

INVESTIGATION FOR CALCULATION METHODS USED IN ANALYZING THE PHYSICS CHARACTERISTICS OF NUCLEAR POWER REACTOR

Nguyen Tuan Khai¹, Nguyen Minh Tuan², Tran Quoc Duong², Hoang Van Khanh¹,
Phan Quoc Vuong¹, Tran Viet Phu¹, Tran Vinh Thanh¹, Nguyen Thi Mai Huong¹,
Nguyen Thi Dung¹ and Le Tran Chung¹

¹*Institute for Nuclear Science and Technology, Vietnam Atomic Energy Institute
179 - Hoang Quoc Viet, Ha Noi*

²*Nuclear Research Institute, Vietnam Atomic Energy Institute
1- Nguyen Tu Luc, Dalat, Lam Dong*

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ABSTRACT: The project aims at nuclear human resource development and enhancement in research capability in reactor physics and kinetics at Nuclear Energy Center (Institute for Nuclear Science and Technology) and Nuclear Reactor Center (Nuclear Research Institute, Dalat). The main research items of the project can be summarized as follows: i) Considering possibility on using modern calculation techniques and methods in investigating neutronic characteristics and neutronics-thermalhydraulics coupling. This item is proposed to carry out based on international collaboration with Prof. Le Trong Thuy, San Jose University, US. ii) Carrying out the collaborative activities in research and training between Nuclear Energy Center (Institute for Nuclear Science and Technology) and Nuclear Reactor Center (Nuclear Research Institute, Dalat). iii) Opening two-week training course on nuclear reactor engineering (25/Nov. -12/Dec. 2013) in collaboration with Japan Atomic Energy Agency (JAEA).

1. INTRODUCTION

Development of nuclear human resource and enhancement in research capability in reactor physics and kinetics including both research and power reactors are one of the priority targets for research orientations of Vietnam Atomic Energy Institute (VINATOM) in period 2014-2020. This task is assigned to Nuclear Energy Center, Institute for Nuclear Science and Technology (INST) and Nuclear Reactor Center, Dalat Nuclear Research Institute (NRI). At present most of the staffs who are working at Nuclear Energy Center (INST) are young and less experienced. They were supported by VINATOM to pursue the above mentioned research, including:

- Research project at basis level in 2010 on calculations for some physics and thermal-hydraulic parameters for VVER-1000 type by Pham Tuan Nam,
- Research project at basis level in 2011 on calculations for some physics parameters for fuel assembly of VVER-1000 using MCNP4C2 by Nguyen Van Hien,
- Research project at basis level in 2012 on consideration for neutronic characteristics of PWR 900 MWe of Japanese technology by Phan Quoc Vuong,

- Research projects at basis level in 2010, 2011 and 2012 on neutronic characteristics of the OTTO recycling for new generation of reactors by Hoang Van Khanh.

Since 2010 VINATOM has proposed a long-term strategy in nuclear power human resource development via establishing the qualified research groups at INST. Therefore, the target of this project is to develop the qualified human resource, gradually enhance research capability on power reactor physics and kinetics.

2. CONTENTS AND RESULTS

The project has been deployed and carried out based on the research contents written in the proposal. The obtained results can be summarized as follow:

- **Item 1:** Investigating possibility of using some modern calculation methods and techniques in analysis of reactor physics and kinetics characteristics. This is carried out based on collaboration with Prof. Le Trong Thuy at San Jose University, US through two scientific seminars on (1) Conventional methods of calculation for light water reactors, and (2) Some orientations for calculation of reactor core physics characteristics from light water reactor (LWR) to high temperature gas cool reactor (HTGR) presented by Prof. Thuy. Also we had a detail discussion with Prof. Thuy on how we can establish a long-term collaboration on research and training, especially for the goal of research capability enhancement for young people in coming years.

In framework of this research item we have performed scientific reports focusing on the calculation methods for neutron transport and neutronic characteristics in reactor core, including:

- (1) Numerical methods for neutron transport research
- (2) Nuclear data edition for reactor physics calculations
- (3) Multi-group analysis in reactor core calculations of LWR
- (4) Multi-group diffusion theory and harmonic functions
- (5) Monte-Carlo simulation method in analysis for neutron transport and diffusion
- (6) A calculation program written for neutron transport in reactor core of PWR

These are very fundamental knowledge that the young researchers should be equipped in order for approaching to high-level research requirements. We have proposed to investigate and resolve the neutron transport and diffusion in moderator of light water reactor (LWR) as an illustration for the calculation methods and technique mentioned in the above reports. The obtained main results were presented in a paper “Simulation for neutron transport in reactor moderator and proper thickness of light water reflector” which will be published in scientific conference of young researchers at VINATOM on this October 2014, and also in master thesis written by Phan Quoc Vuong, a young researcher at Nuclear Energy Center, INST. The thesis is planned for defend in this August at Institute for Nuclear Technique and Environmental Physics, Hanoi University of Technology (HUT). The figures 1-3 show the main results of the paper.

