Report on the 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017)

YOSHIKAWA Hidekazu[1,2], ZHANG Zhigang[1], ZHAO Qiang[1], and ZHANG Zhijian[1]

1. Fundamental Science on Nuclear Safety and Simulation Technology Laboratory, Harbin Engineering University, No. 145, Nantong Street, Harbin 150001, China (zg_zhang@hrbeu.edu.cn)
2. Symbio Community Forum, Co. Research Institute of for Applied Sciences, 49 Tanaka-Ohi-Cho, Sakyo-ku. Kyoto, 606-8202 Japan (yosikawa@kib.biglobe.ne.jp)

Abstract: The 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017) was held on September 25, 2017 at Harbin Engineering University in Harbin, China, with the objective of discussing the progress of NVR project now conducted at HEU and to promote further progress of the NVR project activities. In this workshop, both the subjects of fuel modeling and neutronics were discussed among the four major subjects of the NVR project by inviting the two experts from foreign countries. This report summarizes the presentations and discussions at the workshop.
Keyword: numerical virtual reactor; nuclear fuel behavior modeling; 3D transient neutron transport equation

1 Introduction

The 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017) was held on September 25, 2017 at Meeting Room No.439, No.31 Bldg, Harbin Engineering University in Harbin, China. The major topics of this international Workshop are related with the fuel performance modeling and 3D neutron transport simulation as related with the Numerical Virtual Reactor (NVR) project now conducted at Harbin Engineering University (HEU). This report will give readers of this journal (IJNS) a comprehensive summary of the one-day workshop.

2 Workshop program and participants

The 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017) was organized by the College of Nuclear Science and Technology of Harbin Engineering University (HEU). The time table of the one-day workshop is as shown in **Table 1**. There were totally ca. 30 participants which include seven speakers and HEU organizers, senior master students, Ph.D. students and young teachers at College of Nuclear Science and Technology (CNST), HEU, and two experts from Nuclear Power Institute of China. The list of the seven speakers is given in **Table 2**. **Photo 1** shows the group photo of all attendants while **Photo 2** a snap of the workshop room, where you can see Prof. Lin Shao taking part in the workshop by skype.

Photo 1. Group photo of all attendants.

Photo 2. Snapshot of the workshop room.

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Table 1. Time table of the 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017) on September 25, 2017

Part 1 Chaired by Prof. Hidekazu Yoshikawa		
Time	Topic	Presenter
9:00-9:10	Opening address	Prof. ZHAO Qiang
9:10-9:30	Overall research introduction for NVR in HEU	Dr. Li Lei
9:30-10:00	Group photo in front of 31 Bldg.	
10:00-11:20	Review of fuel modeling in the context of Harbin NVR	Mr. Martin A. Zimmermann
11:20-12:30	Multi-scale modeling on radiation damage effect in materials used in reactor core-plan and progress	Dr. Yan Qiang and Dr. Wang Qingyu with Prof. Lin Shao participation by Skype
12:30-14:30	Lunch break	
14:30-15:10	Phase field modeling of micro-structure evolution in nuclear materials	Prof. Lin Shao by video presentation

Part 2 Chaired by Prof. Zhang Qian		
Time	Topic	Presenter
15:10-16:40	Transient simulation for 3D neutron transport	Prof. Xu Yunlin
16:40-17:00	Coffee break	
17:00-18:00	Implementation of a parallel 2D MOC algorithm based on spatial domain decomposition method	Mr. Song Peitao

Table 2. List of speakers

No.	Name	Title/Affiliation
1	Dr. Li Lei	Lecturer, College of Nuclear Science and Technology, HEU
2	Mr. Martin A. Zimmermann	Senior Scientific Advisor, Nuclear Energy and Safety, Swiss
3	Dr. Yan Qiang	Lecturer, College of Nuclear Science and Technology, HEU
4	Dr. Wang Qingyu	Lecturer, College of Nuclear Science and Technology, HEU
5	Prof. Lin Shao	Associate Professor, Department of Nuclear Engineering, Texas A&M University
6	Prof. Xu Yunlin	Professor, University of Michigan
7	Mr. Song Peitao	PhD candidate student, College of Nuclear Science and Technology, HEU

3 Synopsis of workshop presentations

The contents of the six presentations are briefly introduced in the following.

