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History and Present Situation of Kinki University Reactor (UTR-KINKI)

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ABSTRACT

The Kinki University Reactor (UTR-KINKI) is an Argonaut type teaching and research reactor and one of two university reactors in Japan. Historically, the UTR-KINKI achieved its first criticality in 1961 as the first private nuclear reactor in Japan. The power of the reactor was 0.1 W originally and it was upgraded to 1 W in 1974. In the last fifty one years, the UTR-KINKI has been used by the students and researchers from all over Japan for educational and research purposes. Currently, the fuel conversion of the UTR-KINKI is extremely difficult because it will require more cost and manpower than Kinki University can afford as a private university. Besides, special circumstances due to the Fukushima accident such as the uncertain future revisions of nuclear regulation in Japan have made the problem more difficult. Under these circumstances, we decided to start the limited feasibility study on the technical part of the conversion.

1. Introduction

The reactor UTR-KINKI is an Argonaut type teaching and research reactor with maximum thermal power of 1W, and the first private and university-owned reactor in Japan. Since its first criticality in 1961, UTR-KINKI has been widely utilized by students and researchers from all over Japan for educational and research purposes. Because of the extremely low thermal power, the reactor core generates negligible heat and that makes the reactor safe and secure. For the same reason, the construction of the reactor is very simple and suitable for the education in reactor physics. In the past, there used to be five university-owned reactors in Japan but three of them have already been shut down, therefore UTR-KINKI is now one of the two university-owned reactors remaining in Japan and is playing an irreplaceable part in nuclear and radiation science education. Especially after the Fukushima accident in 2011, the role of UTR-KINKI in

Japan has become more important than ever to respond to growing concern about nuclear energy and to support the public to understand nuclear energy and radiations scientifically.

In this paper, the history and overview of UTR-KINKI are presented as well as the response to the GTRI program.

2. Specification of UTR-KINKI

The reactor UTR-KINKI is a light water moderated and graphite reflected reactor. The reactor core is divided into two parts to have a dry and uniform irradiation field at the center of the reactor. Each core is filled with light water moderator and contains six fuel assemblies. The biological shield surrounding the core is a tank filled with water and sand. The reactor has four control rods (regulating rod, shim-safety rod, safety rod #1 and #2) in which cadmium plates are used as neutron absorbers.

Due to its low thermal power, there is no need for cooling function and the burn-up of fuel is negligible. Furthermore, the residual radioactivity is very small and the level of leakage radiation during operation is also low enough for experimenters to work at close range from the reactor. Figs. 1 and 2 show the outer appearance and reactor core of UTR-KINKI.

