Exam 1: NE533: Nuclear Fuel Performance

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

1. (15 pts) Uranium mononitride (UN) is a fuel being considered for use in light water reactors. Consider UN to have an enrichment of 19.5% 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 5E12 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. (12 pts) Derive the relationship for temperature drop over the 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?

1. (20 pts) Calculate the centerline temperature. Assume gap is all He.

Cladding k: 0.15 W/cm-K; Fuel k: 0.03 W/cm-K; Coolant h = 2.5 W/cm2-K; Q = 350 W/cm3; RF=0.6 cm; tg=0.003 cm; tclad=0.05 cm; Tcool = 550 K

If we empirically account for the temperature dependence of the thermal conductivity, how does the centerline temperature change? Assume fresh fuel.

1. (12 pts) Given a rod of 3.2 m in length, LHR0 = 300 W/cm, and =1.1:
   1. What is the LHR at z=0.8 m?
   2. Which is the coolant temperature at this point? Assume water: CP = 4200 J/kg-K, mdot = 0.3 kg/s-rod, inlet temperature = 500 K
2. (8 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.
3. (8 pts) What are the departure from nucleate boiling and the critical heat flux?
4. (3 pts) Explain the difference between fertile, fissile and fissionable.
5. (3 pts) List two reasons why we don’t use pure metallic U as a fuel form?
6. (4 pts) What is smear density? Why is this necessary?
7. (3 pts) Name two primary fission product species. Provide justification.
8. (4 pts) What is the role of cladding?
9. (3 pts) What does the “fuel system” consist of?
10. (4 pts) What are the three aspects that I define as constituting fuel performance?