NE 795 Advanced Reactor Materials and Materials Performance

Exam 4

The associated point values provide an indication of the expected thoroughness of response.

1. Why are different cladding/structural materials required for advanced reactor systems? (8 pts)

Materials such as zircaloy or stainless steels are either susceptible to void swelling, embrittlement, excessive creep, high corrosion rates, or a loss of properties at high temperatures. Existing materials qualified for LWRs likely do not possess the material properties to withstand the high temperature, high flux/fluence, and corrosive environments in advanced reactors. Zircaloy has compatibility issues, undergoes phase changes, exhibits anisotropic properties, and a lack of high T mechanical performance. Stainless steels undergo excessive void swelling, display high rates of corrosion, and have high irradiation creep rates. Ferritic or F/M steels and Ni alloys offer property domains which are more suitable to the harsh and novel environments in advanced reactors.

1. What are some considerations when optimizing the composition for F/M steels? (8 pts)

Solid solution strengthening, precipitation hardening, corrosion resistance, irradiation creep resistance, phase stabilization, corrosion, microstructure, formability, etc. Properties of F/M steels offer some fundamental advantages with regards to high temperature behaviors and resistance to void swelling, but many properties can be modified or tailored via small additions of alloying elements. Examples include Cr for oxidation corrosion resistance, C for precipitate hardening, Mo for solid solution strengthening.

1. Why do ferritic steels swell considerably less than austenitic steels? (6 pts)

There are likely a confluence of factors which contribute to the improved swelling resistance of ferritic steels over austenitic steels.

1. What role do the oxide particles play in ODS steels? (5 pts)
2. What are some advantages and disadvantages of Ni alloys? How is strength improved in Ni alloys? (8 pts)
3. What are the unique features of conditions inside research reactors compared to LWRs? (10 pts)
4. Why is amorphization of concern in research reactors? (6 pts)
5. What are benefits and drawbacks of U-Si fuel compared to U-Al fuel? Why is there a push towards U-Mo fuel? (6 pts)
6. Describe the differences in U3Si and U3Si2 swelling. (6 pts)
7. The gamma phase of U-Mo is not the thermodynamically stable phase at research reactor temperatures. Why is this phase the dominant phase in-reactor? (7 pts)
8. What effect does the solidus/liquidus gap have on fabrication of U-Mo fuels? (6 pts)
9. Discuss the evolution of fission gas bubbles in U-Mo fuel as a function of burnup. (10 pts)
10. What is the role of the Zr layer in U-Mo monolithic fuels? (6 pts)
11. Why is Al ideally suited for the research reactor environment when it is unable to be used in LWRs? (8 pts)