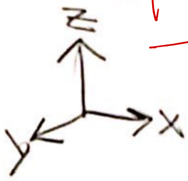
Late −18

$$\begin{array}{r} 86 \\ -18 \\ \hline 68 \end{array}$$

$\boxed{68}$



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ii.

(1) ① $T'(x_0) = 0$, $x_0 = 0$

② $x_1 = x$, $T(x_1) = T_1$

CARTESIAN COORDINATES

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

Assume:

- ★ k = Constant i.e. $k \neq$ func of x ✓
- ★ Temp does not vary along y, z (i.e symmetric about y, z) ✓
- ★ Steady State (SS) → $\partial/\partial t(\text{" "}) = 0$ ✓
- ★ Q is invariant with x (i.e. constant) ✓
- ★ fuel is rectangular or box shaped

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

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

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

using BC #1 → $C_1 = 0$ ✓

$$\int k\,\partial T = \int [-Qx]\,\partial x$$

$$kT(x) = -\frac{Qx^2}{2} + C_2$$

use BC #2 - $T(x_1) = T_1$ ✓

$$kT_1 = -\frac{Qx_1^2}{2} + C_2$$

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$$C_2 = kT_1 + \frac{Qx_1^2}{2}$$

so

$$kT(x) = -\frac{Qx^2}{2} + kT_1 + \frac{Qx_1^2}{2}$$

$$k(T(x) - T_1) = \frac{Q}{2}[x_1^2 - x^2]$$

$$\boxed{T(x) = \frac{Q}{2k}[x_1^2 - x^2] + T_1}$$

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② Calc centerline T & T(r=0.4 cm)

$k_{coat} = 0.05\ W/cmK$ $k_{clad} = 0.15\ \frac{W}{cmK}$, $k_{gap} = 0.25\ W/cmK$
$k_{fuel} = 0.005\ W/cmK$ — $K_F = 0.5\ W/cm \cdot K$

$h_{cool} = 5.5\ W/cm^2 \cdot K$ 1 cm = 0.01 m
$T_\infty = 800\ K$
$Q = 400\ W/cm^3$

$$T_{coat}^{out} = T(r_4) = \frac{Q}{2\, h_{cool}} R_{fuel} + T_\infty$$

$$T_4 = \frac{400\ W/cm^3}{(2)(5.5\ W/cm^2 \cdot K)}(0.6\ cm) + 800\ K$$

$$\underline{T_4 = 821.82\ K}$$ ✓

$$T_3 = \frac{Q\, t_{coat}}{2\, k_{coat}} R_f = \frac{(400)(0.01)(0.6)}{2 \times 0.05} + T_4$$

$$\boxed{T_3 = 845.82}$$ ✓

$$T(r_2) = T_2 = \frac{Q\, \cancel{t_{clad}}}{2\, k_{clad}} R_f + T_3$$

$$= 847.32\ K$$

just ~~off~~ Some thing here, but you didnt show all

$\Delta T_{cl-co} = 40K$

$T_1 = T(r_1) = \frac{Q\, t_{gap}}{2 k_{gap_f}} R_f + T_2$

- also here something off, not sure

$\Delta T_{f\,calc} = 96\,K$

$T_1 = 1007.32\,K$

$T_0 = \frac{Q}{4 k_{fuel}} R^2_{fuel} + T_1$

→ wrong k_f units

$\boxed{T_0 = 8207.32\,K}$

at $r = 0.4\,cm$

$\boxed{T(0.4\,cm) = \frac{Q(0.6^2 - 0.4^2)}{4 \times k_{fuel}} + T_1 = 5007.32\,K}$

- procedure correct

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Calculating heat generation rate for a given fu...

... about 200 MeV of energy is available due to a fission (210 MeV

... section of the target nuclide (tabulated)

... density

... $(\dot{\phi})$, Temp, fuel, etc.

...ity, σ_f is the ... that fission is

$0.145\ W/cm\,K$ ✓

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③ $k_{fuel} = 14.5\ W/mK$ $\quad E = 0.195$

$\rho_{fuel} = 15.67\ g/cm^3$

$S_i = 28$ amu

$\sigma_f = 5.7 \times 10^{-22}\ cm^2$

a) $\dot{\phi} = 2 \times 10^{12}\ n/cm^2 \cdot s$

$Q = E_f N_f \sigma_f \dot{\phi}$

also

$\frac{34}{1 U_3Si_2}$

$$N_f = \frac{\rho_{fuel}\ N_A\ E}{(235E + 238(1-E)) + 1.2 \times 16}$$

→ # of these atoms

$$= \frac{15.67 \times 6.023 \times 10^{23}}{269.77} \times 0.195$$

$$= 6.82 \times 10^{21}\ \frac{U^{235}\text{ atoms}}{cm^3}$$

$$E_f = \frac{200 \times 10^6\ eV}{\text{fission}} \times 1.602 \times 10^{-19}\ J/eV$$

$$= 3.2\cancel{1}8 \times 10^{-11}\ J$$

$$\boxed{Q = 250.6\ W/cm^3}$$

b) using excel to change enrichment

for $\rho = 10.97\ g/cm^3$

$\boxed{E = 0.2784 \text{ or } 27.84\%}$

→ need to solve for x w/ same N_f

→ show work

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Calculating heat generation rate for a given fuel

