CMR

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Internal Assesment Test - I

Sub:	Utilization of Electrical Power							Code:	15EE742
Date:	19/03/2018	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE
Answer Any FIVE FULL Questions									

		Marks	OBE	
			CO	RBT
1	A 15 KW,220 V single phase resistance employs nickel-chrome wire for its heating elements. If the wire temperature is not exceed 1000 ^{0}C and the temperature of the charges is to be 600^{0}C. Calculate the diameter and length of the wire. Assume radiating efficiency as 0.6 and emissivity as 0.9.	[10]	CO1	L3
2	Explain with diagram (a) Direct Resistance Heating (b) Indirect Resistance Heating.	[10]	CO1	L3
3	With neat sketch explain the working of Ajax-wyatt Furnace.	[10]	CO1	L3
4	List the classifications of the Welding. With neat schematic diagram explain the operation of Carbon Arc Welding and Butt Welding.	[10]	CO1	L3
5a	State and explain Faraday's laws of electrolysis.	[5]	CO1	L2
5b	Explain the basic principle of electrolysis with neat sketch.	[5]	CO1	L2
6	A piece of an insulating material is to be heated by dielectric heating. The size of the piece is 10x10x3 cm. A frequency of 20 megacycles is used and the power absorbed is 400 watts. Calculate the voltage necessary for heating and the current flows in the material. The material has a relative permittivity of 5 and power factor of 0.05.	[10]	CO1	L3
7a	Compare the advantages of power frequency heating and high frequency heating.	[5]	CO1	L2
7b	With block diagram explain the working of Air conditioning unit.	[5]	CO1	L2

8a	Define the following terms (i) Luminous flux (ii) Luminous efficiency (iii) Luminous Intensity	[6]	CO2	L1
8b	State the inverse square law and Lambert cosine law with respect to illumination.	[4]	CO2	L2

1

Solution. Power supplied $P = 15 \times 1000$ watts

For a circular element,

$$P = \frac{V^2}{R} = \frac{V^2 a}{\rho l} = \frac{\pi V^2 d^2}{4\rho l}$$

$$\therefore \quad \frac{d^2}{l} = \frac{4\rho P}{\pi V^2}$$

For nickel chrome wire,

$$\rho = \frac{1.016}{10^6} \text{ ohm-m}$$

$$\therefore \quad \frac{d^2}{l} = \frac{4 \times 1.016}{10^6} \times \frac{15 \times 1{,}000}{\pi \times (220)^2}$$

$$= \frac{15.34}{121\pi \times 10^5}$$

$$\frac{l}{d^2} = \frac{121\pi \times 10^5}{15.34} \qquad \ldots(1)$$

$$H = 5.72 \times 10^4 \, ke \left[\left(\frac{T_1}{1{,}000} \right)^4 - \left(\frac{T_2}{1{,}000} \right)^4 \right] \text{ watts sq. m.}$$

$T_1 = 1{,}000 + 273 = 1{,}273°\text{C}$ absolute,

$T_2 = 600 + 273 = 873°\text{C}$ absolute.

$$H = 5.72 \times 10^4 \times 0.6 \times 0.9 \left[\left(\frac{1.273}{1{,}000} \right)^4 \right] - \left[\left(\frac{873}{1{,}000} \right)^4 \right]$$

$$= 6.32 \times 10^4 \text{ watts/sq.m.}$$

Area of the radiating surface,

$$= \pi dl \text{ sq. m.}$$

Heat dissipated $= \pi dl \; H = P$

$$\therefore \quad \pi dl \times 6.32 \times 10^4 = 15 \times 10^3 \; ;$$

$$dl = \frac{15 \times 10^3}{\pi \times 6.32 \times 10^4} = \frac{3}{12.64\pi}$$

$$\therefore \quad d^2 l^2 = \left(\frac{3}{12.64\pi} \right)^2 \qquad \ldots(2)$$