Fig. 1 The outer appearance of UTR-KINKI

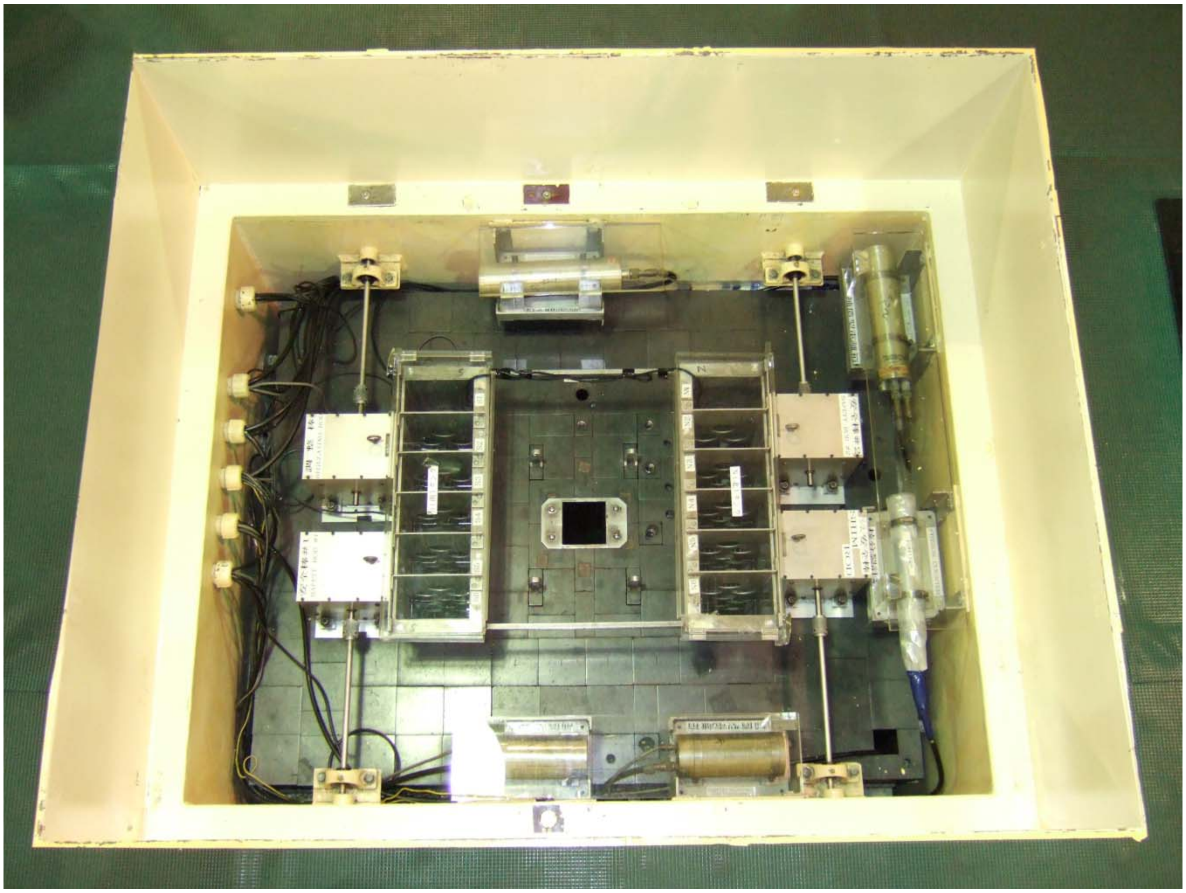

Fig. 2 The reactor core of UTR-KINKI

The fuel element of UTR-KINKI is a plate fuel which consists of 1.0 mm-thick fuel meat with 0.5 mm-thick aluminum cladding. The composition of the fuel meat is UAl_4-Al (HEU). A fuel assembly consists of twelve fuel plates. Fig. 3 shows the configuration of a fuel plate. Fig. 4 shows the outer appearance of a model fuel assembly.

The nuclear characteristics of UTR-KINKI are summarized in Table 1.

Table 1. The nuclear characteristics of UTR-KINKI

Maximum excess reactivity	0.5% δk/k
One-rod stuck margin	0.5% δk/k
Temperature coefficient	-0.008% δk/k/^{o}C
Void coefficient	-0.18% δk/k/%void
Rod reactivity worth	
Regulating rod	> 0.1% δk/k
Shim-safety rod	> 0.54% δk/k
Safety rod	> 0.54% δk/k
Start-up neutron source	Pu-Be 1 Ci (1.4x10^6 n/sec)
Maximum thermal neutron flux	~1.2x10^7 n/cm^2/sec

