RECENT IMPROVEMENTS IN HANARO

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1. Introduction

During the last six years since HANARO commenced power operation in 1995, the facility has been improved and enhanced continuously. Every performance of reactor systems is being measured and analyzed to confirm that all the results of the reactor performance meet design values. The utilization facilities in HANARO have been equipped following the installation schedule within the given budget. Recently some improvements have been made in the systems to enhance their functions. The first one is fuel failure detection system (FFDS) using NaI, which was not so sensitive to monitor gamma activity due to the fuel failure and the system was renovated by changing NaI with BF_3. The second is pool cover, which is presently used to prevent any materials from being dropped into the reactor pool during the reactor operation. The function of this pool cover has been changed to accommodate some utilization facilities on the cover to provide a convenient working place. The third improvement is the aluminum plugging of the infrequently using vertical irradiation holes in the reflector tank in order to increase the neutron flux of frequently using holes. The aluminum plugging of the holes caused significant neutron increases to the actively utilizing holes. In this paper described are how the system and component are improved and what the present expansion of utilization fields is in HANARO and what kinds of action are taken in order to enhance the utilization of the facility. And then, finally the prospect of the facility was drawn as a conclusion.

2. Fuel Failure Detection System (FFDS)

Fuel failure in any reactor should be detected as soon as possible for the reactor safety and for the radiation protection of all people in the hall. The monitoring of gamma or delayed neutrons from the coolant makes early detection of fuel failure possible. It is important in the failed fuel detection system how fast and accurate the fuel failure be detected. In the HANARO, FFDS [1] consists of three NaI detectors that are located below the common return line of the primary cooling loop. The NaI detectors are shielded by 9 inch thick lead except a collimator of 0.5 inches diameter because the HANARO has no decay tank so that the radiation level at the detector position is very high due to ^{16}N. Major gamma energies of fission products and activation product except ^{16}N are lower than 2 MeV. ^{16}N decays by emitting high energy gamma above 6 MeV. Measuring total gamma activity whose energy range is below 2 MeV was not so sensitive to detect fuel failure because the high energy gamma due to ^{16}N built up Compton background to the detector. Therefore, ^{16}N effect was compensated by using two Single Channel Analyzer (SCA). But the NaI detector system was still unstable because the compensated values are small compared to the Compton background. To solve the problems of FFDS using NaI, BF_3 proportional counter detecting delayed neutron was installed and its function has been tested for two years. The results of the test were very satisfactory in that measurement was sensitive to the fuel failure and the system was stable. Existing NaI system is considered to use for power monitoring.

3. Pool Cover Change

Pool cover is presently used to prevent any materials from being dropped into the reactor pool during the reactor operation. Neutron Transmutation Doping(NTD) facility is now being manufactured with the installation schedule in the later part of this year on the cover. This facility must be set up exactly above the NTD holes to maintain the verticality from the facility to the hole. A new supporting cover above the pool is necessary in order for NTD facility to be set up on the cover. The supporting cover should be movable because it should be moved out from the pool during the time of fuel loading and unloading. This new cover comes to provide a convenient working place to any experimental activities to be done in the pool center. The present pool cover will be replaced by the new supporting cover.

4. Aluminum Plugging

There are 25 vertical holes in the reflector tank of HANARO. These small or large holes are filled with pool water. When the holes are not used, the water columns of the infrequent using holes by absorbing thermal neutron cause significant neutron loss to the using holes. However, if these water columns are replaced by aluminum cylinders, significant increases of neutron flux for each frequent use hole are confirmed. Fig.1 reveals the analyzed results of the neutron saving at various irradiation holes. Fig.2 shows measurement results of the neutron flux increase in the beam port of HRPD as an example. Thus, infrequently using vertical holes are scheduled to be plugged with aluminum cylinders in order to increase the neutron flux of frequent utilizing holes from the later part of this year.

