Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 7-8, 2015

Development of Educational and Training Simulator for Emergency Response to Chinese Nuclear Accidents

Juyub Kim[a*], Juyoul Kim[a], Sukhoon Kim[a], Seunghee Lee[a], Taebin Yoon[a], Li-Chi Cliff Po[b]
[a]*FNC Technology Co., Ltd., 32F, 13, Heungdeok 1-ro, Giheung-gu, Yongin, Korea*
[b]*Micro-Simulation Technology (MST), 10 Navajo Court, Montville, NJ 07045, USA*
[*]*Corresponding author: yubjoo@fnctech.com*

1. Introduction

Currently, lessons learned from Fukushima Daiichi Nuclear Accident are main issues for the safety of nuclear power plant. One of the lessons in the emergency response category is that information on the nuclear power plants of neighboring countries should be organized and the consequence can be assessed. In addition, many reactors have been constructed and are under construction on the eastern coast of China recently. Korea might be directly affected by an accident of Chinese nuclear power plant since Korea is located in the westerly belt.

Thus, the simulator system for the nuclear accident in neighboring countries such as China, Japan and Taiwan is needed to be developed in order to support the emergency response. The simulator system should have three main functions: source term estimation, atmospheric dispersion prediction and dose assessment.

A PC-based nuclear power plant accident simulator which can estimate the source term of accident especially for the purpose of education and training is under development for the representative reactor model in China as a part of the simulator system.

2. Representative Reactor Model in China

As of February 2015, 23 and 25 power reactors are in operation and under construction in China, respectively [1]. In order to select the representative reactor model, following characteristics were considered:

- Number of reactors
- Operation Period
- Power capacity
- Distance

Table I shows the number of reactors in China by type and model including reactors which are under construction. CPR-1000 is a dominant reactor model and takes about 46% of total number of power reactors in China.

Most Chinese power reactor has been constructed after 2000 and more than half of total reactors are younger than 10 years [2]. Thus, the operation period is not a main factor in case of China.

As the power capacity of reactor increases, the consequence of accident becomes greater. Also, the distance from the source to the receptor decreases, the consequence of accident becomes greater. In this study, power reactors with the power capacity of above 1,000 MWe and the distance within 1,000 km from the nearest inland boundary of Korea are considered. There are 18 reactors in this condition and CPR-1000 is a dominant reactor model also with 56% in this group (Table I).

Therefore, CPR-1000 has been selected as the representative reactor model in China.

Table I: Number of Reactor by Type and Model

Type	Model	Total No. of Reactor	A	B	A+B
HTGR	HTR-PM	1	0	1	0
PWR	M310	4	0	0	0
	CPR-1000	**22**	**22**	**10**	**10**
	CNP-600	6	0	4	0
	CNP-300	1	0	1	0
	PHWR CANDU 6	2	0	2	0
	VVER V-428	2	2	2	2
	VVER V-428M	2	2	2	2
	AP-1000	4	4	4	4
	EPR-1750	2	2	0	0
	ACPR-1000	2	2	0	0
Total		48	34	26	18

A: No. of reactors above 1,000 MWe
B: No. of reactors within 1,000 km from Korea
A+B: No. of reactors above 1,000 MWe and within 1,000 km from Korea

3. PC-based Nuclear Power Plant Simulator for CPR-1000

3.1 PCTRAN/CPR-1000

PCTRAN is a PC-based nuclear power plant simulator and has several modules for each reactor type. It is widely used especially for the training purpose in IAEA, universities and so on. PCTRAN/CPR-1000 is under development for simulation of CPR-1000 reactor model in China by international joint research of FNC Technology and Micro-Simulation Technology. It will have the capability to simulate the normal operation including transient, DBA (Design Based Accident) and severe accident of CPR-1000. Figure 1 shows the main display of PCTRAN/CPR-1000 module.

