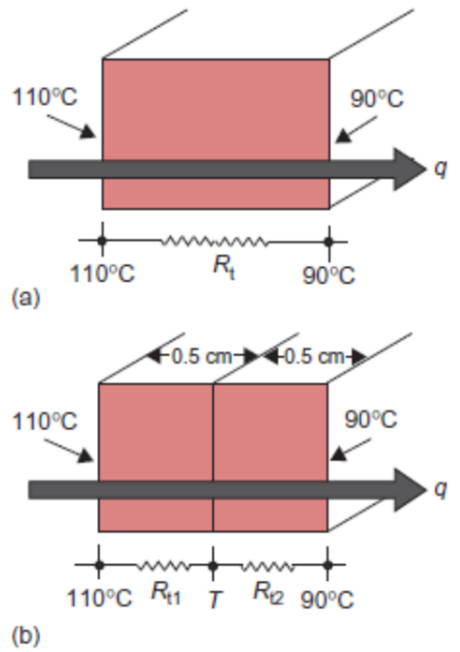
FAQs

1. One face of a stainless-steel plate 1 cm thick is maintained at 110 °C, and the other face is at 90 °C (Figure below). Assuming steady-state conditions,

a) calculate the rate of heat transfer per unit area through the plate using the thermal resistance concept. The thermal conductivity of stainless steel is 17 W/(m °C).

b) Determine the temperature at 0.5 cm from the 110 °C temperature face.



(a)

$$R_t = \frac{(x_2 - x_1)}{kA}$$

= 0.01/(17 x 1) = 5.88 x 10^{-4} °C/W

$$q_x = \frac{(T_1 - T_2)}{R_t}$$

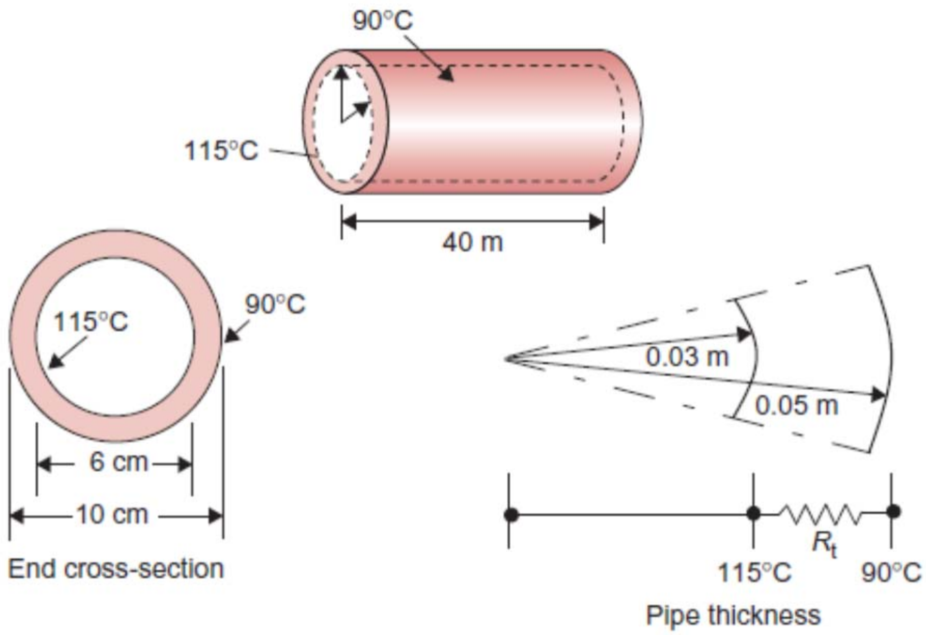
= (110-90)/(5.88 x 10^{-4}) = 34,013 W

(b)

R_{t1} = (0.05)/(17 x 1) = 2.94 x 10^{-4} °C/W

T = T_1 – (q x R_{t1}) = 110 – (34,013 x 2.94 x 10^{-4})
= 100 °C

2. A 2-cm-thick steel pipe (thermal conductivity543 W/[m °C]) with 6 cm inside diameter is being used to convey steam from a boiler to process equipment for a distance of 40 m. The inside pipe surface temperature is 115 °C, and the outside pipe surface temperature is 90 °C (Figure below). Calculate the total heat loss to the surroundings under steady-state conditions.



