BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B.TECH. **SEMESTER : V**
BRANCH: MECHANICAL **SESSION : MO/2022**

SUBJECT: ME315 HEAT & MASS TRANSFER

TIME: 3:00 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Explain the physical significance of thermal conductivity of the material. [2]

Q.1(b) A solid steel ball 5 cm in diameter and initially at 450°C is quenched in a controlled environment at 90°C with convection coefficient of 115 W/m^2K. Determine the time taken by centre to reach a temperature of 150°C. Take thermo-physical properties as: [3]
C = 420 J/kgK ; ρ = 8000 kg/m^3 ; k = 46 W/mK

Q.1(c) A steel pipe line (k=50W/m/K) of I.D. 100mm and O.D. 110 mm is to be covered with two layers of insulation each having a thickness of 50 mm. The thermal conductivity of the first insulation material is 0.06 W/mK and that of the second is 0.12 W/mK. Calculate the loss of heat per meter length of the pipe and the interface temperature between the two layers of insulation when the temperature of the inside tube surface is 250 °C and that of the outside surface of the insulation is 50°C. [5]

Q.2(a) A turbine blade 6cm long and having a cross sectional area 4.65 cm^2 and perimeter 12 cm, is made of stainless steel (*k* = 23.3 W/mK). The temperature at the root is 500°C. The blade is exposed to a hot gas at T_∞=870°C. The heat transfer coefficient between the blade surface and gas is 442 W/m^2K. Determine the temperature distribution ($T-T_\infty$) expression and rate of heat flow at the root of the blade. Assume tip of the blade to be insulated. [5]

Q.2(b) A pipe carrying steam having an outside diameter of 20 cm runs in a large room and is exposed to air at a temperature of 30°C. The pipe surface temperature is 400°C. Calculate the loss of heat to surroundings per metre length of pipe due to thermal radiation. The emissivity of the pipe surface is 0.8. What would be the loss of heat due to radiation if the pipe is enclosed in a 40cm diameter brick conduit of emissivity 0.91? [5]

Q.3(a) Define and explain the dimensionless quantities: [5]
(i) Nusselt number (ii) Reynolds number (iii) Prandtl number
(iv) Grashof's number (v) skin friction coefficient

Q.3(b) Air, at a pressure of 8 kN/m^2 and a temperature at 250°C, flows over a 0.3 m wide and 1 m long flat plate at a velocity of 8 m/s. If the plate is to be maintained at a temperature of 78°C, estimate the rate of heat to be removed continuously from both sides of the plate. [5]

Q.4(a) Draw and explain the various regimes of pool boiling of water. [4]

Q.4(b) Consider a cubical block 10 cm x 10 cm in size and suspended in still air at 20°C. All surfaces of the block are maintained at 160°C. Determine total heat loss from the block. Thermo-physical properties of air at mean film temperature of 90°C are: $v = 22.1 \times 10^6$ m^2/s ; k = 0.03217 W/m°C ; Pr = 0.69 [6]

Q.5(a) Define Fick's Law of Diffusion. [2]

Q.5(b) Explain fouling and effect of fouling resistance on overall heat transfer coefficient in heat exchangers. [3]

Q.5(c) A counter flow concentric tube heat exchanger is used to cool engine oil (c = 2130 J/kg K) from 160°C to 60°C with water, available at 25°C, as cooling medium. The flow rate of cooling water through the inner tube of 0.5 m diameter is 2 kg/s while the flow rate of oil through the outer annulus O.D. = 0.7 m is also 2kg/s. If the value of the overall heat transfer coefficient is 250 W/m^2K, how long the heat exchanger be to meet its cooling requirement? [5]

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