3.1 Overall research introduction for NVR in HEU

Dr. Li Lei (HEU) presented the overall introduction and the research progress of Numerical Virtual Reactor project conducted at HEU. He summarized the result of the phase 1 research (period between 2013-2016 with the budget of 17 Million RMB where the researches were focused on neutronics and thermal-hydraulics modeling and coupling in reactor vessel, and modeling for main components such as steam generator, turbine, condenser, *etc.*) and introduced its phase 2 research plan (period between 2017-2020 with the budget of 120 Million RMB). The phase 2 NVR project is being undertaken by HEU and NPIC (Nuclear Power Institute of China), and the focus areas are: (i)neutronics, thermal-hydraulics, fuel performance under neutron irradiation, flow-induced vibration in reactor vessel, (ii)multi-physics coupling method, (iii)extend the calculation domain of high fidelity to a complete assembly, and finally to the whole reactor core, and (iv)V&V (Validation and verification), UQ (uncertainty quantification), and research fruit delivery to industry.

As far as the research plan of fuel performance simulation is concerned, Dr. Li Lei stressed that the object-oriented multi-scale modeling with reduced parameter dependence will be adopted to develop as the combination of Monte Carlo and both the kinetic Monte Carlo and continuum method/ phase field theory to give defect kinetics on the basis of interatomic potential and molecular dynamics. The relevant codes system will be developed by the researchers' team of HEU and Texas A&M.

3.2 Review of fuel modeling in the context of Harbin NVR

From the presentation of Dr. Martin A. Zimmermann (Swiss Federal Nuclear Safety Inspectorate, Switzerland), Prof. Lin Shao took part in the workshop discussion via skype from Texas, USA. Mr. Zimmermann made a comprehensive review on the long research history of nuclear fuel modeling to be considered for the context of Harbin NVR project. He introduced key phenomena relevant for fuel behavior with their typical modeling approaches, needs for the validation of the modeling, boundary fuel performance under neutron irradiation, conditions obtained from the other major areas of NVR project, and overview of the fuel modeling codes around the world. He concluded his presentation by proposing several ideas for NVR project to augment the research activities in the area of fuel modeling. The detail of Mr. Zimmermann's presentation is described in his paper [1] of this issue.

3.3 Multi-scale modeling on radiation damage effect in materials used in reactor core-plan and progress

Dr. Yan Qiang and Dr. Wang Qingyu with the participation of Prof. Lin Shao via Skype presented their plan and research progress of multi-scale modeling on radiation damage effect in materials used in reactor core. To be compared with the traditional fuel modeling research activities worldwide, Prof. Lin Shao stressed the uniqueness and significance of their proposed approaches to understand the radiation damage phenomena of nuclear reactor core materials from the framework of microscopic observation and modeling. The proposed multiscale modeling structure is as illustrated in Fig.1. Some numerical simulation examples were also presented by their developed DEEPER (Damage creation and particle transport in matter) code. It seems that the right-hand side of Fig.1 will correspond to the hierarchy of various material damage phenomena from microscopic to macroscopic stages.

3.4 Phase field modeling of micro-structure evolution in nuclear materials

In relation with the presentation made in 3.3, the video presentation of Prof. Lin Shao had been made on the phase field modeling of micro-structure evolution in nuclear material. Detail of Professor Lin Shao' proposed multiscale modeling structure is already published in [2].

