

Alloy600, 690 800

Electrochemical Properties and Stress Corrosion Cracking of
Alloys 600, 690, and 800 in Solutions Containing
Boric Acid and Chloride

*,

,

150

Alloy600, 690 800

320°C 3% H₃BO₃ 0.2g/ Cl⁻
Parameter(P_{SCC}) SCC
Alloy 600MA, 600TT, 690TT
800 SCC C- ring Reverse U- bend(RUB)
320°C 350°C 3% H₃BO₃ 0.2g/ Cl⁻
27% H₃BO₃, 2g/ Cl⁻ C- ring 320°C 3% H₃BO₃
0.2g/ Cl⁻ SCC SCC가 RUB
350°C 27% H₃BO₃, 2g/ Cl⁻ 1920 600TT,
600MA , 690TT 800 SCC가

Abstract

Electrochemical characteristics and stress corrosion cracking(SCC)of Alloy 600, Alloy 690 and Alloy 800 have been studied in boric acid solution with chloride. Electrochemical characteristics were measured in mixed solution of 3% H₃BO₃ and 0.2g/ Cl⁻ at 320°C. SCC resistance was predicted with Parameter(P_{SCC}) including current density ratio obtained at two different scan rates. P_{SCC} increased with a following sequence: Alloy 600MA, 600TT, 690TT and Alloy 800. SCC test was carried out with C-ring specimens and reverse U-bend(RUB) specimens at 320°C and 350°C. Test

solutions were mixture of 3% H₃BO₃ and 0.2g/ Cl⁻ at 320°C and mixture of 27% H₃BO₃ and 2g/ Cl⁻ at 350°C. C-ring specimens test in the solution of 3% H₃BO₃ and 0.2g/ Cl⁻ at 320°C for 2400hrs did not show SCC. RUB specimen of Alloy600MA and 600TT showed SCC after 1920 hours exposure to the solution of 27% H₃BO₃ and 0.2g/ Cl⁻ at 350°C

1.

Ni-base Inconel (PWR) . , 가 가
 (stress corrosion cracking), (wastage or thinning), (pitting), (denting),
 가
 [1].
 2 (Na⁺, Cl⁻, K⁺, SO₄²⁻)
 Na⁺, K⁺ 가 가
 Cl⁻, SO₄²⁻ 가 가
 가 2
 [2~4].
 Alloy600, 690 Philippe Berge[5,8]
 R.N.Parkins [6]
 가 SCC 가 . R.W.Staehle [7]
 가 SCC 가
 Alloy600, 690, 800
 R.N.Parkins scan rates R.W.Staehle SCC 가 C-ring SCC

2.

가.

Alloy600, 690 800
 22.23mm, 1.27mm (tube)
 가 . 3% H₃BO₃, 0.2g/ Cl⁻ 27% H₃BO₃, 2g/ Cl⁻가

. Table1

. Table2

Table.1. Chemical composition of the specimens.

Material	Chemical composition (wt%)							
	C	Si	Mn	P	S	Cr	Ni	Co
		Mo	Ti	Cu	Al	Fe	B	N
Alloy 600MA	0.04	0.03	0.27	-	0.001	15.21	75.34	-
		-	-	0.12	0.22	8.03	-	-
Alloy 600TT	0.026	0.22	0.30	-	<0.001	15.12	73.77	0.015
		-	0.36	0.006	0.26	9.21	-	-
Alloy 690TT	0.02	0.36	0.31	0.01	0.001	30.0	59.6	-
		0.013	0.33	0.01	0.023	9.26	0.001	0.033
Alloy 800	0.014	0.53	0.53	0.008	0.003	22.35	33.91	0.03
		-	0.45	0.032	0.17	-	-	0.017

Table.2. Mechanical properties of the specimens.

