Application of Multi-Hole Structures to the HANARO Irradiation Capsule

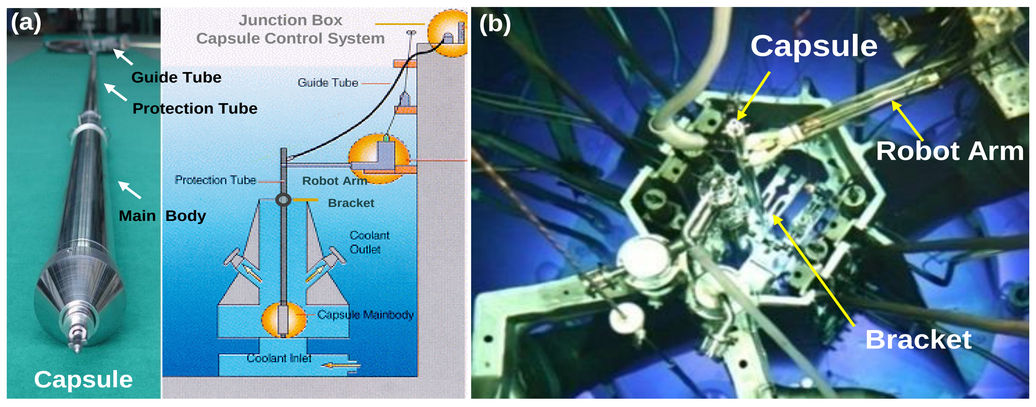
Kee-Nam Choo(knchoo@kaeri.re.kr), Seong-Woo Yang, Seng-Jae Park, Yoon-Taek Shin

Korea Atomic Energy Research Institute

◆ Introduction

✓ **HANARO irradiation capsules** have been most actively used for the irradiation of nuclear materials. Due to recent shutdowns of reactor for a long time, a number of user requests for neutron irradiation testing have accumulated at HANARO these days. In this paper, the progress and status of a development of a multi-hole structured capsule to use a cost-expensive irradiation capsule effectively are described.

