RESEARCH REACTOR: A POWERHOUSE OF NUCLEAR TECHNOLOGY IN KOREA

J. HA, I.C. LIM, S.Y. OH, S. WU
Korea Atomic Energy Research Institute (KAERI),
Research Reactor Utilization·Development Department,
Daejeon,
Korea

Abstract

The nuclear era in Korea was opened with the 100 kW KRR-1 of which construction started in 1959. The second research reactor, 2 MW KRR-2, was finished in 1972, around when the first nuclear power plant project was launched. Then the next research reactor HANARO, a 30 MW multi-purpose reactor, started the operation in 1995 and has made the technologies for the research reactor development and utilization matured. The competitiveness of Korean research reactor technology was acknowledged by being selected as the supplier of 5 MW JRTR for Jordan. In addition, Korea is sharing its research reactor technologies with many other countries in the areas of training, engineering service, neutron beam instrument manufacturing, and supply of RI goods production equipment and of the advanced research reactor fuel material. KAERI, as a nuclear research institute, has a well-established R&D infrastructure together with the research reactor operation and utilization technology. It can contribute for the new comers to establish a research reactor facility as well as a research environment using the facility as a tool to build-up their nuclear technology and service capability for their public.

1. INTRODUCTION

As of year 2011, Korea is operating 21 nuclear power plants, which share 36% of the domestic electricity generation, and constructing 5 NPPs in parallel. The share is the 6th highest one in the world and provides stable electricity in low cost for the nation. Such stable and low electricity cost has contributed greatly to the fast development of the Korean economy from the disaster of the Korean War (1950–1953). All the achievements in the nuclear power industry are by virtue of continuous R&D on nuclear technology.

The nuclear R&D in Korea started with the establishment of Korea Atomic Energy Research Institute or KAERI in 1959. In 1958, the Korean government decided to build a research reactor in KAERI, and the 100 kW TRIGA Mark-II reactor, KRR-1 (Korean Research Reactor No. 1), was selected as the first research reactor in Korea. This introduction of a research reactor had opened the nuclear era in Korea. After that, the research reactor has played a great role for the nuclear technology development in Korea. At the end of 2009, the Korean consortium composed of KAERI and DAEWOO E&C was selected as the supplier of the Jordan Research and Training Reactor (JRTR). It was an achievement making Korea as an international nuclear system supplier in 50 years after the introduction of nuclear technology to Korea. In this view, the research reactor is a powerhouse of nuclear technology in Korea.

In the course of research reactor technology development in Korea, many technical achievements have been made and they can be shared with the research reactor people in the world.

This paper describes the brief history and status of research reactor development in Korea and provides the information which will be helpful for the people considering the use of research reactor as a central tool for the development of nuclear technology.

2. RR DEVELOPMENT IN KOREA

2.1 KRR-1, KRR-2 and AGN-201K

The initial criticality of KRR-1 was achieved on March 19th of 1962 and it has been utilized for the training of university students and engineers, neutron activation analysis (NAA), and RI production. In 1969, its power was upgraded to 250 kW by the domestic technology. It went to the permanent shutdown in 1995 and it will be open to the public as a nuclear museum in 2013. It had been operated more than 36 000 hours until the shutdown and contributed to fostering about 3400 persons in addition to the regular RI production and NAA[1].

The project of KRR-2 (2 MW TRIGA Mark-III) was initiated in 1968. At that time, Korean government was considering the introduction of a nuclear power plant in late 1970's and the construction of KRR-2 aimed at forming a larger infrastructure for nuclear technology development and fostering experienced nuclear engineers. KRR-2 went to the permanent shutdown in 1995 and decommissioned in 2005.

These two reactors had contributed to human resource development, the development of basic nuclear technology, and research reactor utilization technology. The utilization technology grownup there became the basis of the utilization technology development in HANARO. The built-up basic nuclear technology and the national need to enlarge the share of nuclear power in the electricity generation brought about the establishment of a national nuclear technology self-reliance program, which was conducted from 1983 to 1999, and KAERI was at the center of the program.

On the other hand, Colorado State University of USA donated 0.1 W AGN-201 critical assembly to Kyeong-Hee University in 1976. In 2007, this reactor was upgraded to 1 W with the renovations in I&C system, shielding and ventilation. It is being used for the training of students and engineers and for the industrial application such as neutron detector calibration. This reactor stared the operation in 1967 but still conducts its unique role[2].

