

Utilization of HANARO Irradiation Facilities in 2010

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1. Introduction

HANARO is an open-pool type multi-purposed research reactor located at the Korea Atomic Energy Research Institute (KAERI), in Korea. To support the national research and development programs on nuclear reactors and nuclear fuel cycle technology in Korea, various neutron irradiation facilities such as the rabbit (small non-instrumented capsule) irradiation facilities, the capsule irradiation facilities, and the fuel test loop facilities have been developed and actively utilized for the irradiation tests requested by numerous users [1].

In this paper, the recent utilization of the facilities to support the National R&D Projects relevant to the present and future nuclear systems of Korea is described.

2. Utilization of Irradiation Facilities

As HANARO represents a multi-purpose research reactor, it plays a major role in nuclear technology development and the utilization of radiation technology in Korea. Owing to its stable operation and the build-up of various research results as well as the support of the government for the reactor, more research demands for the utilization of HANARO are arising. One of the major uses of the HANARO reactor focuses on its irradiation service. The irradiation facilities of HANARO have been actively utilized for various nuclear fuel and material irradiation tests requested by users from research institutes, universities, and industries. Utilization of HANARO is summarized in Fig. 1. One of the major irradiation fields is the support of R&D relevant to the commercial nuclear power reactor such as ageing management and the safety evaluation of its components and another field is the progress of science and technologies (fundamental research, future nuclear systems).

The national research and development program on nuclear reactors and nuclear fuel cycle technology in Korea requires numerous in-pile tests at HANARO. The main activities of the capsule development and utilization programs are focused on the in-reactor material tests, safety-related research and development for nuclear reactor materials and the components of commercial reactors, and basic research.

Fig. 2 shows the trends of the irradiation specimens and the time requested by users up to 2010. The increasing trends of the irradiation tests were recently disturbed by the installation of the CNRF and FTL.

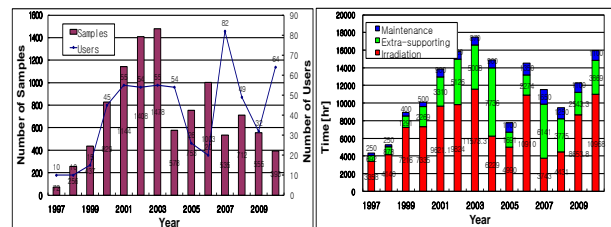


Fig. 2. Annual trends of HANARO users, samples, irradiation times

Since 1995, 10,000 specimens from research institutes, nuclear industry companies and universities, have been irradiated at HANARO for 92,000 hours using the developed capsule and rabbit irradiation systems. The capsules were mainly designed for the irradiation of a RPV, reactor core materials, and Zr-based alloys. Most capsules were made for KAERI material research projects, but some capsules were made as part of national projects for the promotion of HANARO utilization for universities and for the irradiation tests requested by international research projects. The facilities at HANARO has also been applied to several commercial-based irradiation tests relevant to the extension of life time of the current nuclear power reactor (Kori-1), new alloy and fuel developments (Doosan Heavy Industry Company (DHI) and KRPCO Nuclear Fuel Company (KNF)), and control rod material evaluation (Westinghouse Electric Company of the US). The archive material of RPV of the Kori-1 reactor that is the 1st nuclear power plant in Korea was irradiated and evaluated to support the extension of the life time of the reactor and the neutron irradiation performance of the Korean-made commercial RPV materials was also evaluated in HANARO. Several capsules were irradiated for the evaluation of the neutron irradiation properties of the parts of the nuclear fuel assemblies fabricated by the KNF.

Contribution of Neutron Irradiation

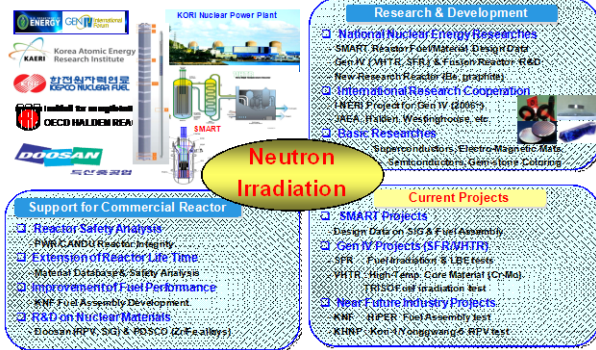


Fig. 1. Contribution fields of HANARO neutron irradiation.