Multiply (1) and (2),

$$l^3 = 14250, \; l = 24.24 \text{ m}$$

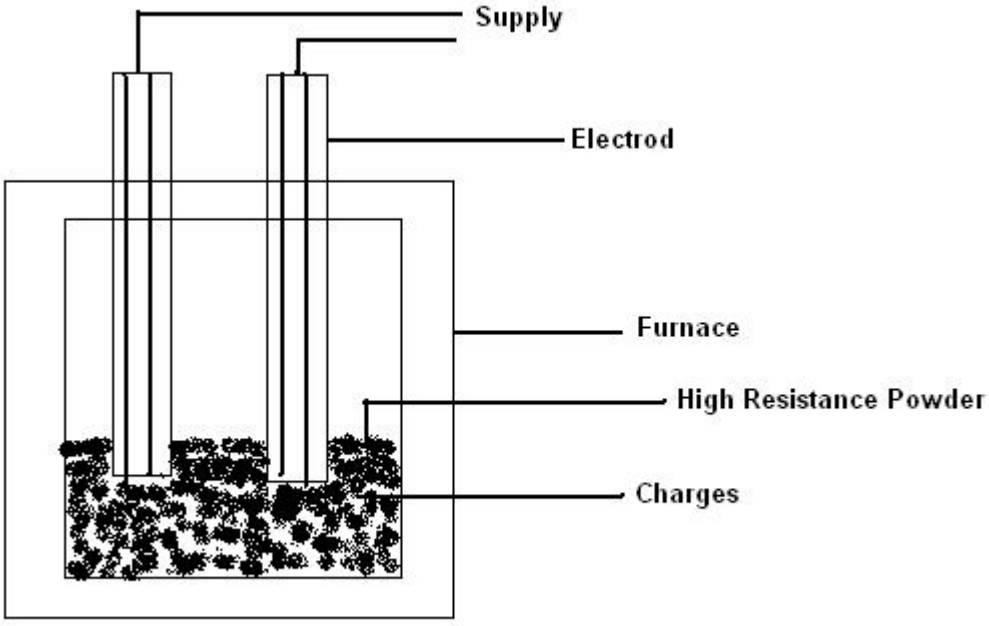
and $d = 0.312$ cm

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

2. 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 heat produced in the material will be $H=I^2Rt$ Joules. There are two types of Resistance heating – Direct Resistance heating and Indirect Resistance heating.

(a) Direct Resistance heating

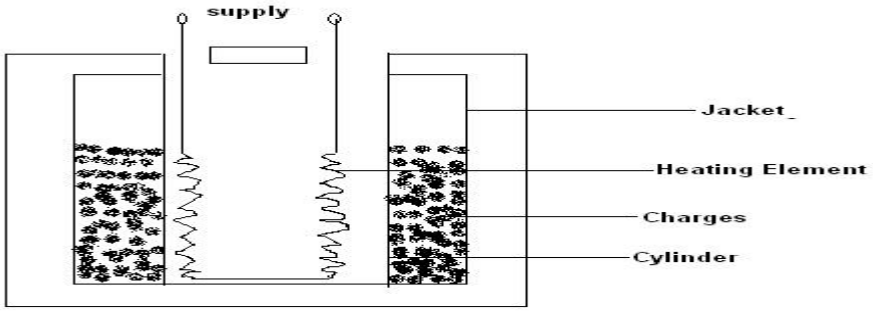


The charge to be heated is taken as resistance and current Is passed through it. The charge may be in the form of powder, pieces or liquid. Two electrodes are immersed in the charge and connected to the supply. A high resistive powder is sprinkled over the surface of pieces to avoid short circuit. Uniform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

----------(5 Marks)

