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Recent studies on fuel properties and irradiation behaviors of Am/Np-bearing MOX

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There remain challenges in studies of properties and irradiation behaviors of mixed oxide (MOX) fuels, which aims at reduction in volume and toxicity of high-level radioactive wastes, because of the influential factors such that the fuel reaches very high temperature exceeding 2000 K and oxygen content in the fuel continuously varies depending on surrounding conditions. High temperature and steep temperature gradient of MOX in fast reactor bring about the unique phenomena of pore migration resulting in restructuring and redistribution of elements. In this study, we report our experimental results of the property studies on Am/Np-bearing MOX and discuss how these properties influences on the irradiation behaviors.
Oxygen potentials of Am/Np-bearing MOX have been collected by gas equilibrium technique and reported by the group of the authors. Both Am and Np inclusions in terms of substituting U increase the oxygen potential of MOX with the Am and the Np changing from quadrivalent to trivalent. The effects of Am/Np inclusion were analyzed via defect chemistry and quantitatively incorporated with the exiting models which relates oxygen-to-metal (O/M) ratio, contents of Pu, Am, and Np, temperature and oxygen partial pressure.
Inter-diffusion coefficients of U-Pu, U-Am and U-Np in MOX have been obtained by using diffusion couple technique. Although the measurement results could contain uncertainty, some important trends were obtained, i.e. the inter-diffusion coefficient of U-Am is the largest and that of U-Pu is the second. O/M is significantly influential such that the inter-diffusion coefficients were larger at the O/M=2 than those of O/M<2 by several orders.
The pore migration along temperature gradient during irradiation is considered to arise due to the vaporization and condensation of actinide species in pores. Especially, large vapor pressure of UO3 is the dominant property for the pore migration. The increase of the oxygen potential of MOX with Am/Np leads to more UO3 and the acceleration of the pore migration.
The redistributions of actinide elements were also considered with the relationship of the pore migration, i.e. diffusion in solid phase to relax the inhomogeneity caused by the vaporization and condensation of UO3. Thus, the inter-diffusion coefficients can directly influence on the magnitude of the redistribution.
The obtained properties were modelled with the parameters such as temperature and oxygen partial pressure. This enable the integrated time developing evaluation including the temperature profile of fuel irradiation by simulation code.

Country/Int. organization

Japan

Authors: HIROOKA, Shun (Japan Atomic Energy Agency); Dr KATO, Masato (Japan Atomic Energy Agency); Mr YOKOYAMA, Keisuke (Japan Atomic Energy Agency)

Presenter: HIROOKA, Shun (Japan Atomic Energy Agency)

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