

Study on the CRUD Generation with Piping Materials in NPP in High Temperature Water

373-1

270

가

EDX

Abstract

High temperature - high pressure apparatus was developed to simulate nickel ferrite corrosion products. Nickel base alloy (Inconel 690) and iron base alloy (SA106 Gr. C) were corroded at 270 in the corrosion product generator. Ni ions and Fe ions dissolved by corrosion reaction were transported to the corrosion product accumulator through high pressure balance stainless steel tube because the CRUD generation mechanism in nuclear power plant was the solubility change with temperature.

To evaluate the property of simulated corrosion products, scanning electron microscope observation and EDX analysis were performed. SEM observation of corrosion product showed the needlelike structure of oxide and crystal structure of oxide depending on precipitating location. The crystal oxide is the mixture of nickel ferrite and chromium ferrite, which is similar to the CRUD in nuclear power plant.

1.

가

(CRUD)

1

(Ni_xFe_{3-x}O₄)가

[1].

Ni/Fe 가 1

x=1

NiFe₂O₄가

Ni/Fe 가 0.5

x<1

Ni/Fe 가 0.5

가 NiO

[2].

CRUD Ni/Fe 가 1.0

mixed Fe, Cr

spinel

가 [3],

CRUD

Ni/Fe 가

0.5

가

[2].

CRUD Ni/Fe 가 0.06 0.3

[4].

2.

1.

가

1

가

, 1

가

230 ~ 330

1

가 가

[5].

1

가

cladding

가

가

가

[1].

가

가

270

anodic polarization

가

가

가

304 stainless

steel

cathodic protection

304 stainless steel anodic

activation

가

가

loop

10cc/

가

가

loop

가

loop

pipe

heating tape

가

autoclave

2

가

acid

cleaning

가 test

section

. Test section

1/2" 316 stainless steel tube

band heater

가

3 .

2.

가 . 2.5 liter

Inconel 690 SA 106 Gr. C 가

Inconel 690 SA 106 Gr. C 1

2 .

loop .

, 270 ,

300 magnetic pump , 10cc/ loop

potentiostat 450mV

가 , 4 1

. 270 500mV_{SHE}

270 INCONEL 690 -720mV_{SHE}

[6, 7], 450mV 가

270 . 5

EDX

3.

test section

5 . #1

tube #2

tube 가

. Test section ,

가
 Test section 가 U-
 300 가
 #1 #2 SEM 6
 #1 autoclave
 3 EDX
 Autoclave Fe
 20 At% Si Test
 section , #1
 autoclave
 가 Si
 ICPMS
 2 Si
 Si
 gasket Rulon O-ring 가
 #2 가
 #1
 Fe: Ni: Cr 가 39.75: 6.87: 1.95 Ni/Fe 가
 0.17 Ni/Fe 가 0.5 $Ni_xFe_{3-x}O_4$ ($x < 1$)
 가 [2], #2
 $Ni_{0.7}Fe_{2.3}O_4$ $Cr_{0.3}Fe_{2.7}O_4$ 가
 CRUD
 6 (b) EDX
 가 Cr
 SUS 316
 가
 가 #2 SUS 316
 Ni, Cr, Fe

#2

4.

Autoclave
tube autoclave SUS 316
SEM EDX
가
가 Fe: Ni: Cr
가 39.75: 6.87: 1.95 $Ni_{0.7}Fe_{2.3}O_4$ $Cr_{0.3}Fe_{2.7}O_4$ 가
CRUD

5.

#2

, 가 1
가

- [1]. KEPRI, 1, KRC-90N-J04, 1993
[2]. A.K. Strasser, J. Santucci, "Corrosion Product Buildup on LWR Fuel Rods", *EPRI NP-3789*, 1985
[3]. C.A.Bergmann, J.Roesmer, "Primary-side Deposites on the PWR Steam Generator Tubes", *EPRI NP-2968*, 1983

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- [5]. Y.L. SANDLER and R.H.KUNIG, *Nucl. Sci. Eng.*, 77, 211, 1981
- [6]. Y.J.Kim, P.L.Andresen, "Effect of Surface Property on Electrochemical Kinetics in High Temperature Water", *Water Chemistry in Nuclear Reactor Systems 2002*, French Nuclear Energy Society, 2002
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1. INCONEL 690 SA106 Gr. C

	C	Mn	P	S	Si	Cr	Ti	Al	Cu	Co	Ni	Fe
SA106 Gr.C	0.19	1.22	0.009	0.007	0.27	0.05	-	0.029	0.013	0.003	0.11	Bal.
Inconel 690	0.02	0.26	0.004	0.001	0.33	29.5	0.32	-	-	0.012	Bal.	10.4

2.