Material	Test	Heat No.	UTS (Mpa)	YS (Mpa)	EL (%)	Thermal Treatment	Grain Size (ASTM No.)
Alloy 600MA	C-ring, U-bend	NX8688	669	276	50	MA at 980°C 2.25min	6.47
Alloy 600TT	C-ring U-bend	5230	702	316	46	MA950 2min 750~750°C 12hrs	9
Alloy 690TT	C-ring U-bend	753175	722	334	49	Annealed at 1080°C 1min->TT at 725°C 10hrs	6.07
Alloy 800	C-ring U-bend	467730		406	39	Annealed at 990°C	9.0~9.5

water 10ml), 2.5V, 30sec

(phosphoric acid 80ml,

5%

natal (methanol 95ml, nitric 5ml)

2.5V, 30sec

10mm X 12mm Alloy600, 690 800 #600~ #1200
 가 0.05 μ m polishing
 (spot welding) (heat shrinking
 Teflon tube)

320°C Ag/AgCl Ni-Plate M352
 corrosion software 가 486PC EG&G 273A potentiostat 가 Scan
 rates unstable film stable film
 scan scan rate 99.99%
 가 1 30 320°C
 0.2V 600 900
 20mV/sec 1200
 0.2mV/sec

scan rate (scanning rate ratio)
 scan rates scan scanning rate ratio [R_{SR}]
 scans SCC 가
 가 SCC parameter [P_{SCC}] 가 R_{SR}

$$R_{SR}[E] = I[E]_{20mV/s} / I[E]_{0.2mV/s} \text{ ----- (1)}$$

$$SCC \propto R_{SR}[E] I[E]_{20mV/s} \text{ ----- (2)}$$

(2) R_{SR} SCC 가 scan crack tip
 가

$$SCC[E] \propto R_{SR}^2(E) I(E)_{0.2mV/s} \text{ ----- (3)}$$

(3) a stress corrosion cracking (SCC) Parameter (P_{SCC})

. C-ring

Alloy600, 690, 800 . [Table 1]
 12mm가 60°가 Fig.1
 4 150%
 ASTM G[48] 가 Alloy600 . C-
 ring (apex) 가

$$Odf = OD - \Delta$$

$$\Delta = f\pi D^2 / 4EtZ$$

: OD = 가 C-ring
 Odf = 가 C-ring
 $\Delta =$ 가
 $f =$
 $D =$ (OD- t)
 $t =$
 $E =$
 $Z =$

. U-bend

800 3/4" (19.05mm) 1/24" Alloy600, 690
 [Table 1.2] tube
 wire cutting 1 mendrel bender
 Reverse U-bend
 4 Fig.2 304
 Alloy600

3.

SCC가 scan 가 Parkins [6]~[7]
 . Parkins Fig.3 가 SCC가 slip event
 film - free dissolution
 scan 가 가
 SCC R_{SR} P_{SCC}
 R_{SR}
 SCC가 Alloy 600MA, 600TT,
 690TT 800 scan (Fig.4. ~Fig.7). Alloy
 600MA가 scan 가 가 600TT, 690TT, 800

600MA가 scan 가 690TT가 가
 Cr 가 가 가 . Staehle [7]
 SCC P_{SCC} (SCC 가
) . Fig.8~11 SCC 가
 SCC
 Fig.8~Fig11 Alloy600MA, 600TT,
 690TT 800 P_{SCC} 가 SCC
 가 P_{SCC} 가 가 R_{SR}
 steady -state transite currents 가 . Fig.3
 R_{SR} steady-state current
 Fig.8~Fig.11 SCC 가 Parkins I / I
 Staehle P_{SCC} 가 . I / I Alloy 600MA,
 600TT, 690, 800 . 0.2mV/s scan Cr
 가 가 가 가 가 SCC
 가 , Cr
 SCC . Table3 SCC 가
 600MA, 600TT, 690TT 800 SCC 가
 가 2400 SCC . Table4
 C- ring P_{SCC}^M P_{SCC} E_{SCC}^M P_{SCC}^M
 $\Delta E^{1/2}_{SCC}$ SCC 가
 Brint [8] Alloy600 SCC
 가 SCC
 Cr . M.W.Maan [9] 가

