PROBLEM 8-11N QUESTION

Comparison Of Thermal Energy That Can Be Extracted From A Spherical Hollow Fuel Pellet Versus A Cylindrical Annular Fuel Pellet

Consider an annular cylindrical annular fuel pellet of length L, inside radius, R_V, and outside radius R_{foc}. It is operating at q_c''' , such that for a given outside surface temperature, T_{fo}, the inside surface temperature, T_V, is just at the fuel melting limit T_{melt}.

A fellow engineer claims that if the same volume of fuel is arranged as a sphere with an inside voided region of radius R_V and operated between the same two surface temperature limits, i.e., T_V and T_{fo}, more power can be extracted from the spherical fuel volume then from a cylindrical fuel pellet. In both cases volumetric generation rate is radially constant.

Is the claim correct? Prove or disprove it. Please use the nomenclature of Fig. 1. Assume no sintering occurs.
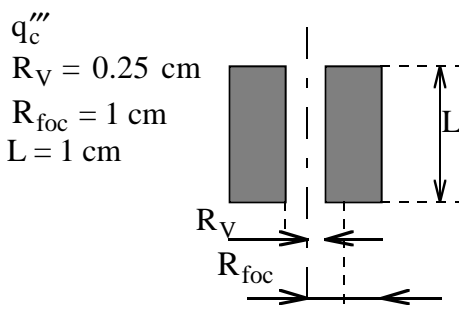
Given:

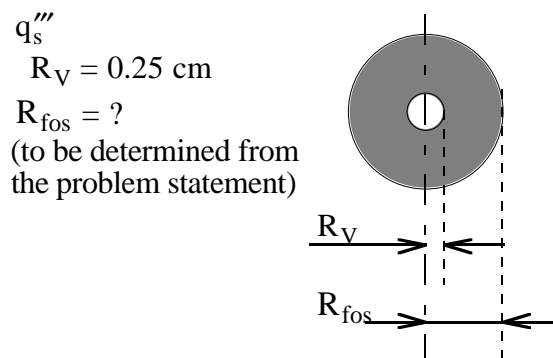The one dimensional heat conduction equation in the radial direction in spherical coordinates is: $\dfrac{1}{r^2} \dfrac{d}{dr}\left(kr^2 \dfrac{dT}{dr} \right) + q''' = 0$

For a sphere: $V_S = \dfrac{4}{3}\pi R^3$ and $A_S = 4\pi R^2$

Cylindrical Annular Fuel Pellet:

q_c'''
$R_V = 0.25$ cm
$R_{foc} = 1$ cm
$L = 1$ cm

R_V
R_{foc}
L

Spherical Hollow Fuel Pellet:

q_s'''
  $R_V = 0.25$ cm
$R_{fos} = ?$
(to be determined from the problem statement)

R_V
R_{fos}

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