◆ HANARO Irradiation Capsule Systems

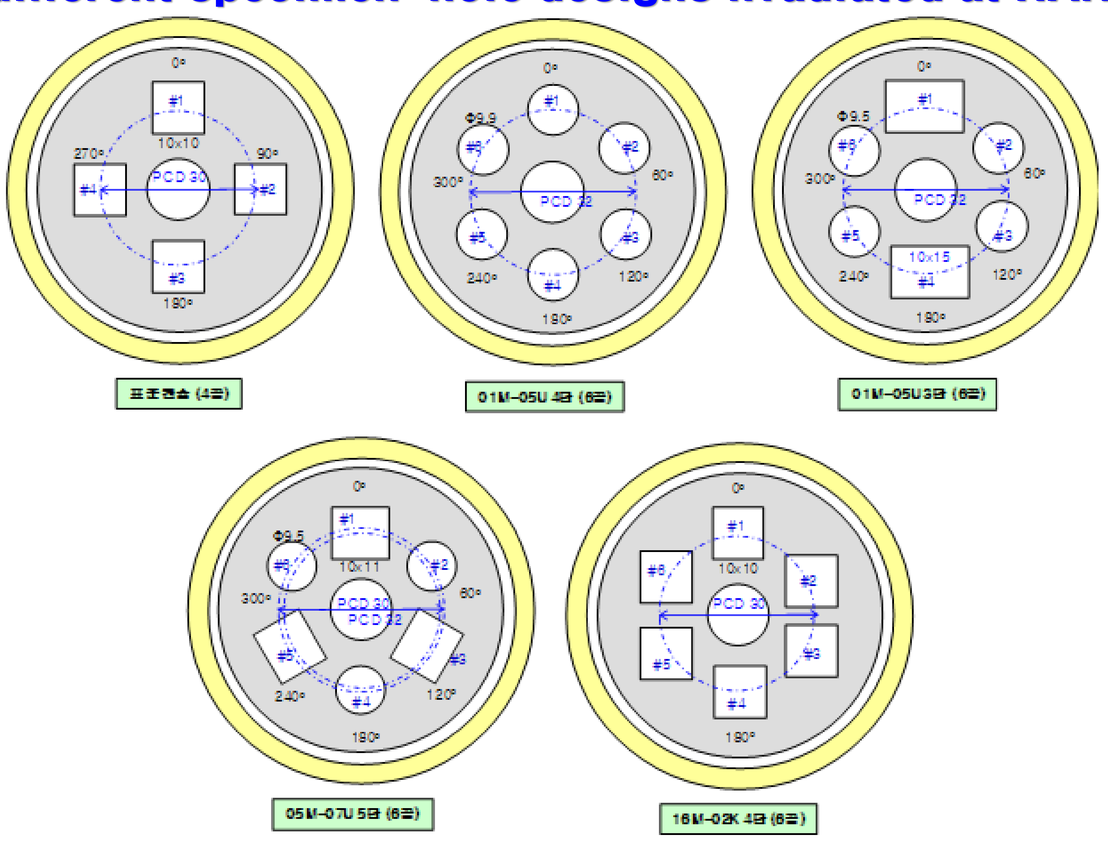


◆ Neutron irradiation capsules having multi-hole structures irradiated at HANARO

Capsule	Irradiation Condition	Specimen / Design	Irradiation Temp.
01M-05U	24MW CT	Zr, Ti alloy / 6 hole	280~350℃
05M-07U	30MW CT	Zr, Ti alloy / 6 hole	292~344℃
16M-02K	30MW CT	ARAA (Fe) / 6 hole	300~329℃
04M-22K	Out-pile test	STS (Fe) / 5 hole	-
05M-06K	Out-pile test	STS (Fe) / 5 hole	-

* ARAA: Advanced Reduced-Activation Alloy

◆ Cross sections of the irradiation capsules having different specimen-hole designs irradiated at HANARO



◆ Temperatures of the 16M-02K capsule at 30 MW power

Stage	TC	GENGTC		ANSYS		Measured*	
		He 1atm	0.4K He	He 1atm	0.4K He	He 1atm	He 40torr
1	TC1	201	281	198	<370	222	338
	TC2	201	281	198	<370	214	332
	TC3	230	312	204	<370	220	324
	TC4	230	312	204	<370	215	310
2	TC5	226	296	206	<441	218	312
	TC6	243	305	220	<441	224	313
3	TC7	245	303	282	369	230	334
	TC8	245	303	282	369	232	337
	TC9	265	329	274	369	231	311
	TC11	265	329	274	369	225	288
4	TC10	251	311	235	<369	242	315
	TC13	241	303	217	<370	239	299
5	TC12	233	300	211	<370	227	302
	TC14	206	282	187	<370	221	300

* Heater power 0, control rod at 468mm

1) Design history of a specimen allocation

1) A typical HANARO irradiation material capsule consists of three main parts: a protection tube (5 m), a guide tube (9.5 m), and the capsule's main body including specimens.
2) The irradiation specimens are generally located in the center of the standard irradiation capsule. However, multi-hole designs of the specimens have been frequently adopted in several capsules to increase an economic efficiency of the volume or to improve the uniformity of specimen temperature at HANARO.
3) Although a lot of 4-hole structured capsules have been successfully irradiated at HANARO, 5-hole and 6-hole structured capsules were scarcely tested. Therefore, the safety of those multi-hole capsules was not fully proved.

2) Temperature analysis of the 16M-02K capsule having a 6-hole design

1) A new capsule (16M-02K) having a 6-hole specimen allocation was designed, fabricated, and irradiated for an evaluation of the neutron irradiation properties of the Advanced Reduced Activation Alloy (ARRA) of a Fusion reactor.
2) The irradiation temperature of the specimens was preliminary analyzed by using the GENGTC and compared to the results by the ANSYS codes.
3) The temperature of the ARAA specimens was stably controlled in the range of 295-337℃ during a reactor operation cycle(100th cycle) at HANARO.
4) Considering the stable behavior of the specimen temperatures and design experience of the capsule, the 6-hole design could be safely applicable for an irradiation testing of the most Fe and Zr-based nuclear materials at HANARO.

◆ Conclusion

✓ The progress and status of a development of a multi-hole irradiation capsule at HANARO to increase an economic efficiency of the volume or to improve the uniformity of specimen temperature were summarized.
✓ The 6-hole structured capsule of the 16M-02K was designed, fabricated, and successfully irradiated for an evaluation of the neutron irradiation properties of the ARRA of a Fusion reactor.
✓ Considering the stable behavior of the specimen temperatures and design experience of the capsule, the 6-hole design could be safely applicable for an irradiation testing of the most Fe and Zr-based nuclear materials at HANARO.