Menoufiya University
Faculty of Engineering
Shebin El-Kom
Academic Year 2013-2014

Department: Mech. Power Eng.
Year: Third year
Subject / Heat Transfer MPE 312
Time: 3 hours
Date: 6/1/2014

Please, answer the following questions: [Total 100 marks]

يصرح باستخدام معادلات وجداول وخرائط أ.د/ محمد خليل وكذلك كتاب د/ محمد حبيب.

Question (1): [15 marks]

1.1) *Please, identify the following statements as true or false with correcting the false party:* [5 marks]

a) *The rate of heat dissipation from a flat plate of area o.5 m^2 and thickness 5 mm having a uniform internal heat source of 3 MW/m^3 is 7.5 kW.*

) *The effectiveness of a long and thin rectangular aluminum fin (k = 200 W/m.K), 1 mm thick, 8 mm long and 25 cm width in case when h = 10 W/m^2K is about 4.*

c) *The electro-magnetic waves of heat radiation propagate through the intervening space with the acoustic velocity.*

d) *The view factor between one half a long hollow cylinder and its axial cover is $\pi/2$.*

e) *The radiation surface resistance of an enclosure vanishes.*

1.2) *Water flows inside a steel pipe (k =43 W/m.K) of 2.5 cm outer diameter. The wall thickness is 2 mm. The convective heat transfer film coefficient on the inner side is 500 W/m^2K, while that on the outer side is 12 W/m^2K. Calculate the overall heat transfer coefficient.*

If the pipe is covered with a layer of asbestos (k = 0.18 W/m.K), while still surrounded by a convective environment with h = 12 W/m^2K, determine the critical insulation radius.

Will the rate of heat transfer be increased or decreased by adding an insulation thickness of 10 mm. [10 Marks]

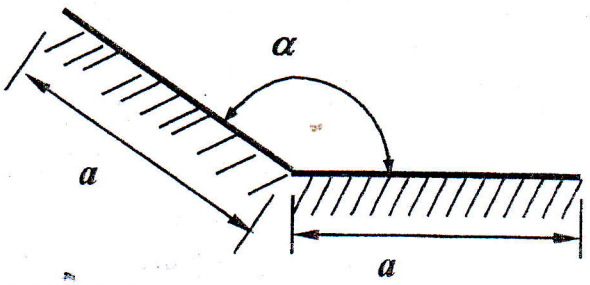
Question (2): [20 marks]

2.1) *A thin annular aluminum fin (k = 200 W/m.K) is mounted on 40 mm outer diameter heated tube. The fin is of constant thickness (0.4 mm) and has an outer radius 60 mm. The tube wall temperature is 140°C, the surrounding temperature is 20°C, and the average convective heat transfer coefficient is 16 W/m^2K. Calculate the heat loss from the fin, the maximum possible heat loss and the heat loss without a fin as well as the fin efficiency and effectiveness.* [10 Marks]

2.2) *A long aluminum cylinder 5 cm diameter and initially at 200°C is exposed to a convection environment at 60°C and h = 1720 W/m^2K. Calculate the temperature at a radius of 2 cm and the heat lost per unit length, 23 seconds after the cylinder is exposed to the environment. Take for aluminum: k = 215 W/m.K, ρ = 2700 kg/m^3, c = 900 J/kg.K. (Please, use Heisler charts).* 10 Marks]

Question (3): [15 marks]

3.1) *Two long strips of equal width form an angle (α). Find the view factor between the two strips as a function of (α).* [5 marks]



3.2) *Two perpendicular walls have a common edge. Each wall is 120 by 240 cm, the 120 cm edge being common. Wall (1) is vertical and has an emissivity of 0.7 and a temperature of 923K. Wall (2) is horizontal and has an emissivity of 0.4 and a temperature of 703K. Determine the radiation configuration factor and the net heat transfer between the two walls. Take Stefan – Boltzmann's constant $\sigma = 5.67\times10^{-8} W/m^2.K^4$.* [10 marks]

Question (4):

4.1- (3 marks)

Prove that the heat convection and friction factor for fully developed laminar flow in triangular-constant heat flux channel with top angle of 30° and 90° is nearly constant at the same Reynolds number and flow prosperities.

