Exam 2: NE591-10: Nuclear Fuel Performance

1. For each of the following scenarios, does thermal expansion lead to stress? (6 pts)

a)

b)

c)



1. Name three US fuel performance codes: (6 pts)
2. What is the valence state of U in UO2? What are the possible valence states of U? (5 pts)
3. Provide an example of a 0-D defect. Provide an example of a 3-D defect. (6 pts)
4. Name three properties that vary as a function of stoichiometry in UO2. (6 pts)
5. How does grain size affect the mechanical properties of a material? (8 pts)
6. Define strain hardening. What causes strain hardening? (8 pts)

1. Given the below stress/strain curve, answer the following questions:



* 1. Label the yield stress, the ultimate tensile stress, and the fracture stress. (6 pts)
  2. How would one determine the Young’s modulus from the stress-strain curve? (4 pts)

1. Describe the differences between elastic and plastic deformation. (8 pts)
2. Consider a fuel rod with a pellet radius of 4.5 mm that is experiencing a linear heat rate of 250 W/cm. Assume the pellet is made from Uranium Nitride. What is the maximum stress experienced by the pellet, assuming that uranium nitride has k = 0.1 W/cm-K, E = 290 GPa, ν = 0.3, and α = 8.2e-6 1/K? (12 pts)
3. Consider the stress state in a zircaloy fuel rod pressurized to 20 MPa with an average

radius of 5.6 mm and a cladding thickness of 0.6 mm.

1. Calculate all three components of the stress using the thin walled cylinder approximation. (6 pts)
2. Calculate all three components of the stress assuming a thick-walled cylinder. (8 pts)

1. Calculate the maximum strain. (4 pts)
2. Calculate the centerline temperature of the fuel before and after thermal expansion. Rf = 0.5 cm. tgap = 0.08 cm, tclad = 0.1 cm, TCO = 350 K, kfuel = 0.05 W/cm-K, kgap = 1E-3 W/cm-K, kclad = 0.15 W/cm-K, LHR = 325 W/cm, αc = 4.5x10-6 1/K, αf = 12x10-6 1/K, Tref(fuel=clad) = 300 K. (18 pts)
3. At what pressure will a thin-walled fuel rod exceed its fracture stress? (6 pts)

At what strain does this occur? (6 pts)