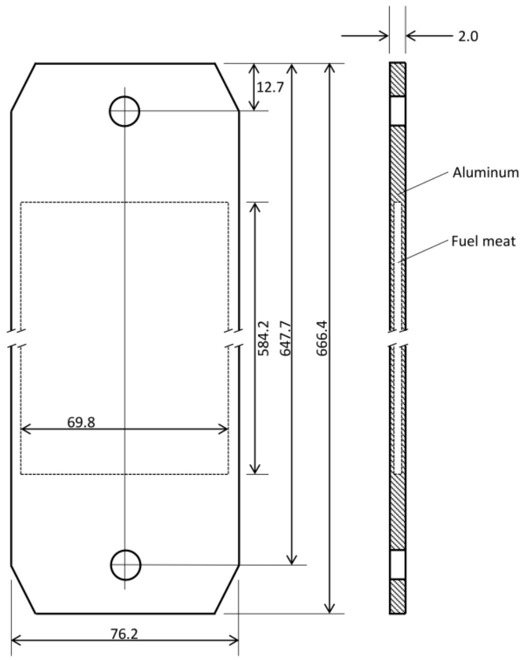

Fig. 3 The configuration of a fuel plate of UTR-KINKI

Fig. 4 The outer appearance of a model fuel assembly

3. History of UTR-KINKI

In 1959, a UTR (University Teaching and Research Reactor) was displayed and operated for 18 days in the USAEC (United States Atomic Energy Commission) Atoms for Peace Exhibit in the Tokyo International Trade Fair. The first president of Kinki University, Koichi Seko, visited this exhibit and was convinced that the human resource development in nuclear engineering would be essential for Japan's future. He decided to buy a UTR and established Atomic Energy Research Institute at Kinki University in Higashi-osaka, Japan. On November 11, 1961, UTR-KINKI achieved the first criticality with maximum thermal power of 0.1 W. This was the first criticality at a private and university-owned reactor in Japan. The maximum thermal power of the reactor was upgraded to 1 W in 1979. Fig. 5 shows the first criticality of UTR-KINKI recorded at 20:53, November 11, 1961.

Since the first criticality 51 years ago, UTR-KINKI has greatly contributed to the human resource development in nuclear engineering in Japan. Currently, UTR-KINKI is one of the two university-owned reactors remaining in Japan and nine universities utilize UTR-KINKI for the education of the students majoring nuclear engineering.

In 1981, the cooperative research program using UTR-KINKI was initiated by MEXT (Ministry of education, culture, sports, science and technology in Japan). This program has supported a various experimental studies using UTR-KINKI in detector developments, irradiation on biological samples and health physics studies. More than 40 universities and institutes in Japan have utilized UTR-KINKI in the framework of this program. In 2011, the reactor operations for 24 research subjects were conducted and accounted for 63% of the total machine time of the year.

Fig. 5 The Emperor Hirohito visits the Atoms for Peace Exhibit in the Tokyo International Trade Fair in 1959.

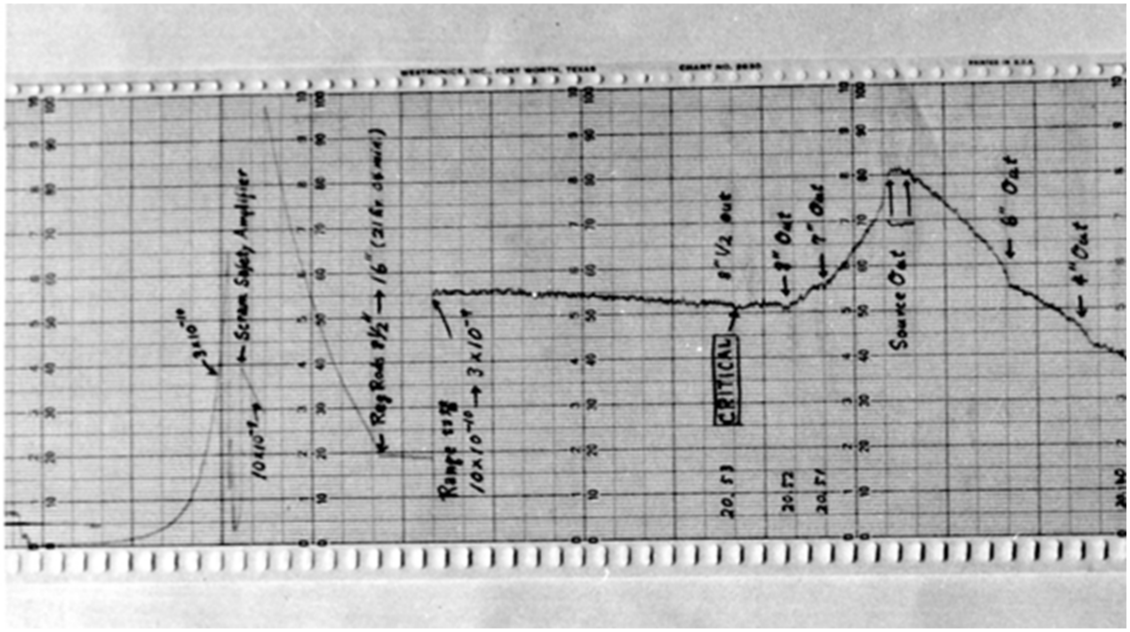

Fig. 6 The first criticality of UTR-KINKI recorded at 20:53, November 11, 1961.

