BEHAVIOR OF ROCK-LIKE OXIDE FUELS UNDER REACTIVITY INITIATED ACCIDENT CONDITIONS

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Summary

Rock-like oxide (ROX) fuel, a kind of inert matrix fuel, has been developed at JAERI as an optional method for burning excess Pu in light water reactors (LWRs). The ROX-LWR system can attain high Pu transmutation rate, however, its smaller Doppler reactivity coefficient may cause severer reactivity initiated accident (RIA). Thus, addition of resonant materials e.g. Th in ROX fuel, or heterogeneous core configuration with ROX and UO_2 fuels are considered to improve the coefficient. To optimize their remedy condition quantitatively, it is essential to grasp the ROX fuel behavior under RIA conditions.

RIA simulating experiments have been performed for un-irradiated ROX fuels using the Nuclear Safety Research Reactor (NSRR) in JAERI. Three kinds of ROX fuel (simulated by replacing Pu with U) were tested : (1) yttria stabilized zirconia (YSZ) single-phase type, (2) YSZ + spinel ($MgAl_2O_4$) matrix type and (3) YSZ particle dispersed spinel matrix type. Three fuel rods for each kind were fabricated. Their specifications are the same as those of 17x17 PWR fuel except for their length (pellet stack length : 135 mm). Each fuel rod were subjected to pulse-irradiation of 5 - 14 ms width in the NSRR. The test parameter is peak fuel enthalpy which ranged from 3.2 to 12.4 GJ/m^3.

Transient behavior of the tests rods such as cladding temperature and strain were measured at the pulse irradiations. Post-pulse examinations such as metallography of the rod cross section were also carried out. The data obtained were examined comparing with the data on un-irradiated UO_2 fuels previously tested in the NSRR. The main results are as follows :

(1) The failure threshold enthalpy is found to be about 10 GJ/m^3 for the three kinds of ROX fuel. This is comparable to that of UO_2 fuel.
(2) ROX fuels are found to fail by cladding burst at high temperature, together with molten fuel release to coolant. This failure mode is quite different from that of UO_2 fuel which typically fails at quenching by cracking of embrittled cladding thinned by melting.
(3) In spite of the fuel release, no significant mechanical energy generation due to fuel-coolant interaction was observed for the three types of ROX fuel in the tested enthalpy range.
(4) The maximum cladding temperatures of the two kinds of spinel matrix ROX fuels were lower by about 200 K than that of YSZ single-phase ROX and UO_2 fuel at the same enthalpy level, because of lower fuel melting (eutectic) point of YSZ/Spinel system (2210 K).

Although the fuel composition has some effect on the fuel behavior at RIA, the failure threshold enthalpies for the three kinds of ROX fuel showed no apparent difference. The threshold was comparable to that of UO_2 fuel, and no significant mechanical energy was generated. These results will be utilized to optimize the ROX fuel cores in LWRs, taking account of the RIAs.

Desired technical area : 2. Design and performance of Innovated fuels, Inert matrix fuels