The Behavior of Fission Gases in the Defect Fuel Condition

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1. Introduction

Diffusion coefficient measurements were taken using trace-irradiated Simfuel specimens. Diffusion coefficients of Xe-133 in the Simfuel matrix were obtained by post-irradiation annealing tests. The simulated values of the burnup of the specimens were 27,300 MWD/MTU and 55,000 MWD/MTU. The annealing temperatures were 900℃. Oxygen potential of the atmosphere was fixed at 320 kJ/mol. Steam partial pressure was controlled by a thermostat set at 40℃. A Mixed-Gas (4%H/He) was used as a carrier gas. The released fraction of the fission gases were measured and compared with the stable condition. The temperature was low, however, fractional release rose quickly as the temperature increased. This value was similar to D at 1467℃ in the stable condition.

2. Methods and Results

2.1 Experiments

Simfuels were used in this study. The simulated values of the burnup of the specimens were 27,300 MWD/MTU(S-1), 55,000 MWD/MTU(S-2). They were cut into $8mm^3$ cubes (2x2x2 mm). The 27,500 MWD/MTU pellets contained metallic precipitates, while the 55,000 MWD/MTU pellets contained solid solution only. After irradiation in the Hanaro reactor, annealing tests were performed.

M. Imamura & K Une[i] studied high temperature steam oxidation of UO2 fuel pellets. In this paper, the atmosphere for the 0.2%H2/H2O mixture is almost the same as that in the defective rods. The Oxygen potential is -280kJ/mol at 900 □. However, this study was performed at a lower oxygen potential of -320kj/mol. The 40kJ/mol difference was deemed to be too small to influence the results of this study.

The partial pressure of the steam was 0.05 Bar(5%) at about 40□. When gas flow is provided by pure He-gas, cracks occurred in the pellets, and the surface of the specimens and the wall of the aluminum crucible were stained with it's powders. Therefore, the gas provided was a mixture of H(1%)/He and the temperature of the furnace was heated to 900□. This was how the defective conditions were simulated. Oxygen potential, calculated by HSC-code in this condition, was -320kJ/mol.

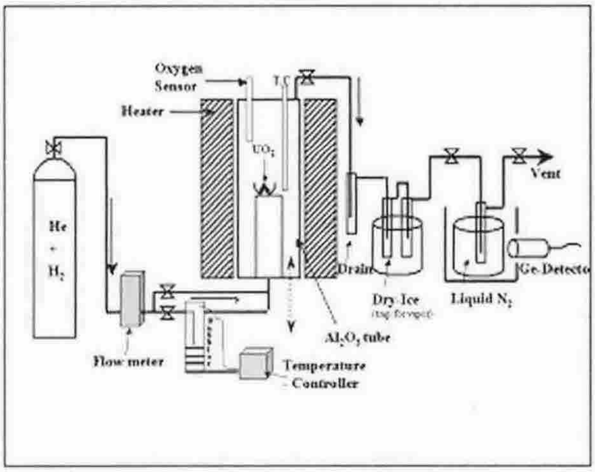

Fig. 1. Schematic drawing of the apparatus

2.2. Experiment results.

The fractional release data of the defective conditions were compared with the results of the sound conditions. This study was performed with two-specimens (S-1, S-2).

The release-fraction of fission gases from S-1 was exceeded by 5%, after 76 minutes from the start. Therefore, this data doesn't agree with Eq.(1). The value of f from S-2 was less than 1%.

In the case of S-1, the condition of the specimen's surface affected the release-fraction. However, the appearance of S-2 was maintained before the annealing time. The total release-fractions were compared and the results showed that the data of the S-2-test are about one order lower than that of S-1 (fig.2).

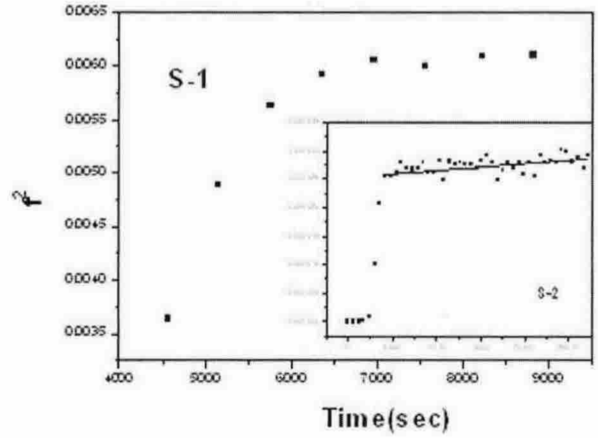

Fig-2 Fractional release(S-1, S-2)

$$f^2 = \frac{36}{\pi}\frac{Dt}{a^2} \qquad (1)$$

The diffusion coefficient of xenon from S-2 could be known, but wasn't calculated from S-1 for excess-release.

2.3. The diffusion coefficient of Xe-133

Nobody has yet studied the diffusion coefficient of Xe-133 from SIMFUEL at the defect fuel conditions.

The diffusion coefficient (D) of S-1 didn't exist, but since the fractional release (f) is above 3%, this value of S-2 could be calculated by the least-square method.

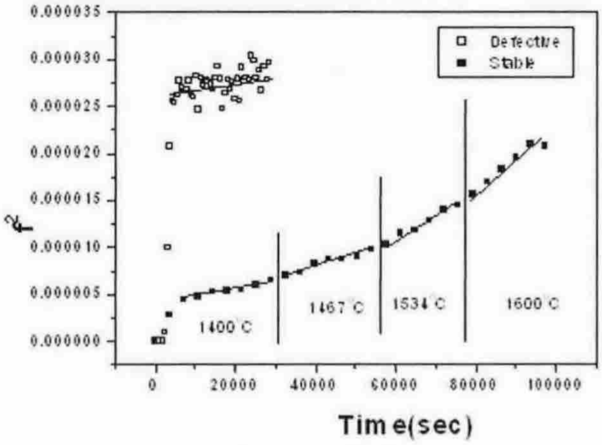

Fig-3 Fractional release (Stable & S-2)

3. Conclusion

The diffusion coefficient of fission gas (fig.3) of the defective fuel condition is almost the same as that of the sound fuel condition at 1467℃. The data of this study approached the data of our references. Table 1 shows the verification of the results of this study.

Table-1 Comparison of diffusion coefficients.

Experiments	Diffusion coefficients (m2/sec)
S-2	1.27E-17
Matzke[1]	7.4E-23 ~ 2.9E-16
Une[ii]	9.79E-19 ~ 3.5E-17
Mac Ewan[iii]	8.2E-19
Baker[iv]	1.2E-19 ~ 1E-16
Cornell[v]	1.2E-19 ~ 4.5E-21

[i] M. Imamura, K Une, " High temperature steam oxidation of UO2 fuel pellet", J.Nucl.Mater. 247(1997)131-137

[ii] K.Une, I.Tanabe, M.Oguma,' Effects of Additives and The Oxygen Potential on The Fission Gas Diffusion in UO_2 Fuel.', J.Nucl.Mater. 150 (1987) 93

[iii] J. R. MacEwan and W. H. Stevens, J.Nucl.Mater., 11 (1964) 77

[iv] C.Baker, J.C.Killeen, Proc. Int. Conf. On Materials for Nuclear Reactor Core Applications, Bristol UK,(1987) BNES, p.153

[v] R.M.Cornell,' The growth of fission gas bubble in irradiated uranium dioxide.', Phil.Mag. 19(1969)539

[1] Hj.Matzke, 'Gas release mechanisms in UO_2- A critical review.', Radiation Effects, 53 (1980) 219-242