## Development of Finite Element Model for Handling Characteristic Evaluation of Spent Nuclear Fuel

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### 1. Introduction

Spent Nuclear Fuels (SNFs) have been stored in spent fuel pools of the each pressurized water reactor nuclear power plant since the plants started commercial operation. The estimations for quantities of the SNFs are around 13,000 tons [1]. The top nozzles of some SNFs were separated during handling due to the Inter-Granular Stress Corrosion Cracking (IGSCC) [2].

To evaluate the handling characteristics of the SNF, a Finite Element (FE) model was developed considering the top region in the fuel, and the analyses were performed using the developed model in this study. The model is generated based on the Westinghouse (WH) 17×17 type fuel assembly (FA) because the FA is the heaviest among the FAs with the IGSCC concern.

### 2. Finite Element Model for the Guide Tube to Top Nozzle Joint

*2.1 Single Guide Tube to Top Nozzle Joint*

The analyses and tests were carried out using the single guide tube to top nozzle joint. The analysis model and test specimen are illustrated in Fig. 1 and 2. The boundary and loading conditions were that the end of guide tube was fixed and the top nozzle plate was moved.

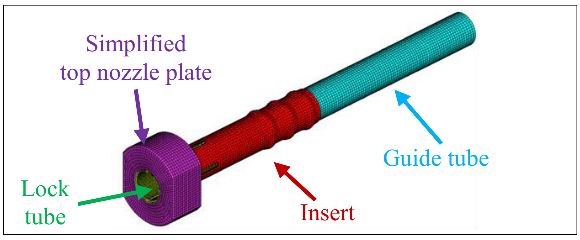


Fig. 1. FE model for single guide tube to top nozzle joint.

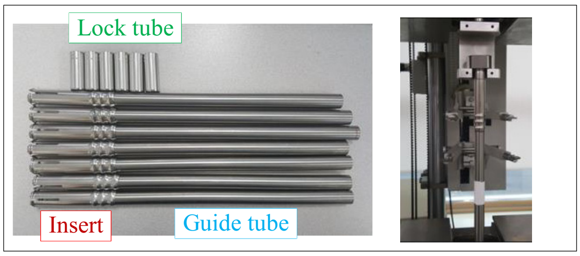


Fig. 2. Test specimen and equipment for single guide tube to top nozzle joint.

*2.2 Full FE Model for Guide Tube to Top Nozzle Joint*

The full FE model was generated for the top region of WH 17 type FA. The model consists of a top nozzle, 24 inserts, 24 guide tubes and 24 lock tubes. Fig. 3 shows the full FE model and the loading/boundary conditions.

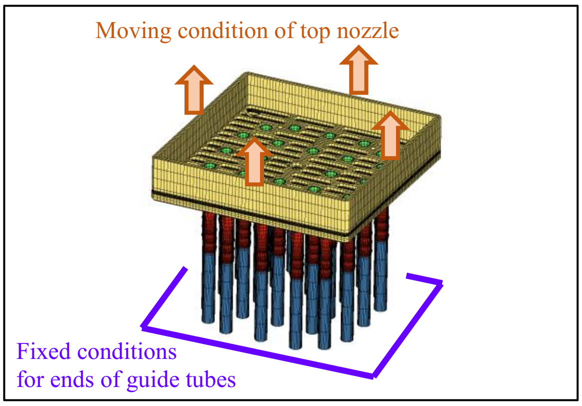


Fig. 3. Full FE model for single guide tube to top nozzle joint.

## 3. Results of Analysis and Test

The analyses and tests were performed until the separation between the insert and the top nozzle. Fig. 4, 5 and 6 are the non-dimensional load-displacement curves from each analysis and test. The each non-dimensional value is calculated based on the average values of maximum reaction forces and displacements from the tests.

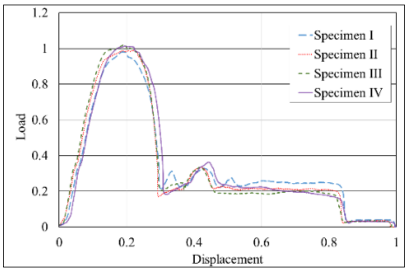


Fig. 4. Load-displacement curve for single test model.

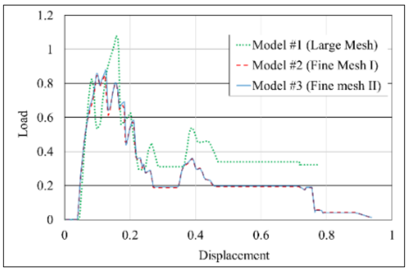


Fig. 5. Load-displacement curve for single FE model.

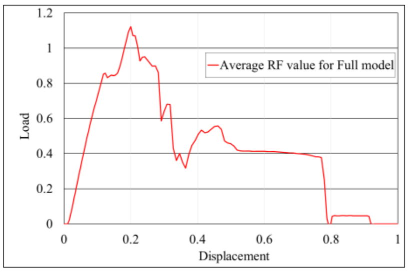


Fig. 6. Load-displacement curve for full FE model.

Fig. 4 and 5 is the test and analysis results for the single model and Fig. 6 is the analysis results for full FE model. In Fig. 6, each load for displacement is average value for 24 guide tubes. The reason for using the average value is to evaluate the suitability of the full FE model from comparisons between the full model and the single model results.

From these comparisons, it can be known that the trends are similar although the non-dimensional loads are a little different. However, the maximum load of Model #1 (large mesh) in the single FE model and that of full FE model are very similar. If the fine meshes are used in the full FE model, the load values may be approached to the test values for the single model.

## 4. Conclusion

The full FE model is developed to evaluate the handling characteristics of the SNF. The suitability of the developed FE model is verified from the comparisons among analysis/test results. In the future, the test will be performed using the same full specimen as the full FE model.

## ACKNOWLEDGMENTS

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