Based on the accumulated experience and the users' sophisticated requirements, HANARO has recently

started new support of R&D relevant to future nuclear systems including the SMART and GEN IV Reactors (VHTR, SFR). The development of future nuclear systems is one of the most important projects planned by the Korean government.

The SMART is one of the most advanced small and medium sized reactors (SMRs) [2]. There has also been a growing interest in small- and medium-sized reactors in developed countries that have deregulated their electricity market, calling for flexibility in power generation. The Korean government decided recently to develop the system as one of its new growth engines and to obtain the standard design approval on SMART from the Korean licensing authority by 2011. The SMART R&D is now facing the stage of so-called 'engineering verification and approval of standard design' toward application to DEMO reactors. Therefore, the material performance under the relevant environment is required to be evaluated. Because the SMART steam generators are located inside the reactor vessel, the degradation of the fracture toughness of the Alloy 690 heat exchanger tube should be clearly determined for a design lifetime neutron fluence. However, the neutron irradiation characteristics of the alloy are barely known. Therefore, irradiation tests of the Alloy 690 materials to obtain the neutron irradiation characteristics of the alloy have been successfully performed in HANARO [3].

The Generation IV (GEN-IV) International Forum, or GIF, was chartered in July 2001 to lead the collaborative efforts of the world's leading nuclear technology nations to develop next-generation nuclear energy systems to meet the world's future energy needs. Among the six GEN-IV systems, Korea has participated in the VHTR and SFR R&D programs. The VHTR is one of the leading reactor designs participated in by Korea and the US. At present, no candidate alloy has been confirmed for use as either the cladding or structural material in VHTR's. To meet these challenges, a Generation IV R&D plan for the structural materials in VHTR's was initiated as an I-NERI Project. To obtain the VHTR environmental and irradiation effects on high-temperature candidate materials of Fe-Cr-Mo alloys, irradiation tests have been successfully performed in HANARO [4].

KAERI also seeks to develop the technologies needed to test nuclear fuels for the VHTR and SFR systems. The reduced fuel elements of U-Zr and U-Zr-Ce fuels for the SFR system have been fabricated and are being irradiated in the HANARO since November, 2010 (low burn-up test). To effectively support the R&D relevant to the VHTR system, the development of technologies concerning TRISO fuel irradiation testing is being preferentially developed in HANARO.

The Korean government plans to take another step forward in research reactor development. It is currently reviewing a plan to build another research reactor which would take five years for completion if work starts in 2011. The new reactor's major functions will be to realize new technologies applicable to a research reactor,

production of radioisotopes, and neutron transmutation doping. The new reactor, once completed, is expected to make an enormous contribution to resolving the radioisotopes shortage problem worldwide. It will also become the most up-to-date research reactor available in the world. This will make it possible to accommodate more irradiation test in HANARO and will stimulate the irradiation research program.

3. Conclusion

HANARO irradiation facilities such as the rabbit irradiation facilities, the capsule facilities, the Fuel Test Loop facility for irradiation tests of nuclear fuels and materials have been developed at HANARO. The rabbit and capsule systems are actively being utilized for the irradiation tests of fuels & materials of the commercially operating nuclear reactors in Korea. Although HANARO has been applied on several commercially based irradiation tests, recent irradiation tests have been related to the National R&D projects relevant to the present nuclear power reactors. Based on the accumulated experience and the users' sophisticated requirements, HANARO has recently started new support of R&D relevant to the future nuclear systems of the SMART, VHTR, and SFR. The development of future nuclear systems is one of the most important projects planned by the Korean government. A new research reactor that is for radioisotope production, NTD and the demonstration of reactor design is under planning in Korea. This will make it possible to accommodate more irradiation test in HANARO and will stimulate the irradiation research program.

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