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NUCE 497
Exam # 2

Q1) Solution:

-10, 15/25 -4, no discussion of temperature

1) Quick change in a gap of cladding due to thermal expansion. Point 1 is when gap start changing ~~due~~ from initial stage due to the thermal expansion.

2) Increase in gap due to densification. In this point we will start seeing the increase in cladding gap due to densification.

3) Gap getting smaller and smaller and when it finally gets to contact at point 4.

-2 Why is the gap getting smaller?

4) Gap initially comes to contact with pallet and the cladding ~~the cladding~~ gap start getting nearer and near to contact with fuel pallet.

-2, fission gas release cause T increase before gap closure

5) Gap started getting connected and we started getting PCI. (Pallet cladding interaction).

-2, T increases due to fuel k decrease with burnup

Q2) Solution:

-29, 1/30

avg: grain size = 8 microns:

volumetric neutron flux: 2.0×10^{13} fission / $cm^3 \cdot s$.

Assume: uniform temperature = 900°c.

a) To find = fission gas diffusion coefficient = ?

-5

b) $y = 0.3017$.
$t = 2$ years.

To find = # of gas atom/cm^3 released.

# of gas atoms released after 2 years is given by.

$$N_{released} = f N_{gas}.$$

-9

-15

Q3) **Solution:**

-11, 19/30

$T = 600K$, for 1 year

Initial thickness = 0.6 mm.

Critical time for transition:

$$t^* = 6.62 \times 10^{-7} \exp\left(\frac{11949}{600K}\right) = 295 \text{ days.}$$

Critical thickness for transition.

$$\delta^* = 5.1 \exp\left(\frac{-550}{600}\right) = 2.04\,\mu m.$$

oxide thickness after 1 years.

$$\delta(\mu m) = \delta^* + K_L(t - t^*)$$

$$K_L = 7.48 \times 10^6 \exp\left(\frac{-12500}{600}\right) = 6.7 \times 10^{-3}$$

$$\delta = 2.04 + 6.7 \times 10^{-3}(365 - 295)$$

$$\delta = 2.509\,\mu m.$$

total weight gain (mg/dm²)

$$\delta(\mu m) = \frac{W(\frac{mg}{dm^2})}{14.7}.$$

$$W = 2.509 \times 14.7$$

$$W = 36.88\ mg/dm^2$$

∴ The oxide weight gain in mg/dm² after this time = $\boxed{36.88\ \frac{mg}{dm^2}}$

b) To find zirlo wall thickness after this time = ?

initial = 0.6 mm

after transition = 2.509 um.

-2, Metal lost = oxide thickness/1.56
-2, ZIRLO thickness is lost, not gained

∴ Total = 0.6 mm + 2.509 um

= 600 um + 2.509 um

= $\boxed{602.509 \text{ um}}$ or 0.602509 mm

c) Solution:

Assume hydrogen pickup fraction = 15%.

To find : weight ppm of hydrogen in cladding after 1 year.

$$\delta_{ZrO_2} = \frac{W/(mg/dm^2)}{14.7} = W = 36.88 \ mg/dm^2$$

$$N_O = \frac{W/N_{av}}{M_O} = \frac{0.036 \times 0.6022 \times 10^{24}}{16} = N_O = 1.388 \times 10^{21} \text{ oxygen } \cancel{\text{hydrogen}} \text{ atoms}/dm^2$$

$$N_H = 2N_O = 2 \times 1.388 \times 10^{21} = 2.77 \times 10^{21} \text{ hydrogen atoms}/dm^2$$

$$N_{H-Zr} = 2fN_O = 2 \times 0.15 \times 1.388 \times 10^{21} = 4.16 \times 10^{20} \text{ hydrogen atoms}/dm^2$$

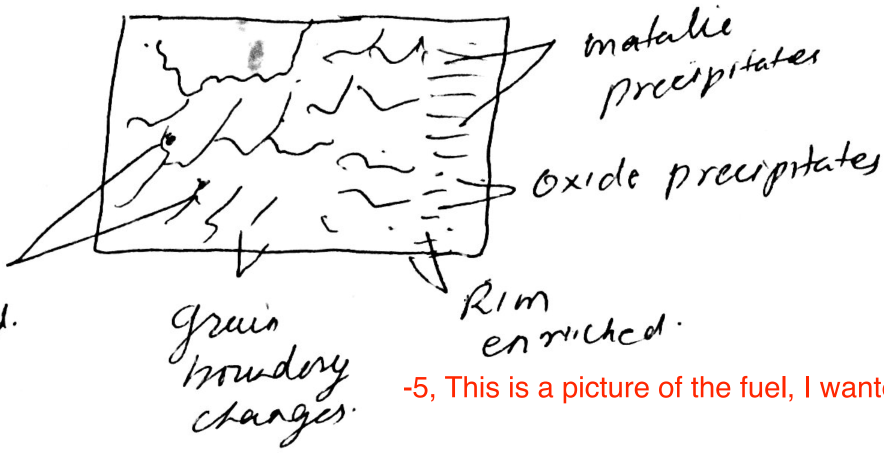
$$W_H = \frac{N_{H-Zr} M_H}{N_{av}} = \frac{4.16 \times 10^{20} \times 1}{0.6022 \times 10^{24}} = 6.9 \times 10^{-4} \text{ g of H in the cladding.}$$

$$C_H = \frac{W_H}{W_{Zr}} = \frac{W_H}{\rho_{Zr} V_{Zr}} = \frac{W_H}{\rho_{Zr}(t_{Zr} A)} = \frac{W_H}{\rho_{Zr}\left(t - \frac{\delta_{ZrO_2}}{PBR}\right) A}.$$

$$C_H = \frac{6.9 \times 10^{-4}}{6.5\left(600 - \frac{2.50}{1.56}\right)\left(10 \times 10 \times 10^{-4}\right)} = \boxed{1.77 \times 10^{-5} \text{ wt. ppm}}$$

-2, Easier to use eqtn, answer should be 17.87 wt.ppm

d) Solution:



-5, This is a picture of the fuel, I wanted a picture of the cladding

-4.5, 10.5/15

Q4) Solution:

a) In Reactivity Initiated Accident (RIA) due to the large and rapid reactivity insertion: fission rate and fuel temperature rapidely increases. Due to change in fuel temperature, fuel expands in milliseconds and hits the cladding. The sudden change or jump in temperature also causes a pressure jump in fission gas which results in cracking on cladding, causing it to break.

→ But in loss of coolant accident (LOCA). the fuel and cladding experiences: decrease in temperature and decrease in coolant pressure.

-2, Both have high temperatures in the fuel

b) The similiarites between the fuel and cladding behavior in a RIA and a LOCA is that both the accident will cause the fuel and cladding failure ~~in~~ in neuclear reactor. In both cases cladding ~~temperature and fuel temperature~~ and fuel have high chances of bursting of clad and fuel breaking into pieces.

c) One potential accident tolerant fuel concept is concept of improving fuel properties. If we ~~increase~~ improve fuel properties than:

→ Lower fuel operating temperature.
→ minimized cladding internal oxidation
→ minimized fuel relocation / dispersion.
→ Higher fuel melt temperature.

-2.5, How would you improve fuel properties?

∴ If we improve fuel properties it can tolerate loss of active cooling for a considerably longer period.