22.39 HW#1 Due Sept. 13, 2006 (Topic of Lecture 2)

Fall 2006 Problem Statement

For this problem you will develop design relationship between various core parameters.

Assume the following core characteristics for questions 1 and 2:

(1) a typical commercial PWR having 193 identical fuel assemblies

(2) L = 3.66 m and D = 3.37 m (T&K, Vol. I, Table 2-3)

(3) radial and axial power profiles given by the *cos* J_0, distribution (given in Table 3-3 in Todreas and Kazimi, *Nuclear Systems* Vol. I)

(4) Q_{core} is total thermal power

(5) P is the fuel pin pitch

(6) d_{fs} is the diameter of fuel pellet (the subscript fs stands for "fuel surface")

(7) 17 x 17 fuel pin locations in each assembly

(8) assume that all of the pin locations are fueled.

(9) neglect the interassembly spacing

(10) q''' is the volumetric energy generation rate in the fuel

1. For a core power of 1800MW_{th}, plot the variation of peak volumetric energy generation versus core diameter, keeping core height constant, for several different values of P/d_{fs} (Keep in mind that for an actual PWR, P/d_{fs}~1.3).
NOTE: Understand that in general, the pitch-to-diameter ratio refers to the outer diameter of the cladding.

2. A certain PWR has the following characteristics:

- coolant mass flow rate of 0.341 kg/s for each channel
- inlet temperature of 278°C
- core center point fuel linear energy generation rate, q'_0 , is 44 kW/m
- Fuel pin diameter (d_{cs}) of 9.5 mm

- Zircalloy cladding, 0.57 mm thick
- pitch to diameter ratio 1.33 (NOTE: now we are back to talking about the diameter of the cladding outer surface (d_{cs}))
- active fuel height is 3.66 m
- the neutronic extrapolation distance is 0.1 m
- the power distribution is the cos J_0 given in Table 3-3 of T&K Vol. I
- you may neglect the width of the gap, i.e., the fuel starts where the cladding stops.

The following properties can be assumed independent of temperature:
- fuel conductivity = 2.163 W/m K
- clad conductivity = 13.85 W/m K
- water conductivity = 0.5 W/m K
- gap conductance = 5700 W/m^2 K
- water viscosity = 8.69 x 10^{-5} kg/m s
- water heat capacity = 6270 J/kg K
- water density = 704 kg/m^3

Calculate and plot the axial temperature distribution in the coolant, outer and inner cladding surfaces, and fuel surface and centerline for cylindrical fuel pins, one at the core centerline and the other at the core periphery. Indicate on the plot(s) the axial point of highest fuel centerline, highest fuel surface, clad inner, and clad outer temperatures. You may calculate one heat transfer coefficient and apply it to the entire core.

What observations can you make on the relative fuel conditions from the core center to the core periphery – i.e. in which location(s) is fuel being used to its fullest potential?

What observations can you make on the relative fuel conditions? e.g. which fuel is being used to its fullest potential?