Menoufia University Faculty of Engineering Shebin El-Kom Second (Spring) Semester Examination Academic Year: 2019-2020	Minufiya University	Department: Mechanical Power Engineering Year: Higher Diploma Subject: Applied Heat Transfer Code: [MPE 512] Time Allowed: 3 hours Date: 23/8/2020

Allowed Tables and Charts: Heat transfer correlations and properties tables.

Answer the Following Questions [100 Marks]

Question (1) (25 marks)

1-a) Does insulating of cold surfaces save energy? Explain. ***(5 marks)***

1-b) A pipe is insulated such that the outer radius of the insulation is less than the critical radius. Now the insulation is taken off. Will the rate of heat transfer from the pipe increase or decrease for the same pipe surface temperature? ***(4 marks)***

1-c) Prove that the critical radius of insulation for cylindrical walls is given by:

$$r_{cr} = \frac{k_{in}}{h_o}$$ ***(4 marks)***

1-d) Hot water at 110 °C flows in a cast iron pipe (k = 52 W/m · °C) whose inner radius is 2.0 cm and thickness is 0.3 cm. The pipe is to be covered with adequate insulation so that the temperature of the outer surface of the insulation does not exceed 30 °C when the ambient temperature is 22 °C. Taking the heat transfer coefficients inside and outside the pipe to be h_i = 80 W/m^2 · °C and h_o = 22 W/m^2 · °C, respectively, determine the thickness of fiber glass insulation (k = 0.038 W/m · °C) that needs to be installed on the pipe. ***(12 marks)***

Question (2) (25 marks)

2-a) What is the reason for the widespread use of fins on surfaces? ***(4 marks)***

2-b) The fins attached to a surface are determined to have an effectiveness of 0.9. Do you think the rate of heat transfer from the surface has increased or decreased as a result of the addition of these fins? ***(4 marks)***

2-c) Hot water is to be cooled as it flows through the tubes exposed to atmospheric air. Fins are to be attached in order to enhance heat transfer. Would you recommend attaching the fins inside or outside the tubes? Why? ***(5 marks)***

2-d) A hot surface at 100 °C is to be cooled by attaching 3 cm long, 0.25 cm diameter aluminum pin fins (k = 237 W/m · °C) to it, with a center-to-center distance of 0.6 cm. The temperature of the surrounding medium is 30 °C, and the heat transfer coefficient on the surfaces is 35 W/m^2 · °C. Determine the rate of heat transfer from the surface for a 1 m × 1 m section of the plate. Also determine the overall effectiveness of the fins. ***(12 marks)***

Question (3) (25marks)

3-a) What is the physical significance of the Nusselt number? How is it defined? ***(4 marks)***

3-b) What is external forced convection? How does it differ from internal forced convection? Can a heat transfer system involve both internal and external convection at the same time? Give an example. **(4 marks)**

3-c) In which mode of heat transfer is the convection heat transfer coefficient usually higher, natural convection or forced convection? Why? **(4 marks)**

3-d) Exhaust gases at 1 atm and 300 °C are used to preheat water in an industrial facility by passing them over a bank of tubes through which water is flowing at a rate of 6 kg/s. The mean tube wall temperature is 80 °C. Exhaust gases approach the tube bank in normal direction at 4.5 m/s. The outer diameter of the tubes is 2.1 cm, and the tubes are arranged in-line with longitudinal and transverse pitches of SL = ST = 8 cm. There are 16 rows in the flow direction with eight tubes in each row. Using the properties of air for exhaust gases, determine

a) The rate of heat transfer per unit length of tubes,
b) The pressure drop across the tube bank, and
c) The temperature rise of water flowing through the tubes per unit length of tubes.

(13 marks)

Question (4) (25 marks)

4-a) Show that the Reynolds number for flow in a circular tube of diameter D can be expressed as

$$\mathrm{Re} = \frac{4\dot{m}}{\pi D \mu}$$ **(5 marks)**

4-b) Hot water at 90 °C enters a 15 m section of a cast iron pipe (k = 52 W/m. °C) whose inner and outer diameters are 4 and 4.6 cm, respectively, at an average velocity of 0.8 m/s. The outer surface of the pipe is exposed to the cold air at 10 °C in a basement, with a convection heat transfer coefficient of 15 W/m^2. °C. Taking the walls of the basement to be at 10 °C also, determine

a) The rate of heat loss from the water, and
b) The temperature at which the water leaves the basement. Disregard any heat transfer by radiation. **(10 marks)**

4-c) Consider a 0.8 × 0.8 m thin square plate in a room at 25 °C. One side of the plate is maintained at a temperature of 60 °C, while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is

a) Vertical,
b) Horizontal with hot surface facing up, and
c) Horizontal with hot surface facing down. **(10 marks)**

With my best wishes