Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Development of New Capsule Technology for a Control of the Neutron Fluence of a Specimen

K.N. Choo, M.H. Choi, M.S. Cho, Y.T. Shin, S.J. Park and B.G. Kim
HANARO Utilization Technology Development Div., Korea Atomic Energy Research Institute
150 Deokjin-dong, Yuseong-ku, Daejeon 305-353, Korea, knchoo@kaeri.re.kr

1. Introduction

Various irradiation devices have been developed at HANARO (High flux Advanced Neutron Application ReactOr) [1]. Among the irradiation facilities, a capsule is the most useful device to cope with the various test requirements.

Extensive efforts have been made to establish design and manufacturing technology for a capsule and temperature control system, which should be compatible with HANARO's characteristics [2,3]. 5,600 specimens from 32 domestic research institutes, 2 nuclear industry companies and 67 universities, have been irradiated in HANARO for 53,000 hours using the irradiation capsule system since 1995 [4].

In an irradiation test using a capsule, the neutron fluence of a specimen is mainly dependent of the reactor operation time. For the required specific fluence of the specimens, the reactor operation period has been controlled in HANARO. However it became difficult because of an increased number of reactor users and a stabilized reactor operation schedule. Therefore, short time irradiation tests such as RPV materials requiring only a 2 day-irradiation for a life time neutron fluence requires new capsule technology.

A mock-up capsule (04M-22K) was designed, fabricated and tested for the development of new capsule technology for controlling the neutron fluence in HANARO irrespective of the reactor operation. In this paper, the current status of the development of the capsule is described.

2. Capsule Design Concept

Fig. 1 shows the conceptual design of the fluence control capsule. The system mainly consists of a main capsule, a protecting tube, a junction box, and a lifting device. Five subcapsules simulating square and round bar type specimens are accommodated in the capsule and each sub capsule can be taken out of the HANARO core during a reactor operation. The subcapsule could be lifted up by a pulling out mechanism using a steel wire. To take the subcapsule out of the reactor core, the length of the capsule would be twice as long as that of the conventional capsule.

Moreover, the fluence control capsule will make it possible to irradiate specimens at different temperatures and with different fluences. With this one capsule, five different total fluences at five different temperatures can be ideally realized. Usually, one capsule realizes only one irradiation fluence at one temperature. Thus, it takes several years and an expensive irradiation cost for several capsules to carry out a systematic irradiation at different temperatures with different neutron fluences.

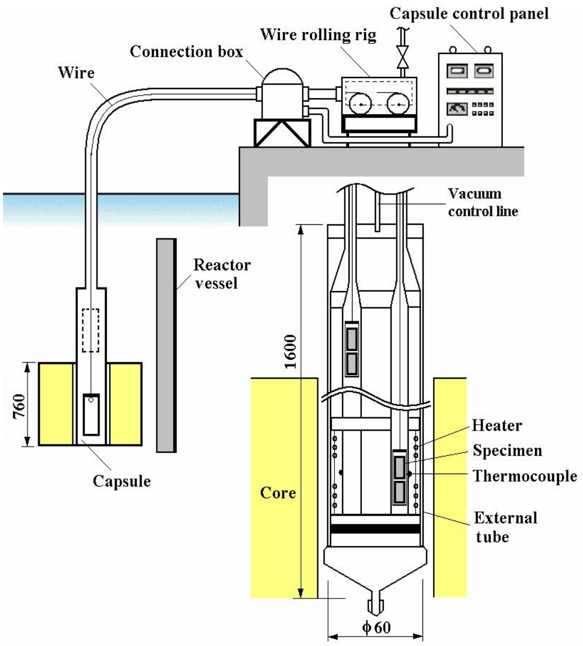

Figure 1. Schematic diagram of fluence control capsule.

3. Fabrication and Performance Tests

A mock-up capsule(04M-22K) was designed, manufactured and out-of-pile tested to confirm the capsule technology. The mock-up capsule consists of three main parts which are connected to each other: protection tube (5m), guide tube (9.5m) and capsule main body. The main body including specimens and instruments is a cylindrical shape tube of 60mm in diameter and was designed to the same length as a conventional capsule. The main body has 4 stages with independent micro-electric heaters and contains 12 thermocouples. The electric heaters were coiled on the outer surfaces of the aluminum block. Specimens were inserted in the aluminium block at the lower three stages.