2.2 HANARO

In the middle of 1980s, Korea started several vigorous nuclear programs to localize nuclear power technologies such as the CANDU fuel technology, PWR fuel technology and PWR technology. Along with the investment in the power reactor technology, investments were also made on research reactor technology. The project to build HANARO, which is a 30 MW open-pool type multi-purpose research reactor, started in 1985 and its initial criticality was achieved in Feb. 1995. The project was led by KAERI, and it was a combination of various indigenous nuclear technologies from the design to the commissioning. Figure 1 shows a bird eye view of HANARO complex consisting of various experimental facilities. HANARO has been utilized for neutron science, irradiation test of reactor materials and nuclear fuel, radioisotope production, neutron transmutation doping (NTD) of Si ingots, neutron activation analysis, neutron radiography, and so on. The neutron beam research has contributed to the development of new materials such as hydrogen storage material, development of Li battery, and the characterization of fuel cell. The irradiation facility in HANARO has been used for the development of new fuels such as high burn-up PWR fuel, DUPIC (Direct Use of PWR fuel IN Candu), HANARO fuel and U-Mo fuel. HANARO fulfils the most of the domestic demands for Ir-192 and I-131. As for NTD, HANARO is sharing about 10~15% of the world doping demand. Meanwhile, in order to accommodate various needs in utilization areas, KAERI has installed new utilization facilities step by step since the initial criticality of HANARO. Recent achievement is the installation of the cold neutron research facility (CNRF) in 2009. In parallel with these activities, KAERI is conducting the research reactor fuel development as well. For instance, KAERI has developed an atomized technique that produces high-quality research reactor fuel material. As a result of

fuel R&D, HANARO has loaded with KAERI-made fuel since 2005. Now KAERI is the world leader in the area of U-Mo fuel development.

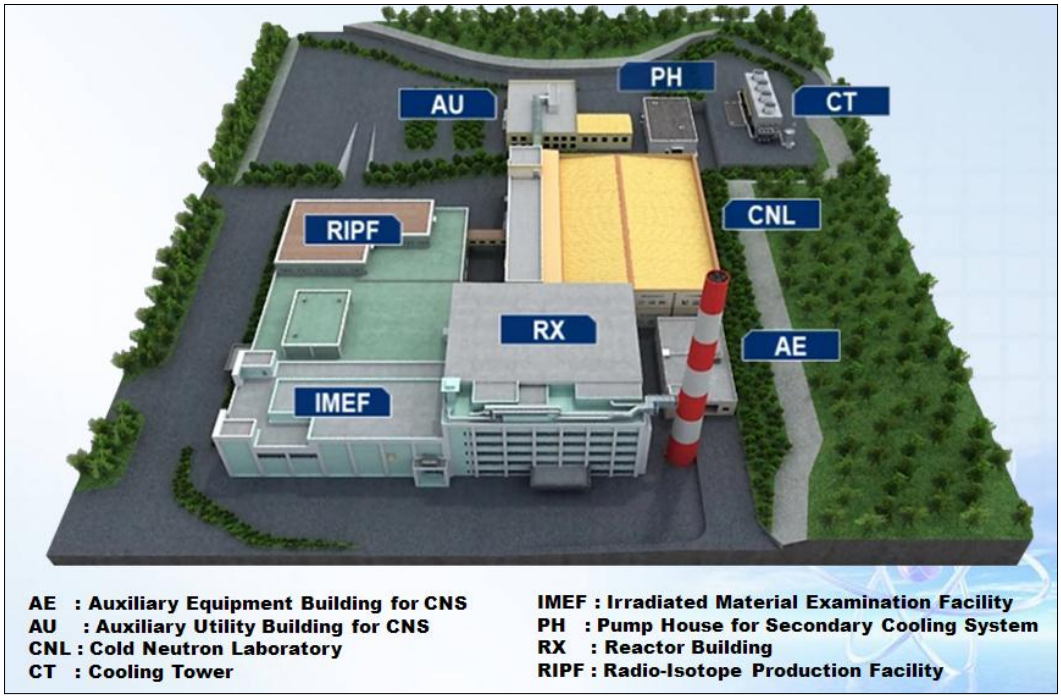

Fig. 1. View of HANARO complex.

2.3 Jordan Research and Training Reactor

In January 2009, the Jordan Atomic Energy Commission (JAEC) issued the Request for Proposals for the first nuclear reactor in Jordan. JAEC aimed 'at acquiring a research reactor that would serve as an integral part of the nuclear technology infrastructure,' and the reactor would become the focal point for the nuclear science and technology. Through the international bidding process, the consortium of KAERI and DAEWOO E&C was selected as the supplier and the JRTR construction project officially launched on August 2010. Now the application for the construction permit is under review by the regulatory body.

The JRTR is a 5 MW multi-purpose, open-pool type research reactor. It will be loaded with typical MTR type fuels of low enriched uranium. It will equip four horizontal beam ports and more than 20 vertical holes for irradiation services such as RI production, NAA, and NTD.

KAERI believes that not only the design and construction capability of Korea but also the utilization technology of research reactors in Korea helped to get additional points during the bid evaluation. In addition to constructing a safe and high performance research reactor, KAERI pays much attention to how to operate and utilize the reactor. On the other hand, the JAEC as the owner and the KAERI consortium as the contractor share a common understanding of the project. Reminding that the JRTR is the first whole nuclear facility to be built abroad for Korea and it is the first essential nuclear facility in Jordan, the importance of successful construction cannot be overemphasized because it is crucial for the future of nuclear community in both countries.

