Exam 2: NE533: Nuclear Fuel Performance

1. (10 pts) Consider a fuel rod with a pellet radius of 0.45 cm that is experiencing a linear heat rate of 250 W/cm.
   1. What is the maximum stress experienced by the pellet? kf = 0.15 W/cm-K, E = 180 GPa, ν = 0.4, and α = 14x10-6 1/K?
   2. Given = 120 MPa, how far do cracks extend into the fuel?
2. (14 pts) Consider the stress state in a zircaloy-clad fuel rod pressurized to 55 MPa with an average radius of 0.52 cm and a cladding thickness of 0.05 cm.
   1. Calculate all three components of the stress using the thin-walled cylinder approximation.
   2. Calculate all three components of the stress at r=0.5 cm assuming a thick-walled cylinder.
3. (15 pts) Calculate the change in the gap thickness due to thermal expansion. Do not perform iterations. Rf = 0.52 cm. tgap = 0.005 cm, TCO = 550 K, tclad = 0.08 cm, kfuel = 0.04 W/cm-K, kgap = 0.003 W/cm-K, kclad = 0.15 W/cm-K, LHR = 175 W/cm, αc = 10x10-6 1/K, αf = 14x10-6 1/K, Tref(fuel=clad) = 300 K.
4. (10 pts) What are the hoop and radial stresses in the cladding due to thermal expansion? DT=50 K; ac=8x10-6; E=100 GPa; n=0.34; tc=0.06 cm; Ri=0.55cm.
5. (4 pts) What is the difference between elasticity and plasticity?
6. (8 pts) Define strain hardening. What causes strain hardening?
7. (6 pts) What three things must all fuel performance codes be able to do? List two fuel performance codes currently being utilized.
8. (4 pts) Provide an example of a 0-D defect. Provide an example of a 3-D defect.
9. (4 pts) How do grains form in the sintering process of fuel?
10. (8 pts) Describe the concept of microstructure-based (mechanistic) fuel performance modeling and why it is beneficial.
11. (8 pts) What is meant by microstructure? Given an example of a processing technique and the impact it has on the microstructure and related properties.
12. (6 pts) Briefly discuss the role different kinds of fission products play on thermal conductivity changes.
13. (8 pts) What is the high burnup structure? What causes it to form? What are its impacts?