4.2 - (6 marks)

The flow of oil in a journal bearing can be approximated as parallel flow between two large plates with one plate moving and the other stationary. Such flows are known as Couette flow. Consider two large isothermal plates separated by 2-mm-thick oil film. The upper plate moves at a constant velocity of 12 m/s, while the lower plate is stationary. Both plates are maintained at 20°C.

(a) Obtain relations for the velocity and temperature distributions in the oil.

(b) Determine the maximum temperature in the oil and

(c) The heat flux from the oil to each plate.

4.3- (7 marks)

A 12-cm-high and 20-cm-wide circuit board houses 100 closely spaced logic chips on its surface, each dissipating 0.05 W. The board is cooled by a fan that blows air over the hot surface of the board at 35 °C at a velocity of 0.5 m/sec. The heat transfer from the back surface of the board is negligible. Determine the average temperature on the surface of the circuit board assuming the air flows vertically upwards along the 12- cm-long side by:

(a) ignoring natural convection and (b) considering the contribution of natural convection. Disregard any heat transfer by radiation.

Question (5): (13 marks)

5.1- (6 marks)

Water is boiled at atmospheric pressure by a horizontal polished copper heating element of diameter D = 5 mm and emissivity ε= 0.05 immersed in water. If the surface temperature of the heating wire is 350 °C, determine the rate of heat transfer and the heat transfer coefficient from the wire to the water per unit length of the wire. If the heater element is nickel, what would be the heat transfer rate? Determine also the thermal characteristics of the Leidenfrost point.

5.2- (7 marks)

Combustion air in a manufacturing facility is to be preheated before entering a furnace by hot water at 90ºC flowing through the tubes of a tube bank located in a duct. Air enters the duct at 15ºC and 1 atm with a mean velocity of 3.8 m/s and flows over the tubes in normal direction. The outer diameter of the tubes is 2.1 cm and the tubes are arranged in staggered arrangement with longitudinal and transverse pitches of $S_L = S_T$ = 5 cm. There are eight rows in the flow direction with eight tubes in each row. Determine:

(a) The rate of heat transfer per unit length of the tubes,

(b) The pressure drop across the tube bank, and

(c) What is the percentage change in the heat transfer coefficient if the flow is in a parallel direction?

5.3- (3 marks)

Three different industrial tubes made of cast iron; galvanized iron and concrete are proposed to be used in a double pipe water-to-water heat exchanger unit. The tubes have an inside diameter of 10 [cm]. Choose the suitable material required to be manufactured in the heat exchanger unit if the water flowing inside the tubes operates at a complete turbulence region of Reynolds number equals to 10^5.

Question (6): (18 marks)

6.1-(7 marks)

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 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m^2. °C, determine the length of the heat exchanger required to achieve the desired heating surface. Take the specific heats of water and geothermal fluid to be 4.18 and 4.31 kJ/kg.°C, respectively. What is the Effectiveness of the heat exchanger?

6.2- (4 marks)

Three different heat exchanger units operate at the same capacity ratio of zero. The units are proposed to be used in an indirect liquid cooling system for the purpose of power transistor cooling process. The heat exchanger units are: parallel flow, counter flow and cross flow with both fluids unmixed. The three units operate at the same specified number of transfer units of 2. If this value increases by 65%, choose the suitable unit required to be used in the cooling process. Neglecting any thermal losses from the heat exchanger to the environment, determine the percentage increase or decrease in the effectiveness if the double-pipe parallel-flow heat exchanger is used instead of double-pipe counter-flow heat exchanger. What is your answer if the same capacity ratio of unity is used? Assume all the other conditions remain the same.

6.3- (7 marks)

Steam of three liquids: water; acetic acid and aniline are proposed to be condensed on the outer surface of three tubes of a condenser unit. The tubes, 2.54 cm diameter, are horizontally placed. The outer surface of the tubes is separately exposed to the saturated steam of each previous proposal liquids at atmospheric pressure. If the average wall surfaces temperature is maintained at 95 °C for each case during the experiments by the flow of cool water through the tubes. It is required to choose the suitable liquid to be used in this condenser unit.