At the mean film temp tF = 60°C the properties are thermal diffusivity $\alpha = 7.2 \times 10^{-3}$ m²/sec. Thermal conductivity k = 0.213 w/mk kinematic viscosity v = 0.65×10^{-4} m²/sec; density $\rho = 956.8$ kg/m³.

7. Saturated steam at atmospheric pressure condenses on the outer surface of a vertical tube of length 1m and outer diameter 75 mm. The tube wall is maintained at a uniform surface temp of 40°C by the flow of cooling water inside the tube. Estimate the steam condensation rate and the heat transfer rate to the tube. What water flow rate will result in a 5°C temp difference of water between the outlet and inlet of pipe ? Also calculate the flow Reynolds number to check the assumption of laminar flow conditions. 20

8. A one-shell, two tube pass heat exchanger having 3000 thin wall brass tubes of 20 mm diameter has been installed in a steam power plant with a heat load of 2.3×10^8w. The steam condenses at 50°C and the cooling water enters the tubes at 20°C at the rate of 3000 kg/s. Calculate the overall heat transfer coefficient, the tube length per pass, and the rate of condensation of steam. Take the heat transfer coefficient for condensation on the outer surfaces of the tubes as 15500 w/m²k and the latent heat of steam as 2380 kJ/kg Further presume the following fluid properties : 20

c = 4180J/Kgk, $\mu = 855 \times 10^{-6}$ Ns/m², k = 0.613 w/mk, Pr = 5.83.

Roll No. .....

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B. E. 6th Sem. (Mech. Engg.)

Examination – May, 2009

Heat Transfer

Paper : ME-306-E

Time : Three hours] *[Maximum Marks : 100*

Before answering the question, candidates should ensure that they have been supplied the correct and complete question paper. No complaint in this regard, will be entertained after examination.

Note : Attempt any *five* questions.

1. (a) A person who sits in front of a fireplace feels warm. Through what processes of heat transfer does he receive heat ? 4

   (b) A solar plane 1 m × 1.25 m, receives solar radiation 1500 watts. Calculate surface temperature of the plane if the ambient temperature is 25°C and the convective heat transfer coefficient of the air film over the surface of plane is 12.5 w/m² deg. 12

   (c) Write the rate equations for the three modes of heat transfer. 4

2. Prove that heat loss Q per square of outside surface area of a hollow sphere heated from within is equal to

$$Q = \frac{k(t_1 - t_2)}{(r_2 - r_1) \times \frac{r_2}{r_1}}$$ Symbols have their usual meanings.

A spherical furnace with 25 cm internal diameter and 30 cm external diameter is made of refractory material of mean thermal conductivity 0.45 kcal/m-hr-deg. Find the hourly loss of heat if the temperatures at the inner and outer surfaces are 400°C and 25°C respectively. What would be the reduction in heat loss when the furnace is covered with 20 mm thick insulation of conductivity k, 17.45 w/m deg. 20

3. An infinite slab of 20 cm thickness and thermal conductivity 20 w/mk separates two fluid having temperatures 35°C and 25°C respectively. The heat transfer coefficient on the hot fluid side is 25w/m²k and that on the cold fluid side is 50 w/m²k, if the heat generation in the slab is at uniform rate of 6 kw/m³ set up an expression for the temperature distribution in the slab Proceed to determine : 20

   (a) maximum temperature in the slab and its location

   (b) temperature at the centre of slab and at the two surfaces.

   (c) Heat transferred from each surface.

4. The steel ball bearings of 40 mm diameter and initially at uniform temperature of 600°C are quenched in an oil bath maintained at 50°C temperature. The heat transfer coefficient between the ball bearings and oil is 325 w/m²K and the thermodynamic properties of bearings can be taken as : K = 45w/mk, $\alpha = 1.25 \times 10^{-5}$ m²/s. Determine :

   (a) time duration for which bearings must remain in oil to attain 225°C temp.

   (b) amount of heat removed from bearings during this time

   (c) the instantaneous heat transfer rate from the bearings when they are first immersed on oil and when they reach 225°C. 20

5. (a) Define Lambert's cosine law of radiation and prove that the intensity of radiation is always constant at any angle of emission for a diffused surface. 12

   (b) Define the following terms as applied to radiation heat transfer : 8

      (i) Black, gray and real surface

      (ii) Spectral and special distribution of energy

      (iii) Specular and diffused reflection

      (iv) Emissive power and intensity of radiation.

6. In a certain pharmaceutical process, castor oil at 35°C flows over a flat plate at 6cm/s. The plate is 6 m long, is heated uniformly and maintained at a surface temp of 95°C. Make calculations for : 20

   (a) hydrodynamic and thermal boundary layer thickness at the trailing edge of the plate

   (b) total drag per unit width on one side of the plate

   (c) Local heat transfer coefficient at the end of the plate

   (d) total heat flux from the surface per unit width.