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? (4 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)
7. 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. What is the maximum stress experienced by the pellet, assuming that the fuel 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 at the midpoint assuming a thick-walled cylinder. (8 pts)
3. Calculate the maximum strain, with the stress components from (b) and with E=180 GPa and ν=0.28. (4 pts)
4. Calculate the centerline temperature of the fuel before and after thermal expansion. Rf = 0.5 cm. tgap = 0.02 cm, TCO = 450 K, kfuel = 0.05 W/cm-K, kgap = 0.04 W/cm-K, kclad = 0.15 W/cm-K, LHR = 325 W/cm, αc = 4.5x10-6 1/K, αf = 15x10-6 1/K, Tref(fuel=clad) = 300 K. (18 pts).

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