A Proposal to upgrade KREM with respect to Scale and Code Deficiency

Sang Yong Lee [a*]
[a]*KEPCO International Nuclear Graduate School,*
658-91 Haemaji-ro Seosaeng-myeon Ulju-gun, Ulsan 689-882, Republic of Korea
[*]*Corresponding author: sangleey@kings.ac.kr*

1. Introduction

Korea Realistic Evaluation Model (KREM) basically follows Code Scale Applicability and Uncertainty (CSAU) [1] methodology (Fig.1 and 2). Since KREM was approved by the Korean authority in 2002, it has been applied to support several important domestic and foreign projects such as APR-1400(Advanced Power Reactor) design, APR-1400 export to United Arab Emirates (UAE) and U.S. NRC design certification of APR-1400. Encouraged by these activities, I would like to propose some suggestions to modify and improve KREM.

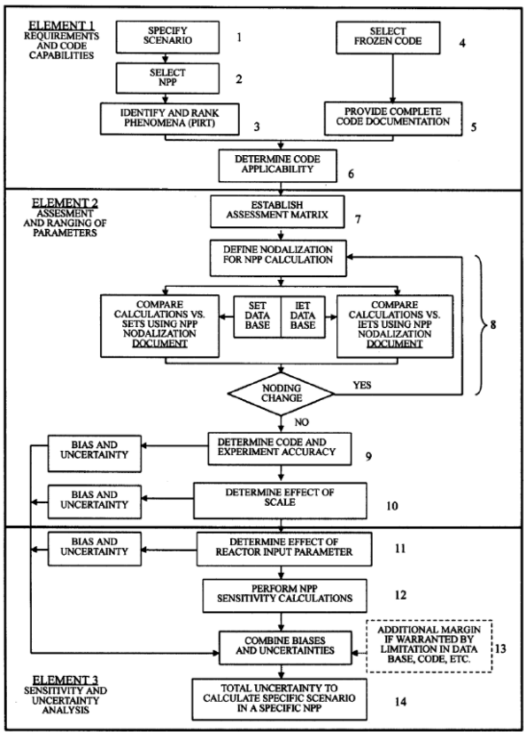

Fig.1. TRAC-CSAU Methodology

The first suggestion is related with the Experimental Data Covering (EDC) process (Fig.2). In this paper, it is shown that the EDC process can be formulated with respect to the scaled system uncertainty quantification. The second suggestion is concerning the bias due to the scale deficiency related with the multi-dimensional effect. A proposal to extend KREM to have multi-dimensional capability is made so that the related bias can be removed.

2. Scaled System Uncertainty Quantification and EDC

EDC is a very unique feature in KREM. It is mainly designed for the confirmation of the adequacy of the uncertainty parameters and their ranges.

The main part of the EDC process is to perform the Simple Random Sampling Calculation (SRSC) using the selected uncertainty parameters. A typical result of SRSC is shown Fig.3 for the reflood experiment, FLECHT-34006.

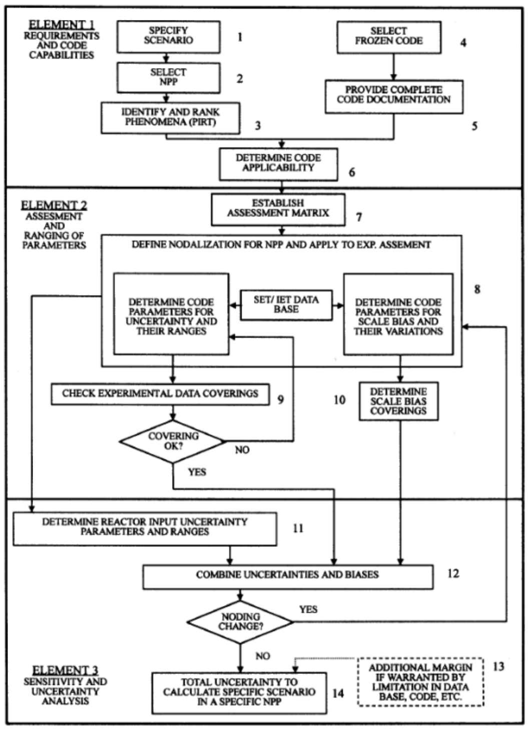

Fig.2. KREM Methodology

The essential idea of the EDC process was not recognized during the KREM developmental stage because the above mentioned confirmation was the sole important objective.

But, when the whole EDC process is looked into carefully, it is nothing but a process to quantify the uncertainty for the concerned scaled test facility using the simple random calculation. This process is called as the Scaled System Uncertainty Quantification (SSUQ) for further discussions.

