New Design of a Pneumatic Irradiation Facility (PTS #1, 3) at the HANARO Research Reactor

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1. Introduction

Pneumatic transfer system (PTS) is essential for a sample neutron irradiation for the reactor neutron activation analysis. There are several types of a PTS according to the purpose of an experiment and its alternative design is possible. The design of a PTS is also based on parameters such as the neutron flux and distribution, temperature, gamma heating of the irradiation site, cooling of the irradiation tube as well as the radiation dose rate, material and type of rabbit, and the safety of the reactor operation, and so on.

In this paper, the new design of PTS #1 and #3 are described as the facilities to be used in an irradiation of target materials including a delayed neutron activation analysis (DNAA) in the HANARO research reactor. In addition, the operation and control of the system and future applications are presented.

2. Methods and Results

These PTSs are to be installed into two holes (NAA #1, IP-7) in the reflector tank of a reactor as shown Figure 1.

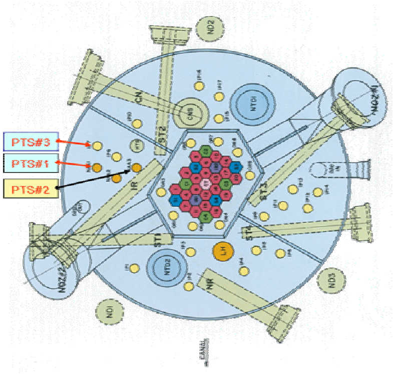

Figure 1. Irradiation sites of PTS #1 and #3 at HANARO research reactor.

2.1 Fundamental Concept

This paper will be limited to a description of the design of a new system and its applications. PTS #1 for an INAA is a simple shuttle system where a rabbit is sent from a loader/receiver in a NAA lab to an irradiation hole (NAA #1) and returns to it after the irradiation time is elapsed and the system is manually operated by a mechanical controller. The component of PTS #3 for both INAA and DNAA is much like that of PTS #1, but an automatic counter system is added and operated by a programmable logic controller (PLC) connected with a MCA coupled to a BF_3 proportional counter for the measurement.

2.2 Structural Components

The basic composition consists of six systems as follows; 1) irradiation and transfer system (controller, irradiation tube, transfer tube, auto-loader, loader-receiver, receiver, air cushion valve assembly, diverter, photo sensor and high purity polyethylene or graphite rabbit), 2) N_2 gas supplier system, 3) gas exhaust system, 4) emergency system, 5) shielding system (loader-receiver, receiver, transfer line), 6) DNAA counting system.

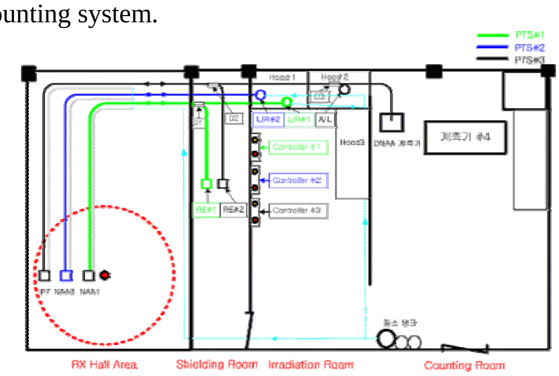

Figure 2. Layout of PTS #1 and PTS #3.

2.3 System Design

The design of the new PTS is functionally illustrated in Figure 2. The irradiation sites in these systems are located near the reflector by considering the thermalized neutron and flux (about 3E+13 $n \cdot cm^{-2} \cdot s^{-1}$), gamma heating rates (< 1-5 $Watts \cdot g^{-1}$). The ratio of the thermal to epithermal neutron is more than 1000.

The irradiation system consists separately of an irradiation tube and an exhaust tube to contact it with the cooling water of the reactor. The inner diameter of the irradiation and transfer tube is identical with each other. The interval between the rabbit and the transfer tube is about 0.7 mm by considering the radius of the curvature and the diameter of the tubes. The loader/receiver of PTS #1 is located in a fume hood, whereas the receiver is located in a Pb shielding box. The auto-loader of PTS #3 is placed in the PTS lab and the counter for the DNAA is installed in same place. Several features of the two systems are functionally equivalent. Both systems operate with gas entering both ends of the transfer tube and the N_2 gas pressure from the main supplier is usually between 15 and 25 psig. A rabbit in either of the transfer tubes thus moves to the location where a gas exhaust line is opened and stops at the receiving place. The gas supplier and exhaust line are located at both the loading and irradiation system in the reactor pressure tank. The gas supplier and the exhaust line are also placed in the delayed neutron counter.

