon and Graphite are used for D.C.
- Electrode is not consumed, the arc length remains constant, arc is stable and easy to maintain.

Contd...

Consumable Electrodes

- Provides filler materials.
- Same composition.
- This requires that the electrode be moved toward or away from the work to maintain the arc and satisfactory welding conditions.

Contd...

Consumable electrodes are three kinds:

(a) Bare

(b) Fluxed or lightly coated

(c) Coated or extruded / shielded

- For automatic welding, bare electrode is in the form of continuous wire (coil).

Electrode coating characteristic

1. Provide a protective atmosphere.
2. Stabilize the arc.
3. Provide a protective slag coating to accumulate impurities, prevent oxidation, and slow the cooling of the weld metal.
4. Reduce spatter.
5. Add alloying elements.
6. Affect arc penetration
7. Influence the shape of the weld bead.
8. Add additional filler metal.

GATE-1994

The electrodes used in arc welding are coated. This coating is not expected to

(a) Provide protective atmosphere to weld
(b) Stabilize the are
(c) Add alloying elements
(d) Prevents electrode from contamination

Electrode coatings

l. Slag Forming Ingredients. asbestos, mica, silica, fluorspar, titanium dioxide, Iron oxide, magnesium carbonate, Calcium carbonate and aluminium oxide.

2. Arc Stabilizing Ingredients. or ionizing agents: potassium silicate, TiO_2 + ZrO_2 (Rutile), Mica, Calcium oxide, sodium oxide, magnesium oxide, feldspar ($KAI\ Si_3\ O_8$)

Contd...

3. Deoxidizing Ingredients. Cellulose, Calcium carbonate, dolo- mite, starch, dextrin, wood flour, graphite, aluminium, ferromanganese.

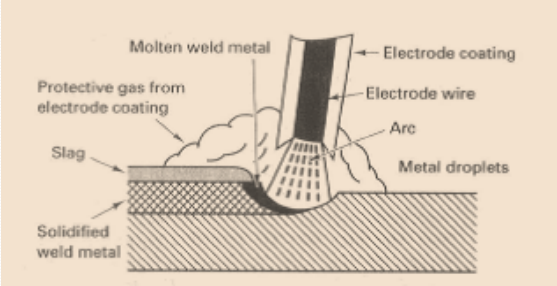
4. Binding Materials Sodium silicate, potassium silicate, asbestos.

5. Alloying Constituents to Improve Strength of Weld

6. TiO_2 and potassium compounds increase the melting rate of the base metal for better penetration.

7. Iron powder provides higher deposition rate.

Contd...



Contd...

- The slag is then easily chipped.
- Coatings are designed to melt more slowly than the filler wire.

Binders

- AC arc welding used potassium silicate binders.
- DC arc welding used sodium silicate binders.
- Potassium has a lower ionization potential as compared with sodium.

IES 2007

The coating material of an arc welding electrode contains which of the following?

1. Deoxidising agent
2. Arc stabilizing agent
3. Slag forming agent

Select the correct answer using the code given below:

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

IES-1997

Assertion (A): The electrodes of ac arc welding are coated with sodium silicate, whereas electrodes used for dc arc welding are coated with potassium silicate binders.

Reason (R): Potassium has a lower ionization potential than sodium.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-2002

Match List I with List II and select the correct answer:

List I (Ingredients) functions)	**List II (Welding**
A. Silica	1. Arc stabilizer
B. Potassium oxalate	2. De-oxidizer
C. Ferro silicon	3. Fluxing agent
D. Cellulose	4. Gas forming material

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	3	4	2	1	(b)	2	1	3	4
(c)	3	1	2	4	(d)	2	4	3	1

Welding Flux

Available in three forms

- Granular
- Electrode wire coating
- Electrode core

Welding Positions

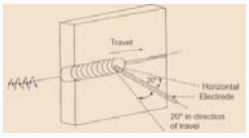


Fig. The position of electrode for horizontal welding

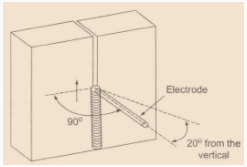


Fig. Positioning of electrode for welding in vertically upward position

Welding Current

- Welding current depends upon: the thickness of the welded metal, type of joint, welding speed, position of the weld, the thickness and type of the coating on the electrode and its working length.
- Welding current, I = k. d, amperes; d is dia. (mm)

Welding Voltage

- The arc voltage depends only upon the arc length

$V = k_1 + k_2 l$ Volts

Where l is the arc length in mm and k_1 and k_2 are constants,

k_1 = 10 to 12; and k_2 = 2 to 3

The minimum Arc voltage is given by

$V_{min} = (20 + 0.04\ l)$ Volt

Arc Length

- For good welds, a short arc length is necessary, because:
  1. Heat is concentrated.
  2. More stable
  3. More protective atmosphere.

