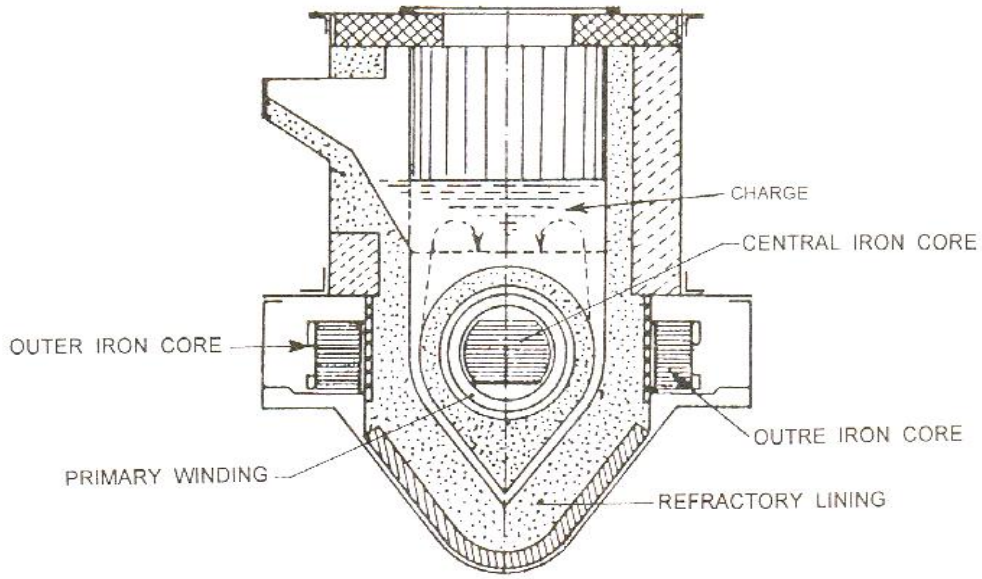
Solution for First Internal Test – 7th Semester EEE

Electrical Power Utilization-10EE72

1. The advantages of Electric heating over other conventional methods of heating are :
    - Economical : electric furnaces are cheaper in initial cost as well as maintenance cost. Electrical energy is also very cheap as it is being produced on a large scale.
    - Cleanliness :Since dust and ash are completely eliminated in electric heating system, it is a clean system and cleaning costs are rendered to a minimum.
    - Absence of flue gases : Since no flue gas is produced in this system, there is no risk of atmosphere or objects being heated and operation is hygienic.
    - Ease of control : Simple, accurate and reliable temperature control can be had either by hand operated or by fully automatic switches.
    - Automatic protection : Automatic protection against over currents or over heating can be provided through suitable switch gears in the electric heating system.
    - Upper limit of temperature : There is no upper limit of temperature obtainable obtainable except the ability of material to withstand heat.
    - Special heating requirements : Uniform heating of material, heating of one particular portion of job, heating of non – conducting materials and heating without oxidation can be met only in electric heating system.
    - High efficiency of Utilization : The overall efficiency of electric heating is comparatively higher since in this system, the source can be brought directly to the point where heat is required, thereby reducing the losses. There is no product of combustion in which heat losses are involved.
    - Better working conditions : Electric heating system produces no irritating noise and also the radiating losses are low.

- Safety : Electric heating is quite safe and responds quickly. 10Marks)

