Shearing Analysis of Disassembly Machine in HeadEnd

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1. Introduction

Mechanical head-end processing of SF (Spent Fuel) disassembly and shearing nuclear fuel rods (tube+pellet) shall be performed in advance as the head-end process of the pyro-process for the recycling of SF. Also, for oxidation treatment of the nuclear fuel, a device is required to shear the SF rods generated from the nuclear plant. In this paper, we tried to calculate the optimal shearing force of the light water reactor rods (PWR 16x16), and design the nuclear fuel rods shearer reflecting this. For this, simulated SF shearer (Prototype-1) and simulated nuclear fuel rods were made and the shearing stress formula was derived to carry out the basic device test. Also, using the shearing formula the calculated value of the shearing stress of the aluminum pellet and the experiment value using the device were compared. As a result, the degree of maintaining the original form of the cross section of the rods after the shearing was relatively nice, and the aluminum shearing force theory and the average experiment value almost matched. Also, using the derived shearing force formula, the shearing forces of the zircaloy hull and the spent fuel pellet were calculated, and SF shearer design plan was made. Using the shearing force formula calculated with the diameters of the hull and the pellet as the process variables, you can get the shearing forces of various PWR spent fuel rods.

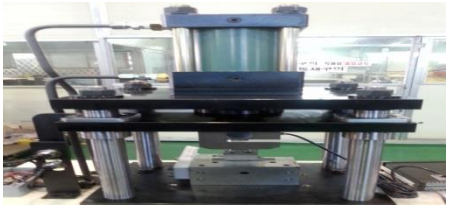
2. Main Contents

2.1 Summary of the rods shearer

Prototype-1 is the 2^{ND} device to derive the data and to design SF rods shearer by testing with nuclear fuel rods that simulated 16x16 PWR SF rods. The basic device is composed to shear 1 rod each time, and it is fixed to prevent shaking during the shearing process. Main composition largely includes shearing part, frame part, hydraulic part, clamping part, and load cell, etc.

2.2 Experiment method

As in figure 1-a, a Prototype-1 with the maximum capacity of the load cell of 2 ton is made. Also, as in figure 1-b, Zircaloy (Zry-4) hull was used, aluminum and cement were inserted in the form of pellet to make the simulated rods, and the shearing test was carried out. For this, first the shearing stress formula was derived and the basic device test was carried out. Also, the calculated value of the shearing stress of the aluminum pellet using the shearing formula and the experiment value using the device were compared. Using the derived shearing force formula, the shearing forces of Zry-4 hull and the pellet, which is the SF, were calculated. Based on the above data, PWR 16x16 SF shearer design was made.



(a) Pototype-1

(b) Rods

Fig.1. Prototype-1 device and rods for sharing test.

2.3 Rods shearing formula derivation

To calculate the optimal shearing stress of PWR 16x16 rods (hull+pellet), the shearing formula (1) and formula (2) were used to design new device, and the Prototype-1 of figure 1-a was used to get the value of the experiment shearing force. Also, τ_1 of the aluminum material using the formula (1) and formula (2), the calculated τ_2 value of the zircaloy material, and the experiment value were compared.

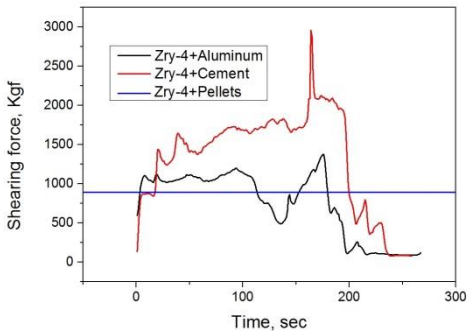
$$w_1 = \frac{\pi}{4}(x_2{}^2 - x_1{}^2)\tau_1 \qquad (1)$$

$$w_2 = \frac{\pi}{4} dx_1{}^2 - \bullet\, \tau_2 \qquad (2)$$

(τ_1: pellet shearing stress, τ_2: hull shearing stress, w_1: pellet shearing force, w_2: hull shearing force, d_2: hull diameter, d_1: pellet diameter)

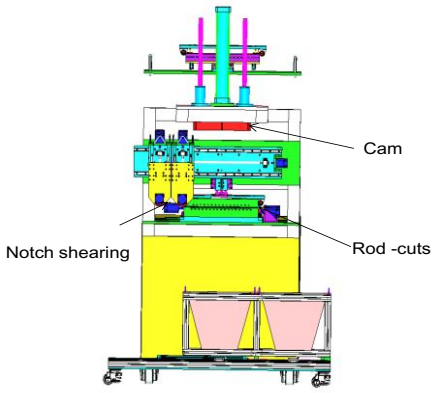
2.4 Experiment result and device design

As in figure 2-b, the degree of maintaining the original form of the sheared cross section was relatively good. As in figure 2-a, the aluminum shearing force was 1120 kgf. Also, the theoretical value of the uranium (UO_2) pellet, which is SF, was 879 kgf. Among the rod-cut shearing forces, cement was 1750 kgf. Figure 2-c is a newly designed shearer.



(a)Results

(b)sheared rods



(c)New design

Fig.2. Theoretical, experimental results and new design.

3. Conclusion

The shearing stress formula was derived, and the basic device test was carried out. Also, the calculated shearing force value of the aluminum pellet using the shearing formula and the experiment value using the device were compared. As a result of the shearing test, the degree of maintaining the original form of the sheared rod was relatively good, The shearing formula was used to indirectly get the shearing force of the hull and the pellet of the actual SF, and the data was obtained to be used in the design of the head-end process shearer for SF recycling. Also, you can get the shearing forces of various PWR spent fuel rods using the calculated shearing force formula with the diameters of the hull and the pellet as the process variables.

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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