NUREG/IA-0434

International Agreement Report

The Development and Application of TRACE/PARCS Model for Lungmen ABWR

Prepared by:
Jong-Rong Wang, Chia-Ying Chang*, Hao-Tzu Lin, Chunkuan Shih*

Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.
1000, Wenhua Rd., Chiaan Village, Lungtan, Taoyuan, 325, Taiwan

*Institute of Nuclear Engineering and Science, National Tsing Hua University
101 Section 2, Kuang Fu Rd., HsinChu, Taiwan

K. Tien, NRC Project Manager

Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Manuscript Completed: April 2013
Date Published: December 2013

Prepared as part of
The Agreement on Research Participation and Technical Exchange
Under the Thermal-Hydraulic Code Applications and Maintenance Program (CAMP)

Published by
U.S. Nuclear Regulatory Commission

AVAILABILITY OF REFERENCE MATERIALS IN NRC PUBLICATIONS

NRC Reference Material

As of November 1999, you may electronically access NUREG-series publications and other NRC records at NRC's Public Electronic Reading Room at http://www.nrc.gov/reading-rm.html. Publicly released records include, to name a few, NUREG-series publications; *Federal Register* notices; applicant, licensee, and vendor documents and correspondence; NRC correspondence and internal memoranda; bulletins and information notices; inspection and investigative reports; licensee event reports; and Commission papers and their attachments.

NRC publications in the NUREG series, NRC regulations, and Title 10, "Energy," in the *Code of Federal Regulations* may also be purchased from one of these two sources.

1. The Superintendent of Documents
   U.S. Government Printing Office
   Mail Stop SSOP
   Washington, DC 20402–0001
   Internet: bookstore.gpo.gov
   Telephone: 202-512-1800
   Fax: 202-512-2250
2. The National Technical Information Service
   Springfield, VA 22161–0002
   www.ntis.gov
   1–800–553–6847 or, locally, 703–605–6000

A single copy of each NRC draft report for comment is available free, to the extent of supply, upon written request as follows:
Address: U.S. Nuclear Regulatory Commission
Office of Administration
Publications Branch
Washington, DC 20555-0001
E-mail: DISTRIBUTION.RESOURCE@NRC.GOV
Facsimile: 301–415–2289

Some publications in the NUREG series that are posted at NRC's Web site address http://www.nrc.gov/reading-rm/doc-collections/nuregs are updated periodically and may differ from the last printed version. Although references to material found on a Web site bear the date the material was accessed, the material available on the date cited may subsequently be removed from the site.

Non-NRC Reference Material

Documents available from public and special technical libraries include all open literature items, such as books, journal articles, transactions, *Federal Register* notices, Federal and State legislation, and congressional reports. Such documents as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings may be purchased from their sponsoring organization.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at—
The NRC Technical Library
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852–2738

These standards are available in the library for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from—
American National Standards Institute
11 West 42nd Street
New York, NY 10036–8002
www.ansi.org
212–642–4900

Legally binding regulatory requirements are stated only in laws; NRC regulations; licenses, including technical specifications; or orders, not in NUREG-series publications. The views expressed in contractor-prepared publications in this series are not necessarily those of the NRC.

The NUREG series comprises (1) technical and administrative reports and books prepared by the staff (NUREG-XXXX) or agency contractors (NUREG/CR-XXXX), (2) proceedings of conferences (NUREG/CP-XXXX), (3) reports resulting from international agreements (NUREG/IA-XXXX), (4) brochures (NUREG/BR-XXXX), and (5) compilations of legal decisions and orders of the Commission and Atomic and Safety Licensing Boards and of Directors' decisions under Section 2.206 of NRC's regulations (NUREG-0750).

NUREG/IA-0434

International Agreement Report

The Development and Application of TRACE/PARCS Model for Lungmen ABWR

Prepared by:
Jong-Rong Wang, Chia-Ying Chang*, Hao-Tzu Lin, Chunkuan Shih*

Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.
1000, Wenhua Rd., Chiaan Village, Lungtan, Taoyuan, 325, Taiwan

*Institute of Nuclear Engineering and Science, National Tsing Hua University
101 Section 2, Kuang Fu Rd., HsinChu, Taiwan

K. Tien, NRC Project Manager

Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Manuscript Completed: April 2013
Date Published: December 2013

Prepared as part of
The Agreement on Research Participation and Technical Exchange
Under the Thermal-Hydraulic Code Applications and Maintenance Program (CAMP)

Published by
U.S. Nuclear Regulatory Commission

ABSTRACT

TRACE code developed by US NRC is an advanced thermal hydraulic system code for nuclear power plant safety analysis. The feature of 3-D reactor vessel simulation in TRACE allows complex flow modeling and this kind of vessel is employed in Lungmen TRACE model. PARCS is a multi-dimensional neutronic simulator which is able to incorporate a 3-D reactor core with one-to-one fuel assembly simulation for the realistic representative. The state-of-the-art is that PARCS is capable of being coupled to TRACE, which provides the temperature and flow field information to PARCS during calculations. In this research, the TRACE/PARCS model of Lungmen nuclear power plant is established first. Then, the TRACE/PARCS model is used for two transient analyses - 3 RIPs trip and HPCF inadvertent startup. These events could test the ability of the coupling of TRACE and PARCS. Moreover, SNAP, a user-friendly interface developed by the US NRC and APT, provides users a graphical working environment and enables to animate the simulation as an alternative presentation of calculation results.

FOREWORD

The US NRC (United States Nuclear Regulatory Commission) is developing an advanced thermal hydraulic code named TRACE for nuclear power plant safety analysis. The development of TRACE is based on TRAC, integrating RELAP5 and other programs. NRC has determined that in the future, TRACE will be the main code used in thermal hydraulic safety analysis, and no further development of other thermal hydraulic codes such as RELAP5 and TRAC will be continued. A graphic user interface program, SNAP (Symbolic Nuclear Analysis Program) which processes inputs and outputs for TRACE is also under development. One of the features of TRACE is its capacity to model the reactor vessel with 3-D geometry. It can support a more accurate and detailed safety analysis of nuclear power plants. TRACE has a greater simulation capability than the other old codes, especially for events like LOCA.

Taiwan and the United States have signed an agreement on CAMP (Code Applications and Maintenance Program) which includes the development and maintenance of TRACE. INER (Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.) is the organization in Taiwan responsible for the application of TRACE in thermal hydraulic safety analysis, for recording user’s experiences of it, and providing suggestions for its development. In this report, the TRACE/PARCS model of Lungmen NPP has been built and the analysis of 3 RIPs trip and HPCF inadvertent startup are performed.

