Modification of Tablet Press for Compaction of U_3O_8 Powder in Hot Cell

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1. Introduction

The head-end process in pyroprocessing converts a used PWR (Pressurized Water Reactor) fuel into feed forms suitable to the electrolytic reduction process that converts oxides to metals [1]. In the head-end process of KAERI, fuel material is first recovered in the form of fragments by slitting decladding of fuel rod-cuts. After slitting decladding, fuel material adhered to cladding is recovered in the form of U_3O_8 powder by low temperature oxidation of cladding around 500 °C. For removing the fission products of cesium and iodine during sintering of green U_3O_8 pellets in the head-end process, fuel fragments could be oxidized to be pulverized into fine U_3O_8 powder at low temperature of 500°C. The fine U_3O_8 powder cannot be directly applied to mesh-type cathode baskets with an opening size of 0.045 mm in the electrolytic reduction process. Hence, U_3O_8 powder need to be pelletized and then sintered into porous UO_2 pellets. In this present work, the modification of a small-sized commercial tablet press was performed to compact the U_3O_8 powder into green pellet in hot cell of DFDF.

2. Press modification

2.1 Modification requirements

Press must be modified to meet the following requirements:

1) Press must be smaller than rear-door because press must be charged through rear-door (W 730 X H 860 mm) into hot cell of DFDF.
2) Die filling of powder into the die must be improved by vibrator or mechanical feed system because U_3O_8 powder has a poor flowability.
3) Die and punches must be easily replaced.

2.2 Press size

The press size (before: W 450 X D 680 X H 740 mm, after: W 555 X D 680 X H 740 mm) was increased by an improvement of a die filling method, but press can be passed through rear door.

2.3 Die filling

Feeder scraper/hopper module for die filling of powder was designed to be driven by rack gear module connected with pinion gear of motor module as shown in Fig. 1. For vibrating filling of powder into die hole, vibration module consists of T-type pin horizontally inserted into coil spring. Whenever one tooth of pinion gear turns, vibration is generated by compression and expansion of coil spring due to repeating contact and non-contact of pin with an obstacle acting as a limit. Die filling of powder was controlled by timer and speed controller of motor module. Powder filling depth in die was controlled by the height of changeable insert blocks.

2.4 Die and punches module

The die and punches are not easy to be individually replaced by MSM in hot cell. However,

die and punches can be modularly replaced by die and punches module as shown in Fig. 2. Die and punch module can be replaced using MSM and remote tools by following procedures (Fig. 1):

1) move the feeder scraper/hopper module to the left side,
2) move the limit switch module from normal operation to replacement position,
3) move the feeder scraper/hopper module to right side end,
4) remove lock the pin and draw the die and punches module front using a L-type tool.

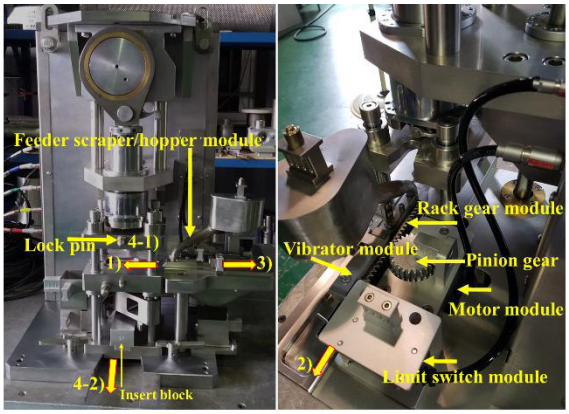

Fig. 1. Modified press and replacement procedures of the die and punches module.

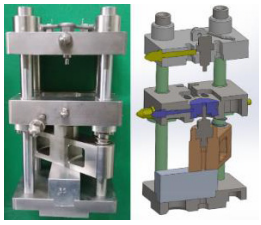

Fig. 2. Die and punches module.

3. Pre-operation test

Pre-operation test was performed using ceria powder of a very poor flowability. Filling density of ceria powder by effectively vibratory filling for three seconds (Table 1) was higher than pour density of that. Filling density of U_3O_8 powder for used nuclear fuel might be estimated by pour density of U_3O_8 powder and ratio of filling to pour density.

Table 1. Compaction characteristics of ceria powder

Filling depth (mm)	Filling density (%TD)	Ratio of filling to pour density	Comp. pressure (MPa)	Green density (%TD)	Integrity of green pellet
8.1	1.35	1.12	119	53.2	Good
9.1	1.50	1.25	64	46.4	Poor
10.1	1.65	1.37	65	-	Poor

4. Conclusions

Die filling of powder into the die was improved by vibrator. It was confirmed by pre-operation test using ceria powder of a very poor flowbility. Die and punches was easily replaced by modularization.

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REFERENCES

[1] H. Lee, et al., “Current Status of Pyroprocessing Development at KAERI”, Science and Technology of Nuclear Installations, 2013, 1-11 (2013).