TECHNICAL NOTE

Ion-Nitriding after Welding Improves SCC (Stress Corrosion Cracking) Resistance of Stainless Steel Weldments†

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KEY WORDS: (Stress Corrosion Cracking) (Weldment) (Stainless Steel) (Ion-Nitriding)

Weldments of stainless steel tubes are much crack susceptible for SCC (stress corrosion cracking) in general. This short note is concerned in an improvement for SCC resistance of weldments of SUS 304 stainless steel tubes using the technique of the surface nitriding treatment[1]. The experimental results showed much improvement for SCC resistance in the weldment by this treatment.

The tubes used are SUS 304TB (C: 0.04, Si: 0.52, Mn: 1.51, P: 0.028, S: 0.001, Ni: 9.35, Cr: 18.50%, σ_y: 31 and σ_u: 63 kgf/mm^2, El: 80%) with 60.5 mmϕ OD and 8.7 mm thick. The shape of weld test specimen was shown in **Fig. 1** and welding variables used was shown in **Table 1**. Welding was completed with 4 layers with 7 passes.

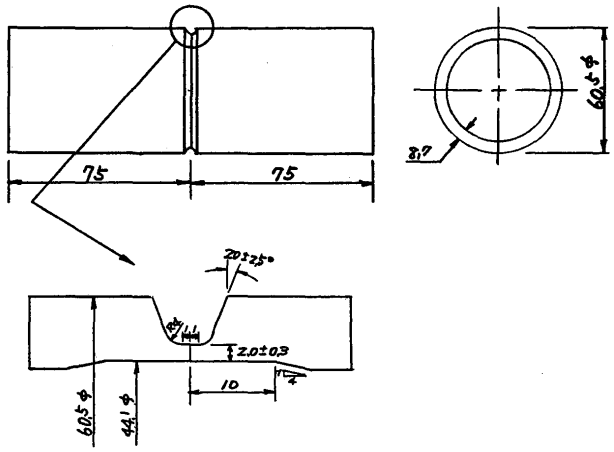

Fig. 1 Joint geometry of SUS 304 TB tubes

Table 1 Welding parameter for SUS 304 TB tube joint (filler wire Y308L)

Layer	Pass No.	Welding process	Welding condition				
			Current (A)	Voltage (V)	Speed (mm/min)	Heat input (KJ/cm)	Interpass temp. (°C)
1	1	Manual GTA	120	10.2	75	9.8	21
2	2	Automatic GTA with pulsed current	*100-115	9.5	66	9.3	30
	3		*100-115	9.5	66	9.3	45
3	4		*107-135	9.5	63	10.9	44
	5		*107-135	9.5	63	10.9	76
4	6		*100-125	9.5	65	9.9	84
	7		*100-125	9.5	65	9.9	93

* Base and peak current for lower and higher current respectively.

After welding the specimens were ion-treated with N_2-H_2 gas for nitriding[1] or argon gas for various temperatures. Then the specimens were treated for SCC resistance comparing with as-welded specimens. The SCC test was done in immersion type in a boiling 42%$MgCl_2$ solution for max. 20 hrs.

Table 2 showed the condition for ion-treatment after welding and the results of cracking after SCC tests. Cracks in mark x were observed only on inner surface in HAZ of the tube joint. **Figure 2(a)** and **(b)** showed typical macroviews of inner surface of welded tubes with many SCC-cracks in HAZ in as-welded condition and noncracked in ion-nitriding treated specimens higher than 550°C after SCC test, respectively.

As shown in Table 2 SCC-cracks were observed as-welded, 400°C ion-nitrided, and 400°C and 750°C argon

