ROCK-LIKE OXIDE FUELS FOR BURNING EXCESS PLUTONIUM IN LWRS

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Summary

On the disposition of excess plutonium, R&D study has been performing in JAERI on the plutonium rock-like oxide (ROX) fuels and their once-through burning in light water reactors (the ROX-LWR system). Features of the ROX-LWR system are almost complete burning of plutonium and the direct disposal of spent ROX fuels without reprocessing. The ROX fuel is a sort of the inert matrix fuel and consists of mineral-like compounds such as magnesium spinel ($MgAl_2O_4$), corundum (Al_2O_3) and yttria stabilized zirconia (YSZ) which are very stable chemically and physically. Plutonium is incorporated in the YSZ phase making a solid solution. This treatment is of importance from the non-proliferation point of view. Once such a solid solution of plutonium and YSZ is formed, it is practically impossible to separate plutonium from the solid solution.

YSZ is known to be very stable against both neutron and fission fragments irradiations and has a high melting temperature (about 2960K), and therefore is the most hopeful candidate for the inert matrix. However, its thermal conductivity is extremely low (about 2W/m·K) less than a half of that of UO_2. To improve thermal conductivity and to reduce the fuel center temperature, powder mixture fuel of YSZ and spinel/corundum was proposed. Heavy fission fragment irradiation may cause these materials to be amorphous, leading to large swelling and/or high fission gas release. A particle dispersed fuel where about 200μm YSZ particles are dispersed homogeneously in the spinel/corundum matrix is proposed to reduce the damaged volume in the spinel/corundum matrix to the minimum. On these ROX fuels irradiation was finished and post irradiation examination is under way. The main results so far obtained are: (1) YSZ single-phase fuel showed an excellent irradiation behavior, ie. low fission gas release (<3%), negligible swelling and no appreciable restructuring. (2) The particle dispersed fuels showed lower swelling and higher fission gas release than those of powder mixture fuels. (3) Spinel matrix fuels showed some amounts of spinel decomposition and restructuring.

High Plutonium transmutation rate can be attainable for the ROX fuel at the expense of smaller Doppler reactivity coefficient which may cause very severe fuel damage in the reactivity initiated accident (RIA). Reactor physics analysis on the event showed that addition of some resonant materials such as ^{238}U, ^{232}Th and Er was effective to improve the Doppler reactivity coefficient. However, addition of these nuclides makes the Pu transmutation a little lower. Another way to improve the coefficient is to compose a heterogeneous core, for example $1/3ROX+2/3UO_2$. Reduction of power peaking in the core is the key for this option. Along with these calculation analyses, pulse irradiation experiments were performed on the ROX fuels in order to investigate the fuel behavior under RIA conditions. Test results showed that the failure threshold enthalpy of ROX fuel rods was more than $10GJ/m^3$ and is rather similar to that of conventional UO_2 fresh fuel rods. Comparison of fuel rod failure mode between the ROX and UO_2 fuel will also be given.

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