PROBLEM 8-9N QUESTION

Thermal Conduction Problem Involving Design Of A BWR Core

A core design is proposed which locates BWR type UO_2 pins in holes within graphite hexagonal blocks (Fig. 1). These blocks then form a core of radius R_o. The achievable linear heat power of the core (MW/m) is desired as a function of core radius, R_o(m) for constraints of Table 1. Present the result as a plot. Constants and terms are defined in Figure 2 and Table 1.

Basically these constraints exist under decay power conditions where the outside of the core radiates its energy to a passive air chimney. However , the outside of the core which is in touch with a vessel at the same temperature is limited to 500˚C. The clad outside temperature, T_{co}, which radiates to the graphite, T_{gi}, is also constrained, here to a temperature 649˚C.

Constants and Constraints for Homogenized Core Power Analysis

Table 1

Constraints	Constants
$T_{co} < 649˚C$	$A_{cell} = 7.30 \times 10^{-4}\ m^2$
$T_{go} < 500˚C$	$d_1 = 12.5$ mm
	$d_2 = 19.8$ mm
	$\epsilon_1 = 0.6$
	$\epsilon_2 = 0.7$
	$k_g = 60$ W/m
	$\sigma = 5.669 \times 10^{-8}\ W/m^2 \cdot K^4$
	$\frac{1}{\epsilon_1} + \frac{d_1}{d_2}\left(\frac{1}{\epsilon_2} - 1\right) = \epsilon$ $\epsilon = 1.937$

Unit Cell Dimensions
Part 1

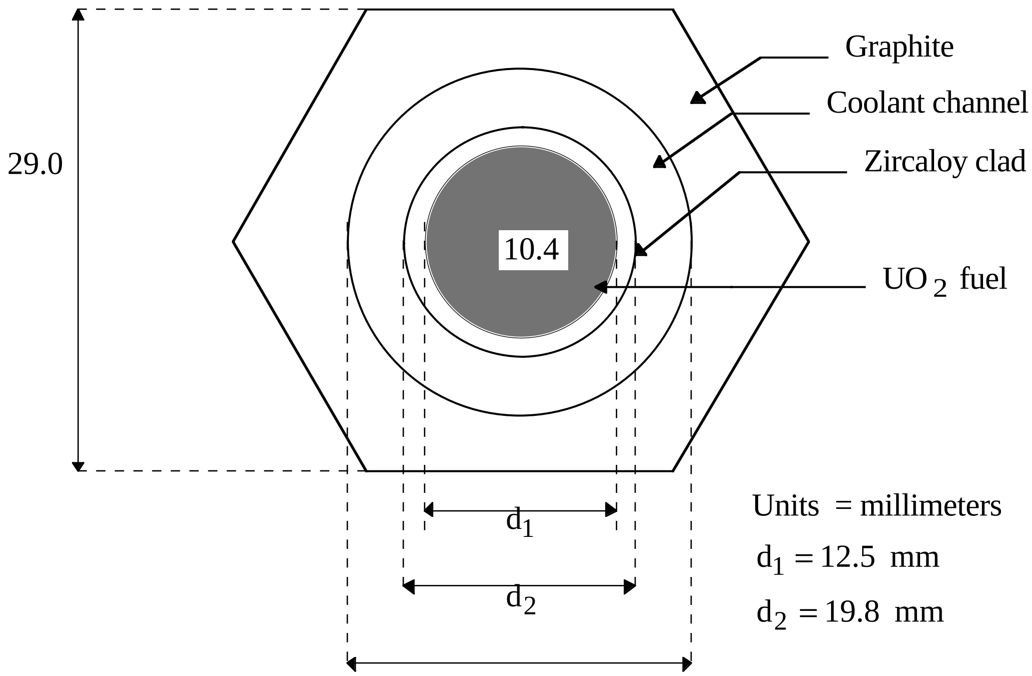

Figure 1

Unit cell using BWR fuel pin in MHTGR prismatic block holding the ratio of fuel to graphite constant.

Coolant channel size established by taking the area of water normally associated with a pin in conventional BWR.

Configuration of Solid Core and Variables

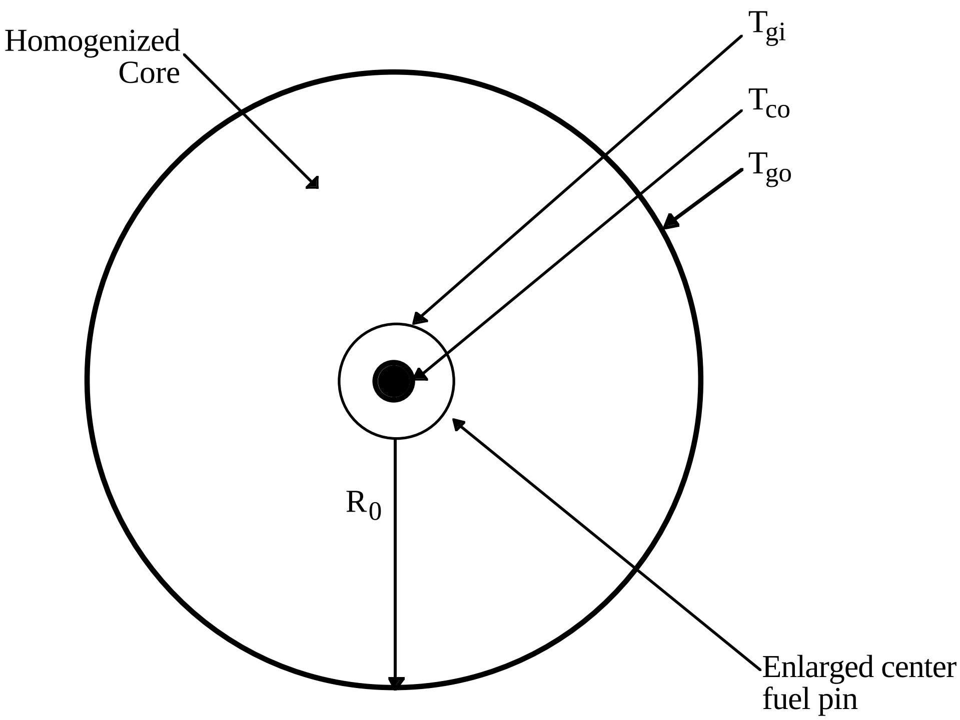

Figure 2

Notes:

T_{gi} is the temperature at the inner surface of the matrix graphite surrounding the fuel pin.
T_{go} is the temperature of the matrix graphite at the core outer surface.
T_{co} is the temperature at the clad outer surface.
d_1 and d_2 are shown in the Fig. 1.