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337654(37)

BE (6th Semester)

Examination, April-May, 2018

(New Scheme)

Heat and Mass Transfer

Time Allowed : 3 hours *Maximum Marks* : 80

Minimum Pass Marks : 28

Note : (*i*) Part (*a*) of each question is compulsory. Attempt any **two** parts from (*b*), (*c*) and (*d*) of each question.

(*ii*) The figures in the right-hand margin indicate marks.

1. (*a*) Define critical radius of insulation. [2]

(*b*) State and derive the general heat conduction equation in Cartesian coordinates. [7]

(*c*) Prove that for one-dimensional heat conduction in cylindrical wall, the thermal resistance is [7]

$$R_{th} = \frac{1}{2\pi KL} \ln \frac{r_2}{r_1}$$

(*d*) Steam at 320°C flows in a cast iron pipe (k=80W/mK) whose inner and outer diameters are D_1=5cm and D_2 = 5. 5 cm respectively. The pipe is covered with 3 cm thick glass wool insulation with k=0.05W/mK. Heat is lost to the surroundings at 5°C. The surroundings film coefficient is 18W/m^{2}K. The inside heat transfer coefficient is 60W/m^{2}K. Find the rate of heat loss from the steam per unit length of the pipe. Also find the temperature drop across the pipe and insulation. [7]

2. (*a*) Define Lump. [2]

(*b*) Derive temperature distribution and heat transfer rate for an infinitely long fin. [7]

(*c*) Derive temperature distribution and instantaneous heat transfer rate for lumped parameter analysis. [7]

(*d*) An ordinary potato can be approximated as a 5cm diameter sphere. It is initially at a temperature of 5°C and it is dropped into boiling water at 95°C. Taking h = 1200W/m^{2}K, determine how long will it take for the centre of the potato to reach 70°C. [Take k_{potato}= 0.627W/mK] [$\alpha = 0.151 \times 10^{-6}$ m^2/s]. [7]

3. (*a*) Define hydrodynamic boundary layer. [2]

(*b*) Prove by dimensional analysis that the Nusselt number is a function of Prandtl number and Reynolds number for forced convection.

(*c*) A 6m long horizontal water pipe with 8cm diameter passes through a large room whose temperature is 20°C. If the outer surface of the pipe is 70°C, determine the rate of heat loss from the pipe by natural convection. [7]

(*d*) Engine oil at 60°C flows over the upper surface of a 5cm long flat plate whose temperature is 20°C with a velocity of 2m/s. Find the total drag force and rate of heat transfer per unit width of the entire plate. [Oil properties at 40°C arc, $\rho = 876 kg/m^3$, $P_r = 2962$, $k = 0.144 W/mK$ and $\nu = 2.48 \times 10^{-4}\ m^2/s$] [7]

4. (*a*) Define burn-out point. [2]

(*b*) Derive the relation for average heat transfer coefficient for laminar film condensation over vertical plate. [7]

(*c*) The condenser of a steam power plant operates at a pressure of 7.38 kPa. The steam at this pressure condenses on the outer surface of horizontal tubes through which cooling water circulates. The outer diameter of the pipe is 3 cm and outer surface temperature is maintained at 30°C. Determine the (*i*) rate of heat transfer to the cooling water, (*ii*) rate of condensation of steam per unit length of a tube [at 40°C and 7.38kPa, $h_{fg} = 2407 \times 10^3 J/kg$, $\rho_r = 0.05 kg/m^3$. [7]

(*d*) Explain with neat sketch, the boiling curve and boiling engines. [7]

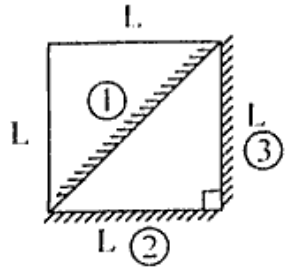
(Turn Over)

5. (*a*) Define capacity ratio. [2]

(*b*) Prove that for a parallel flow heat exchanger, the LMTD is

$$\frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}$$ [7]

(*c*) Find all slope factors for the given surfaces. (Take length of all surfaces perpendicular to plane of paper as unity). [7]



(*d*) A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin walled and has a diameter of 1.5cm. If overall heat transfer coefficient is $640 W/m^2K$, then find the length of the heat exchanger required to achieve the derived heating. [7]

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