Jorrod Cesmaldi
Exam 1

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Question 1

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a) uranium 235, 0.7% U_{235} naturally

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b.) $Q = E_f N_f \sigma_f \varphi_{th}$ $E_f = 3\times10^{-11}$ J/fis $\sigma_f = 585.1$ b

$\varphi_{th} = 3.2\times10^{13} \frac{n}{cm^2 \cdot s}$ $\rho_{U_3Si_5} = 7.5 \frac{gU}{cm^3}$ $\rho_{U_3Si_2} = 11.31 \frac{gU}{cm^3}$

$N_f\, U_3Si_2 = q \frac{\rho_U N_A}{M_U} = \frac{(11.31)\times0.6022\times10^{24}}{(235\cdot 0.03)+(238)(0.97)}(0.03) = 8.58\times10^{20}$ at 235

$Q = (3\times10^{-11})(2.577\times10^{19})(585.1\times10^{-24}\ cm^2)(3.2\times10^{13} \frac{n}{cm^2 \cdot s})$

$= 1482.3$ W/cm^3

$N\, U_3Si_5 = \frac{q\, \rho_U N_A}{M_U} = \frac{(8.58\times10^{20})(238)}{(7.5)(6.022\times10^{23})} = 0.0446 = \boxed{4.46\%}$

$\rho_{U_3Si_5} = 7.5 \frac{gU}{cm^3}$

c.) U_3Si_5 would rank below U_3Si_2 due to the higher enrichment necessary to produce the same power output.

-3, thermal conductivity?

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Question 2

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a.) $R_f = 0.45cm$ $t_g = 0.008cm$ $t_{cl} = 0.06cm$

$LHR = 250 W/cm$ $t_{cool} = 580K$ $\gamma_{Xe} = 0.05$ $h_{cool} = 2.5 W/cm \cdot K$

$$T_{co} = \underbrace{\frac{250\ W/cm}{2\pi(0.45)(2.5)}}^{35.4\ K} + 580K = 615.4\ K$$

$$T_{IC} = 615.4 + \overbrace{\frac{250 \cdot 0.06}{2 \cdot \pi \cdot 0.45 \cdot 0.17}}^{31.21\ K} = 646.6\ K$$

$$T_S = \overbrace{\frac{250}{2 \cdot \pi \cdot R_f \cdot h_{gap}}}^{311.6\ K} + 646.6K = \boxed{958.16\ K}$$

$$h_{gap} = \frac{k_{He}^{(1-\gamma)} k_{Xe}^{(\gamma)}}{0.008} = \underbrace{\left[\frac{16 \times 10^{-6}(646.6)^{0.79}}{(3.58 \times 10^{-3})}\right]^{(1-0.05)} \left[\frac{0.7 \times 10^{-6}(646.6)^{0.79}}{0.635}\right]^{0.05}}_{= 7.27 \times 10^{-3}}$$

$h_{gap} = 0.2838$

b.) $k_{UN} = 0.2\ W/cm K$ $\nu = 0.25$ $E = 246.7\ GPa$

$$\Delta T = \frac{250}{4\pi 0.2} = 99.5\ K \quad \alpha = 7.5 \times 10^{-6}\ 1/K$$

$$\sigma^* = \frac{\alpha E (99.5K)}{4(1-0.25)} = \frac{(7.5 \times 10^{-6})(246.7\ GPa)}{4(0.75)} = 0.617\ MPa$$

$\sigma_{\theta\theta} = -\sigma^*(1-3\eta)$ Max stress at $\eta = \frac{R_f}{R_f} = 1$

$$\sigma_{\theta\theta} = -0.617(1-3) = \boxed{1.234\ MPa}$$

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c. One would expect this stress to be much higher in UO_2 due to the increased temperature difference as a result of a lower thermal conductivity

d. The thermal conductivity is constant

Steady state

Axisymmetric behavior

-2, There are many more assumptions than these

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Question 3

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$P = 6MPa \quad \bar{R} = 0.56cm \quad t_c = 0.06cm$

a.) The wall thickness is small in comparison to the cylinder radius. This makes the stress constant along the radius.

-2, Isotropic and small strain

b. $\sigma_{\theta\theta} = \frac{pR}{t} = \frac{(6)(0.56)}{0.06} = 56MPa$

$\sigma_z = \frac{pR}{2t} = \frac{(6)(0.56)}{2 \cdot 0.06} = 28MPa$

$\sigma_r = -\frac{1}{2}p = -\frac{1}{2}(6) = -3MPa$

c. The thickness to radius ratio is

-6, Calculate stress using thick walled equations at two radii and compare

$\frac{0.06}{0.56} \times 100 = 10.7\%$

Typically the thickness must be ~1/10 the radius, or less.

This would be ultimately inaccurate to use for this scenario.

d.
$$\begin{bmatrix} \sigma_{\theta\theta} & & \\ & \sigma_{rr} & \\ & & \sigma_{zz} \end{bmatrix} = E \begin{bmatrix} \varepsilon_{\theta\theta} & & \\ & \varepsilon_{rr} & \\ & & \varepsilon_{zz} \end{bmatrix}$$

$$\begin{bmatrix} 56 & & \\ & 28 & \\ & & 3 \end{bmatrix} = 70 \begin{bmatrix} 6.18 \times 10^{-4} & & \\ & 5.44 \times 10^{-5} & \\ & & -4.49 \times 10^{-4} \end{bmatrix}$$

-2, small mistakes in strain calculation