The rabbit in both systems can be manually or automatically placed into either the loader/receiver or auto-loader, sent to the irradiation tube for a preset time and returned to either the receiver or delayed neutron counter when the irradiation time elapses. A transfer path of a rabbit can be controlled by the diverter. In the case of a DNAA, after the irradiation time elapses, the rabbit returns to the neutron counter where it is held by a gas flow column until a preset counting time has elapsed as shown in Figure 3. The gas flow is stopped to permit the rabbit to fall into the rabbit receiver. For the gas supply lines, protection is provided by two serially placed check valves that prevent a back flow of the gas and a flow of water into the gas supplier. Air cushion valve, safety ball valve and a photo-sensor in both systems are also equipped and electrically operated and controlled by the PTS #1 and PTS #3 controllers. All of the valves that are in the transfer system are automatically operated and are left closed when the pneumatic systems are not being used. Both systems have radiation alarm monitors that are located near the receiving systems.

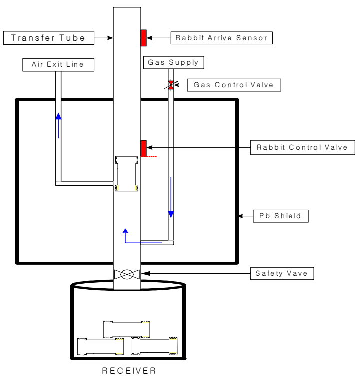

Figure 3. Schematic diagram of neutron counter column in PTS #3.

2.4 Construction and Test

The system will be constructed by an externally qualified manufacturer during 2005. Test of the PTS operation made with a mock-up before the system was installed, and a rabbit was filled with weighted material (about 5 g). The inspection and accomplishment of the system shall by carried out by both an expert and a national qualified auditing organization.

2.5 Applications

The newly designed PTS will be mainly used for the instrumental neutron activation analysis which contains a delayed neutron activation analysis using a nuclear fission reaction. In addition, the system will be used for the production of a radioactive tracer, a irradiation test of several materials, a nuclear fission track method, etc.

3. Discussion

For the safety of the pneumatic system and the reactor operation, the inner temperature and gamma heating of the irradiation tube, cooling of the irradiation tube as well as the radiation dose rate are important parameters and they affect the irradiation time, the material and type of rabbit and the radiation shielding. Another effect is a loss of volatile trace elements from a sample due to an overheating of a rabbit. Pneumatic tube and rabbit materials should be purified to below 1 ppm of the trace element contents. After an exposure to a neutron fluence of about 10^{19} $n.cm^{-2}$ and a decay of one week, the radiation dose rate at the surface of a rabbit is not significant. Thus a graphite rabbit can be used repeatedly and irradiated for as long as possible, if it is not contaminated inside. For an accurate analysis, the transfer time of a rabbit in both systems should be considered. In particular, the velocity of the rabbit in PTS #3 is related to the technique of moving and stopping the rabbit at the counter column and the length of the pneumatic tube comparablely. Therefore, the system should be automated for a DNAA.

4. Conclusion

The aims of this project were to establish the technology for a new pneumatic transfer system (PTS) design in the HANARO research reactor for an increment of the utilization facility and its effectiveness for an instrumental neutron activation analysis (INAA). The specifications for the construction of the new PTS were prepared to improve the accuracy of the transfer time and the safety of its operation, the drawing of the system, and the cost for the PTS construction were evaluated. The results will be used for wider applications for the NAA in many fields by an enlargement of the HANARO utilization facility.

REFERENCES

[1] H.S.Chung, Y.S.Chung, J.S.Woo, H.K.Kim, Y.S.Choi, S.H.Kim, J.H.Moon and S.Y.Baek, Control of pneumatic transfer system for neutron activation analysis, KAERI/TR-1576/00, 2000.

[2] Y.S.Chung, J.H.Moon, S.H.Kim, Y,C.Park, M.J.Kim, J.S.Yu, Y.K.Cho and H.K.Kim, Development of Pneumatic Transfer System Design in HANARO Reactor for Neutron Activation Analysis, KAERI/RR-2463/2004, 2004.

[3] Y.S.Chung, J.H.Moon, Y.J.Chung, S.H.Kim, S,Y,Baek, H.J.Cho, K.W.Park, S.H.Kang, J.M.Lim and Y.J.Kim, Evaluation for Status and Utilization of Neutron Activation Analysis Facility of HANARO Research Reactor(1996-2003), KAERI/ TR-2772/2004, 2004.

[4] F.T.Binford and B.N. Cramer, The High Flux isotope Reactor; A Functional Description, ORNL-3572, May 1964.