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Nemeen Elamawy

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① it operates at low temperature because fuel has high thermal conductivity. ✓ → not a direct cause, but designed

② negative reactivity feed back, when the coolant temperature increase, neutron leakage increase which lead to shut down of the reactor eventually. ✓

③ High margin from liquid state to gas state because it requires 700 K to get to sodium in gaseous state ✓

④ Na has high heat capacity ✓

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[2] we alloy uranium because by adding Zr to the uranium

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we decrease the temperature of the gamma phase boundaries and lowering the diffusion rate. and gamma phase has isotropic swelling because it is a cubic crystal structure. also Zr decrease the pores formation and swelling.

adding Pu to uranium increase the fission rate and gives higher burnup but it increases the diffusion rate and increases swelling.

- increase T_{melt}

[3] metallic fuel get swelled by fission gas bubbles formation in case of gamma uranium or by forming loops of interstitial or vacancies like the case of alpha uranium.

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it was observed that by having more space between the fuel and the clad this let the fission gas released to the gap before FCMI and relief the stresses on the cladding.

the large plenum helps in containing the rare earth fission products, alkali and alkline fp.

- reduces the pressure inside cladding

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⑤ Thermal Conductivity ~~decrease~~ increase with high burnup

5/8 by sodium infiltration, when ~~fission products~~ fission gas ~~released~~ bubbles are formed, then the gas is vented to the plenum then sodium log in and that is how the thermal conductivity increased again.

- but K_m decreases @ start due to porosity

④ The constituent distribution of metallic fuels

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① Zr enriched region ✓
② Zr depleted region ✓
③ Zr as fabricated region ✓

~~also Pu has localized region because of the incomplete mixing of the fuel.~~

- why?
- concern?

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⑥ Fuel cladding chemical interaction happens in metallic fuel as localized when Creek happens in the fuel adjacent to the inner surface of the cladding. 11/15

- more likely, but not required

FCCI Cladding cause the material to lose their mechanical strength and even their thermal properities. Causing material degradation and ~~fracture~~ cause its failure.

- Cladding wastage

~~Oxygen is the primary element~~

- The rind layer that protective layer which formed due to the ~~oto~~ environment of casting mold when this layer cracks this make it easier for FCCI.

- fission products coming to the cracks in the cladding deposite their and FCCI starts ✓

- FPs diffuse down T gradient
- low melting phases
- brittle intermetallics

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mox redistribution

- central void region, forms due to accumulation of voids and vacancies
- columnar grains.
- elongated grains, forms due to irradiation - large equiaxed grains
- as sintered region.

due to pore migration, we have lenticular pores which are very small pores moves according to the temperature gradient (Soret diffusion) when it moves from hot to cold region in the fuel, it forms columnar region ~~casing~~ destroying the microstructure.

- not Soret, but evaporation/condensation
- very high T required for pore migration

(8) Pu and oxygen vary spatially in MOX fuel pin

5/8 - as the temperature changes oxygen concentrate in the cold region on the fuel ~~pellet~~ surface. ✓

✓ - Same with Pu concentrate in the hot regions.

- why does Pu concentrate around central void?
- oxygen has concentration profile, not necessarily high concentration; gradual gradient
- Pu agglomerates?

(9) JoG is oxide build up layer between fuel (slug pellet) and the cladding.

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it occurs because when fission products form oxides it goes to condense in the colder region which is at the edges of the fuel.

- volatile FPs diffuse down T gradient
- can form oxides w/ excess O @ rim
- impacts?

(10) Sodium Corrosion

① Type 1, ~~fission products~~ material elements dissolves in the coolant

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② Type 2, oxygen dissolved in the coolant interact with components.

* oxygen can enter the system by opening coolant boundaries for maintainance or refuling.

* when fission happens two oxygen are formed and they don't bond together but the oxygen interacts with the surroundings forming oxides.

- this is in fuel, sodium corrosion occuring on coolant side

- differential solubility w/ temperature