d) A hot ingot casting 25 cm (length) × 25 cm (width) × 1.8 (height) at a temperature of 1200 k is stripped from its mould. The casting is made to stand on the end on the floor of a large foundry whose wall, floor and roof can be assumed to be at 290 k. If the emissivity of casting material is 0.8, calculate the net heat exchange between the casting and the room.

OR

The large parallel plates with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction when a polished aluminium shield of emissivity 0.04 is placed between them. Use method of electrical analogy.

5. a) Explain the term mass transfer.

b) State Fick's law of diffusion.

c) Describe briefly convective mass transfer.

d) Derive the general mass transfer equation in Cartesian co-ordinates.

OR

A vessel contains a binary mixture of O_2 and N_2 with partial pressures in ratio 0.21 and 0.79 at 15°C. The total pressure of the mixture is 1.1 bar. Calculate the following

i) Molar concentration

ii) Mass densities

iii) Mass fractions and

iv) Molar fractions of each species

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Roll No .....

MMTP-103

M.E./M.Tech. I Semester

Examination, December 2014

Heat and Mass Transfer

Time : Three Hours

Maximum Marks : 70

Note: i) Answer five questions. In each question part A, B, C is compulsory and D part has internal choice.

ii) All parts of each questions are to be attempted at one place.

iii) All questions carry equal marks, out of which part A and B (Max.50 words) carry 2 marks, part C (Max.100 words) carry 3 marks, part D (Max.400 words) carry 7 marks.

iv) Except numericals, Derivation, Design and Drawing etc.

v) Assume suitable missing/misprint data, if any.

1. a) Explain the term thermal capacity.

b) Write down an expression for total thermal resistance of a composite cylinder made of two materials having conductivities k_1 and k_2.

c) Derive an expression for temperature distribution in a straight fin of rectangular profile for a infinitely long fin.

d) 55 kg/sec of steam is flowing through a convective steam superheater 35/45 mm in diameter made of steel (h = 38.5 w/m°C). The pressure of dry saturated steam at the inlet of the superheater is 120 bar. The temperature of steam leaving the superheater is 480°C. The heat transfer coefficient from the gas to wall and from wall to gas are 82 w/m^2°C and 1120 w/m^2°C respectively. If the

mean flue gas temperature is 920°C. Determine the outer surface area of the superheater. Take C_{ps} (for steam) = 1.92 kJ/kg°C, saturated temperature at 120 bar = 324.6°C.

OR

Two rods A and B of the same length and diameter protrude from a surface at 120°C and are exposed to air at 25°C. The temperature measured at the end of the rods are 50°C and 75°C. If the thermal conductivity of material A is 20 w/m°C, calculate the thermal conductivity of material B. Adopt the condition of a fin insulated at the tip.

2. a) Differentiate between mechanism of heat transfer by free and forced convection.

   b) List the factors on which convective heat transfer coefficient depends.

   c) What is dimensional homogeneity? Explain its importance.

   d) Consider a cubical block 10 cm × 10 cm in size and suspended in still air at 20°C. All the surfaces of the block are maintained at 160°C and one of its surface lies in horizontal position. Determine the total heat loss from the block.

OR

Show by dimensional analysis that for forced convection $N_u = \phi$ (Re, Pr).

3. a) Explain 'boiling' and enumerate the applications of boiling.

   b) Differentiate between dropwise and filmwise condensation.

   c) Explain briefly various regimes of saturated boiling.

   d) An electric wire of 1.25 mm diameter and 250 mm long is laid horizontally and submerged in water at atmospheric pressure. The wire has an applied voltage of 18 V and carries a current of 45 amperes. Calculate the

      i) Heat flux

      ii) The excess temperature if the following co-relation hold true

$$h = 1.58\left(\frac{Q}{A}\right)^{0.75} = 5.62\left(\Delta t_e\right)^3 \text{ w/m}^2\text{°C}$$

OR

A vertical plate 500 mm high and maintained at 300°C is exposed to saturated steam at atmospheric pressure. Calculate the following

i) The rate of heat transfer

ii) The condensate rate per hour per meter of the plate width for film condensation. Assume the properties of water film at the mean temperature are

$\rho = 980.3$ kg/m^3, k = 66.4 × 10^{-2} w/m°C

$\mu = 434 \times 10^{-6}$ kg/ms and $h_{fg} = 2257$ kJ/kg

4. a) Define geometrical or shape factor.

   b) What is radiation shield.

   c) Derive the relation for radiant heat exchanger between two gray surfaces.