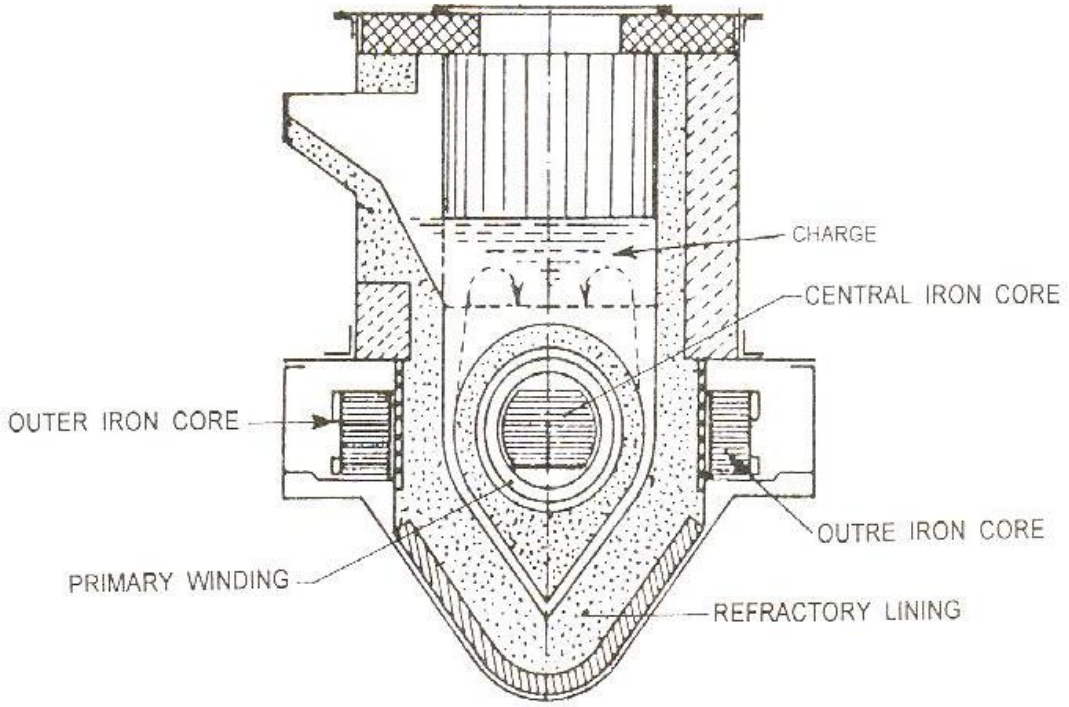
(b) Indirect Resistance heating

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.



----------(5 Marks)

