Reactor Physics Experiments by Korean Under-Graduate Students in Kyoto University Critical Assembly Program (KUGSiKUCA Program)

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1. Introduction

The Reactor Laboratory Course for Korean Under-Graduate Students in Kyoto University Critical Assembly (KUGSiKUCA) program [1] has been launched from 2003, as one of international collaboration programs of Kyoto University Research Reactor Institute (KURRI). This program was suggested by Department of Nuclear Engineering, College of Advanced Technology, Kyung Hee University (KHU), and was adopted by Ministry of Science and Technology of Korean Government as one of among Nuclear Human Resources Education and Training Programs. On the basis of her suggestion for KURRI, memorandum for academic corporation and exchange between KHU and KURRI was concluded on July 2003. The program has been based on the background that it is extremely difficult for any single university in Korea to have her own research or training reactor. Up to this 2006, as shown in Table 1, total number of 61 Korean under-graduate school students, who have majored in nuclear engineering of Kyung Hee University, Hanyang University, Seoul National University, Korea Advanced Institute of Science and Technology, Chosun University and Cheju National University in all over the Korea, has taken part in this program. In all the period, two professors and one teaching assistant on the Korean side led the students and helped their successful experiments, reports and discussions. Due to their effort, the program has succeeded in giving an effective and unique course, taking advantage of their collaboration.

The reactor physics experiments for Korean students have been carried out in as well as Reactor Laboratory Course for Japanese students with Kyoto University Critical Assembly (KUCA) [2]-[5] launched from 1975, such as Approach to criticality, Control rod calibration, Neutron flux and power calibration, and Educational reactor operation. These experiments were conducted in KUCA C-core, which is a water-moderated and -reflected core using a plate type fuel consisted of highly enriched Uranium and Aluminum alloy.

A textbook [6] in full English was published newly in the KUCA for preparing this course and supporting lectures, experiments, discussions and reports in English, adding to a conventional one in full Japanese.

Table 1
Number of participants in KUGSiKUCA program.

University / Year	2003	2004	2005	2006
Kyung Hee Univ.	6	3	3	3
Hanyang Univ.	2	3	3	3
Seoul Nat'l Univ.	—	2	2	4
Chosun Univ.	2	3	3	4
Cheju Nat'l Univ.	2	3	2	3
KAIST	1	1	2	1
Total	13	15	15	18

2. Lectures

Before carrying out the experiments in this course, some Japanese professors went directly to Korea and gave the Korean participants preliminary lectures in English related to the reactor physics experiments in the KUCA C-core. Then, the students were given exercises to be solved concerning with three experimental topics for understanding well the experiments, and have to turn in the exercises as preparatory reports, up to when they could arrive at the KUCA. During their stay at Japan in 10days, at first, they attended lectures of safety regulations and security education concerning with radiation protection for becoming radiation workers and reactor operators, on the basis of KURRI inside regulation. And, they have also taken part in technical lectures of three experimental topics.

3. Reactor Physics Experiments

3.1. Approach to criticality

Approach to criticality has been performed on the basis of inverse multiplication method. Criticality is approached by adding fuel plates in the KUCA C-core. Inverse multiplication rate is measured in three different patters of control rod withdrawal to ensure safe approach to criticality. Plot of inverse multiplication for the fuel mass is made after each fuel loading step, and the critical mass is estimated by extrapolating the curve to zero. Comparison of predicted and measured critical mass, dependence of inverse multiplication rate curves on relative positions of detectors, source and other physical problems are to be solved, as the preparatory reports.

3.2. Control rod calibration

Two methods of control rod calibration are utilized in this experiment; the positive period and the rod drop methods. In the first experiment, the reactor is determined from the measured doubling time to derive the reactivity. The rod drop method is to measure the subcriticality; the rod to be calibrated is dropped from a certain position at the critical state, and the resulting decay of neutron flux is observed and related to the reactivity. Three control rods are calibrated in the experiment. Comparison of measured calibration curve with that obtained by First-order perturbation theory with one-energy-group is to be solved together with discussions on several reactor physics problems, as the preparatory reports.

3.3. Reaction rate distribution and Power calibration

In this experiment, Gold (197Au) is chosen as the activation detector because of its appropriate physical properties. Gold wire supported with thin Aluminum plate is used for relative distribution measurements. Gold foils covered with and without Cadmium cover are also attached on the fuel plates for absolute measurements. The ratio of thermal to epithermal neutron flux is determined by measuring the Cadmium ratio using the activation detectors covered with and without Cd covers. The Hp-Ge detector is used for absolute activity measurement of irradiated Gold foils. The Well-type NaI (Tl) scintillation counter is used for Gamma-ray detection of irradiated Gold wires. Neutron flux distributions in fast and thermal groups, Cadmium ratio and reactor power deduced from thermal flux distributions are to be solved, as the preparatory reports.

4. Exceptional Benefit

In addition to three main experiments, the students have a good opportunity to operate reactor itself through educational reactor operation experiment and to handle highly enriched fuel and to load fuel assembly directly into reactor core through all the process of experiments. And, they have also an experience of SCRAM (TRIP) experiment in the course of this program.

As a final course of this program, they have an exceptional experience in taking nuclear site tour of Japan, such as Kyoto University Reactor (KUR), Pressurized Water Reactor (PWR) at Mihama site of Kansai Electric Power Corporation (KEPCO), Fast Breeder Reactor (FBR) at Monju construction office of Japan Atomic Energy Agency (JAEA), Kumatori Woks of Nuclear Fuel Industries Ltd. (NFI) and Institute of Nuclear Safety System, Incorporated (INSS).

5. Summary

The Reactor Laboratory Course for Korean Under-Graduate Students has been successfully carried out at KUCA of Japan. The total number of 61 Korean under-graduate students majoring in nuclear engineering of 6 universities in Korea has been taken part in this course from 2003 to 2006. In fact, this course was a big challenge for both Korean and Japanese parties at an initial stage, however, it was found surely to be good success and excellent experience for not only students but also professors of Korean and Japan. In the future, it is expected, on the basis of these important experiences, that other reactor laboratory courses could be opened for graduate school students in Korea, and also other countries as international promotion of reactor physics education and international collaboration programs of KURRI.

Acknowledgements

We would like to thank Prof. Chan-Hyeong Kim of Hanyang University, Prof. Goung-Jin Lee of Chosun University and Prof. Han-Gyu Joo of Seoul Nat'l University for their generous and helpful assistance in this course.

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