$\boxed{28}$

(10) Zircaloy clad fuel rod w/ $P = 20$ MPa
$R_c = 5.4$ mm $= 0.54$ cm & $t_{clad} = 0.8$ mm $= 0.08$ c

(a) Calc stress components assuming thin walled approx

2 eqs 2 unknowns → solve

$$\frac{R_i + R_o}{2} = 0.54 \qquad t_c = R_o - R_i$$

$$R_o = t_c + R_i$$

$$\frac{t_c + R_i + R_i}{2} = 0.54$$

$$\frac{0.08\text{ cm} + 2R_i}{2} = 0.54 \Rightarrow R_i = 0.5\text{ c}$$

$$R_o = 0.58$$

$$\sigma_\theta = \frac{P\bar{R}_c}{\delta} = \frac{(20\text{ MPa})(0.54\text{ cm})}{0.08\text{ cm}}$$

$$\sigma_\theta = 135\text{ MPa}$$

4/4

$$\sigma_r = \frac{-P}{2} = -10\text{ MPa}$$

$$\sigma_z = \frac{P\bar{R}_c}{2\delta} = \frac{\sigma_\theta}{2} = \boxed{67.5\text{ MPa}}$$

10

12 cont. see excel tab for 12

W/ thermal exp

$$\Delta\delta_{gap} = \bar{R}_c \alpha_c (\bar{T}_c - T_c^{Ref}) - \bar{R}_F \alpha_F (\bar{T}_F - T_F^{Ref})$$

$$\bar{R}_c = R_F + t_{gap} + t_c/2$$

$$= 0.5\,cm + 0.02\,cm + 0.52\,cm/2$$

letting $t_c \approx R_i = 0.5 + 0.02 = 0.52$ cm

$$\bar{R}_c = 0.78\,cm$$

assume $T_{ci} = \bar{T}_c$

$$\Delta\bar{R}_c = (0.78\,cm)(4.5\times10^{-6}\,K^{-1})(450\,K - 300\,K)$$

$$= 5.27\times10^{-4}\,cm$$

$$\Delta\bar{R}_F = R_F \alpha_F (\bar{T}_F - T_F^{Ref})$$

$$\bar{T}_F = \frac{T_0 + T_s}{2}$$

$$T_s = -\left[\frac{LHR}{4\pi k_F} - T_0\right] = 501.73\,K$$ ✓

so

$$\bar{T}_F = 760.35\,K$$ ✓

$$\Delta R_F = 3.45\times10^{-3}\,cm$$

so $\Delta\delta_{gap} = -2.93\times10^{-3}$ cm do only 1 iteration for gap thickness

(12) $R_F = 0.5\ cm$, $t_{gap} = 0.02\ cm$; $T_{ci} = 450\ K$
$k_F = 0.05\ W/cm \cdot K$; $k_{gap} = 0.04\ W/cm \cdot K$

$k_c = 0.15\ W/cm\ K$; $LHR = 325\ W/cm$

16/16

$\alpha_c = 4.5 \times 10^{-6}\ K^{-1}$; $\alpha_F = 15 \times 10^{-6} \cdot K^{-1}$

$T_F^{Ref} = T_C^{Ref} = 300K$

centerline T, T_0^F (w/o thermal exp)

$$T_{fuel} - T_{ci} = \frac{(LHR)\,t_{gap}}{2\pi R_{fuel} k_{gap}}$$

$$= \frac{(325\ \cancel{W/cm})(0.02\ \cancel{cm})}{2\pi(0.5\ \cancel{cm})(0.04\ \cancel{W/cm}\ K)}$$

$$= 51.73\,K$$

$\underline{T_{Fuel}} = 51.73\ K + 450 = 501.73$ ✓

$$T_0 = T_{Fuel} + \frac{LHR}{4\pi k_{fuel}}$$

$$= 501.73K + \frac{(325\ W/cm)}{4\pi(0.05\ W/cm)}$$

$$\boxed{\text{w/o thermal exp} \quad T_0 = 1018.98K}$$ ✓

new $t_{gap}^{new} = t_{gap}^{0} + \Delta\delta_{gap} = 1.710\times10^{-2}$ cm ✓

$R_F^{new} = \Delta R_F + R_F^{0} = 0.503$ cm

resolve for T_0

$$T_F = \frac{(LHR)\, t_{gap}^{new}}{2\pi R_F k_{gap}} + T_{C1} = 493.85 \text{ K}$$

✓

$$\boxed{T_0 = T_F + \frac{LHR}{4\pi k_F} = 1011.11 \text{ K}}$$

...ow does
6. Define str...
7. What thr...
8. What is...
9. What is... pts)
10. Consi... avera...
a) C...
b) ...

approx

8/8

(13) $R_F = 0.55\,cm$; $\nu = 0.25$, $E = 210\,GPa = 2.1\times10^5\,MPa$

$LHR = 200\,W/cm$; $\alpha_F = 10.5\times10^{-6}\,K^{-1}$ $\sigma_{fract} = 120\,MPa$

$k_F = 0.05\,\frac{W}{cm\cdot K}$

$$\eta = \frac{r}{R_F} \quad \& \quad \sigma^* = \frac{\alpha E (T_0 - T_s)}{4(1-\nu)}$$

$$T_0 - T_s = \frac{(LHR)}{4\pi k_F} = \frac{(200\,W/cm)}{4\pi\,(0.05\,W/cm\cdot K)} = \boxed{318.31\,K}$$

$$\sigma^* = \frac{(10.5\times10^{-6}\,K^{-1})(2.1\times10^5\,MPa)(318.31\,K)}{4(1-0.25)}$$ ✓

$$= 2.34\times10^2\,MPa$$

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

letting $\sigma_{\theta\theta} = \sigma_{fract}$ & solving for r

$$120\,MPa = -(2.34\times10^2\,MPa)(1-3(r^2/R_F^2))$$

$$-5.13\times10^{-1} = 1 - 3[r^2/0.3025\,cm^2]$$

$$-1.513 = -3\,r^2/0.3025\,cm^2$$

$$0.504 = r^2/0.3025\,cm^2$$ ✓

$$0.153\,cm^2 = r^2 \rightarrow \boxed{r = 0.391\,cm}$$

se re