Development of Containment Building Modeling for Nuclear Power Plant Simulator

Sungjin Ahn [a*]
70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, KOREA
[*]Corresponding author: ahnsungjin@khnp.co.kr

1. Introduction

The nuclear power plant simulator is developed to operate similar to the behavior of the plant by utilizing actual plant design data. The primary side hydrothermal phenomenon uses the hydrothermal code such as RELAP(Reactor Excursion and Leak Analysis Program), and the fuel reaction uses the core code to reflect the fuel characteristics of each core cycle. In addition, Balance of Plant(BOP) models are being developed using simulation development environmental tools. Real-time operation of simulators is important because they are developed primarily for operator training purposes. Recently, the computer's performance has steadily improved, enabling real-time implementation even if it contains more information than previously developed simulator data. Further, more sophisticated simulation implementations are possible due to the performance improvement of the simulator development environment tool. In particular, containment modeling improves simulator performance through the above improvements.

2. Methods and Results

In this section, containment modeling is modeled by dividing it into functional parts, and the linkage between the hydrothermal model and the BOP model is explained.

2.1 Containment building configuration modeling

The real containment is a dome shape from the outside view and consists of several compartments and cavities internally. Simulating this in a single volume makes it difficult to accurately model local phenomena, so it is modeled by dividing them into several volumes as shown in Fig 1. Space without compartments, such as steam generators and pressurizers, are modeled by creating separate volumes. The more detailed the containment volume is subdivided, the more detailed the modeling is, but excessive segmentation can be difficult to implement in real time due to the increase of data, requiring proper segmentation. Changes in energy between containment and atmosphere are modeled using thermal structures similar in function to heat exchangers.

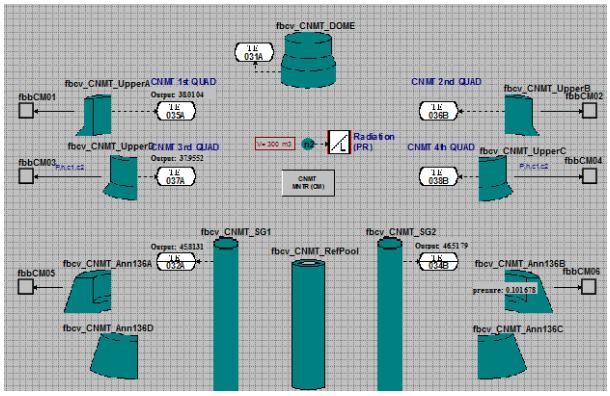

Fig. 1. Containment building configuration modeling

2.2 Gas and water flow modeling for containment building

Connectivity between volumes is required to allow gas or liquid flow of volumes created from containment configuration modeling. Warm air is needed a link between the volumes so that the flow takes place in the direction of the dome ceiling or the volume next to it. Links between volumes are provided to the floor of the containment so that fluids generated by the containment spray or air condensation can be collected in sump tank, etc. It is also necessary to link the hydrothermal code so that the energy generated by the primary system can be reflected in the gas flow.

2.3 Fan modeling for containment building modeling

Inside the containment is a number of functional fans, including control rod cooling fans, CAVITY cooling fans, RCFC and so on. To model this, inter-volume connections are made to match the direction of the gas flow and the electrical and mechanical functions of each fan are implemented separately in detail in the BOP model.

2.4 Containment spray system modeling

It is allowed to model the phenomenon of spray of containment when pressure is increased in an accident such as Loss of Coolant Accident(LOCA). Containment spray system installed in containment dome is grouped and modeled as shown in Fig 2. The spray liquid moves in accordance with the containment liquid flow modeling.

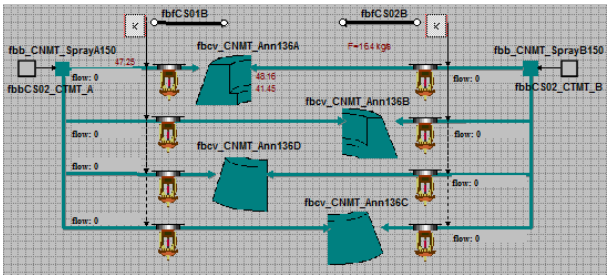

Fig. 2. Containment spray system modeling

2.5 Containment firewater modeling

It was modeled in a similar way to the containment building spray function. In addition, system malfunctions are reflected for operator training.

2.6 Interface with containment model and BOP model or thermal-hydro code

The main purpose of containment modeling is to model the flow of gases and liquids and the movement of heat energy between containment and the atmosphere. Electrical and mechanical characteristics of containment spray or firewater modeling are achieved in the BOP model. This is why interface between containment model and BOP model is required. Simulator environmental tools provide this function so that simulation models with the same mechanical and electrical functions are placed in containment models and BOP models respectively to perform the same functions. The data generated by the thermal-hydro model is transferred to the containment model so that the heat energy generated by the reactor coolant system can be modeled.

3. Conclusions

Nuclear power plant simulators are being developed by simulating all areas of the plant, including instrumentation and control, electricity, fluid, logic and so on. Due to the improvement of computer performance and development tool performance, the containment geometry modeling, gas flow inside containment building, internal air circulation, containment spray, fire water, etc. are also improving in the containment modeling field. It is expected to contribute to improving safety of nuclear power plants as it improves the quality of simulators.

REFERENCES

[1] Oleg Kozlov, fbContainment : FlowBase Tool Extension for Containment System Simulation Modeling Guide, Western Service Corporation, Ver.1.0-2, 2015.