Hamdy Abouelella. 200320496.

Exam 4

Question (1) 89 + 4 = $\boxed{93}$

Reactor condition inside Research reactors. 7/8

* operating temperature $< 100\,^\circ C$ ✓ not quite this low in the fuel
* very high flux compared to LWRs. ✓
* high enriched uranium fuel $\geq 20\%$ ✓

* Geometry.
  * Research reactors are in general smaller than LWRs. ✓
  * Reactor core should be accessable to perform experiments ✓
  * Reactor core design should have alot of water rods ~~Whet~~ where we can ~~be~~ place the materials we want to irradiate.
  * operates at atmospheric pressure. - not necessarily
  * Cool down by natural circulation. - not necessarily

Question (2)

6/8

why Amorphization is a concern?

because in research reactors there is very high and energetic flux which will alter the structure of the core materials and might lead to Amorphization. ✓

⇒ add to that, the operating temperature is very law to allow for recovery of the orignal microstructure. ✓

⇒ Beside, most of the historically used alloys in research reactors showed amorphization behavior. ✓

- what are the effects of amorphization?

Question 3

9/10

* USi has higher U density compared to UAl. ✓
* it also has higher operating temp.
* the gaseous swelling in UAl is limited compared to USi. ✓
* Both USi, UAl form interaction layers with Al. ✓
* UMo. has higher density of fissile atoms than both UAl and USi. ✓
* one of the major drawbacks of USi is the development of swelling with burn up. ✓
* UMo also have better swelling resistance. - only at low BU

Question 4

5/6

differences in U3Si and U3Si2 swelling ?

→ U3Si has high bubbles formation rate ✓
but those bubbles are not stable.

→ U3Si2 has low bubbles formation rate ✓
but the bubbles are stable.

- lower viscosity in U_3Si_2 leads to differences in amorphous swelling behavior

Question (5)

6/6

* Because radiation induceed point defects will allow recombination and formation of γ-phase. ✓

* Mo - is a strong γ- stabilizer. ✓

* temperature is not enough for diffusion to occur and another phase to form. ✓

→ slow transformation kinetics of $\gamma \to \alpha$ phase

Question 6

3/6

the answer could be! → haha!

* it affects the phase of UMo Fuel that will dominate. ✓

* affect the compounds that will form between U-and Mo. ✓

→ Mo-rich phase, will solidify first, leading to Mo-rich and lean regions. Mo-rich grain interiors, depleted boundaries, etc.

Question (7)

10/12

* Fission gas bubbles in UMo fuel as a function of burnup.

UMo has unique swelling behavior → swelling can be divided onto solid + gaseous.

gaseous swelling is due to fission gas bubbles.

in UMo fuels the behavior of the fuel in terms of fission gas bubbles formation rate depend heavily on burnup.

→ at low burnup,

fission gas bubble formation rate is slow

- fission gas bubble superlattice forms

* once we reach a certain burnup which is associated with causing grain refinement (microstructure changes)

- swelling is low, not bubble formation

↓

this will affect the swelling behavior.

→ at high burnups

the fission gas bubble formation is high.

due to grain refinement where grain boundaries act as bubbles nucleation sites

* temperature will affect this behavior as well

Question (8)

8/8

role of Zr-layer in UMo. monolithic fuels.

↳ limit the interaction between UMo and Al which ✓
leads to an interaction layer ~~swell~~ which suffer
from swelling due bubble gas formation. ✓

* Consequences of adding this layer.

✓

⇒ No- further interaction between UMo - Al.

⇒ Zr will interact with Al forming an interaction ✓
region consisting of Zr-Al compounds.

⇒ this will limit the swelling behavior a little bit

⇒ Zr will interact with UMo forming an interaction ✓
layer which develop with burn up and time

Question (9)

8/8

that's because the operating conditions in Research reactors are totally different from LWR. ✓

⇒ in light water reactors the operating temp is very high compared to operating limits of all known Al-alloys. ✓ ✓

200 — 300°C

⇒ in Research reactors operating temperatures < 100°C fails withing the safe limits of using Al-alloys. ✓

⇒ add to that the compatibility, cheapness and fabricability of Al-alloys. ✓

Question (10)   8/8

⇒ considerations when optimizing the composition for F/M Steels?

we can categorize ~~or~~ considerations while optimizing F/M Steels into.

phase related Consideration. ✓

* phase stabilizers which will allow the formation of ferritic and martensitic phases should be added. ✓

* optimized amount of C should be present to allow the formation of martensitic phase. ✓

* Corrosion resistance consideration ✓

* elements that are known to form passive oxidation layer like Cr, Al should be added to increase alloy resistance to corrosion.

Question (11)

ferritic vs Austenitic swelling behavior.

9/10

Ferritic steels swell less than Austenitic steels due to the inherent structure properties.

1- high free volume ratio. ✓

the free volume in BCC steels is higher that free volume in FCC steels, leading to higher strain field of interstitials ✓ more repulsion between defects and increased propability of recombination. ✓

2. Vacancy has less barrier energy in BCC than FCC ✓ allowing more mobility in BCC than FCC and Faster recombination. ✓

3. vacancy - carbon binding energy ✓
the binding energy between vacancy and carbon atom is BCC is higher than FCC. So, precipitates will act as ✓ sink for vacancies.

4. dislocations are less mobile in BCC and are a prefered ✓ sink for vacancies.

- solute atoms interaction w/ dislocations + vacancies

Question (12)   10/10

* role of oxide particles in ODS Steels.

↓

oxide particles are mainly used to embede (impede) dislocations motion by locking dislocations (motion) in the glide plan. ✓

* the oxide particles are incoherent with the matrix and have larger strength, so higher stress is required to overcome pinning particles. ✓
which means increasing the strength.

⟹ Also, it has been reported that incoherent particles ✓ act as sinks for Radiation induced point defects.

* ODS Steels have high temperature resistance properties more superior than F/M steels. ✓
→ in other words higher creep resistance. ✓
→ higher operating temperatures. ✓
→ both of them have good swelling resistance. ✓