

'2000

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Design and Fabrication of HANARO Instrumented Capsule for the Irradiation of Reactor Vessel Materials Manufactured by HANJUNG co.

150

() 4,5 4
(RPV) SA508 cl.3 가
(99M-01K & 02H) .
98M-02K .
가 ,
가 5
, 12 Ni-Ti-Fe/Sapphire 가
RPV base
round compact tension, charpy insert, PCVN(pre-cracked V-notch charpy insert), small tensile, SP(small punch), MBE(magnetic Barkhausen effect)
CT 290 ± 10
, (E>0.82 MeV) 9.0x 10¹⁹ (n/cm²) .

Abstract

For the irradiation of the RPV(Reactor Pressure Vessel) material used in Yonggwang Units 4-5 and Ulchin Unit 4 Korean PWR nuclear reactors that was fabricated by HANJUNG Co, HANARO instrumented capsules (99M-01K & 02H) were designed and fabricated. The capsules were designed based on the 98M-02K capsule that was successfully irradiated in HANARO. In the detail design, various design improvements were considered such as use of actual irradiation temperature in part design and the effect of control rod location and burnup of nuclear fuel on the

gamma heating rate. There are 5 stages having specimens and independent electric heaters in the capsule mainbody. 12 thermocouples and 4 sets of Ni-Ti-Fe Neutron Fluence Monitors were also inserted in the capsule to measure the temperatures of the capsule parts and thermal/fast neutron fluences, respectively. Various types of specimens such as round compact tension, charpy insert, PCVN(pre-cracked V-notch charpy insert), small tensile, SP(small punch), and MBE(magnetic Barkhausen effect) specimens were inserted into the capsule. The specimens will be irradiated in the CT test hole of HANARO at 290 ± 10 up to the fast neutron fluence ($E > 0.82$ MeV) of 9.0×10^{19} (n/cm^2).

1.

가

[1-5].

(RPV)

290 ± 10 가 30MW 가 6

가 40

$7.26 \times 10^{19} n/cm^2$ 가 가

() 가 3

() PRV 가

(99M-01K & 02H)

98M-02K

[6].

[7-9].

가 5 , 12

Ni-Ti-Fe 가

4,5 4 base round

compact tension, charpy insert, PCVN(pre-cracked V-notch charpy insert), small tensile, SP(small punch), MBE(magnetic Barkhausen effect)

CT 290 ± 10 , RPV

40 7.26×10^{19} (n/cm^2) ($E > 0.82$ MeV)

RPV 가

가가

가

2. 99M-01K & 02H

()

가 99M-01K (Material, K KAERI) 99M-02H(H HANJUNG)

98M-02K [6] 1

gamma heating rate gap

99M-01K 02H

98M-02K

60mm STS 316

5 Al

He 1

[7,8] 99M-01K 02H

Guide spring 4551.75mm

1" (1+1/4)" Junction Unit Junction Box (2).

가 guide arm

3

4.5

4

base round

compact tension, charpy, PCVN(pre-cracked V-notch charpy), SP(small punch), MBE(magnetic Barkhausen effect) 98M-02K

charpy 1/3 insert charpy

insert IMEF

가 99M-01K 99M-02H

charpy 98M-02K 1

20MW 가 290 ± 10 99M-01K 1 1/2" RCT(round compact tention) 0.4T-RCT

99M-01K 99M-02H 1,

Gamma heating (99M-01K 1)
가 round compact ,
4 charpy ,
gamma 3,4,5 가
가 ,

MCNP
gamma heating rate [10].
Gamma prompt & delayed gamma
, 4

가 350mm 450mm 3 gamma
heating 4 99M-01K 02H gamma
heating control rod 400mm .
20% 가 gamma
가 99M-02H RCT charpy
, 4 6 gamma heating
가 [10], 99M-01K gamma heating 가
가 5 99M-01K & 02H
gamma heating curve .
 290 ± 10 .
가 He heater
. 98M-02K
1 1atm He
, 25psi He 가

[8]. , 99M-01K 99M-02H
0.4K_{He=1atm} gap
. 98M-02K 0.4K_{He=1atm} 1 ,
35psi [8]. 98M-02K
, 25psi He ,
10 torr 가 , 가
0.4K_{He=1atm}
. 50-100torr
 290 ± 10 .

