

## The Utilization Status of the Irradiation Holes in the Core at HANARO

Ho-young Choi, W.H. In, C.S. Lee, K.H. Lim  
HANARO Management Division, Korea Atomic Energy Research Institute,  
1045, Daeduk-daero, Yusung-gu, Daejeon, Korea  
choihy@kaeri.re.kr

### 1. Introduction

HANARO had reached first criticality in Feb. 1995, and achieved the design power of 30 MWth in Sept. 2004. After first criticality, it has been in use for fuel & material irradiation tests, radioisotope production, the study using neutron-beam, NAA(neutron activation analysis) and NTD(neutron transmutation doping). This paper analyzes the status of utilization of the irradiation holes in the core at HANARO from 1996 to 2008. The irradiation holes in HANARO are composed of vertical irradiation holes in core and in reflector tank. The vertical irradiation holes such as CT1, IR1, IR2 are located at inner core, with  $4.39 \times 10^{14}$  n/cm<sup>2</sup>-sec of the maximum thermal neutron flux. And 4 holes (OR3, OR4, OR5, OR6) are located in outer core with about  $3.36 \times 10^{14}$  n/cm<sup>2</sup>-sec of the maximum thermal neutron flux as shown in Table 1. These irradiation holes are used for fuel & material Irradiation tests, medical & industrial radioisotope production and etc.[1]. Fig. 1 shows the location of irradiation holes in HANARO.

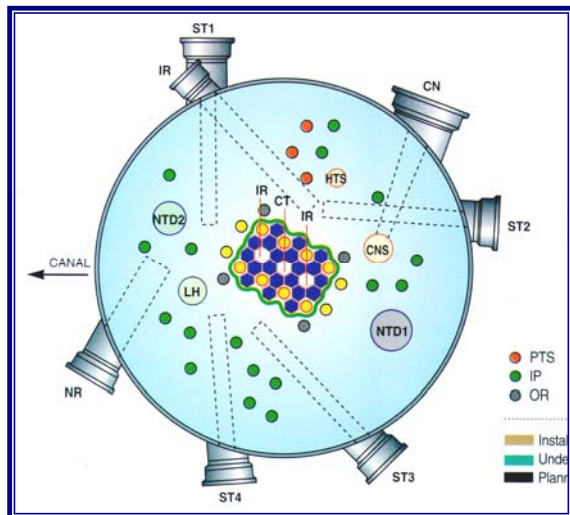


Fig. 1. Location of irradiation holes

Table 1. Condition and use of vertical irradiation holes

Position	Name	Num. of holes	Thermal flux (n/cm <sup>2</sup> -sec)	Service
In core	CT	1	$4.39 \times 10^{14}$	Fuel and material irradiation test
	IR	2	$3.93 \times 10^{14}$	Fuel and material irradiation test
	OR	8	$3.36 \times 10^{14}$	RI production

### 2. The utilization status of the irradiation holes

Fig. 2 shows the utilization factors of 7 irradiation holes in the core. The utilization factors are the ratio of the occupied days of the irradiation holes to reactor operation days.

The use of irradiation holes in the core was not active from 1995 to 1997. In this period, the reactor physics and power increasing tests had been performed and the equipments and facilities were not prepared[2].

After equipments and facilities such as capsules and rigs for RI production and material test were developed, irradiation holes' usage was increased and the use rate has exceeded 90% from 2002. The use rate of the irradiation holes was slightly decreased in 2007 and 2008, because IR1 hole has been occupied by FTL(fuel test loop) to irradiate PWR and CANDU of 3-pin nuclear fuel as a same condition of the commercial nuclear power plant. FTL is planned to irradiate 3-pin PWR test fuel from 2009[2].

