Question ①.

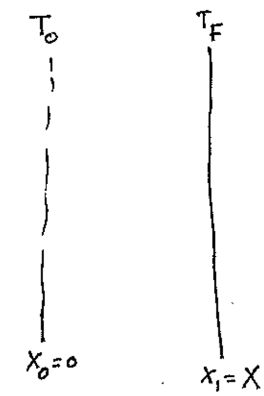
Simplified conduction equation.

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

$\Downarrow$

assumptions to get to this equation.

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



$X_0=0 \longrightarrow T$

$X_1=X \longrightarrow T(x_1)=T_1$

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

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

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

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

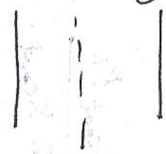
$$K(T-T_0)=-\frac{\varphi \cancel{X}^2}{2}\Bigg|_{X_0}^{X}.$$

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

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

Hamdy Aboueleila.

Fuel pellet w/o, Coating



Question ②

Coating.

$k = 0.015$ W/cm.K.

Cladding ⇒ $k = 0.15$ W/cmK

Fuel. $k = 0.05$ W/cm-K

Gab $k = 0.004$.

T (coating surface) $= 600\,°K$

$Q = 250$ 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	T_{c_i} clad.	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.

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

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

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

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

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

$$T_f - 625 = 93.75$$

$$T_f = 718.75 \text{ K}.$$

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

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

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

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

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

$$T_{c_i} - 600 = 25\,°K$$

$$T_{ci} = 625\,°K$$

$$T_o - T_{fuel} = \frac{Q R_F^2}{4k}$$

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

$$T_o = 1168.75\,°K$$

with Coating.

Fuel.	gab	clad.	coat.	
$k = 0.05$ W/cm.K	$k = 0.004$ W/cm.K	$k = 0.15$ W/cm.K	$k = 0.015$ W/cm.K	
$R_f = 0.6$ cm.	$t_{gab} = 0.005$ cm	$t_{clad} = 0.05$ cm.	$t_{coat} = 0.01$ cm	
$T_0 = ?$	T_f	T_{ci}	T_{co}	T_{coat}
				600K.

Fuel.

$$T_0 - T_{fuel} = \frac{q R_f^2}{4k}$$

$$T_0 - 768.75 = \frac{250 * 0.6^2}{4 * 0.05}$$

$$T_0 = 1218.75 \text{ K}$$

gab

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

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

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

$$T_f - 675 = 93.75$$

$$T_f = 768.75.$$

clad.

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

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

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

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

coat.

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

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

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

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

Question (3)

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/cm^2-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.

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

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

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

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

~~Q = 524 w/cm^3~~

Q = 524 w/cm^3

For UO_2.

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

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 =

Question (4)

$l = 2Z_0 = 3.5\ m \Longrightarrow Z_0 = 1.75.$

$lHR^0 = 350\ w/cm$

$\gamma = 1.3$

lHR at $Z = 1.4\ m$?

$$lHR\left(\frac{Z}{Z_0}\right) = lHR^0 \cos\left(\frac{\pi}{2\gamma}\left(\frac{Z}{Z_0} - 1\right)\right)$$

$$lHR\left(\frac{Z}{Z_0}\right) = 350 \cos\left(\frac{\pi}{2 \times 1.3}\left(\frac{1.4}{1.75} - 1\right)\right)$$

$$lHR\left(\frac{Z}{Z_0}\right) = 349.99\ w/cm.$$

$C_p = 4200\ J/kg.k$

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

$$\Delta T_{cool} = \frac{2\gamma}{\pi} \frac{Z_0\ lHR^0}{\dot{m} C_p}\left[\sin\left(\frac{\pi}{2\gamma}\right) + \sin\left(\frac{\pi}{2\gamma}\left(\frac{Z}{Z_0} - 1\right)\right)\right]$$

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

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

$\Downarrow$

need to check the calculations again.

Question (5)

Back words euler.

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

$dt = 0.5$

$t_n = 1.5.$

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

$t_0 = 0.$

$Y_0 = 4$

$t = 0.5.$

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

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

$t = 1$

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

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

$t = 1.5$

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

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

$$Y_3 = 4.196$$

Question 9

⇒ increase the heat capacity and efficiency
⇓
energy o/p.

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

⇒ Compound UF_6

Question 10

* finite difference

* finite volume

* finite element method.

Question 6

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

fissile → fission will occur + chain reaction

fissionable → ~~fission~~ fission will occur ~~with cer~~

Question 7

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

Question 8

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

⇓

heat capacity and the limit of thermal conductivity

⇓

if modifyied ← used to limit structural changes and swelling

Question 11

Question 12