Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22, 2009

Preliminary Study on application of MARS Code to KINS Realistic Evaluation Methodology

Byung Gil Huh*, Dong Gu Kang, Deog-Yeon Oh, Young Seok Bang and Sweng Woong Woo
Korea Institute of Nuclear Safety, 19 Gusong, Yuseong, Daejeon 305-338
*huha@kins.re.kr**

1. Introduction

Nowadays, the best estimate method with the uncertainty evaluation has been broadly used worldwide in licensing of NPP. In Korea, the LBLOCA analysis using the best-estimate methods to replace the old conservative evaluation method (EM) was performed by the licensee in several plants such as Kori Unit 1, KSNP and Shinkori Units 3&4. The KINS (Korea Institute of Nuclear Safety) has also conducted the regulatory audit calculation by using the KINS Realistic Evaluation Methodology (KINS-REM) to confirm the validity of licensee's calculation [1,2]. The RELAP5/MOD3.3 code has been used in KINS-REM.

Currently, KINS has performed the verification and validation works of the MARS code which is the major part of the best-estimate reactor transient analysis system (RETAS). The backbones of MARS code are RELAP5/MOD3.2 and COBRA-TF [3]. The MASR was dialed for the best estimate calculations including the uncertainty evaluation and its applicability to the LBLOCA was justified through the BEMUSE program of OECD/NEA [4].

In this study, the preliminary assessment was performed to confirm the applicability of MARS to KINS-REM. Since the dialing method of MARS is different from that of RELAP5/MOD3.3 in KINS-REM, the effect for the code change can be evaluated. The accident scenario is selected as the LBLOCA of Shinkori Units 3&4.

2. Uncertainty Evaluation for LBLOCA of Shinkori Units 3&4

Through the licensing process of Shinkori Units 3&4 whose construction permit was issued in 2008, the audit calculation was performed by using the KINS-REM [2]. The sampling sets used in reference [2] were consistently used in this study while the frozen code was changed from RELAP5/MOD3.3 to MASR.

In KINS-REM, the final peak cladding temperature (PCT_{final}) is obtained as below;

$$PCT_{final} = PCT_{95/95} + B_{SCALE} + B_{IET} + B_{SET} + B_{PLANT} \quad (1)$$

where $PCT_{95/95}$ are the PCT with 95% confidence and 95% probability level. B_{SCALE}, B_{IET}, B_{SET} and B_{PLANT} are the bias due to the scale, the accuracy of code/model for the integral/separate effect tests and the system parameters which is not considered in determination of $PCT_{95/95}$, respectively.

2.1. Dialing Method of RELAP5 and MARS

Table I shows the uncertainty range and distribution which is used in this study. Among 18 uncertainty parameters, 6 parameters including the Dittus-Boelter correlation are related to the heat transfer model and they are activated in the non-reflood phase. In the KINS-REM, the RELAP5/MOD3.3 was dialed that the sampling value was multiplied for these 6 separate models, respectively. Therefore, the Zuber model for CHF phenomena which was used in the reflood phase was not considered in dialing of KINS-REM. The uncertainty range and distribution for them was determined through the data covering studies for the related experiments. On the other hand, the MARS was dialed for the sampling value to be considered the separate regions of the boiling curve. Therefore, the sampling value could be applied to all phases including the reflood phase.

Table I: Uncertainty Range and Distribution

No	Models/parameters	Range (Distribution*)
1	Gap conductance (Clad roughness)	0.4~1.5 (U)
2	Fuel thermal conductivity	0.847~1.153 (U)
3	Core power	0.98~1.02 (N)
4	Decay heat	0.934~1.066 (N)
5	Groeneveld-CHF	0.17~1.8 (N)
6	Chen-nucleate boiling HT	0.53~1.46 (N)
7	Transition Boiling Criteria	0.54~1.46 (N)
8	Dittus-Boelter (liquid)	0.606~1.39 (N)
9	Dittus-Boelter (vapor)	0.606~1.39 (N)
10	Bromley film boiling	0.428~1.58 (N)
11	Break C_D	0.729~1.165 (N)
12	Pump 2-f head multiplier	0.0~1.0 (U)
13	Pump 2-f torque multiplier	0.0~1.0 (U)
14	SIT actuation pressure (MPa)	4.03~4.46 (N)
15	SIT water inventory (m^3)	45.31~54.57 (N)
16	SIT temp. (K)	294.11~321.89 (U)
17	SIT loss coefficient	10.8~25.2 (N)
18	HPSI water temp. (K)	283~321.89 (U)

* U : Uniform, N : Normal

2.2 Results and Discussion

The uncertainty combinations for parameters in Table I were obtained by the simple random sampling (SRS) process. 124 input decks for steady state and transient were calculated with the related models dialed in MARS. Five high-ranking PCTs among 124 transient calculations are shown in Table II and the $PCT_{95/95}$ is 1208.9 K at 10 sec in a blowdown phase of No. 92 run. In this study, the biases such as SET (B_{SET}), IET (B_{IET}), scale (B_{SCALE}) and specific plant (B_{PLANT}) were not evaluated by using the MARS. If the effect of the biases is neglected, the total uncertainty for PCT (PCT_{final}) is obtained as 1208.9 K.

