Birzeit University
Mechanical & Mechatronics Engineering Department
ENMC 4411 Thermal Fluid Engineering
Homework # 6
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16.4 The steady-state temperature distribution in a one dimensional wall of thermal conductivity 50 and thickness 50 mm is observed to be $T(^{o}C) = a + bx^2$, where $a = 200^{o}C$, $b = -2000^{o}C/m^2$, and x is in meters.
(a) What is the volumetric energy generation rate in the wall?
(b) Determine the heat fluxes at the two wall faces. In what manner are these heat fluxes related to the volumetric energy generation rate?

16.10 The walls of a refrigerator are typically constructed by sandwiching a layer of insulation between sheet metal panels. Consider a wall made from fiberglass insulation of thermal conductivity ki = 0.046 and thickness Li = 50 mm and steel panels, each of thermal conductivity kp = 60 and thickness Lp = 3 mm. If the wall separates refrigerated air at $T_\infty,i = 4^{o}C$ from ambient air at $T_\infty,o = 25^{o}C$, what is the heat transfer rate per unit surface area? Coefficients associated with natural convection at the inner and outer surfaces may be approximated as $hi = ho$ =5 .

16.15 The rear window of an automobile is defogged by passing warm air over its inner surface. If the warm air is at $T_\infty,i = 40^{o}C$ and the corresponding convection coefficient is hi = 30 , what are the inner and outer surface temperatures of 4-mm-thick window glass, if the outside ambient air temperature is $T_\infty,o = -10^{o}C$ and the associated convection coefficient is ho =65 ?

16.23 A stainless steel (k = 14) tube used to transport a chilled pharmaceutical has an inner diameter of 36 mm and a wall thickness of 2 mm. The pharmaceutical and ambient air are at temperatures of $6^{o}C$ and $23^{o}C$, respectively, while the corresponding inner and outer convection coefficients are 400 and 6 , respectively.
(a) What is the heat transfer rate per unit tube length?
(b) What is the heat transfer rate per unit length if a 10-mmthick layer of calcium silicate insulation ($k$ins = 0.050) is applied to the outer surface of the tube?

16.50 Consider the use of rectangular, straight, stainless steel (k= 15) fins on a plane wall whose temperature is $100^{o}C$. The adjoining fluid is at $20^{o}C$, and the associated convection coefficient is The fin is 6 mm thick and 20 mm long.
(a) Calculate the fin efficiency, effectiveness, and heat rate per unit length.
(b) Compare the foregoing results with those for a fin fabricated from pure copper (k = 400).

16.57 The end of a rectangular bar surrounded by insulation is maintained at 100°C and is exposed to ambient air as shown in the schematic. A linear array of pin fins (*N* = 10) is affixed to the end surface to enhance the heat transfer rate from the bar. The pin fins (*k* = 65) are 3 mm in diameter and 12 mm long. The ambient air temperature is 25°C, and the convection coefficient over the bar end surface and pin fins is 10 W/m2 # K.

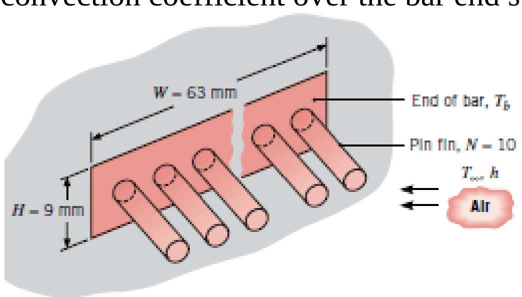

Figure P16.57

Determine the percentage increase in the heat transfer rate associated with attaching the pin fins to the bar end.

16.65 Energy storage systems commonly involve a *packed bed* of solid spheres, through which a hot gas flows if the system is being charged or a cold gas flows if it is being discharged (Fig. P16.65). In a charging process, heat transfer from the hot gas increases thermal energy stored within the colder spheres; during discharge, the stored energy decreases as heat transfer occurs from the warmer spheres to the cooler gas.

Consider a packed bed of 75-mm-diameter aluminum spheres (ρ = 2700 kg/m3, *c* = 950, *k* = 240) and a charging process for which gas enters the storage unit at a temperature of *Tg,i* = 300°C. If the initial temperature of the spheres is *Ti* = 25°C and the convection coefficient is *h* =75 how long does it take a sphere near the inlet of the system to accumulate 90% of the maximum possible energy?

What is the corresponding temperature at the center of the sphere? Is there any advantage to using copper instead of aluminum?