Registration No. : | | | | | | | | | | |

Total number of printed pages – 3

B. Tech

PCME 4305

Sixth Semester Regular Examination – 2014

HEAT TRANSFER

BRANCH(S) : MECH

QUESTION CODE : F 324

Full Marks – 70

Time : 3 Hours

*Answer Question No. **1** which is compulsory and any **five** from the rest.*

The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

(a) Why gas has lower thermal conductivity than solid ?

(b) What is the difference between fin effectiveness and fin efficiency ?

(c) What is fully developed flow condition for a flow through tube ?

(d) What is Newton's law of viscosity and thus define an ideal fluid.

(e) Which types of condensation is preferable and why ?

(f) Write the significance of Grashof no. in respect of natural convection.

(g) Show that for an ideal fluid $\beta = 1/T$ where β is the volumetric coefficient of thermal expansion and T is in K.

(h) What is the 'surface resistance' and 'space resistance' in respect of radiation exchange between two surfaces ?

(i) What is the surface temperature of Sun and how is it estimated ?

(j) What is a compact heat exchanger ? Give one example.

P.T.O.

2. A turbine blade, 6.25 cm long , cross-sectional area 4.5 cm^2, perimeter 12 cm, is made of stainless steel (k = 26.16 W/m K). The temperature of the root is 500° C the blade is exposed to a hot gas at 800° C, and the average heat transfer coefficient is 0.465 kW/m^2 K. Determine the temperature and the rate of heat flow at the root of the blade. Assume that the tip is insulated. 10

3. (a) A hollow cylinder with inner radius 30 mm and outer radius 50 mm is heated at the inner surface at a rate of 10^5 W/m^2 and dissipates heat by convection from the other surface into a fluid temperature 100° C with a heat transfer coefficient of 400 W/m^2 K. There is no energy generation, and the thermal conductivity of the solid is assumed to be constant at 15 W/m K. Calculate the temperatures of the inside and outside surfaces of the cylinder. 6

(b) What is critical thickness of insulation ? Explain the variation of heat transfer with the variation of insulation thickness. 4

4. (a) Water flows over a flat plate measuring 1 m × 1 m with a velocity of 2 m/s. The plate is at a uniform temperature at 90° C and the water temperature is 10° C. Estimate the length of the plate over which the flow is laminar and the amount heat transfer from that part of the plate. The properties of water at 50° C are : 5

$\rho = 988.1$ kg/m^3 , $\nu = 0.556 \times 10^{-6}$ m^2/s, Pr=3.54 and k= 0.648 W/m K

(b) With a neat sketch, discuss the different stages of pool boiling. 5

5. A nuclear reactor with its core constructed of parallel vertical plates 2.2 m high and 1.45 m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960° C, while the lowest allowable temperature of bismuth is 340° C. Calculate the maximum possible heat dissipation from both sides of each plate. For the convection coefficient the appropriate correlation is : 10

$Nu = 0.13\ (Gr \cdot Pr)^{1/3}$ Where the properties evaluated at the mean film temperature of 650° C for bismuth are : $\rho = 10^4$ kg/m^3, $\mu = 8.67 \times 10^{-4}$ kg/m-s, $c_p = 150.7$ J/kgK, k = 13.02 W/m K.

6. (a) Show that the emissive power of a black body is π (Pi) times the intensity of radiation. 5

(b) A thermocouple (0.25 mm diameter) placed in a hot gas stream, that is flowing through a 250 mm diameter duct, reads a temperature of 800° C. The convective heat transfer coefficient produced by the gas stream is 120 W/m^2-K. The duct wall (emissivity is 0.7) temperature is 500° C. Calculate the true temperature of the gas. 5

7. The condenser of a large steam power plant is a shell-and-tube heat exchanger having a single shell and 30,000 tubes, with each tube making two passes. The tubes are thin-walled with 25 mm diameter and steam condenses on outside of the tubes with $h_0 = 11$ kW/m^{2}K. The cooling water flowing through the tubes is 30,000 kg/s and the heat transfer rate is 2 GW. Water enters at 20° C while steam condenses at 50° C. Find the length of the tubes in one pass. Properties of water at 27° C are $c_p = 4.18$ kJ/kg K, $\mu = 855 \times 10^{-6}$ N s/m^2, k = 0.613 W/m K and Pr = 5.83. The correction factor may be taken as 1. 10

8. Write notes on the following : 2.5×4

(a) Stefan-Colbourn analogy

(b) Radiation shield

(c) Lumped heat capacity system

(d) $\varepsilon \sim$ NTU chart.