GENGT C code ,
symmetric geometry 99M-01K RCT
non-symmetric geometry 가 GENGTC
symmetric

가 가 2) 1)

98M-02K 2

, 3,4,5

ring

가

gamma heating

가

GENGT C, Heating 2f, ANSYS

code , GENGTC code

6 99M-01K 99M-02H 3,4,5

99M-01K 99M-02H

0.1mm

7 99M-01K (1)

(1)

가 가 가

12 가

가 Ni-Ti-Fe Sapphire Fluence Monitor(F/M)가 Al Holder

가

()

3.

99M-01K 02H

가, He leak , heater

가가

, 20MW

CT 290 ± 10

20MW CT He 1

gamma heating

138 248 He gas 1 0.4K_{He,1atm}

(35 torr)

37.4 143

micro-heater 20 80

290 ± 10

40

7.26x 10¹⁹ (n/cm²) (E>0.82 MeV) 1-9.0x 10¹⁹ (n/cm²)

가 . IMEF Cask IMEF F/M

4.

() 4,5 , 4
 가 (99M-01K & 99M-02H) .
 ,
 ,
 , Sapphire F/M
 99M-01K & 02H CT 290 ± 10 ,
 (E>0.82 MeV) 9.0x10¹⁹ (n/cm²) ,
 가
 가가 .

1. , KAERI Report, KAERI/RR- 1510/94 (1995).
2. , KAERI Report, KAERI/RR- 1760/96 (1997).
3. K.N. Choo et als, Design of a new capsule controlling neutron flux and fluence and temperature of test specimens, J. Kor. Nucl. 29(2), 148 (1997).
4. Y.H. Kang et als, Structural analysis for the HANARO irradiation capsule through vibration test, Pro. of 6th ASRR symposium, Mito, Japan, march 1999.
5. , ANSYS , '99 , Seoul, Korea, October 1999.
6. , (98M-02K) , KAERI , KAERI/TR- 1392/99 (1999).
7. , (97M-01K) , KAERI , KAERI/TR- 1393/99 (1999).
8. (98M-02K) , KAERI , (2000).
9. , (98M-02K) , '99 , Seoul, Korea, October 1999.
10. , 99M-01K (I), (II), , HAN-RR-CR-00-006/007, 2000 1 .

Table 1. Specimens loaded in 99M-01K capsule.

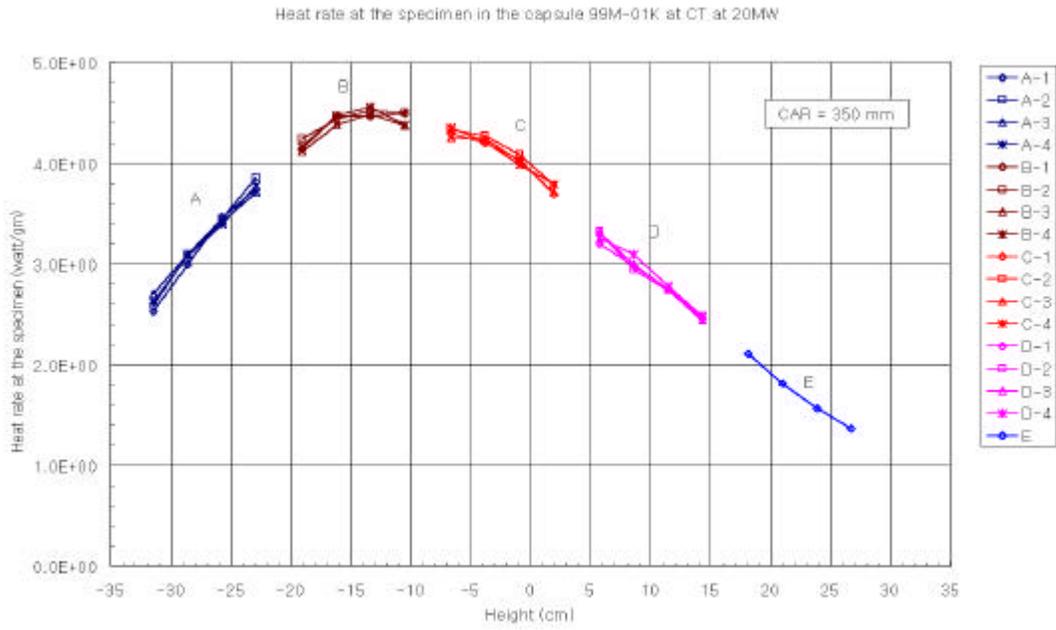
				1
1	0.4T - RCT (10x 27) ²	1x 11=11	Round Bar 1 (27x114 mm)	Y4(3), Y5(4), U4W (4)
2	Charpy (10x 10x55)	4x2 = 8	Square Bar 1 (20x 20x 114 mm)	Y4
3	Charpy (10x 10x55)	4x 1 = 4	Square Bar 4 (10x 10x 114mm)	Y4
	PCVN (10x 10x55)	3x 1 = 3		Y4
	SP (10x 10x0.5)	1x 80=80		(Y4,Y5,U4,U4W)x20
	MBE (10x2.5x 1)	1x 16=16		(Y4,Y5,U4,U4W)x4
4	PCVN (10x 10x55)	4x2 = 8	Square Bar 4 (10x 10x 114mm)	Y4
5	Charpy (10x 10x55)	3x 1 = 3	Square Bar 4 (10x 10x 114mm)	U4 / U4W
	PCVN (10x 10x55)	1x 1 = 1		Y4

