Question ①.

85

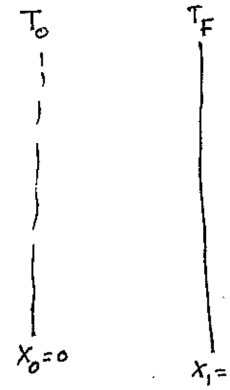
Simplified conduction equation.

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+\varphi=0.$$

$$\Downarrow$$

12/12 assumptions to get to this equation.

- ⇒ steady state $\frac{dT}{dt}=0.$
- ⇒ axisymmetric $\frac{dT}{dz}=0.$
- ⇒ constant in z direction,
- ⇒ constant thermal conductivity.



$$X_0=0 \longrightarrow T_0$$
$$X_1=X \longrightarrow T(X_1)=T_1$$

$$\frac{\partial}{\partial x}k\frac{\partial T}{\partial x}=-\varphi$$

$$k\frac{\partial T}{\partial x}=-\varphi X\Big|_{x_0}^{X}.$$

$$k\frac{\partial T}{\partial x}=-\varphi X$$

$$\int_{T_0}^{T}k\,dT=-\int_{x_0}^{x}\varphi X\,dX.$$

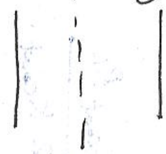
$$K(T-T_0)=-\frac{\varphi \cancel{X}^2}{2}\Big|_{X_0}^{X}.$$

$$T-T_0=-\frac{\varphi x^2}{2K}$$

$$\boxed{T_0-T=\frac{\varphi x^2}{2K}}$$

Hamdy Abouelella.

Fuel pellet w/o coating



Question ②

16/16

Coating.

$K = 0.015$ W/Cm.K.

Cladding $\Rightarrow$ $K = 0.15$ W/Cm.K

Fuel. $K = 0.05$ W/Cm-K

Gab $K = 0.004$.

T (Coating surface) $= 600\ °K$

$\Phi = 250$ W/Cm^3

$R_F = 0.6$ cm

Fuel.
gab
clad.

Solution.
⇓

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without Coating.

Fuel center line. | Fuel outer radius. | gab | clad.

T_{c_i} | T_{c_o}

$K = 0.05$ W/cm.K, $R_F = 0.6$ cm.

$K = 0.004$ W/cm.K, $t_g = 0.005$ cm

$K = 0.15$ W/cm.K, $t_{clad} = 0.05$ cm.

600 K.

$$T_o - T_{fuel} = \frac{\Phi R_F^2}{4K}$$

$$T_o - 718.75 = \frac{250 * (0.6)^2}{4 * 0.05}$$

$$T_o = 1168.75\ °K$$

$$T_f - T_{c_i} = \frac{\Phi R_f}{2 h_{gab}}$$

$$h_{gab} = \frac{k_{gab}}{t_{gab}}$$

$$h_{gab} = \frac{0.004}{0.005} = 0.8$$

$$h_{gab} = 0.8 \text{ W/cm}^2\cdot K$$

$$T_f - 625 = \frac{250 * 0.6}{2 * 0.8}$$

$$T_f - 625 = 93.75$$

$$T_f = 718.75\ K.$$

$$T_{ci} - T_{cool} = \frac{\Phi}{2 h_{cool}} R_F$$

$$h_{clad} = \frac{K_{clad}}{t_{clad}}$$

$$h_{clad} = \frac{0.15 \text{ W/cm.K}}{0.05 \text{ cm.}}$$

$$h_{clad} = 3 \text{ W/cm}^2\cdot K.$$

$$T_{c_i} - 600 = \frac{250 \text{ W/cm}^3 * 0.6 \text{ cm}}{2 * 3 \text{ W/cm}^2\cdot K}$$

$$T_{c_i} - 600 = 25\ °K$$

$$T_{ci} = 625\ °K$$

with Coating.

Fuel.

$k = 0.05\ W/cm\cdot K$

$R_f = 0.6\ cm.$

$T_o = ?$

$$T_o - T_{fuel} = \frac{q R_f^2}{4k}$$

$$T_o - 768.75 = \frac{250 * 0.6^2}{4 * 0.05}$$

$$T_o = 1218.75\ K$$

gab

$k = 0.004\ W/cm\cdot K$

$t_{gab} = 0.005\ cm$

T_f

$$h_{gab} = \frac{k_{gab}}{t_{gab}} = 0.8$$

$$T_f - T_{ci} = \frac{q R_f}{2 h_{gab}}$$

$$T_f - 675 = \frac{250 * 0.6}{2 * 0.8}$$

$$T_f - 675 = 93.75$$

$$T_f = 768.75.$$

clad.

$k = 0.15\ W/cm\cdot K$

$t_{clad} = 0.05\ cm.$

T_{ci}

$$T_{ci} - T_{co} = \frac{q\, t_{clad} R_F}{2 k_{clad}}$$

$$T_{ci} - 650K = \frac{250 * 0.05 * 0.6}{2 * 0.15}$$

$$T_{ci} = 650 + 25$$

$$T_{ci} = 675^\circ K$$

coat.

$k = 0.015\ W/cm\cdot K$

$t_{coat} = 0.01\ cm$

T_{co}

$$T_{co} - T_{coat} = \frac{q\, t_{coat} R_f}{2 K_{coat}}.$$

$$T_{co} - 600 = \frac{250 * 0.01 * 0.6}{2 * 0.015}$$

$$T_{co} - 600 = 50^\circ K$$

$$T_{co} = 650^\circ K.$$

$T_{coat/c}$

$\underline{\underline{600K.}}$

Question (3)

12/14

Fuel $\longrightarrow$ UN

enrichment = 19.5 % $\longrightarrow$ 0.195

ρ = 12.3 g/cm^3

σ = 570 barns.

