

- ① Derive relationship for temp drop in cartesian
 $T'(x_0) = 0$ $x_0 = 0$ $x_1 = X$ $T(x_1) = T_1$

$$\frac{d}{dx} \left(k \frac{dT}{dx} \right) + Q = 0$$

assume SS, axisymmetric, constant in z , +
 const. Thermal conductivity

$$\frac{d}{dr} \left(rk \frac{dT}{dr} \right) = -Qr \quad \Rightarrow C, ?$$

$$\frac{dT}{dr} = \frac{-Qr}{2k} \quad \text{where did that } 2 \text{ come from?}$$

$$T(r) = -\frac{Qr^2}{4k} + C_2 \quad r^2 = x^2 + y^2$$

$$T(x, y) = -\frac{Q(x^2 + y^2)}{4k} + C_2$$

\downarrow
 $2k$

\downarrow
 $?$

on the right track more or less

8/12

79

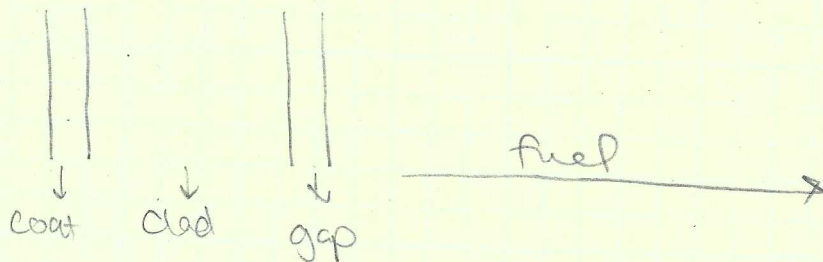
② Compute fuel centerline temp w/ + without coating

$$\begin{aligned} k_{\text{coat}} &= 0.015 \\ k_{\text{clad}} &= 0.15 \\ k_{\text{fuel}} &= 0.05 \\ k_{\text{gap}} &= 0.004 \end{aligned}$$

$$\begin{aligned} T_{\text{cool, at}} &= 600 \text{ K} \\ Q &= 250 \text{ W/cm}^2 \\ R_f &= 0.6 \text{ cm} \end{aligned}$$

$$\begin{aligned} t_{\text{gap}} &= 0.005 \\ t_{\text{clad}} &= 0.05 \\ t_{\text{coat}} &= 0.01 \end{aligned}$$

$$T_{\text{co w/o clad}} = 600 \text{ K}$$



Assume coating linear temp profile

$$T_{\text{oc}} - T_{\text{coat}} = \frac{LHR + \text{coat}}{2\pi R_f k_{\text{coat}}} \quad LHR = \pi R_f^2 Q_{\text{av}}$$

$$LHR = \pi (0.6)^2 (250) = 282.743$$

$$T_{\text{oc}} = \frac{LHR + \text{coat}}{2\pi R_f k_{\text{coat}}} + T_{\text{coat}} = \frac{282}{2\pi (0.6)} \left(\frac{0.01}{0.015} \right) + 600 = 650$$

$$T_{\text{ic}} = \frac{LHR}{2\pi R_f} \frac{t_{\text{clad}}}{k_{\text{clad}}} + T_{\text{oc}} = 675 \text{ K}$$

$$T_f = \frac{LHR}{2\pi R_f} \frac{t_{\text{gap}}}{k_{\text{gap}}} + T_{\text{ic}} = 768 \text{ K}$$

$$T_o = \frac{LHR}{4\pi k_{\text{fuel}}} + T_{\text{fuel}} = 1218 \text{ K}$$

without

$$T_{\text{ic}} = \frac{LHR}{2\pi R_f} \frac{t_{\text{clad}}}{k_{\text{clad}}} + T_{\text{oc}} = 625$$

$$T_f = \frac{LHR}{2\pi R_f} \frac{t_{\text{gap}}}{k_{\text{gap}}} + T_{\text{ic}} = 718$$

$$T_o = \frac{LHR}{4\pi k_{\text{fuel}}} + T_f = 1168 \text{ K}$$

$$T_o, \text{ with coat} = 1218 \text{ K}$$

$$T_o, \text{ without coat} = 1168 \text{ K}$$

③ $^{235}_{92}\text{U}$ $x = 19.5\%$ $\rho = 12.3 \text{ g/cm}^3$ $\sigma_f = 570$