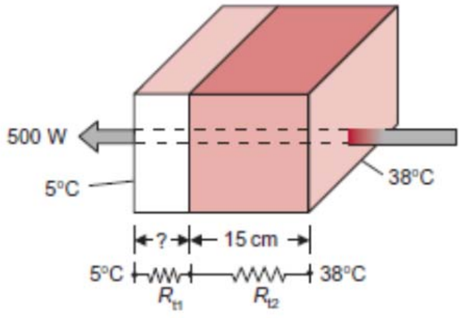
Solution

$$R_t = \left[\frac{\ln(r_o/r_i)}{2\pi Lk}\right] = \ln(0.05/0.03)/(2\pi \text{ x } 40 \text{ x } 43) = 4.727 \text{ x } 10^{-5}\ {}^{o}\text{C/W}$$

q = (115 – 90)/ 4.727 x 10^{-5} = 5,28,903 W

3. A cold storage wall (3 m x 6 m) is constructed of 15-cm-thick concrete (thermal conductivity = 1.37 W/[m ^{o}C]). Insulation must be provided to maintain a heat transfer rate through the wall at or below 500 W (Figure below). If the thermal conductivity of the insulation is 0.04 W/(m ^{o}C), compute the required thickness of the insulation. The outside surface temperature of the wall is 38 ^{o}C, and the inside wall temperature is 5 ^{o}C.

Solution



(a)

$$q = \frac{T_2 - T_1}{R_{tB} + R_{tC} + R_{tD}}$$

$= (38 - 5)/(R_{t1} + R_{t2})$

$R_{t2} = 0.15/(1.37 \times 18) = 0.0061\ ^{o}C/W$

Therefore,

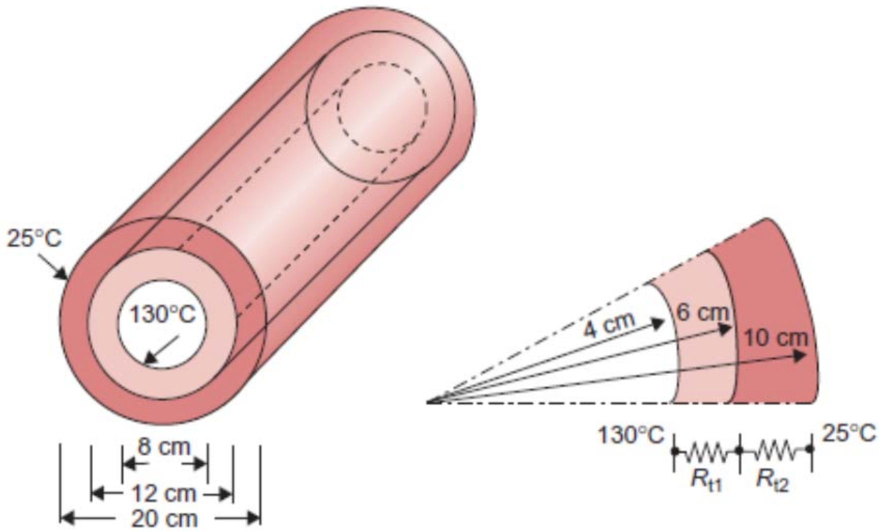
$500 = (38 - 5)/(R_{t1} + 0.0061)$

$R_{t1} = (38 - 5)/500 = 0.06\ ^{o}C/W$

(b) $\Delta x_B = R_{tB} k_B A$

$= 0.06 \times 0.04 \times 18 = 0.043 = 4.3$ cm

4. A stainless-steel pipe (thermal conductivity = 17 W/[m ^{o}C]) is being used to convey heated oil (Figure below). The inside surface temperature is 130 ^{o}C. The pipe is 2 cm thick with an inside diameter of 8 cm. The pipe is insulated with 0.04-m-thick insulation (thermal conductivity = 0.035 W/[m ^{o}C]). The outer insulation temperature is 25 ^{o}C. Calculate the temperature of the interface between steel and insulation, assume steady-state conditions.



Solution

Thermal resistance in the pipe layer is, from Eq. 24

$R_t = \left[\frac{\ln(r_o/r_i)}{2\pi Lk} \right]$ = ln(0.05/0.033)/(2π x 40 x 43) = 4.727 x 10^{-5} °C/W

Therefore

$$q_r = \frac{(T_i - T_o)}{\left[\frac{\ln(r_o/r_i)}{2\pi Lk} \right]}$$ = (115 – 90)/(4.727 x 10^{-5}) = 5,28,903 W

Total heat loss from the 40 m long pipe is 5,28,903 W