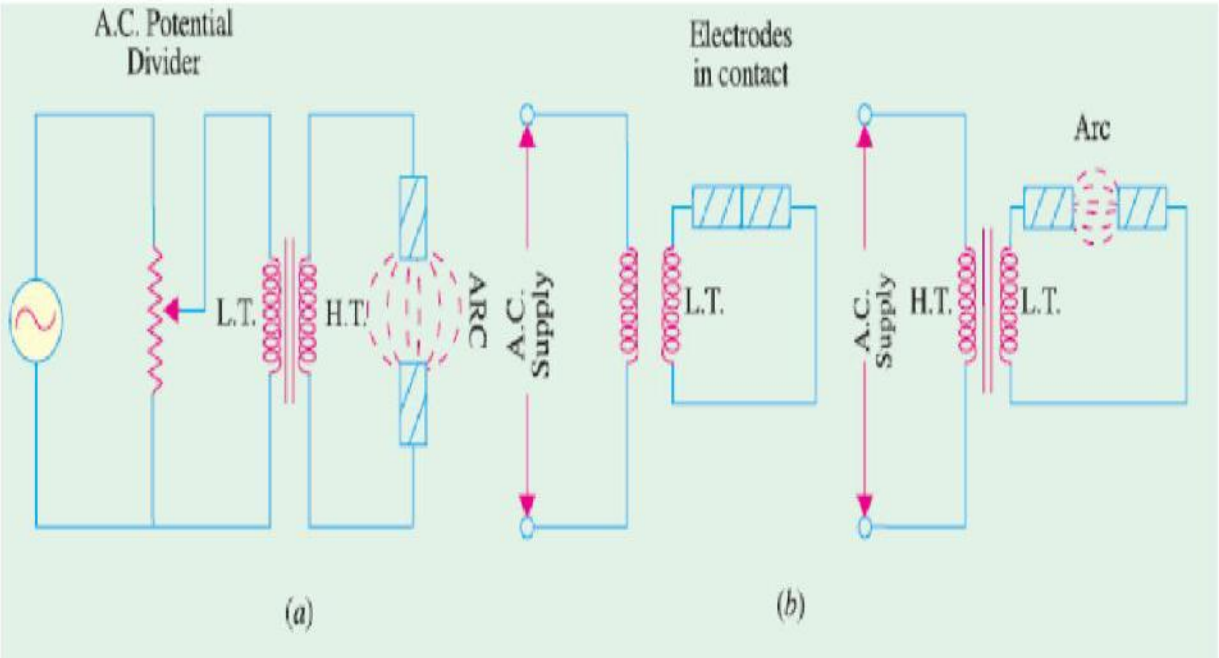
2. (a)Ajax Wyatt Vertical Core Furnace



It is an improvement over the core type induction furnace. The magnetic coupling in this furnace is better than core type furnace. Leakage reactance is comparatively low and frequency is high, hence it is high frequency furnace. It employs vertical crucible instead of horizontal. The circulation of Molten metal takes place round the 'V' portion by convection currents. Inside the furnace is lined depending upon the charge. The top of the furnace is covered with an insulated cover which can be removed for charging. Hydraulic arrangements are usually made for tilting the furnace to remove the molten metal. ----(7 Marks)

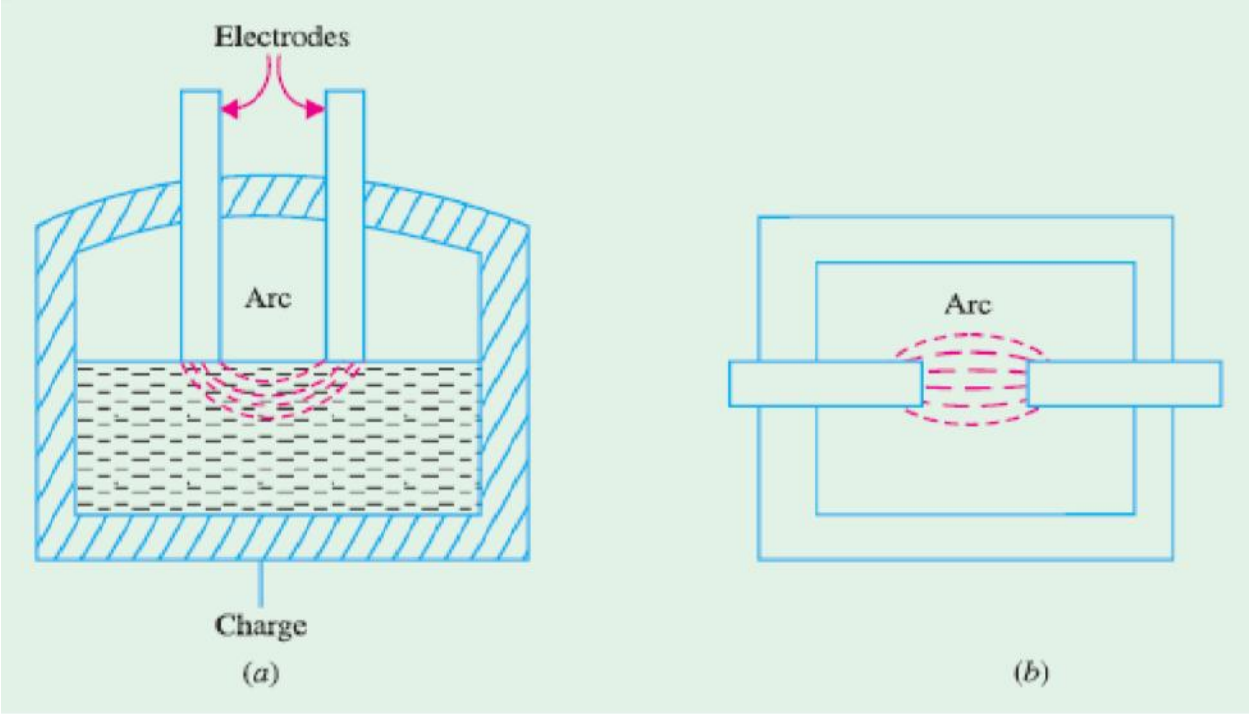
(b)It employs vertical crucible instead of horizontal. The system avoids the pinch effect due to the weight of the charge in the main body of the crucible. The magnetic coupling in this furnace is better than core type furnace. Leakage reactance is comparatively low and frequency is high, hence it is high frequency furnace.----------(3 Marks)

