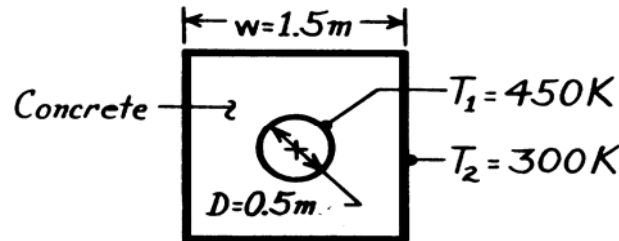


PROBLEM 4.17

KNOWN: Dimensions and boundary temperatures of a steam pipe embedded in a concrete casing.

FIND: Heat loss per unit length.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Negligible steam side convection resistance, pipe wall resistance and contact resistance ($T_1 = 450\text{ K}$), (3) Constant properties.

PROPERTIES: Table A-3, Concrete (300K): $k = 1.4\text{ W/m}\cdot\text{K}$.

ANALYSIS: The heat rate can be expressed as

$$q = Sk\Delta T_{1-2} = Sk(T_1 - T_2)$$

From Table 4.1, the shape factor is

$$S = \frac{2\pi L}{\ln\left[\frac{1.08 w}{D}\right]}$$

Hence,

$$q' = \left[\frac{q}{L}\right] = \frac{2\pi k(T_1 - T_2)}{\ln\left[\frac{1.08 w}{D}\right]}$$

$$q' = \frac{2\pi \times 1.4\text{ W/m}\cdot\text{K} \times (450 - 300)\text{ K}}{\ln\left[\frac{1.08 \times 1.5\text{ m}}{0.5\text{ m}}\right]} = 1122\text{ W/m.}$$

<

COMMENTS: Having neglected the steam side convection resistance, the pipe wall resistance, and the contact resistance, the foregoing result overestimates the actual heat loss.