

Analysis on the Cutting Method of SF Rods Supplied to Decladding

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1. Introduction

Mechanical head-end processing of SF (Spent Fuel) disassembly, extraction of the rods, and the shearing of the extracted rods shall be performed in advance as the head-end of the pyro electro-reduction process. Generally, the characteristics of the cutting method in the head-end process are different according to wet method or dry method. Especially, the pyro-process, which is a dry process, shall have the efficient extraction method analysis connected to the post process of the mechanical head-end process in advance. Therefore, this study analyzed the feasibility of PWR SF rods cutting method, which is a part of the unit process, for the design of a high efficiency head-end process. For this, considerations for the use of various tools, cutting method, and the characteristics of SF rods were analyzed. Also, the advantages and the disadvantages of the durability, structure, required time, function, handling, maintenance, radiation resistance, operability, size of the device, power, microporosity, and the effect of decladding of the cutting, shearing, wire cut, and horizontal slit method were analyzed. As a result, assuming the use of the hydraulic power, when the mechanical decladding is not considered, we found that the shearing method was most advantageous. Through the analysis of the SF cutting method, the above analysis results can be used in the design of the head-end process of SF nuclear fuel cycle dry process.

2. Main Contents

2.1 Considerations on the cutting method

In table 1 and table 2, compass saw / grinding saw are used widely for SF rods cutting in the air or in the water inside the hot cell. The cutting in water uses wet method cutting to minimize the spread of the dust and to prevent the flare generation from the fine particle of zircaloy during the cutting. The design shall be made for easy replacement of the cutting wheel, collection of zircaloy powder from the generation of mass ultra fine particles (1 μm or less), and for the prevention of the powder accumulation around the equipment.

Laser cutting method is equipment developed to remove the structure of SF rods assembly, and it can cut without generating dust. The equipments requiring maintenance are installed outside the hot cell, and the grip mechanism and the laser cutter are installed inside the hot cell. The disadvantages are that minute control






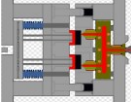
of the cutting depth is not possible and the price of the equipment is high.

Wire method (Wire EDM) is the method of cutting with the brass electrode passing through by the cut metal, and electrons are released to the metal, and the wire is disposed after going passing through the metal object one time. The diameter of the wire is $\phi 2 \sim 12$ mm, wire length is 0~6,000 ft, and the cutting speed of the 1 inch thick stainless steel is 28 inch/hr. Shearing/cutting methods are the method of cutting with shearer of a structure such as punch or die for the cutting of SF assembly and rods. The advantage is no generation of fine particles that are hard to remove from the shearer. Also, it has the disadvantage of the sheared cross section being rough and blunt, but the operation is quick and the productivity is high. The cutting method is cutting with a structure such as disk saw or scissors. The advantage is good cross section and used for precise cutting, but it generates fine particles.

Table 1. Considerations of cutting tools for spent fuel rod

Method	Summary	Considerations
Compass saw / Grinding type	-Used in the air or in water inside the hot cell	-Compression of the cutting part is excellent -Excessive dust generated -Need dust collection device -Consideration for use of lubricant -Consideration for modularization
Laser	-No dust generation -Cannot have fine control of the cutting depth -Equipment is expensive	-Considerations for material, thickness, speed, and power consumption -Installed outside the hot-cell, cutter is installed inside.
Wire EDM	-Electron release cutting method	-Nuclear fuel dust accumulation - Consideration for possible modularization
Punch, Disk Saw, Scissors	-Generation of fine particles that are hard to remove from the equipment	-Consideration for length and compression -Need dust collection system -Consideration for use of lubricant -Consideration for modularization

Table 2. Kinds of cutting tool for spent nuclear fuel rod

Type	Cutting Tool	
Compass saw / Grinding type cutting	 Compass saw method	 Grinding method
Laser cutting method	 Laser head and sensor head	
Wire EDM method	 Wire method	
Punch, Disk saw, Scissors cutting method	 Disk saw method	 Punch method

2.2 Analysis according to the cutting method

The advantages and disadvantages were analyzed for cutting with random direction, shearing in one direction such as punch, wire cutting using wire discharge processing, and the horizontal slit method developed in this study were analyzed as in table 3. As a result of the analysis, assuming the use of the hydraulic power, when the mechanical cladding is not considered, we could see that the shearing with high productivity was most advantageous.

Table 3. Analysis on criterion according to cutting

Criteria	Cutting	Shearing	Wire Cut	Horizontal Slit
Durability	-Low	-High	-Low	-Low
Structure	-Scattering, cooling	-Simple	-Complex	-Collection and Separation device
Required Time	-Requires cutting time	-Quick with high productivity	-Requires cutting time	-Direct pellet / hull separation
Function	-Dust scattering	-Piston cycle, simple	-Complex shape processing	-Multi slit, cutting
Handling	-Good	-Good	-Difficult	-Difficult
Maintenance	-Easy	-Easy	-Difficult	-Easy
Radiation Resistance	-Good	-Good	-Weak	-Weak
Operation	-Easy	-Easy	-Difficult	-Easy
Size of Device	-Light weight possible	-Big device	-Big utility part	-Light weight possible

Power	-Electricity	-Hydraulic	-Electricity	-Electricity
Microporosity	-Good cutting -Easy curve and straight line processing -Precise	-Blunt cross section -Fragility destruction, Rough	-Good cutting -For high hardness. -High precision processing	-Good slit surface -Good cut surface
Required power	-Small	-Large	-Small	-Large
Decladding effect	-Good	-Reduced hull separation ratio	-Good	-Good

2.3 Characteristics of SF rods

For SF rods cutting device design and manufacturing, the material and the characteristics of the raw material shall be studied. Zircaloy is a type of a zirconium alloy, a material for nuclear reactor, it is an alloy made for improvement of the corrosion resistance of the zirconium against high temperature water, it has small cross section for absorbing neutron, good mechanical property, and it can be processed as plate, rod, tube, and wire, etc. Also, it is used for core internal tank, fuel sheath, and cooling pipe material.

3. Conclusions

Assuming the use of hydraulic power, and not considering the mechanical decladding, you can see that shearing is the best. Compared to the shearing method, the cutting method has the disadvantage of low productivity, but when high degree of maintaining original form is required, or if the chip separation by scattering and cooling device is supplemented, the cutting method is better. Also, the horizontal slit device has the disadvantage of low productivity from the low durability, but assuming the improvement of the processing speed using high durability tool, if secure experimental verification and if you supplement the separate complex pellet/hull separation device, the horizontal slit method is better.

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