PROBLEM 1.28

KNOWN: Length, diameter, surface temperature and emissivity of steam line. Temperature and convection coefficient associated with ambient air. Efficiency and fuel cost for gas fired furnace.

FIND: (a) Rate of heat loss, (b) Annual cost of heat loss.





ASSUMPTIONS: (1) Steam line operates continuously throughout year, (2) Net radiation transfer is between small surface (steam line) and large enclosure (plant walls).

ANALYSIS: (a) From Eqs. (1.3a) and (1.7), the heat loss is

$$q = q_{conv} + q_{rad} = A \left[h \left(T_s - T_{\infty} \right) + \varepsilon \sigma \left(T_s^4 - T_{sur}^4 \right) \right]$$

where $A = \pi DL = \pi (0.1 \text{m} \times 25 \text{m}) = 7.85 \text{m}^2$.

Hence,

$$q = 7.85m^{2} \left[10 \text{ W/m}^{2} \cdot \text{K} (150 - 25) \text{K} + 0.8 \times 5.67 \times 10^{-8} \text{W/m}^{2} \cdot \text{K}^{4} (423^{4} - 298^{4}) \text{K}^{4} \right]$$
$$q = 7.85m^{2} (1,250 + 1,095) \text{W/m}^{2} = (9813 + 8592) \text{W} = 18,405 \text{ W}$$

(b) The annual energy loss is

$$E = qt = 18,405 \text{ W} \times 3600 \text{ s/h} \times 24 \text{ h/d} \times 365 \text{ d/y} = 5.80 \times 10^{11} \text{ J}$$

With a furnace energy consumption of $E_f = E/\eta_f = 6.45 \times 10^{11}$ J, the annual cost of the loss is

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$$C = C_g E_f = 0.01$$
 $MJ \times 6.45 \times 10^5 MJ =$

COMMENTS: The heat loss and related costs are unacceptable and should be reduced by insulating the steam line.

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