REACTOR LABORATORY COURSE FOR STUDENTS WITH KYOTO UNIVERSITY CRITICAL ASSEMBLY (KUCA)

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ABSTRACT

It is considered that critical assemblies are the most useful tools for the education of nuclear engineering and technology. With use of the Kyoto University Critical Assembly (KUCA), a joint reactor laboratory course of graduate level is offered every summer since 1975 by nine associated Japanese universities, and more than 1800 students attended this course. The course is consisted of several experiments for reactor physics (critical mass measurement, control rod calibration, and neutron flux measurement) and educational reactor operation.

1. INTRODUCTION

A critical assembly has been used for an experimental facility in the field of nuclear engineering, especially in reactor physics research. Moreover, it is one of the most useful tools for the education of nuclear engineering and technology, because students can obtain the basic concept of nuclear reactor through experiments in a critical assembly, educational operation of a reactor and handling of fuel assemblies by themselves. In recent years, the computer technology of a simulator system for reactor operation has made rapid progress, and most of the operators in a nuclear power station are trained with use of a simulator, which make a contribution successfully for safety operation of reactor. However, as for education of students majoring in nuclear engineering to understand a reactor, it is essential to carry out experiments using a “real” reactor. In addition, after the criticality accident at a nuclear fuel facility located at Tokai-mura of Japan in 1999, safety regulation for all facilities handling nuclear materials has become very strict, therefore, to carry out the experiments in a critical assembly is very good chance for students to realize the safety regulation for a reactor facility and treatment of nuclear materials.

The joint reactor laboratory course with use of KUCA (Kyoto University Critical Assembly) at KURRI (Kyoto University Research Reactor Institute, located at Kumatori, Osaka shown in Fig. 3) is started in 1975, and it has been offered every summer by ten associated Japanese universities of Japan. Since then, more than 1800 undergraduate and graduate students have taken the course. The course is consisted of several reactor physics experiments and educational reactor operation [1] .

2. Explanation of KUCA

The KUCA is a multi-core type critical assembly established in 1974 as a facility for the joint use study on reactor physics for researchers of all universities in Japan, which has three independent cores called A, B and C-core. A cross sectional view of KUCA building is shown in Fig. 1.

