Mechanism Design for PWR 16x16 Spent Fuel

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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.

For the disassembly, the nozzles fixed at the top and bottom of the assembly shall be removed. For this, design requirements were set and 16x16 PWR SF assembly was analyzed. Also, the requirements of SF disassembler were reflected to derive the core mechanism for the disassembler, and Solid Works was used to carry out 3D module analysis for the concept design.

The throughput of 50 kg HM/day and 250 working days (full capacity) per year were assumed, and based on KSFA type (16x16), the condition was set to be able to process the fuel of 10 Ton HM/year with 85% availability.

PWR SF disassembler concept design material can be utilized in the head-end process of SF dry process.

2. Main Contents

2.1 16x16 PWR SF assembly analysis

SF disassembler's design standard is designed based on 16x16 PWR SF assembly dimensions. As in figure 1, the dimensions of the assembly are as follows.

The number of rods is 236, and the total length is 452.5 cm. The length of the rods is 409.4 cm, and the width is 20.7 cm. The outer diameter of the rods is 0.952cm, rod thickness is 0.057cm, total weight is 651.0kg, uranium weight is 486 kg, and zircaloy weight is 138 kg.

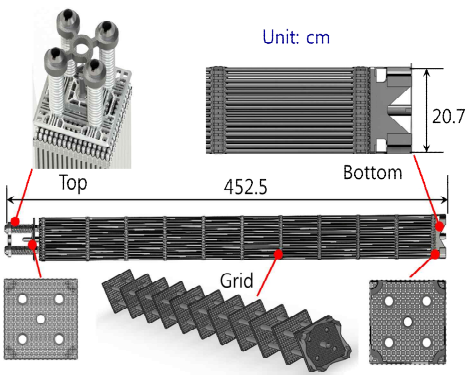
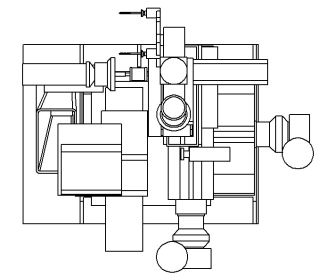


Fig. 1. 16 x 16 PWR SF assembly.

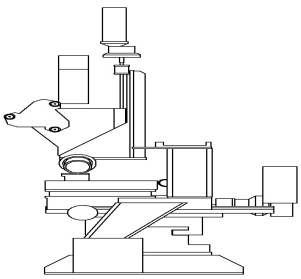
2.2 Spent fuel disassembler design requirements

Figure 2 is 2D concept design of SF disassembler. For concept evaluation, the following major requirements were reflected.

The maximum clamping forces that play the role of fixing support for fuel assembly are 240 kg for each grid and 900 kg for the bottom nozzle. It shall provide the function of cutting and removing the top and bottom nozzle of the guide tube and it shall provide the precise position control in 3 axis direction. (Precision of positioning: ± 0.25mm) Also, cutting tool replacement shall be easy, and if possible, it shall provide cooling and lubrication function for the cutting tool, and at the same time, it shall provide the functions to collect cuttings, fines, and various hardwares for the disposal in the future. It shall be designed to block the natural ignition of Zr fine generated during the process, and fines filter replacement shall be easy.



(a) Top



(b) side

Fig. 2. Spent fuel disassembler 2D concept.

2.3 SF disassembly core mechanism design

SF disassembler core mechanism is designed to carry out the following works. The recognition of the position of the assembly, automatic position movement of the joint of the grid supporting top and bottom nozzle of the assembly, drilling work while recognizing the location

of the joint, and collection function of the separated top and bottom nozzle, etc.

SF disassembler core mechanism composition is as follows. Drilling head/upper X-Y-Z turn table/ low X-Y turn table/clamping driver / discharge container /servo DC motor.

