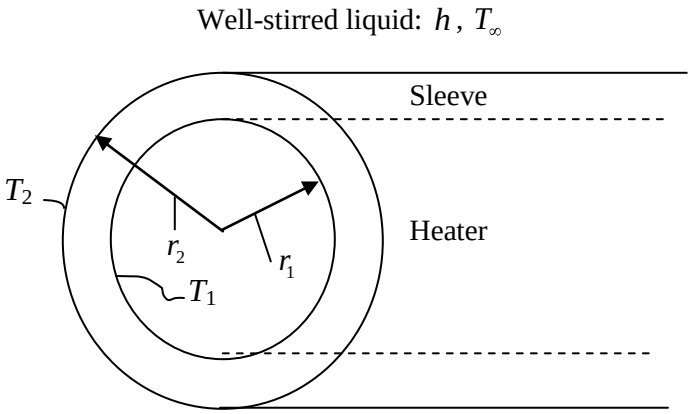
Problem Set # 3

Given: Mon. Sep. 24 **Recommended Completion Date:** Wed., Oct. 03
Do not submit for grading

Problem 1: A rod-type electrical heater is inserted into a special corrosion-resistant steel sleeve. The thermal contact between the heater outer surface and the sleeve inner surface is excellent. The unit is used to heat a liquid in a well-stirred tank. The length of the heater is *L*. Experiments on the unit yield the following data:



Steady-state operation data:

r_1 = 0.03 m; r_2 = 0.035 m

L = 1.0 m; T_∞ = 235.17 °C

T_1 = 252 °C; T_2 = 250 °C

Total power input of the heater is q = 4891.20 W

(a) Calculate the value of the thermal conductivity of the sleeve material: k_{sleeve} = ?

(b) What is the value of the heat transfer coefficient, *h*, on the outside surface of the sleeve?

(c) What value of r_2 will minimize the overall temperature difference ($T_1 - T_\infty$) for the rated heater output, and what is this minimum possible temperature difference? Assume r_1, k_{sleeve}, *h*, *L*, and T_∞ stay unchanged.

Ans.: (a) k_{sleeve} *=60 W/m-K; (b)* h *= 1499.8 W/m²-K; (c)* r_2*=0.04 m;* ΔT_{min}*=16.71 °C*

Problem 2: A very long rod 5 mm in diameter is attached with excellent thermal contact at one end to a wall that is maintained at T_{wall} = 100 °C. The curved surface of the rod and its other end are exposed to ambient air at a temperature of T_∞ = 20 °C; and h = 50 W/m²-°C. The rod is made of an aluminum alloy whose thermal conductivity is k_{Al} = 180 W/m-°C.

(a) Determine the temperature distribution along the rod.

(b) Determine the total rate of heat loss from the rod to the air.

(c) After several years of operation, the total rate of heat loss from this rod to the air drops by 20% due to the development of thermal contact resistance at the end where it is joined to the wall. If T_{wall}, h, T_∞, and k_{Al} stay unchanged, calculate the contact coefficient, $h_{contact}$.

Ans.: (b) 4.215 *W; (c)* $h_{contact}$ =10733.32 W/m²- °C

Selected Problems from the Textbook

(Incropera et al., 2007) Please do the following problems: **3. 37, 3.61, 3.120, 3.133 OR**

(Incropera et al., 2011) Please do the following problems: **3. 48, 3.71, 3.130, 3.145**