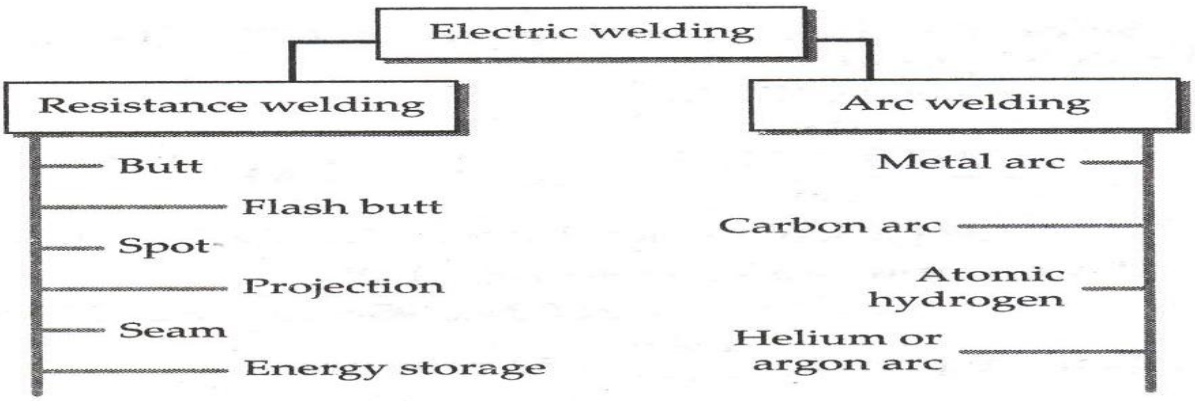
3. Ajax Wyatt Vertical Core Furnace



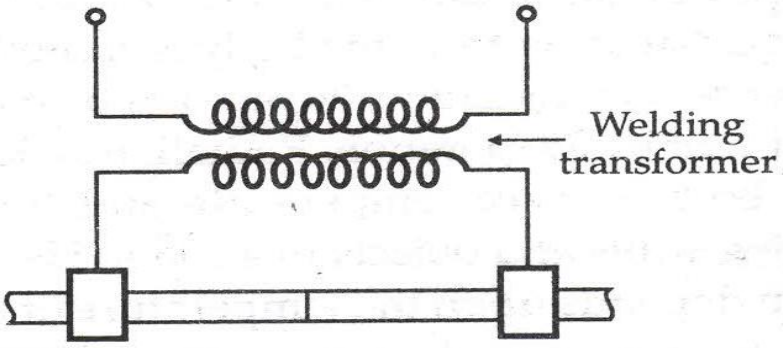
It is an improvement over the core type induction furnace. The magnetic coupling in this furnace is better than core type furnace. Leakage reactance is comparatively low and frequency is high, hence it is high frequency furnace. It employs vertical crucible instead of horizontal. The circulation of Molten 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. 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.----------(10 Marks)

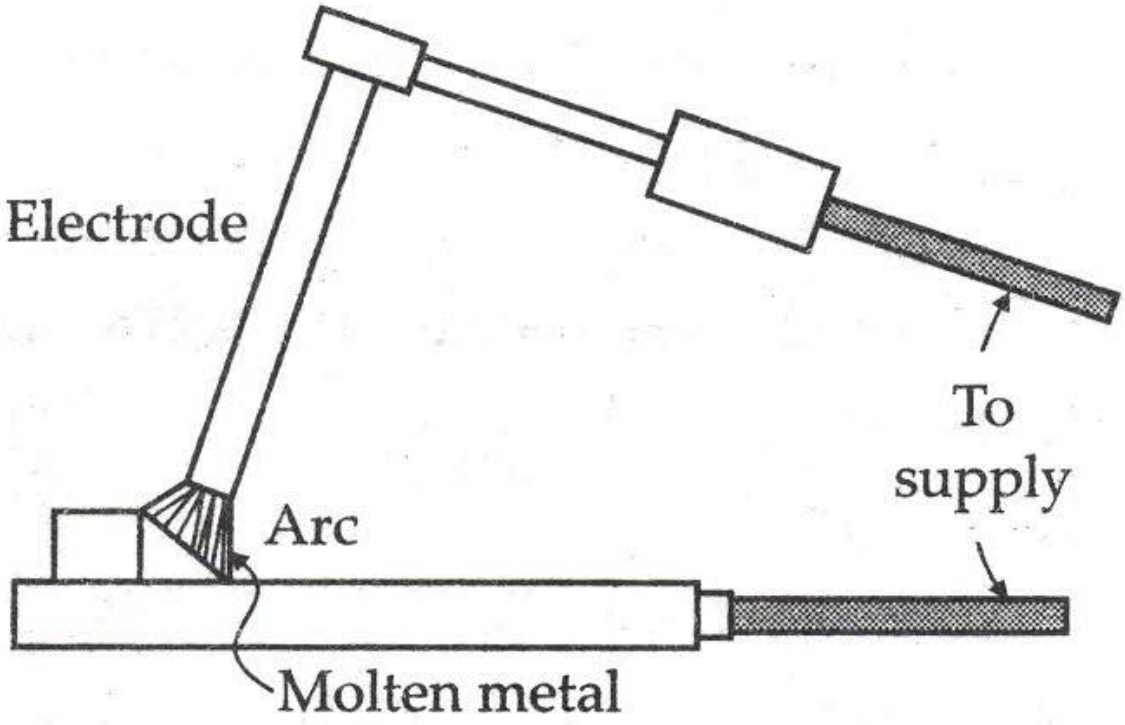
4. Types of Welding



(a) Butt Welding. Rods, pipes and wires are welded in this way. One part is held in a fixed clamp and the other is held in a moving clamp. The two parts are brought together and pressure is applied along the axial direction by a spring. A heavy current is passed from the welding transformer which creates the necessary heat at the joint due to the comparatively high resistance of the contact area. Due to the pressure of the spring, molten metal is forced out producing a bulged joint.



