91/100

MATT McCLOSKEY Pg 1

NucE 497 - Websection - Prof. Jones

TEST 2

4/21/17 - 4:45p - online

1) Attached

Paste Calibri (Body) 12

-3, 22/25

1:

1.1: As the fuel heats up, it expands and makes the gap between the fuel and cladding shrink rapidly.

1.2: densification within the pellets occurs at the fuel becomes less porous, thus the gap gets larger -1, gap getting larger increases T

1.3: As fuel swelling due to irradiation damage and mechanical creep occurs the gap slows consistently, thus allowing the centerline temperature of the fuel to decrease. However, the FPs don't allow the fuel temp to drop consistently with the gap, lower conductivity. The gradient of temps within the fuel grow as products grow within.

1.4: The cladding and the fuel meet, thus there is a rise in the temps of the fuel. This is bc the conductivity at the gap is staying the same throughout, but fission products are being released. The bump is due to the clad giving way to the fuel for a short period of time.

-2, Bump is due to fission gas release and then more swelling

1.5: the fuel and clad remain in contact and the fuel temps, as well as the gradients between the two increase. There is not physical movement between the two, but increasing pressure from fission products which are lowering the conductivity, which is contributing to this result.

4A)

In an RIA accident, the fuel and cladding undergo a drastic change in a very short amount of time which can cause the clad to bubble or possibly burst and for fuel to escape. In LOCA there are the same concerns, but not as rapidly. Locas are due to the coolant not being able to remove heat from the rods, so they heat up, but are more easily mitigated by emergency systems.

They both have similar consequences, except in RIA's the problem occurs more within the fuel that is having a runaway reaction. The clad is challenged from the inside. In a LOCA, the boundary layer is changed and the outside of the cladding is challenged primarily by lack of heat transfer. There is more opportunity for the fuel to escape in cladding break during RIA bc, the fuel is often fractured or melted so that it can escape through even the smallest cladding breaks.

4B)

As mentioned above the similarities are that both the clad and the fuel become very hot and there is a risk that they will fail. Both result in very high heats that may melt the fuel and cause failure in the cladding. Each type of accident challenges the fuel or the cladding primarily, just in different directions.

2) $\phi = \cancel{2\times10^{13}}\ 2\times10^{13}\left[\frac{fis}{cm^2 s}\right]$

$T = 900°C = 1173K$

-2, 28/30

A) $D_m = ?$

$\cancel{D_m = 2.23\times10^{3}\exp\left(\frac{-7620}{T}\right) = \boxed{3.36\left[\frac{cm^2}{s}\right] = D_m}}$

B) $y = .3017$

$N_{FG} = y\,\underbrace{q N_u C_f\,\phi_0}_{\text{Assume } 2\cancel{8}\times10^{13}\, n/(cm^2 s)}\, t$

$N_{fg} = (.3017)(3\times10^{13})(6.31\times10^{7})$

$= \cancel{5.71\times10^{20}\left[at/cm^3\right]}\ 3.81\left[at/cm^3\right]$

$f = ?$

$f = 4\sqrt{Dt/\pi a^2} - \frac{3}{2}Dt/a^2$ $\quad 7.726\times10^{-8}$

$D = D_1 + D_2 + D_3$

$k_B = 8.62\times10^{-5} \rightarrow$

$D_1 = 2\times10^{-36}\,\dot{F} = \cancel{6\times10^{-23}}\ 4\times10^{-23}$

$D_2 = 1.41\times10^{-21}\exp\left(\frac{-1.19}{k_B T}\right)\sqrt{\dot{F}} = 4.9\times10^{-20}$

$D_3 = 7.6\times10^{-6}\exp\left(-3.03/k_B T\right) = 7.35\times10^{-19}$

$\boxed{\text{Part A: } D = 7.84\times10^{-19}\left[cm^2/s\right]}$

-0, You used eqns from old slides with typos, D = 8.94e-17 cm2/s

Wrong Short t $\rightarrow$ $f = 4\sqrt{\frac{Dt}{\pi(8\times10^{-4}cm)^2}} - \frac{3}{2}\frac{Dt}{a^2} = .01985 - 1.15\times10^{-4} = .01973$

$\cancel{f = 1 - \frac{.0662}{\frac{Dt}{a^2}}\left(1 - .93e^{-\pi^2 \frac{Dt}{a^2}}\right) = (.07071)}$

$\boxed{FGR = 3.81\times10^{20} \times .01973 = 7.517\times10^{18}\left[At/cm^3\right]}$

2c) Out of Pile

D changes!