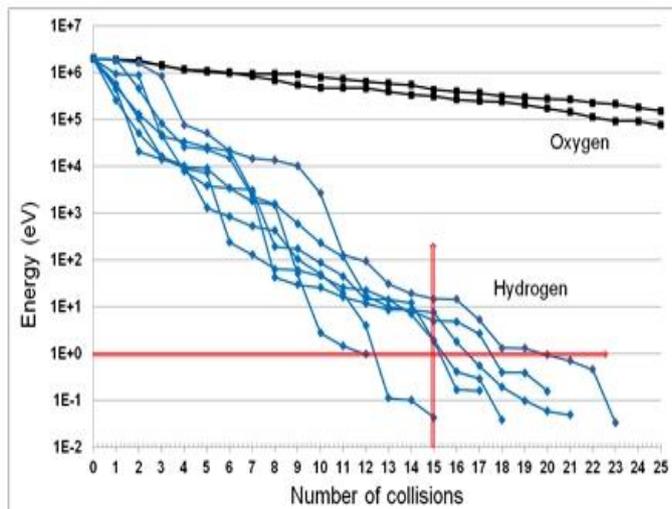


Figure 1: Energy decrease of 2 MeV neutrons with number of collisions in Hydrogen and Oxygen.

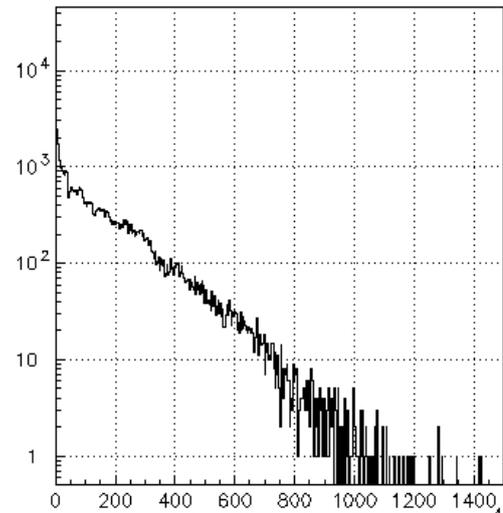


Figure 2: Neutron energy spectrum at the fuel rod.

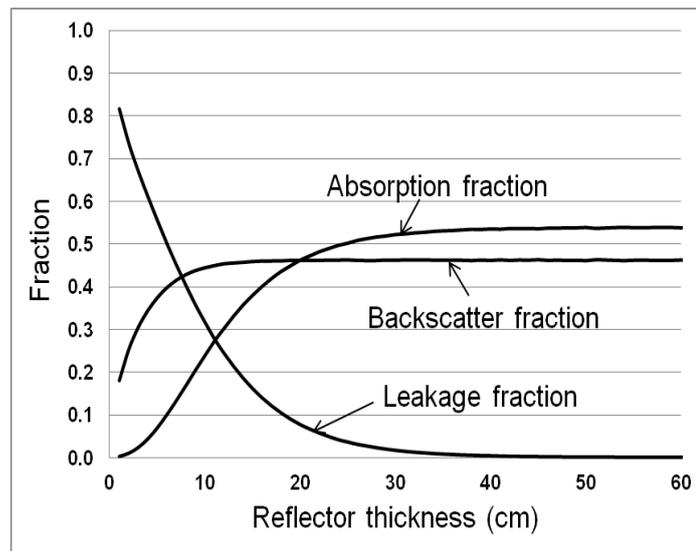


Figure 3: Simulation results on neutron backscattering, absorption and leakage fractions as a function of the reflector thickness.

We have regularly seminars presented by young researcher who are responsible for a given topics. The reports have been reviewed by the experienced scientists.

- **Item 2:** Deployment for research collaboration and training activities between Nuclear Energy Center, INST and Nuclear Reactor Center, Dalat NRI.

In 2013 two young researchers (Le Tran Chung and Ta Duy Long) from Nuclear Energy Center, INST have been sent to Dalat NRI for 4 months to participate in some oriented research collaborations such as analysis for neutronic characteristics of HEU and LEU assemblies, and neutronic-thermal hydraulic coupling calculations.