3. Arc furnaces



Principle of operation

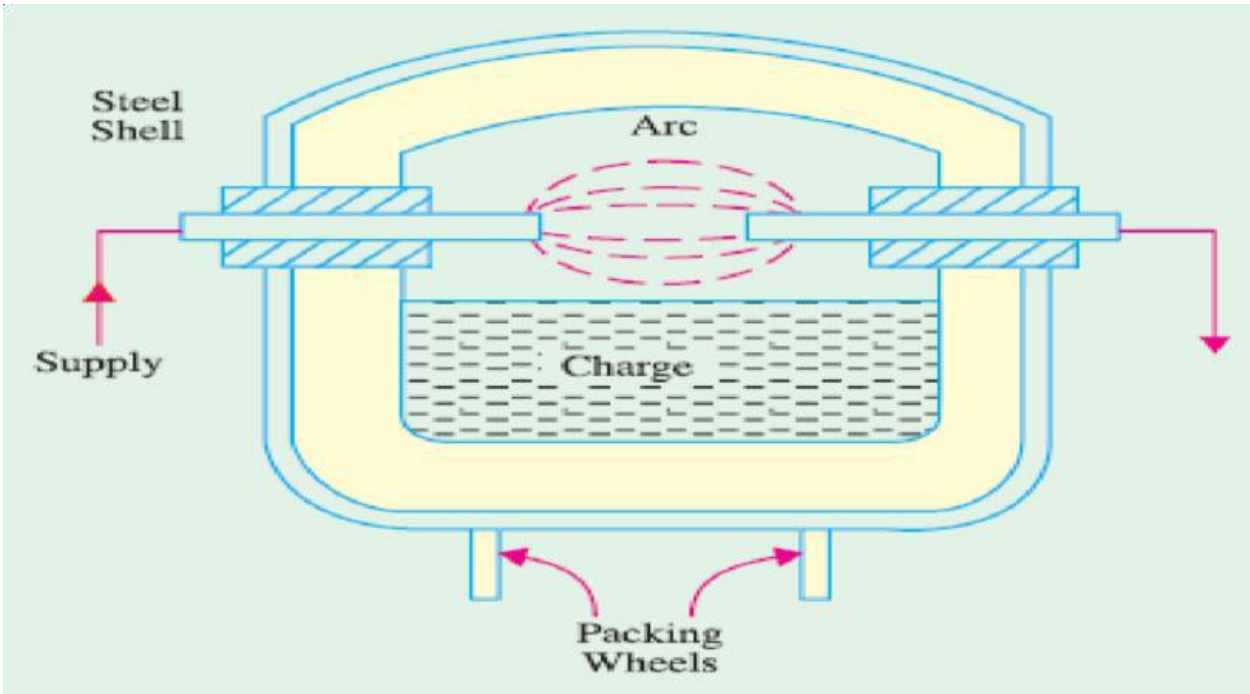
When a high voltage is applied across an air gap, the air in the gap gets ionized under the influence of electrostatic forces and becomes conducting medium.Current flows in the form of a continuous spark called the arc.A very high voltage is required to establish an arc across an air gap.To maintain an arc small voltage maybe sufficient.An arc can also be produced by short circuiting the two electrodes momentarily and then withdrawing them back.In this method, high voltage is not required.Arc drawn between two electrodes produces heat and has a temperature between 1000^0C and 3500^0C depending on the material of the electrodes used. There are two types of Arc Furnaces – Direct arc furnace and Indirect arc furnace.



