Analysis on Disassembling Methods of Nozzle for PWR Spent Fuel

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1. Introduction

Mechanical head-end processing of 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 PWR. And efficient analysis of SF disassembling methods in connection with the pyro head-end shall be performed in advance. Therefore, this study compared and analyzed the characteristics of the SF disassembling methods for the design of a high efficiency head-end process. For this, radial blade cutting, axial single cutting, radial multi cutting, and slant multi cutting methods were analyzed. As a result of the comparison and the analysis, we selected the slant multi cutting method, which can handle the nuclear fuel rods of all shapes, can prevent fire from the dust generation, and generates less wastes with high disassembling efficiency. The above analysis results can be utilized for the design of the head-end process for SF dry process through the comparison and analysis of the PWR SF disassembling methods.

2. Disassembling analysis

2.1 Radial blade cutting

For the removal of the top/bottom nozzle of the assembly, radial blade cutting method, that is the saw rotation method, has an advantage of easy maintenance. This method is used for the cutting of the zircaloy rod in WSMP (Westinghouse Specialty Metals Plant). 2 saw devices are mounted in the cutting device part, and the process speed can be improved by about 5 minutes for each nuclear fuel assembly. This method may have the cases of the guiding tube (grid) spring becoming loose or rods being extended. But, for PWR SF assembly, when the end of the rod is closer to the top nozzle than the blade thickness, the rods cutting is not carried out. If rod top nozzle is cut in such condition, it will damage the seal welding of the rod pressure port and causes radiation of gas product from the rod, so the rod shall be verified whether it touches the top nozzle through the visual inspection in the hot cell in advance (Fig. 1).

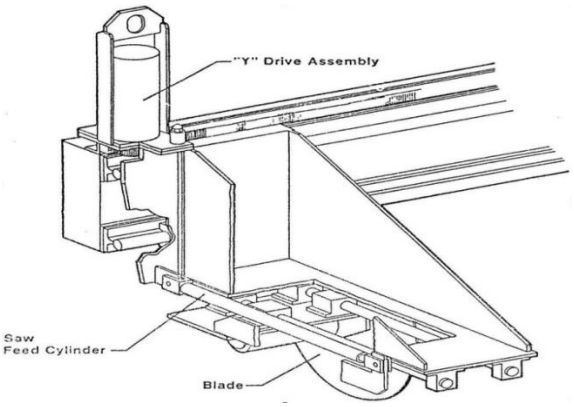

Fig. 1. Radial blade cutting methods on axis.

2.2 Axial single cutting

The removing method of PWR bottom nozzle is as follows.

Table is placed at the position to remove the nozzle, it is fixed to the bottom nozzle part with a short pin (②), the bottom nozzle fixture (④) and tube cutter (⑰) rotate to be in the position, touching the first fuel assembly, the fixture is placed on the bottom nozzle, and the clamp (⑧) starts.

As in Fig. 2, single-revolution tube cutter cuts each guiding tube from right above the selected welded part to the top grid space part. The tube cutter is moved to the position that can cut each guiding tube by the tool plate motion system. The positions of the guiding tubes are pre-programmed for all types of rods assembly types that will carry out the rods extraction. After the cutter cutting the last guiding tube of the assembly, the bottom nozzle is placed on the nozzle container plate. As such, PWR fuel assembly finishes the preparation to remove the rods.

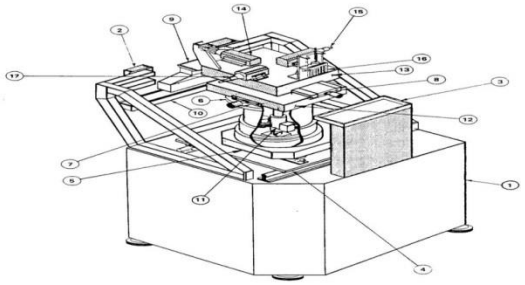

Fig. 2. Axial single cutting methods on axis.

2.3 Radial multi cutting

This method can place the fuel assembly on the transportation table by moving the tilting device to horizontal position, and when the tilting device returns to the initial vertical position, the transportation table moves to horizontal direction and moves to the bottom nozzle removing part. The top and bottom nozzles are separately removed, and the bottom nozzle is removed first (Fig. 3). After securing enough space between the nut and the bottom nozzle by pushing the bottom nozzle, 8 guiding tubes are removed at the same time with radial cutting at the point where the top and the bottom nozzle meet each other. During the cutting process, the spring is maintained to prevent falling off. For the bottom nozzle, to prevent the rods deformation during the cutting, comb is inserted between the rods, and 8 guiding tubes are cut and removed at the same time at the inner side of the bottom nozzle.

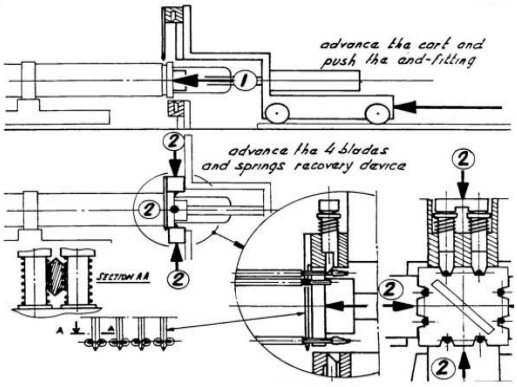

Fig. 3. Radial multi cutting methods on axis.

2.4 Slant multi cutting

For PWR SF assembly, the top guiding tube and instrument tube are cut from inside to outside using multi blade cutting head (Fig. 4). By drilling the instrument tube at the point where top and bottom nozzle meet the base plate, make a hole for multi blade cutter insertion. Insert the multi blade cutter far enough from each other and cut all guiding tubes and the instrument tube at the same time. At this time, the grid is removed along with the bottom nozzle while it is attached to the top and bottom nozzle along with some cut tubes. Through such a process, gripper can access to the rods more easily. During the cutting work, nitrogen is continuously supplied.

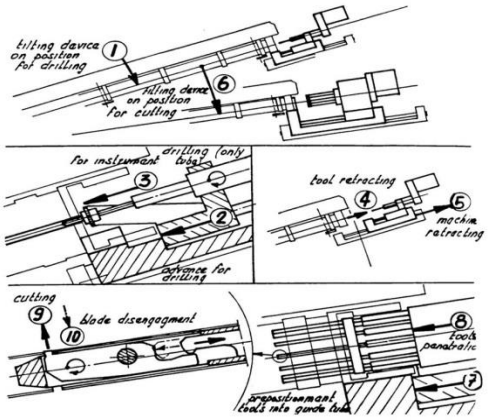

Fig. 4. Slant multi cutting methods on axis.

3. Conclusion

To select reasonable and high efficient target for PWR SF disassembling methods, major targets were selected and comparison and analysis were carried out. For this, radial blade cutting, axial single cutting, radial multi cutting, and slant multi cutting methods were analyzed. As a result of the comparison and the analysis, we selected the slant multi cutting method, which can handle the PWR SF assembly of all shapes, can prevent fire from the dust generation, and generates less wastes with high disassembling efficiency. Also, this method has the general usage that can be applied not just to dry process but also to wet process. The above analysis results can be utilized for the design of the head-end process for SF dry process through the comparison and analysis of the PWR SF disassembling methods.

ACKNOWLEDGEMENTS

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