1 : Y=Yonggwang, U=Ulchin, W=Weld, 2 : all dimension in mm

Table 2. Specimens loaded in 99M-02H capsule.

				1
1	PCVN (10x 10x55) ²	4x2 = 8	Square Bar 1 (20x 20x 114 mm)	Y5
2	Charpy (10x 10x55)	4x2 = 8	Square Bar 1 (20x 20x 114 mm)	U4W
3	Charpy (10x 10x55)	4x 1 = 4	Square Bar 4 (10x 10x 114mm)	U4W
	PCVN (10x 10x55)	3x 1 = 3		U4W
	SP (10x 10x0.5)	1x 80=80		(Y4,Y5,U4,U4W)x20
	MBE (10x2.5x 1)	1x 16=16		(Y4,Y5,U4,U4W)x4
4	PCVN (10x 10x55)	4x2 = 8	Square Bar 4 (10x 10x 114mm)	U4W
5	Charpy (10x 10x55)	3x 1 = 3	Square Bar 4 (10x 10x 114mm)	Y5
	PCVN (10x 10x55)	1x 1 = 1		U4W

1 : Y=Yonggwang, U=Ulchin, W=Weld, 2 : all dimension in mm



4. (20MW)

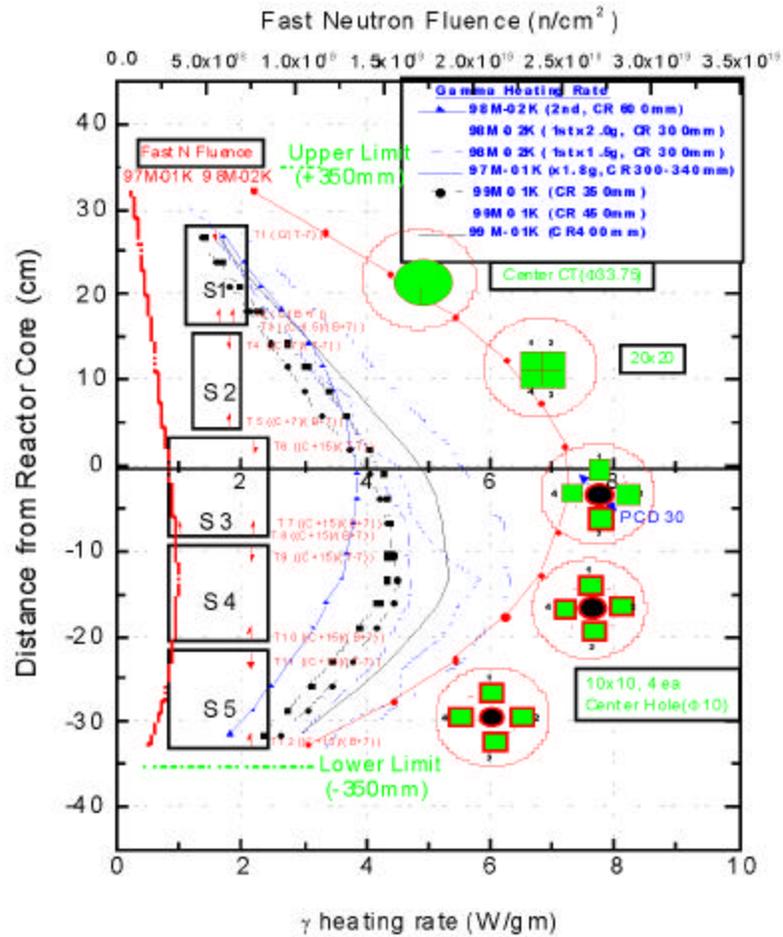


Fig. 5 Gamma heating rate of 99M-01K & 02H capsules that will be irradiated in the HANARO CT hole. (C=center, T=top, B=bottom)

