Optimized Complete Decladding Condition for Simulated Damaged Fuel of 20 cm Length

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1. Introduction

In KAERI, stabilization technology for damaged spent fuel is currently being developed by converting UO_2 pellet in clad of damaged fuel to U_3O_8 powder followed by powder recovery through mechanical impaction and processing the recovered U_3O_8 powder into the form suitable for disposal. In our previous study, for powder recovery as mechanical impaction strategy, we demonstrated that air knocker based pneumatic vibration was not effective [1] and proposed an air cylinder-based vibration [2]. The proposed approach was preliminary tested against simulated damaged fuel of 20 cm and found to be applicable to powder recovery [2]. However, no systematic studies were conducted for the derivation of complete decladding condition such as oxygen concentration, effect of air cylinder force. In this study, we evaluated the effect of operating condition on the decladding process for the derivation of complete decladding condition

2. Methods and Results

2.1 Experimental apparatus

The previously fabricated thermogravimetric analysis equipment[2] was slightly modified to be applicable to the present study besides the subsequent reduction test converting U_3O_8 powder to UO_2 powder as shown in Fig. 1.

Fig. 1. Air-cylinder based oxidative decladding equipment

The length of fuel basket was 23 cm accommodating 0 to 20 cm fuel rod-cut and the basket is connected to shaft of air-cylinder mounted at the top of the equipment. The reciprocating motion of air cylinder allows U_3O_8 powder resulted from oxidation reaction to be easily discharged from the cladding [2]. In this study, the action of air cylinder is controlled by digital controller; during 3 s, the cylinder has reciprocating motion at an interval of 0.5 s and idle time during 12 s. In all tests, the employed rod-cuts have the length of approximately 2.8 cm. The gauge pneumatic pressure for air cylinder movement was fixed to 1.5 kg/cm^2 and heating rate was adjusted to 10 ºC/min. For oxidizing gas, oxygen and nitrogen mixture was used.

2.2 Effect of Oxygen content

We have tested oxidation decladding under 25 to 75% O_2 content. The gas flow rate was adjusted to 0.5 liter/min through mass flow controller and the temperature of furnace was raised to 520 ºC approximately leading to 500 ºC of inner temperature near rod-cut. Fig. 2 shows that as oxygen content was raised, the decladding rate was also increased. The overall reaction time at 75% O_2 content was found to be reduced by 66% compared to that of 25% O_2 content.

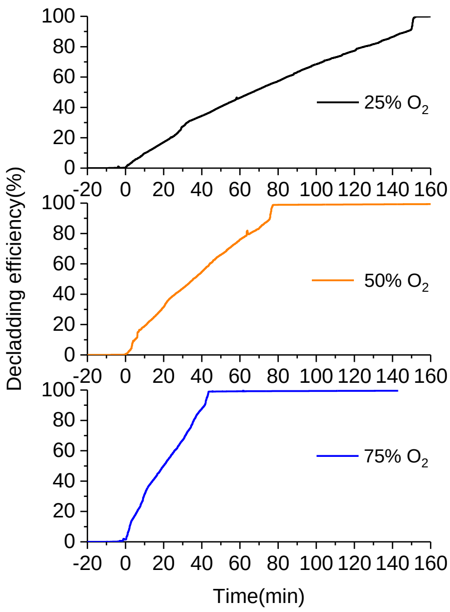

Fig. 2. Effect of oxygen content on decladding of 2.8 rod-cut

2.3 Effect of Heater temperature

Fig. 3 demonstrates the effect of heater temperature on the decladding rate. Heater temperature was fixed to 550, 520 and 475 °C to induce the temperature near rod-cut to be approximately 530, 500 and 450 °C. Flow rate of inlet gas was fixed to 0.5 liter/min and oxygen content to 75%. As temperature was increased from 475 to 520, the rate of decladding was also increased, however, for higher temperature, such similar improvement was not clearly achieved.

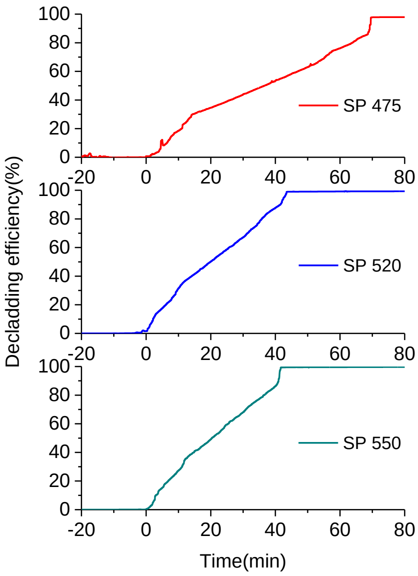

Fig. 3. Effect of heater temperature on decladding of 2.8 rod-cut

2.4 Effect of flow rate

We implemented the oxidation test at different flowrate of 0.5 and 1 liter/min, respectively. The heater temperature and oxygen content were fixed to 520°C and 75% respectively. In general, flow rate also affects the oxidation behavior of UO_2 pellet or fragment, however, as revealed in fig. 4, for rod-cut, the flowrate of oxidizing gas was found not to nearly affect the oxidization rate. This behavior is clearly associated to the constant surface area of UO_2 pellet exposed to outer environment. Due to such limited reaction surface, the consumption rate of oxygen due to oxidation become much less than oxygen replenishment rate and thus the flow rate of current order of magnitude does not affect the oxidation rate. It implies that in oxidative decladding of rod-cut, higher flow rate is not recommended.

In all tests, all rod-cut were found to be completely decladded. Based on the above basic test, the completely decladding condition is provisionally determined as follows; Heater temperature of 520 °C, oxygen content of 75%, flowrate of 0.5 liter/min and pneumatic pressure of 1.5 kg/cm^2. However as this condition is determined for 2.8cm rod-cut, for rod-cut of 10 or 20 cm, the complete decladding condition is expected to be slightly different

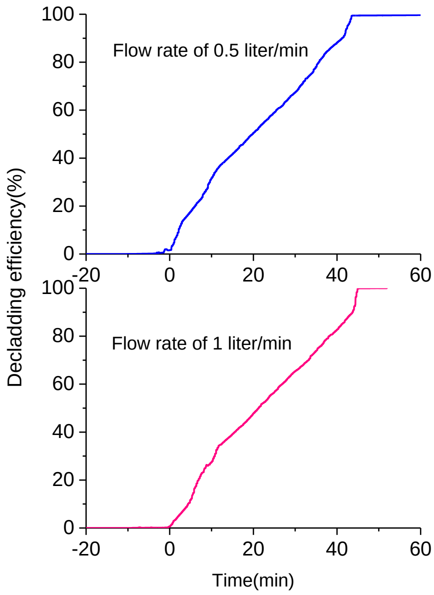

Fig. 4. Effect of flow rate on decladding of 2.8 rod-cut

3. Conclusion

In this study, for the derivation of complete decladding condition, we implemented basic study for different decladding behavior to different condition and derived the decladding condition for rod-cut of 2.8 cm. Based on the present basic study, we will derive the decladding condition for rod-cut of higher length such as 20 cm and determine optimal decladding condition.

Acknowledgements

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