NE 620/860 - Applied Reactor Physics - Lab 2

References

- Lectures 4, 5, 6
- CASMO-4 Manual

Software/Hardware

You'll again need access to *eigendoit.ksu.mne.edu* via an MNE or your machine for using CASMO-4 via SSH. To run CASMO-4, you'll need the appropriate paths set. To do so, execute the following in your home directory:

```
homersimpson@eigendoit:~$ cp /share/apps/.studsvikrc .
```

Tasks

Four Factors

A key output of CASMO-4 is the two-group data produced for the homogenized pin (or assembly). Consider a UO_2 fuel pin having the following properties:

- $\rho = 10$ g/cm^3
- 4 w/o enriched (w/o enriched means "percent of U that is ^{235}U by mass")
- fuel pellet radius is 0.4096 cm
- cladding inner radius is 0.4180 cm
- cladding outer radius is 0.4750 cm
- pin pitch (distance between pin centers) is 1.2598 cm
- hot PWR conditions (fuel temperature of 900 K, coolant temperature of 300 K)

Use CASMO-4 to produce two group cross sections. Derive the two-group, four-factor formula for the homogenized pin cell, and define what each term represents. Substitute the cross sections computed by CASMO-4 into the four-factor formula and compare to the computed eigenvalue. Are they identical? close? Why or why not?

Geometry

Start with the same model used in the previous task. Then use CASMO-4 to produce a curve of the four factors versus the P/D ratio, where P is the pin pitch and D is the fuel diameter. Vary the P/D ratio by modifying the fuel radius (i.e., keep the pitch constant). What P/D ratio does the original model have and why? (*Hint*: consider what happens if the water density suddenly increases or decreases, which would have the same effect as the P/D going up or down.)

Cladding Options

Zirconium-based alloys (e.g., Zr-4) are currently used for PWR fuel cladding, but owing to their behavior under accident conditions, alternative, "accident-tolerant" cladding materials are being studied by numerous groups. Two options under consideration are: - FeCrAl (21% Cr, 5.8% Al, 0.7% Si, 0.4% Mn, and 0.08% C by mass) with $\rho = 7.25$ g/cm^3 - SiC with $\rho = 3.21$ g/cm^3 Each material is being studied as a thin, protective layer over traditional cladding.

To understand the impact of these materials, assume that the original model cladding is reduced in thickness by 150 μm and replaced by the FeCrAl alloy or SiC. What is the impact on reactivity? How much would the enrichment need to be increased or decreased to compensate?

Depletion

Consider the original model. Deplete it to 40 MWd/kg. How does the reactivity change as a function of time? What fraction of the pin power comes from ^{235}U as function of time? From ^{239}Pu?

Temperature

Consider the original model. Compute the fuel temperature and coolant temperature coefficients as a function of P/D. Explain the trends using the four factors. *Hint*: Recall that $\alpha = d\rho/dT$ and that $\ln(fp\epsilon\eta) = \ln(f) + \ln(p) + \ln(\epsilon) + \ln(\eta)$.