Exam 1: NE533: Nuclear Fuel Performance

Show all work. Label question number in your response. Pay attention to units.

1. (14 pts) Uranium mononitride (UN) is a fuel being considered for use in light water reactors. Consider UN to have an enrichment of 19% and a density of 12.3 g/cm3. Assume the fission cross section is 587 barns. Nitrogen atomic number=14.
   1. What is the heat generation rate, given a neutron flux of 2E13 n/cm2-s?
   2. What enrichment of UO2 would be required to obtain the same heat generation rate? UO2 density is 10.97 g/cc.
2. (20 pts) Calculate the temperature at the midpoint of the cladding and at r=0.2 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 50 mm, kox=0.015 W/cm-K. How does this change the centerline temperature?

1. (10 pts) Given a rod of 3.6 m in length, LHR0 = 250 W/cm, and =1.1:
   1. What is the LHR at z=2.1 m?
   2. Which is the coolant outlet temperature? Assume water: CP = 4200 J/kg-K, mdot = 0.2 kg/s-rod, inlet temperature = 500 K.
2. (10 pts) Assuming that the only contribution to the degradation of thermal conductivity is porosity, what porosity value corresponds to a burnup of 5% FIMA? Assume an average fuel temperature of 1200 K.
3. (10 pts) Why do we need to enrich U? What compound is utilized in the enrichment process? Describe the centrifuge-based enrichment of U, including why it works.
4. (10 pts) What are the departure from nucleate boiling and the critical heat flux?
5. (4 pts) List two reasons why we don’t use pure metallic U as a fuel form?
6. (5 pts) What is smear density? Why is this necessary?
7. (3 pts) Other than porosity, what is a source of thermal conductivity degradation in UO2?
8. (4 pts) Name two primary fission product species. Provide justification.
9. (5 pts) What is the role of cladding?
10. (5 pts) What does the “fuel system” consist of?
11. (5 pts) What are the three aspects that I define as constituting fuel performance?