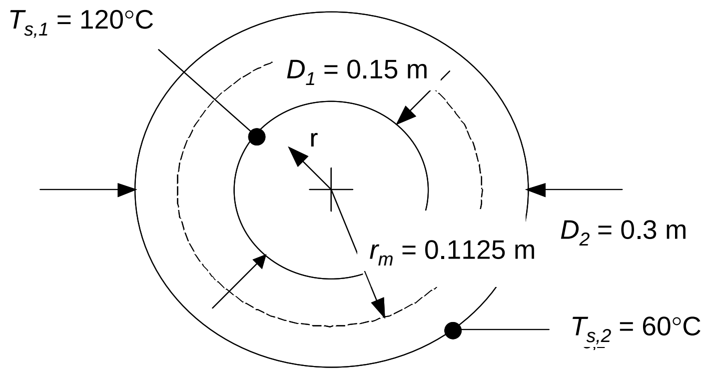
PROBLEM 3.65

KNOWN: Dimensions and surface temperatures of a glass or aluminum spherical shell.

FIND: (a) Mid-point temperature within the shell for a glass shell, (b) Mid-point temperature within the shell for an aluminum shell.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Constant properties, (3) One-dimensional heat transfer, (4) No internal energy generation within the shell.

ANALYSIS: (a) The conduction heat rate into the dashed control surface must equal the conduction heat rate out of the dashed control surface. Hence, from Eq. 3.40

$$q_r = \frac{4\pi k\left(T_{s,1} - T(r_m)\right)}{(1/r_1) - (1/r_m)} = \frac{4\pi k\left(T(r_m) - T_{s,2}\right)}{(1/r_m) - (1/r_2)}$$

or,

$$T(r_m) = \frac{1}{\left(\dfrac{1}{(1/r_m)-(1/r_2)}\right)+\left(\dfrac{1}{(1/r_1)-(1/r_m)}\right)}\left(\frac{T_{s,1}}{(1/r_1)-(1/r_m)}+\frac{T_{s,2}}{(1/r_m)-(1/r_2)}\right)$$

$$= \frac{1}{\left(\dfrac{1}{(1/0.1125\text{m})-(1/0.15\text{m})}\right)+\left(\dfrac{1}{(1/0.075\text{m})-(1/0.1125\text{m})}\right)}\times$$

$$\left(\frac{120°\text{C}}{(1/0.075\text{m})-(1/0.1125\text{m})}+\frac{60°\text{C}}{(1/0.1125\text{m})-(1/0.15\text{m})}\right)$$

= 80°C <

(b) The temperature distribution is independent of the shell material. Hence, $T(r_m)$ = 80°C <

COMMENTS: (1) The temperature distribution is not linear. Assuming a linear distribution would be a serious error. (2) The conduction heat rate through the sphere will be much higher for the aluminum shell since the thermal conductivity of aluminum is much greater than that of glass.