Element	Mass	Distilled Water
Si	29	No data
Cr	53	0.1080 ppb
Mn	55	0.0807 ppb
Fe	57	0.3026 ppb
Ni	60	0.0844 ppb
Cu	63	0.0374 ppb
Zn	66	0.0478 ppb

3. EDX

Elements	#1 (At %)	#2 ¹ (At %)	#2 ² (At %)	#3 (At %)
O	30.79	47.87	34.49	67.28
Si	27.28	3.56	0	22.22
Cr	6.89	1.95	21.44	1.79
Fe	25.23	39.75	35.6	8.01
Ni	4.87	6.87	8.47	0.69

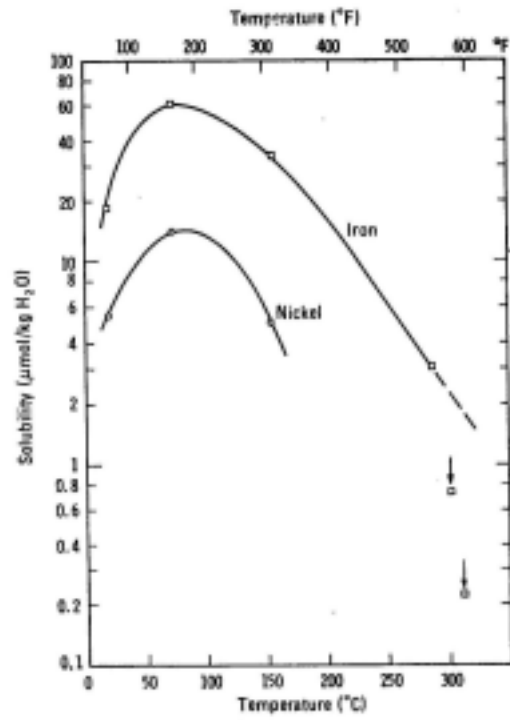
#1. Tube #1

#2¹. Tube #2

#2². Tube #2

#3. Autoclave