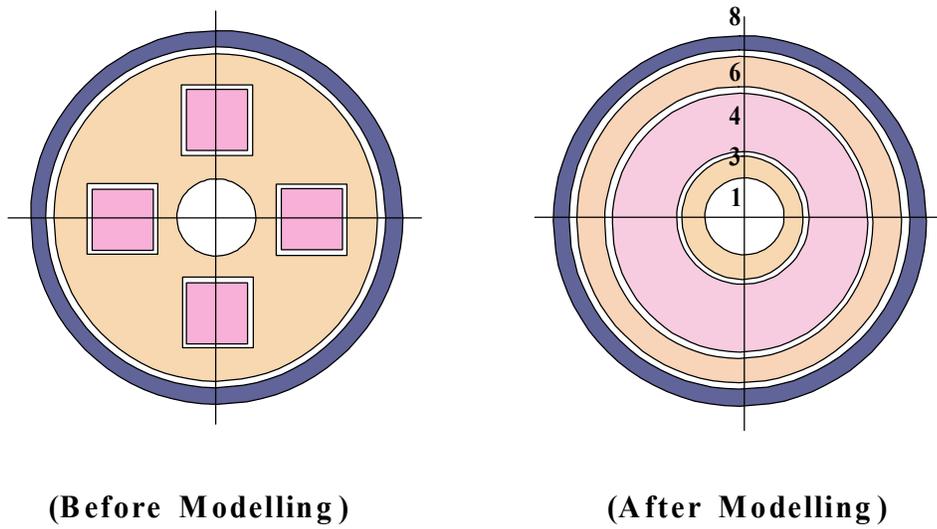


Fig. 6 Calculation model for stages 3, 4, 5 of 99M-01K & 02H capsules.

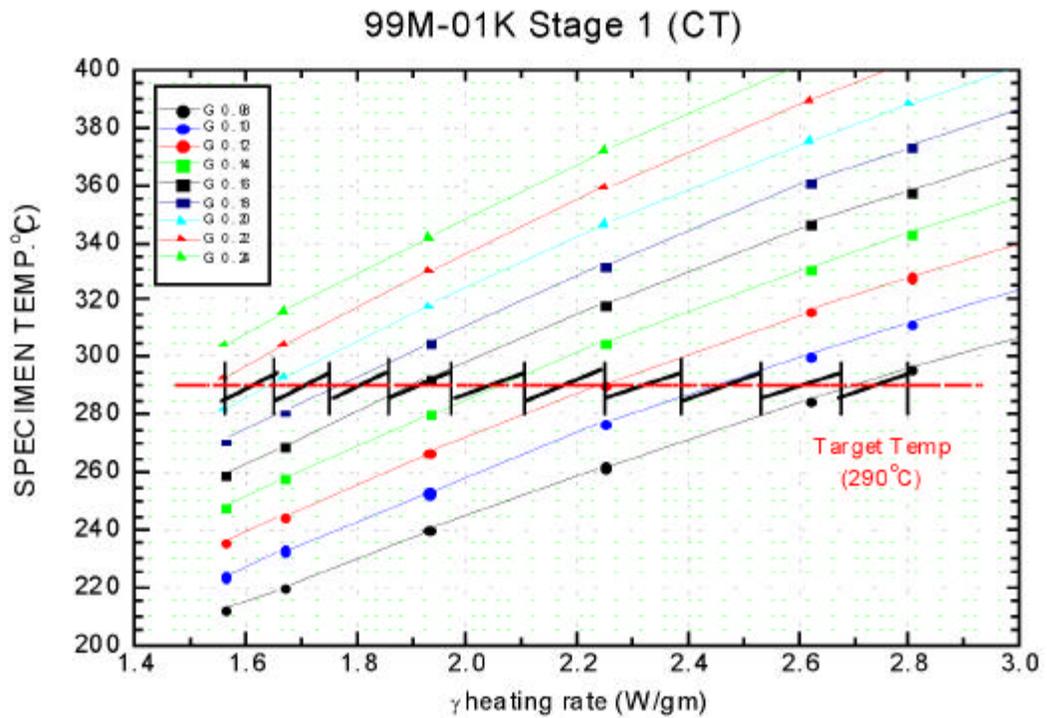


Fig. 7 Gap determination at Stage 1 of 99M-01K capsule (R-CT).