Exam 1: NE591-10: Nuclear Fuel Performance

Show all work. Label question number in your response. You do not need to restate question.

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. (18 pts) The below fuel pellet has an exterior cladding coating. Calculate the centerline temperature, and the temperature at r=0.4 cm.

Outer coating k: 5 W/m-K; Cladding k: 15 W/m-K; Fuel k: 0.5 W/cm-K; Gap k: 25 W/m-K; Coolant h: 5.5 W/cm2-K; T(cool): 800 K; Q = 400 W/cm3;

r1=0.6 cm; r2= 0.8 cm; r3 = 0.85 cm; r4 = 0.86 cm;



1. (14 pts) U3Si2 is a uranium silicide fuel being considered for use in light water reactors. Consider this fuel to have a thermal conductivity of 14.5 W/(m-K), an enrichment of 19.5%, and a density of 15.67 g/cm3. Assume the fission cross section is 570 barns.
   1. What is the heat generation rate, given a neutron flux of 2E12 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 m in length, a LHR0 = 150 W/cm, and a  of 1.1:
   1. What is the LHR at z=1.8 m?
   2. Which coolant sees a larger change in outlet to inlet temperature?
      1. water: CP = 4200 J/kg-K, mdot = 0.22 kg/s-rod
      2. sodium: CP=1404 J/kg-K, mdot = 0.12 kg/s/rod
3. (16 pts) Perform both a forward and a backward Euler time stepping to approximate the function. Compute with a timestep of dt=0.33, expanding to tn=2.

y(t0) = 6

t0 = 1

dy/dt = 4t-3t2

1. (5 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. (4 pts) Name two primary fission product species. Provide justification.
6. (8 pts) What are the three ways that space is discretized for numerical solutions? Which type is used in state-of-the-art fuel performance simulations? Why?