CONTENTS

Page

ABSTRACT ... iii

FOREWORD ... v

CONTENTS ... vii

FIGURES ... ix

EXECUTIVE SUMMARY ... xi

ABBREVIATIONS ... xiii

1. INTRODUCTION ... 1-1

2. DESCRIPTION OF LUNGMEN MODELS ... 2-1
2.1 Lungmen TRACE Model ... 2-1
2.2 Lungmen PARCS Model ... 2-2
2.3 Lungmen TRACE/PARCS Coupling ... 2-3

3. RESULTS AND DISCUSSION ... 3-1
3.1 Steady State Results ... 3-1
3.2 Transients Results ... 3-3
3.2.1 3 RIPs Trip ... 3-3
3.2.2 HPCF Inadvertent Startup ... 3-5

4. CONCLUSIONS ... 4-1

5. REFERENCES ... 5-1

FIGURES

Page

1. **Lungmen TRACE model** 2-1
2. **206 CHAN assignment in Lungmen TRACE model** 2-2
3. **205 control rod pattern of Lungmen PARCS model** 2-3
4. **Axial relative power difference between PARCS and SIMULATE-3** 3-2
5. **Radial relative power difference between PARCS and SIMULATE-3** 3-2
6. **The comparisons of core inlet flow for 3 RIPs trip** 3-3
7. **The comparisons of reactivity for 3 RIPs trip (a) Void reactivity, (b) Doppler reactivity, and (c) Total reactivity** 3-4
8. **The comparisons of power for 3 RIPs trip** 3-5
9. **Responses of power, steam flow rate, core inlet flow rate and feedwater flow rate for HPCF inadvertent startup** 3-6
10. **Responses of Water level and pressure rise for HPCF inadvertent startup** 3-7
11. **Reactivity responses of the prediction analysis for HPCF inadvertent startup** 3-7
12. **Lungmen animation model for HPCF inadvertent startup** 3-8

EXECUTIVE SUMMARY

Lungmen nuclear power plant (NPP) is the first ABWR plant in Taiwan and still under construction. It has two identical units with 3,926 MWt rated thermal power each and 52.2×10^6 kg/hr rated core flow. The core has 872 bundles of GE14 fuel, and the steam flow is 7.637×10^6 kg/hr at rated power. There are 10 RIPs (reactor internal pumps) in the reactor vessel, providing 111% rated core flow at the nominal operating speed of 151.84 rad/sec.

According to the user manual, TRACE is the product of a long term effort to combine the capabilities of the NRC's four main systems codes (TRAC-P, TRAC-B, RELAP5 and RAMONA) into one modernized computational tool. NRC has ensured that TRACE will be the main code used in thermal hydraulic safety analysis in the future without further development of other thermal hydraulic codes, such as RELAP5 and TRAC. Besides, the 3-D geometry model of reactor vessel, which is one of the representative features of TRACE, can support a more accurate and detailed safety analysis of NPPs. On the whole TRACE provides greater simulation capability than the previous codes, especially for events like LOCA.

PARCS is a multi-dimensional reactor core simulator which involves a 3-D calculation model for the realistic representation of the physical reactor while 1-D modeling features are also available. PARCS is capable of coupling the thermal-hydraulics system codes such as TRACE directly, which provide the temperature and flow field data for PARCS during the calculations.

This research focuses on the development of the Lungmen NPP TRACE/PARCS model. The TRACE/PARCS model is used for two transient analyses - 3 RIPs trip and HPCF inadvertent startup. These events could test the ability of the coupling of TRACE and PARCS. The trends of these parameters are generally in consistent with FSAR data. Besides, the animation model of Lungmen NPP is also established by using SNAP code. The analysis results of TRACE/PARCS can be observed in the animation model of Lungmen NPP.

ABBREVIATIONS

ABWR	Advanced Boiling Water Reactor
APT	Applied Programming Technology
CAMP	Code Applications and Maintenance Program
ECCS	Emergency Core Cooling System
FSAR	Final Safety Analysis Report
HPCF	High Pressure Core Flooder
HPCI	High Pressure Coolant Injection
INER	Institute of Nuclear Energy Research
NRC	Nuclear Regulatory Commission
NPP	Nuclear Power Plant
PARCS	Purdue Advance Reactor Core Simulator
RCIS	Rod Control & Information System
RCPB	Reactor Coolant Pressure Boundary
RFCS	Recirculation Flow Control System
RPV	Reactor Pressure Vessel
SCRRI	Selected Control Rod Run-In
SNAP	Symbolic Nuclear Analysis Package
TPC	Taiwan Power Company
TRACE	TRAC/RELAP Advanced Computational Engine

1. INTRODUCTION

Lungmen NPP, a GE-designed ABWR, is owned by Taipower Company. It has two identical units with 3926 MWt rated core thermal power and 52.2×10^6 kg/hr rated core flow each. The reactor core is comprised of 872 fuel assemblies and will be loaded with GE14 fuel in the initial core. Each GE14 fuel assembly has 10×10 arrays consisting of 92 fuel rods and 2 water rods with each occupying four equivalent fuel rod positions. The annular region in the lower downcomer of the reactor pressure vessel accommodates 10 RIPs which can provide core flow up to 111% of the rated capacity. Six of the 10 RIPs are connected to a motor-generator set (M-G Set) while the remaining 4 RIPs are not connected as such and are powered directly by the 13.8 kV Bus.

TRACE code developed by NRC is an advanced thermal hydraulic system code for nuclear power plant safety analysis. The feature of 3-D reactor vessel simulation in TRACE allows complex flow modelling and this kind of vessel is employed in Lungmen TRACE model. One of the features of TRACE is 3-D reactor vessel simulation which allows complex flow modeling. PARCS is a multi-dimensional neutronic simulator which is able to incorporate a 3-D reactor core with one-to-one fuel assembly simulation for the realistic representative. The state-of-the-art is that PARCS is capable of being coupled to TRACE, which provides the temperature and flow field information to PARCS during calculations. TRACE is responsible for NPP safety analysis simulating thermal-hydraulic system, and PARCS is responsible for the neutronic calculation in core according to the variations evaluated from TRACE. TRACE/PARCS model are believed to be the best-estimate calculations.

This research focuses on the development of the Lungmen NPP TRACE/PARCS model. Lungmen NPP TRACE/PARCS model is used for two transient analyses - 3 RIPs trip and HPCF inadvertent startup. These events could test the ability of the coupling of TRACE and PARCS. The transient data from FSAR [1] have been used to compare the analysis results of Lungmen NPP TRACE/PARCS model. Moreover, SNAP, a user-friendly interface developed by the U.S. NRC and APT, provides users a graphical working environment and enables to animate the simulation as an alternative presentation of calculation results.

2. DESCRIPTION OF LUNGMEN MODELS

2.1 Lungmen TRACE Model

SNAP v 2.2.1 and TRACE v 5.0p3 are used in this research. First, the system and operating data [1]-[5] for Lungmen NPP are collected. Second, several important control systems such as RIPs control system, steam bypass and pressure control system and feedwater control system etc. are established by SNAP and TRACE. Third, other necessary components (e.g., reactor pressure vessel and main steam piping) are added into the TRACE model to complete the TRACE model for Lungmen NPP. Figure 1 shows the major thermal-hydraulic components simulated in Lungmen NPP TRACE model. The 3-D VESSEL component is comprised of 11 axial levels, 4 radial rings where the outer ring models the downcomer, and 6 azimuthal sectors (separately in 36°, 36°, 108°, 36°, 36°, 108° apart) for a total of 264 computational cells. The 4 separate main steam lines are connected to the four 36° sectors, the 6 feedwater lines are connected to each azimuthal sector individually, and the 2 loops of HPCF system are connected to the 6th axial level of VESSEL above the core as design. Ten RIPs are arranged into three groups. The first two groups, with 3 RIPs each, are connected to M-G sets. The third group, which has 4 RIPs, is not connected to M-G sets. The simulation for core in Lungmen NPP TRACE model has been modified by replacing 206 CHAN components for the previous 18 CHAN components for finer calculation in core [3]. In TRACE model, the CHAN component is in lieu of fuel assemblies in core; the 872 fuel assemblies are assigned to 206 CHAN components with each CHAN component consisting of 3 to 7 fuel assemblies and the assignment is shown in Figure 2; this assignment is also mapped to Lungmen NPP PARCS model for coupling.

