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Design of metal fuel pin for test irradiation in FBTR and for future reactors.

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In India, a structured R&D program on the development of metallic fuel and associated fuel cycle for Fast Breeder Reactors (FBRs) is undertaken so as to realize commercial metal fuel FBRs in the future. Towards this, initially test irradiation of sodium bonded metal fuel pins in Fast Breeder Test Reactor (FBTR) core was proposed and hence the pin design for various compositions of metal fuel was carried out and they are currently being irradiated in FBTR. The compositions include Natural U- 6%Zr, Enriched U -6%Zr, Natural U-19%Pu-6%Zr and Enriched U-23%Pu-6%Zr. Three pins of each type are being irradiated in FBTR and their current burn-up levels are 2.26, 15, 19.5 and 3.75 GWd/t respectively. For a typical test pin irradiation (Enriched U-23%Pu-6%Zr), three sodium bonded metal fuel pins of length 531.5 mm are arranged inside a capsule which is kept inside an ISZ 100 special SA. The thermal and mechanical design of the pin was carried out and the safe operation of fuel pin is ensured for a peak Linear Heat Rating (LHR) of 318 W/cm and for a target burn-up of 100 GWd/t. Also during transients, the maximum allowable flow reduction in the ISZ100 SA was found out to arrive at the blockage limits. During manufacturing of sodium bonded pin, bubbles get trapped inside the bond sodium and hence analysis was carried out to determine the allowable bubble size in a pin.
For the design basis transients, the design safety limits for the metal fuel pin (fuel and clad) have been arrived at by analysis. Also, a 2-D transient mathematical model has been developed for predicting fuel melting and movement of melt interface with respect to time. It was observed that fuel melting starts when the reactor power reaches 1.45 times the nominal power.
Based on the above inputs, for a power reactor fuel composition (Natural U-19%Pu-6%Zr), the thermal and mechanical design of sodium bonded metal fuel pin was also carried out. Thus, this paper details about the design aspects of sodium bonded metal fuel pin which includes arriving the size of fuel pin, fission gas plenum length, allowable linear power, allowable bubble size in the bond sodium and the safety limits for transient events.

Country/Int. organization

India

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