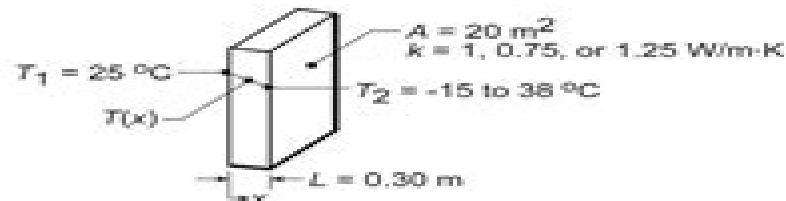


## PROBLEM 1.2

**KNOWN:** Inner surface temperature and thermal conductivity of a concrete wall.

**FIND:** Heat loss by conduction through the wall as a function of ambient air temperatures ranging from  $-15$  to  $38^\circ\text{C}$ .

**SCHEMATIC:**



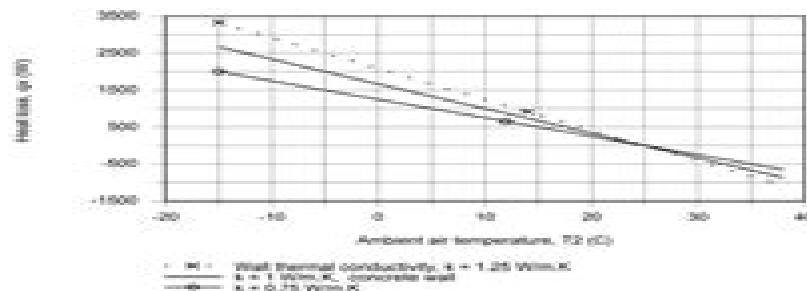
**ASSUMPTIONS:** (1) One-dimensional conduction in the  $x$ -direction, (2) Steady-state conditions, (3) Constant properties, (4) Outside wall temperature is that of the ambient air.

**ANALYSIS:** From Fourier's law, it is evident that the gradient,  $dT/dx = -q_x^*/k$ , is a constant, and hence the temperature distribution is linear, if  $q_x^*$  and  $k$  are each constant. The heat flux must be constant under one-dimensional, steady-state conditions; and  $k$  is approximately constant if it depends only weakly on temperature. The heat flux and heat rate when the outside wall temperature is  $T_2 = -15^\circ\text{C}$  are

$$q_x^* = -k \frac{dT}{dx} = k \frac{T_1 - T_2}{L} = 1\text{ W/m}\cdot\text{K} \frac{25^\circ\text{C} - (-15^\circ\text{C})}{0.30\text{ m}} = 133.3\text{ W/m}^2. \quad (1)$$

$$q_x = q_x^* \times A = 133.3\text{ W/m}^2 \times 20\text{ m}^2 = 2667\text{ W}. \quad (2)$$

Combining Eqs. (1) and (2), the heat rate  $q_x$  can be determined for the range of ambient temperature,  $-15 \leq T_2 \leq 38^\circ\text{C}$ , with different wall thermal conductivities,  $k$ .



For the concrete wall,  $k = 1\text{ W/m}\cdot\text{K}$ , the heat loss varies linearly from  $+2667\text{ W}$  to  $-867\text{ W}$  and is zero when the inside and ambient temperatures are the same. The magnitude of the heat rate increases with increasing thermal conductivity.

**COMMENTS:** Without steady-state conditions and constant  $k$ , the temperature distribution in a plane wall would not be linear.

# Solution Manual Heat Transfer Incropera 5th Edition

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