Technical Issues of Remote Assembler for TRU Fuel Assembly

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1. Introduction

Recently, the amount of accumulated spent fuels will exceed the capacity of the interim storages because domestic nuclear power plants discharges approximately 760 tons of spent fuel per year. A prototype generation-IV sodium-cooled fast reactor (PGSFR) is being considered as a future nuclear system to reduce the amount of LWR spent fuels and radiotoxicities by recovering TRU materials from the spent LWR fuels through pyro-electrochemical processing (PEP) [1]. Thus, complete nuclear fuel cycle can be achieved by remotely fabrication of TRU element, rod and fuel assembly between PEP and PGSFR. However, the fabrication of TRU fuels should be undergone with completely remote operation in radiation-shielded hot cell. Especially, there are lack of experiences on the design of remote fabrication facility for TRU fuel assembly except FCF (Fuel Cycle Facility) at EBR-II (Experimental Breeder Reactor II, U.S.) in 1960s [2,3]. Fig. 1 shows the schematic view of fuel assembly for PGSFR. In this study, design criteria for remote assembler for TRU fuel assembly are reviewed and technical issues for remote fabrication of TRU fuel assembly are proposed.

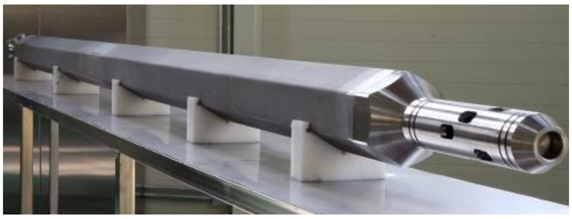

Fig. 1. Schematic view of fuel assembly for PGSFR.

2. Design criteria and technical issues

2.1 Assumption

Fuel rods are remotely fabricated in pre-processes from fuel elements to wire wrapping and final products of fuel rods are vertically stored near the assembling machine with adequate cooling system for removing decay heat of fuel elements.

- The structural pars of fuel assembly are manufactured and supplied with two preassemblies (i.e., upper and lower preassemblies) outside of the hot cells by normal shop procedures. Upper preassembly is consisted of handling socket, upper shield and duct, and lower preassembly is noise piece and lower shield.
- Fabrication procedure of fuel assembly can be divided into three main steps; (1) Rod bundle assembling, (2) Assembling upper and lower preassemblies and duct welding process, (3) Dimension inspection and non-destructive examination (NDE) of welds.

2.2 Design criteria

The objective of the remote assembler is to assemble the TRU fuel assemblies that can be loaded in SFR. The operations of assembling procedures should be done by totally remote methods. Especially, fuel rods should not be inclined from the vertical during the entire assembling process because of redistribution of bonded sodium by their decay heat.

- The machine should be designed to have modular parts to maintaining remotely in the hot cell with master-slave manipulation (MSM), overhead cell crane and viewing equipment. All parts of the machine inserted through a port within a limited diameter and handled with a specific weight limit, each part of the machine should be considered its size and weight.
- During the assembling operation, the application of complex mechanisms should be avoided and mechanical MSMs are to mainly be used. The use of overhead cell crane or other different-type MSM should be avoided or minimized because these in-cell facilities are not always ready to use.
- Radiation-shielded materials should be used for

all parts of the machine, which can be substituted simplified replacement procedure.

- Maximum temperature of the TRU fuel assembly should be below allowable temperature determined by the properties of the final PEF products.
- During the operation of assembling procedure, the working hours should be limited.

Table 1. Summary of technical issues of each remote manufacturing steps at the assembling machine

Steps	Technical issues
Rod bundle	· Fuel rod remote handling method with MSM (Length: 2,250 mm, OD: 7.4 mm) · Tolerance control of bottom end cap of fuel rod, mounting rail, lower shield that are assembled each other · Maintaining rod bundle shape during assembling procedure
Mating assemblies and welding	· Guiding methods and maintaining straightness for vertically mating of two preassemblies · Handling methods of heavy structural parts without additional in-cell equipment · Application of welding and post weld heat treatment (PWHT) methods in hot cell
Inspection and NDE	· Application of measuring sensors for fuel assembly dimensions with high irradiation resistance · Selection of remote NDE methods for welding parts and definition of defect threshold size for quality control · Application of tensile tests for welds and fixing deformed duct with a straightener
Common points	· Application of pneumatic system of each assembling steps and specification of cooling system (flow rate and positions) · Definition of allowable temperature in assembler, inspector, welding machine · Remote maintenance of the assembling machine

2.3 Technical issues of a remote assemblerz

Based on the above assumption of the TRU fuel assembly fabrication procedure, predictable technical issues of each assembling step are summarized in Table 1. For example, the length of the fuel rod in PGSFR is 2,250 mm and more than two times longer when compared with design data at EBR-II. So, the fuel rod for PGSFR is too slander to handle remotely with single MSM without auxiliary tools. This means that an additional jig should be designed for maintaining the vertical of the fuel rod as well as resolving small tolerance between lower end cap of fuel rod and mounting rail.

3. Summary

In this study, assembling procedure of TRU fuel assembly was reviewed and divided into rod bundle assembling, mating preassemblies and welding, and inspection and non-destructive examination. Based on this assumption, the design criteria of a remote assembler for TRU fuel assembly of PGSFR is defined and predictable technical issues are proposed.

ACKNOWLEDGEMENTS

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