M_N = 14 M(u) = 235

Mono. → 50 % N, 50% U.

$\phi = 5 * 10^{12}$ n/cm²-s.

$\Longrightarrow$ M(UN) $\Longrightarrow$

$M(U) = (235 * 0.195) + (238 * 0.805) = 237.415.$

$M(UN) = (0.5 * 237.415) + (0.5 * 14) = \underline{125.7075}$ g/mol.

$$N_f = \frac{\rho * A_v * \text{atom fraction} * \text{enrichment}}{M}$$

$$N_f = \frac{12.3\, g/cm^3 * 6.023*10^{23} * 0.5 * 0.195}{125.7075} = 5.75 * 10^{21}\ {}^{235}U/cm^3$$

$$Q = E_f\ (\underline{N_f * \phi})\ \sigma_f$$

$$Q = 200 * 10^6 * 1.6 * 10^{-19} * 5.75*10^{21} * 5 * 10^{12} * 570 * 10^{-24}.$$

~~Q = 524 w/cm³~~

$Q = 524$ w/cm³

For UO_2.

$$Q = 524\ w/cm^3 = \frac{200*10^6 * 1.6*10^{-19} * (N_f) * 5*10^{12} * 570*10^{-24}.}{}$$

$\Downarrow$

N_F = same as ~~befor~~ for UN.

$$N_f = \frac{\rho * Av * \text{atom fraction} * \text{enrichment}}{M.}$$

$$5.75*10^{21} = \frac{10.97 * 6.023*10^{23} * \frac{1}{3} * X}{M(UO_2)}$$

$$M(U) = X \cdot 235 + (1-X) \cdot 238$$

$$M(UO_2) = \left[(X \cdot 235) + (1-X) \cdot 238\right] + 2*16$$

✓

$$5.75*10^{21} = \frac{10.97 * 6.023*10^{23} * \frac{1}{3} * X}{\left[X \cdot 235 + (1-X) \cdot 238\right] + 32}$$

✓

X = enrichment =

almost there

Question (4)

8/12

$l = 2Z_o = 3.5\ m \Longrightarrow Z_o = 1.75.$

$lHR^o = 350\ w/cm$

$\gamma = 1.3$

radians, not degrees

lHR at $Z = 1.4\ m$?

$$lHR\left(\frac{z}{z_o}\right) = lHR^o \cos\left(\frac{\pi}{2\gamma}\left(\frac{z}{z_o} - 1\right)\right)$$ ✓

$$lHR\left(\frac{z}{z_o}\right) = 350 \cos\left(\frac{\pi}{2 \times 1.3}\left(\frac{1.4}{1.75} - 1\right)\right)$$

$$lHR\left(\frac{z}{z_o}\right) = 349.99\ w/cm.$$

$C_p = 4200\ J/kg.k$

$\dot{m} = 0.22\ kg/s.rod.$

$$\Delta T_{cool} = \frac{2\gamma}{\pi}\ \frac{z_o\ lHR^o}{\dot{m}\ C_p}\left[\sin\left(\frac{\pi}{2\gamma}\right) + \sin\left(\frac{\pi}{2\gamma}\left(\frac{z}{z_o} - 1\right)\right)\right]$$ ✓

$$\Delta T_{cool} = 0.83 \times \frac{1.75 \times 350}{0.22 \times 4200}\left(\sin(1.2) + \sin\left(1.2\left(\frac{1.4}{1.75} - 1\right)\right)\right)$$

$$\Delta T_{cool} = 9.2 \times 10^{-3}\ K.!!$$

need to check the calculations again.

- right eqns, just needed radians

Question (5)

Back words euler.

$$Y_{n+1} = Y_n + dt\, Y'_{n+1}$$

$dt = 0.5$

$t_n = 1.5.$

$\frac{dy}{dt} = t * \exp(-2t)$

$t_0 = 0.$

$Y_0 = 4$

18/18

$t = 0.5.$

$$Y_1 = Y_0 + dt\, Y'_1$$

$$Y_1 = 4 + (0.5) * \left[0.5 \exp(-2 * 0.5)\right] \approx 4.09.$$

$t = 1$

$$Y_2 = Y_1 + dt\, Y'_2$$

$$Y_2 = 4.09 + 0.5 \left[1 \exp(-2 * 1)\right] = 4.159.$$

$t = 1.5$

$$Y_3 = Y_2 + dt\, Y'_3$$

$$Y_3 = 4.159 + 0.5 \left[1.5 \exp(-3)\right]$$

$$Y_3 = 4.196$$

Question ⑨

5/8

⇒ increase the heat capacity and efficiency
energy o/p

⇒ it also allow us to operate at thermal neutron spectrum.

⇒ Compound UF_6

- centrifuge method?

Question ⑩

4/6

* finite difference

* finite volume

* finite element method.

- advantage or weakness?

Question (6)

3/4

fertile → can be converted into fissile atom by bombarding with neutrons.

fissile → fission will occur + chain reaction

fissionable → ~~fission~~ fission will occur ~~with ex~~ - - -

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Question (7)

4/4

(1) swelling
(2) anisotropic irradiation growth
(3) thermal stability.
(4) thermal conductivity.

Question (8)

7/8

ration between fuel atoms to the volume it's occupying ~~in the fuel.~~ inside the cladding

⇓

heat capacity and the limit of thermal conductivity

if modifyied → used to limit ⇓ structural changes and swelling

Question 11

0/8

Question 12

2/5