ME 533 OSAZUWA IGHODOSAGIE . Exam 1

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Fertile: A fuel material which in itself is not fissionable but following neutron absorption can produce fissionable products e.g ^{238}U produces ^{239}Pu.

Fissile: Fuel material capable of ~~undergoing~~ sustaining a fission process e.g ^{235}U.

Fissionable: A material capable of undergoing ~~and sustaining~~ a fission process even with slightest probability of doing so. e.g ^{235}U. x → fission w/ high E neutron

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Disadvantages of pure uranium as fuel include:

(a) Low thermal conductivity. x this is a good point of metallic U

(b) Swelling tendency of uranium under thermal and irradiation stress — anisotropically

4/4 Smear density is defined as the ratio of fuel volume to the total internal volume of the fuel element it self. It subsequently depends on the shape — cylinder, sphere, e.t.c of the fuel.

It is important as it helps fuel design engineering in terms of understanding the nature and degree of swelling the fuel will undergo in it's life time, which consequently determines it's performance and tendency / nature of reacting to sustained temperature and irradiation stress.

— needed to allow for swelling and fission gas release

(a) Since only ^{235}U is fissile, we need to enrich uranium to increase the amount / density of ^{235}U per sample to increase / improve the fission process and thus fuel efficiency.

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(b) Uranium ~~He~~ Hexafluoride.

(c) UF_6 gas is placed in a fast spinning centrifuge. The heavy molecules → ^{238}U are pushed outwards under centrifugal forces, leaving lighter molecules — ^{235}U inwards. ~~This is the~~ on.

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	Strength	Weakness
(a) Finite difference:	(a) Simple and Easy to code	Difficult to model complex boundary conditions.
(b) Finite volume	(b) Accomodates heterogeneous properties	complicated, at least in comparison to finite difference
(c) Finite element	(c) Can model all geometry	Complicated and expensive.

It is the ratio of the heat flux that causes all water to turn to steam to the actual heat flux.

It determines our safety limit.

↳ and what is the CHF?

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(a) - Fuel kernel
- Buffer layer
- Inner pyrolitic carbon layer
- Silion carbide layer
- outer pyrolitic carbon layer

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(b) Molten Salt reactors. - in some cases, but not commonly

(a) $Z = 3.5m$ $\gamma = 1.3$

$Z_0 = \frac{3.5}{2}$ $LHR^0 = 350\ W/cm$

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- I think you were using degrees instead of radians...

$$LHR\left(\frac{1.4}{3.5}\right)m = LHR^0 \cos\left(\frac{\pi}{2\gamma} \cdot \left(\frac{Z}{Z_0} - 1\right)\right]$$

$$\therefore LHR\left(\frac{1.4}{3.5}\right)m = 350 \times \cos\left(\frac{3.14}{2(1.3)} \times \left(\frac{1.4}{\frac{3.5}{2}} - 1\right)\right) \Rightarrow 349.99\ W/cm.$$

$\cancel{= 350 \times}$

$\cancel{= 349.97}$ W/cm.

(b) $$\Delta T_{cool} = \frac{1}{\gamma} \times \frac{Z_0 \times LHR^0}{m \times Cp_0} \times \left(\sin\gamma + \sin\left(\gamma\left(\frac{Z}{Z_0} - 1\right)\right)\right)$$

$$= \frac{1}{1.3} \times \frac{1.75 \times 350}{4200 \times 0.22} \times \left(\sin(1.3) + \sin\left(1.3\left(\frac{1.4}{\frac{3.5}{2}} - 1\right)\right)\right)$$

$$\Rightarrow 0.0092545^\circ K.$$

*right equations, but the answers don't make sense

@ $Q = E_f \times N_f \times \sigma_f \times \phi$

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$= (200 \times 10^6 eV) \times (1.602 \times 10^{-19}) \times 570 \times 10^{-24} \times 5 \times 10^{12} \times N_f$ ✓

where N_f = Mass of Uranium at 19.5% enrichment $= 235 \times 0.195 + 238 \times 0.805 = 237.4$ amu.

Mass of Uranium mononitride $= (0.96 \times 237.4) + (0.04 \times 14) = 228.46$

~~227.904 +~~

$\therefore N_f = \dfrac{12.3 \times 6.022 \times 10^{23} \times 0.96 \times 0.195}{228.46} \Rightarrow 6.069 \times 10^{21}$

UN = 50% U, 50% N

$\Rightarrow$ 554.216 W/cc //

- overestimated due to incorrect mass

(b)

$\dfrac{dy}{dt} = t \times 10^{-2t}$ $\quad t_0 = 0,\ y_0 = 4. \quad \Delta t = 0.5$

t * exp(-2t)

Backward: $y_{n+1} = y_n + \Delta t\, y'_{n+1}$

no → 10^{-2t}

yes → e^{-2t}

~~$t_0 = 0$~~, ~~$y_1 = y_0$~~ $\quad y_1 = y_0 + \Delta t\ (y_{0+1})$

~~$y_{n+1} =$~~ $\quad y_1 = 4 + 0.5\,(0.5 \times 10^{-2(0.5)})$

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$y_1 = 4 + 0.025$

correct process

$y_1 = 4.025$.

t

$y_2 = 4.025 + 0.5\,(1 \times 10^{-2(1)})$

$= 4.075$.

$y_3 = 4.075 + 0.5\,(1.5 \times 10^{-2(1.5)})$

$= 4.07575$ //

2) Without coating i.e fuel has no coating.

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$2\pi R_f = 3.768$

$LHR = 250$

ⓐ ① Temp inside cladding = Temp outside cladding + $\frac{LHR \times \text{cladding thickness}}{2\pi R_f \times K_{cladding}}$

$$= 600 + \frac{250 \times 0.05cm}{2\pi(0.6) \times 0.15}$$

$Q = 250\ W/cm^3$

$Q \neq LHR$

$$= 600 + 22.12$$

$$= 622.12\,K.$$

$LHR = \pi R_f^2 Q = 283\ W/cm$

② Temp outside fuel (ie fuel surface) = $622.12 + \frac{250 \times \text{gap thickness}}{3.768 \times K_{gap}}$

$$= 622.12 + \frac{250 \times 0.005}{3.768 \times 0.004}$$

$$= 705.06\,°K.$$

③ Centre line $\Rightarrow 705.06 + \frac{250}{4\pi K_f}$

$$\Rightarrow 705.06 + \frac{250}{4(3.14)(0.05)}$$

$$\Rightarrow 1103.15\,°K.$$

1169 K

ⓑ with coating:

① Temp inside cladding is same = 622.12 K.

② Temp outside fuel coating = $622.12 + \left[\frac{250 \times (0.005 - 0.01)}{3.768 \times 0.004}\right]$

$T_{coating} = 600\,K$

$$\Rightarrow 539.18\,°K$$

- from problem statement

(3) Temp at surface of fuel proper $= 539.18^\circ K + \dfrac{250 \times \text{thickness of coating}}{3.768 \times K \text{ of coating}}$

$$= 539.18^\circ K + \frac{250 \times 0.01\,cm}{3.768 \times 0.015}$$

$$\Rightarrow 583.41^\circ K.$$

(4) Temp at Center line $= 583.41 + \dfrac{250}{4\pi K_f}$

$$\Rightarrow 981.50^\circ K //.$$

- Coating is on top of the cladding
- Oxide coating here will only increase the fuel temp
- will still have ΔT_{clad}, ΔT_{gap}, ΔT_{fuel}, on top of ΔT_{coat}

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