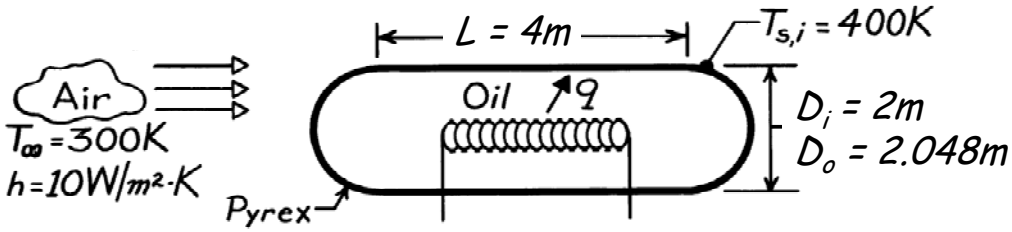
PROBLEM 3.63

KNOWN: Geometry of an oil storage tank. Temperature of stored oil and environmental conditions.

FIND: Heater power required to maintain a prescribed inner surface temperature.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) One-dimensional conduction in radial direction, (3) Constant properties, (4) Negligible radiation.

PROPERTIES: *Table A-3*, Pyrex (300K): k = 1.4 W/m·K.

ANALYSIS: The rate at which heat must be supplied is equal to the loss through the cylindrical and hemispherical sections. Hence,

$$q = q_{cyl} + 2q_{hemi} = q_{cyl} + q_{spher}$$

or, from Eqs. 3.33 and 3.41,

$$q = \frac{T_{s,i} - T_\infty}{\frac{\ln(D_o/D_i)}{2\pi Lk} + \frac{1}{\pi D_o L h}} + \frac{T_{s,i} - T_\infty}{\frac{1}{2\pi k}\left[\frac{1}{D_i} - \frac{1}{D_o}\right] + \frac{1}{\pi D_o^2 h}}$$

$$q = \frac{(400-300)\,K}{\frac{\ln 1.024}{2\pi(4m)1.4\ W/m\cdot K} + \frac{1}{\pi(2.048m)4m\left(10\ W/m^2\cdot K\right)}} + \frac{(400-300)\,K}{\frac{1}{2\pi(1.4\ W/m\cdot K)}(0.5-0.4883)\,m^{-1} + \frac{1}{\pi(2.048m)^2\,10\ W/m^2\cdot K}}$$

$$q = \frac{100K}{6.74\times10^{-4}\ K/W + 3.886\times10^{-3}\ K/W} + \frac{100K}{1.33\times10^{-3}\ K/W + 7.59\times10^{-3}}$$

$$q = 21{,}930W + 11{,}210W = 33{,}140W. \quad <$$