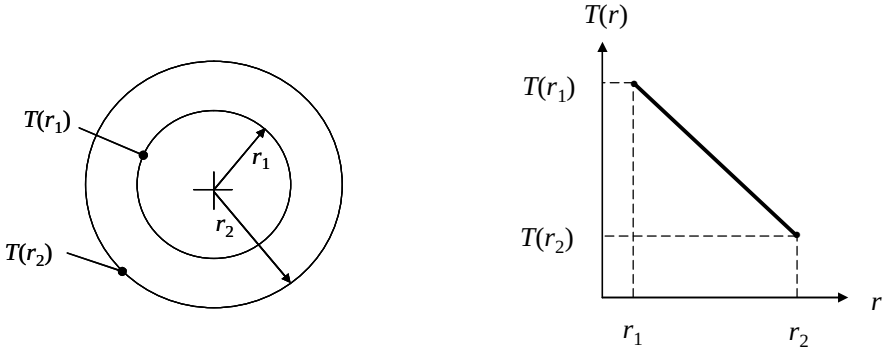
PROBLEM 2.38

KNOWN: Cylindrical shell under steady-state conditions with no energy generation.

FIND: Under what conditions is a linear temperature distribution possible.

SCHEMATIC:



ASSUMPTIONS: (1) Steady state conditions. (2) One-dimensional conduction. (3) No internal energy generation.

ANALYSIS: Under the stated conditions, the heat equation in cylindrical coordinates, Equation 2.26, reduces to

$$\frac{d}{dr}\left(kr\frac{dT}{dr}\right)=0$$

If the temperature distribution is a linear function of r, then the temperature gradient is constant, and this equation becomes

$$\frac{d}{dr}\left(kr\right)=0$$

which implies kr = constant, or $k \sim 1/r$. The only way there could be a linear temperature distribution in the cylindrical shell is if the thermal conductivity were to vary inversely with r. <

COMMENTS: It is unlikely to encounter or even create a material for which k varies inversely with the cylindrical radial coordinate r. Assuming linear temperature distributions in radial systems is nearly always both fundamentally incorrect and physically implausible.