HW 1.3

By

Team 01 - Joel Adriano, Brynn Jewell, Jacob Leonard, and Alex Rogemoser

MET 440 - Heat Transfer

Dr. Ayala

CH4 Problems

Question 4-47

4-47. A cylindrical heat source and a cylindrical heat sink, each having a radius of 10 cm and a length of 8m, are buried in an infinite medium of fireclay brick [$k = 1 W/(m \cdot °C)$], 15 cm apart and parallel to each other. The surfaces of the cylinders are measured to be 500°C and 400°C, respectively. Determine the steady heat flow from one cylinder to the other.

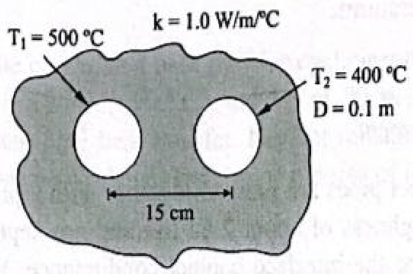
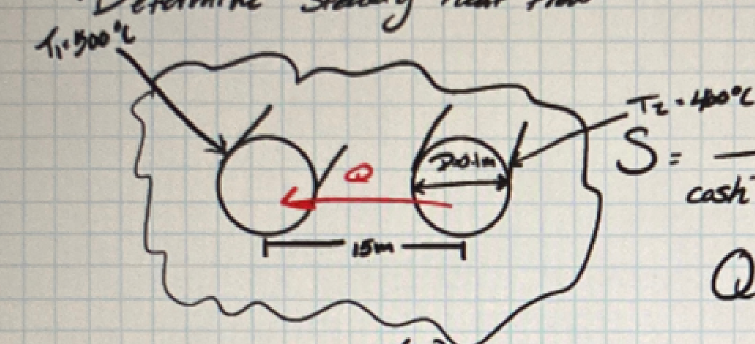


Figure P4-47

Solution

47 A Cylidrical heat source & cylindrical heat Sink have a radius of 10cm & length 8m are buried in an infinite medium of fire clay brick ($K = 1 W/m°C$) are 15m apart surfaces are $T_1 = 500°C$ & $T_2 = 400°C$ Determine steady heat flow



Equation from Table 4.2

$$S = \frac{2\pi L}{\cosh^{-1}\left[(z^2 - R_1^2 - R_2^2)/(2R_1R_2)\right]}$$

$$Q = Sk\Delta T$$

$$S = \frac{2\pi(1)}{\cosh^{-1}\left[\frac{(15^2 - 0.1^2 - 0.1^2)}{2(0.1)(0.1)}\right]} = 0.05019$$

$$Q = (0.05019)(1\ W/m^2°C)(500 - 400)$$

$$Q = 5.0159\ W/m^2$$

Question 4-51

4-51. A hot water pipe with an outside radius of 1 cm is embedded eccentrically inside a long cylindrical concrete block radius of 10 cm. The distance between the center of the pipe and the cylinder is 7 cm. The outside surface of the concrete is maintained at 25°C. The heat loss from the hot water to the concrete is 100 W/m length. Determine the wall temperature of the pipe.

Solution

51. $Q = SK\Delta T$

$$Q = \frac{2\pi L}{\cosh^{-1}\dfrac{(.01)^2 + .1^2 - .07^2}{2(.01)(.1)}} \cdot .76\,(T_1 - 25°C)$$

$$100\ \frac{W}{m} = 2.97(T_1 - 25°C)$$

$$\boxed{T_1 = 58.7°C}$$

Question 4-54

4-54. An iron rod of length $L = 30$ cm, diameter $D = 1$ cm, and thermal conductivity $k = 65$ W/(m · °C) is attached horizontally to a large tank at temperature $T_0 =$ 200°C, as illustrated in the accompanying figure. The rod is dissipating heat by convection into ambient air at $T_\infty = 20$°C with a heat transfer coefficient $h_\infty =$ 15 W/(m^2 · °C). What is the temperature of the rod at distances of 10 and 20 cm from the tank surface?.

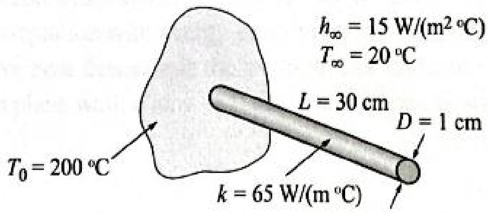


Figure P4-54

Solution

54. $T(.1) = \dfrac{(T_0 - T\infty)(\cosh m(L-x))}{\cosh mL} + T\infty$

$m = \sqrt{\dfrac{hP}{AK}} = \sqrt{\dfrac{15\,(.01\pi)}{65\,\pi\,.005^2}} = 9.61$

$T(.1) = \dfrac{(200-20)(\cosh 9.61(.3-.1))}{\cosh(9.61 \times .3)} + 20°C = \boxed{90.1°C}$

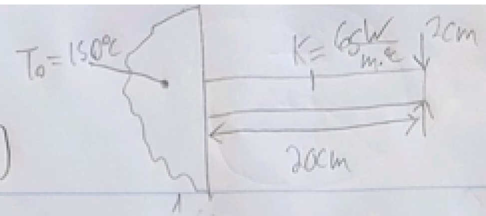
$T(.2) = \dfrac{(200-20)(\cosh 9.61(.3-.2))}{\cosh(9.61 \times .3)} + 20°C = \boxed{50.1°C}$

Question 4-56

4-56. An iron rod of length $L = 20$ cm, diameter $D = 2$ cm, and thermal conductivity $k = 65$ W/(m·°C) is attached to a large surface at $T_0 = 150$°C. The rod has dissipated heat into the ambient air at $T_\infty = 20$°C with a heat transfer coefficient $h_\infty = 15$ W/(m^2·°C). Calculate the heat transfer rate from the rod to the ambient.

Answers: (b) 0.25, (c) 11.6 W.

5(b)



$T_\infty = 20°C$ $Q = ?$

$h = 15 \frac{W}{m^2 \cdot °C}$

Assuming Tip is Adiabatic

$Q_{fin} = M \tanh mL$

$M = \sqrt{hP \cdot KA}\ \theta_0$ $\theta_0 = T_0 - T_\infty$

$M = \sqrt{h \cdot \pi \cdot D \cdot K \cdot \frac{\pi}{4} \cdot D^2}\ (T_0 - T_\infty)$

$M = \sqrt{h \cdot \frac{\pi^2}{4} \cdot D^3 \cdot K}\ (T_0 - T_\infty)$

$M = \sqrt{15 \frac{W}{m^2 \cdot °C} \cdot \frac{\pi^2}{4} \cdot 0.02m^3 \cdot 65 \frac{W}{m \cdot °C}}\ (150°C - 20°C)$

$M = 18.03$

$m = \sqrt{\frac{hP}{KA}} = \sqrt{\frac{h \cdot 4}{KD}} = \sqrt{\frac{15 \frac{W}{m^2 \cdot °C} \cdot 4}{65 \frac{W}{m \cdot °C} \cdot 0.02m}}$

$m = 6.79$

$Q_{fin} = 18.03 \tanh 6.79 \cdot 0.2m$

$Q_{fin} = 15.8\ W$