Homework 4 - Aidan Sharpe

1

The wall of a house is 7[m] wide, 6[m] high, and 0.3[m] thick with $k = 0.6[\text{W}/(m \cdot K)]$. The surface temperature on the inside of the wall is 16°C and the temperature on the outside is 6°. Find the heat flux through the wall and the total heat loss through it.

Heat flux is given by

$$q''_x = -k\frac{dT}{dx}$$

$\Delta T = 10$, $k = 0.6$, $\Delta x = 0.3$

$$q''_x = -0.6\frac{10}{0.3} = -20[\text{W}/\text{m}^2]$$

Total heat loss is the product of heat flux and the area:

$$-20(6 \times 7) = -840[\text{W}]$$

2

A 20[mm] diameter copper pipe is used to carry heated water. The external surface of the pipe is subjected to a convective heat transfer coefficient of $h = 6[\text{W}/(\text{m}^2 \cdot \text{K})]$. Find the heat loss by convection per meter length of the pipe when the external surface temperature is 80°C and the surroundings are at 20°C. Assuming black body radiation, what is the heat loss by radiation?

$$\dot{Q} = hA(T - T_f)$$

$h = 6$, $A = 2\pi 0.02l$, $T = 80$, $T_f = 20$

$$\dot{Q} = 6(2\pi 0.02x)(80 - 20) = 45.2389x$$

Heat loss due to convection is 45.2389[W/m].

$$q'' = \sigma T_s^4 = 5.67 \times 10^{-8}(80 + 273.15) = 2 \times 10^{-5}[\text{W}/\text{m}^2]$$

The total heat loss is the product of surface area and thermal flux:

$$2 \times 10^{-5}(2\pi 0.02x) = 2.516x[\text{W}]$$

3

A plate 0.3[m] long and 0.1[m] wide, with a thickness of 12[mm] is made from stainless steel ($k = 16[\mathrm{W}/(\mathrm{m}\cdot\mathrm{K})]$), the top surface is exposed to a 20°C airstream. In an experiment, the plate is heated by an electrical heater (also 0.3[m] by 0.1[m]) positioned on the underside of the plate and the temperature of the plate adjacent to the heater is maintained at 100°C. A voltmeter and ammeter are connected to the heater and these read 200[V] and 0.25[A] respectively. Assuming that the plate is perfectly insulated on all sides except the top surface, what s the convective heat transfer coefficient?

Heat transfer from heater to plate:

$$P = IV = 200 \times 0.25 = 50\mathrm{W}]$$

$$q'' = \frac{50}{0.3 \times 0.1} = 1666.667[\mathrm{W}/\mathrm{m}^2]$$

Heat transfer from the plate to the air:

$$q'' = 1666.667 = \frac{d\dot{Q}}{dA}$$

$$\dot{Q} = hA(T_{\text{plate}} - T_{\text{air}})$$

$$h = \frac{q''}{T_{\text{plate}} - T_{\text{air}}} = \frac{1666.667}{100 - 20} = 20.833[\mathrm{W}/(\mathrm{m}^2{\cdot}\mathrm{K})]$$