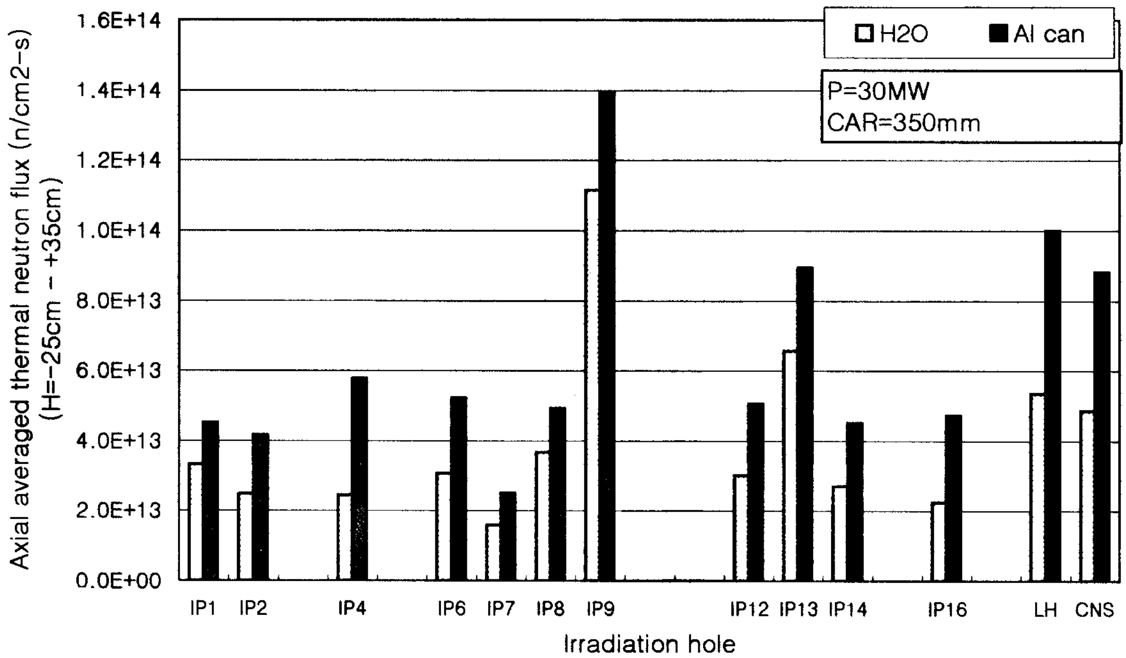

Fig. 1. Neutron increases by using aluminum plug

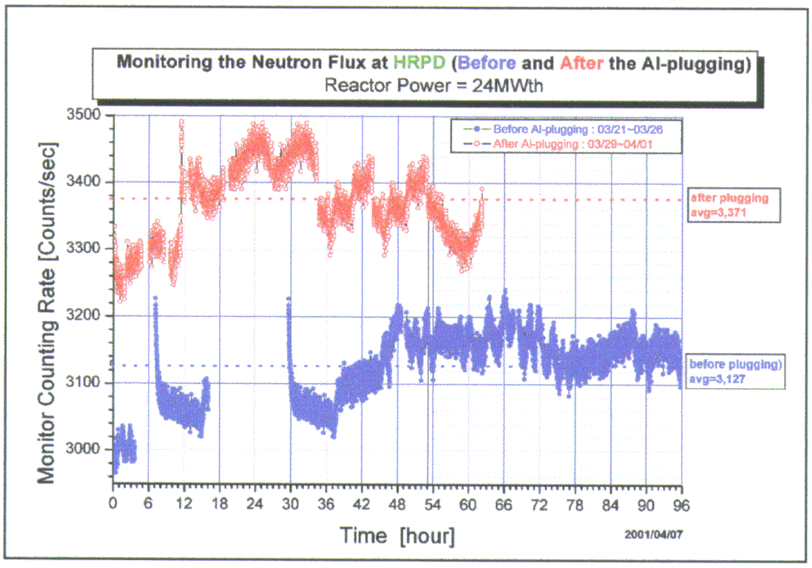

Fig.2. Measured count rates of neutron increase in HRPD

5. Expansion of Utilization Fields

Neutron beam instruments such as HRPD, FCD and NRF are actively utilized and SANS is now in commissioning stage, and then PNS is being installed with the schedule of commissioning starting in 2002. A Reflectometer is now under design at ST3 beam port. The design of CNS and TAS is scheduled to start from 2003 The design targets of BNCT in the beam characteristics are: thermal neutron flux $\geq 2 \times 10^9$ n/cm^2/s, the ratio of thermal-to-fast neutron flux ≥ 100, gamma ray dose rate $\leq$ 0.5 Gy/hr, and the irradiation time $\leq$ 2 hours. The beam performance test of BNCT facility is scheduled to execute within this year [2]. For the on-site measurement of boron concentration, PGAA system is being developed. At present, the measurement of beam characteristics in PGAA is being conducted and the improvement of beam quality by focusing technique is scheduled in the near future [3].
There are two vertical NTD holes (NTD-1 and NTD-2) in the reflector tank. The study on the NTD facility was commenced from 1988, however it could be neither continued, nor the facility be installed due to no demand from industries. Because the most important factors for the facility design are the exact size of silicon crystal to be irradiated and the specification of silicon crystal that has to be supplied by industries. Last year, the shut-down of Riso reactor in Denmark forced KAERI to use NTD holes in HANARO for silicon irradiation. HANARO is expected to fill the gap caused by Riso [4].

