67/100

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1.a) U-235

-10, 20/30

Si: 28.1 u

U_n: 238 u

e_n: 0.72%

$$U_3Si_5 = 5(28.1u) + 3(238u) = \underline{854.5u}$$

$$\text{wt \% } 235: \quad \frac{3 \cdot 238u \cdot .72\%}{854.5u} = \boxed{0.59\% \text{ wt}}$$

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

$$Q_1 = Q_2$$

$$\cancel{E_f} \cdot N_{U_3Si_5} \cdot (e_{U_3Si_5}) \cdot \cancel{\sigma_f} \cdot \cancel{\phi_{th}} = \cancel{E_f} \cdot N_{U_3Si_2} (e_{U_3Si_2}) \cancel{\sigma_f} \cdot \cancel{\phi_{th}}$$

$$e_{U_3Si_5} = e_{U_3Si_2} \cdot \frac{N_{U_3Si_2}}{N_{U_3Si_5}}$$

$$= 3\% \cdot \frac{769.9}{854.5} = 2.7\%$$

1.b)

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

$$Q_1 = Q_2$$

$$N_{f_1} = N_{f_2}$$

$$N_f = 3 \cdot g \cdot N_a \cdot \delta \cdot MM$$

$$MM_{U_3Si_2} = (238)3 + (28)2 = \underline{770\ g/mol}$$

$$MM_{U_3Si_5} = (238)3 + (28)5 = \underline{854\ g/mol}$$

δ_U ~~12.2 g/cm^3~~ 11.31

$$\cancel{3} \cdot (.03) \cdot \cancel{N_a} \cdot (\cancel{12.2\ g/cm^3}) / 770\ g/mol$$

$$= \cancel{3}(g)\cancel{N_a}(7.5\ g/cm^3)/854\ g/mol$$

$$\frac{.03 \cdot \cancel{12.2}\ 11.31/770}{7.5/854} = \cancel{5.4\%}\ 5.0\%$$

* But since $\underline{\delta_U}$ given instead of δ, use MM of U fraction only!?

-2, Only the dU fraction is needed

$$\frac{.03 \cdot \cancel{12.2}\ 11.31/\cancel{770}\ (238 \cdot 3)}{7.5/(238 \cdot 3)} = \boxed{\cancel{4.5\%}}\ \boxed{4.2\%}$$

1.c)

	Thermal Cond (W/cm/K)	Density (g U/cm^3)	Comparable Enrichment
U_3Si_5	.125	7.5	4.2%
U_3Si_2	.23	11.31	3%

U_{235} Fuel effiency of U_3Si_5 is higher!

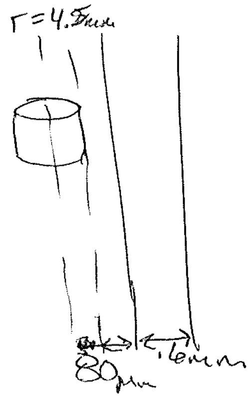
$$4.2\% \cdot 7.5\ g\,U/cm^3 = \underline{0.315\ g\ U_{235}/cm^3}$$

$$11.31\ g\ U/cm^3 \cdot 3\% = 0.339\ g\ U_{235}/cm^3$$

$$\Rightarrow \frac{.339 - .315}{.339} = \boxed{7\% \text{ less } U_{235} \text{ used by switching to } U_3Si_5}$$

-8, U3Si5 is worse, because the dU and the thermal conductivity are worse

2.a) -13, 22/35



580K

$$T_{co} = T_{cool} + \frac{LHR}{2\pi R_F h_{cool}}$$

$$= 580K + \frac{250 W/cm}{2\pi(4.5mm)\, 2.5 W/cm^2\text{-}K}$$

$$= \underline{615.3\ K}$$

* Assumed K_c For Zr

$$T_{IC} = T_{oc} + \frac{LHR \cdot t_c}{2\pi R_F \cdot K_c}$$

$$= 615.3K + \frac{250 W/cm \cdot 0.6 mm}{2\pi(4.5mm)\cdot \boxed{0.17 W/cm/K}}$$

$$= \underline{646.5\ K}$$

$$T_s = T_{IC} + \frac{LHR}{2\pi R_F \cdot \left(\frac{K_{gap}}{t_g}\right)} \quad ; \quad K_{gap} = 16E\text{-}6 \cdot T_K^{.79}$$

$$= \underline{.0027\ W/cm\text{-}K}$$

-1, 0.00227

$$= 646.5K + \frac{250 W/cm}{2\pi(4.5mm)\frac{.0027 W/cm\text{-}K}{80\mu m}}$$

$$= \boxed{912.7\ K}$$

2.b)

