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CONTRIBUTION OF HANARO IRRADIATION TECHNOLOGIES TO NATIONAL NUCLEAR R&D

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HANARO is a multipurpose research reactor located at the Korea Atomic Energy Research Institute (KAERI). Since the commencement of its operation in 1995, various neutron irradiation facilities, such as rabbit irradiation facilities, fuel test loop (FTL) facilities, capsule irradiation facilities, and neutron transmutation doping (NTD) facilities, have been developed and actively utilized for various nuclear material irradiation tests requested by users from research institutes, universities, and industries. Most irradiation tests have been related to national R&D relevant to present nuclear power reactors such as the ageing management and safety evaluation of the components. Based on the accumulated experience as well as the sophisticated requirements of users, HANARO has recently supported national R&D projects relevant to new nuclear systems including the System-integrated Modular Advanced Reactor (SMART), research reactors, and future nuclear systems. This paper documents the current state and utilization of irradiation facilities in HANARO, and summarizes ongoing research efforts to deploy advanced irradiation technology.

KEYWORDS : HANARO, Irradiation Test, Utilization Status, Contribution to National Nuclear R&D, Advanced Irradiation Technology

1. INTRODUCTION

The High Flux Advanced Neutron Application Reactor (HANARO) is an open pool type multipurpose research reactor with 30MW thermal power located at the Korea Atomic Energy Research Institute (KAERI) in Korea. Both general design features and detailed information about this reactor are available on the HANARO home page (http://hanaro.kaeri.re.kr). In an effort to boost the nation's research capability, HANARO was conceived and constructed in the 1980s using domestic reactor technology from KAERI [1]. HANARO has been operated as a platform for basic nuclear research in Korea and the functions of its systems have been improved continuously since its first criticality in February 1995. It is now being successfully utilized in areas such as fuel and material irradiation tests, neutron beam research, radioisotope production, neutron activation analysis, and neutron transmutation doping to meet industrial, academic, and research demands.

To support the national research and development programs for nuclear reactors and nuclear fuel cycle technology in Korea, various neutron irradiation facilities such as rabbit (small non-instrumented capsule) irradiation facilities, capsule irradiation facilities, and fuel test loop facilities have been developed and actively utilized for the irradiation tests requested by numerous users [2,3]. Continuing efforts to improve the capabilities and instrumentation of the facilities have been in progress at KAERI [4-6]. The irradiation facilities have been mostly utilized for the KAERI research projects related to the National Nuclear R&D Projects relevant to a commercial nuclear power reactor such as the ageing management and safety evaluation of the components. However, some irradiation tests were performed for scientific research of universities and for several commercial-based projects. Another research reactor that will specialize in radioisotope production and the demonstration of reactor design is under construction in Korea. Therefore, HANARO will specialize more on irradiation research. Based on its accumulated irradiation experience, HANARO has recently started new support of R&D relevant to new nuclear systems including power and research reactors.

In this paper, not only the status of HANARO irradiation facilities but also the utilization of the facilities and the prospect of development of the HANARO irradiation technology to support the National R&D Projects relevant to the present and future nuclear systems of Korea are described.

2. HANARO AND IRRADIATION FACILITIES

2.1 HANARO Reactor

In April 1995, KAERI completed the construction of a high performance multipurpose research reactor named HANARO which means, in Korean, "uniqueness". The core features a combination of a light water cooled and moderated inner core and a light water cooled but heavy water moderated outer core. The inner core has 28 fuel sites and 3 test sites. Three test sites are hexagonal shaped and used for capsules, fuel test loop (FTL), and radioisotope (RI) production. The outer core consists of 4 fuel sites and 4 test sites, which are embedded in the reflector tank. There are several vertical test holes such as CT, IR1, IR2 (hexagonal type) and OR (cylindrical type) in the core of HANARO, and additionally, Large Hole (LH), Hydraulic Transfer System (HTS), Neutron Transmutation Doping (NTD) and Irradiation Position (IP) positions in the reflector region of the reactor for nuclear fuels and materials irradiation testing, RI production and Si doping, as shown in Fig. 1. Table 1 shows the characteristics of the reactor test holes for a fuel/material irradiation at HANARO [7]. The neutron flux of the vertical test holes varies markedly depending upon the location in the reactor core. The seven horizontal beam ports such as ST1, ST2, ST3, ST4, NR, CN and IR in the reflector region of the reactor are being actively applied for scattering and diffraction of neutrons, neutron radiography, and the out-of-core neutron irradiation facilities (Cold Neutron Reflection Facilities (CNRF), Boron Neutron Capture Therapy (BNCT) and dynamic Neutron Radiography (NR)).

At present, another research reactor that will specialize in radioisotope production and demonstrations of reactor designs is under construction in Korea. Therefore, HANARO will specialize more on the irradiation research of nuclear fuels and materials.

2.2 Irradiation Facilities at HANARO

Various neutron irradiation facilities such as the rabbit irradiation facilities, the loop facilities and the capsule irradiation facilities for irradiation tests of nuclear materials, fuels and radioisotope products have been developed at HANARO [2,3]. Among the irradiation facilities at HANARO, the capsule and rabbit systems have been used for the irradiation of nuclear materials, and the FTL was installed in IR1 by the end of 2008.

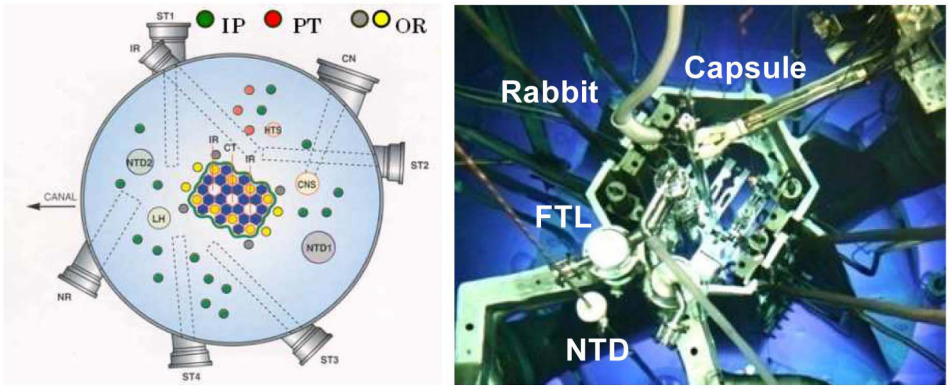

Fig. 1. Configuration and Photograph of the HANARO Core.

Table 1. Characteristics of the Test Holes for a Material Irradiation at HANARO

Location	*Hole*		Inside Dia. (cm)	Neutron Flux (n/cm^2. sec)		Remarks
	Name	No		Fast Neutron (>0.82 MeV)	Thermal Neutron (<0.625 eV)	
Core	CT	1	7.44	1.95 x 10^{14}	4.30 x 10^{14}	Fuel/material test Radioisotope production
	IR	2	7.44	1.80/1.76 x 10^{14}	3.83/3.80 x 10^{14}	
	OR	4	6.00	1.92~2.01 x 10^{13}	2.94~3.30 x 10^{14}	
Reflector	LH	1	15.0	7.35 x 10^{11}	9.72 x 10^{13}	Fuel/material test Radioisotope production
	HTS	1	10.0	1.72 x 10^{11}	8.82 x 10^{13}	
	IP	17	6.0	1.43 x 10^{9}~ 2.17 x 10^{12}	2.16 x 10^{13}~ 1.81 x 10^{14}	