In framework of this item we have performed 4 scientific reports, including:

(1) Analysis for neutronic characteristics of HEU (36%) and LEU (19.7%) assemblies of VVR-M2 using MCNP and SRAC codes.

(2) Analysis for neutronic-thermal hydraulic characteristics for steady state of PWR assembly at burnup 0 GWd/ton and 45 GWd/ton using MCNP and COBRA-EN.

(3) Analysis for Main Steam Line Break incident for VVER-1000 (AES92) using RELAP5.

(4) A series of practical assignments with PCSTRAN prepared for training course on nuclear reactor engineering at INST in framework of NUTECH program between VINATOM and JAEA.

This is a good basis for us to prepare a joint-research project on comprehensive neutronic characteristics of VVER-1000 technology between Nuclear Energy Center, INST and Nuclear Reactor Center, Dalat NRI.

Item 3: Cooperation in nuclear human resource development with JAEA.

In framework of NUTECH program between VINATOM and JAEA, a training course on nuclear reactor engineering (Follow-up Training Course-FTC) was held for the first time in Northern region from 25/Nov. -12/Dec. 2013 at INST, Hanoi. The JAEA has dispatched three Japanese experts to participate in and give the lectures for the course. We invited eight Vietnamese lecturers coming from VINATOM and VARANS to give the lectures for the course, three of them are young researchers at INST who have participated in the instructor training course (ITC) at IAEA. The course has recruited 20 participants from the organizations and universities concerning national nuclear power program of the country such as Vietnam Agency for Radiation and Nuclear Safety (VARANS), Vietnam Atomic Energy Agency (VAEA), VINATOM, Hanoi University of Technology (HUT), Hanoi University of Science (HUS), Hanoi University of Electricity and Institute of Energy (IOE).

The course was successfully taken place, where the lectures are well prepared, and the participants followed fully and actively. The JAEA experts have appreciated the contents and obtained results of the course, and recommended these FTCs should be continued in next years.

3. CONCLUSION

The project members have fully carried out the registered contents which can be summarized as follows:

- Investigating the methods of physics and mathematics, and nuclear data update to resolve the neutron transport and diffusion problem in reactor core. The research content has been presented in 6 scientific reports and a calculation program on the neutron transport and diffusion. The obtained main results are written in a paper for the scientific conference of young researchers on this October 2014, and are scientific content of a master thesis.

- Giving a support for young researchers in research and training collaboration on reactor physics and safety analysis between Nuclear Energy Center, INST and Nuclear Reactor Center, Dalat NRI.

- Giving an active contribution in VINATOM-JAEA cooperation on nuclear human resource development via the training courses on reactor engineering at INST.

In conclusion in development strategy of VINATOM for the 2014-2020 period, research on power reactor technology is one of the prioritized orientations. We have prepared a proposal with the items on (1) the current manpower status, (2) research and training orientation and (3) staff planning on vision to 2020. We wish that VINATOM kindly consider and support for us in implementing the scientific and training targets proposed.

REFERENCES

- [1] John R. Lamarsh, "Introduction to Nuclear Engineering", Prentice Hall, Upper Saddle River, New Jersey 07458, 2001.
- [2] J. Lepponen, "Diffusion Code Group Constant Generation Using the Monte Carlo Method", In Proc. XII Meeting on Reactor Physics Calculations in the Nordic Countries. Halden, Norway, May 17-18, 2005.
- [3] J. J. Duderstadt and L. J. Hamilton, "Nuclear Reactor Analysis", John Wiley & Sons, Inc., 1976.
- [4] National Nuclear Data Center, Brookhaven National Laboratory, <http://nndc.bnl.gov>.
- [5] J. Lepponen, "A new assembly-level Monte-Carlo neutron transportation code for reactor physics calculation", In Proc. International Topical Meeting on Mathematics and Computation, Supercomputing, Reactor Physics and Nuclear and Biological Applications, M&C 2005. Avignon, France, Sept. 12-15, 2005.
- [6] George I. Bell & Samuel Glasstone, "Nuclear reactor theory", Van Nostrand Reinhold Company, 450 West 33rd Street, New York, N.Y 10001.
- [7] MCNP manual Vol I, II, III-Los Alamos National Laboratory.
- [8] Thermal-Hydraulics of Nuclear Reactor-Uchida Masaaki, Tokai Training Center, Nuclear Technology and Education Center, Japan Atomic Energy Research Institute.