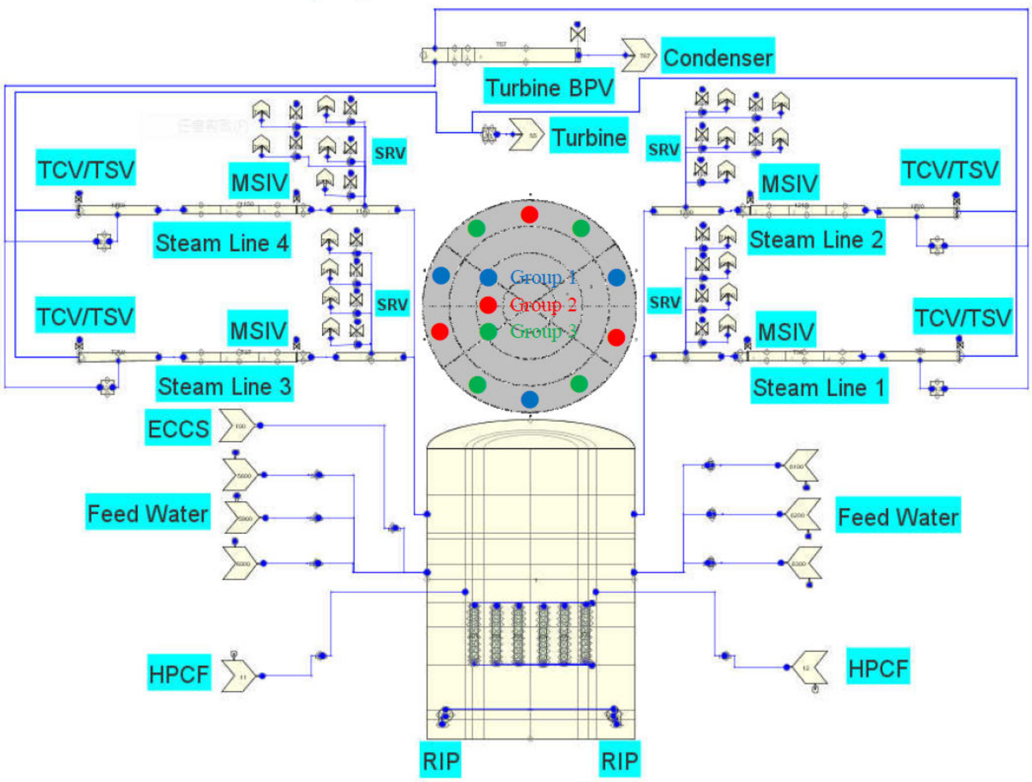

Figure 1 Lungmen TRACE model

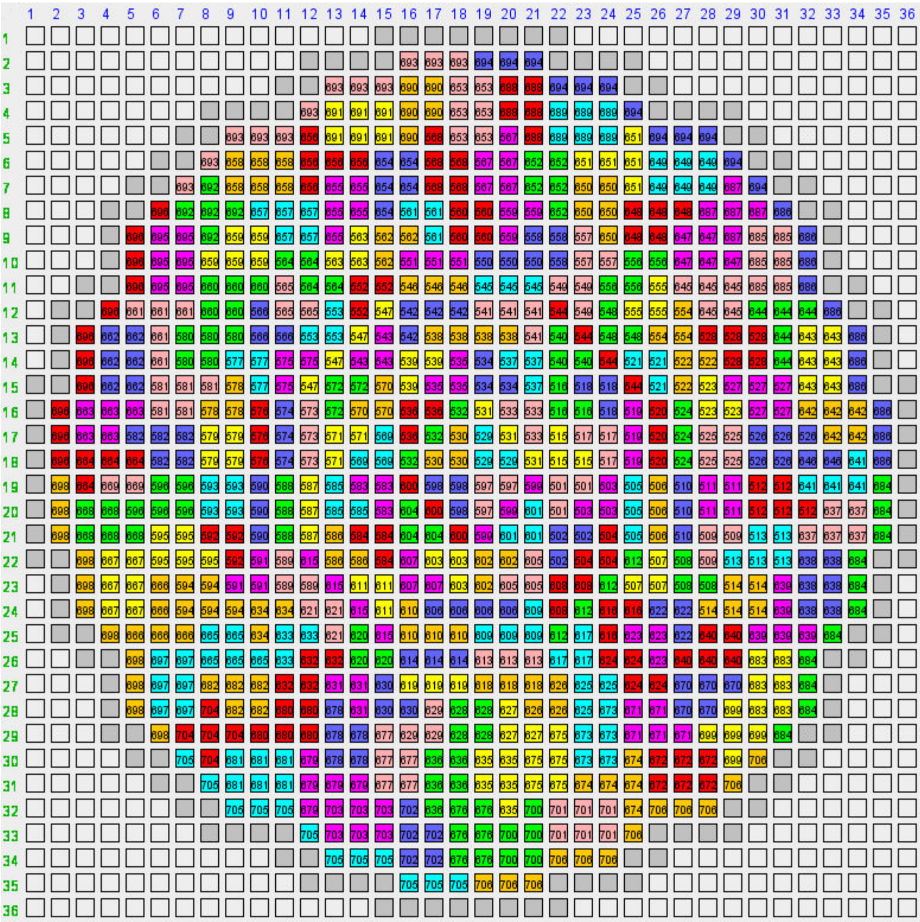

Figure 2 206 CHAN assignment in Lungmen TRACE model

2.2 Lungmen PARCS Model

In this work, 3-D core simulator PARCS V 3.0 is used. The model composed of 872 neutronic nodes representing 872 fuel assemblies one-to-one in radial direction. The active core height is 381 cm, which is modeled in PARCS with 25 axial layers. At the top and bottom of the active core, there exist two 15.24-cm-thick axial reflector regions. A total 205 control rods are also simulated as shown in Figure 3.

When processing, the PARCS model relies on the use of a special macroscopic cross-section file, PMAX. GenPAMXS code reformats the outputs of the lattice physics code, CASMO-4 in this work, as PMAX files which is able to comply with the cross-section format required in PARCS.