(*b*) ***Carbon arc Welding.*** The electrode is of carbon which is made negative with respect to the work if d.c. is used. If the carbon electrode is made positive, the carbon particles have a tendency to go into the welded joint and cause brittleness. The electrode should therefore be negative and the work positive. Only d.c. can be used. The heat from the arc forms a molten pool and the extra metal required to make the weld is supplied by a filler rod of the same composition as that of the molten metal. This process is also used in welding copper and its alloys.



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

5(a) Faraday's Laws of Electrolysis

First Law. The weight of a substance liberated from an electrolyte in a given time is proportional to the quantity of electricity passing through the electrolyte. That is $W \propto Q \propto It$ where I is the current and t is the time.

$$\therefore \qquad W = ZI\,t$$

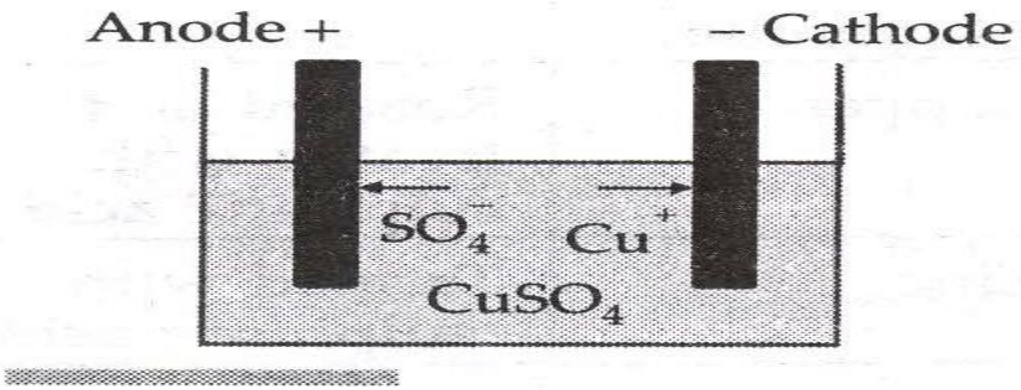
Second Law. If the same current flows through several electrolytes, the weights of ions liberated are proportional to their chemical equivalents.

----------(5 Marks)

5 (b) Principle of Electrolysis

Consider the case of copper sulphate dissolved in water. It dissociates into positively-charged copper ions and negatively-charged sulphates ions. If two electrodes are placed in the solution and one of them is made positive and the other negative, the positively charged ions travel towards the cathode and the negatively-charged ions travel towards the anode. They give up their respective charges on reaching the electrodes and become ordinary molecules of the respective radicals. Therefore copper is deposited at the cathode as metal. The sulphate ions collect at the anode and react with water giving out oxygen.

$$2\,H_2O + 2\,SO_4 = 2\,H_2SO_4 + O_2$$



Oxygen is liberated as gas at the anode and H_2SO_4 is formed. If the cathode is made of copper, the sulphuric acid attacks it forming copper sulphate and liberating hydrogen.

$$H_2SO_4 + Cu = CuSO_3 + H_2$$

----------(5 Marks)