Through the concept analysis, as in figure 3, it was found that drilling method is structurally suitable for PWR SF disassembly. Drilling method, which is PWR method, drills only the top and bottom nozzle and guide tube locking part, so it generates chips with sizes bigger than the fine powder reducing the danger of fire. Also, if you make the drilling part and guide tube entrance angle to be 15° or more in the design in the future, the generated chips enter inside the guide tube to prevent the spread of the generated wastes.

Figure 3 is a enlarged partial drawing of the drilling part. Drilling part has 3 drill blades. To recognize the location coordinates of x, y, and z in the right side of the figure, first the vision recognition of the radiation resistant camera is necessary, and the dimensions of all PWR spent fuel assembly shall be stored in the data servo. SF disassembler works with 2 drill blades in turn, so it can prevent over-heating, but to increase the safety of preventing fire, air cooling system is installed in the drill holder.

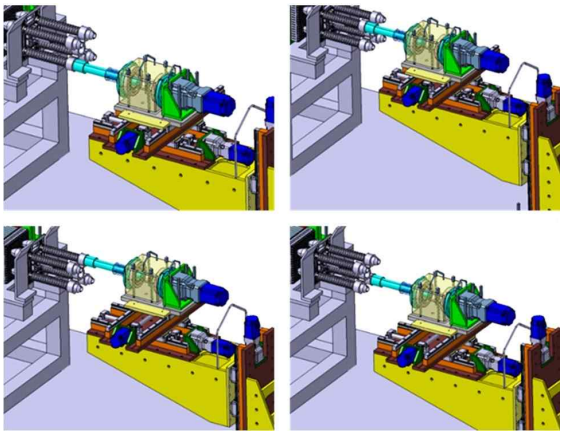


Fig. 3. Drilling module of spent fuel disassembler.

2.3 Spent fuel disassembler 3D

SF disassembler (Figure 4) has rotary drilling module. SF disassembler to remove top•bottom nozzle uses rotary drilling module and X-Y slide module for PWR disassembling process. The removal of top•bottom nozzle uses the same method. SF disassembler includes drive and sensor required for drilling module positioning. Also, function to collect and control crud, fines, and pellet is additionally provided to the device, and vacuum device is designed.

SF disassembler is a welded structure and plate assembly, and has servo drive system, sensor, and support are mounted to carry out position control function. This system is composed of 8 main modules that can be mounted and removed.

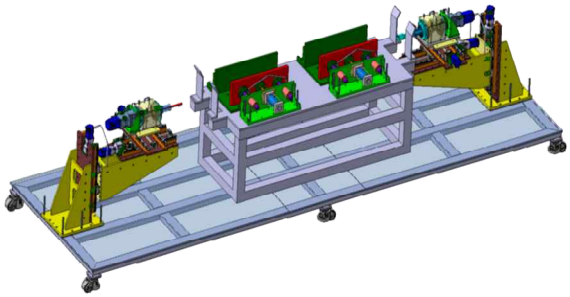


Fig. 4. Spent fuel disassembler 3D.

3. Summary

For the SF disassembler concept design requirements setting, PWR 16x16 SF assembly dimensions are analyzed. Also, major requirements for disassembler were derived to derive the core mechanism. The major requirements are as follows.

The maximum clamping forces for the assembly are 240 kg for each grid and 900 kg for the bottom nozzle. The precision of the position in 3 axis direction is ± 0.25mm. Also, for disposal, it shall provide functions to collect cuttings, fines, and various hardwares. For SF disassembling, drilling method was adopted.

According to the type of PWR SF, the drilling position is different, so it was designed as a structure for position control and for the control of X, Y, and Z at the bottom and center of the disassembler.

SF disassembler has the general usage with the structure to disassemble all PWR SF assemblies operated domestically. To improve the remote maintenance, Solid Works program tool was used to compose 8 main modules, and SF assembly disassembler concept was designed in 3D.

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).

REFERENCES

[1] J. S. Yoon, et al., “A Real-Time Graphic Simulator to Monitor Spent Fuel Dismantlement Devices,” International journal of American Nuclear Society, vol 139, pp263-273, Sep., 2002.