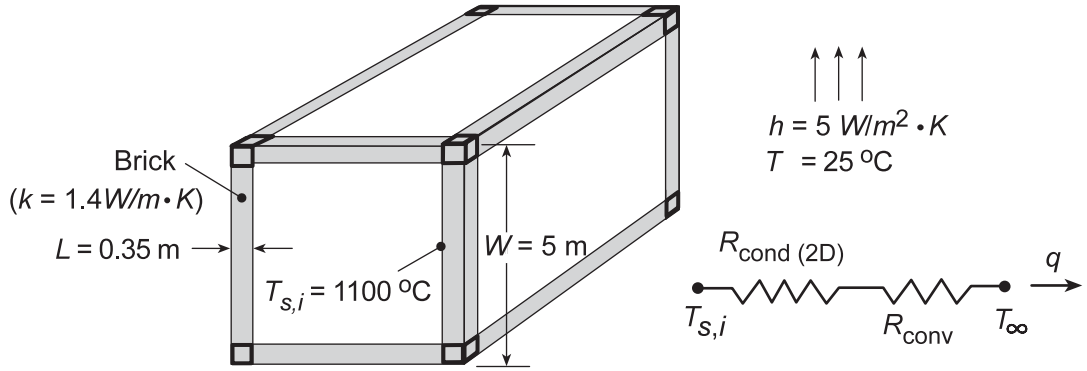
PROBLEM 4.26

KNOWN: Dimensions, thermal conductivity and inner surface temperature of furnace wall. Ambient conditions.

FIND: Heat loss.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state, (2) Uniform convection coefficient over entire outer surface of container, (3) Negligible radiation losses.

ANALYSIS: From the thermal circuit, the heat loss is

$$q = \frac{T_{s,i} - T_\infty}{R_{cond(2D)} + R_{conv}}$$

where $R_{conv} = 1/hA_{s,o} = 1/6(hW^2) = 1/6[5\ W/m^2 \cdot K(5\ m)^2] = 0.00133$ K/W. From Equation (4.21), the two-dimensional conduction resistance is

$$R_{cond(2D)} = \frac{1}{Sk}$$

where the shape factor S must include the effects of conduction through the 8 corners, 12 edges and 6 plane walls. Hence, using the relations for Cases 8 and 9 of Table 4.1,

$$S = 8(0.15L) + 12 \times 0.54(W - 2L) + 6A_{s,i}/L$$

where $A_{s,i} = (W - 2L)^2$. Hence,

$$S = \left[8(0.15 \times 0.35) + 12 \times 0.54(4.30) + 6(52.83)\right] m$$

$$S = (0.42 + 27.86 + 316.98)\,m = 345.26 m$$

and $R_{cond(2D)} = 1/(345.26\ m \times 1.4\ W/m \cdot K) = 0.00207$ K/W. Hence

$$q = \frac{(1100 - 25)^\circ C}{(0.00207 + 0.00133)\,K/W} = 316\,kW \quad <$$

COMMENTS: The heat loss is extremely large and measures should be taken to insulate the furnace. Radiation losses may be significant, leading to larger heat losses.