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System Response Analysis of Rod Ejection Accident for OPR1000 Using Korea Non-LOCA Analysis Package

Yo-Han Kim, Chang-Kyung Sung, Hwang-Yong Jun
Korea Electric Power Research Institute, 103-16 Munji-dong Yuseong-gu, Daejeon, 305-380
johnkim@kepri.re.kr

1. Introduction

Korea Electric Power Research Institute (KEPRI) of Korea Electric Power Corporation (KEPCO) has been developed the non-loss-of-coolant accident (non-LOCA) analysis methodology, called as the Korea Non-LOCA Analysis Package (KNAP), for the typical Optimized Power Reactor 1000 (OPR1000) plants. The RETRAN hot spot model (HSM) of KNAP has been contrived to replace the functions of STRIKIN-II code of ABB-CE, which is used for the rod ejection accident (REA) analysis. The HSM could be used to estimate the fuel temperature, fuel enthalpy, cladding surface temperature, *etc*., which are used to confirm the safety limits of REA. In this work, to estimate the feasibility of HSM, the typical cases of REA were analyzed and the results were compared with those calculated by the CESEC-III and STRIKIN-II, which were used to prepared the final safety analysis report (FSAR) of Ul-Chin Units 3 & 4 (UCN-3/4). Through the study, it was concluded that the HSM of KNAP showed the acceptable results.

2. Plant Modeling

2.1 Reactor Coolant System Modeling

Prior to analysis, the reactor coolant system (RCS) of object plants, UCN-3/4, was modeled with several volumes and junctions to simulate the accident. The core was partitioned into 6 vertical volumes and hydraulic channels, respectively. In the case of steam generators, tubes and secondary sides were modeled with 12 and 14 volumes, respectively, to represent the U-tube bundles and two feedwater-paths or economizer. In fact, the standard RCS model for UCN-3/4 had been developed and used in the KNAP.

2.2 Hot Spot Modeling

Based on the review over the STRIKIN-II model, the average and hot spot channel model presenting the fuel assemblies were developed. To reflect the characteristic of STRIKIN-II's hydraulic channels, the hot spot channel was divided up to 25 meshes of 0.5 ft height and 12 – 19 segments in radial direction. Through the sensitivity analysis, it was found that more fine meshes showed almost the same results compare with those of the selected standard model.

3. REA Analysis

3.1 Descriptions

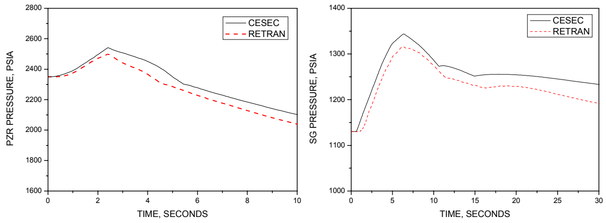
The REA is defined as the mechanical failure of control rod mechanism pressure housing resulting in the ejection of control rod assembly and drive shaft. The reactivity increases following the ejection, the thermal power also boosted up to 1.6 times to rated thermal power in the full power condition, and fuel rods possibly led to localized damage. Due to the extremely low probability and severe consequence, this event is classified as an ANS plant condition IV incident. On the viewpoint of system response, the safety criteria are the average fuel pellet enthalpy or temperature, the peak RCS pressure, and the cladding temperature. Any other limitations are covered with these criteria.

3.2 Accident Analysis

The conditions led to REA would be classified into 4 cases, such as hot zero power (HZP) at the beginning of cycle (BOC), hot full power (HFP) at BOC, HZP at the end of cycle (EOC), and HFP at EOC. In the case of UCN-3/4, however, only two cases, *i.e.*, HFP and HZP, were selected with acceptable conservatism. To compare the results of this study with those calculated from CESEC-III or STRIKIN-II codes, the same initial conditions and assumptions were used. Most of them were quoted from the FSAR.

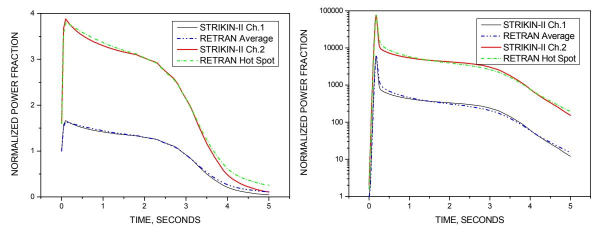
Figure 1 shows the pressurizer and steam generator secondary side pressure, respectively. The results of RETRAN show lower pressure trends due to the comprehensive non-equilibrium pressurizer and multi-node steam generator secondary side models. On a standpoint of variation, however, they show the similar trends each other.

As mentioned in the figure 2 the calculated power from HSM also show the similar trend to those estimated by STRIKIN-II code. And it would be found that the power fractions of the hot spot or channel 2 of STRIKIN-II were jumped to about 400% of the initial power, although the powers were risen up to about 160% in the case of the average channel or channel 1 of STRIKIN-II.



(a) PZR pressure (b) SG pressure

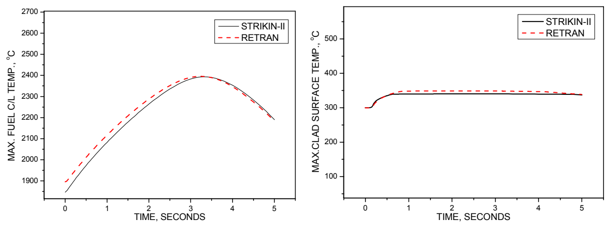
Figure 1. Pressure comparison at HFP



(a) HFP (b) HZP

Figure 2. Power comparison at HFP & HZP

In the case of the fuel temperature, the temperature was calculated through the heat conductors used to represent the fuel assemblies and the maximum was the temperature of the most inner node. The maximum cladding temperature was also estimated from the heat conductors used for claddings. The results show the similar trends to those from STRIKIN-II code as depicted in figure 3.



(a) Max. fuel temp. (b) Max. cladd. temp.

Figure 3. Max. fuel & cladding temperature comparison

4. Conclusion

The rod ejection accident was analyzed to estimated the feasibility of the KNAP developed by KEPRI. The results of the analysis were compared with those calculated by CESEC-III or STRIKIN-II codes which were used to prepare the FSAR of UCN-3/4. Through the feasibility study, it was concluded that the developed methodology and model showed the acceptable results and could be used further works.

Acknowledgements

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