Radial Porosities and Pore Sizes of the Pellets of the K23 Fuel Rod Discharged from Ulchin 2 Nuclear Power Plant

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1. Introduction

For the verification of the performance of a high burnup fuel rod, the post-irradiation tests for the K23 fuel rod discharged from Ulchin 2 are underway [1]. As a part of the post-irradiation tests, the microstructures of the pellets of the K23 fuel rod are being measured and analyzed. Microstructures such as porosity, pore size distribution, and grain size are very important in determining the material properties of a high burnup fuel pellet. The study shows the micrographs of the K23 fuel pellets measured by an OM and a SEM, and the radial porosity and the radial pore size of the pellets.

2. Measurement and Analysis of Pores

Disk specimens were prepared to measure the microstructures of the K23 fuel pellets by an OM and a SEM. Every specimen was grinded and polished, but not etched. The micrographs of 500 and 900 magnifications were taken in the radial direction of the pellets by an OM (Reichert-Jung Telatom II). The SEM specimens were coated by a gold coater (Polaron SC 7610), and then the micrographs of 1000 magnification were taken in the three radial directions of the pellets by a SEM (Philips XL-30).

The two-dimensional size distributions of the pores in the OM and SEM micrographs were analyzed by a Microsoft Excel and an image analyzer (Image-Pro PLUS 5.0). The distributions from OM and SEM micrographs were combined to get the three-dimensional size distributions of the pores. Porosities and pore sizes were calculated in the radial direction of the pellets using the three-dimensional distributions of the pores [2].

3. Porosities and Pore Size Distribut ions

Fig. 1 shows the radial porosities with burnup. The porosities increase with burnup. This means that fission gas bubbles are formed with burnup. The porosities are rapidly increasing near the reduced pellet radius of 0.95. This is because the so-called rim structure begins to fully develop. The porosities near the pellet surfaces are 10.4 and 17.8 % at the burnups of 48 and 65 GWd/MTU, respectively. Fig. 2 shows the radial variation of the pore sizes. The pore sizes increase with burnup. The bubbles increase in size with burnup since gas pressure in the bubble increases with burnup. The pore sizes decrease from the radial centers of the pellets to the region in which rim structures begin to fully develop. The pore sizes rapidly increase in the fully developed rim region. In the SEM micrographs of 1000 magnification were measured many small pores which were not detected in the OM micrographs of 500 and 900 magnifications.

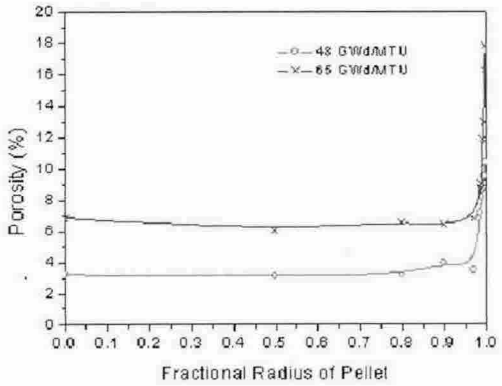

Fig. 1Radial porosities of the K23 fuel pellet

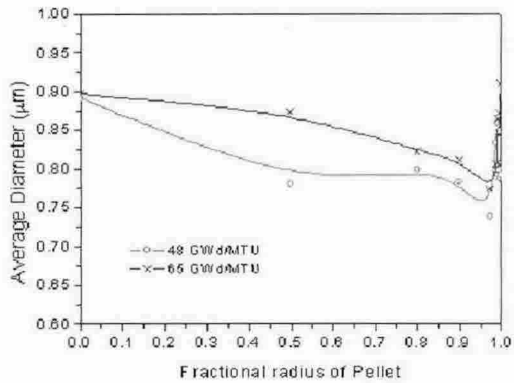

Fig. 2Radial pore sizes of the K23 fuel pellet

4. Conclusion

Porosity and pore size of the pellets of the K23 fuel rod discharge from Ulchin 2 nuclear power plant increases with burnup. The rim structures were formed at the burnups of 48 and 65 GWd/MTU. The maximum porosities at the rim regions are 10.4 and 17.8 % at the burnups of 48 and 65 GWd/MTU, respectively. The pore sizes decreased from the radial center of the pellets to the regions in which rim structures begin to fully develop, and then rapidly increased. It is effective to use the micrographs of high magnification to include small bubbles which are usually produced in the high burnup fuel pellets.

REFERENCES

[1] Lee, C.B., etc., High Burnup Fuel Safety Tests and Evaluation Technology Development, KAERI/RR-2312/2002 (2003).
[2] Kim, Y.M., etc., "Effects of Additives, Seed and Pore Former on the Shape and Size of Pores in UO_2 Pellets," KNS Spring Topical Meeting (2000).