Matthew Feigler
Nuc 497

Next exam, make sure you scan is clearer than this

62/100

1\. a) $k = 12.5$ W/mK U_3Si_5 natural enrichment)
$\rho = 7.5$ g

-3, 27/30

Fissile Isotope U-235 with enrichment naturally of .7 %

b) $Q = E_f N_f \sigma_f \phi_{th}$

$\phi_{th} = 3.2e^{13}$ n/cm²s
$M = 238$
$E_f = 3\times10^{-11}$ J/s
$\sigma_f = 5.5\times10^{-22}$ cm²
$\rho(U_2Si_3) = 11.31$ g/cm³

Assume E_f, σ_f, ϕ_{th} are same for U_3Si_5 and U_2Si_3

$N_3 = N_2$

$$x\frac{(7.5)(N_A)}{238} = \frac{(.03)(11.31)(N_A)}{238}$$

$$\boxed{x(U_3Si_5) = 4.5\%\ \text{Enrichment}}$$

c) Due to a lower fuel density U_3Si_5 requires a higher enrichment than U_2Si_3. This makes it a slightly worse fuel choice in terms of energy.

-3, Thermal conductivity?

2\. a) $r_f = .45$ cm
$\delta_{gap} = .008$ cm
$t_c = .06$ cm
$Q = 250$ W/cm
$T_{cool} = 580$ K
$4X_e = 5\%$
$h_{cool} = 2.5$ (W/cm²K)
$k_c = .17$ W/cmK

-12, 22/35

$$T_{co} = T_{cool} + \frac{Q}{2 \cdot h_{co}}\left(f\right) = 580 + \frac{(250)(.45)}{(2)(2.5)}$$

$$T_{co} = 602.5\ \text{K}$$

-1, should be 615.4

$$T_{ci} = \frac{Q \, t_c}{2 k_c} + T_{co}$$

$$T_{ci} = \frac{(250)(.45)(.06)}{(2)(.17)} + 602.5\ \text{K}$$

$T_{ci} = 622.35\ K$

-1, should be 646.6

$k_{He} = 16\times10^{-6}(T^{.79})$

$k_{xe} = .7\times10^{-6}(T^{.79})$

$$T_{surf} = \frac{Q}{2h_{gap}} \cdot r_f + T_{ci}$$

$$h_{gap} = \frac{k_{He}^{.05} \cdot k_{xe}^{.95}}{t_{gap}}$$

$h_{gap} = .276\ W/cm^2 K$

$$T_{surf} = \frac{260}{(2)(.276)}(.45) + 622.35\ K$$

$$\boxed{T_{surf} = 826.154\ K}$$

-1, should be 958 K

b) UN what is Max stress

$E = 246.7\ GPa$

$\nu = .25$

$\alpha = 7.5e^{-6}\ 1/K$

$k_f = .2\ W/cm\ K$

$$T_o = T_s + \frac{Q}{4k} \cdot r_s^2$$

$$\Delta T = \frac{250}{(4)(.2)} \cdot .45^2$$

-4, DT = 99.5 K

$\Delta T = 63.28$

$$\sigma^* = \frac{(7.5e^{-6})(246.7e^9)(63.28)}{4(1-.25)}$$

$\sigma^* = 39.03\ MPa$

$\sigma_{rr} = -\sigma^*(1-\eta^2)$

$\sigma_{\theta\theta} = -\sigma^*(1-3\eta^2)$

$\sigma_{zz} = -2\sigma^*(1-2\eta^2)$

$$\boxed{\sigma_{max} = \sigma^* \cdot 2 = 78.06\ MPa}$$

c) The stress would be lower because it has a small temperature gradient.

-5, UO2 has a much smaller thermal conductivity so the DT would be much higher

2d. Assumptions

#1

1. $K_{el} = .17\ W/mK$
2. No thermal Expansion
3. in temperature Calculation.

#2

1. $K_P = .2$
2. No Thermal Expansion in temperature calculation

-22, 13/35

3. $P = 6\,MPa$
$r_{AV} = .056\,cm$
$t_{cl} = .006\,cm$

-3, Stress is constant across thickness

a) Assumptions 1. Static Body
2. Gravity is negligible
3. Axisymmetric
4. Isotropic material response
5. $\varepsilon_{rr} = \frac{\partial u_r}{\partial r}$, $\varepsilon_{\theta\theta} = \frac{u_r}{r}$, $\varepsilon_{zz} = \frac{\partial u_z}{\partial z}$
$\varepsilon_{rz} = \frac{1}{2}\left(\frac{\partial u_r}{\partial z} + \frac{\partial u_z}{\partial r}\right)$

b) $\sigma_\theta = \frac{Pr}{t} = \frac{6\times10^6 \cdot .0056}{.0006}$

$\boxed{\sigma_\theta = 56\,MPa}$

$\boxed{\sigma_z = \frac{PR}{2t} = 28\,MPa}$

$\sigma_r = -\frac{1}{2}P$

$\boxed{\sigma_r = -3\,MPa}$

-10, Calculate stress using thick walled equation at two radii and compare answers

c) The thin walled method is rather accurate giving approximate answers but it is not conservative

d) $E = 70\,GPa$
$\nu = .41$

$\sigma = E\varepsilon$

$$\boxed{\begin{pmatrix}\sigma_\theta\\ \sigma_r\\ \sigma_z\end{pmatrix} = \frac{1}{70\,GPa}\begin{pmatrix}1 & -.41 & -.41\\ -.41 & 1 & -.41\\ -.41 & -.41 & 1\end{pmatrix}\begin{pmatrix}\varepsilon_\theta\\ \varepsilon_r\\ \varepsilon_z\end{pmatrix}}$$

-4, Didn't write in tensor form
-5, Calculate strains from stresses from part b