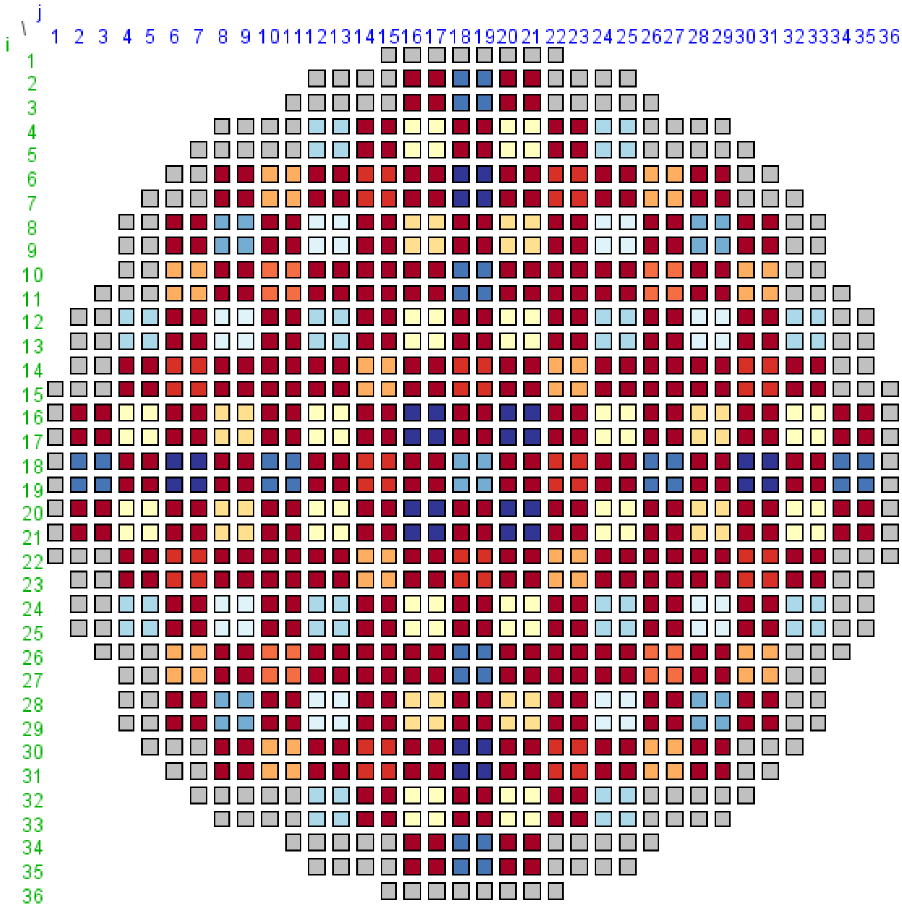

Figure 3 205 control rod pattern of Lungmen PARCS model

2.3 Lungmen TRACE/PARCS Coupling

In TRACE/PARCS model, the overall controls of the coupled transient, such as convergence checks and trip initiation are handled by TRACE. For fast steady state initialization, a neutronic calculation skipping strategy is used, i.e., PARCS calculation was done only once every 10 time advances in TRACE. In addition, the reflector nodes in PARCS are not mapped to thermal-hydraulic channels since the reflector thermal-hydraulic properties are fixed. Fuel assemblies are mapped into 206 thermal-hydraulic CHANs as shown in Figure 2 according to the distribution of the CHANs in TRACE model. The numbers in the figure indicate channel number assignments of the fuel assemblies and "0" corresponds to the reflector region.

3. RESULTS AND DISCUSSION

3.1 Steady State Results

To ensure that the data at steady state in TRACE model for Lungmen nuclear power plant are consistent with FSAR chapter 15, the steady state analysis should be conducted prior to transient analysis. As shown in Table 1, the steady state results are in good agreements with FSAR.

Table 1 The comparisons of FSAR and TRACE/PARCS for the steady state

Parameter	FSAR	TRACE standalone / Error (%)	TRACE/PARCS / Error (%)
Power (MWt)	3926	3926 / 0	3926 / 0
Steam flow (kg/s)	2122	2121.2 /0.04	2121.2 / 0.04
Core flow (kg/s)	14500	14487 / 0.09	14610 / 0.76
Dome pressure (MPa)	7.2	7.16 / 0.56	7.16 / 0.56
NRWL (m)	13.42	13.43 / 0.07	13.43 / 0.07

Lungmen SIMULATE-3 model, a verified core physics code, was used to examine the performances of Lungmen TRACE/PARCS model. The results of comparing the differences between TRACE/PARCS and SIMULATE-3 in axial and radial directions are shown as Figure 4 and Figure 5, respectively. In Figure 4, the axial relative power profile calculated by TRACE/PARCS is compared against SIMULATE-3 at the same condition. The distributions of the axial relative power profiles of both codes are similar, especially at the upper part of the core. As shown in Figure 5, the maximum difference in radial direction is under 25% and the difference is symmetric.

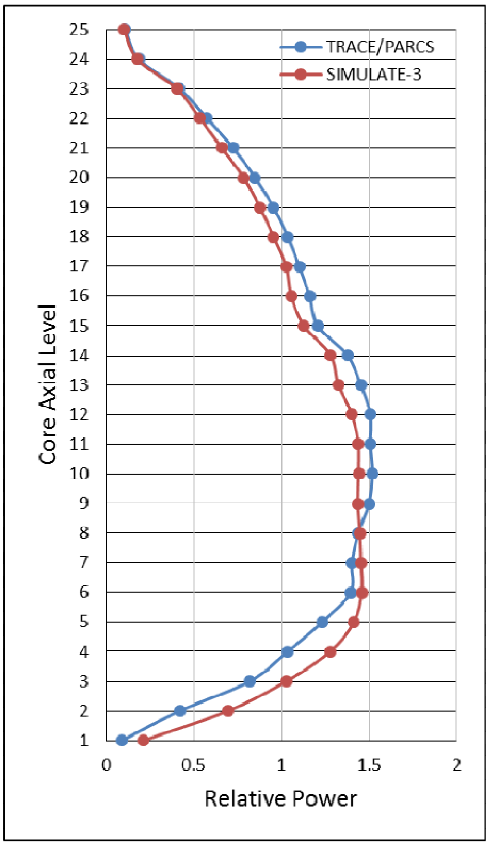

Figure 4 Axial relative power difference between PARCS and SIMULATE-3

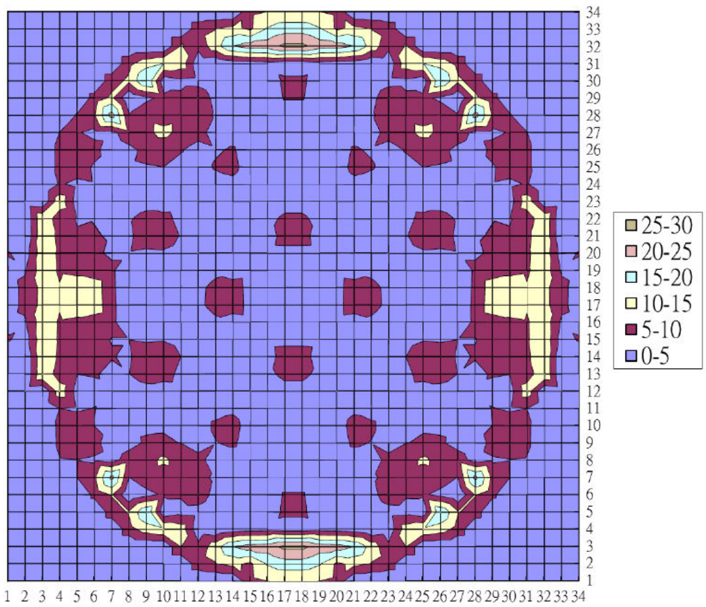

Figure 5 Radial relative power difference between PARCS and SIMULATE-3

3.2 Transient Results

3.2.1 3 RIPs Trip

In 3 RIPs trip transient, the core inlet flow drops immediately following the trip of RIPs. The reduction of core inlet flow leads to the increase of core void fraction and also negative reactivity which results in the decrease of the core power. At about 6 second, the core flow and power reaches its steady state. The simulation results of selected important system parameters are compared against FSAR data.