crystal
layer



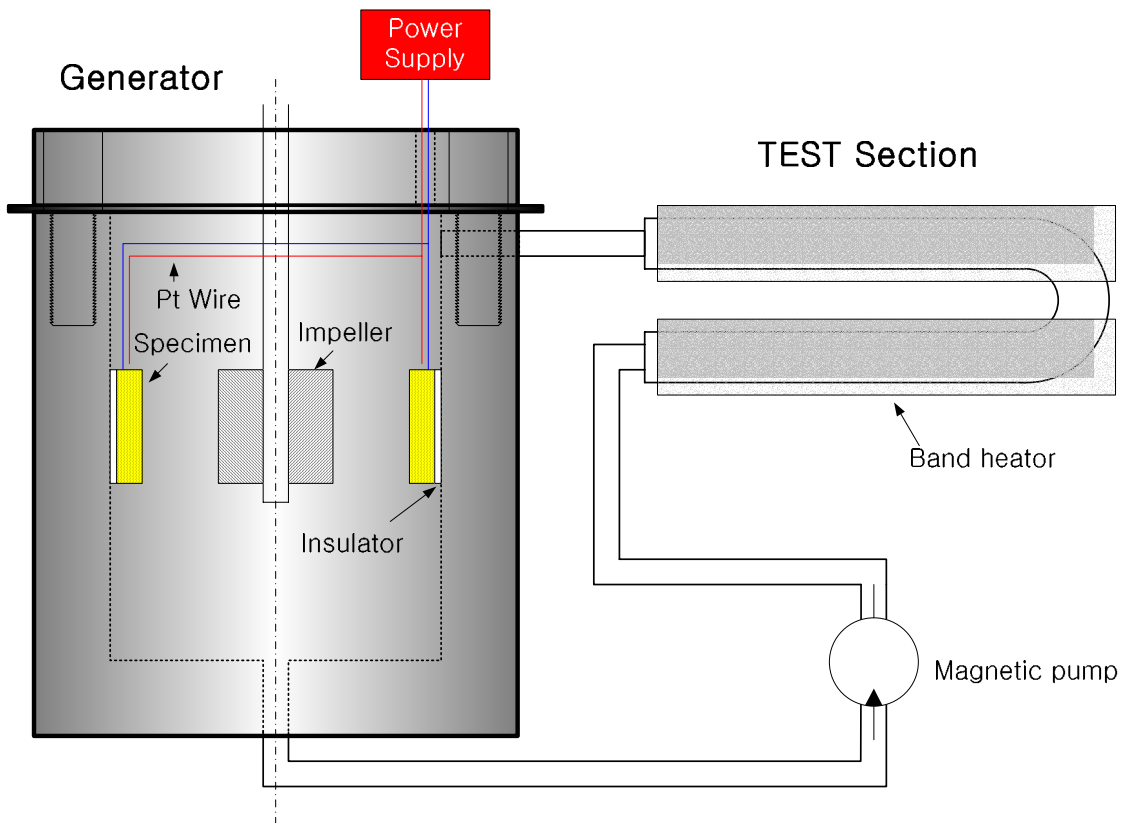
1. 0.2M

가

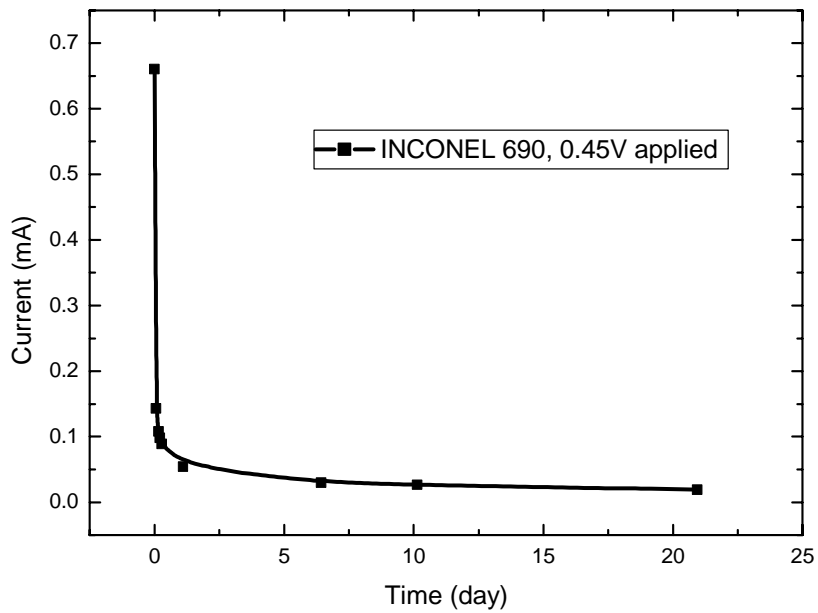
[6]



2.



3.

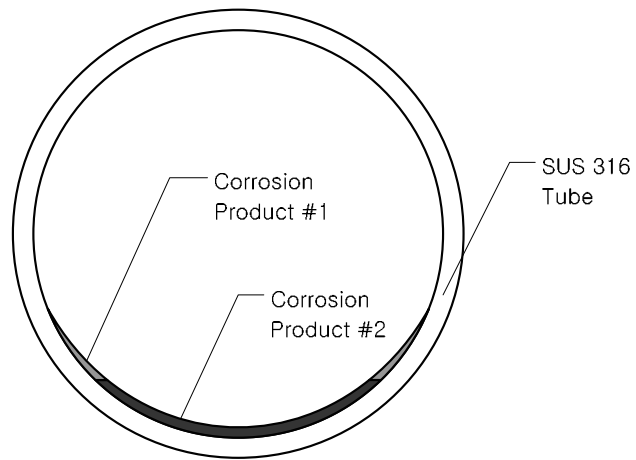


4. INCONEL

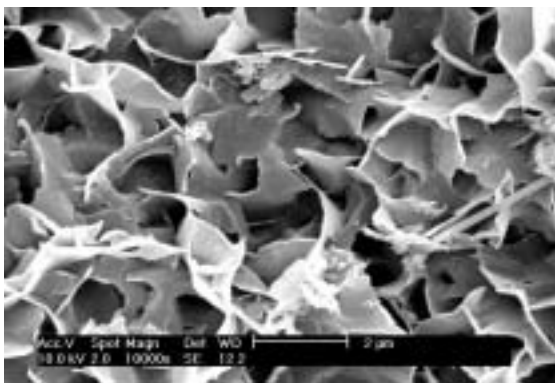
450mV

가

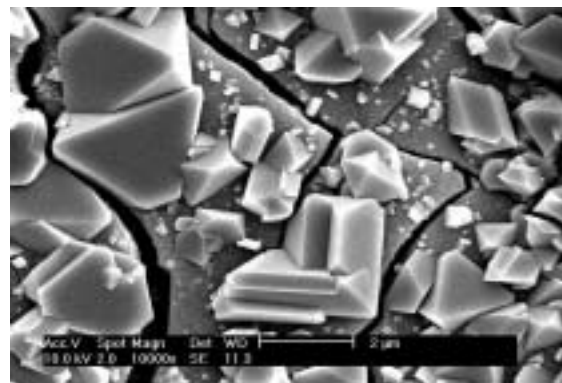
,



5. test section



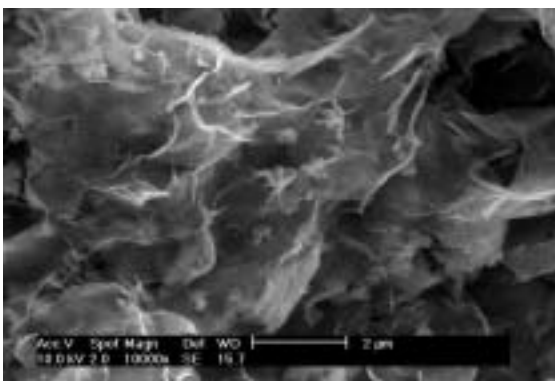
(a)



(b)

6. (b)#2

SEM (X 10,000) (a) #1,



7. Autoclave
(10,000)

SEM (X