Assume Fuel dimensions measured at this temp

$$\sigma = -E \cdot \Delta T \cdot \alpha$$

$$= -246.7 GPa(-912.7K + \boxed{300K})\, 7.5E\text{-}6 \tfrac{1}{K}$$

$$=$$

2. b) Assume the pellet is constrained:

$$\sigma = -E(\Delta T)\alpha$$

Hoop stress is largest:

$$\sigma_{\theta\theta} = \frac{1}{2}\Delta T \frac{\alpha E}{1-\nu}\left(1 - 2\frac{R_i}{\delta}\left(\frac{r}{R_i} - 1\right)\right)$$

-6 Wrong DT, should be from Ts to T0

$$= \frac{1}{2}(912.7K - 300K)\frac{7.5e^{-6}\ 1/K \cdot 246.7GPa}{1 - .25}$$

-2, max stress with eta = 1

@ Max stress

$$\cdot\left(1 - 2\frac{4.5mm}{.6mm}(1-1)\right)$$

$$= \boxed{0.756\,GPa \text{ @ surface}}$$

2.c) U-N has a much ↑ conductivity than UO_2 ⇒ ~~big~~ lower Ts.

UO_2 $\sigma_{\theta\theta}$ will be higher for this reason.

-3, Ts is the same, but low UO2 thermal conductivity results in higher T0 and DT

2.a) Axisymmetry, isotropic material, K independant of T, no geometry change (such as gap size)

-1, there are several more assumptions

-10, 25/35

3. a) Force is constant over length,

Axisymmetric,

Isotropic material response,

$\frac{\partial x}{\partial t} = 0$, Gravity is negligable

b) $P = 6MPa$, $r = 5.6mm$, $\delta = 0.6mm$

$$\overline{\sigma_\theta} = \frac{P \cdot r}{\delta} = \frac{6MPa \cdot 5.6mm}{0.6mm} = \boxed{56MPa}$$

$$\overline{\sigma_z} = \frac{P \cdot r}{2\delta} = \frac{6MPa \cdot 5.6mm}{2(0.6mm)} = \boxed{28MPa}$$

$$\overline{\sigma_r} = -\frac{1}{2}P = -\frac{1}{2} \cdot 6MPa = \boxed{-3MPa}$$

c) Compare to thick wall sol'ns @ $r = R_i$

-4, Calculate stress at two radii and compare

$R_i = 5.6mm$

$R_o = 6.2mm$

$$\sigma_{rr} = -P = -6MPa$$

$$\sigma_{\theta\theta} = P \cdot \frac{(R_o/R_I)^2 + 1}{(R_o/R_I)^2 - 1} = 59.1MPa$$

$$\sigma_{zz} = P \frac{1}{(R_o/R_I)^2 - 1} = 26.6MPa$$

Hoop stress most important, $\frac{56}{59} = 95\%$ correct

σ_r off by factor of 2, σ_z is close.

Thin wall should be conservative (but I find it is not in this case)

$$3.a) \quad \cancel{\bar{\sigma}_\theta(R) = \frac{P \cdot R}{\delta}}$$

$$\cancel{\epsilon = \begin{bmatrix} \frac{P \cdot R}{\delta} & 0 \\ 0 & \frac{P}{\delta} \end{bmatrix} =}$$

3.a) * What is the displacement??

$$\begin{bmatrix} \sigma_{rr} \\ \sigma_{\theta\theta} \end{bmatrix} = \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} 1-\nu & \nu \\ \nu & 1-\nu \end{bmatrix} \begin{bmatrix} u_{r,r} \\ u_r/r \end{bmatrix}$$

$$= \frac{70\,GPa}{(1.41)(0.18)} \begin{bmatrix} .59 & .41 \\ .41 & .59 \end{bmatrix} \begin{bmatrix} u_{r,r} \\ u_r/r \end{bmatrix}$$

-2, tensors are missing zz component

-4 Calculate the strains from the stresses from part b

$$= \begin{bmatrix} 162.7 & 113.1 \\ 113.1 & 162.7 \end{bmatrix} \begin{bmatrix} u_{r,r} \\ u_r/r \end{bmatrix}$$

Stress tensor

Strain tensor is $\begin{bmatrix} u_{r,r} & 0 \\ 0 & u_r/r \end{bmatrix}$

but what is displacement, u for this??

Next page

3 a) Just looking @ Hoop stress:

u(r) isn't

Given elastic expansion,

$$\varepsilon = \frac{\sigma}{E} \Rightarrow$$

$$\begin{bmatrix} 2.32 & 1.62 \\ 1.62 & 2.32 \end{bmatrix}$$