The inclusion of the operational parameter such as inlet flow rate of the experimental test facility as an uncertainty parameter was debated long during the developmental stage of KREM. Some of them, not all of them, were decided to be included to guarantee the covering of the experimental value. The uncertainty of the inlet flow rate of the FLECHT test, for example, was the one included. But, if the EDC process is regarded as the SSUQ process, then, the inclusion of the operational parameters of the test facilities is the natural process of the uncertainty quantification.

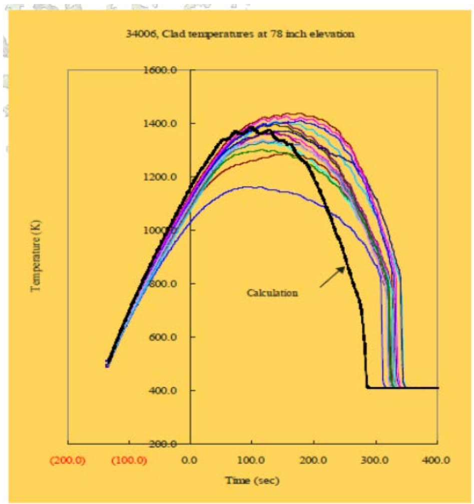

Fig.3. Simple Random Sampling Calculation for FLECHT-34006

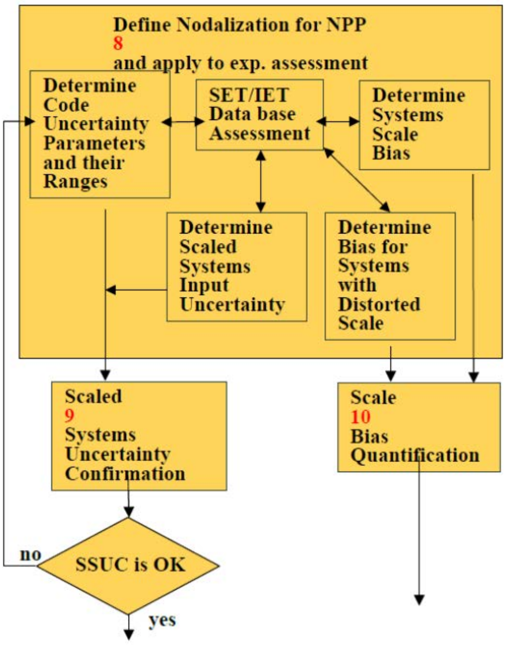

Fig.4. Modified KREM steps related with SSUQ

Therefore, it is recommended that future KREM should be modified to include the operational parameters during the SSUQ process. This inclusion is also consistent with the uncertainty quantification of the target reactor system in which uncertainties of the operational parameters are fully reflected.

With this modification, the procedural chart of KREM is changed as shown in Fig.4. This modification helps KREM users have clearer understanding of the involved steps. One additional benefit of the modification is that the terminology SSUQ is more descriptive than the term EDC.

3. COBRA-TF for Multi-dimensional Phenomena

The downcomer behavior during the Large Break Loss of Coolant Accident (LB-LOCA) is truly two or three dimensional phenomena. As RELAP5 is a one-dimensional code, it is not appropriate to apply RELAP5 to model the phenomena. Therefore, in KREM, the dimensional code deficiency of RELAP5 is treated with the bias or the penalty based on the simulation of the full scale test facility, Upper Plenum Test Facility (UPTF). This is really not a best estimate approach.

Author developed a code system, COBRA-RELAP by combining RELAP5 with COBRA-TF [2] during early nineties. It is further improved to be MARS. COBRA-TF is a full three dimensional multi-fluid code. The natural way to extend KREM is to use COBRA-TF for the concerned 3-dimensional phenomena. Recently, it has been extensively studied and documented.

One of the obstacles to develop the three-dimensional code was the lack of the experimental test data in old days. Fortunately, UPTF test data are heard available these days [3]. Data from Cylindrical Core Test Facility (CCTF) and Slab Core Test Facility (SCTF) are not available yet. But, they are not essential for KREM since it is well known that the core behavior of the typical Pressurized Water Reactor (PWR) during LB-LOCA is mainly one-dimensional phenomena.

4. Conclusions

The terminology SSUQ is introduced to replace the term EDC in KREM to naturally include the operational parameters. COBRA-TF is strongly recommended to handle the multi-dimensional phenomena in the improved KREM.

REFERENCES

[1] B. Boyack. et. al., “Quantifying Reactor Safety Margins: Application of Code Scaling, Applicability, and Uncertainty Evaluation Methodology to a Large-Break, Loss-of-Coolant Accident”, US. NRC, NUREG/CR-5249, 1989.
[2] R. K. Salko, M. N. Avramova, “COBRA-TF (CTF) Theory Manual”, The Pennsylvania State University, Department of Mechanical and Nuclear Engineering, Reactor Dynamics and Fuel Management Group, March, 2015.
[3] W. P. Baek, Private communication.