Cutting Force Test of Cutting Blade Modules for Slitter Design

Young-Hwan Kim*, Yung-Zun Cho, and Young-Soon Lee
Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Korea
*Corresponding author: yhkim3@kaeri.re.kr

1. Introduction

Mechanical head-end processing of SF disassembly, extraction of the rods, and the shearing of the extracted rods shall be performed in advance as the head-end process of the pyro electro-reduction process. Also, for oxidation processing of the spent fuel in the head-end process, slitting decladding device for decladding of the cut rods is necessary. For the concept design of the device, after checking the decladding condition of the pellet and the hull and considering the cutting force requirements of the cutting blade, a tool to test simulated rods and cutting force was manufactured. Also, we used the zry-4 tube with AL6061 pellets instead of spent fuel tube with high toxicity, and as the role of the simulated pellet, to prevent from running down, it was punched at both ends and fixed. As the major requirements, 50 kg HM/day throughput and 250 working days (full capacity) per 1 year were assumed, and based on KSFA type (16x16), it was conditioned to process 10 Ton HM/year fuel with 85 % availability. Cutting force test results of cutting blade can be utilized for the head-end decladding process of SF dry process.

2. Methods and Results

2.1 Summary of slitter

The slant slitter is cut as follows. When a cutting rod of the spent nuclear fuel is placed in the module entrance, it is inserted into the center of module by the extrusion pin. A cutting rod of spent nuclear fuel is passed through the module and is simultaneously separated into several pieces by the blades inside the module, and the pieces of the pellets in the fuel rod are recovered.

As in Fig. 1, screw press-in part transfers the force to the screw by the servo motor, and the load cell and punch fixing part are operated at the bottom. When the cutting blade module installed at the bottom has the structure of measuring the cutting force when the rods are penetrated and cut, and standard TM screws and nuts are used. The length of the part of the simulated rods and punch where they go through the cutting module and reach the bottom was set to be about 420 mm or more. Ball bush and guide axis were installed on both ends for the balance and for soft press-in without external interference. The bottom base plate was composed of the hole to fix the support axis, and to settle down the cutting blade module 2-CUT module and 3-CUT module (Fig. 2). Capacity of 100 kg- 1 Ton was selected for load cell, and RS232C is embedded in the controller.

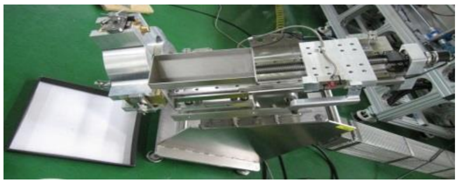

Fig. 1. Spent Fuel slant slitter for slitting test.

Fig. 2. Blade types and simulated fuel rods.
(2-CUT module and 3-CUT module)

2.2 Experiment method

As in Fig. 3, the roller gradient of the cutting module was changed to visually observe the slitting degree of Zry-4 tube, and the data measured in the load cell was obtained using RS232 communication. During the slitting using Zry-4, the gap in the cutting blade was measured, and Ø 9.5 mm was used for Zry-4 rods. Also, the roller gradient used the adjustment plat as in Fig. 4. Also, aluminum pellet were inserted into the blank tube with length 250 mm for the testing to derive the optimal gradient value.

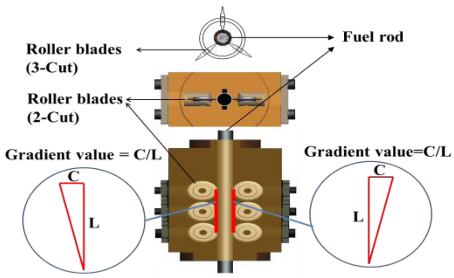

Fig. 3. Rollers gradient of 2-CUT and 3-CUT module.

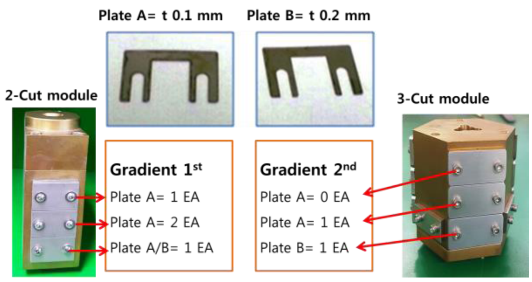

Fig. 4. Gradient variable of modules using the plate.

2.3 Experimental result and consideration

In the slitting decladding device (Fig. 1), cutting modules (Fig. 2) were used to give changes to the stepwise cutting speed, and using RS232 communication, the data measured in the load cell (BS-7220) were shown. Fig. 5 is the shape of the slitting after the experiment using 2-CUT module and 3-CUT module.

