Evaluation of the Effect of Debris Clogging in the Fuel Bottom Nozzle on Fuel Performance

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1. Introduction

For the nuclear fuel used in OPR1000 and APR1400, a debris filtering bottom nozzle is installed to prevent fuel damage by debris on lower region that shown in Fig. 1. If the flow path of the bottom nozzle is blocked by debris during operation, the flow rate of the coolant flowing into the fuel assembly decreases and then the temperature may rise. Also, if the clogged area of the bottom nozzle increase, the coolant flow rate in the fuel decrease, which can affect fuel integrity. Therefore, the effect of the blockage ratio of the fuel bottom nozzle due to debris on the cooling water flow rate of the sub-channel was analyzed.

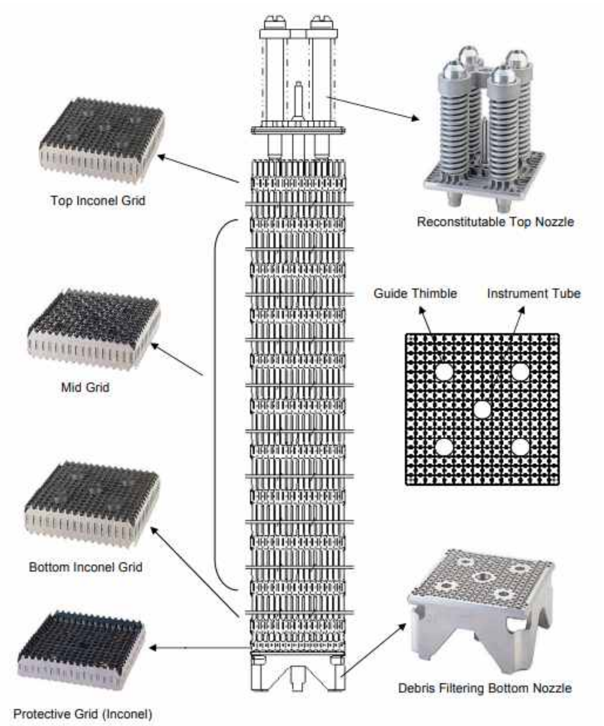

Fig. 1. Plus7 Fuel Assembly Configuration

2. Methods and Results

In the previous study, even if 70% of the cross-sectional area of the lower part of the mid grid is blocked, it was evaluated that the flow rate recovers at the upper part of the mid grid [1]. Therefore, it is assumed that the flow path is blocked at the lower end of the first mid grid that located at a height of 530 mm from the lower end of the fuel. CFD (Computational Fluid Dynamics) was performed by applying a 1/8 symmetry model (Fig. 2) in consideration of symmetric arrangement of fuel rad and bottom nozzle. Analyzing the flow rate by height of the sub-channel at the top of the blockage area by assuming the bottom nozzle channel blockage by case, and calculating the flow recovery ratio according to the blockage ratio to evaluate the fuel integrity due to channel blockage. Figure 3 shows the result of flow recovery ratio via clogging ratio and calculation height. As a result of flow analysis, the initial flow distribution according to the blockage of the bottom nozzle is very different according to the blockage ratio, but it is found that it recovers quickly after passing through the mid grid, and when it reaches the first mid grid, the flow is almost recovered. Therefore, even if the bottom nozzle is clogged by debris, it is judged that the cooling performance will not be affected from the top of the first mid grid.

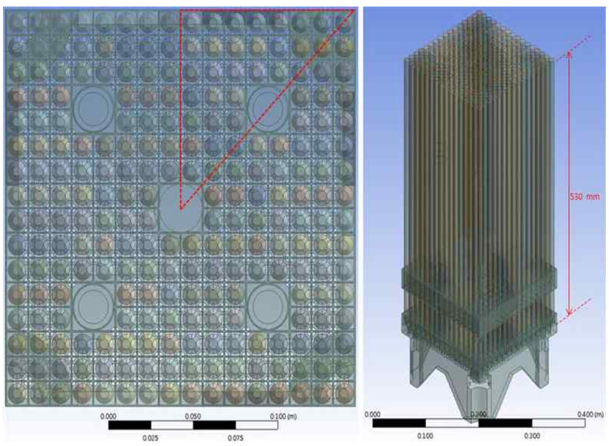

Fig. 2. Calculation Domain of Plus7 Fuel Assembly

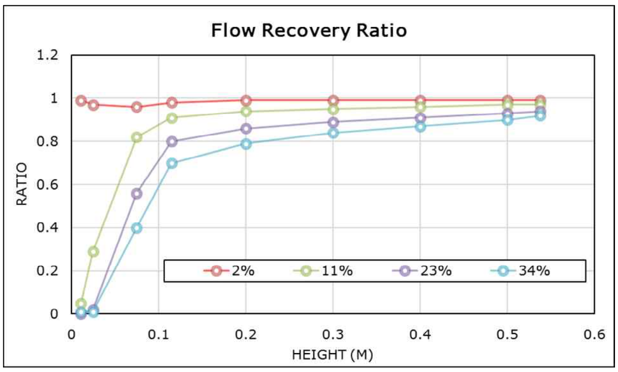

Fig. 3. Flow Recovery Ratio against Height

3. Conclusions

Even if 34% of the bottom nozzle is clogged by debris, the cooling performance will not be affected from the top of the first mid grid. In order to confirm more accurate fuel integrity, it is necessary to additionally analyze changes in temperature and pressure of fuel rad caused by blockage of the flow path.

REFERENCES

[1] J.M. Creer, J.M. Bates, A.M. Sutey, Turbulent Flow in a Model Nuclear Fuel Rod Bundle Containing Partial Flow Blockages, Nuclear Engineering and Design 52, p. 15-33, 1979