① Angélica María López Morales #1

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$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+Q=0 \qquad T'(x_0)=0 \quad x_0=0$$
$$T(x_1)=T_1 \quad x_1=X$$

$$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)=-Q$$

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$$k\frac{\partial T}{\partial x}=-Qx+C_1$$

$$0=-Q\cdot 0+C_1 \Rightarrow C_1=0$$

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

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

$$T=-\frac{Q}{k}\frac{x^2}{2}+C_2$$

$$T_1=-\frac{Q}{k}\frac{X^2}{2}+C_2$$

$$C_2=T_1+\frac{Q}{k}\frac{X^2}{2}$$

$$T=-\frac{Q}{2k}x^2+T_1+\frac{Q}{k}\frac{X^2}{2}$$

$$\boxed{T-T_1=\frac{Q}{2k}(X^2-x^2)}$$

To get the provide equation it was assumed:
1. steady state
2. axisymmetric
3. Temperature is constant in z
4. The thermal conductivity is constant

Angelica Lopez Morales #2

18/18

(2) $T_0 = ?$

$T(r = 0{,}4\,cm) = ?$

$K_{cot} = 5 \frac{W}{mK}$

$K_{clad} = 15 \frac{W}{mK}$

$K_f = 0{,}5\,W/cm\text{-}K$

$K_g = 25\,W/m\text{-}K$

$h_{cool} = 5{,}5\,W/cm^2K$

$T_{cool} = 800\,K$

$Q = 400\,W/cm^3$

$r_1 = r_f = 0{,}6\,cm$

$r_2 = r_{c_1} = 0{,}8\,cm$

$r_3 = r_{co} = 0{,}85\,cm$

$r_4 = r_{cot} = 0{,}86\,cm$

$$T_{cot} = \frac{Q}{2h_{cool}} R_f + T_{cool}$$

$$= \frac{400\,W/cm^3}{2 \cdot 5{,}5 \frac{W}{cm^2K}} \cdot 0{,}6\,cm + 800\,K$$

$$= 821{,}81\,K \checkmark$$

$$T_{co} - T_{cot} = \frac{Q \cdot t_{cot}}{2 \cdot K_{cot}} \cdot R_f$$

$$T_{co} = \frac{400\,W/cm^3\,[0{,}86\,cm - 0{,}85\,cm] \cdot 0{,}6\,cm}{2 \cdot 5 \frac{W}{mK} \cdot \frac{1\,m}{10^2\,cm}} + 821{,}81\,K$$

$$= 845{,}81\,K \checkmark$$

$$T_g - T_{co} = \frac{Q\,t_{clad}}{2K_{clad}} \cdot R_f$$

$$T_g = T_{CI} = \frac{400\,W/cm^3 \cdot (0{,}85 - 0{,}8)\,cm \cdot 0{,}6\,cm}{2 \cdot 15 \frac{W}{mK} \cdot \frac{1\,m}{10^2\,cm}} + 845{,}81\,K$$

$$T_g = 885{,}81\,K = T_{CI} \checkmark$$

#3

$$T_f - T_{CI} = \frac{Q}{2h_{gap}} R_f$$

$$T_f = \frac{400\,W/cm^3\,[0{,}8-0{,}6]cm}{2\;25\frac{W}{\cancel{m}K}\cdot\frac{\cancel{m}}{10^2 cm}} \cdot 0{,}6\,cm + 885{,}81\,K$$

$$= 981{,}81\,K$$

$$T_0 = \frac{Q}{4k}R_f^2 + T_f = \frac{400\,W/cm^3\cdot(0{,}6\,cm)^2}{4\cdot 0{,}5\frac{W}{cmK}} + 981{,}81\,K = \underline{1053{,}81\,K}$$

$$T(r_i=0{,}4) = \frac{Q}{4k}(R_f^2 - r^2) + T_f$$

$$= \frac{400\,W/\cancel{cm^3}}{4\;0{,}5\,W/\cancel{cm}K}(0{,}6^2 - 0{,}4^2)\cancel{cm^2} + 981{,}81\,K$$

$$= \underline{1021{,}81\,K}$$

10/14

(3) $k_f = 15{,}5\,W/mK$

$e = 0{,}195$

$\rho_f = 15{,}67\frac{g}{cm^3}$

$\sigma_f = 570\cdot 10^{-24}\,cm^2$

$\phi_n = 2\cdot 10^{12}\frac{n}{cm^2 s}$

a) $Q = E_f \cdot N_f \cdot \sigma_f \cdot \phi$

$U = 235\cdot 0{,}195 + 238\cdot 0{,}805 = 237{,}415\,aum$

$mass(U_3Si_2) = 3\cdot 237{,}415 + 2\cdot 28$

$= 768{,}24\,aum$

$$N_{U\text{-}235} = 15{,}67\frac{\cancel{g}}{cm^3}\cdot\frac{\cancel{mol}}{768{,}24\,\cancel{g}}\cdot 6{,}022\cdot 10^{23}\frac{atom}{\cancel{mol}}\cdot 0{,}195$$

$$\cdot\frac{3U}{1\,U_3Si_2}$$

$$= 7{,}18\;10^{21}\,atom/cm^3$$

#4

$$Q = 200\,\text{MeV} \cdot 10^6 \frac{\text{eV}}{\text{MeV}} \cdot 1{,}602 \cdot 10^{-19} \frac{\text{J}}{\text{eV}} \cdot 7{,}18 \cdot 10^{21} \frac{\text{atom}}{\text{cm}^3} \cdot 570 \cdot 10^{-24}\,\text{cm}^2 \cdot 2 \cdot 10^{12} \frac{n}{\text{cm}^2 s}$$

