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Feasibility Study for Oxidative Decladding of Simulated Damaged Spent Fuel Rod of 10 cm

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1. Introduction

For the management of damaged spent fuel occurring in Nuclear Reactor operation, KAERI is being focused on the development of stabilization technology for damaged spent fuel by recovering nuclear materials from damaged spent fuel and processing the materials into the form suitable for disposal. For recovery of nuclear materials of damaged fuel rod, among the developed various oxidative decladding method [1], oxidative decladding of fuel rod held in vertical position with vibrating effect aiding powder discharge from rodcut was proposed and tested against rod-cut of 5 cm under air atmosphere [2]. Complete fuel recovery was achieved, however, this decladding method was not tested for rodcut longer than 5 cm. In this study, we applied the proposed decladding strategy to rodcut of 10 cm and evaluated the feasibility of the proposed method for application to more lengthened rodcut

2. Methods and Results

2.1 Experimental apparatus

The previously fabricated thermogravimetric analysis equipment[2] was employed to declad fuel rod of 10 cm through pneumatic vertical vibration. Fuel basket with reinforced bottom plate was newly fabricated to avoid breakaway of bottom plate from main body of basket resulting from periodic mechanical impact between bottom plate and rodcut. Since total length of the fuel basket is 23cm, it is capable of accommodating 10 to 20 cm fuel rodcut. As shown in Fig. 1, the hole of diameter 5mm allows discharge of oxidized U_3O_8 powder to powder container located at the bottom of vertical tube furnace.

Fig. 1. Fuel basket for 10 to 20-cm rodcut

2.2 Oxidative Test for Rodcut of 10 cm

We have tested oxidation decladding for rodcut of 10 cm under 50% O_2 – 50% N_2 gas atmosphere. The gas flow rate was adjusted to 500 ml/min through mass flow controller and the temperature of furnace was raised to 560 ^oC at a heating rate of 10 ^oC/min. The bottom temperature of fuel basket was measured using internally inserted thermocouple and found to reach at 520 ^oC after thermal equilibrium was obtained. The recording of powder mass and pneumatic vibration were simultaneously initiated when bottom temperature of fuel basket was raised to 400 ^oC since no oxidation behavior was not observed below this temperature although oxidation is considered to substantially occur [3].

Fig. 2 shows continuously measured weight of U_3O_8 powder released from rodcut of 10 cm; even with 10 hous of oxidation, rodcut was not completely decladded with the decladding efficiency of 93%. The powderization rate was found to be progressively decreased as oxidation reaction was progressed implying that powderization in upper region of rodcut was not well developed compared to the powderization in bottom region in which powders are readily discharged form cladding due to gravitational force. As revealed in Fig. 3, the uncladded UO_2 was found to locate between 2 to 3 cm region from top side of rodcut with slightly expanded cladding implying rapid UO_2 oxidation reaction.

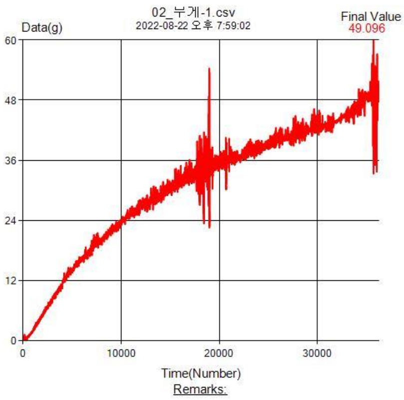

Fig. 2. Real-time measured weight of oxidized U_3O_8 powders separated from 10 cm rodcut

For comparison [2], in Fig. 4, we listed 10 cm rod-cut after oxidative decladding under pure oxygen atmosphere: volume expansion in cladding was also observed in similar region and even rupture was observed. This expansion behavior significantly deteriorates the decladding efficiency and thus should be avoided in oxidative decladding of rodcut length above 10 cm.

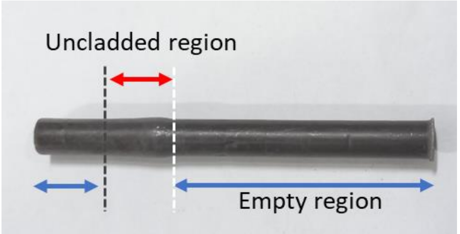

Fig. 3. Partially decaldded rod-cut of 10 cm

Fig. 4. Partially decaldded rod-cut of 10 cm after oxidative decladding under 100% O_2 atmosphere

Since such volume expansion is commonly found in upper region of rodcut, for the improved powderization required for complete decladding of rodcut, different vibration mechanism should be made although such mechanism may not effective as compared to current air-knocker based vibration effect mainly affecting bottom region of rodcut. For this, in Fig.5, we schematically illustrated the vibration mechanism based on pneumatic cylinder movement; through vertical movement, the powder in upper and bottom region is expected to be readily discharged from the cladding. We will demonstrate the applicability of pneumatic cylinder-based vibration on powder recovery by testing against 20 cm fuel rod, respectively.

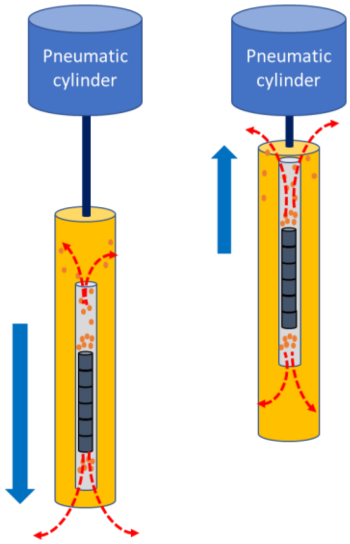

Fig. 5. Powder recovery based on pneumatic cylinder movement.

3. Conclusion

The oxidative decladding of simulated damaged fuel in vertical position was tested against 10 cm rodcut; it was found that volume expansion in cladding was observed and complete decladding was not achieved. Besides the vibration effect, alternative strategy was found to be need for powder discharge in upper region of rodcut and simple strategy for resolving such problem was proposed. A further research is being conducted to derive optimal oxidation condition for complete decladding for rodcut length larger than 10 cm.

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