Table.3 Properties of SCC Parameters in 3% H₃BO₃ and 0.2g/ Cl⁻ at 320°C

Material Parameter	600MA	600TT	690TT	800
P_{SCC}^M (A/cm ²)	1000	300	200	30
E_{SCC}^M (V)	-160	-200	-250	-200
$\Delta E^{1/2}_{SCC}$ (V)	-230	-280	-300	-250

Table.4. Result of the C- ring test 3% H₃BO₃ and 0.2g/ Cl⁻ at 320°C

	H ₃ BO ₃	Cl ⁻	Material		Result()
			Heat .N.O	Specimen	
320°C	3%	0.2g/l	600MA	C- ring	X(2400)
			600TT		X(2400)
			690TT		X(2400)
			800		X(2400)

Pillipe Berge [5] 102°C H₃BO₃ 27%
 Cl⁻ 가 330 ,
 . 250°C, 가 50g/l Cl⁻ 2000
 . H₃BO₃ 가 Cl⁻가 가
 가 가 290°C,
 가 40w% H₃BO₃, 50ppm Cl⁻ .
 350°C, H₃BO₃ 27%, Cl⁻ (2g/l), 1920 600MA, 600TT
 690TT, 800 SCC가 . 600TT가 600MA
 가 . SCC 600MA U-bend
 Fig.12 . Fig.13 SEM 600MA
 . Fig.14 Alloy600TT . Fig16
 Alloy600TT SEM . Table5 U-bend

Table.5. Results of the reverse U-bend test.

	H ₃ BO ₃	Cl ⁻	O ₂	Material		Result()
				Heat No.	Specimen	
350°C	27%	2g/l	aerated	600MA	Reverse U-bend	IG(1920)
				600TT		IG(1920)
				690TT		NO(1920)
				800		NO(1920)

IG:intergranularcracking NO: no cracking

pH, O₂, H₃BO₃ Cl⁻

4.