Contd...

A long arc results in

- Large heat loss into atmosphere.
- Unstable arc.
- Weld pool is not protected.
- Weld has low strength, less ductility, poor fusion and excessive spatter.

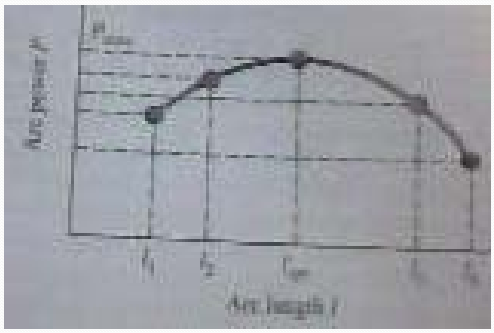
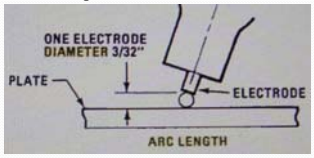
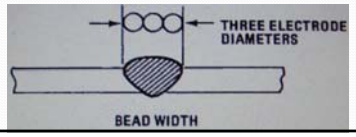


Fig. Arc Power Vs Arc Length

Arc length should be equal to the diameter of the electrode size



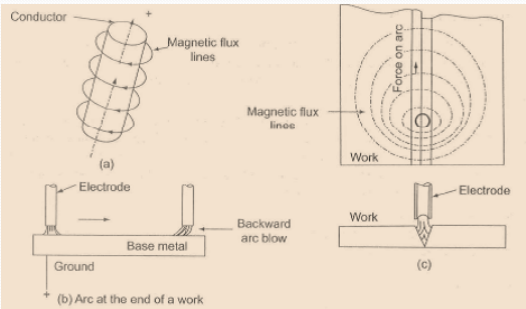
Bead width should be equal to three diameter of the electrode size



GATE-2002, Conventional

The arc length-voltage characteristic of a DC arc is given by the equation: V = 24 + 4L, where V is voltage in volts and L is arc length in mm. The static volt-ampere characteristic of the power source is approximated by a straight line with a no load voltage of 80 V and a short circuit current of *600A. Determine the optimum arc length for maximum power.*

Arc blow in DC arc welding



Contd...

- Arc blow occurs during the welding of magnetic materials with DC.
- The effect of arc blow is maximum when welding corners where magnetic field concentration is maximum.
- The effect is particularly noticeable when welding with bare electrodes or when using currents below or above
- Again the problem of arc blow gets magnified when welding highly magnetic materials such as Ni alloys, because of the strong magnetic fields set up by these metals.
- Cause: Unbalanced magnetic forces.

Contd...

Effect of arc blow

- Low heat penetration.
- Excessive weld spatter.
- Pinch effect in welding is the result of electromagnetic forces
- Weld spatter occurs due to
  - High welding current
  - Too small an electrode arc

Contd...

The effects of arc blow can be minimized with D.C. welding by

- Shortening the arc.
- Reduce current
- Reducing weld speed.
- Balance magnetic field by placing one ground lead at each end of the work piece.
- Wrapping the electrode cable a few turns around the work piece.

IES-2001

Arc blow is more common in

(a) A.C. welding
(b) D.C. welding with straight polarity
(c) D.C. welding with bare electrodes
(d) A.C. welding with bare electrodes

IES-2001

Pinch effect in welding is the result of

(a) Expansion of gases in the arc
(b) Electromagnetic forces
(c) Electric force
(d) Surface tension of the molten metal

GATE-1992

A low carbon steel plate is to be welded by the manual metal arc welding process using a linear V - I characteristic DC Power source. The following data are available :

OCV of Power source = 62 V

Short circuit current = 130 A

Arc length, L = 4 mm

Traverse speed of welding = 15 *cm/s*

Efficiency of heat input = 85%

Voltage is given as V = 20 + 1.5 L

Calculate the heat input into the workprice

Gas shields

- An inert gas is blown into the weld zone to drive away other atmospheric gases.
- Gases are argon, helium, nitrogen, carbon dioxide and a mixture of the above gases.
- Argon ionizes easily requiring smaller arc voltages.It is good for welding thin sheets.

