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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course No.: ME 6145
Course Title: *Convective Heat Transfer*

Winter Semester: A.Y. 2022-2023
Time: 3.0 Hours
Full Marks: 150

There are **06 (Six)** Questions. Answer all of them. Marks in the margin indicate full marks. Do not write on this question paper. Symbols carry their usual meanings. Assume reasonable values for any missing data. Programmable calculators are not allowed.

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1. a. Physically, what does the Grashof number represent? How does the Grashof number differ from the Reynolds number? **[25]**
b. Why are finned surfaces frequently used in practice? Why are the finned surfaces referred to as heat sinks in the electronics industry?
c. Under what conditions does natural convection enhance forced convection, and under what conditions does it hurt forced convection?
d. In an ordinary double-pane window, about half of the heat transfer is by radiation. Describe a practical way of reducing the radiation component of heat transfer.
e. What does the effective conductivity of an enclosure represent? How is the ratio of the effective conductivity to thermal conductivity related to the Nusselt number?

2. 6-m-long section of an 8-cm-diameter horizontal hot water pipe shown in **Figure 1** passes through a large room whose temperature is 20°C. If the outer surface temperature of the pipe is 70°C, determine the rate of heat loss from the pipe by natural convection. **[25]**

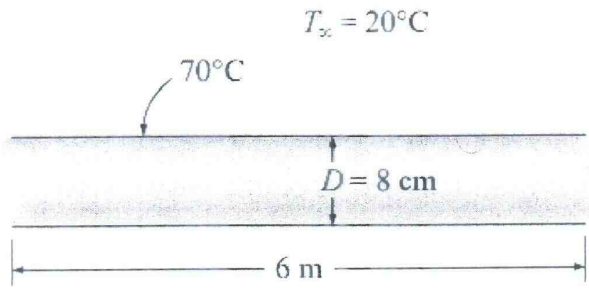

Figure 1

3. Boiling is probably the most familiar form of heat transfer, yet it remains to be the least understood form. After hundreds of papers written on the subject, we still do not fully understand the process of bubble formation and we must still rely on empirical or semi-empirical relations to predict the rate of boiling heat transfer. The pioneering work on boiling was done in 1934 by S. Nukiyama, who used electrically heated Nichrome and platinum wires immersed in liquids in his experiments. Nukiyama noticed that boiling takes different forms, depending on the value of the excess temperature and different boiling regimes are observed. These regimes can be illustrated on the curve which is a plot of boiling heat flux versus the excess temperature. The specific shape of the curve depends on the fluid–heating surface material combination and the fluid pressure, but it is practically independent of the geometry of the heating surface. Draw the typical boiling curve for water at 1 atm pressure and identify the different boiling regimes. Also, explain the characteristics of each regime in details. **[25]**

4. [25]

a. What is the modified latent heat of vaporization? For what is it used? How does it differ from the ordinary latent heat of vaporization?

b. Explain how burnout is caused. Why is the burnout point avoided in the design of boilers?

c. What is the difference between film and drop-wise condensation? Which is a more effective mechanism of heat transfer?

d. How does the presence of a non-condensable gas in a vapor influence the condensation heat transfer?

e. What is the major cause for the premature degradation of the performance of some heat pipes?

5. [25]

a. What is the role of the baffles in a shell-and-tube heat exchanger? How does the presence of baffles affect the heat transfer and the pumping power requirements? Explain.

b. What are the common causes of fouling in a heat exchanger? How does fouling affect heat transfer and pressure drop?

c. What are the common approximations made in the analysis of heat exchangers?

d. Heat exchanger is to be selected to cool a hot liquid chemical at a specified rate to a specified temperature. Explain the steps involved in the selection process.

e. Consider a heat exchanger in which both fluids have the same specific heats but different mass flow rates. Which fluid will experience a larger temperature change: the one with the lower or higher mass flow rate?

6. [25] Hot oil is to be cooled in a double-tube counter-flow heat exchanger (as shown in **Figure 2**). The copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. Water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s. Taking the average temperatures of the water and the oil to be 45°C and 80°C, respectively, determine the overall heat transfer coefficient of this heat exchanger.

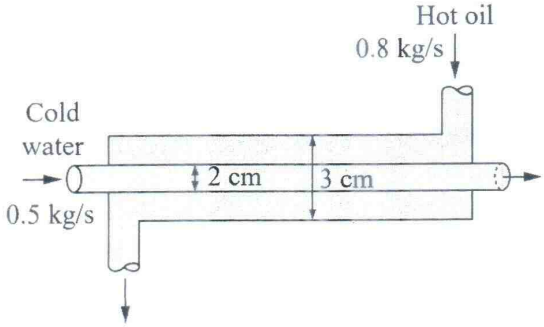

Figure 2

Nusselt number for fully developed laminar flow in a circular annulus with one surface insulated and the other isothermal (Kays and Perkins, Ref. 8.)

D_i/D_o	Nu_i	Nu_o
0.00	—	3.66
0.05	17.46	4.06
0.10	11.56	4.11
0.25	7.37	4.23
0.50	5.74	4.43
1.00	4.86	4.86