Effect of Fuel Burn-ups on Kr-85 Release Behavior during OREOX Process

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1. Introduction

In recent, the dry process for fabricating fuel pellets from spent fuel as recycling technology has been well demonstrated by establishing an optimized process for fuel fabrication through a number of batch processes using typical PWR spent fuel [1]. As considering a strategy for extending the burn-up in LWR fuel, experimental verification for investing the effect of fuel burn-up on fuel fabrication is necessary. One of key parameters influencing the fuel fabrication characteristic would be amount of fission products contained in spent fuel. The spent fuel material goes through three cycles of the OREOX (Oxidation and REduction of OXide fuel) process to produce fuel powder suitable for fuel fabrication. During the OREOX, it is anticipated that some gaseous fission products are released from spent fuel materials which are exposed to high temperature up to 700°C. This paper describes the release behaviors of fission gases with the variation of fuel burn-up during OREOX process.

2. Experimental and Results

2.1 Experimental

Table 1 shows spent fuel characteristics used in this experiment. The average burn-up of the spent PWR fuel rods ranges from 27,300 to 65,000 MWD/tU discharged from Gori #1 and Uljin # 2.

Table 1. Spent fuel characteristics used in this work

Rod No.	G23 Assembly		K23 Ass. -M03
	5B	K10A	
Enrichment	3.21%		4.2%
Burn-up(GWD/tU)	27.3	35	65
Decay time(yrs)	16	18	3
Discharged year from NPP	1986.10 Gori # 1		2001.5 Uljin # 2

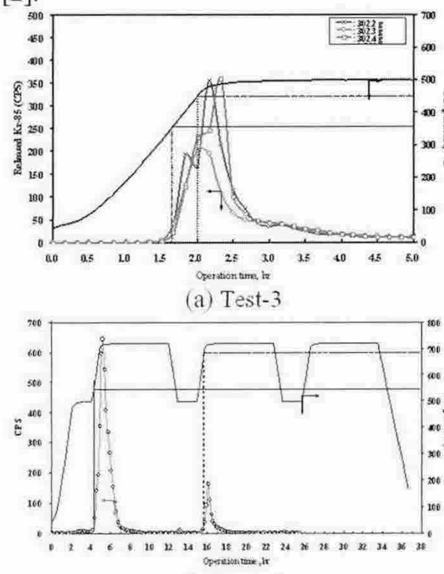
Release behavior of fission gases, which is typically Kr-85, during OREOX was analyzed by the measuring system installed in glove box at hot cell area [2]. Typical test-runs for Kr-85 release behavior were performed, as summarized in Table 2, during OREOX process which is composed of 3 cycles of oxidation at 450°C in air and reduction at 700°C in 4%H_2/Ar.

Table 2. Test conditions for fission gas release experiments.

Test No.	Burn-up (MWD/tU)	Test conditions	Wt. (g)
Test-1	27,300	3 cycles OREOX	500
Test-2	35,000	3 cycles OREOX	200
Test-3	65,000	Oxidation, 500°C	300
Test-4	65,000	3 cycles OREOX	300
Test-5	65,000	Reduction, 500°C → Oxidation, 700°C	10

2.2 Typical Release Characteristic of Kr-85 fission gas

Typical results of Kr-85 release behavior from spent fuel material during OREOX process are represented in Fig. 1 [2].


(a) Test-3

(b) Test-4

Figure 1. Release of Kr-85 fission gas in Test 3 and 4.

Spent fuel material used in Test-4 was powder material oxidized in Test 3. Kr-85 fission gas started to release at 350°C during spent fuel oxidation in Test 3 as referred in Fig. 1(a). But, Test-4 showed that no release of Kr-85 fission gas was observed in 1st oxidation step of 1st cycle of OREOX and followed to release in 1st reduction step of 700°C as shown in Fig. 1(b). Release of Kr-85 was detected in 2nd OREOX cycle, and the release rate of Kr-85 increased sharply and then decreased to non-detectable level. These results imply that the release behavior of Kr-85 fission gas is strongly dependent on temperature history in addition to gas atmosphere. General observation showed that fission gases such as Kr, Xe etc. in spent fuel are distributed in both grain-boundaries and intra- or inner grain-boundaries. Release of Kr-85 in 1st oxidation step at 500°C would be from grain-boundary inventory that typical grain size in spent fuel is similar to average particle size of oxidized power. Further thermal treatment of OREOX process provides driving force for Kr-85 release from intra and inner grain-boundaries with the combination of thermal diffusion and transport along with oxygen potential change or sufficient lattice mobility [3].