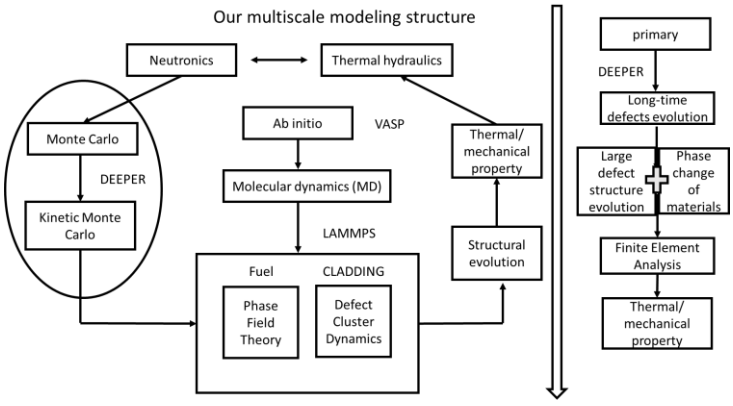

Fig. 1 The proposed multiscale modeling structure

3.5 Transient simulation for 3D neutron transport

The presentation of Prof. Xu Yunlin (the University of Michigan) consisted of two parts. In the first place, Prof. Xu Yunlin introduced two American projects of CASL and MOOSE in relation with the HEU's NVR project. The second part of his presentation was related with the introduction of the numerical method for solving the 3D dynamic transport equation. He made an elegant reduction of the numerical procedure on how the 2D/1D MOC method can be applied to solve dynamic 3D neutron transport equation. This solver of transient 3D neutron transport equation was implemented in MPACT and an example simulation for Watts Bar plant was also presented to show its effectiveness.

3.6 Implementation of a parallel 2D MOC algorithm based on spatial domain decomposition method

Mr. Song Peitao (HEU) presented his work on parallel 2D MOC algorithm based on spatial domain decomposition method with its application for an international benchmark problem called C5G7. His work had been performed during his internship at the University of Michigan under the supervisory of Prof. Xu Yunlin. The possibility of implementing such PhD students' work product of parallel 2D MOC algorithm at the University of Michigan in HEU's HPC will be thought to be needed in order to accelerate the NVR project at HEU.

4 Concluding remarks

The 22nd International Workshop on Nuclear Safety and Simulation Technology (IWNSST2017) was held on September 25, 2017 at Harbin Engineering University in Harbin, China, with the objective of discussing the progress of NVR project now conducted at HEU and to promote further progress of the NVR project activities. In this workshop, both the subjects of fuel modeling and neutronics were discussed among the four major subjects of the NVR project by inviting the two experts from foreign countries.

The authors of this report would like to conclude this report by giving two comments for the progress of relevant activities of NVR project art HEU on the basis of the discussions made in this workshop.

(1) Concerning fuel pin modeling, it was very impressive that Mr. Zimmerman had made kind advice to take note on the traditional fuel pin modeling approach in his presentation, while Dr. Yan Qiang and Dr. Wang Qingyu had presented their new approach for multi-scale modeling on radiation damage effect in materials as was shown in Fig.1. It was a bit regret that Prof. Lin Shao could not show up at the workshop discussion but only took part via internet so that the discussion on how the traditional modeling approach can mediate the part of multi-scale modeling on radiation damage effect in materials more effectively to other areas of neutronics and thermos-hydraulics parts in NVR. On the other hand, HEU's new experimental research under preparation stage at HEU related with the reactor material study was already published in this IJNS by Prof. Lin Shao [3], in which accelerator-based ion bombardment is proposed as a surrogate irradiation source to simulate neutron damage in nuclear reactors. It seems that the part of fuel pin modeling of NVR project by HEU becomes very unique and promising if all of the three elements from (i) accelerator-based ion bombardment, via (ii) multi-scale modeling, and (iii)macroscopic modeling will be consistently organized to hand over the other two parts of neutronics and thermal-hydraulics.

(2) Concerning neutronics, the PhD students dispatched from HEU to USA by the support of HEU's NVR project in turn have (and will have) mastered and developed advanced numerical parallel 2D MOC algorithm at the University of Michigan. In future, it is expected that those students will bring back their mastered methods and software to be installed and tested on the existing HPC environment at HEU for further improvement of HPC at HEU before their final delivery to the industry in China.

References

[1] ZIMERMANN, M.A.: On the need of fuel modeling for Harbin Numerical Virtual Reactor (NVR), Nuclear Safety and Simulation, 8(4), pp. 264-274, 2017.

[2] CHEN, T.Y., CHEN, D., SENCER, B.H., and SHAO, L.: Molecular dynamics simulations of grain boundary thermal resistance in UO2, Journal of Nuclear Materials, 452(2014) pp.364-369.

[3] SHAO, L.: Ion accelerator based radiation simulations of neutron damage in reactors: issues and challenges in experiments and modeling, Nuclear Safety and Simulation, 6(3), pp. 234~241, 2015.