$D = D_1 + D_2 + D_3$

(using same eq'n) $\Rightarrow D = 1.45\times10^{-17} + 1.46\,10^{-12} = 1.42\times10^{-12} \left[\frac{cm^2}{s}\right]$

Out of pile

$.1 = f = 6\sqrt{\frac{Dt}{\pi a^2}} - 3\frac{Dt}{a^2} \rightarrow \boxed{t = 884[s] \approx 15[min]}$

-1, Math error in t

Scanned by CamScanner

2C) 200°C -> 2273K

trapped At/cm^3? $3.81\times10^{20} - 7.517\times10^{18} = 3.73\times10^{20}$

$\boxed{\text{Amt released: } 3.73\times10^{19} [At/cm^3]}$

t:?

Never mind, Try to accept this ->

D changes:

$D = D_1 + D_2 + D_3$

(using same eq'n) $= 1.25\times10^{-17} + 1.16\times10^{-8}$ 2.24×10^{-6} 9.67×10^{-11} $= 1.42\times10^{-12}$

Short amt. of time

$f = 4\sqrt{\frac{Dt}{\pi(8\times10^{-4})}}$ => $\boxed{t = 98.4 [s] \approx 15 [min]}$

-0, 30/30

3)A) 600K, t = .6 mm, t = 1 yr

δ?

$t^* = 6.62\times10^{-7} \exp\left(\frac{11949}{T}\right) = 295$ day

$\delta^* = 5.1 \exp\left[\frac{-550}{T}\right] \rightarrow 2.03\,\mu m$

$\delta = \delta^*/t$

$K_L = 7.48\times10^{6} \exp\frac{-12500}{T} = 6.7\times10^{-3}$

$\delta = \delta^* + K(t - t^*) = 2.03 + 6.7\times10^{-3}(70)$

$\delta = 2.5 [\mu m]$

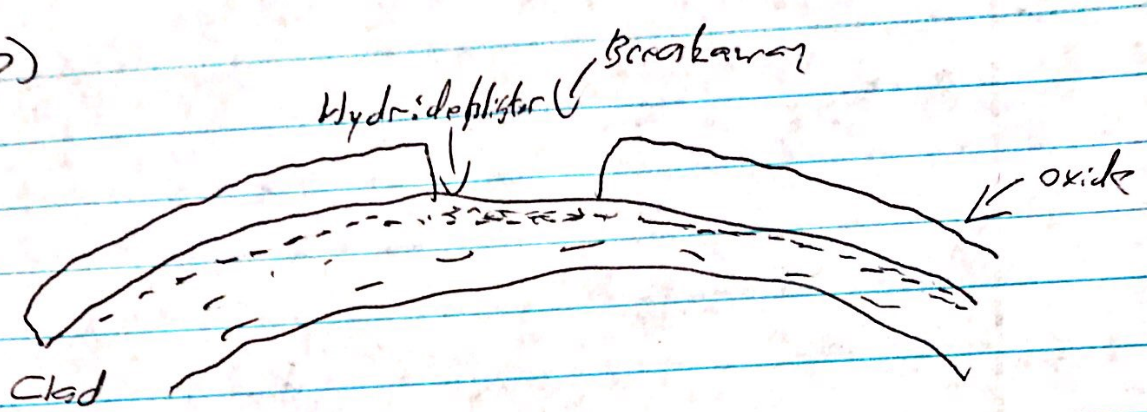
$\boxed{W = \delta \times 14.7 = 36.72 [mg/dm^2]}$

B) $t_{clad} = t_i - \frac{\delta}{PBR} = .6\,mm - \frac{2.5\times10^{-3}\,mm}{1.56} = \boxed{.5983 [mm] = t_{clad}}$

c) $C_H^{clad} = \frac{2f\delta\, \rho_{oxide}\, f_{ZrO_2}\, M_H/M_O}{t_{clad} \times \rho_{metal}} = \frac{2(.15)(2.5)(5.68)(.26)(1/16)}{(.5983)(6.5)} \times10^6$

$\boxed{C_H^{clad} = 17.8 [wt.\,ppm]}$

3D)



4A) Attached

4A) -4, 11/15

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4C)

Using silicon carbide composite cladding is a prospect for fuel improvement. It has no mechanical high temp creep no activation and a low neutron cross section which would make it effective during operation, after removal from the reactor and in accident cases it would likely hold up longer than zirconium. The lack of high temp creep would be the reason for this mainly.

-2, Primary benefit is improved oxidation kinetics so less H production