Direct and Indirect Arc furnace

Direct Arc furnace

The arc is formed between the electrodes and the charge. In this type of furnace, charge acts as one of the electrodes and the charge is heated by producing arc between the electrodes and the charge. Here the arc in in direct contact with the charge and the heat is produced by the flow of current through the charge itself. Therefore the charge can be heated to the highest temperature. For a single phase arc furnace, two electrodes are taken vertically downward through the roof of the furnace to the surface of the charge. Direct Arc Furnace is commonly used for the production of Steel.



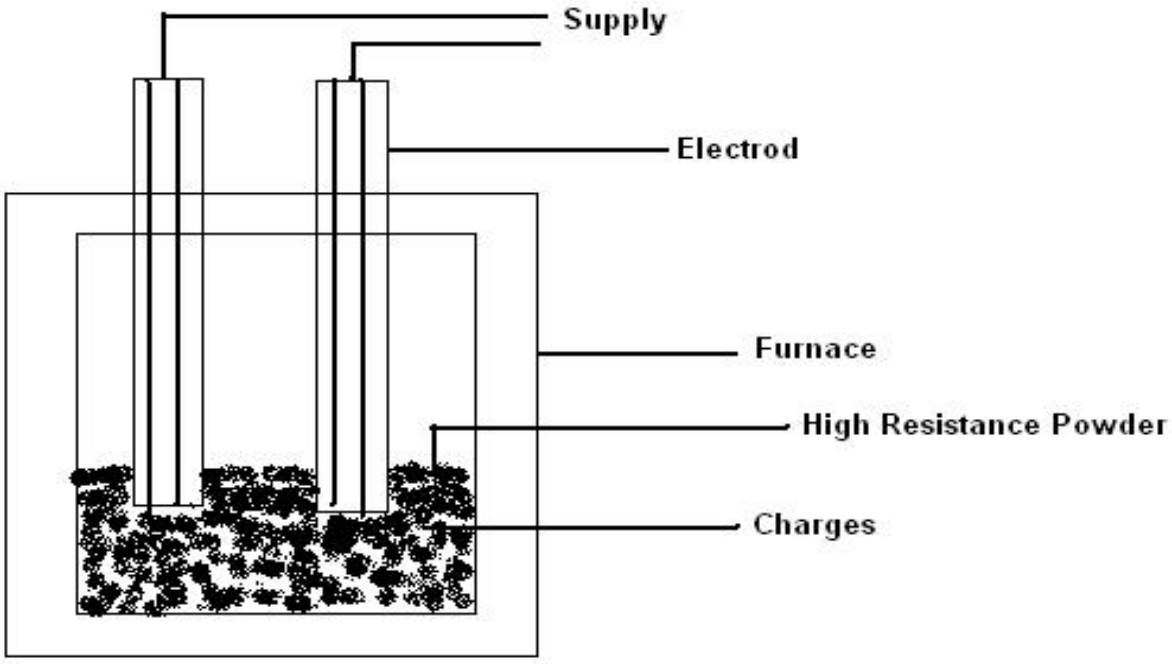
Indirect Arc Furnace

In this type of furnace, arc is formed between two electrodes above the charge.Heat is transmitted to the charge mainly by radiation.The temperature of the charge is lower than that in the case of direct arc furnace.Since in this furnace, current does not flow through the charge, there is no stirring action and the furnace is required to be rocked mechanically.Therefore the furnace is made of cylindrical shape, with the electrodes projecting through the chamber from each end and along the horizontal axis. ……(10 Marks)