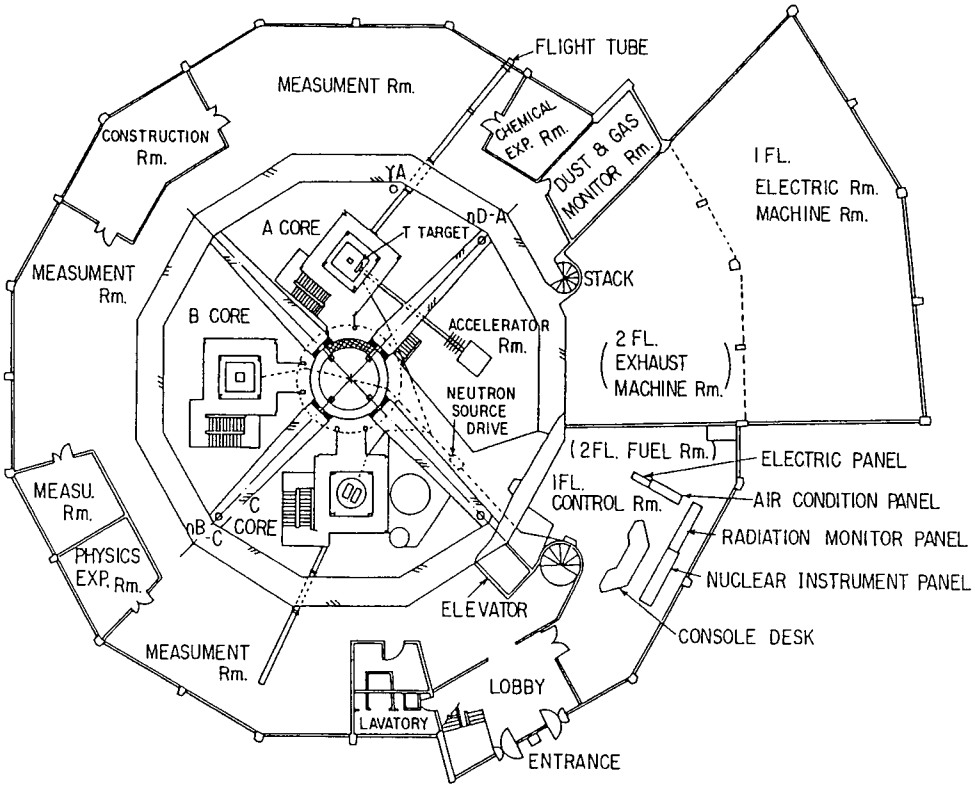

Figure 1. A plan view of the KUCA building

The present reactor laboratory course has been carried out at the C-core which is a light water moderated and reflected core using a plate-type fuel, which is 1.5-mm-thickness consisted of highly enriched uranium and aluminum alloy meat region with aluminum cladding. It is available to use three pitches of fuel plates in this core to change the neutron spectrum in the core region. A fuel element is assembled by inserting fuel plates one by one vertically between two aluminum side plates of a fuel frame along grooves of approximately 3.0, 3.5 and 4.5mm in pitch, and these fuel elements are arranged on a grid plate in an aluminum core tank and light water is pumped up into the core tank for operation. In the C core, reactor physics study have been carried out on (1) coupled cores[2], (2) research reactor cores of reduced enrichment uranium fuel[3], (3) criticality safety[4], (4) safety features of reactor cores[5] and so on have been carried out so far.

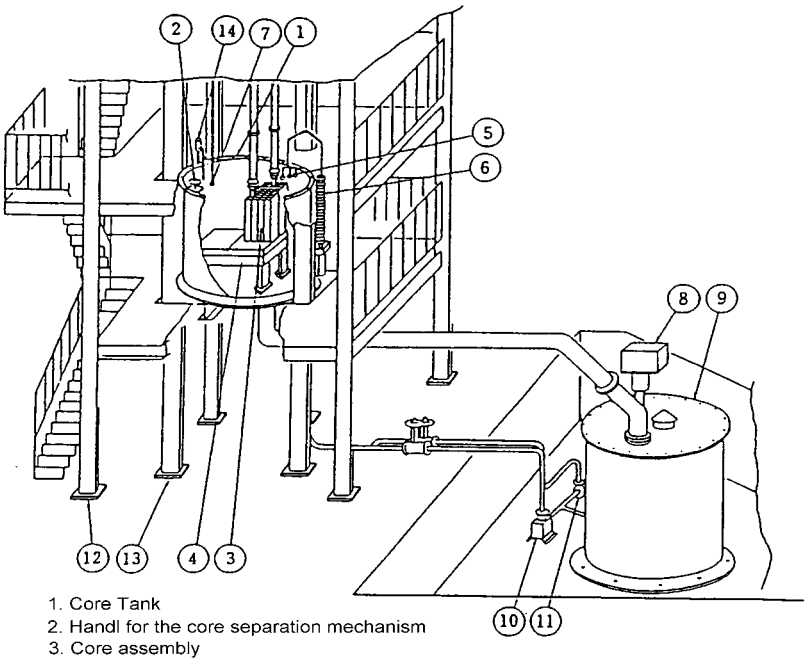

Figure 2 Picture of C-core

3. The Reactor Laboratory Course

The joint reactor laboratory course of graduate level using KUCA has been offered every summer since 1975 by 10 associated Japanese universities shown in Fig. 3 (Hokkaido University, Tohoku University, Tokyo Institute of Technology, Musashi Institute of Technology, Tokai University, Nagoya University, Osaka University, Kobe University of Mercantile Marine, Kyushu University and Kyoto University) in addition to a reactor laboratory course of undergraduate level for Kyoto University. The joint course has been institutionalized with the background that it is extremely difficult for a single university in Japan to have her own research or training reactor, and one of the main purposes for constructing KUCA was to establish the joint course for student education. By their effort, the united faculty team of the joint course have succeeded in giving an effective, unique one-week course, taking advantage of their collaboration. This is the first authorized course to interchange course credits between Kyoto University and other leading universities. Most of the students were belong to the graduate school of engineering and majoring in nuclear engineering. These laboratory courses are opened for four weeks (three weeks for the joint

course and one week for the undergraduate course) to take two credits and a total of 1,822 students including some students from abroad have taken this course in the 27 years as listed in Table I. The Ministry of Education, Culture, Sports, Science and Technology of Japanese Government prepared the most of the budget for this course of graduate.

