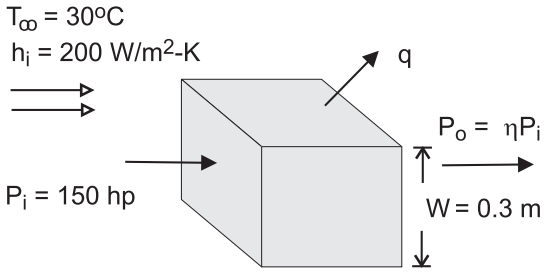
PROBLEM 1.33

KNOWN: Width, input power and efficiency of a transmission. Temperature and convection coefficient for air flow over the casing. Emissivity of casing and temperature of surroundings.

FIND: Surface temperature of casing.

SCHEMATIC:



ASSUMPTIONS: (1) Steady state, (2) Uniform convection coefficient and surface temperature, (3) Radiation exchange with large surroundings.

ANALYSIS: Heat transfer from the case must balance heat dissipation in the transmission, which may be expressed as $q = P_i - P_o = P_i (1 - \eta) = 150\ \text{hp} \times 746\ \text{W/hp} \times 0.07 = 7833\ \text{W}$. Heat transfer from the case is by convection and radiation, in which case

$$q = A_S\left[h\left(T_S - T_\infty\right) + \varepsilon\sigma\left(T_S^4 - T_{sur}^4\right)\right]$$

where $A_S = 6\ W^2$. Hence,

$$7833\,\text{W} = 6\left(0.30\,\text{m}\right)^2\left[200\,\text{W/m}^2\cdot\text{K}\left(T_S - 303\text{K}\right) + 0.8\times5.67\times10^{-8}\,\text{W/m}^2\cdot\text{K}^4\left(T_S^4 - 303^4\right)\text{K}^4\right]$$

A trial-and-error solution yields

$$T_S \approx 373\,\text{K} = 100°\text{C} \qquad <$$

COMMENTS: (1) For $T_s \approx 373$ K, $q_{conv} \approx 7{,}560$ W and $q_{rad} \approx 270$ W, in which case heat transfer is dominated by convection, (2) If radiation is neglected, the corresponding surface temperature is T_s = 102.5°C.