4. Resistance heating

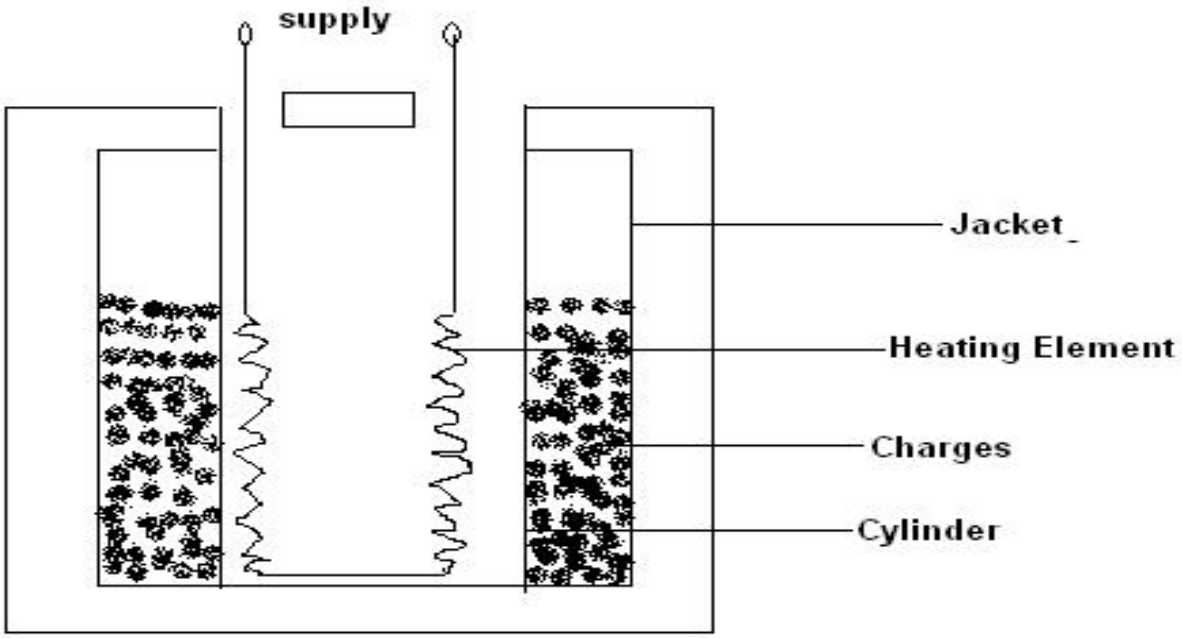
Electrical heating is based on the principle that when electric current passes through a medium heat is produced. Let us take the case of solid material which has resistance 'R' ohms and current flowing through it is I amps for 't' seconds then heatproduced in the material will be $H=I^2Rt$ Joules. There are two types of Resistance heating – Direct Resistance heating and Indirect Resistance heating.

Direct Resistance heating



The charge to be heated is taken as resistance and current Is passed through it.The charge may be in the form of powder, pieces or liquid.Two electrodes are immersed in the charge and connected to the supply.A high resistive powder is sprinkled over the surface of pieces to avoid short circuit.Uniform heating and high temperature can be obtained.Automatic temperature control is not possible.

Indirect Resistance heating



The current is passed through a wire or other resistance forming the heating element.The heat produced which is proportional to I^2R loss produced in the heating element id transferred to the charge by convection or radiation.The heating element is kept in a cylinder. It is surrounded by a jacket containing the charge.Uniform heating can be obtained.Automatic temperature control is possible.----------(10 Marks)

5. Advantages of Electric welding

- Welding is the lowest cost joining method.
- It affords lighter weight through better utilization of materials.
- It joins all commercial metals.
- It can be used anywhere.
- It provides design flexibility.

Disadvantages of Electric welding

- Welding depends on human factor.
- It often needs internal inspection.

