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Design Analysis of Disassembler Connection Devices for Spent Fuel Assembly

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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-process that can recycle the light water reactor spent fuel(SF). For the operation of the Pyro head-end process, the design of the connecting systems between the spent fuel disassembly process and the extraction process is required. For this, the device composition and preparation concept of the connecting system are set considering the arrangements between the spent fuel head-end unit processes. The connecting system between the spent fuel disassembly process and the extraction process is composed of vertical/horizontal handler, assembly turntable, etc. Also, the requirements for the SF disassembly connection system design for mechanical head-end process was derived. The characteristics were analyzed and modularized reflecting the requirements for each connecting system, and 3D modeling was carried out using Solid Works tool. The above analysis results can be utilized in the head-end process design of the SF dry process through the spent fuel disassembly connecting system concept design.

2. Main Contents

2.1 Device connecting head-end process concept

As in figure 1, it is composed of the major unit processes of the head-end, which are spent fuel assembly down ender, disassembly device, rods extraction device, extraction rods cutting device, cut rods oxidation de-cladding device, spent fuel powder mixing device, and high temperature volatile oxidation device. Also, to connect the disassembly device and the rods extraction device, it is composed of spent fuel assembly horizontal/vertical handler, spent fuel assembly turn table, etc.

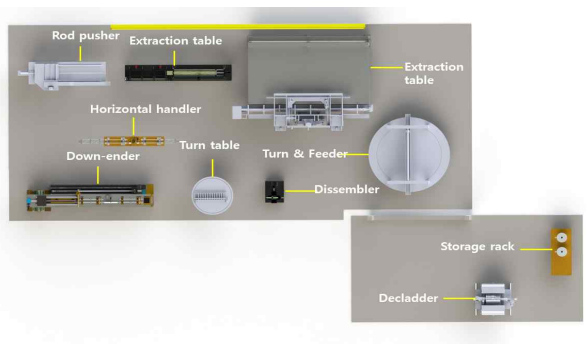


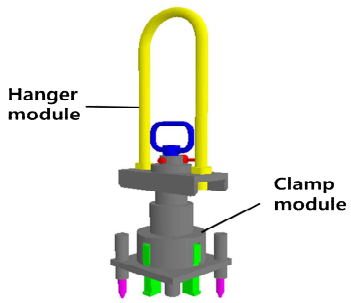
Fig. 1 Connection devices in head-end process.

2.2 Assembly Vertical/Horizontal Handler

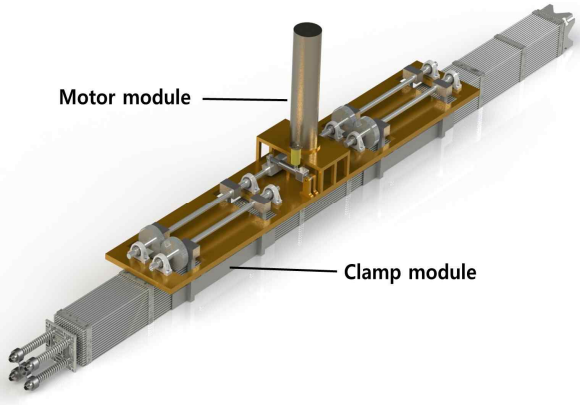
Figure 2 is a concept design for spent fuel assembly vertical/horizontal handler. The following major requirements are reflected to evaluate the device connecting preparation concept.

- Safe clamping device shall be provided, and the force condition is the same as the case of the turntable.
- Considering the safety factor, the lifting capacity shall be at least 3 tons.
- The finish of the movement of all clamping operations shall be verified by a suitable sensor.

In figure 2-a, spent fuel assembly vertical handler is designed as a structure that can handle PWR 16x16 spent fuel assembly. The zone, in which spent fuel assembly can be handled, is only used for lifting spent fuel assembly from the pool and for settling onto vertical scanner and spent fuel assembly down ender. It can also be used in the case of storing in the storage rack. The principle of the spent fuel assembly vertical handler is placing on the top nozzle of the PWR 16x16 spent fuel assembly and lifting with crane for immediate locking, and it is the mechanical structure of unlocking by unlocking only the locking device after loading in the vertical scanner and spent fuel assembly down ender. In figure 2-b, the zone in which the horizontal/vertical handler can be handled for spent fuel assembly is used for turntable, extraction table, and rod rotation/supply device. The principle of the assembly horizontal handler is locking to horizontal PWR 16x16 spent fuel assembly by the operation of the driving motor and bevel gear. Also, when the shape of the PWR spent fuel assembly is changed, you only need to change the location of the limit sensor. Spent fuel assembly vertical/horizontal handler is composed of welded structure steel and mechanically composed mounting/removing part, and clamp part driven by the bevel gear. This system is composed of 2 main modules that can be mounted and removed.



(a) vertical type



(b) horizontal type

Fig. 2 Vertical/horizontal assembly handler

2.3 Spent fuel assembly turntable

Figure 3 is the concept design of the spent fuel assembly turntable. For the evaluation of the device connecting preparation concept, the following major requirements are reflected.

- It plays the role of fixing support for spent fuel assembly.

Maximum clamping forces are
- for each grid: 240 kg
- for bottom nozzle: 900 kg

- It plays the role of the support for the hopper collecting waste material and crud.

- It shall provide the precise location selection function in the longitudinal and vertical direction.

- The finish of all clamping works shall be verified by a suitable sensor.

To remove the top nozzle and the bottom nozzle of the spent fuel assembly, it requires a device fixing and rotating the spent fuel assembly. To be positioned as a drilling module of the spent fuel disassembling device, precise control of the rotating angle of the spent fuel assembly turntable for 180°, and the force control that can safely clamp the supporting grid part is essential. The spent fuel assembly turntable device is conceptualized as a structure that can control the rotating angle and the clamping force.

The spent fuel assembly turntable has rotating plate controller and clamp sensor mounted on the welded structure steel. Also, it has a servo DC motor that can control uniform angle. This system is composed of 4 main modules that can be mounted and removed.

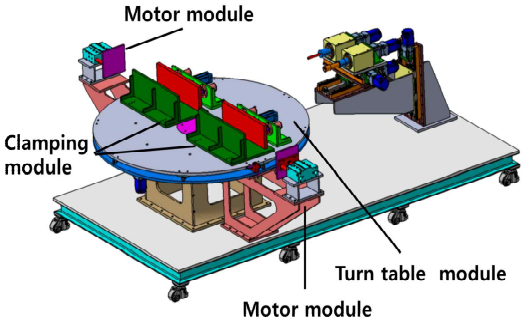


Fig. 3. Spent fuel assembly turn table

3. Summary

To derive the preparation concept for PWR SF assembly disassembly connecting system, the targets were selected and the characteristics analysis were carried out. For this, the connecting system between the spent fuel disassembly process and the extraction process is composed of the vertical/horizontal handler, assembly turntable, etc., and the design requirements for SF disassembly connection system for mechanical head-end process were derived. The major requirements for vertical handler are minimum lifting power of 3 tons considering the safety factor, and the maximum clamping force that plays the role of fixing support for the spent fuel assembly on the spent fuel assembly turntable shall not be over 240 kg for each grid and 900 kg for the bottom nozzle. For remote maintenance of the connecting systems, modularization analysis was carried out using Solid Works tool. The above analysis results can be utilized in the design of a high efficiency head-end process of SF nuclear fuel cycle dry process.

Acknowledgements

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