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Irradiation behaviour of the large grained UO_2 fuel pellet in the transient conditions

Yuji Kosaka[1], Seiichi Watanabe[2]
[1] *Nuclear Development Corporation, 622-12 Funaishikawa, Tokai-mura, Ibaraki 319-1111, Japan*
[2] *Mitsubishi Heavy Industries, Ltd., 1-1, Wadasaki-cho 1-chome, Hyogo-ku, Kobe 652-8585, Japan*

Abstract

It is important subject to extend the discharged burnup in order to reduce the total mass of spent LWR fuels and the fuel cycle costs. It is also considered that the more flexible design consideration will be required for the high duty fuel, i.e. high power rating operations as well as high burnup, in the future.
In such a high duty fuel rod design, it is the key issue to suppress the fission gas release from the view point of the fuel rod inner pressure design. The large grain UO_2 pellet is one of the candidates to meet such a requirement by reducing the fission gas release especially at high power and/or high burnup.
Several types of the large grain pellet have been developed and demonstrated by some researchers with and without additives. We have demonstrated the fuel performance of the large grain pellet in the PWR irradiation conditions, which was fabricated with no additive but with active UO_2 powder through the conventional palletizing process for the normal grain size pellet.
It is considered that larger grain would bring longer averaged diffusion length of fission gas atoms from the matrices to the grain boundaries, which would result in the increment of the fission gas retention in the grain during the steady state conditions. According to this mechanism of the fission gas retention, there may be a concern about the larger gas bubble swelling of the large grain pellet at the rapid power transient conditions which may increase the potential of the PCMI failure.
In this paper, we focus on the differences of the dimensional change in comparison among the pellets with the different grain sizes at the rapid power transient conditions. We carried out the power ramp tests on the high burnup fuel rods of normal and large grain pellet with no additive, which had been irradiated in the PWR conditions up to around 60GWd/t at peak position. The detailed PIE works were carried out on these ramped test rods and the results revealed that the volume increment due to the power ramp clearly showed the dependence on the grain size as well as the fission gas release and suggested that the larger grain may suppress the gas bubble swelling at the rapid power transient conditions. Regarding the accidental conditions, recently the RIA condition tests were carried out on the similar high burnup fuel rod of the large grain pellet with no additive, and the reported results also suggested the suppression of the volume increase during power transient (RIA pulse-irradiation). The reason of the difference of such volume changes during the power transient will be discussed in the relation with the microstructures especially the gas bubble formation in the fuel matrix in comparison with the performance of the other large grain pellet with additives.
According to the experimental results above, we can conclude that the large grain pellet with no additive does not deteriorate the irradiation performance during the power transient conditions from the view point of the gas bubble swelling.