Design of Furnace Tray for Improved UO_2 Fragment Oxidation Rate

JuHo Lee*, Yung-Zun Cho, Sang-Chae, Jeon, and Young-Soon Lee
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989 beon-gil, Yuseong-gu, Daejeon, Republic of Korea
*jhlee835@kaeri.re.kr

1. Introduction

In KAERI, porous UO_2 pellet is considered as feed material for oxidation reduction of Pyroprocessing. Since the fabrication of porous UO_2 pellet begins with U_3O_8 powder produced by oxidation of UO_2 fragment recovered from fuel rod slitting, for the optimal oxidation of UO_2 fragment, a study is required to examine UO_2 fragment oxidation in macroscopic scope distinguished from the conventional study aimed at microscopic level [1].

2. Experiment

2.1 Equipment change

The present PRIDE furnace was slightly modified since the large heating zone compared to the amount of sample and gas circuit prevent the rapid response of oxygen concentration in output gas stream. An assembly of alumina crucibles was installed in the heating zone to reduce the control volume involved in oxidation process and part of discharged output stream was introduced to the furnace to maintain furnace pressure above the specified value.

2.2 Experimental Procedure

The sample with known amount of UO_2 fragment is introduced into quartz beaker of 250 ml and located in the assembly of alumina crucibles. After fresh air is introduced into the furnace at a flowing rate of 2 liter/min, furnace is heated to 500^{o}C at a heating rate of 5^{o}C/min and maintained until the cell voltage of output gas stream, an alternative expression of oxygen concentration, reaches to maximum. A moisture trap was installed into the sampling loop of oxygen analyzer of output gas stream to minimize the effect of moisture on oxygen measurement. After oxidation process is ended, the oxidized fragments are recovered and the density and particle size distribution to the depth of produced U_3O_8 powder are evaluated. Two samples are used; 230 g UO_2 fragment corresponding to packing height of 1 cm and 345 g of 1.5 cm.

3. Results

Fig. 1 demonstrates that oxidized U_3O_8 powder is expanded to about four times its UO_2 fragment volume. Reaction time was estimated approximately to be 6 hr 20 min for packing height of 1 cm and 8 hr of 1.5 cm and both samples were found to be completely oxidized to U_3O_8 powder based on the evaluated weight change. Table 1 shows the density of U_3O_8 powder of two samples to the powder depth. It implies that the powder in lower region are relatively more compacted than that in above region and thus density becomes increased as the powder depth increases.

Table 1. Density of U_3O_8 powder to the powder depth

Depth interval (cm)	Density (g/cm^3)	
	Packing height of 1 cm	Packing height of 1.5 cm
0 – 2	1.92	2.04
2 – 4	1.35	1.70
4 >	-	1.37

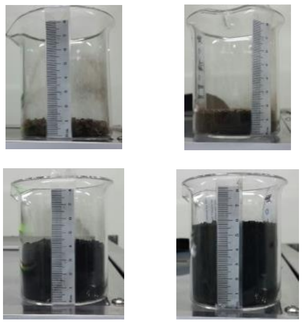

Fig. 1. Volume expansion of two samples after oxidation: packing height of 1 cm (left) and 1.5 cm (right).

4. Conceptual Design of furnace tray

As exhibited in Table 1, the density of U_3O_8 powder increases with depth since upper part of U_3O_8 powder exerts pressure against below part of powder. This implies that the improved oxidation rate of UO_2 fragment can be achieved by continually eliminating upper part of growing U_3O_8 powder preventing oxygen penetration to lower part. Fig. 2 shows the furnace tray satisfying such characteristic by inducing overflow of powder; as oxidation proceeds, part of growing U_3O_8 powder is discharged into the hole and thus the unreacted UO_2 fragment is likely to be more readily oxidized compared to the oxidation with simple tray

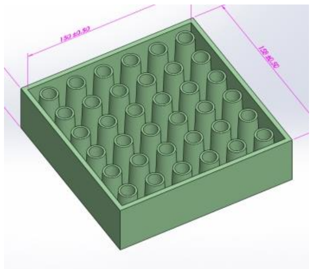

Fig. 2. Proposed furnace tray.

5. Conclusion

The effect of packing height on oxidation behavior is evaluated through oxidation using quartz beaker. The oxidized U_3O_8 powder was found to expand approximately four times the original volume of UO_2 fragment regardless of packing height. However, the U_3O_8 packing density of bottom was increased as the packing height increases. The proposed furnace design is expected to yield improved oxidation rate, however, the demonstration and the revision of the furnace design is currently in progress.

REFERENCES

[1] P. Taylor, "Thermodynamic and kinetic aspects of UO2 fuel oxidation in air at 400 – 2000K", Journal of Nuclear Material, 344, 206-212 (2005).