1. Alloy600, 690 800

320°C 3% H₃BO₃ 0.2g/ Cl⁻
 (P_{scc}) SCC

. P_{scc} Alloy 600MA, 600TT, 690TT

800

2. C-ring 가 3% H₃BO₃ 0.2g/ Cl⁻ 320°C

2400

3. Reverse U-bend 27% H₃BO₃, 2g/ Cl⁻, O₂ 350°C 1920

600TT 600MA . 600TT가 600MA

가

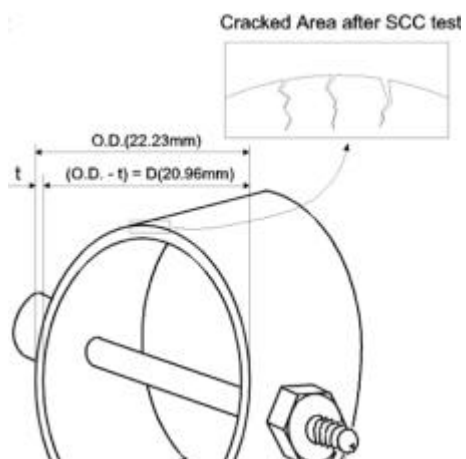


Fig.1 Dimension of the C-ring specimen

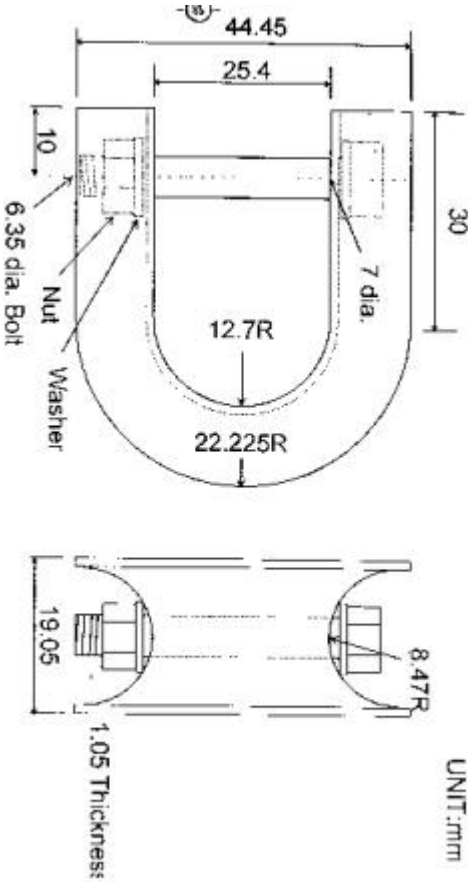


Fig.2 Dimension of the Reverse U-bend specimen

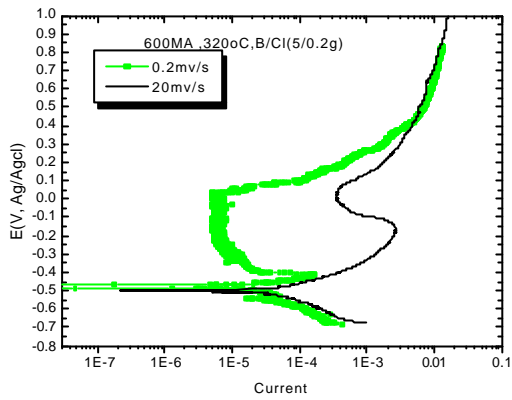


Fig.4 The polarization curves of Alloy 600MA in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

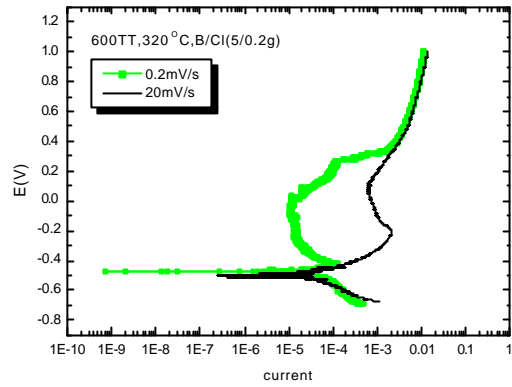


Fig.5 The polarization curves of Alloy 600TT in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

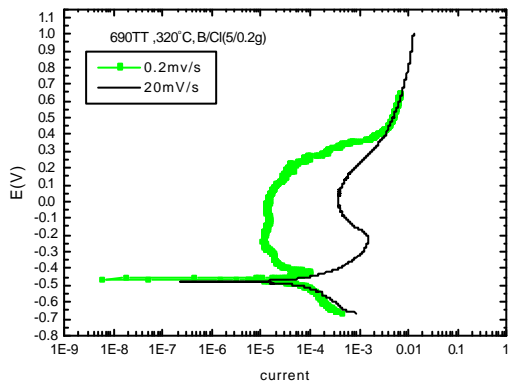


Fig.6 The polarization curves of Alloy 690TT in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

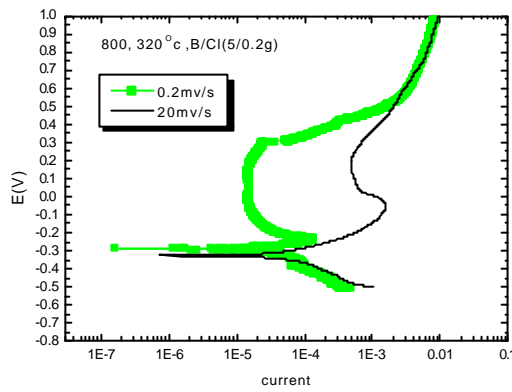


Fig. 7 The polarization curves of Alloy 800 in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