Most of these limitations can be overcome by means of good controls and supervision.

Electric arc welding

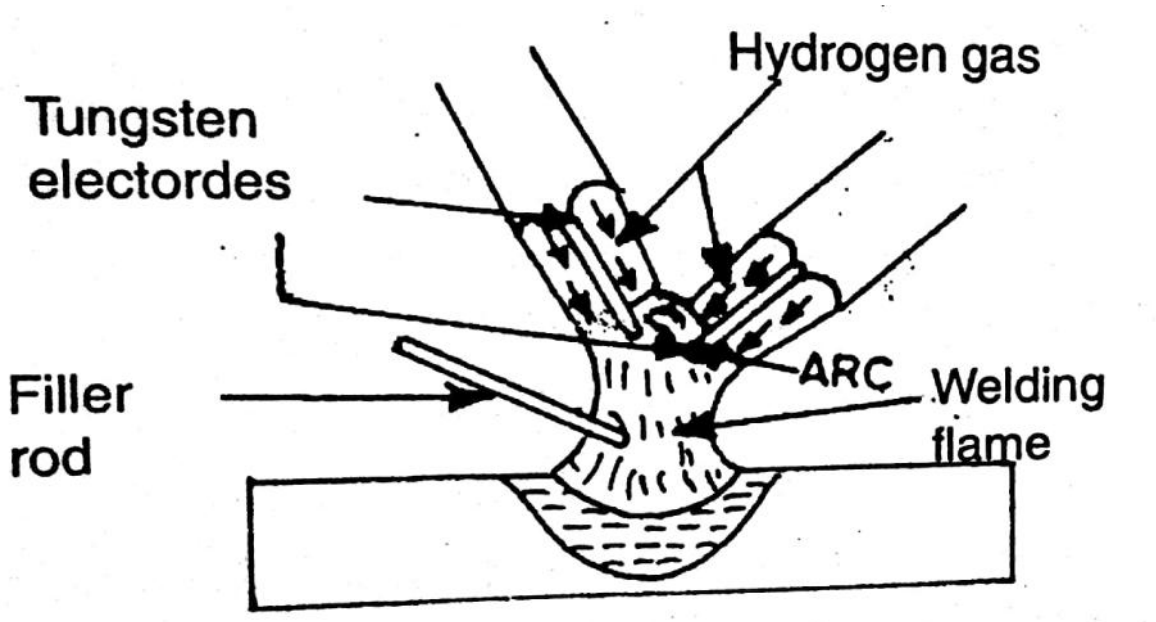
Arc welding is that process in which the pieces of metal to be welded are brought to the proper welding temperature at point of contact by the heat liberated at the arc terminals and in the arc stream so that the metals are completely fused into each other forming a single solid homogenous mass after it solidifies.The voltage necessary to strike the arc is higher than that required to maintain it.The temperature is of the order of 3600 degree celsius at which mechanical pressure is not required for joining.This type of welding is known as non pressure welding.

Types of Arc welding

Arc welding can be classified into five groups mainly carbon arc welding, metal arc welding, atomic hydrogen arc welding, inert gas metal arc welding and submerged arc welding.

Atomic hydrogen Arc welding

Heat is obtained from an alternating current arc drawn between two tungsten electrodes in an atmosphere of hydrogen.As the hydrogen gas passes through the arc, the hydrogen molecules are broken up into atoms.They recombine on contact with the cooler base metal generating intense heat sufficient to melt the surfaces to be welded together with the filler rod if used.The envelope of hydrogen gas also shields the molten metal from oxygen and nitrogen and thus prevents weld metal from deterioration.

