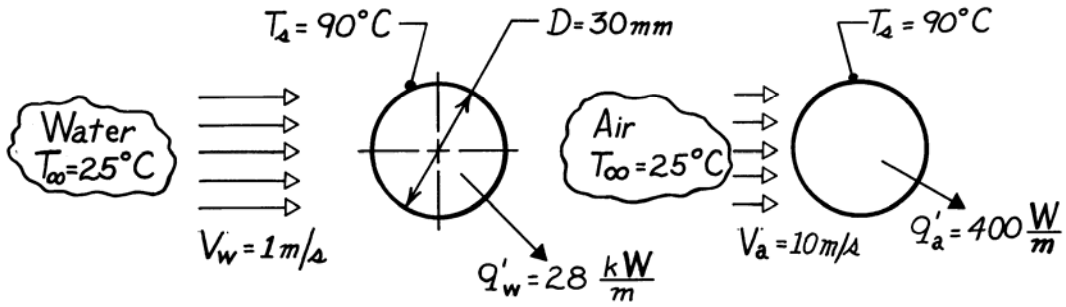
PROBLEM 1.21

KNOWN: Long, 30mm-diameter cylinder with embedded electrical heater; power required to maintain a specified surface temperature for water and air flows.

FIND: Convection coefficients for the water and air flow convection processes, h_w and h_a, respectively.

SCHEMATIC:



ASSUMPTIONS: (1) Flow is cross-wise over cylinder which is very long in the direction normal to flow.

ANALYSIS: The convection heat rate from the cylinder per unit length of the cylinder has the form

$$q' = h(\pi D)\ (T_S - T_\infty)$$

and solving for the heat transfer convection coefficient, find

$$h = \frac{q'}{\pi D\ (T_S - T_\infty)}.$$

Substituting numerical values for the water and air situations:

Water
$$h_W = \frac{28 \times 10^3\ \text{W/m}}{\pi \times 0.030\text{m}\ (90\text{-}25)^\circ\ \text{C}} = 4{,}570\ \text{W/m}^2 \cdot \text{K} \quad <$$

Air
$$h_a = \frac{400\ \text{W/m}}{\pi \times 0.030\text{m}\ (90\text{-}25)^\circ\ \text{C}} = 65\ \text{W/m}^2 \cdot \text{K}. \quad <$$

COMMENTS: Note that the air velocity is 10 times that of the water flow, yet

$$h_w \approx 70 \times h_a.$$

These values for the convection coefficient are typical for forced convection heat transfer with liquids and gases. See Table 1.1.