Development of a Reinforcement Device, SAFER, to Ensure the Handling Integrity of PWR Spent Nuclear Fuel for Dry Storage in Korea

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1. Introduction

As reported at Nuclear Regulatory Commission (NRC) Information Notice 2002-09, the North Anna power plant and some power plants including a Korean plant experienced top nozzle separation of a certain type of Westinghouse type fuel. The top nozzle separation had occurred at the bulge joints connecting the stainless steel grid sleeves to the Zircaloy-4 guide tubes. The root cause was known as Intergranular stress-corrosion cracking accelerated by the presence of chlorides, fluorides, and sulfates [1].

In this study, we have developed SAFER (Safe Adapting FastenER), which is a reinforcement device connecting the top nozzle and guide tube of the Westinghouse type fuel assembly, in order to prevent top nozzle separation during fuel handling.

2. Development of SAFER

2.1 General Description

The SAFER has been developed through the procedure shown in Fig.1. That is, the related patents have been investigated to avoid patent infringement, the finite element analysis model and the prototype model have been developed and modified, and finally, the performance of the optimized reinforcement device has been evaluated through the verification tests.

The SAFER is an anchor type reinforcement device as shown in Fig. 2. The SAFER consists of three parts, which are clamping outer sleeve, fastening inner rod and adjustable nut. The fastening mechanism of the SAFER uses contour of bulge deformation in the inner surface of the guide tube. The clamping method of SAFER is to adjust the length of the clamping outer sleeve with the adjustable nut to match the outer sleeve tip into the bulge groove in the guide tube of fuel assembly, and then tighten the fastening inner rod to be fastened the clamping outer sleeve tip against the guide tube bulge groove.

2.2 Finite Element Analysis

A finite element model has been developed considering the connection part of the representative fuel using the ABAQUS which is the multi-purpose commercial finite element analysis software. Fig. 3 shows a representative FE analysis result of the 17x17 fuel assembly with bulge connections.
2.3 Verification Test

To evaluate the fastening force of the device, the fastening strength tests have been performed as shown in Fig. 4. In this test, 4 SAFERs were installed at the outer corners of the 17x17 fuel assembly top nozzle and guide tubes. The other guide tubes were free from connection with the top nozzle. Fig. 5 shows typical normalized test results of the verification tests. In this test, one SAFER has been shown to withstand a load close to the weight of a fuel assembly, and even with only four SAFERs installed in a fuel assembly with top nozzle separation concern, it is expected to get additional fastening force more than 3 times the weight of fuel assembly.

3. Conclusion

The SAFER developed in this study is expected to provide a very strong fastening force in the fuel assembly with top nozzle separation concern, and it is considered that SAFER will guarantee the integrity when handling the fuel assembly for dry storage in the future.

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REFERENCES