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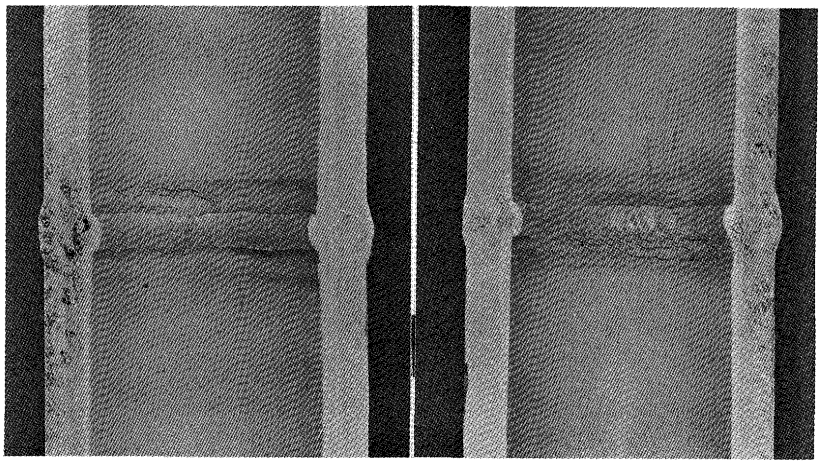
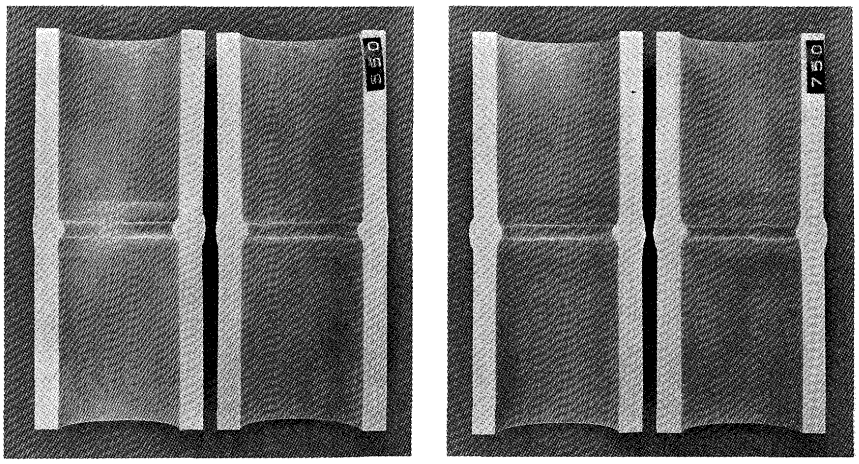
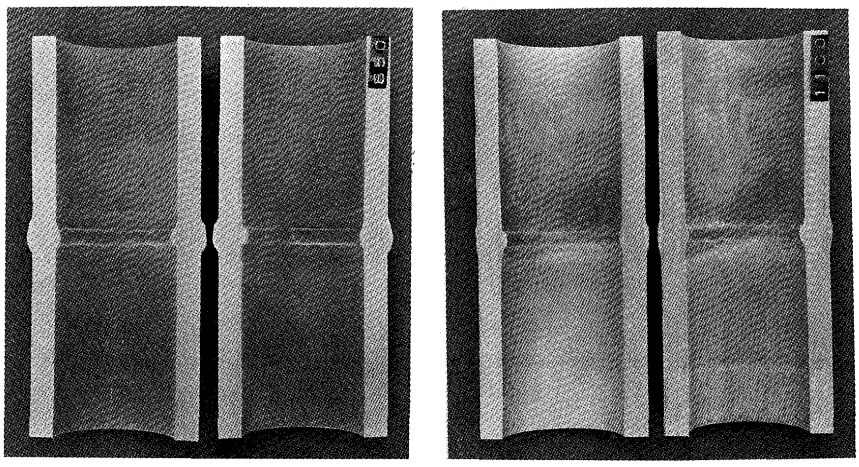


(a) Cracked surface after 1 hr test (As-welded specimen)



550°C, 3 hrs 750°C, 3 hrs



850°C, 3 hrs 1100°C, 3 hrs

(b) Noncracked surfaces after 20 hrs test (Ion-nitrided specimen)

Fig. 2 Macroscopic pictures of inner surface of tube specimens after SCC test

Table 2 Ion-treatment in nitrogen and argon atmospheres, and SCC test result

Ion-Treatment			SCC Test(Hr) Results*			
Atmosphere	Temp.(°C)	Time(Hr)	1	5	10	20
No Treatment(As-welded)			X	-	-	-
N_2+H_2(1:1) 10 Torr (Nitriding)	400	3	-	-	-	X
	550	3	O	O	O	O
	750	3	O	O	O	O
	750	3	-	-	-	O
	850	3	O	O	O	O
	1100	3	O	O	O	O
Ar 100% 10 Torr	400	3	-	-	-	X
	750	3	-	-	-	X

Note * Tested with PT
X: Cracked at inner surface of welded joint
O: Crack free at both surfaces
-: Not tested

ion-treated specimens, while there was no crack in the specimens which were nitrided with 550, 750, 850 and 1100°C, 3 hrs. Treatment in argon atmosphere showed no improvement for SCC resistance.

The treated specimens with nitriding higher than 550°C showed hardened and nitride layers in both surfaces of the test tubes. There was no any layer, of course, in the specimens treated in argon atmosphere.

In conclusional remarks in this note the welded tube specimens of austenitic stainless steel are much improved for SCC resistance in boiling 42%$MgCl_2$ solution when ion-nitriding treatment is done for temperature higher than 550°C after welding. However, argon ion-treatment didn't show any beneficial effect for SCC resistance of the welded joint even if treating temperature is elevated as 750°C.

The reason why the SCC resistance is so improved by ion-nitriding technique is not comfirmed at the present but is considered due to both beneficial effects of the reduction of residual stress of the weldment by nitriding and the protective coating of nitride layer on the surfaces.

Reference

1) F. Matsuda, K. Nakata, K. Tohmoto: Trans. JWRI, 12 (1983) 2, 111-116.