Contd...

- Helium, most expensive, has a better thermal conductivity, is useful for thicker sheets, copper and aluminium welding, higher deposition rate.
- The arc in carbon dioxide shielding gas is unstable, least expensive, deoxidizers needed.
- It is a heavy gas and therefore covers the weld zone very well.

Carbon Arc welding

- Arc is produced between a carbon electrode and the work.
- Shielding is not used.
- No pressure
- With or without filler metal
- May be used in "twin arc method", that is, between two carbon (graphite) electrodes.

IES 2010

Assertion (A): Straight polarity is always recommended for Carbon-electrode welding.

Reason (R): Carbon arc is stable in straight polarity.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

Tungsten Inert Gas welding (TIG)

- Arc is established between a non-consumable tungsten electrode and the workpiece.
- Tungsten is alloyed with thorium or zirconium for better current-carrying and electron-emission characteristics.
- Arc length is constant, arc is stable and easy to maintain.
- With or without filler.

Contd...

- Very clean welds.
- All metals and alloys can be welded. (Al, Mg also)
- Straight polarity is used.
- Weld voltage 20 to 40 V and weld current 125 A for RPDC to 1000 A for SPDC.
- Shielded Gas: Argon
- Torch is water or air cooled.

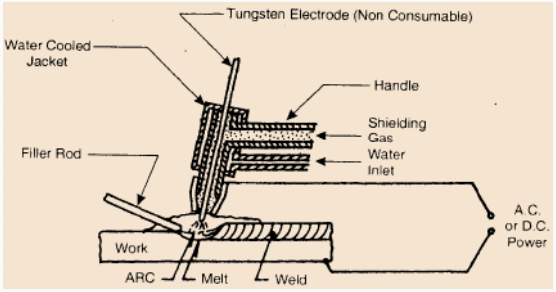
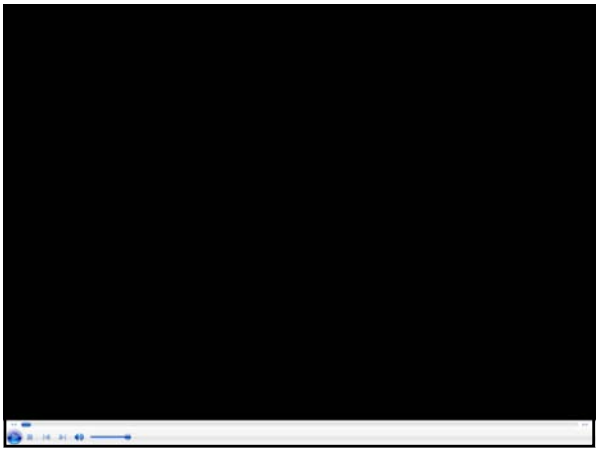


Fig. TIG



GATE 2011

Which one among the following welding processes used non – consumable electrode?

(a) Gas metal arc welding
(b) Submerged arc welding
(c) Gas tungsten arc welding
(d) Flux coated arc welding

IES 2010

In an inert gas welding process, the commonly used gas is

(a) Hydrogen
(b) Oxygen
(c) Helium or Argon
(d) Krypton

GATE-2002

Which of the following arc welding processes does not use consumable electrodes?

(a) GMAW
(b) GTAW
(c) Submerged Arc Welding
(d) None of these

IES-1994

Which one of the following welding processes uses non- consumable electrodes?

(a) TIG welding
(b) MIG welding
(c) Manual arc welding
(d) Submerged arc welding.

IES-2000

Which one of the following statements is correct?

