BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR, HOW-3

B.E. (Mech) Part-III 5th Semester Final Examination, 2012

SUBJECT: HEAT TRANSFER (ME-503)

Branch: Mechanical Engineering.

Time: 3 Hrs. Full Marks: 70

FIRST HALF

Answer any three questions. All questions are of equal value.

1. (a) Define and state the physical significance of Grashof number. Consider two fluids, one with a large co-efficient of volume expansion and the other with a small one. In which fluid will a hot surface produce a stronger free convection flow?

(b) A horizontal steam pipe of 25 mm diameter has a surface temperature of 250^0C and a surface emissivity of 0.95. Determine the radiation and convective heat loss from the pipe if

(i) the pipe passes through still air at temperature of 30^0C.

(ii) instead of still air, air flow is forced at right angles to the pipe with a velocity of 20 m/s.

Use the following correlation for natural convection:

$Nu = 0.53(Gr\,\Pr)^{0.25}$ for $10^3 < Ra < 10^9$

Use suitable correlation for forced convection in the second case.

The thermo-physical properties of air are as follows:

At 140^0C:	$\nu = 27.8\times10^{-6}$ m^2/s,	k = 0.03487 W/m.K	and Pr = 0.684
and at 30^0C:	$\nu = 16.0\times10^{-6}$ m^2/s,	k = 0.02673 W/m.K	and Pr = 0.701

2. (a) With the help of a neat sketch explain the working of a shell and tube type heat exchanger. Why baffles are used in this type of heat exchanger?

(b) State the limitations of LMTD method of heat exchanger analysis.

(c) Water flowing at the rate of 225 kg/h is to be heated from 35^0C to 95^0C by means of concentric tube heat exchanger. Oil flowing at the rate of 225 kg/h with inlet temperature of 210^0C is to be used as hot fluid. The overall heat transfer co-efficient based on the outer diameter of inner tube is 550 W/m^2-K. Determine the length of the heat exchanger, if the outer diameter is 100 mm. Specific heat of oil may be taken as 2095 J/kg-K.

3. (a) What is a radiation shield? Derive an expression for the rate of radiation exchange, when a radiation shield is inserted between two large parallel plates. Also show that heat transfer rate will be reduced to $\frac{1}{n+1}$ time the heat transfer rate without radiation, when n number of shields (having the same emissivity with that of the plates) are inserted.

(b) A gray diffuse opaque surface ($\alpha = 0.8$) is at 100^0C and receives an irradiation 1000 W/m^2. If the surface area is 0.1 m^3, calculate the radiosity of the surface and net heat transfer rate from the surface. Also calculate the above quantities, if the surface is black.

4. (a) Starting from Planck's law of black body radiation, derive Rayleigh-Jean's Law and Wien's Displacement Law.

(b) A cylinder (L = 2r) is shown in figure 1. Determine the shape factor of the cylindrical surface with respect to the base. You can use figure 2 for determining the shape factor between two discs of equal diameter separated by a distance.

5. Write short notes (any three):

(i) Effectiveness-NTU method of heat exchanger analysis

(ii) Kirchoff's law in radiation

(iii)RayleighNumber

(iv) Compact heat exchange

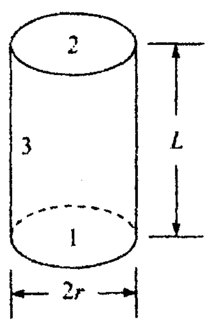

Figure 1: Cylinder

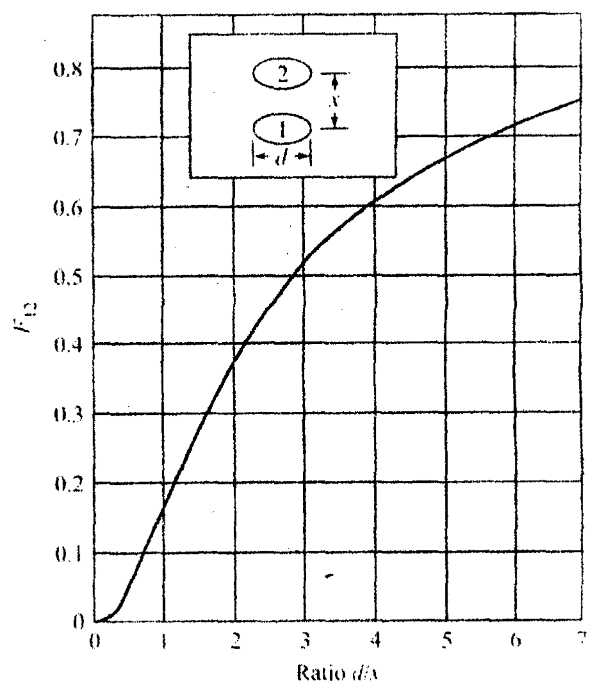

Figure 2: Shape factor

Bengal Engineering and Science University Shibpur

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Second Half

Answer Q5 from this half AND any two questions from the rest of this half

1. (a) Find the steady state temperature distribution and the radial heat flow rate through an infinitely long hollow cylinder having inner and outer radii of r and R, respectively. The temperatures at the two radii are maintained at T_i and T_o

   (b) Heat is transferred from hot oil to cold water in a concentric pipe heat exchanger. The heat transfer coefficient on the water side is 140 W/m^2K and on the oil side is 150 W/m^2K. The pipes are made of galvanized iron (GI). Unfortunately the rate of heat transfer is grossly inadequate and the oil is not cooled sufficiently. If the GI pipes are replaced by copper (with higher thermal conductivity) pipes costing more, see if it is a good decision. The thermal conductivity of GI is 30 W/mK.

2. Find the steady state temperature distribution in an infinitely long solid cylinder of radius R in which heat is being generated in a uniform rate of $\bar{q}$ units per unit volume. The thermal conductivity is k. The heat transfer coefficient at the surface is h and the ambient temperature is T_f. Prove that the maximum temperature occurs at the centre and is given by

$$T_{max} = T_f + \frac{\bar{q}R}{2}\left(\frac{R}{2k} + \frac{1}{h}\right).$$

3. Calculate the heat loss rate from the surface of a rectangular fin of length (L= 2 cm) on a plane wall. The thickness of the fin is 2 mm and its breadth b is 20 cm. Take the excess temperature above the ambient temperature at the base of the fin as 200°C, h=15 W/m^2K and k= 45 W/mK and assume that heat loss from the fin tip is negligible.

4. Derive three dimensional unsteady state heat conduction equation with heat generation in spherical coordinates by considering elemental control volume.

5. (a) Find an expression for the two-dimensional steady state temperature distribution in a rectangular plate. The three edges x=o, x=a and y=0 are maintained at a temperature T=0, while the fourth edge y=b is maintained at a temperature T_g. Neglect temperature variation in the z-direction.
   (b) A long rectangular steel bar (cross-section 10 cm x 5 cm) is kept in an environment such that the two 10 cm faces are maintained at 30°C, one 5 cm face is at 30°C and the other is at 130°C. Find the steady state temperature along the centre line of the bar.