117
14

a) Want Q given $\phi = 5 \times 10^{12} \text{ n/cm}^2 \text{ s}$

$$Q = E_f N_f \sigma_f \phi \quad E_f \sim 200 \text{ eV} \times 1.602 \times 10^{-19} \text{ J/eV} = 3.204 \times 10^{-17}$$

molar mass $^{235}_{92}\text{U} = (235 \cdot 0.195) + (238 \cdot 0.805) + 14$ - math is wrong here

$$N_f = 12.3 \times \left(\frac{6.022 \times 10^{23}}{231.415} \right) \times \left(\frac{1}{1} \right) \times (0.195) = 5.745 \times 10^{21}$$

$$Q = (3.204 \times 10^{-17}) (5.745 \times 10^{21}) (570 \times 10^{-24}) (5 \times 10^{12})$$

$Q = 5.246 \times 10^{-4}$ units? off by 7 orders of magnitude...

b) $N_f = \frac{Q}{E_f \sigma_f \phi} = 5.745 \times 10^{21}$

$$N_f = 10.97 \left(\frac{6.022 \times 10^{23}}{\text{mm}} \right) (x_f)$$

$$\frac{x_f}{\text{mm}} = \frac{5.745 \times 10^{21}}{10.97 \times 6.022 \times 10^{23}} = 0.00869$$

$$\frac{x_f}{235x_f + 238(1-x_f)} = 0.00869$$

8.7×10^{-4}

$$x_f \sim 0.206$$

$x_f \sim 0.24$

right process

④ $L = 3.5 \text{ m}$ $LHR^\circ = 350$ $\gamma = 1.3$

a) $LHR @ z = 1.4$

$z_0 = \frac{L}{2} = 1.75$

$LHR\left(\frac{1.4}{3.5}\right) = (350) \cos\left(\frac{\pi}{2(1.3)}\left(\frac{1.4}{3.5} - 1\right)\right)$
 $= 261.979$

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b)

$T_{cool} - T'_{cool} = \frac{1}{\dot{m} C_{pw}} z_0 \times LHR^\circ \int_0^{z/z_0} \cos\left[\frac{\pi}{2\gamma}\left(\frac{z}{z_0} - 1\right)\right] dz$ ✓

⑤

$\frac{dy}{dt} = t e^{-2t}$

$t_0 = 0$ $y_0 = 4$

0/12

4/4 Fissile isotopes are isotopes that readily undergo fission in the thermal neutron energy range. Fertile isotopes are isotopes that transmute to fissile isotopes by capturing neutrons. Fissionable isotopes are isotopes that only readily fission with fast spectrum neutrons.

4/4 Pure metallic U is undesirable as a fuel because it has a low melting point & is susceptible to significant swelling.

8/4 ⑧ Swing density is the ratio of the fuel volume to the total internal volume of the fuel element. This is necessary to accurately depict how much of the entire fuel element is actually fuel vs other non-fissile materials.

8/8 ⑨ U-235 is a naturally occurring fissile isotope that only makes up 0.7% of natural uranium. For use in most reactors, uranium must be enriched to higher concentrations of U-235 (3-5%) to sustain fission reactions. Uranium is enriched as gaseous UF_6 .

Centrifuge-based enrichment spins the UF_6 gas at high speeds to separate the U-235 from the U-238. U-238 is slightly heavier than U-235 so the centrifugal force forces the U-238 further toward the outside than the U-235. The gas can be siphoned off at the center to pull out the slightly higher enriched gas. This process must be repeated several times until the desired U-235 concentration is achieved.

6/6 ⑩ The three ways space is discretized are: (1) finite difference; (2) finite volume; and (3) finite element. The finite difference method is simple & fast computationally, but it is difficult to use with complex geometries & BCs.

8/8 ⑪ Departure from nucleate boiling is when the hottest channel in a reactor exceeds the critical heat flux that causes dryout which greatly reduces the ability of the coolant to remove heat from the fuel & can cause the clad & fuel to exceed safe temperatures.

The critical heat flux is the point at which the coolant transitions from nucleate boiling to transition boiling.

(12) The layers from inside to outside of TRISO Fuel

- 1) Fuel kernel ✓
- 2) Buffer
- 3) Inner pyrolytic Carbon ✓
- 4) SiC ✓
- 5) Outer pyrolytic Carbon ✓

Reactors that use this type of fuel include High Temperature Gas Reactors ✓

#8 allows for fuel swelling and fission gas release