...V of energy is available due to a fission (210 MeV ... (tabulated)

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a) LHR(Z = 1.8 m)

LHR is not per K

$LHR^{\circ} = 150 \text{ W/cm K} \Rightarrow 1.5 \times 10^4 \text{ W/m K}$

$Z_0 = \frac{L}{2} = 1.5 \text{ m}$

assuming radians

$LHR^{\circ} = LHR(1.5 \text{ m})$

$LHR(1.8/1.5) = (1.5 \times 10^4 \text{ W/m K}) \cos\left(\frac{\pi}{2.2}\left(\frac{1.8}{1.5} - 1\right)\right)$

$\boxed{LHR(1.8 \text{ m}) = 1.44 \times 10^4 \text{ W/m K}}$

b) $\Delta T = \frac{1}{1.43} \frac{Z_0 \, LHR^{\circ}}{\dot{m} \, c_{pw}} \left(\sin(\underbrace{1.43}_{\pi/2 \times 1.1}) + \sin(1.43 \mid \frac{=}{Z_0}\right.$

$\Delta T_i = 17.3 \times$ { "sin (1.43 ")
$= 16.86$

$\Delta T_{ii} = 93.39$ { " ")
$= 92.47$

would prefer you show work

$\boxed{\Delta T_{ii} > \Delta T_i}$

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(5) $y(t_0) = 6 = y(1)$ $t_n = 2$

$y'(t) = 4t - 3t^2$ $dt = 0.33$

Fwd Euler

$y(t_1) = y(t_0) + \Delta t\, y'(t_0)$

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$t_0 = 1$

$t_1 = t_0 + dt = 1.33$

$t_2 = t_1 + dt = 1.66$

$t_3 = t_2 + dt = 1.99 \approx 2$

$y(t_0) = 6$

$y(t_1) = 6.33$

$y(t_2) = 6.3343$

$y(t_3) = 5.798$

$y(t_1) = 6 + 0.33 \times (4(1) - 3(1)^2)$

$y(t_2) = y(t_1) + 0.33 \times (4 \times (1.33) - 3(1.33)^2)$

$y(t_3) = y(t_2) + 0.33\,(4 \times 1.66 - 3(1.66)^2)$

$y(t_4) = y(t_3) + 0.33\,(4 \times 1.99 - 3 \times 1.99^2)$

Bckward Euler

$y(t_1) = y(t_0) + dt * y'(t_1)$

or

$y_{n+1} = y_n + dt * y'_{n+1}$

$y_1 = 6 + 0.33 \times (4 \times 1.33 - 3 \times (1.33)^2)$

Backward

$y_0 = 6$

$y_1 = 6.0043$

$y_2 = 5.467$

$y_3 = 4.174$

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(6) Fissionable - can undergo fission @ high or low neutron energy -only w/ high E

Fertile can become fissile via transmutation

fissile - able to undergo fission w/ low energy neutron

(7) (1) many phases α, γ, β

4/4 (2) α-U shrinks in 1-D & expands along other 2-directions (thermally unstable)

(8) Smear density is ratio of fuel mass to total volume w/in fuel rod. It is

3/4 used to ~~compare~~ the relative swelling of fuels → required b/c of swelling

(10) ^{96}Rb & ^{144}Xe

-wanted something about double hump distribution..

3/4 $$^1_0n + {}^{235}U \rightarrow {}^{236}U \rightarrow {}^{144}Xe + {}^{90}Sr + 2\,^1_0n$$

$$^1_0n + {}^{235}U \rightarrow {}^{236}U \rightarrow {}^{96}Rb + {}^{137}Cs + 3\,^1_0n$$

(11) 3 space discretization Methods

Finite element → used in S.O.T.A codes

6/8 Finite difference

Finite volume

all 3 used in state of art codes

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Finite difference was the 1st method developed

Finite volume is very useful when flux is approx. equal @ interfaces

Finite ~~volume~~ element is most flexible & useful in complex geometries but very intricate so not used when not needed

⑨ We enrich U to increase fissile atoms in fuel. UF_6 is used in centrifuge process. The difference in isotopic mass allows separation by centrifugal force i.e. ^{238}U gets pushed to outside of centrifuge container & allows ^{235}U to be drawn out from center.

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