Preliminary Study for Oxidative Decladding of Simulated Damaged Spent Fuel held in Vertical Position

Ju Ho Lee*, Sun Seok Hong, Jae Won Lee, Yung-Zun Cho, Jong Kwang Lee
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea
**Corresponding author: jhlee835@kaeri.re.kr*

1. Introduction

For the management of damaged spent fuel occurring in Nuclear Reactor operation, the repacking techniques such as canning is widely considered, however, such approach cannot eliminate the potential concern existing during transportation, interim storage and final disposal. Therefore stabilization technology for damaged spent fuel is being developed by recovering nuclear materials from damaged spent fuel and processing the materials into the form suitable for disposal. For a damaged fuel rod, due to deformation in cladding tube, it is difficult to recover UO_2 pellets using existing mechanical decladding methods and thus an alternative strategy based on oxidative decladding (voloxidation) is desired. However, this decladding technique was mainly applied to fuel rod in rotating drum. In this study, for efficient decladding of damaged fuel in hotcell environment, we develop an oxidative decladding technique applicable to 20 cm rodcut held in vertical position. For the derivation of optimal oxidation condition, the characteristics of oxidation behavior of rodcut of 5 cm was preliminary evaluated.

2. Methods and Results

2.1 Simulated Damaged Spent Fuel

Two of simulated damaged spent fuel in length 50 cm were prepared from simulated fuel rod fabrication equipment. Zircaloy-4 tube cladding filled with depleted UO_2 pellets were annealed at 1000 ºC under argon atmosphere of 70 bar during 30 min. As revealed in Fig. 1. in all fabricated fuel rods, bamboo shape resulting from high pressurizing effect and strong compaction between cladding tube and UO_2 pellet were commonly observed. The fabricated rods were cut to 5, 10 and 20 cm of rodcuts, respectively, for the evaluation of the effect of rodcut length on nuclear material recovery rates

Fig. 1. Fabricated simulated damaged spent fuel rodcuts (left) and section of rodcuts (right)

2.2 Custom-made Thermogravimetric Analysis Equipment

For the efficient separation of powder from rodcuts, we consider the rodcuts held in vertical position which allows the release of powder due to gravitational force. As shown in Fig. 2. a vertical tube furnace was slightly modified as follows: the bottom of tube was connected to acryl box containing high-precision electronic balance(GX-403A) allowing on-line measurement of U_3O_8 powders released from rodcuts. The released powder is collected to beaker mounted on electronic balance. For the evaluation of vibration effect on powder release rates, the upper mask of tube was modified to allow vertical movement of basket containing rodcuts. The oxidizing gas, air, was introduced into acryl box and discharged through upper tube mask and thermocouple was inserted to the bottom of basket for the exact measurement of oxidation temperature. The released gas was partially introduced to oxygen monitoring sensor for the additional evaluation of reaction proceeds.

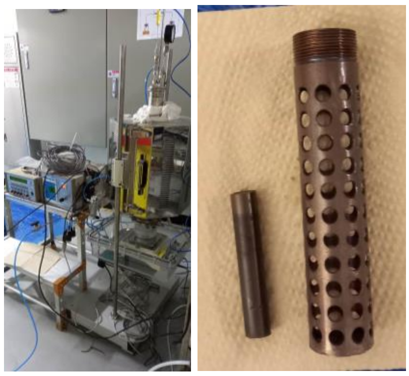

Fig. 2. Custom-made bottom-loading thermogravimetric analysis equipment (left) and basket for 5-cm rodcut (right)

2.3 Oxidative Test for Rodcut of 5cm

Using the TGA equipment, we implemented oxidation test for 5-cm rodcuts. After installing basket loading rodcut to the middle of tube furnace, air was introduced to tube furnace and temperature was raised to 550 ºC at

a rate of 10 ºC/min. After powderization begins, manual vertical vibration is periodically exerted to the basket three or four times every minute to ease the release of powder from cladding tube. Fig. 3 shows continuously measured weight of U_3O_8 powder released from rodcut; 6 hour was required to complete the oxidation of UO_2 pellet in 5 cm rodcut. Oxidation was found to begin at 400 ºC [2] and the increasing rate below 10000s was found to be higher than that of the remaining region since, in this early stage of oxidation reaction, the U_3O_8 powders occurring at the upper side of rodcut can be easily discharged from the rodcut due to volume expansion and vertical vibration effect. Based on the weight recording data from 10000s to 20000s, the recovering rate of nuclear material was estimated to 4.3 g/hr, implying 29 hours required to recovery of nuclear material in 20 cm rodcut.
Fig. 4 shows that through visual inspection, nuclear materials was completely separated from 5-cm cladding tube implying the potential applicability of vertical oxidative cladding in recovering nuclear material from damaged spent fuel.

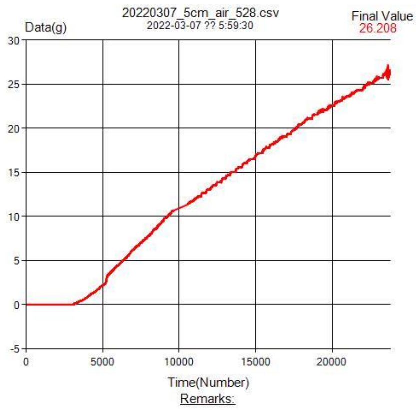

Fig. 3. Real-time measured weight of oxidized U3O8 powders separated from 5 cm rodcut

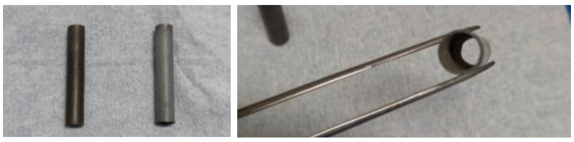

Fig. 4. Comparison of 5cm rodcuts before and after oxidation test (left) and completely decaldded hull (right)

3. Conclusion

The oxidative decladding of simulated damaged fuel in vertical position was tested against 5 cm rodcut; it was found to require 6 hours for complete oxidation under periodically vertical vibration and this low decladding rate should be increased to enhance throughput of vertical oxidative decladding. A further research is being conducted to derive optimal oxidation condition by adjusting oxygen content, oxidation temperature and vibration effect.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (No. 2021M2A7A 1080748)

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