Atomic energy workshop for school teachers and the public was started in 1987, soon after the Chernobyl accident, and it has provided these people with a place to learn scientific knowledge on nuclear energy and radiations through experiencing. The workshop includes the experimental courses of reactor operation, neutron radiography and radiation measurement, and the lectures on nuclear science and engineering. The number of participants has been growing in the past 25 years. In 2011, nearly 500 people were participated in the workshop. In addition, after the Fukushima accident, UTR-KINKI is playing a large role in responding to the public's growing concern about nuclear energy and radiations. Approximately 2000 visitors were received in 2011.

4. The response of Kinki University to GTRI program

The fuel of UTR-KINKI had not been regarded as an object of the RERTR program because it was bought and has been owned by Kinki University and there has been no need for refueling. Since the GTRI program has been initiated, however, the fuel has been regarded as an object of the program along with other "gap materials" of several facilities in Japan.

In February 2008, Kinki University Atomic Energy Research Institute (AERI) received a visit by the delegate of the U. S. Department of Energy (DOE) and recognized this problem for the first time. AERI intends to follow the Japanese government's policy on this issue when it is made by the government. However, there are a lot of difficulties in the conversion of UTR-KINKI currently.

Firstly, the conversion of UTR-KINKI will require a large amount of legal processes to fit the facility to present regulations and that will go far beyond technical and physical matter. Under Japanese law, UTR-KINKI is operated based on the permission approved at the time when the reactor was established in 1960. If the fuel should be converted, the work on the conversion would not only be the replacement of the fuel, but it would also demand large numbers of modifications over the whole facility under the present regulations. The amount of the legal processes required for the modifications would be comparable to those required for the establishment of a new reactor.

Secondly, UTR-KINKI is one of the two university-owned reactors remaining in Japan and an irreplaceable facility for the human resource development in nuclear engineering. The conversion would stop operation for several years and that would reduce the opportunities for students to learn nuclear engineering through experiments. A wide range of negative impacts to research work are also inevitable by interrupting experiments and irradiations using UTR-KINKI.

Thirdly, as Kinki University is a private university, it cannot afford the cost of the conversion, the modification of facility and the transport of spent fuels.

After the first meeting, DOE and AERI had several meetings and exchange views concerning the conversion of UTR-KINKI. In March 2011, DOE and AERI agreed to initiate the feasibility study on the conversion of UTR-KINKI under the condition that the completion of the study is not a commitment to convert the reactor. Just after this agreement, however, the Fukushima accident occurred on March 11, 2011 and delayed the work on the feasibility study. In addition, due to that the accident gave a large impact on Japan’s policy on nuclear energy and reactors, it has become highly possible that the laws and regulations on the reactors in Japan will undergo significant changes in the near future. Under these special circumstances after the accident, DOE and AERI decided to conduct the feasibility study only on its technical part. AERI is preparing for the launch of the feasibility study.

5. Summary

In the past 51 years, UTR-KINKI has been widely utilized for the human resource development in nuclear engineering, the education for the public and school teachers and a variety of research subjects on science and engineering. Especially after the Fukushima accident, UTR-KINKI is playing a large role in responding the public’s growing concern about nuclear energy and radiations. As for the GTRI program, it is extremely difficult for Kinki University to convert UTR-KINKI currently, but DOE and AERI agreed to initiate the feasibility study on the conversion of UTR-KINKI under the condition that the completion of the study is not a commitment to convert the reactor. The work on the feasibility study has been delayed due to the Fukushima accident occurred in 2011. DOE and AERI recently decided to conduct the feasibility study only on its technical part because the significant changes of laws and regulations on nuclear energy and reactors in Japan are expected in the near future.