337654(37)

BE (6th Semester)
Examination, April-May, 2017

[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 and attempt any **two** parts from (*b*), (*c*) and (*d*) of each question.

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

UNIT-I

1. (*a*) What is thermal diffusivity ? [2]

(*b*) Derive general equation for Fourier's Law of Heat Conduction. [7]

(*c*) A small electric heating application use wire of 2mm diameter with 0.8mm thick insulation ($k = 0.12 W/m^{O}C$). The heat transfer coefficient (h) on the insulated surface is $35 W/m^{2\,O}C$.

Determine the critical thickness of insulation in the case and the critical thickness is used, assuming the temperature difference between the surface of the wire and surroundings air remains unchanged. [7]

(*d*) Derive an expression for steady state temperature distribution in finite slab of thickness 'L' in which heat is being generated at Q per unit volume and one surface is insulated while other one exposed to fluid at temperature 'T_a' with convective heat transfer coefficient 'h'. [7]

UNIT-II

2. (*a*) What is the Newtonian heating and cooling process ? [2]

(*b*) The aluminium square fins (0.5mm and 0.5mm) of 1cm long provide on the surface of an electronic semiconductor device to carry 46mW of heat energy generated by the electronic device with the condition that the temperature should exceed $80^{O}C$. The temperature of surrounding medium is $40^{O}C$. Given that K_{Al} = 190W/m.K., h = 12.5W/m^2K.

Find the number of fins required to carry out the above duty. Neglect heat loss from the end of fins. [7]

(*c*) Derive the expression for heat dissipation from a fin insulated at the tip. [7]

(*d*) The steam of $300^{O}C$ passing through a steel tube. A thermometer packet of steel (k = 454W/mK) of inside diameter 14mm and 1mm thick is used to measure the temperature. Calculate the length of thermometer packet need to measure the temperature within 1.8% permissible error. The diameter of steam tube is 95mm. Take heat transfer coefficient as 93W/m^2K and tube wall temperature as $100^{O}C$. [7]

UNIT-III

3. (*a*) Explain Prandtl number (Pr) and its physical significance. [2]

(*b*) Derive the expression for forced laminar flow in tubes, the value of Nusselt's number Nu_D=4.36 for the constant wall heat flux condition. [7]

(*c*) A nuclear reaction with its core constructed of parallel vertical plates 2.25m high and 1.5m wide has been designed on free convection heating of liquid bismuth. Metallurgical considerations limit the maximum surface temperature of the plate to $975^{O}C$ and the lowest allowable temperature of bismuth is $325^{O}C$.

Estimate the maximum possible heat dissipation from both the sides of each plate. The appropriate correlation for the convection coefficient is Nu=0.13 (Gr Pr)$^{1/3}$, where the different parameters are evaluated as the mean film temperature. [7]

(*d*) Within a condenser shell, water flows through one hundred thin-walled circular tubes having diameter 22.5mm and length 5mm, which have been arranged in parallel. The mass flow rate at water is 65kg/s and its inlet and outlet temperatures are known to be $22^{O}C$ and $28^{O}C$ respectively. Predict the average convection coefficient associated with water flow. [7]

UNIT-IV

4. (*a*) Explain the utility of effectiveness of NTU method. [2]

(*b*) Derive the expression for long mean temperature difference (LMTD) of a counterflow heat exchanger. [7]

(*c*) A horizontal tube of diameter 20mm is exposed to dry stream at $100^{O}C$, the tube surface temperature is maintained at $84^{O}C$ by calculating water through it. Calculate the rate of formation of condensate per meter length of the tube. [7]

(*d*) A certain heat exchangers has $17.5m^2$ area available for the heat transfer. It is used for cooling oil at $200^{O}C$ by using water available at $20^{O}C$. The mass flow and specific heat of oil are 1000 kg/ hr and 1.9 kJ/kgK and the mass flow and sepecific heat of water are $300W/m^2$. Estimate the outlet temperature of oil and water for parrallel flow and counterflow arrangements by using NTU method. [7]

UNIT-V

5. (*a*) Define shape factor for radiation. [2]

(*b*) Define intensity of radiation and prove that the intensity of normal radiation is $\frac{1}{\pi}$ times the total emissive power. [7]

(*c*) Derive the expression for heat transfer between the two concentric non-black infinite length cylinders with the one cylinder surrounds the other cylinder. [7]

(*d*) Determine the number of shields required to keep the temperature of the outside surface of a hollow brick of a furnace at $100^{O}C$ when the temperature of the inside surface of lining as well as of shield as 0.87. Heat transfer to the surroundings from the other outer surface takes place by radiation and convection.

The heat transfer coefficient for natural convection is given by :

$h_a = 1.44\ (\Delta t)^{0.33}\ W/m^2K$

t_a = (air temperature) = $28^{O}C$ [7]

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