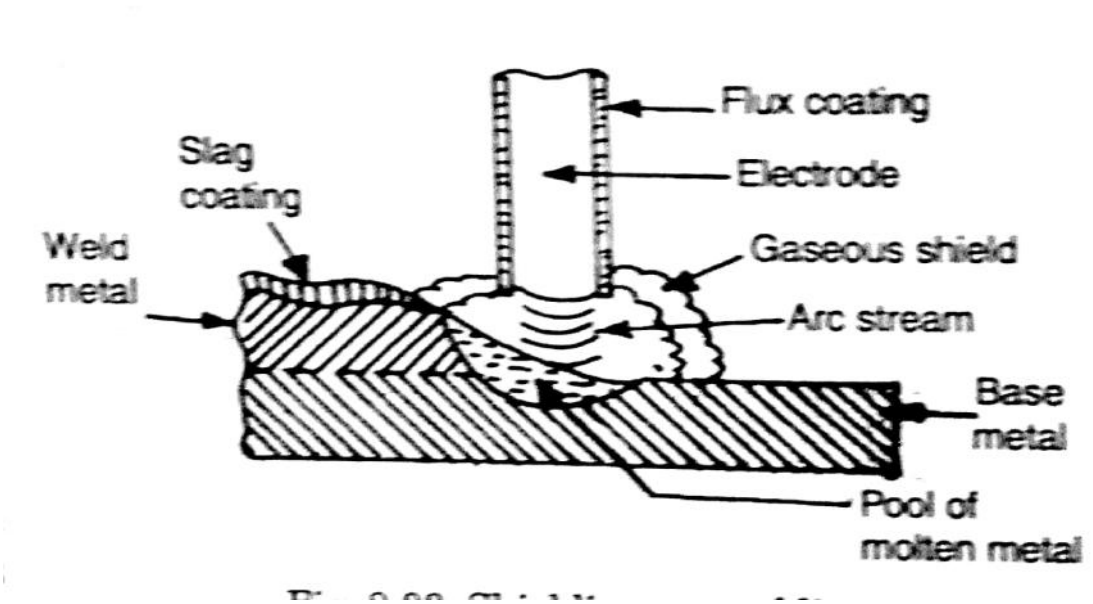


Atomic hydrogen Arc welding

Application :Atomic hydrogen welding being expensive is used mainly for high grade work on stainless steel and most non-ferrous metals.

Inert Gas Metal Arc welding

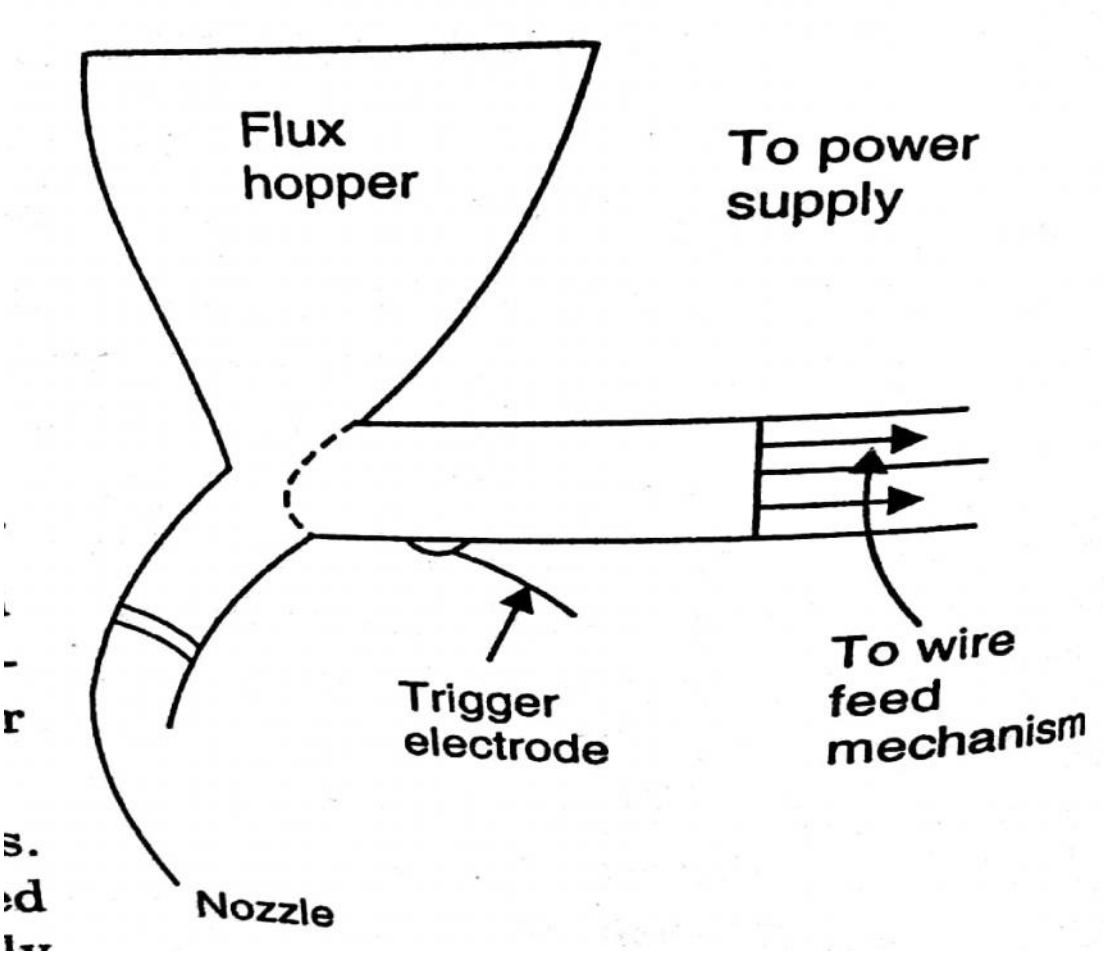
Here the shielding is done by the use of a flux coating on the electrode which will protect the metal from the atmosphere.An envelope of inert gas is formed around the arc and the weld. Welds made with a completely shielded arc are more superior to those deposited by an ordinary arc.This type of welding is otherwise known as Shielded Arc welding.In this system molten weld metal is protected from the action of atmosphere by an envelope of chemically reducing or inert gas.As molten metal has an affinity for oxygen and nitrogen if exposed to the atmosphere it will enter into combination with these gases forming oxides and nitrides.Due to this chemical combination metal becomes weak and brittle.