Table II: Five High-ranking PCTs for 124 runs

	No. Case	Node	Blowdown		Reflood	
			Time(s)	PCT(K)	Time(s)	Clad. Temp.(K)
1	25	14	10.	1276.2	52.	1207.7
2	16	14	10.	1221.6	46.	1053.4
3	92	14	10.	1208.9	48.	1144.4
4	11	14	10.	1206.2	48.	1070.9
5	3	14	12.	1180.2	48.	1056.2

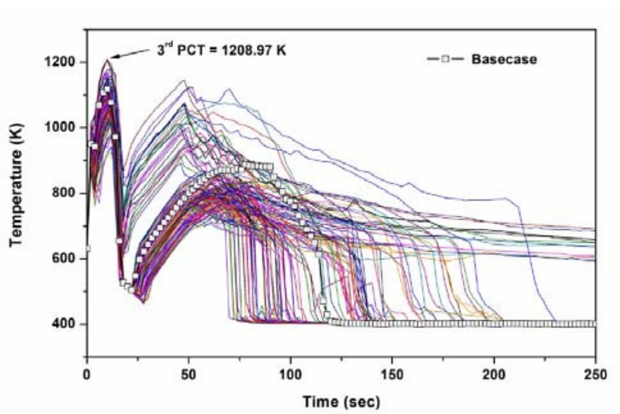

Fig. 1. Fuel Cladding Temperature (MARS)

The fuel cladding temperature excluding the code runs for two high-ranking PCTs was shown in Fig. 1. In the blowdown phase, the behavior of the cladding temperature is similar to that for RELAP5. The $PCT_{95/95}$ from the RELAP5 calculation was 30 K higher that from MARS. In the reflood phase, the cladding temperature between two cases is quietly different, especially on the quenching behavior. As shown in Fig. 1, the fuel cladding for 11 code runs was not predicted to quench till 250 seconds. On the other hand, the fuel cladding was quenched at about 200 seconds in all cases in the RELAP5 calculation. This may be resulted from the difference of the dialing method as described above. The appropriate uncertainty range in the heat transfer model of non-reflood phase may result in an unexpected conservative effect on the reflood phase since the model in non-reflood phase is different from that in reflood phase. Thereby, the uncertainty range should be revaluated carefully for the heat transfer model on a reflood phase. Also, from the BEMUSE program, it was known that the uncertainty effect on the CHF model was significant to the PCT behavior in reflood phase of MARS analysis. We could identified from Fig. 2 that the code runs which have small uncertainty values for CHF model, show non-quenching phenomena as shown in Fig. 1.

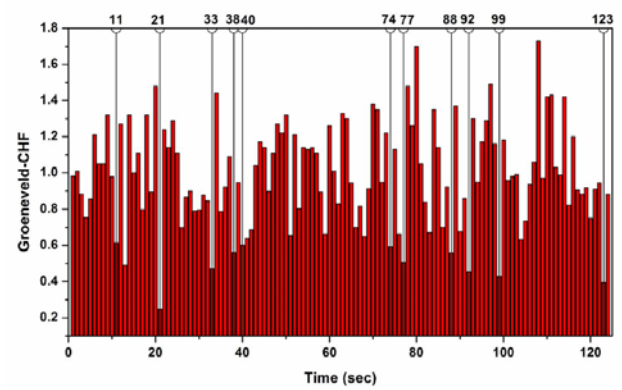

Fig. 2. Distribution of 124 Sampling values for Groeneveld-CHF

4. Conclusion

In this study, the applicability of MARS to the KINS-REM has been evaluated for the LBLOCA analysis of Shinkori Units 3&4. The PCT difference between two codes may result from the dialing method of the uncertainty model. The more detailed analysis for the separate heat transfer model would be needed to consider the uncertainty range appropriately.

REFERENCES

[1] KINS, Evaluation of ECCS Performance of Kori Unit 1 Using KINS Best-Estimate Methodology, KINS/RR-531, 2007.
[2] KINS, Evaluation of ECCS Performance for Large Break Loss of Coolant Accident of Shinkori Units 3&4, KINS/AR-873, 2008.
[3] KAERI, MARS Code Manual, KAERI/TR-3402, 2005.
[4] OECD/NEA, BEMUSE Phase V Draft Report, 2008.