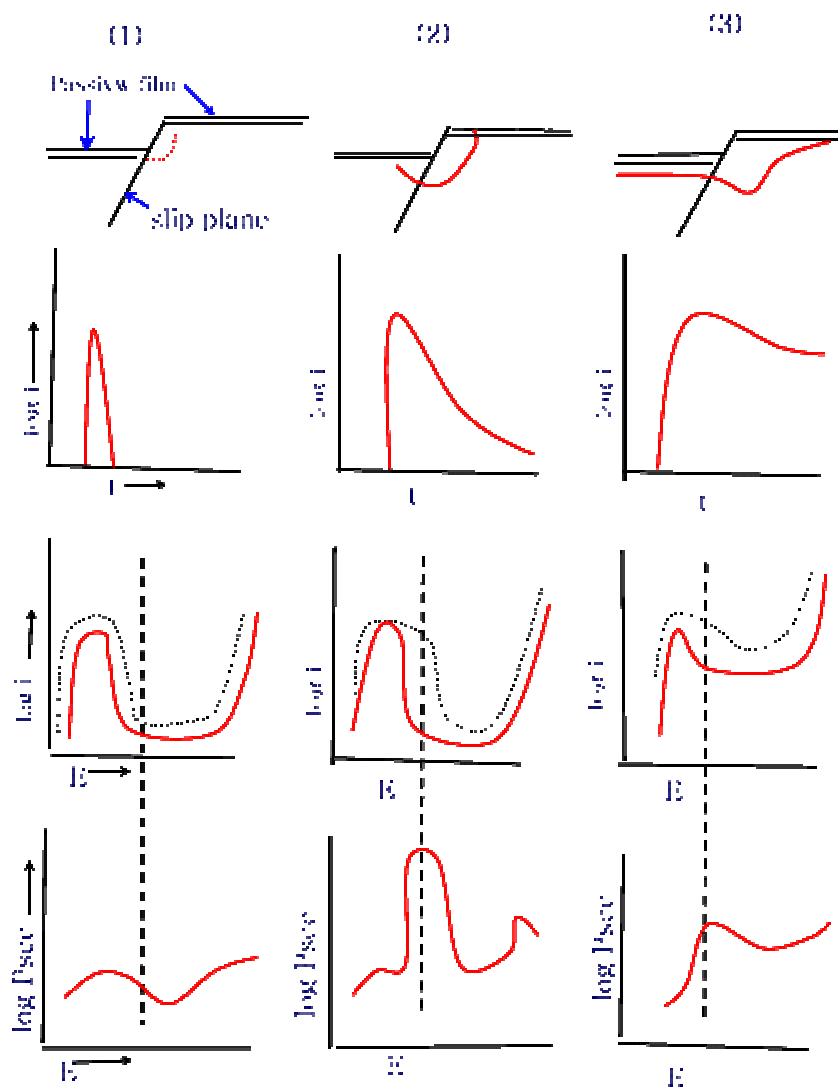


Fig.3 Schematics of three case of fast, intermediate, and slow repassivation corresponding to (1), (2) and (3) [fast is dotted line and slow is solid line] from Stehle..

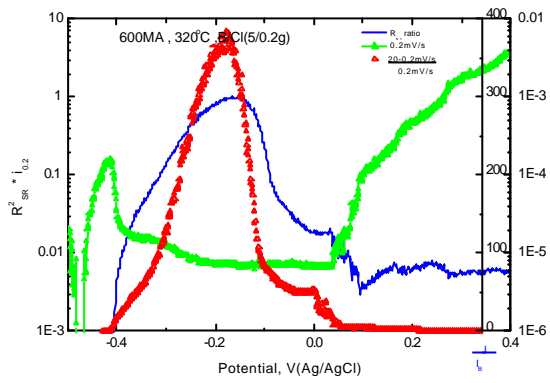


Fig.8 P_{SCC} Vs I/I Vs polarization curve of Alloy 600MA in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