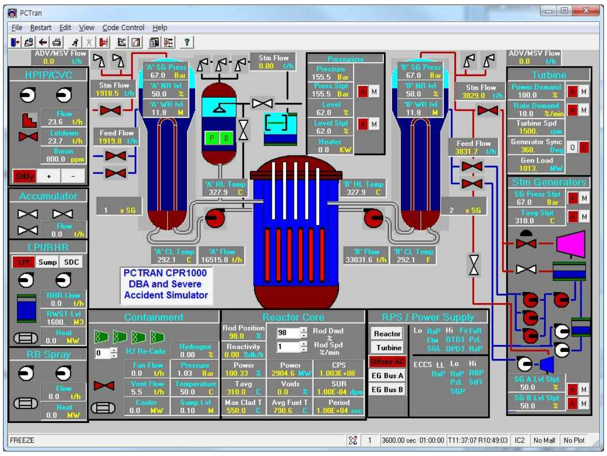

Fig. 1. Main Display of PCTRAN/CPR-1000

3.2 Transient Scenario Simulation

In order to verify the function of PCTRAN/CPR-1000 module, hypothetic DBA scenario was simulated.

Initial condition was set to MOC (Middle of Cycle) and normal operation was continued for 1 hour. After 1 hour, SGTR (Steam Generator Tube Rupture) occurred with the 5% of full tube rupture in the steam generator A. SGTR continued approximately 10 hours and then calculation was terminated manually. Figure 2 shows the results of I-131 and Xe-133 released to the environment.

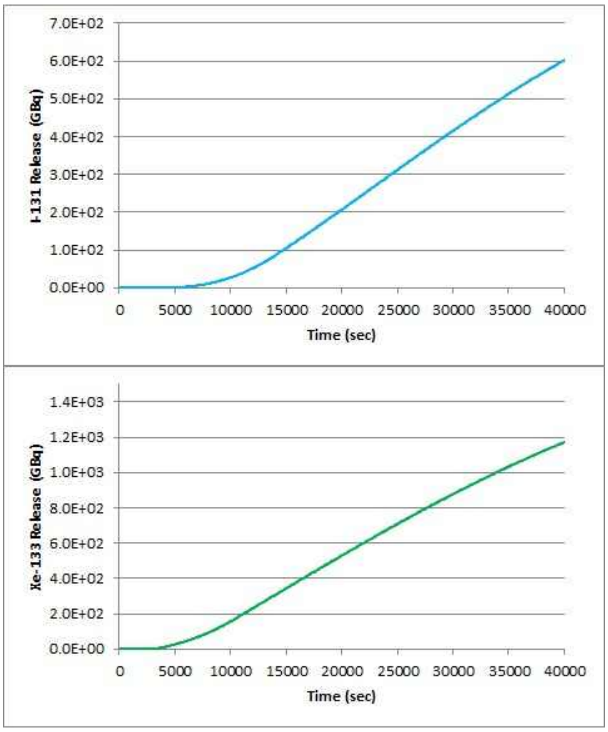

Figure 2. Release of I-131 (Top) and Xe-133 (Bottom)

4. Conclusions

As a part of the educational and training simulator for the nuclear accident from neighboring countries, a PC-based nuclear power plant simulator, PCTRAN/CPR-1000, is currently developed especially for the CPR-1000 reactor model which is the representative reactor model in China.

An example simulation of SGTR scenario was performed with the PCTRAN/CPR-1000 module. The result showed that normal operation and DBA conditions were simulated swiftly with the speed of 16 times faster than real time. Thus, it would be a good source term estimation module for the educational and training simulator.

The module of normal operation and DBA for CPR-1000 is under development. In further study, the module for severe accident as well as DBA will be developed, so that the SBO (Station Blackout) accident such as Fukushima Daiichi Nuclear Accident could be assessed. In addition, the modules for atmospheric dispersion prediction and dose assessment will be developed. These modules will form the integrated PC-based nuclear accident simulator system. The system could assist the decision making for emergency response and especially might be useful for education and training of emergency staffs.

ACKNOWLEDGMENTS

This work was supported by the Nuclear Safety Research Program through the Korea Radiation Safety Foundation(KORSAFe), granted financial resource from the Nuclear Safety and Security Commission(NSSC), Republic of Korea (No. 1403007)

REFERENCES

[1] IAEA, Power Reactor Information System, https://pris.iaea.org/PRIS/home.aspx

[2] Korea Institute of Nuclear Safety, Establishment of Nuclear Information Database System for Neighboring Countries, KINS/RR-861, 2011