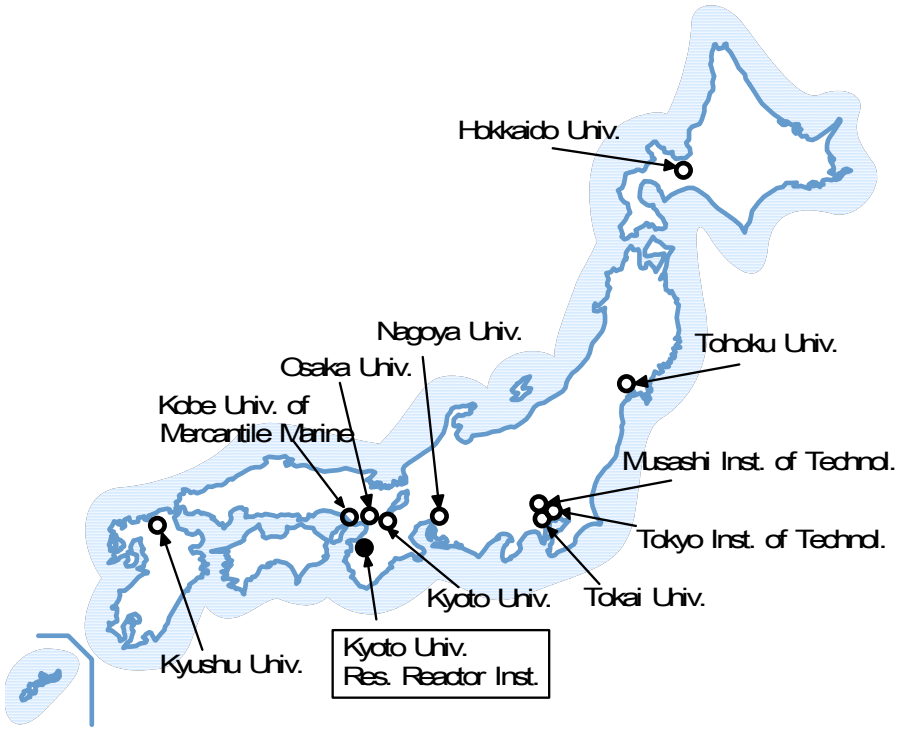

Figure 3 Location map of 10 associated universities and KURRI

The present subjects which can be offered in the reactor laboratory course are as follows:

(1) Critical mass measurement including criticality approach experiment,
(2) Control rod calibration,
(3) Measurement of neutron flux distribution and power calibration,
(4) Educational reactor operation,
(5) Neutron correlation experiment by the Feynman- α method,
(6) Reactivity measurement by the pulsed neutron method.

Usually the subjects (1)-(4) are carried out in the joint course and all students participated in the KUCA experiment should attend lectures given previously in the individual university. The maximum number of students in this course is restricted to 24 per week, because of limitation of manpower, space of KUCA building, and budget. A special textbook for this course written in Japanese is prepared by representatives of all teachers participated in the joint reactor laboratory course, which is revised every once in several years. The weekly schedule of the course and the core configuration employed in the course are also decided through discussion with all teachers.

Recently, since many graduate students whose major in undergraduate level were different from nuclear engineering have attended this course, basis of nuclear engineering, such as reactor physics and radiation detection, should be lectured to them beforehand. For this reason, the textbook of this laboratory course has revised in these years to be understood even by beginners of nuclear engineering and also to be utilized by the specialist of this field. Figure 4 shows the theme of master thesis of graduate students who have attended the reactor laboratory course in 2001.

