NucE 497I

HOMEWORK 3

Related neutronics parameters (power and burnup)

A 17x17 PWR fuel assembly is constructed of fuel rods consisting of pellets with diameter of 7.4 mm *(Table 1.4, Chapter 1 of Class Notes)*

Table 1.4 Fuel rod dimensions

BWR	**9x9**	**8x8**	
Pellet o.d. (mm)	9.055	10.274	
Cladding o.d. (mm)	10.770	12.294	
Cladding thickness (mm)	0.7672	0.889	
PWR	**15x15**	**16x16**	**17x17**
Pellet o.d. (mm)	9.1	8.3	7.4
Cladding thickness	0.6	0.6	0.6

The pellets are made of UO_2, which has density of 10.5 g/cm^3. The uranium is enriched to 4.5 % in ^{235}U.
(Formulae 4.1 from Chapter 4 of Class Notes)

(4.1)

$$\phi(r) = CI_0(\kappa r)$$

for solid pellets, and

$$\phi(r) = C\left(I_0(\kappa r) + \left[\frac{I_1(\kappa r_0)}{K_1(\kappa r_0)} \right] K_0(\kappa r) \right)$$

for annular pellets

where

$$\kappa = \sqrt{\Sigma_a / D}\ ,\ \Sigma_a = \sum_k \sigma_{a,i} \overline{N}_i\ ,\ D = \frac{1}{3\Sigma_s} = \frac{1}{3\sigma_s \overline{N}_{tot}}$$

and

I,K	=	modified Bessel functions
C	=	a constant
σ_a, σ_s	=	absorption and scattering cross sections
$\overline{N}$	=	pellet-average atom concentration
r_0	=	the pellet outer radius
i	=	subscript indicating all U and Pu isotopes

Using this formulae for radial flux (power) distribution in a solid pellet, calculate flux distribution for fresh fuel when the reactor is first brought to nominal power.

The modified Bessel functions are explained in Appendix 5 of LaMarsh and Baratta (pages 757-759).

Click Here for Appendix 5

Use the microscopic cross-section values from *(Table 3, Chapter 4 of Class Notes)*

Table 3. Cross-section values

Isotope	LWR		HWR	
	σ_f (barns)	σ_c (barns)	σ_f (barns)	σ_c (barns)
^{235}U	41.5	9.7	107.9	22.3
^{238}U	0.00	0.78	0.00	1.16
^{239}Pu	105	58.6	239.18	125.36
^{240}Pu	0.584	100	0.304	127.26
^{241}Pu	120	50	296.95	122.41
^{242}Pu	0.458	80	0.191	91.30

The constant C in formulae 4.1 above can be calculated from the power per unit length of fuel rod (P= 150 W/cm) in a similar manner as given in LaMarsh and Baratta (pages 277-279 – Infinite cylinder).

Click Here for Pages 277-279

a) (40) Calculate the number densities of different nuclides present in fresh pellet. How these number densities will change and which new nuclides will appear with burnup in this pellet?

b) (60) Calculate and plot the radial flux distribution in fresh pellet and explain why we have such distribution. How this distribution will change with burnup and why?