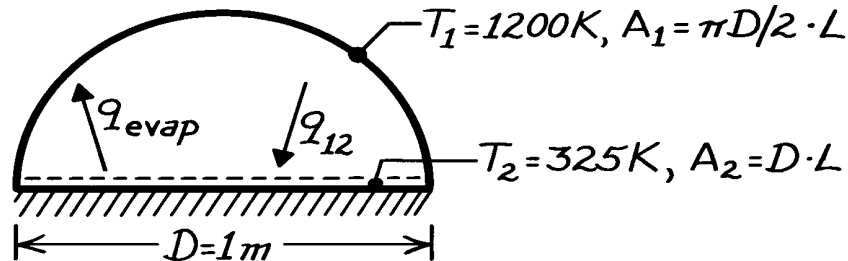


PROBLEM 13.18

KNOWN: Surface temperature of a semi-circular drying oven.

FIND: Drying rate per unit length of oven.

SCHEMATIC:



ASSUMPTIONS: (1) Blackbody behavior for furnace wall and water, (2) Convection effects are negligible and bottom is insulated.

PROPERTIES: Table A-6, Water (325 K): $h_{fg} = 2.378 \times 10^6 \text{ J/kg}$.

ANALYSIS: Applying a surface energy balance,

$$q_{12} = q_{\text{evap}} = \dot{m} h_{fg}$$

where it is assumed that the net radiation heat transfer to the water is balanced by the evaporative heat loss. From Eq. 13.13

$$q_{12} = A_1 F_{12} \sigma (T_1^4 - T_2^4).$$

From inspection and the reciprocity relation, Eq. 13.3,

$$F_{12} = \frac{A_2}{A_1} F_{21} = \frac{D \cdot L}{(\pi D/2) \cdot L} \times 1 = 0.637.$$

Hence

$$\dot{m}' = \frac{\dot{m}}{L} = \frac{\pi D}{2} F_{12} \sigma \frac{(T_1^4 - T_2^4)}{h_{fg}}$$

$$\dot{m}' = \frac{\pi (1 \text{ m})}{2} \times 0.637 \times 5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \cdot \text{K}^4} \frac{(1200 \text{ K})^4 - (325 \text{ K})^4}{2.378 \times 10^6 \text{ J/kg}}$$

or

$$\dot{m}' = 0.0492 \text{ kg/s} \cdot \text{m}.$$

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COMMENTS: Air flow through the oven is needed to remove the water vapor. The water surface temperature, T_2 , is determined by a balance between radiation heat transfer to the water and the convection of latent and sensible energy from the water.