IRRADIATION PERFORMANCE COMPARISON OF EXPERIMENTAL AND PROTOTYPIC LENGTH METALLIC (U-10ZR) FUEL

Jon Carmack, Douglas Porter, Heather Chichester, and Steven Hayes,
Idaho National Laboratory, P.O. Box 1625, Idaho Falls, Idaho 83415-6188, jon.carmack@inl.gov

Abstract

Metallic fuelled fast reactors have demonstrated excellent operational and safety performance. Sodium cooled fast reactors are candidate systems for accomplishing the transmutation of minor actinide elements. Two fast reactors, the Experimental Breeder Reactor II (EBR-II) and the Fast Flux Test Facility (FFTF) have tested and demonstrated the performance of metallic (U-10Zr) alloy fuel. The EBR-II reactor featured a 13.5 inch core height and the FFTF a 91.4 cm core height. This paper explores the steady state performance differences between these two core sizes through the X447 EBR-II experiment and the MFF-3 and MFF-5 assembly irradiations in FFTF. The experiments conducted in the EBR-II and the FFTF provide invaluable data on the performance and behavior of metallic nuclear fuels. Understanding the behaviours that may be impacted by fuel column height is needed to accurately predict fuel pin and assembly performance and provide the reactor designers with the data needed when increasing fuel pin height.

The X447 experiment was conducted in the EBR-II as part of the Integral Fast Reactor program's development and testing of metallic fuel. After achieving a burnup of 5 at.% (288 EFPD), the assembly was removed from the reactor, reconstituted as X447A, and reinserted into the reactor. No fuel pin failures were detected or observed at this interim burnup but four fuel pins were selected from the assembly and subjected to postirradiation examination. After re-insertion into EBR-II, the X447A experiment achieved 10 at. % BU (641 EFPD) and was removed from the reactor. The experiment was designed to operate at high temperature (630°C to 660°C PICT). The high cladding temperatures were expected to challenge the creep rupture resistance of the cladding alloy, HT9, as fission gas pressure increased and FCCI thinned the cladding wall. Two fuel pin breaches occurred at approximately 10 at.% burnup.

The MFF series of metallic fuel irradiations [1] provides an important potential comparison between fuel performance data generated in EBR-II and that expected in a larger scale fast reactor. The FFTF reactor contained standard fuel with a 91.4 cm (36-inch) tall fuel column and a chopped cosine neutron flux profile resulting in a core with peak cladding temperature at the top of the fuel column but with peak burnup near the centerline of the core. The peak fuel centerline temperature was midway between the core center and the top of fuel, lower in the fuel column than that in the EBR-II fuel pins. The MFF-3 and MFF-5 qualification assemblies operated in FFTF to greater than 10 at. % burnup with no pin breaches. The MFF-3 assembly operated to 13.8 at.% burnup with a peak inner cladding temperature of 643°C. The MFF-5 assembly operated to 10.1 at.% burnup with a peak inner cladding temperature of 651°C. This can be compared to the two pin breaches experienced in X447 at approximately 10 at.% burnup and peak inner cladding temperatures of 648°C and 638°C respectively. A selection of the X447 postirradiation examination was published in 1993 [2]. Comparison of the X447 postirradiation and the MFF post irradiation indicates that fuel behavior is similar between long and short fuel

column heights and predictable when considering the flux, power, and temperature profiles of the fuel.

References

[1] Pitner, A.L. and Baker, R.B. "Metallic Fuel Test Program in the FFTF." *Journal of Nuclear Materials*, v. 204 (1993) pp. 124-130.

[2] Pahl, R.G., C.E. Lahm, and S.L. Hayes, "Performance of HT9 Clad Metallic Fuel at High Temperature." *Journal of Nuclear Materials*, v. 204 (1993) pp. 141-147.