3. TECHNOLOGY SHARE

The continuous development of research reactor technology together with the stable operation and utilization of HANARO made it possible to share the technologies with the other people working for research reactor. Followings are the examples:

— Operator training for Taiwan research reactor commissioning and CARR of China;
— Export of U-M powders and U foil;
— Upgrade of the primary cooling system of GRR-1 which is a 5 MW reactor in Greece;
— Consultation on the upgrade of I&C system for TRR-1 which is a 2 MW reactor in Thailand;
— Cooperation for the Position Sensitive Detector for JRR-3M in Japan, and;
— Supply of Tc-99m abstraction system, I-131 distillation system and I-131 distribution system.

These are believed to contribute to the reactor technology in many places. For example, the EVITA irradiation program[3] in BRs for the qualification of JHR fuel is using the atomized U-Mo fuel which allows a higher uranium loading.

4. WHAT BEHIND THE SHOWN

Besides the research reactor technology, Korea is one of countries which have the strong nuclear industries, as shown in Figure 2. One can find local experts and industries except the front-end fuel cycle from mining to enrichment. In addition, as the nuclear technology in Korea has been built with the adoption of internationally accepted codes and standards, it is very applicable to overseas projects. The long and active development activities enable Korea to have a well-established regulatory structure, which will be a good reference for the new comers as well.

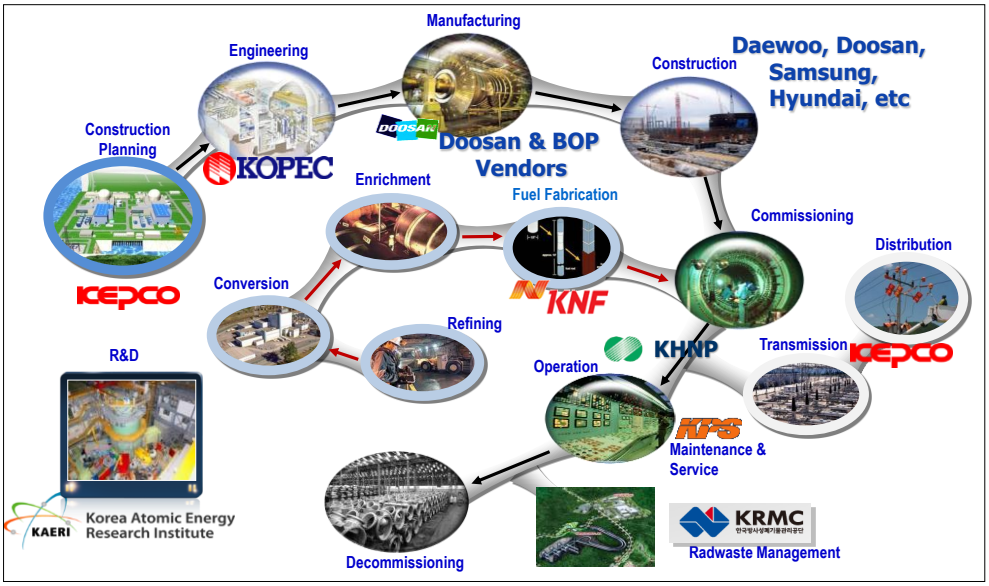

Fig. 2. Nuclear industry in Korea.

KAERI, as a nuclear research institute, has a well-established research infrastructure such as a nuclear training center and research facilities for the safety research, material research and, post-irradiation examination. The trainings are also available in many nuclear schools in Korea including Kyeong-Hee University.

KAERI is conducting many advanced reactor development programs: SMART (System-integrated Modular Advanced ReacTor), SFR, and VHTR. The technologies from

these developments can be applied to the custom design of research reactors including various experimental facilities.

In addition, the established QA system, safety management system, and a computerized information and work process control system for reactor operation, which is called ANSIM (Advanced Nuclear Safety Information System), will be good models for newcomers to establish research reactor facilities.

By combining the strength of KAERI and nuclear industries, Korea has a consortium structure in supplying research reactor system.

As presented by LIM in this conference[4], Korea will construct a new research reactor in which U-Mo plate-type fuel and bottom-mounted control rod drive mechanism will be adopted. This will broaden the horizon of technology which can be shared with the others.

5. CONCLUDING REMARKS

Korea has the 50 years of experience in research reactor technology development and also it has many success stories. It is believed that a need for research reactor will increase in Korea, and many countries have a desire to replace their existing research reactors or starter reactors for the development of nuclear technology, including the introduction of a nuclear power reactor. KAERI will continue to serve in creating valuable technologies, and KAERI is ready to share all its experiences with its foreign partners.

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