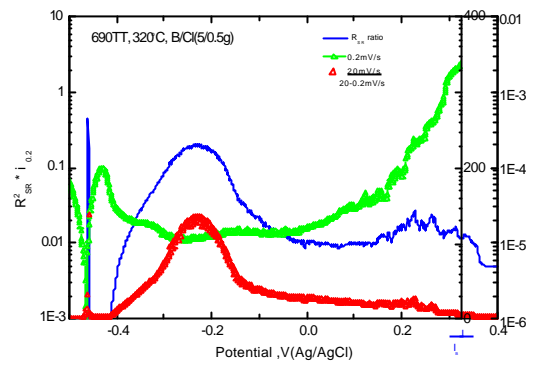


Fig.9 P_{SCC} Vs I/I Vs polarization curve of Alloy 690TT in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

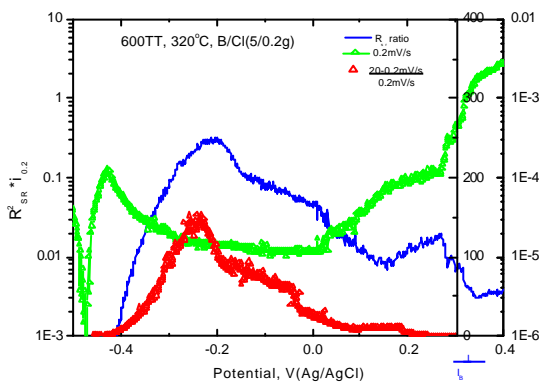


Fig.10 P_{SCC} Vs I/I Vs polarization curve of Alloy 600TT in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C

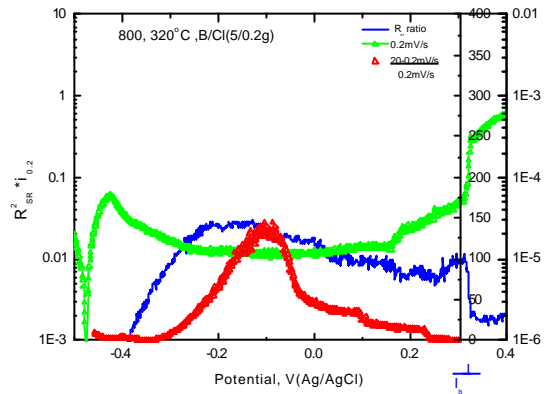


Fig.11 P_{SCC} Vs I/I Vs polarization curve of Alloy 800 in the water of 3% H_3BO_3 and 0.2g/ Cl^- at 320°C .

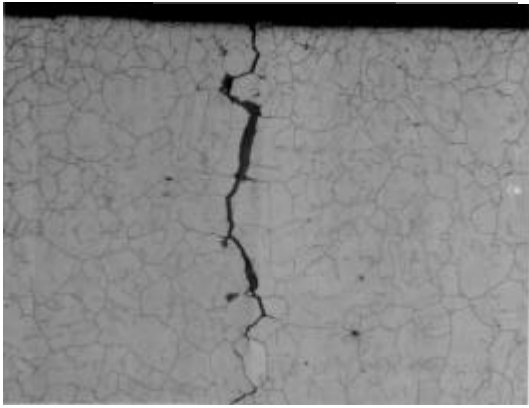


Fig.12 Alloy600MA Optical micrographs showing the cross section in 27% H_3BO_3 and 2g/ Cl^- at 350°C for 1920hrs.

