

PROBLEM 4.9

KNOWN: Heat generation in a buried spherical container.

FIND: (a) Outer surface temperature of the container, (b) Representative isotherms and heat flow lines.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Soil is a homogeneous medium with constant properties.

PROPERTIES: Table A-3, Soil (300K): $k = 0.52 \text{ W/m}\cdot\text{K}$.

ANALYSIS: (a) From an energy balance on the container, $q = \dot{E}_g$ and from the first entry in Table 4.1,

$$q = \frac{2\pi D}{1 - D/4z} k(T_1 - T_2).$$

Hence,

$$T_1 = T_2 + \frac{q}{k} \frac{1 - D/4z}{2\pi D} = 20^\circ\text{C} + \frac{500\text{W}}{0.52 \frac{\text{W}}{\text{m}\cdot\text{K}}} \frac{1 - 2\text{m}/40\text{m}}{2\pi(2\text{m})} = 92.7^\circ\text{C} \quad <$$

(b) The isotherms may be viewed as spherical surfaces whose center moves downward with increasing radius. The surface of the soil is an isotherm for which the center is at $z = \infty$.

