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Irradiation Test of High-density Si Material

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1. Introduction

The feasibility of irradiation test for the high-density Si material entrusted by Guju Inc. was reviewed. The high-density Si material is used for a sealing of the penetration holes of piping at the nuclear power plants. The irradiation test was performed and the density changes between before and after irradiation test were measured. The irradiation tests were performed 2 times for 1 day and 20 days at IP 4 hole of HANARO. The 3 Si specimens irradiated were without flaws and the density changes after irradiation were successfully measured. The result satisfies the requirement of the design specification.

2. Review of design requirement and safety

2.1 Review of design requirement

According to the user requirements, the density change of the specimen should not be larger than 2% for the neutron absorption dosage of $1x10^{11}$ rads and the gamma absorption dosage of $1x10^{9}$ rads. As a result of review for the feasibility of irradiation test, the specimen can reach $1x10^{10}$ rads by gamma and $\sim10^{7}$ rads by neutron during 1 cycle operation at IP4 of HANARO. Thus, it was agreed that the irradiation test could meet only the gamma irradiation condition [1].

The temperature rises with the irradiation test, and this specimen was proved to reach up to 145℃ in calculation. From a viewpoint of temperature, it was assessed that the irradiation test was possible.

The irradiation tests were performed two times for 1 day and 20 days during the 81 operation cycle of HANARO. The 1-day irradiation test was done to investigate if the specimen could be maintained sound in the irradiation condition. No flaws and cracks occurred at three specimens put in one capsule after 1 day irradiation. The density of un-irradiated specimens was 2.44± 0.014905g/cc, and it became 2.54± 0.014905g/cc after 1-day irradiation [2]. Thus, it was confirmed that the specimen was maintained sound and the density change was less than 2% which the user required.

2.1 Review of safety

The generation of heat at IP4 was first estimated for a review of safety of the irradiation test. The properties and the ratio of the chemical elements of the specimen are as in Table. 1.

Table 1. Properties of the high-density Si specimen

Speci-men	Density (g/cc) Size (cm)	Materials		Mass ratio
High-density Si	2.45 (1×1×1)	Dimethyl Siloxane, Dimethylvinyle-Terminated	Si	20%
		Dimethyl Siloxane, Hydroxy-Terminated	Si	20%
		Iron Oxide	FeO3	50%
		Quartz	SiO2	10%

The irradiation was performed at the position C of IP4, which is the third of four capsules from above at the hole. It was assumed, for calculation, that new fuels were loaded at all holes in the core and the position of control rods were 400 mm and 450 mm.

The heat generation was calculated by using MCNP code. The Si specimens were inserted into the small Al. capsule and RI target as in Fig. 1 which was maintained in the He environment of 1 atmosphere.

The heat generation of the high-density Si material at IP4 is listed in Table 2. It is 0.261 W/g from the Si specimen and 0.181 W/g from the small Al. casule and 0.182 W/g from the outer tube. The temperatures were calculated by using the 2-dimensional ANSYS code.

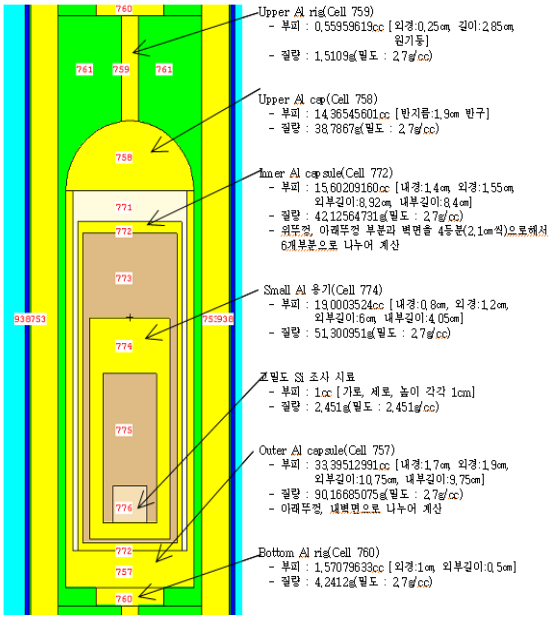

Fig. 1. Irradiation capsule

Table. 2 Heat generation of high-density Si at IP4

Gamma heat at IP4			
Material	Mass(g)	Heat generation (W/g)	Total heat (W) (x1.5)
Si specimen	2.45E+00	1.481E-01	0.544
Al. capsule	5.13E+01	1.244E-01	9.573
inner Al1	6.52E+00	1.094E-01	1.070
inner Al2	7.88E+00	1.159E-01	1.371
inner Al3	7.88E+00	1.329E-01	1.571
outer Al1	5.95E+01	1.191E-01	10.637
outer Al2	3.06E+01	1.211E-01	5.561
upper cap	3.87E+01	1.232E-01	7.165
bottom rig	4.24E+00	1.357E-01	0.863

The thermal conductivities of He and Al were applied in the range of 0.159～0.234 and 2.02～2.49 respectively. The temperature distribution was shown in Fig. 2 and the maximum temperature of the specimen was 141℃[3].

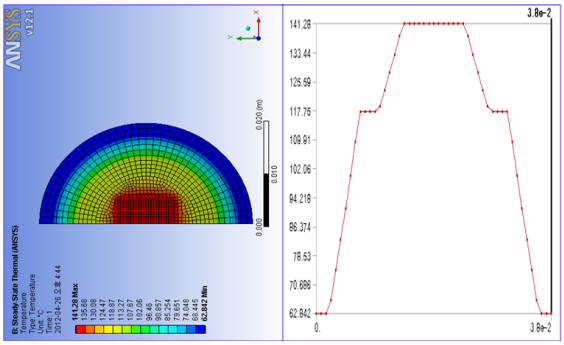

Fig. 2 Distribution of irradiation temperatures

3. Conclusions

The maximum temperature of the high-density Si material was estimated at 141℃ when irradiated at IP4 at HANARO. Consequently, the irradiation test of the Si specimen was assessed possible in HANARO. However, the compounding oil of the specimen which is composed of CH_3 and H, might be burnt and evaporated at high temperature. Thus, Al. foils were stuffed in the space between the specimen and the inner capsule to lower the temperatures, and the inner space was purged and filled up with He for safety even at leak.

Acknowledgements

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