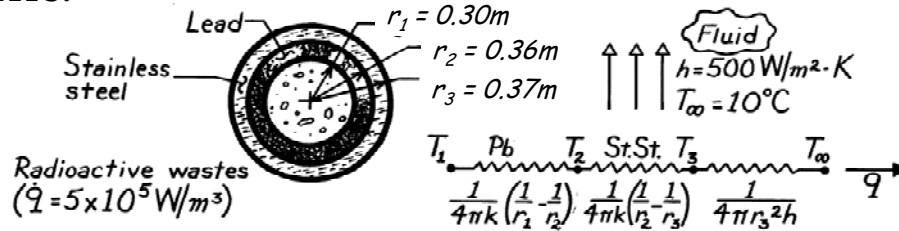


PROBLEM 3.72

KNOWN: Dimensions and materials used for composite spherical shell. Heat generation associated with stored material.

FIND: Inner surface temperature, T_1 , of lead (proposal is flawed if this temperature exceeds the melting point).

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) Steady-state conditions, (3) Constant properties at 300K, (4) Negligible contact resistance.

PROPERTIES: Table A-1, Lead: $k = 35.3 \text{ W/m}\cdot\text{K}$, MP = 601K; St.St.: $15.1 \text{ W/m}\cdot\text{K}$.

ANALYSIS: From the thermal circuit, it follows that

$$q = \frac{T_1 - T_\infty}{R_{\text{tot}}} = \dot{q} \left[\frac{4}{3} \pi r_1^3 \right]$$

Evaluate the thermal resistances,

$$R_{\text{Pb}} = \left[1 / (4\pi \times 35.3 \text{ W/m}\cdot\text{K}) \right] \left[\frac{1}{0.30\text{m}} - \frac{1}{0.36\text{m}} \right] = 0.00125 \text{ K/W}$$

$$R_{\text{St.St.}} = \left[1 / (4\pi \times 15.1 \text{ W/m}\cdot\text{K}) \right] \left[\frac{1}{0.36\text{m}} - \frac{1}{0.37\text{m}} \right] = 0.000396 \text{ K/W}$$

$$R_{\text{conv}} = \left[1 / (4\pi \times 0.37^2 \text{ m}^2 \times 500 \text{ W/m}^2 \cdot \text{K}) \right] = 0.00116 \text{ K/W}$$

$$R_{\text{tot}} = 0.0028 \text{ K/W}.$$

The heat rate is $q = 5 \times 10^5 \text{ W/m}^3 (4\pi/3)(0.30\text{m})^3 = 56,550 \text{ W}$. The inner surface temperature is

$$T_1 = T_\infty + R_{\text{tot}} q = 283\text{K} + 0.00280\text{K/W} (56,550 \text{ W})$$

$$T_1 = 441 \text{ K} < \text{MP} = 601\text{K}.$$

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Hence, from the thermal standpoint, the proposal is adequate.

COMMENTS: In fabrication, attention should be given to maintaining a good thermal contact. A protective outer coating should be applied to prevent long term corrosion of the stainless steel.