The trip of 3 RIPs causes the core inlet flow to decrease simultaneously as shown in Figure 6, and the core inlet flow become steady at around 1.5 second. The amount of void in core becomes greater due to the drop of the core inlet flow. Figure 7 indicates that the significant void reactivity feedback dominants the total reactivity. As a result, the core power drops corresponding to reactivity variations as presented in Figure 8. The trends of these parameters are generally in consistent with FSAR data.

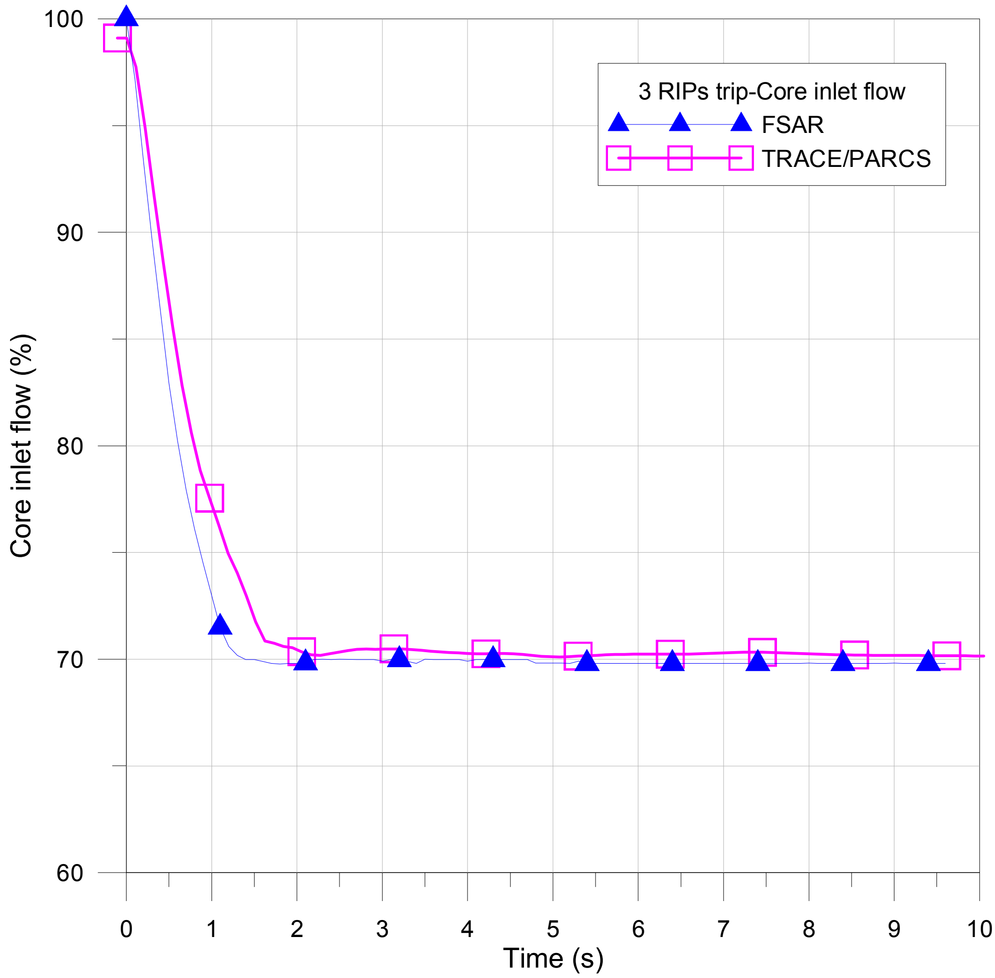

Figure 6 The comparisons of core inlet flow for 3 RIPs trip

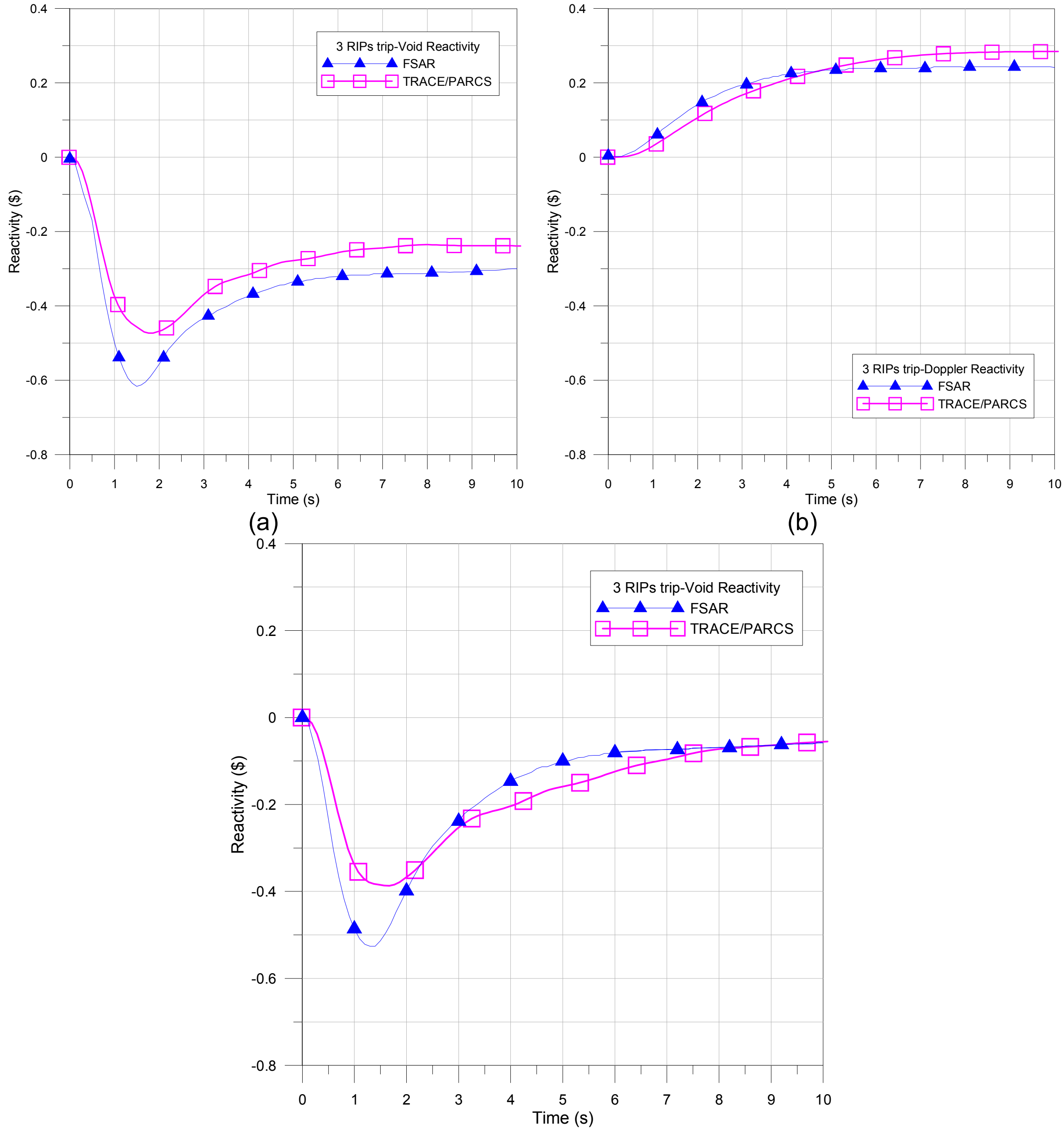

Figure 7 The comparisons of reactivity for 3 RIPs trip
(a) Void reactivity, (b) Doppler reactivity, and (c) Total reactivity

