Exam 1: NE533: Nuclear Fuel Performance

Show all work. Label question number in your response.

1. (12 pts) Derive the relationship for temperature drop over the fuel in cartesian coordinates assuming the following boundary conditions: T’(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. (16 pts) A fuel pellet has a corrosive coating. Calculate the centerline temperature with and without the coating.

Coating k: 0.015 W/cm-K; Cladding k: 0.15 W/cm-K; Fuel k: 0.05 W/cm-K; Gap k: 0.004 W/cm-K; T(coating surface): 600 K; Q = 250 W/cm3; RF=0.6 cm; tg=0.005 cm; tclad=0.05 cm; tcoat=0.01 cm. Assume that TCO without the coating is 600 K.

1. (14 pts) Uranium mononitride (UN) is a fuel being considered for use in light water reactors. Consider UN to have an enrichment of 19.5% and a density of 12.3 g/cm3. Assume the fission cross section is 570 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) Given a rod of 3.5 m in length, LHR0 = 350 W/cm, and =1.3:
   1. What is the LHR at z=1.4 m?
   2. Which is the change in outlet to inlet temperature for water: CP = 4200 J/kg-K, mdot = 0.22 kg/s-rod
3. (12 pts) Perform a backward Euler time stepping to approximate the function. Compute with a timestep of dt=0.5, expanding to tn=1.5.

dy/dt = t\*exp(-2t); t0 = 0; y0 = 4

1. (4 pts) Explain the difference between fertile, fissile and fissionable.
2. (4 pts) List two reasons why we don’t use pure metallic U as a fuel form?
3. (4 pts) What is smear density? Why is this necessary?
4. (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.
5. (6 pts) What are the three ways that space is discretized for numerical solutions? Name a strength or weakness of one of these types.
6. (8 pts) What are the departure from nucleate boiling and the critical heat flux?
7. (5 pts) Identify the layers in a TRISO particle. Provide an example of a reactor that utilizes TRISO-based fuel.