$$Q = 262{,}25\ \text{W/cm}^3$$

✓

b) $\rho_{UO_2} = 10{,}97 \frac{g}{cm^3}$ mass $(UO_2) = 237{,}41 + 2 \cdot 16 = 269{,}41$ awm

$$7{,}18 \cdot 10^{21} \frac{\text{atom}}{\text{cm}^3} = 10{,}97 \frac{g}{cm^3} \cdot \frac{\text{mol}}{269{,}4\,g} \cdot 6{,}022 \cdot 10^{23} \frac{\text{atom}}{\text{mol}} \cdot \frac{1\,U}{1\,UO_2} \cdot \text{enrich.}$$

$$\text{enrig.} = 0{,}108\ \%$$

✗

(9) $CHR = 150\,\text{W/cm}$ a)
$z_0 = 1{,}5$
$H = 1{,}1$

9/12

$CHR = 1{,}8\,m = ?$

$$LHR(1{,}8m) = CHR^0 \cos\left(\frac{\pi}{2H}\left(\frac{z}{z_0} - 1\right)\right)$$

$$= 150 \frac{W}{cm} \cos\left(\frac{\pi}{2 \cdot 1{,}1}\left(\frac{1{,}8}{1{,}5} - 1\right)\right)$$

$$= 143{,}92\ \text{W/cm}$$

✓

Total out - T in

b)

$$T_{cool} - T^{i}_{cool} = \frac{1}{1{,}2} \cdot \frac{1{,}5 \cdot 150\,\text{W/cm}}{\dot{m}\,C_p} \underbrace{\left[\sin\left(\frac{\pi}{2 \cdot 1{,}1}\right) + \sin\left(\frac{\pi}{2 \cdot 1{,}1}\left(\frac{1{,}8}{1{,}5} - 1\right)\right)\right]}_{= 1{,}2715}$$

water $\Delta T = \frac{1}{1{,}2} \cdot \frac{1{,}5 \cdot 150\,\text{W/cm}}{0{,}22 \frac{kg}{s\,rod} \cdot 4200 \frac{J}{kg}} \cdot 1{,}2715$

z = 3

$= 0{,}2580$

-3

#5 :

Sodiu $\Delta T = \dfrac{1,5 \cdot 150}{1,2 \cdot 0,12 \cdot 1404}$ $\cdot 1,2715$

$= 1,415$

Sodium see larger change.

15/16

⑤ $dt = 0,33$ $t_n = 2$ $y(t_0) = 6$ $t_0 = 1$ $y' = 4t - 3t^2$

Forward

$t_0 = 1$ $y(t_0) = 6$

$t_1 = t_0 + \Delta t = 1 + 0,33 = 1,33$ $y_1 = y_0 + dt\, y_1' = 6 + 0,33 \cdot (4-3)$

$= 6,33$

$t_2 = t_1 + \Delta t = 1,33 + 0,33$ $y_2 = y_1 + dt\, y_1' = 6,33 + 0,33 \cdot \left(4 \cdot (1,33) - 3(1,33)^2\right)$

$= 1,66$

$= 6,334$

$y_3 = y_2 + dt\, y_2' = 6,334 + \left(4(1,66) - 3(1,66^2)\right)$

dt

$t_3 = t_2 + \Delta t = 2$

-1

$= 4,7072$

Backward.

$t_0 = 1$ $y(t_0) = 6$

$t_1 = 1,33$ $y_1 = y_0 + dt\, y_1' = 6 + 0,33 \cdot \left[4(1,33) - 3(1,33^2)\right]$

$= 6,004$

$t_2 = 1,66$ $y_2 = y_1 + dt\, y_2' = 6,004 + 0,33 \cdot \left[4(1,66) - 3(1,66^2)\right]$

$= 5,4671$

$t_3 = 2$ $y_3 = y_2 + dt\, y_3' = 5,4671 + 0,33\left[4 \cdot 2 - 3 \cdot 2^2\right)$

$= 4,1471$ ✓

#6

(5) a fissile isotope can undergone fission by absorption of thermal neutron. On the other hand and fissionable isotope can undergone fission as well but by energetic neutrons, Finally a fertile isotope does not undergone fission by thermal or energetic neutron but can ~~a~~ get a neutron an be converter into a fissile isotope. 5/5

(7) (1) Because it drastically swells
(2) Have anisotropic thermal expansion an irradiation growth 4/4

(8) smear density is the radio of the volumen of fuel pellet to fuel element 4/4

smeardensity $= r_1^2 / r_2^2$

it is necessary because the fuell swell so an smear density less than 1 is important to avoid fuel-cladding mechanical and chemical interactions

(9) Uranium need to be enriched because U-235 is an small percent of natural uranion and U-238 doe not undergone fission by thermal nuetron. 8/8

UF_6 is utilize in the enrichment process.

In the centrifue method the gas is placed in a centrifuge cylinder and rotate at high speed because U-235 and U-238 have different mass, the gass mollecules of ~~the~~ U-238 will move towards the outside of the cylinder, then ~~water~~ U-235 ~~test~~ enriched can be obtained

(10) Mo, Cs → fission products yields are effectively the same (double hump distribution) 4/4

(11) ① finite difference.
② finite volomen
③ finite element.
finite element is more correctly used due to more flexibility with geometry and boundary conditions than finite difference which have been traditionaly use. 8/8
Finite volomen is not use because it canot solve for stress