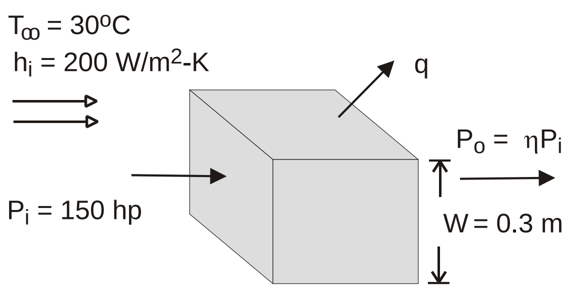
PROBLEM 1.16

KNOWN: Width, input power and efficiency of a transmission. Temperature and convection coefficient associated with air flow over the casing.

FIND: Surface temperature of casing. Thermal convection resistance.

SCHEMATIC:



ASSUMPTIONS: (1) Steady state, (2) Uniform convection coefficient and surface temperature, (3) Negligible radiation.

ANALYSIS: From Newton's law of cooling,

$$q = hA_S\left(T_S - T_\infty\right) = 6\,hW^2\left(T_S - T_\infty\right)$$

where the output power is ηP_i and the heat rate is

$$q = P_i - P_o = P_i\left(1-\eta\right) = 150\,\text{hp} \times 746\,\text{W/hp} \times 0.07 = 7833\,\text{W}$$

Hence,

$$T_S = T_\infty + \frac{q}{6\ hW^2} = 30°C + \frac{7833\ W}{6 \times 200\ W/m^2 \cdot K \times \left(0.3\,m\right)^2} = 102.5°C \qquad <$$

From Eq. 1.11, the thermal resistance due to convection is

$$R_{t,conv} = \Delta T / q_x = \left(T_s - T_\infty\right)/q_x = \left(102.5 - 30\right)K / 7833\ W = 0.00926\ K/W \qquad <$$

COMMENTS: (1) There will, in fact, be considerable variability of the local convection coefficient over the transmission case and the prescribed value represents an average over the surface. (2) The convection thermal resistance could equivalently be calculated from $R_{t,conv} = 1/hA$.