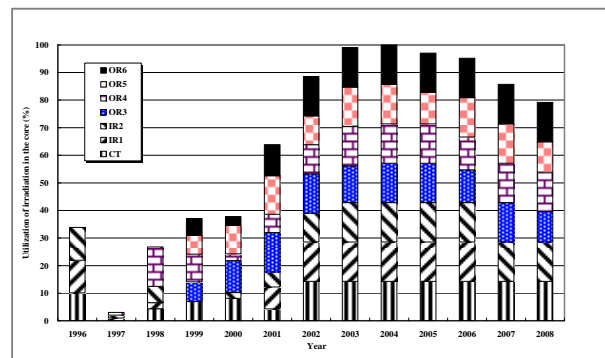


Fig. 2. Utilization factors of irradiation holes

Table 2 and 3 show the annual record of irradiation materials loaded in the irradiation holes. In 1996, HANARO fuel irradiation test was conducted at IR1, 2 and HANARO structural material irradiation testing at CT hole using non-instrument capsule. HANARO fuel irradiation tests at IR hole from 1996 to 1998, were for verification of nuclear fuel performance at a high nuclear power condition. The irradiation holes' usage is increased as capsules were developed such as instrument and non-instrument capsule for nuclear fuel development and material irradiation, radioisotope production capsule, creep capsule and fatigue capsule for material irradiation[2].

For the fuel irradiation, there are many fuel irradiation tests had been performed in HANARO. The fuel irradiation test for HANARO fuel localization

started from 1998. Until 2006, DUPIC nuclear fuel irradiation testing carried out six times at OR holes. The first U-Mo fuel was loaded at the core to carry out irradiation in 2001, and UO<sub>2</sub> nuclear fuel from 2002. U-Zr nuclear fuel irradiation test was done from 2003 to 2006.

capability of fuel performance test. If the FTL starts an irradiation service at IR1, all of the irradiation holes in the core will be fully used.

### REFERENCES

- [1] i.c. lim et al. 'Year 2007 HANARO & Utilization Facility Operation', KAERI/MR-484/2007, 2008.  
[2] c.s. lee, 'Utilization of the irradiation holes in the core at HANARO', KAERI, 2008.

Table 2. Irradiation holes' usage status annually (1996~2002)

Irradiation Hole	1996	1997	1998	1999	2000	2001	2002
CT,IR1,IR2	CAP		ICAP	ICAP	ICAP	ICAP	ICAP
	HANARO (3 rods)	HANARO (3 rods)	HANARO (3 rods)	HANARO (KAERI)	HANARO (KAERI)	Ir-CAP	Ir-CAP
OR Holes			HANARO (6 rods)	HANARO (6 rods) ANL-fuel DUPIC Ir-CAP RI-CAP	ANL-fuel DUPIC Ir-CAP RI-CAP	UMo UZr DUPIC Ir-CAP RI-CAP	DUPIC UO <sub>2</sub> Ir-CAP RI-CAP

Table 3. Irradiation holes' usage status annually (2003~2008)

Irradiation Hole	2003	2004	2005	2006	2007	2008
CT,IR1,IR2	ICAP Ir-CAP	ICAP Ir-CAP	ICAP Ir-CAP	ICAP Ir-CAP	ICAP Ir-CAP	ICAP Ir-CAP
OR Holes	UMo UZr UO <sub>2</sub> Fuel-ICAP Ir-CAP RI-CAP	UMo UZr DUPIC UO <sub>2</sub> Fuel-ICAP Ir-CAP RI-CAP	UZr UO <sub>2</sub> Ir-CAP RI-CAP	UMo UZr DUPIC UO <sub>2</sub> Ir-CAP RI-CAP	UMo UO <sub>2</sub> Fuel-ICAP Ir-CAP RI-CAP	UMo UO <sub>2</sub> Fuel-ICAP Ir-CAP RI-CAP

The APFCAP capsule for PWR fuel was irradiated at OR4 hole from 2002 and the DUOCAP08, dual cooled annular fuel, has been irradiated from at the end of 2008.

The 4<sup>th</sup> U-Mo fuel irradiation test started from Dec. 2008.

In 1998, the first instrumented capsule for a material test in CT hole, and in 1999, iridium and RI capsule to use in OR holes was developed. As a demand for the fuel test increased, the capsule for producing Ir-192 at the CT, IR1, IR2 irradiation holes located in the inner core was developed in 2001. In 2003, the first instrumented capsule for fuel irradiation test was developed. And instrument capsule for fuel irradiation test carried out in 2007 and 2008.

The development of capsules such as creep capsule, material capsule and fuel capsule etc. has enabled to use the irradiation holes actively.

### 3. Conclusions

At the beginning of the HANARO operation, the use of irradiation holes was not active. After developing capsules for fuel and material test, the irradiation test became active. These equipments served for users to use the HANARO easily. Based on the irradiation experience, FTL has been built to increase the