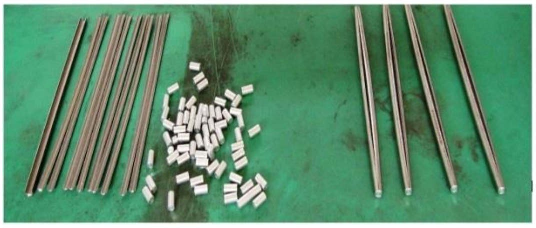

Fig. 5. Slitting shapes of 2-CUT and 3-CUT modules.

In Fig. 6, when 2 -CUT module is used, speed changes of 5, 7.5, 10, 12.5 mm/s were given to measure the change of the force. As a result of the measurement, as the speed increases, you can see that the force also has the tendency of increasing. The maximum force at 5 mm/s was 181.28 kg_f, the maximum force at 7.5 mm/s was 191.72 kg_f, the maximum force at 10 mm/s was 185.95 kg_f, and the maximum force at 12.5 mm/s was 192.33 kg_f. Therefore, if you search for the force at adequate speed, you can observe that the maximum force at 5 mm/s is 181.28 kg_f, which is lower than other speeds.

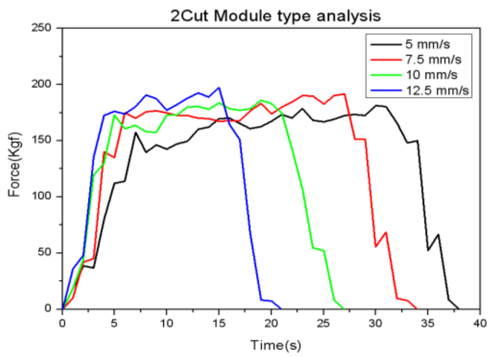

Fig. 6. Forces (kg_f) variations on the 2-CUT module.

In Fig. 7, when 3-CUT module is used, speed changes of 5, 7.5, 10, 12.5 mm/s were given to measure the change of the force. As a result of the measurement, as the speed increases, you can see that the force also has the tendency of increasing. The maximum force at 5 mm/s is 244.03 kg_f, the maximum force at 7.5 mm/s is 293.93 kg_f, the maximum force at 10 mm/s is 281.97 kg_f, and the maximum force at 12.5 mm/s is 393.4 kg_f. Herefore, if you search for the force at adequate speed, you can observe that the maximum force at 10 mm/s is 281.97 kg_f, which is lower than other speeds.

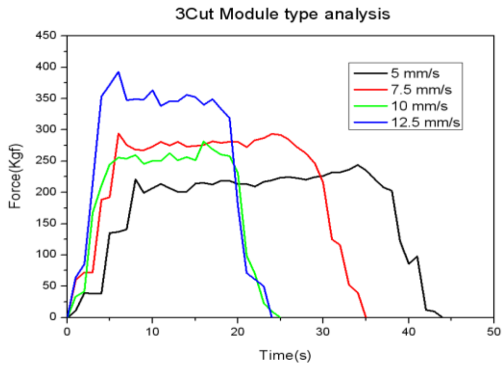

Fig. 7. Forces (kg) variations on the 3-CUT module.

3. Summary

For the concept design of the device, a tool was made to test the simulated fuel rods and cutting force and the cutting force was measured. When 2-CUT and 3-CUT modules were used, the maximum force in 2-CUT at 12.5 mm/s speed change was 197.5 kg_f and the maximum force at 3-CUT was 363.2 kg_f. The change of force in 2-CUT rapidly increases from about 1 second, and you can see that there are increase and decrease of the force change from about 5 seconds to 18 seconds, and it was rapidly decreased and the cut was made. The force change in 3-CUT has higher force at about 5 seconds later than 2-CUT at the speed of 12.5 mm/s, and you can see that it has the same tendency afterwards. If you search for the force at adequate speed from this cutting force test, 2-CUT module requires less slitting force than 3-CUT module, and the cutting time for 250 mm at 12.5 mm/s was 21 seconds, which can cut 4 m fuel rod in 5 minutes. But, there are cases of not completely slitting with 2-CUT module, so it is necessary to supplement this in the future through experiments.

Acknowledgements

This paper is the study carried out with the 2013 funding of the Ministry of Education, Science and Technology and the support from National Research Foundation of Korea (Nuclear Energy Technology Development Project, No. 2012M2A8A5025 696).

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