6. The Enhancement of HANARO Utilization

The government allocated a special research fund from 1999 to enhance the facility utilization. In the first year, a total of 44 research subjects were proposed for the research fund, but 27 subjects were awarded. However, in the second year, 41 research subjects were approved to pursue their research work by utilizing HANARO facilities. Fig.3 shows the trend of users situation. [5]

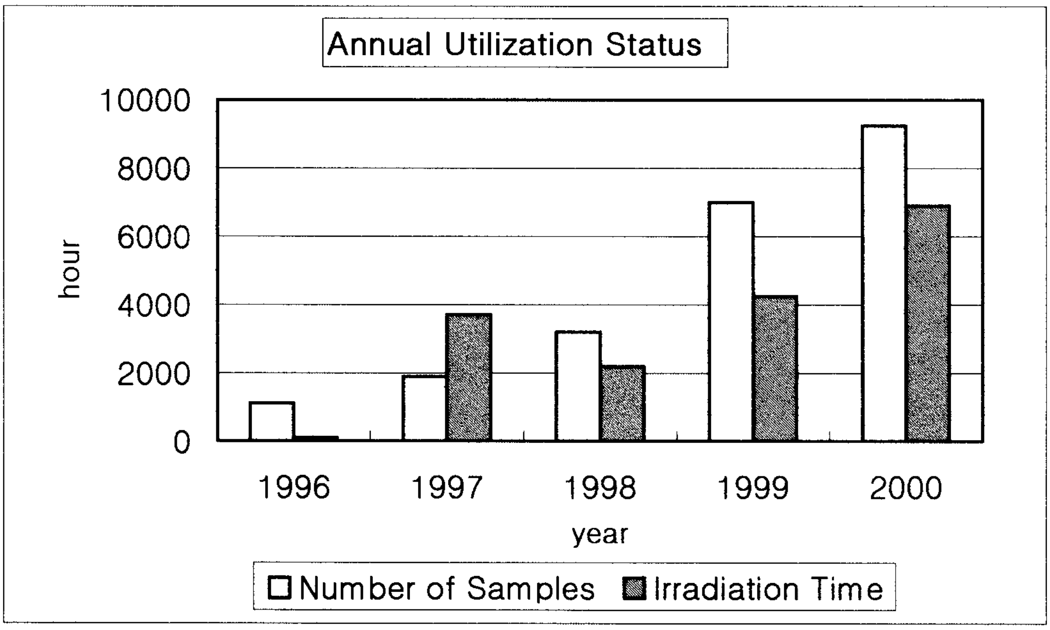

Fig. 3. Annual increases of test samples in HANARO

7. Concluding Remark

The performance of HANARO has been improving continuously and has reached the maturity of technical operability. For the advanced utilization of the reactor, more elaborated facilities are required as well as well-experienced researchers with new idea. User groups in every discipline are being expected to play a leading role for the advanced utilization of HANARO. Recent collaboration activity between Po-Hang Light Source (Accelerator) and HANARO for complementary research work seems to be a good sign for advanced research targets. A Cold Neutron Source (CNS) is the prime facility to be installed in the near future. HANARO is very active in the international cooperation program. IAEA made a guideline that the Regional Cooperation Agreement (RCA) to be led by the member countries themselves. Korea is assigned as the leader country of the research reactor area in Asia and Pacific region. Nuclear science and technology in the Asia region are becoming so intertwined that an advanced utilization of reactor in one country in this area has a far-reaching effect on the others. Hence, it is imperative that HANARO fosters cooperation and collaboration work through advanced research activity.

8. Acknowledgement

This work was performed under the national nuclear programs for international cooperation study sponsored by the Ministry of Science and Technology

9. References

[1] **Lee, B.C. et al.**: "Experience on the fuel failure detection system at HANARO"; JAERI-Conf-99-006(ASRR-VI Proceedings); 1999

[2] **Lee, B.C.; Jun, B.J.**: "Development of BNCT facility in HANARO", Proceedings for 2000 workshop on the utilization of research reactors, FNCA; 2000

[3] **Choi, H.D. et al**: "Development of PGAA facility in HANARO", Proceedings for 2000 workshop on the utilization of research reactors, FNCA; 2000

[4] **Jun, B.J.**: "The analysis of NTD", KAERI document No.:HAN-RO-CR-441-00-35; Oct. 2000

[5] **Kang, Y.H.**: "Annual utilization status", Internal memorandum, KAERI; Dec. 2000