Transportation Analysis of the 14OFA PWR Fuel Assembly

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1. Introduction

As the amount of Spent Nuclear Fuel (SNF) in KOREA domestic spent fuel pool increases dramatically, the storage capability of the Pressurized Water Reactor (PWR) SNF would be saturated by 2024. [1] The SNFs in the pool must be transferred to the designated wet or dry spent fuel storage facility. In the issues of the SNF treatment, handling and transport of the SNF have been considered as an important factors. In this paper, we tried to develop the dynamic analysis model under transportation and performed the analysis model in the time domain.

2. Transient Dynamic Analysis

2.1 Transient Dynamic Analysis in Time Domain

Generally, dynamic analysis of a vibration system performed in the frequency domain to get data of natural frequencies and mode shapes. These data provide a better understanding of frequency characteristic of the system. However, the modal analysis method is not applicable to systems with various contact constraints such as nuclear fuel assemblies. Therefore, the direct analysis method in time domain should be used to analyze the transportation. The acceleration time history data is typically directly input to the load point. In this paper, we use a displacement control that integrates acceleration of less than 0.2g as shown in Fig. 1.

![Fig. 1. Time history displacement by each axis direction.](image)

2.2 Dynamic Analysis Model

![Fig. 2. Dynamic analysis model.](image)

The analysis model consisted of a 14 X 14 full fuel assembly (14OFA) and a basket floor. The time history displacement data is given to the load point (basket floor), and gravity load is applied. Fig. 2 shows the FE model for the dynamic analysis. The specimen was modeled using ABAQUS/explicit, 3D shell element (C3D8R) was used for the fuel assembly, and discrete rigid elements were used for the basket floor. Multi Point Constraints (MPC) was used to represent the spot welding at inner connection of mid-grid for 14OFA. It is assumed that the contact area between each spacer grids and basket floor is a tie condition, because the fuel assembly itself is fixed to the basket during transportation. The material of the guide tube and the fuel rod/spacer grid are SUS304, and Zr-4 at room temperature (from MATPRO) [2].
2.3 Result of Dynamic Analysis

The maximum stress occurs at the contact area between spacer grid and fuel rod as shown in Fig. 3. It was confirmed that a large amount of stress was applied to the portion where the spacer grid and the basket floor contact due to gravity.

Fig. 3. Analysis result of 14OFA under transportation.

3. Evaluation of Contact Force

Contact interaction occurs between the spacer grid itself and the fuel rod due to vibration during transportation. In order to evaluate the integrity of the fuel rod, it is necessary to analyze the maximum contact force generated at the contact position between each spacer grid and the fuel rod. The results are shown in Fig. 4. The maximum contact load is 300N.

Fig. 4. Max. Contact force between fuel rod and spacer grids under transportation.

4. Conclusion

The dynamic simulation consists of two boundary condition: (1) gravity, and (2) dynamic loading. Under the vibration of 0.2g acceleration, the maximum stress of the cladding is under material yield strength. Impact forces at outside the fuel rod were analyzed to evaluate the integrity of the fuel rod during transportation. In the future, we will evaluate the safety of the external contact force received by the fuel rod by using the failure criteria according to the burn-up history and the input data considering the normal transportation excitation or shock excitation.

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REFERENCES