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Fission product and swelling behaviour in FBTR mixed carbide fuel

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The advantages of a fast reactor, especially one that uses Uranium-Plutonium Carbide as its fuel is well documented. Irradiation performance assessment of carbide fuels began with experimental irradiations in EBR-II, FFTF, HFR, Rapsodie and Phenix etc. India has the extensive experience with this type of fuel at the Fast Breeder Test Reactor at Kalpakkam that has been operating for over 25 years. The fuel has attained a peak burn-up of 155 GWd/t at linear heat rating of 400 W/cm, in a large number of fuel pins. Comprehensive post-irradiation examinations (PIE) at various stages up to this high burn-up have yielded a wealth of information on behaviour of mixed-carbide fuel under steady state operations. In this paper, selected recent results on fission product migration, gas release, fuel swelling behaviour and microstructural evolution of the mixed-carbide fuel will be presented. Results of the PIE towards analysing the cause of failure in a fuel pin are also discussed.

Axial distribution of fission products such as 137Cs and 106Ru in the fuel pins was assessed by gamma scanning. A steep increase in the fuel stack length was observed beyond 100GWd/t burn-up indicating onset of FCMI. Fission gas release in fuel pins after a burn-up of 155 GWd/t indicated relatively low gas release of 16%. Systematic change in the fuel-clad gap and cracking pattern was observed with increasing burn-up. Fabrication porosities present in the fuel was found to decrease with increasing burn-up indicating that the fuel swelling is being accommodated in the porosities.

Caesium axial distribution in the failed pin and some of the fuel pins adjacent to it in a failed sub-assembly irradiated at a lower linear power of 260 W/cm. Gas release behaviour showed contrasting trends with higher gas release in the pins adjacent to the failed pin and lower gas release in pins located farther away from the failed pin. The micrograph of the failed pin cross-section at the location of failure showed highly densified fuel region. Asymmetric circumferential cracking was observed, indicating non-uniform temperature around the pin resulting from the diameter increase and local bowing in the fuel pins. Clad carburisation was not observed. The performance assessment through PIE has provided valuable insights into the behaviour of the mixed carbide fuel and cause of failure in a fuel pin.

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