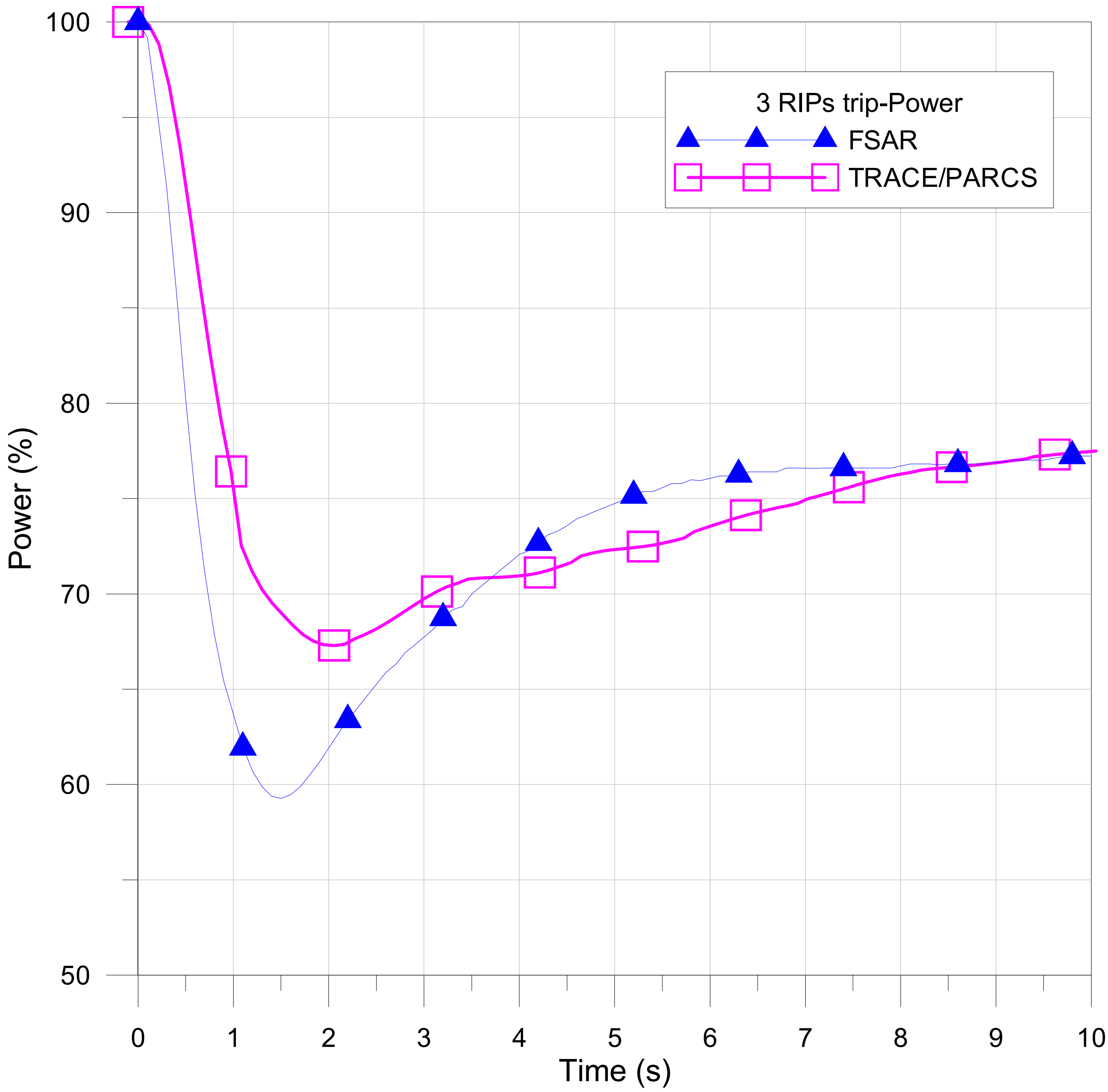

Figure 8 The comparisons of power for 3 RIPs trip

3.2.2 HPCF Inadvertent Startup

In Lungmen NPP, inadvertent startup of the HPCF System is the “increase in reactor coolant Inventory” transient, supposedly due to system malfunction or operator error. HPCF is comprised of two loops flooding water to the RPV above the core. HPCF inadvertent startup is postulated that under normal operation, one loop of the HPCF introduces cold water of 40°C into the upper core plenum, and the full HPCF flow is established within 1 second. The addition of cooler water to the upper plenum results in a reduction in steam flow, causing slight depressurization in the RPV. Despite the transient is mild, the asymmetric injection in the RPV will make temperature and flow field distribute unevenly.

Figure 9 and 10 present the system response for the simulated transient event, inadvertent startup of HPCF. One loop of the HPCF system begins to introduce cold water over the core in the RPV, and within 1 second, the full HPCF flow is established. The additional cooler water into the upper plenum leads to a reduction in steam flow and causes slight depressurization as the pressure regulator responds to the event. In Figure 11, the reactivity responses are no significance. Therefore, in that thermal and pressure variations are relatively small. Hence, this event is a mild transient. The HPCI system in traditional BWRs injects coolant through the downcomer together with feedwater into the reactor core [5]. Compared with the BWRs, the introduction of HPCF over the core in Lungmen ABWR affects the core much more directly.

Even though the inadvertent startup of HPCF is a mild event for Lungmen ABWR, the asymmetry injection in the RPV would make temperature and flow field distribute unevenly. The 3-D vessel simulation in TRACE together with 3-D core simulation in PARCS enables the evaluation for local feedback effects and local responses such that the animation under SNAP interface is able to demonstrate the asymmetric phenomenon of the distribution of temperature, fluid condition, and relative power with 3-D display. The animation model is to embody the calculation results with not only coloured plant icons but also strip plots of the data channel. Figure 12 shows a set of successive screen shots of the animation. As shown in the figure, it's obvious to see the injection of only one loop of HPCF over the core; the strip plot at the bottom presents power, steam flow rate, and feedwater flow rate in percentage with respect to time; the distributions of core power, moderator temperature, and fuel temperature shown on the right hand side; the status of each layer of the VESSEL including void fraction and fluid condition are presented on the left hand side. Through the demonstration of Figure 12, the uneven distribution in the RPV as well as several variations can be observed simultaneously.