Table I Number of participants at the reactor laboratory course of KUCA

Year	Hokkaido Univ.	Tohoku Univ.	Tokyo Inst. Tech.	Musashi Inst. Tech.	Tokai Univ.	Nagoya Univ.	Osaka Univ.	Kobe Univ. Mercantile Marine	Kyushu Univ.	Kyoto Univ. a)	Kyoto Univ. b)	Kyoto Univ. c)	Total
1975	–	4	5	–	1	5	9	–	–	–	19	–	43
1976	5	5	6	–	2	6	9	–	5	–	17	–	55
1977	5	3	5	–	1	5	12	–	7	–	23	–	61
1978	5	3	5	–	3	6	9	4	5	–	26	6	72
1979	5	5	5	–	2	7	10	2	7	–	24	4	71
1980	5	6	7	–	1	7	16	–	–	–	21	–	63
1981	6	5	6	1	2	5	10	3	6	–	21	3	68
1982	6	5	5	1	4	5	9	3	7	–	16	–	61
1983	6	5	7	2	2	7	9	–	7	–	18	–	63
1984	5	5	6	3	3	7	9	3	7	–	18	3	69
1985	5	5	6	3	3	7	9	3	7	–	22	5	75
1986	5	5	6	4	1	6	13	–	8	–	17	–	65
1987	5	5	6	4	2	7	9	3	7	–	21	2	71
1988	6	5	8	5	–	5	9	1	8	–	17	3	67
1989	6	5	5	4	2	5	10	3	8	–	20	3	71
1990	5	5	6	4	2	6	9	3	8	–	17	1	66
1991	5	5	5	3	4	7	9	3	7	–	23	2	73
1992	5	5	5	3	4	7	9	1	9	–	22	2	72
1993	5	5	6	5	–	7	9	3	8	–	20	2	70
1994	5	5	5	4	3	7	9	3	7	–	21	2	71
1995	6	5	5	3	3	7	9	3	7	–	23	2	73
1996	5	5	4	4	2	7	9	3	8	–	18	3	68
1997	5	4	5	4	2	7	10	3	6	–	24	–	70
1998	7	7	6	4	–	7	10	5	9	2	15	1	73
1999	8	8	8	4	1	7	11	5	10	3	20	2	87
2000	10	8	9	5	2	6	9	2	8	4	19	2	84
2001	10	11	10	5	–	5	10	6	8	1	19	3	88
Total	151	144	162	75	52	170	265	65	184	10	541	51	1870

Kyoto Univ. a) : Graduate School of Energy Science
Kyoto Univ. b) : School of Nuclear Engineering
Kyoto Univ. c) : Graduate School of Nuclear Engineering

The typical weekly schedule of this course is as follows:

Monday: Registration, Orientation, Lecture of safety regulation of KUCA, Social Meeting

Tuesday: Lecture and experiments for critical mass measurement, Report writing

Wednesday: Lecture and experiments for control rod calibration, Report writing

Thursday: Lecture and experiments for neutron flux measurement, Educational reactor operation, Report writing

Friday: Report writing, discussion with all students and teachers

Saturday: Clean the rooms and breakup the course

Students and teachers stayed at the lodging of KURRI during this course. Students have a chance to have lectures by distinguished professors from participating universities at the KUCA, and through discussion during this course with other students from different universities, students can establish good communication with each other. Many of the students who have joined the course have jobs in the field of nuclear engineering of Japan, and the course can develop close personal friendships among students that continue in the future professional careers in government, industries, educational and research institutions.

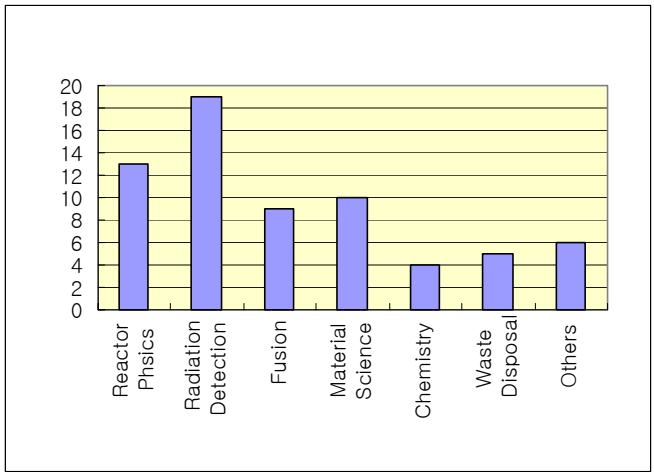

Figure 4 Theme of master thesis of students attended the reactor course in 2001

We have future plans to develop the present reactor laboratory course using KUCA as follows:

(1) In recent years, the present course is planed to learn a basic reactor physics and reactor operation, however, more advanced reactor laboratory course should be prepared to train researchers of reactor physics in master course. This advanced course is also a one-week program with several graduate students.

(2) A new reactor laboratory course is planed to establish for foreign students. For this purpose, we still have many problems to be solved; revise of English textbook for this course, preparation of budget for travel to Japan, and so on. However, this foreign students reactor laboratory course will serve the education for nuclear engineering where critical assembly is not available, and also promote international corporation in the field of nuclear engineering.

CONCLUSIONS

The reactor laboratory course for reactor experiment using KUCA have been carried out for 27 years and about 1800 students have attended this course, and many of the attendants have jobs in the field of nuclear engineering of Japan. In the future, the textbook written by English will be prepared and the new reactor laboratory course lectured in English should be opened for international promotion of reactor physics education.

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