(a) No flux is used in gas welding of mild steel
(b) Borax is the commonly used flux coating on welding electrodes
(c) Laser beam welding employs a vacuum chamber and thus avoids use of a shielding method
(d) AC can be used for GTAW process

Gas Metal Arc Welding (GMAW) or MIG

- A **consumable electrode** in a gas shield.
- Arc is between workpiece and an automatically fed bare-wire electrode.
- Argon, helium, and mixtures of the two can be used.
- Any metal can be welded but are used primarily with the non-ferrous metals.
- When welding steel, some O_2 or CO_2 is usually added to improve the arc stability and reduce weld spatter.

Contd...

- Fast and economical.
- A reverse-polarity dc arc is generally used.

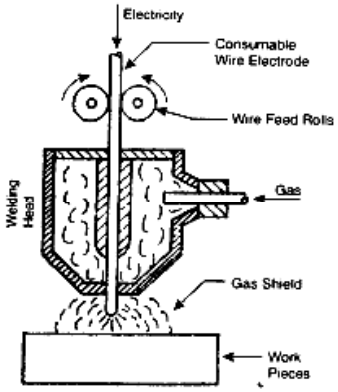
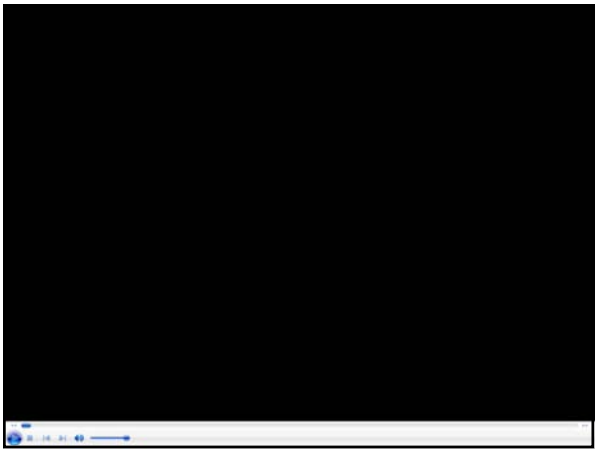


Fig. MIG



IES 2007

In MIG welding, the metal is transferred into the form of which one of the following?

(a) A fine spray of metal
(b) Molten drops
(c) Weld pool
(d) Molecules

IES-1997

Consider the following statements:

MIG welding process uses
1. Consumable electrode
2. non-consumable electrode
3. D.C. power supply
4. A.C. power supply

Of these statements
(a) 2 and 4 are correct
(b) 2 and 3 are correct
(c) 1 and 4 are correct
(d) 1 and 3 are correct

IES 2010

Assertion (A): Inert gas and bare electrode instead of flux coated electrode is used in the case of automatic TIG and MIG welding processes.

Reason (R): Better protection is provided by a cloud of inert gas than the cover created by the flux.

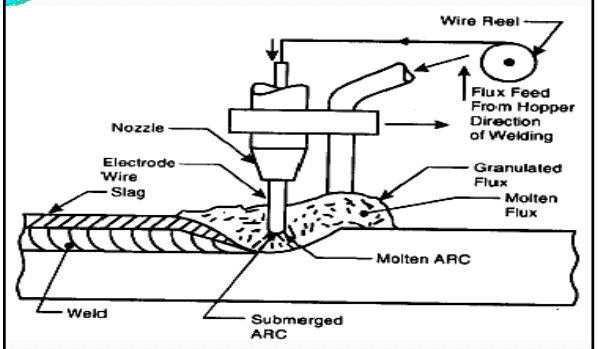
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

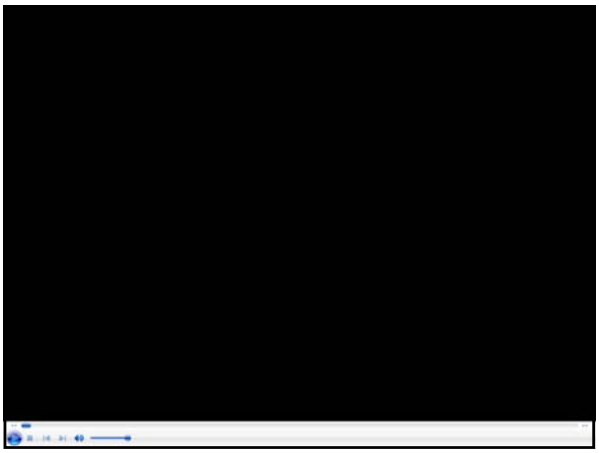
Submerged Arc welding (SAW)