Inert Gas Metal Arc welding

Submerged Arc welding

The submerged arc process creates an arc column between a basic metallic electrode and the work piece.The arc and the molten weld pool are submerged in a finely divided granulated powder that contains appropriate deoxidizers, cleansers and any other fluxing elements.The fluxing powder is fed from a hopper that is carried on the welding head.The tube from the hopper spreads the powder in continous mount in front of the electrode along the line of the weld.



Submerged Arc welding

------(10 Marks)

6. Let one side of the tank = l metres

   Surface area of the tank, $6l^2 = 6m^2$

   Side of the tank, l = 1m

   Volume of the tank = 1 X 1 X 1 = $1m^3$

   Water to be heated daily = 6 X 0.9 m^3 = 5400kg

   (Since 1 cubic metre of water weighs 1000kg)

Heat required to raise the temperature of water = $ms(t_2 - t_1)$ = 5400 X 4200 X (65 -20) = 1020 MJ = 1020/3.6 = 283.5kWh

Losses from the surface of the tank = 6.3 X 6 X (65 -20) X 24/1000 kWh = 40. 8kWh

Energy supplied = 283.5 + 40.8 = 324.3 kWh

Loading in kW = 324.3/24 = 13.5kW

Efficiency of the tank = (output/input) X 100 = (283.5 /324.3) X 100 = 87.4%

----------(10 Marks)

7. Power absorbed, P = 200 W

   Power factor, cos φ = 0.05

   Supply frequency, f = 30 X 10^6 Hz

   Capacitance of the capacitor formed, C = $\epsilon_0\epsilon_r A/t$ = 8.85 X 10^{-12} X 5 X 150 X 10^{-4}/0.2 = 33.2 10^{-12} F

   Voltage required, V =(P / 2πfCcosφ)$^{1/2}$ = (200 / 2π X 30 X 10^6 X 33.2 X 10^{-12} X 0.05)$^{1/2}$ = 800 V

   Current flowing through the material, I = P/ V cosφ = 200/ 800 X 0.05 = 5 A

   Since heat produced α fV^2

   $f_2V_2^2 = f_1V_1^2$

   f_2 = 30 X 10^6X $(800/600)^2$= 53.3 MHz

   ----------(10 Marks)