2.3 Effect of Fuel Burn-ups on Kr-85 Release Behavior

The influence of fuel burn-up on the release behavior of Kr-85 during OREOX process was investigated.

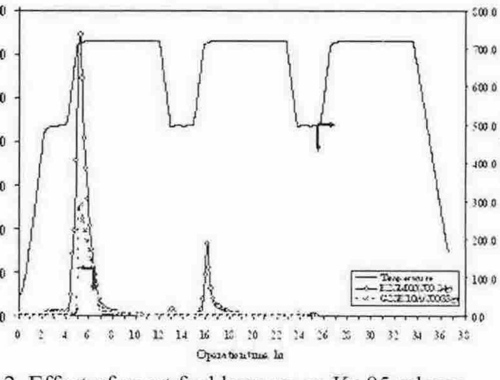


Figure 2. Effect of spent fuel burn-up on Kr-85 release behavior.

Regardless of burn-ups of spent fuel material used, Kr-85 release in 1st oxidation step was not observed. However, release amount of Kr-85 indicating as count number from a high burn-up of K23-M03 spent fuel was higher than that of G23-K10A spent fuel, which is evidently attributed to a higher Kr-85 inventory in spent fuel. The apparent influence of spent fuel burn-up on fission gas release characteristics during OREOX process is that release of fission gas in 2nd OREOX step from a high burn-up spent fuel was observed, on comparing the release trend of a lower burn-up of spent fuel. These results implied that a longer OREOX time was required to completely release with the increase of spent fuel burn-up. The assessment on detail mechanism from the viewpoint of obtaining removal ratio data of fission gas in thermal treatment of spent fuel will be required

2.4 Effect of Gas Atmosphere on Fission Gas Release

The influence of gas atmosphere on fission gas release was evaluated by applying vice versa condition of OREOX process. When reduction step at 700°C was used as 1st step, only thermal diffusion made not so high fission gas release fraction as shown in Fig.3(a), which may be due to the insufficient surface area exposing to gas. Fig. 3(b) shows that a higher release rate during subsequent oxidation step was observed.

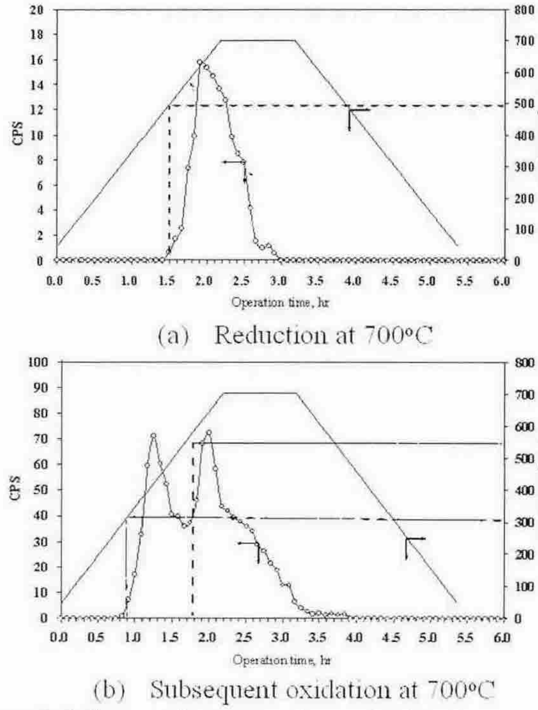


Figure 3. Influence of gas atmosphere on Kr-85 release behavior.

3. Conclusion

The influence of spent fuel burn-ups on fission gas release behavior during OREOX process was investigated. No significant fuel burn-up effect during OREOX process was observed, except that a longer thermal treatment time was required to completely release with the increase of spent fuel burn-up.

ACKNOWLEDGEMENTS

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