(b) The number of tube passes. The velocity of the cooling water is not to exceed 2m/s. 20

9. A condenser is to be designed to condense 225.0 kg of steam per 20 hour at a pressure of 0.15 bar. A square array of 400 tubes, each of 6 mm in diameter, is available for the task. If the tube surface temperature is to be maintained at 26°C, make calculations for the length of each tube. 20

ech 6th Semester (ME) F-Scheme Examination,

May–2017

HEAT TRANSFER

Paper-ME-306-F

allowed : 3 hours] *[Maximum marks : 100*

: *Attempt any **five** questions in total, at least one question from each section. **Question No.1 is compulsory.** Each question carries equal marks (20 marks).*

Discuss the followings : 5×4=20

(a) Critical heat flux and boiling crisis.

(b) Modes of heat flow

(c) Relaxation method

(d) Equation of continuity

Section-A

(a) How does heat transfer differ from thermodynamics ? Is it true to say that heat transfer is essentially thermodynamics with rate equations added ? 10

(b) A stainless steel tube with inner diameter 12 mm, thickness 0.2 mm and length 50 cm is heated etectrically. The entire 15 kw of heat energy generated in the tube is transferred through its outer surface. Work out the intensity of current flow and the temperature drop across the tube wall. For the tube material, take thermal conductivity=18.5 W/m-deg and specific resistance =0.85 W-mm^2/m. 10

3. (a) Prove that the 3-dimensional conduction equation in Cartesian co-ordinates for a homogeneous material, steady state conditions and without heat generation is given by the Laplace equation $\nabla^2 t=0$, where ∇^2 represents the laplaceian operator. Deduce therefrom an expression for one dimensional steady state heat conduction through a slab. 10

(b) Two insulation materials A and B, in powder form, with thermal conductivities of 0.00[illegible] W/m-deg and 0.03 W/m-deg were purchased for use over a sphere of 40 cm diameter. Material A was to form the first layer 4 cm thick and material B was to form the next 5 cm thick. Due to oversight during installation, whole of material B was applied first and subsequently there was a layer formed by material A. Investigate how the conduction heat transfer would be affected. 10

Section-B

4. (a) The handle of a saucepan, 30 cm long and 2 cm in diameter, is subjected to 100°C temperature during a certain cooking operation. The average unit surface conductance over the handle surface is 7.35 W/m^2-deg in the kitchen air at 24°C. The cook is likely to grasp the last 10 cm of the handle and hence the temperature in this region should not exceed 38°C. What should be the thermal conductivity of the handle material to accomplish it ? The handle may be treated as a fin insulated at the tip. 10

(b) Explain a method to obtain solutions to the problem of transient heat conduction in infinitely thick solids. 10

5. (a) A cold wave of 2 weeks duration causes a temperature drop of 25°C at the surface and the temperature variation follows a sinusoidal waveform. Workout the drop in temperature at a depth of 1.2m, and the time lag for a soil having thermal diffusivity $\alpha=0.0018$m^2/hr.

If the base temperature is 6.5°C, calculate the minimum burial depth you would recommend in laying water mains to avoid freezing of water. 10

(b) An 8 cm diameter orange, approximately spherical in shape, undergoes ripening process and generates 18000 kJ/m^2-hr of energy. If external surface of the orange is at 6.5°C, make calculations for temperature at the centre of the orange. Also determine the heat flow from the outer surface of the orange. Take thermal conductivity, k=0.8/m-hr-deg for the orange material. 10

Section-C

6. (a) A nuclear reactor with its core constructed of parallel vertical plates 2.25 m high and 1.5 m wide has been designed on free convection heating of liquid bismuth. Metallurgical considerations limit the maximum surface temperature of the plate to 975°C and the lowest allowable temperature of bismuth is 325°C. Estimate the maximum possible heat dissipation from both sides of each plate. The approximate correlation for the convection coefficient is

$Nu=0.13(Gr\,Pr)^{1/3}$ where the different parameters are evaluated as the mean film temperature. 10

(b) Apply the order of magnitude analysis to establish a functional relationship for the boundary layer thickness. presume zero pressure gradient and constant fluid properties, 10

7. (a) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. Two facing parallel plates radiating only from their facing sides see only each other but the two rectangular plates meeting at right angles do not radiate solely to each other. How do you account for the variation in shape factor ? 10

(b) A plate 0.3 m long is placed at zero angle of incidence in a stream of 15°C water moving at 1 m/s. Find out the streamwise velocity component at the mid-point of the boundary layer, the maximum boundary layer thickness and the maximum value of the normal component of velocity at the trailing edge of the plate. For water at 15°C : ρ=998.9 Kg/m^3 and μ =415.85$\times10^{-2}$ kg/hr-m. 10

Section-D

8. A heat exchanger is to be designed to condense 8 kg/s of an organic liquid (t_{sat}=80°C; h_{fg}=600kJ/kg) with cooling water available at 15°C and at a flow rate of 60kg/s. The overall heat transfer coefficient is 480 W/m^2-deg. Calculate :

(a) The number of tubes required. The tubes are to be of 25 mm outer diameter, 2 mm thickness and 4.85 m length.