Exam 2: NE591-10: Nuclear Fuel Performance

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1. What is the difference between true and engineering stress/strain? (4 pts)
2. Describe the differences between elastic and plastic deformation. (8 pts)
3. Provide an example of a 0-D defect. Provide an example of a 3-D defect. (4 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. What three things must all fuel performance codes be able to do? (6 pts)
8. What is the driving force for fuel densification? (3 pts)
9. What is something that can accelerate grain growth? What can inhibit grain growth? (6 pts)
10. Consider the stress state in a zircaloy-clad fuel rod pressurized to 20 MPa with an average radius of 5.4 mm and a cladding thickness of 0.8 mm.
    a) Calculate all three components of the stress using the thin walled cylinder approximation. (4 pts)
    b) Calculate all three components of the stress at the midpoint assuming a thick-walled cylinder. (8 pts)
    c) Where are the thin and thick wall assumptions identical? (4 pts)
11. 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)
12. Calculate the centerline temperature of the fuel before and after thermal expansion. Only perform one adjustment to the gap thickness. R_f = 0.5 cm. t_{gap} = 0.02 cm, T_{CI} = 450 K, k_{fuel} = 0.05 W/cm-K, k_{gap} = 0.04 W/cm-K, k_{clad} = 0.15 W/cm-K, LHR = 325 W/cm, α_c = 4.5x10^{-6} 1/K, α_f = 15x10^{-6} 1/K, T_{ref}(fuel=clad) = 300 K. Assume inner clad properties are equal to average clad properties. (16 pts)
13. How far do cracks extend into the fuel? (8 pts)
    R_F= 0.55 cm; Poisson's ratio=0.25; E=210 GPa; LHR = 200 W/cm;
    α_{fuel} = 10.5E-6 1/K; $\sigma_{fracture}$=120 MPa; k_F=0.05 W/cm-K