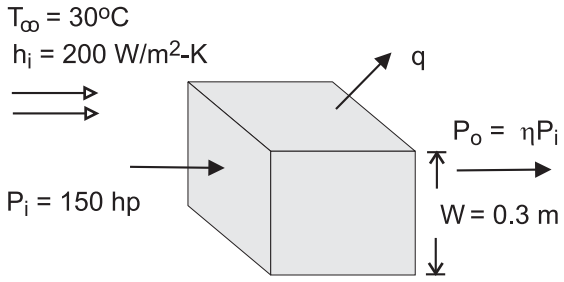
PROBLEM 1.41

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

$$7833\,W = 6\left(0.30\,m\right)^2\left[200\,W/m^2\cdot K\left(T_s - 303K\right) + 0.8\times 5.67\times 10^{-8}\,W/m^2\cdot K^4\left(T_s^4 - 303^4\right)K^4\right]$$

A trial-and-error solution yields

$$T_s \approx 373\,K = 100°C \qquad <$$

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.