**Putting it all Together, Part 2.**

Part 1 instructed you how to use multiple features of Serpent to build a simple LWR core model. The homogeneous fuel loading in the previous example, however, is unrealistic. Real reactor cores are highly heterogeneous in order to optimize fuel burnup and power distribution.

GOAL: To increase the realism of the previous model of light water reactor (LWR). To learn about some of the burnup ("depletion") features available in Serpent.

BACKGROUND: LWR fuel is typically discharged at a burnup value of ~50 MWd/kgIHM (megawatt-days per kilogram of initial heavy metal). However, when LWRs are refueled, every 18 months, only one third of the fuel is discharged. This is because LWRs are commonly operated with 3 "campaigns" of fuel: 1/3 fresh fuel in the outermost region, 1/3 fuel burned to about two-thirds of the discharge burnup value in the centermost region, and 1/3 fuel burned to about one-third of the discharge burnup value in the region in between. In other words, fuel at levels of burnup of ~0, ~16.67 and ~33.33 MWd/kgIHM. This is not exact because the campaigns' rates of burnup are not quite identical.

In order to model a more realistic core, we must fuel the reactor with fuel at appropriate levels of burnup. We simulate refueling by shuffling fuel inwards each time, repeating until the results don't change. This is referred to as an equilibrium cycle. We'll use the previous exercise's input deck as a starting point.

EXERCISES:

1) Compute the total mass of heavy metal ($^{235}U$ and $^{238}U$) in your reactor. The option "-checkvolume" entered in the terminal will give you the fuel volume quickly (note: serpent is using MC method to calculate volume so this will not be 100% accurate, if you needed your results to be accurate do not use checkvolume). At 3GW of thermal power, how long do you have to operate your previous reactor to achieve a burnup of 16.67, 33.33 and 50 MWd/kgIHM?

2) Modify your input deck to perform a depletion calculation and obtain the quantities of all nuclides in the fuel (i.e. actinides, fission products and oxygen) at the above levels of burnup. Use the command "set printm 1" to print the materials at the end of the run. Set the power level to 3GW and the time steps to your values calculated in part 1).

3) Copy LWR to a new folder called "camp." Modify your deck to include 3 concentric rings of fuel pins. You will need to add two new cylinder surfaces, two new pins, and two new lattices of type 6. The rings will be the 3 campaigns of fuel. From the center outward, insert the materials you found in part 2). So at the center will be the materials from fuel burned to 33.33MWd/kgIHM, next 16.67 MWd/kgIHM, then fresh fuel in the outermost ring.

4) Burn your input deck at 3GWth, until the $k_{eff}$ value has dropped below 1. Use multiple time steps and use "command c" when your reactor goes subcritical.

5) Shuffle your fuel inwards and burn again. Compare the quantities of 235U, 239Pu and 238U in each region with those from part 4), and comment. Also compare the burnup values reported by Serpent. Are they what you expected? Comment on these also.