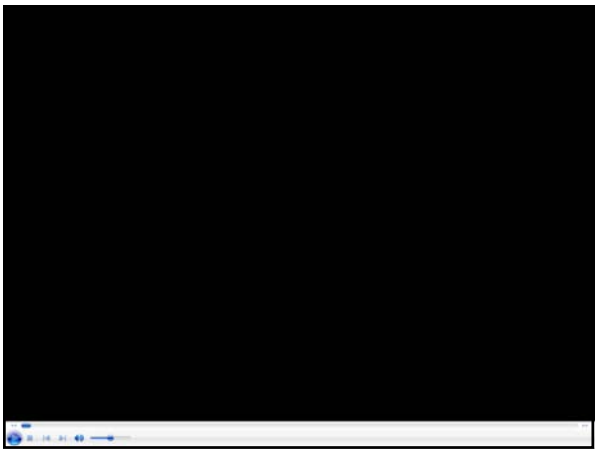
- A thick layer of granular flux is deposited just ahead of a bare wire consumable electrode, and an arc is maintained beneath the blanket of flux with only a few small flames being visible.
- A portion of the flux melts. Molten flux and flux provides thermal insulation, slows cooling rate and produce soft, ductile welds.

Contd...

- **Most suitable for flat butt or fillet welds in low carbon steel (< 0.3% carbon).**
- **The process is not recommended for high-carbon steels, tool steels, aluminum, magnesium, titanium, lead, or zinc.**







Characteristic of submerged arc welding

- High speeds,
- High deposition rates,
- Deep penetration,
- High cleanliness (due to the flux action).

Advantages

- Wire electrodes are inexpensive.
- No weld spatter.
- Nearly 100% deposition efficiency.
- Lesser electrode consumption.

Limitations

- Extensive flux handling,
- Contamination of the flux by moisture.
- Large-grain-size structures.
- Welding is restricted to the horizontal position.
- Chemical control is important

IES 2011

The welding process in which bare wire is used as electrode, granular flux is used and the process is characterized by its high speed welding, is known as:

(a) Shielded arc welding

(b) Plasma arc welding

(c) Submerged arc welding

(d) Gas metal arc welding

IES-2006

In which of the following welding processes, flux is used in the form of granules?

(a) AC arc welding
(b) Submerged arc welding
(c) Argon arc welding
(d) DC arc welding

IES-2005

Which of the following are the major characteristics of submerged arc welding?

1. High welding speeds.
2. High deposition rates.
3. Low penetration.
4. Low cleanliness.

Select the correct answer using the code given below:

(a) 2 and 3 (b) 1, 2 and 3
(c) 3 and 4 (d) 1 and 2

IES-2008

Assertion (A): Submerged arc welding is not recommended for high carbon steels, tool steels, aluminium, magnesium etc.

Reason (R): This is because of unavailability of suitable fluxes, reactivity at high temperatures and low sublimation temperatures.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

GATE-1999

For butt -welding 40 mm thick steel plates, when the expected quantity of such jobs is 5000 per month over a period of 10 year, choose the best suitable welding process out of the following available alternatives.

(a) Submerged arc welding
(b) Oxy-acetylene welding
(c) Electron beam welding
(d) MIG welding

Atomic Hydrogen welding (AHW)

- An a.c. arc is formed between two tungsten electrodes along which streams of hydrogen are fed to the welding zone. The molecules of hydrogen are dissociated by the high heat of the arc in the gap between the electrodes. The formation of atomic hydrogen proceeds with the absorption of heat:

  $H_2 = 2H - 421.2$ k J / mol

- This atomic hydrogen recombines to form molecular hydrogen outside the arc, particularly on the relatively cold surface of the work being welded, releasing the heat gained previously:

  $2H = H_2 + 421.2$ k J / mol.

Contd...

- Temperature of about 3700°C.
- Hydrogen acts as shielding also.
- Used for very thin sheets or small diameter wires.
- Lower thermal efficiency than Arc welding.
- Ceramics may be arc welded.
- AC used.

IES-2005

In atomic hydrogen welding, hydrogen acts as

(a) A heating agent
(b) One of the gases to generate the flame
(c) An effective shielding gas protecting the weld
(d) A lubricant to increase the flow characteristics of weld metal