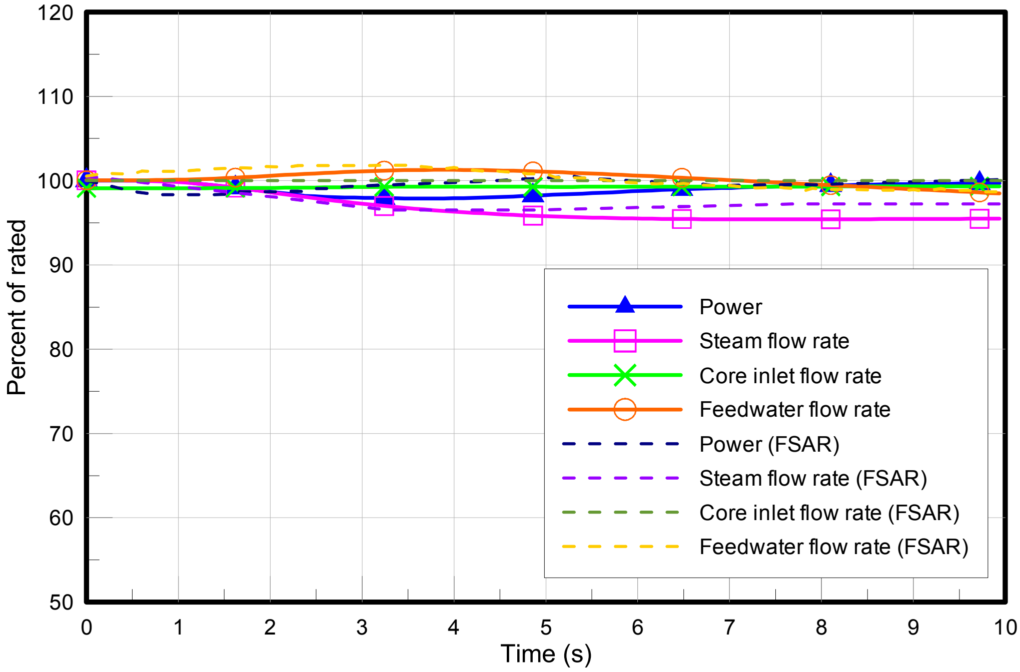

Figure 9 Responses of power, steam flow rate, core inlet flow rate and feedwater flow rate for HPCF inadvertent startup

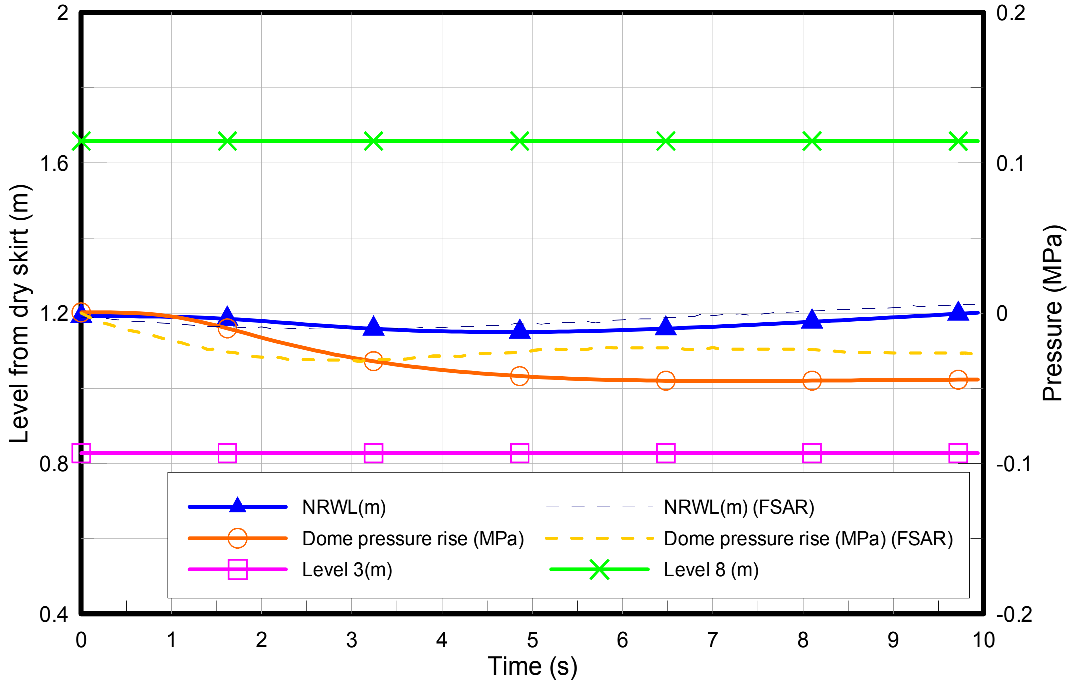

Figure 10　Responses of Water level and pressure rise for HPCF inadvertent startup

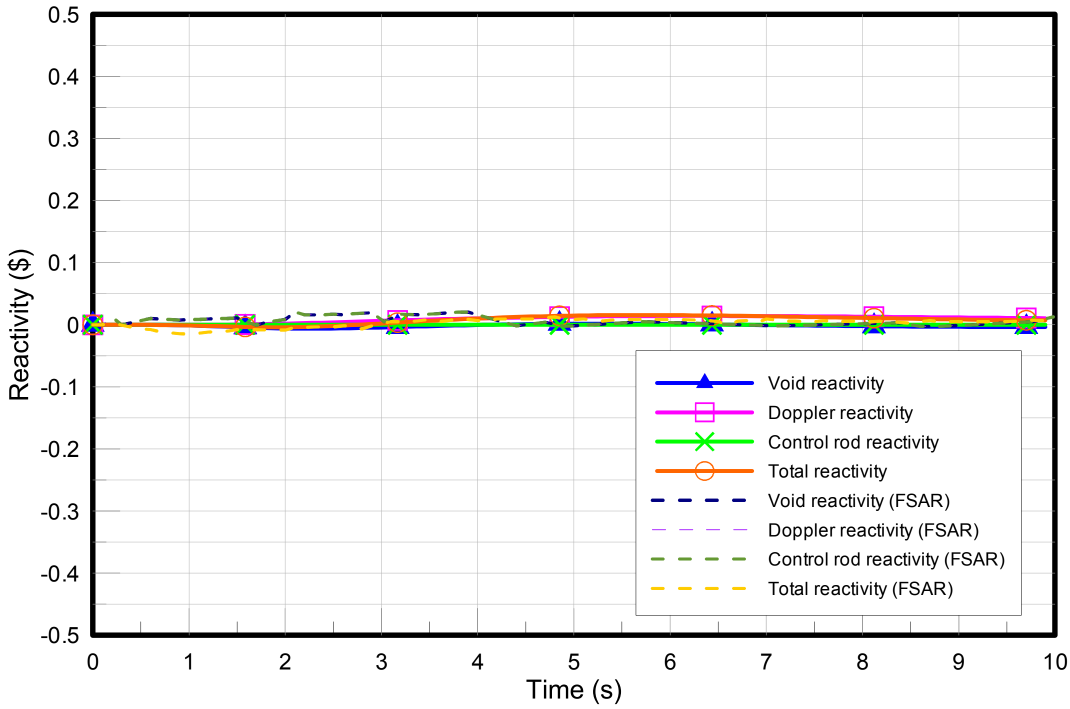

Figure 11　Reactivity responses of the prediction analysis for HPCF inadvertent startup

