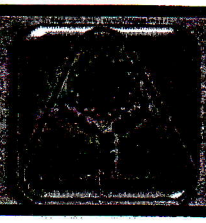
Menoufiya University
Faculty of Engineering
Shebin El-Kom
Academic Year 2015-2016



Department: Mech. Power Eng.
Year: Third year
Subject / Heat Transfer MPE 312
Time: 3 hours
Date: 28/1/2016

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

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

Question (1): **[15 marks]**

1.1) Please, identify the following statements as true or false with correcting the false parts: **[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.*

b) *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) *An opaque material reflects none.*

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]**

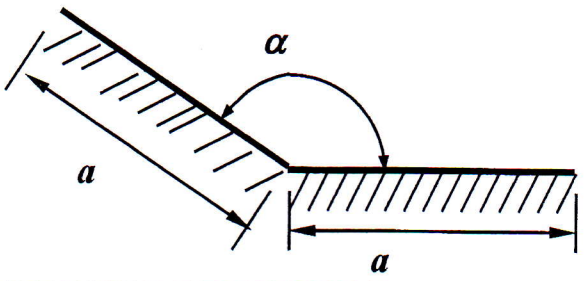
2.1) *A water economizer is built up of round finned iron tubes of an outside diameter of 76 mm. The diameter of the circular fins is 200 mm and the fin thickness is 5 mm. Determine the quantity of heat that will be transferred from the flue gas to the external surface of one economizer tube and the temperature at the tip of a fin, if flue gas temperature is 400°C and the temperature at the base of fins is 180°C, the length of the tube exposed to the hot flue gas is 3 m and the number of fins placed along this length is 150. The coefficient of heat transfer from the hot flue gas to the finned surface is 46.5 W/m^2K and the thermal conductivity of iron is 52.4 W/mK.* **[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 σ = 5.67×10^{-8}W/m^2.K^4.* **[10 marks]**

Question (4): (17 makes)

a) 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. What is your answer if the same capacity ratio of unity is used? Assume all the other conditions remain the same. Neglect any thermal losses from the heat exchangers to the environment. **(4 makes)**

b) A 15-cm-diameter horizontal cylinder (5 m long) has a surface temperature that is maintained at 120 °C. Water at 40 °C is flowing across the cylinder with a velocity of 0.2 m/s. Determine the heat percentage increase or decrease in heat transfer coefficients if the water is flowing (*a*) upward and (*b*) downward. **(6 makes)**

c) Combustion air in a manufacturing facility is to be preheated before entering a furnace by hot water at 90°C flowing through the tubes of a tube bank located in a duct. Air enters the duct at 15°C 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-line 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 heat transfer coefficient,
(c) the pressure drop across the tube bank,
(d) Is the heat transfer coefficient and the pressure drop change if the staggered arrangement duct is used instead of the in-line arrangement. Explain. And,
(e) What is the percentage change in the heat transfer coefficient if the flow is in a parallel direction. Results should be illustrated in clear Table. (7 makes).

Question (5): (16 makes)

a) 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 $2x10^5$. (4 makes)

b) 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 experiment by the flow of cool water through the tubes. It is required to choose the suitable liquid to be used in this condenser unit. Consider the latent heat of vaporization the three liquids is constant and equals to that of water. (4 makes)

c) Consider a 40 m long smooth rectangular duct, with cross-section 200x600 mm length, that is maintained at a constant surface temperature of 40 °C. Air at 10 °C and 1 atm enters the duct with a volumetric flow rate of 0.01 m^3/sec. determine:

a) the outlet temperature of air,
b) the heat transfer rate,
c) the pressure drop,
d) the pumping power requirements to overcome this pressure drop. Evaluate the properties of air at a bulk mean temperature of 20 °C. Is this a good assumption? (8 makes).

Question (6): (17 makes)

a) The pioneering work on boiling was done by S. Nukiyama, who used electrically heated nichrome and platinum wires immersed in water at atmospheric pressure. Nukiyama noticed that boiling takes different forms, depending on the value of the excess temperature ΔT_{excess}. Six different values of the excess temperature boiling regimes are recorded in these experiments: 2, 5, 15, 30, 120 and 1000 °C. Choose the most desirable boiling regime in practice that can be applied indicating the reason.

Disregarding any heat transfer from the unit, determine the heat transfer coefficients from the heating elements to the water. (4 makes)

b) Consider an oil-to-oil double-pipe heat exchanger whose flow arrangement is not known. The temperature measurements indicate that the cold oil enters at 20°C and leaves at 55°C, while the hot oil enters at 80°C and leaves at 45°C. Do you think this is a parallel-flow or counter-flow heat exchanger? Why?

Assuming the mass flow rates of both fluids to be identical, determine the effectiveness of this heat exchanger. (4 makes)

c) Calculate the heat transfer surface area of a double-pipe counter - flow heat exchanger, if the heating water enters the heat exchanger at 97 °C at a rate of 1 [kg/sec] and moves in the inner tube that made of stainless - steel with thermal conductivity of 50 [W/m. K]. The diameter ratio of the pipe is D_2/D_1=40/37 [mm/mm]. The cold fluid required to heat it is also water which moves in the annular space between the two tubes at a flow rate of 1.14 [kg/sec]. As a result, the cold water is heated from 17 °C to 47 °C. The inner diameter of the external pipe is 54 [mm]. Neglecting any thermal losses from the heat exchanger to the environment, determine also the percentage increase or decrease in the heat transfer surface area if the double-pipe parallel - flow heat exchanger is used instead of the double-pipe counter - flow heat exchanger.

What is the effectiveness of both the heat exchangers.? (9 makes)