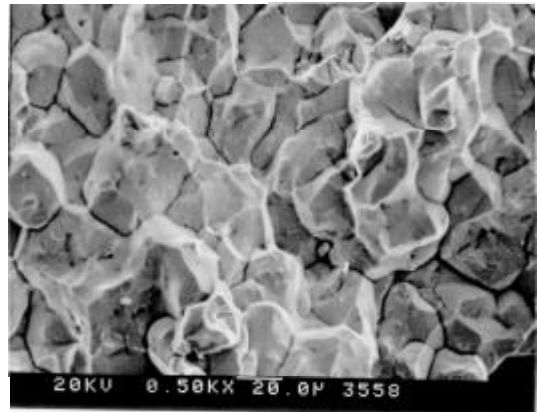


Fig.13 SEM micrographs of 600MA

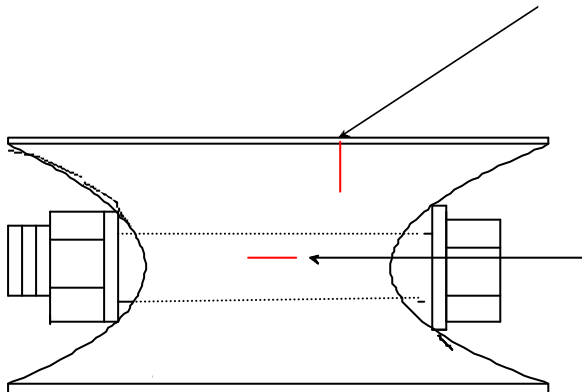


Fig.15 Reverse U-bend specimen

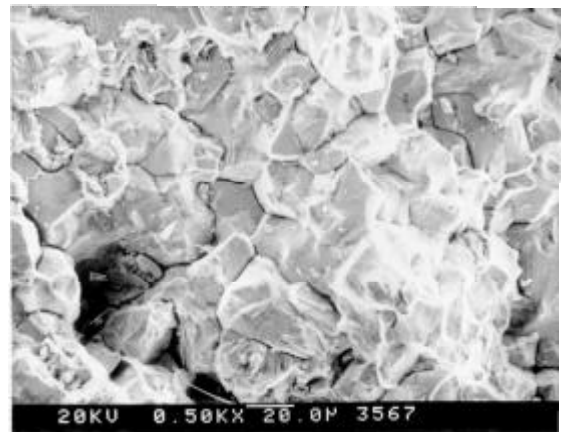


Fig.14 SEM micrographs of 600MA.

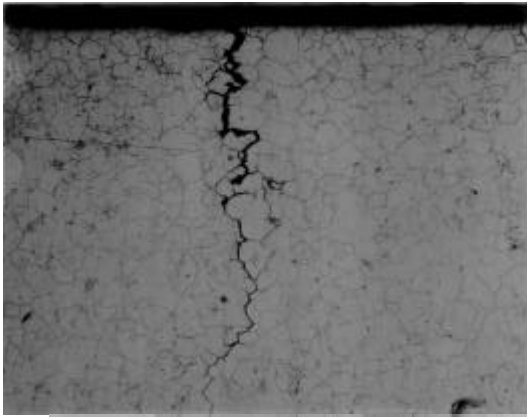


Fig.16 Alloy600TT Optical micrographs showing the cross section in 27% H_3BO_3 and 2g/ Cl^- at 350°C for 1920hrs.

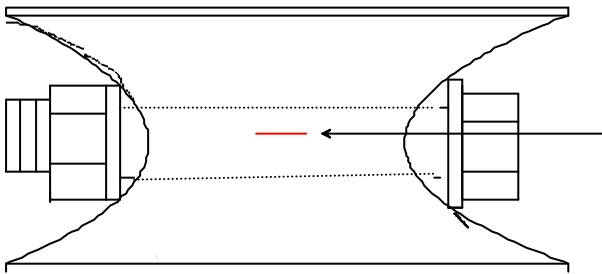


Fig.18 Reverse U-bend specimen

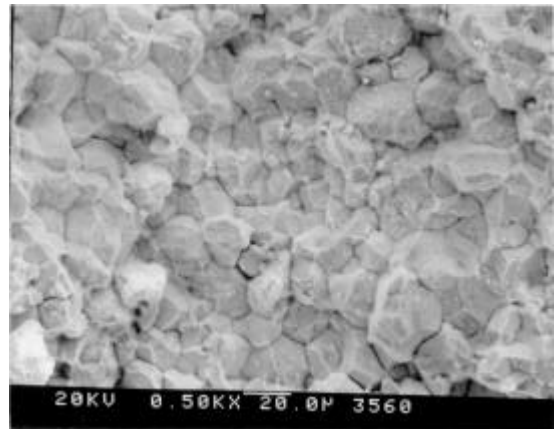


Fig.17 SEM micrographs of 600TT

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