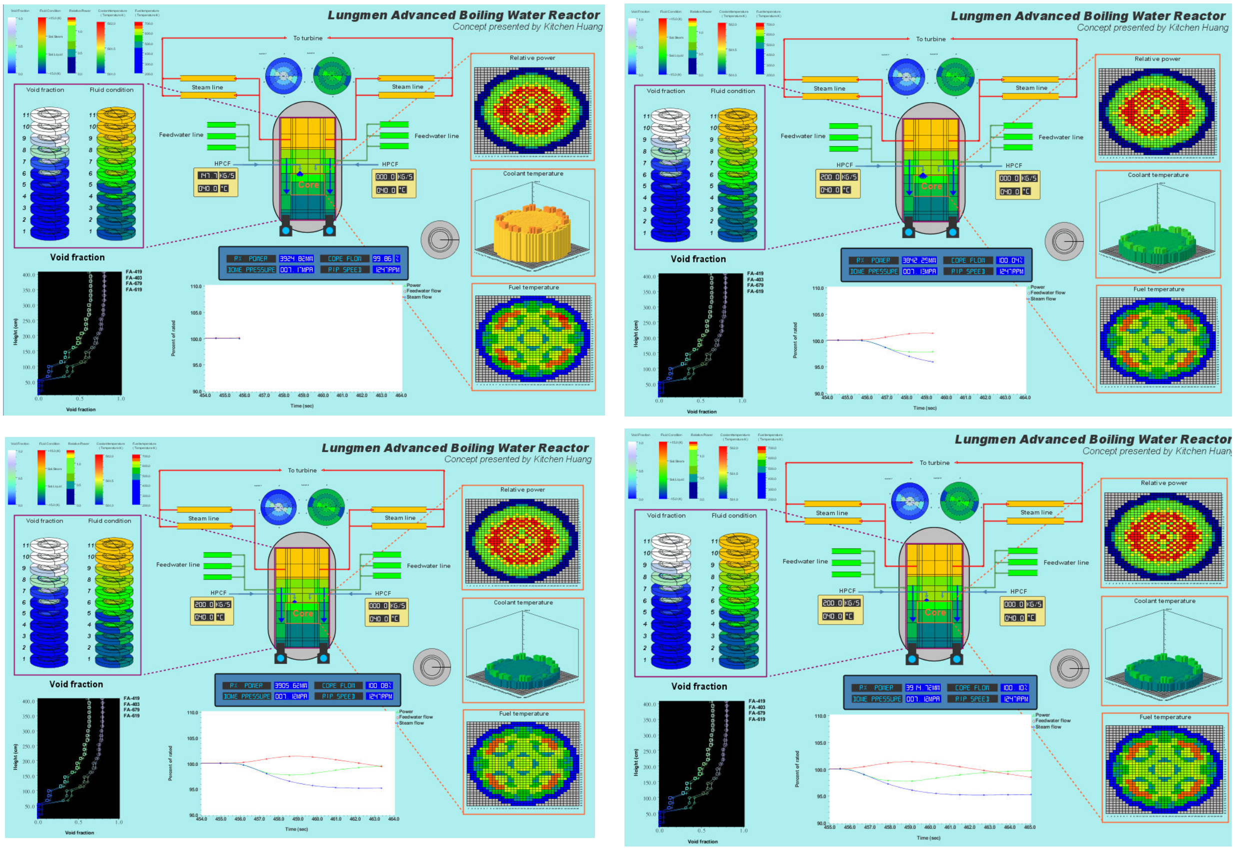

Figure 12　Lungmen animation model for HPCF inadvertent startup

4. CONCLUSIONS

By using SNAP/TRACE/PARCS, this study has developed the TRACE/PARCS model of the Lungmen NPP. There are 206 CHAN components, representing 872 fuel assemblies in core, in order to achieve finer simulation in core. The 3-D VESSEL component in TRACE model incorporating 3-D core simulation by PARCS enables the evaluations of local feedback effects as well as local responses. The proposed TRACE/PARCS model analyzed the transients of 3 RIPs trip and HPCF inadvertent startup. Analytical results indicate that the Lungmen NPP TRACE/PARCS model can predict the behaviors of important plant parameters reflecting consistent trends with FSAR data. As a result, the Lungmen 3-D animation under the interface of SNAP is adequate for the asymmetric phenomenon due to only one loop of HPCF system injection, in which one could observe the variations in the Lungmen ABWR during the transient.

5. REFERENCES

1. Taiwan Power Company, Final Safety Analysis Report for Lungmen Nuclear Power Station Units 1&2 (FSAR), 2007.
2. J.R. Wang, H.T. Lin, Y.H. Cheng, W.C. Wang, C. Shih, “TRACE models and verifications for Lungmen ABWR”, American Nuclear Society Winter Meeting, U.S.A., November 15-19, 2009.
3. H.T. Lin, J.R. Wang, C. Shih, The development and assessment of TRACE model for Lungmen ABWR, KERNTECHNIK, Vol.76, 2011.
4. Taiwan Power Company, Lungmen ABWR Training Manual, 2006.
5. Y.T. Ku, Y.S. Tseng, C. Shih, C.W. Su, J. R. Wang, “The Thermal Hydraulic Behavior in Core Inlet Region of BWR with the Inadvertent Startup of HPCI”, The 9th International Topical Meeting on Nuclear Thermal-Hydraulics, Operation and Safety (NUTHOS-9), Kaohsiung, Taiwan, September 9-13, 2012.

NRC FORM 335 (9-2004) NRCMD 3.7

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)
NUREG/IA-0434

2. TITLE AND SUBTITLE
The Development and Application of TRACE/PARCS Model for Lungmen ABWR

3. DATE REPORT PUBLISHED

MONTH	YEAR
December	2013

4. FIN OR GRANT NUMBER

5. AUTHOR(S)
Jong-Rong Wang, Chia-Ying Chang*, Hao-Tzu Lin, Chunkuan Shih*

6. TYPE OF REPORT
Technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Institute of Nuclear Energy Research
Atomic Energy Council, R.O.C.
1000, Wenhua Rd., Chiaan Village, Lungtan, Taoyuan, 325
Taiwan

*Institute of Nuclear Engineering and Science
National Tsing Hua University
101 Section 2, Kuang Fu Rd., HsinChu
Taiwan

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES
A. Calvo, NRC Project Manager

11. ABSTRACT *(200 words or less)*

TRACE code developed by US NRC is an advanced thermal hydraulic system code for nuclear power plant safety analysis. The feature of 3-D reactor vessel simulation in TRACE allows complex flow modeling and this kind of vessel is employed in Lungmen TRACE model. PARCS is a multi-dimensional neutronic simulator which is able to incorporate a 3 D reactor core with one-to-one fuel assembly simulation for the realistic representative. The state-of-the-art is that PARCS is capable of being coupled to TRACE, which provides the temperature and flow field information to PARCS during calculations. In this research, the TRACE/PARCS model of Lungmen nuclear power plant is established first. Then, the TRACE/PARCS model is used for two transient analyses - 3 RIPs trip and HPCF inadvertent startup. These events could test the ability of the coupling of TRACE and PARCS. Moreover, SNAP, a user-friendly interface developed by the US NRC and APT, provides users a graphical working environment and enables to animate the simulation as an alternative presentation of calculation results.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

TRACE
PARCS
Lungmen NPP
3-D Reactor
Code Application & Maintenance Program (CAMP)
INER (Institute of Nuclear Energy Research, Atomic Energy Council, R.O.C.)
Thermal hydraulic safety analysis
Taiwan
SNAP
LOCA

13. AVAILABILITY STATEMENT
unlimited

14. SECURITY CLASSIFICATION
(This Page)
unclassified
(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

OFFICIAL BUSINESS

NUREG/IA-0434

The Development and Application of TRACE/PARCS Model for Lungmen ABWR

December 2013