Exam 1: NE533: Nuclear Fuel Performance

Show all work. Label question number in your response. Pay attention to units. Point values correspond to expected depth of response.

1. (10 pts) UN is a fuel being considered for use in light water reactors. Consider UN to have an enrichment of 19% and a density of 14.3 g/cm3. Assume the fission cross section is 587 barns. Nitrogen atomic number=14.

What is the heat generation rate, given a neutron flux of 4E12 n/cm2-s? What enrichment of UO2 would be required to obtain the same heat generation rate? UO2 density is 10.97 g/cc.

1. (18 pts) Calculate the temperature at the midpoint of the cladding and at r=0.1 cm. Assume gap is all He.

Cladding k: 0.18 W/cm-K; Fuel k: 0.04 W/cm-K; Coolant h = 1.5 W/cm2-K; Q = 350 W/cm3; RF=0.4 cm; tg=30 mm; tclad=0.05 cm; Tcool = 500 K

Consider an oxide layer on the surface of the cladding, thickness of 60 mm, kox=0.015 W/cm-K. How does this change the centerline temperature?

1. (8 pts) Given a rod of 3.6 m in length, LHR0 = 400 W/cm, and =1.25:

What is the LHR at z=2.1 m? Which is the coolant outlet temperature? Assume water: CP = 4200 J/kg-K, mdot = 0.1 kg/s-rod, inlet temperature = 500 K.

1. (8 pts) Derive the relationship for temperature drop over a plate fuel in cartesian coordinates assuming the following boundary conditions: dT/dx(x0) = 0; x0 = 0; x1 = X; T(x1) = T1; and the simplified equation below. What assumptions were made to get to the provided equation?
2. (6 pts) What compound is utilized in the enrichment process? Describe the centrifuge-based enrichment of U, including why it works.
3. (8 pts) What are the departure from nucleate boiling ratio and the critical heat flux?
4. (5 pts) What is smear density? Why is this necessary?
5. (4 pts) What are two sources of thermal conductivity degradation in UO2?
6. (4 pts) Name two primary fission product species. Provide justification.
7. (4 pts) What is the role of cladding?
8. (4 pts) What does the “fuel system” consist of?
9. (4 pts) What are the three aspects that I define as constituting fuel performance?
10. (6 pts) What are the limitations of the finite difference discretization scheme?
11. (6 pts) Name two positive and two negative aspects of UO2 fuel.
12. (5 pts) What is the conceptual difference between implicit and explicit time integration? Which is more ‘stable’?