Development of the RETRAN Hot Spot Model for KSNP

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1. Introduction

Under the funding of Ministry of Commerce, Industry & Energy, Korea Electric Power Research Institute (KEPRI), the research center of Korea Electric Power Corporation (KEPCO), has been developed the in-house non-loss-of-coolant accident (non-LOCA) analysis methodology for Korea Standard Nuclear Power Plants (KSNP). To develop the methodology, the related documents of EPRI and vendors were examined and the methodologies of some foreign utilities were reviewed also to compensate for lack of capabilities. In fact, one of the major goals of the project is to build the code and methodology systems to replace the restricted codes by U. S. Government mentioned in the Technical Transfer Agreement between KEPCO and ABB-CE. To achieve the goal, KEPRI has developed the methodology based on general-purpose system codes, such as RETRAN, RELAP and MASTER. Despite the efforts, some functional weaks were raised from the users. So, KEPRI has developed the RETRAN hot spot model (HSM) to compensate some functions used for the estimation of the fuel temperature & enthalpy, cladding surface temperature, *etc.* In current methodology for KSNP, the parameters are calculated with STRIKIN-II code, which is one of the restricted codes. In this paper the development of HSM is described. And to estimate the feasibility of the model, the rod ejection accident (REA) was analyzed and the results were compared with those calculated by STRIKIN-II code. Through the feasibility study, it was concluded that the developed model showed the acceptable results and could be used further works.

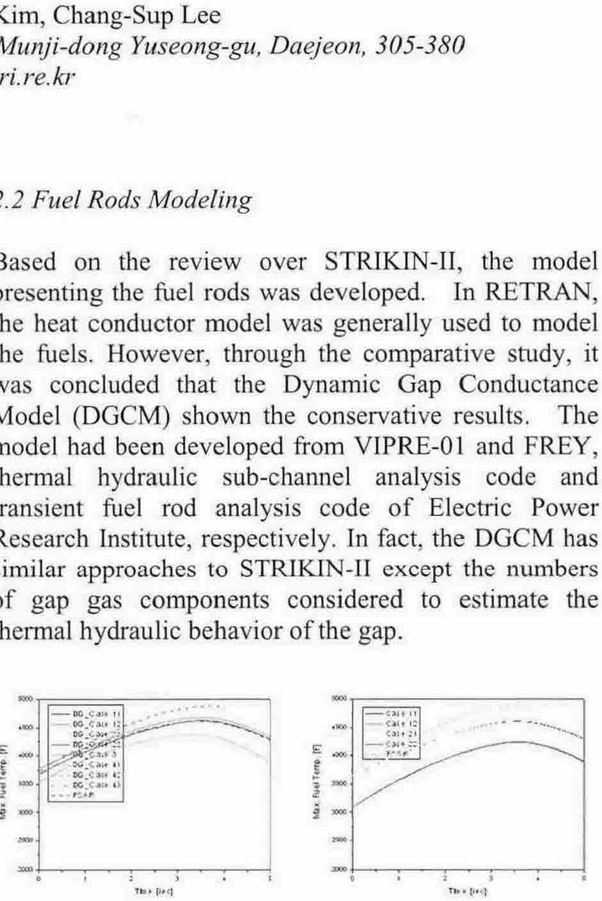
2. Model Development

2.1 STRIKIN-II Code Review

Prior to development, the structures and functions of the STRIKIN-II code were reviewed in detail. The code adopts the point kinetics model for the power generation and the two types of hydraulic channels for the core to calculate the thermal hydraulic parameters in hot assembly and hot channel. The channels would be divided into 20 meshes in axial and radial directions, respectively. The code has the functions to estimate the departure from nucleate boiling (DNBR), peak fuel temperature, fuel stored energy in enthalpy, cladding surface temperature, coolant enthalpy, *etc.* based on the geometrical data of the fuel rods, historical data from fuel rod design code, FATES, and some thermal hydraulic data during a transients.

2.2 Fuel Rods Modeling

Based on the review over STRIKIN-II, the model presenting the fuel rods was developed. In RETRAN, the heat conductor model was generally used to model the fuels. However, through the comparative study, it was concluded that the Dynamic Gap Conductance Model (DGCM) shown the conservative results. The model had been developed from VIPRE-01 and FREY, thermal hydraulic sub-channel analysis code and transient fuel rod analysis code of Electric Power Research Institute, respectively. In fact, the DGCM has similar approaches to STRIKIN-II except the numbers of gap gas components considered to estimate the thermal hydraulic behavior of the gap.



(a) Heat Conductor Model (b) DGCM

Figure 1. Maximum fuel temperature estimated with the heat conductor model and DGCM

2.3 Hydraulic Channel Model

To reflect the characteristic of STRIKIN-II's hydraulic channels, the hot spot channel model was developed. The channel was composed of 25 meshes of 0.5 ft height and divided into 12 – 19 segments in radial direction. Through the sensitivity analysis, it was found that more detail (fine meshes) model showed almost the same results compare with those of the standard model.

2.4 Fuel Enthalpy Calculation

The fuel stored energy in enthalpy would be estimated in about two ways in RETRAN. As the first, RETRAN calculate the internal stored energy (SE**) during transient calculation. So, the fuel enthalpy would be estimated with the parameter as Eq. (1).

$$H = Max\left(\frac{SE**[Btu]\cdot ConFac[cal/Btu]}{\rho_{Min}\cdot V_{fuel-node,i}[g]}\right)_{i=1,25} \quad (1)$$

For the next, the fuel temperature would be used for the estimation with a lookup table of fuel temperature vs. enthalpy. In this study the table of ANL International Nuclear Safety Center (INSC) has been used. Through the comparison between the results with two approaches, the lookup table method showed more conservative results.

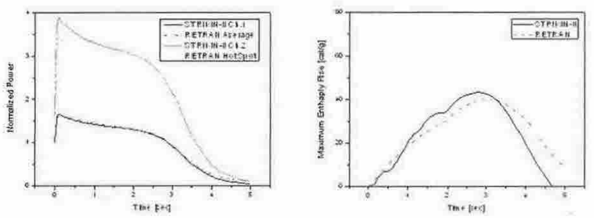
2.5 Feasibility Study

To estimate the feasibility of the model, the rod ejection accident (REA) was analyzed and the results were compared with those calculated by STRIKIN-II code. The radial peaking factors to demonstrate REA are as listed in Table 1.

Table 1. Radial Peaking Factors

	HFP	HZP
Pre-ejection	1.60	2.00
Post-ejection	2.33	12.67

As presented in Fig. 2, the results with HSM showed the similar trends and acceptable values compared with those of STRIKIN-II.



(a) Power (b) Enthalpy Rise

Figure 2. Power and enthalpy rise at hot full power

3. Conclusion

The Hot Spot Model of RETRAN has been developed to compensate the function of STRIKIN-II code. And to estimate the feasibility of the model, the rod ejection accident was analyzed and the results were compared with those of STRIKIN-II code. Through the feasibility study, it was concluded that the developed model showed the acceptable results and could be used further works.

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