6

Solution. The capacitance of the parallel plate condenser that the material forms is given by

$$C = \frac{\varepsilon_0 \varepsilon_r A}{t} \text{ farads}$$

where $\varepsilon_0 = 8.854 \times 10^{-12}$

$\varepsilon = 5$ (given)

t = thickness in metres $= 3 \times 10^{-2}$

A = area in sq. m $= 100 \times 10^{-4} = 10^{-2}$

$$\therefore \quad C = \frac{8.854 \times 10^{-12} \times 5 \times 10^{-2}}{3 \times 10^{2}}$$

$$= 14.75 \times 10^{-12} \text{ farads}$$

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

7(a) Comparison of High Frequency and Power Frequency

S. No.	High Frequency	Power frequency
1	Frequency converter is necessary	Not required.
2	More energy required i.e, 20% to 30% for same rating.	Less energy required.
3	Maintenance cost is more	Less
4	Less turbulence and stirring effect	More
5	Large scrap melts with more oxidation loss.	Large scrap melts with less oxidation loss.
6	No special starting procedure is required	Special starting procedure is required.

----------(5 Marks)

7(b) Air conditioning Units

Such units heat, cool and clean the air. These can easily be moved. Some may be self-contained while others require water, steam or refrigerant. The self-contained units consist of filter, cooling coil, conditioned-air fan, refrigerant compressor, air-cooled condenser and condenser air-duct connections, all enclosed in one cabinet. Such room conditioners are available in sizes 1/4, 1/2 and 3/4 h.p. Water-cooled room conditioners are also available.

The working of the residential air-conditioning equipment can be understood from the various processes as given in Fig. 2.14.

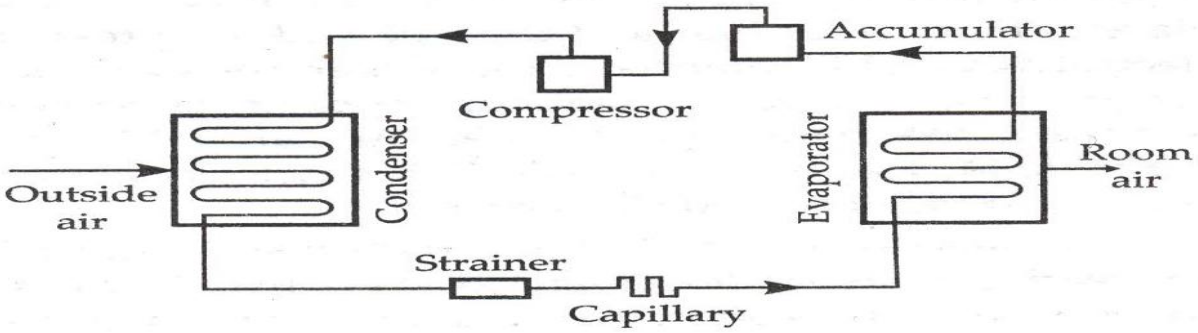


Fig. 2.14 Action in a typical window air-conditioning unit.

Air is drawn in through the evaporator cooling coil. The refrigerant, liquid freon, is made to evaporate which causes the air to cool considerably. The air gives up some heat in evaporating liquid freon. The gas from the evaporator goes to the accumulator through which only dry gas passes on to the compressor. In the compressor the gas is compressed and led into the condenser. The outside air drawn into the condenser cools the compressed gas and it changes into liquid form. The liquid gas passes through strainer and then through a capillary which allows it to pass at the requisite rate.

----------(5 Marks)

8(a)

(i)**Luminous Flux** - The total quantity of radiant energy per second responsible for visual sensation from a luminous body is called Luminous Flux. It is represented as F of Ø and measured in lumens.

(ii) **Luminous Efficiency** It is defined as the visible radiations emitted by it in lumens per watt.

(iii) **Luminous intensity** in any particular direction is the luminous flux emitted by the source per unit solid angle in that direction. It is denoted by I and its unit is candela or candle power (CP).

----------(6 Marks)

8(b) **Inverse square law** It states that the illumination of a surface is inversely proportional to the square of the distance of the surface from the source. $E \alpha I/d^2$

Lambert's Cosine Law This law states that the illumination on any surface is proportional to the cosine of angle between the direction of the incident flux and perpendicular to the area. $E= I \text{ Cos } \alpha/ d^2$

----------(4 Marks)