A gap between the aluminum block and an outer tube provides an appropriate heat removal rate for a temperature control. The gap is filled with helium gas. Fig. 2 shows a cross sectional view of the 3rd stage of the capsule accommodating five subcapsules. These subcapsules could be lifted up using each connected steel wires through the vacant top stage. Specimens will be inserted in these subcapsules or to replace these subcapsules. The structures of the two lower stages are same to a conventional capsule. To compare the easiness of different designs, two transfer tubes were installed in the capsule, being thermally bonded by an aluminum block. Heaters, thermocouples, and specimen lifting wires are connected to a capsule temperature controlling system through a guide tube and a junction box system.

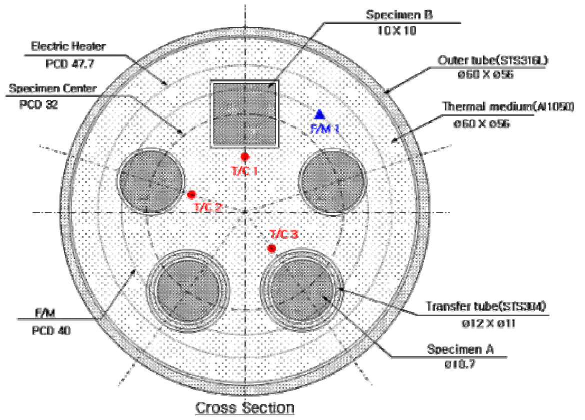

Figure 2. Cross section of a capsule accommodating five subcapsules.

Fig. 3 shows the parts and an assembled fluence control capsule. The mock-up capsule was successfully out-of pile tested under an air environment at room temperature and a temperature of 300℃. The temperature of each subcapsule was monitored by a thermocouple inserted into the bottom of the subcapsule. Although the subcapsules having a transfer tube showed a better mobility, all of the subcapsules were easily lifted up by this pulling out mechanism using a piano steel wire.

3. Application to HANARO

Through parametric out-of-pile tests, an optimal design of the fluence control capsule could be suggested. However, several technical and safety analyses should be performed to apply this capsule in HANARO. The length of the outer tube should be determined according to the HANARO reactor characteristics and some manufacturing techniques should be improved. Finally the safety of the capsule should be strictly examined for an irradiation in the reactor.

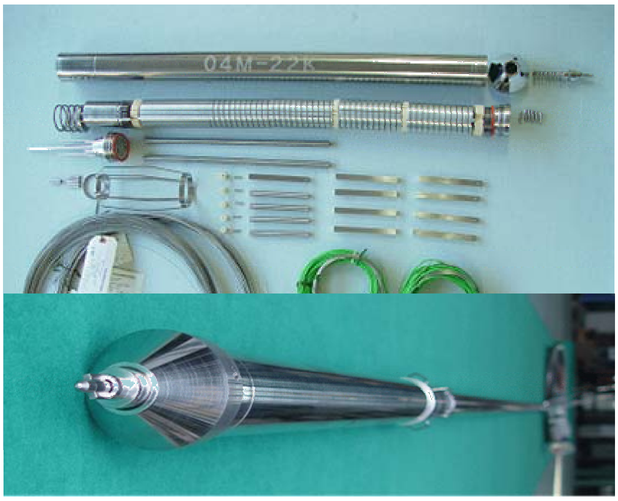

Figure 3. Parts and assembled one of a fluence control capsule.

4. Conclusion

A mock-up capsule (04M-22K) was designed, fabricated and tested for the development of new instrumented capsule technology for a more precise control of the irradiation fluence of a specimen irrespective of the reactor operation. The capsule was successfully out-of-pile tested under an air environment and the obtained results will be very valuable for the development of a capsule for a control of the irradiation fluence of a specimen in HANARO.

Acknowledgement

This study was supported by Korea Science and Engineering Foundation (KOSEF) and Ministry of Science & Technology (MOST), Korean government, through its National Nuclear Technology Program.

REFERENCES

[1] KAERI, HANARO Summarized Report, KAERI, KAERI/PR-001/97, 1997.
[2] Y.H. Kang et als, A study on the development of instrumented capsule for the material irradiation test, KAERI Research Report, KAERI/RR-1760/96, 1997.
[3] Y.H. Kang et als, Safety analysis report (SAR) for the HANARO capsule and related systems, KAERI Technical Report, KAERI/TR-985/98, 1998).
[4] K.N. Choo et als, Irradiation experience and technology development of a material capsule, HANARO 2005 Symposium, 2005, Daejeon, Korea.