Materials Selection for Welding of High-Alloyed Stainless Steels for Flue Gas DeSulfirization Plants

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1. Introduction

Wet Flue Gas Desulfurization(FGD) plants, removing SOx gas by chemical reactions, deal with highly concentrated chloride, thus, pitting resistance is a major criterion of material selection[1-3]. For the newly built FGD plants in Korea, high-alloyed stainless steels, such as N-added 6%Mo superaustenitic stainless steels(UNS N08367) and super duplex stainless steels(UNS S32550) are used in large scale for the highly corrosive areas. For successful application of these alloys, proper selection of welding filler metal is required for the welds to retain proper pitting resistance. Therefore, in this study, pitting corrosion resistance of Gas Tungsten Arc(GTA) and Gas Metal Arc(GMA) welds of high-alloyed stainless steels made with various welding consumables were evaluated under simulated FGD environments.

2. Experimental Procedure

For evaluation of the welding filler metals, 3 Ni-based filler metals were selected. They are ERNiCrMo-3(Inconel 625), ERNiCrMo-10(C-22), ERNiCrMo-4(C-276), having higher Pitting Resistance Equivalent Number(PRE_N=%Cr + 3.3 × %Mo + 30 × %N) than base metal[4,5]. GTA and GMA weldings were made on 6.7mm thick plates of N08367 and S32550. Additionally, nitrogen additions to the welds, in the form of shielding gas, were made on selected GTA welds. Critical Pitting Temperature(CPT), following ASTM G48C method, were evaluated for all weldments using a so-called "Green Death" solution(7vol.% H_2SO_4 + 3vol.%HCl + 1wt.%$FeCl_3$ + 1wt.%$CuCl_2$) simulating the corrosion environments of the FGD plants [2].

3. Results and Discussion

For GTA weldments of N08367, CPT of base metal was 65 ~ 70°C, whereas weldment of ERNiCrMo-3(Inconel 625) had only 45 ~ 50°C, with preferential pitting of weld metal, suggesting that the filler metal might be unacceptable for the N08367 alloy, even though it has been widely used so far. On the other hand, GTA weldments of N08367 made by ERNiCrMo-10(C-22), ERNiCrMo-4(C-276) showed CPT of 60~65°C and 65~70°C, respectively, hence, these two filler metals can provide pitting corrosion resistance equivalent to that of the base metal. The GMA weldments of the N08367 made by the above three filler metals showed almost the same CPT trends with the GTA weldments, suggesting that pitting resistance of welds did not affected by type of arc welding process.

For GTA and GMA weldments of S32550, CPT of ERNiCrMo-3(Inconel 625) weldments was 45~50°C. Most of pittings were initiated at the Heat Affected Zone(HAZ), indicating that it can provide pitting resistance equivalent to that of the base metal.

In terms of the PRE_N value, these results confirmed that in welding of high-alloyed stainless steels, the filler metals should be over-alloyed in their content of Cr, Mo to compensate preferential segregation of those pitting resistant chemical elements along the dendrite boundary[5,6]. This study shows that this compensation can be achieved by selecting filler metals having at least +10 higher PRE_N value than the base metal regardless of the type of arc welding process.

Since the ERNiCrMo-3(Inconel 625) filler metal has far smaller PRE_N value than other two filler metals, the addition of nitrogen to the weld metal in the form of shielding gas can be a cost-effective option to increase the pitting resistance of the weldments[6]. Adding N_2 to the shielding gas (up to 10%) for the GTA welds of N08367 with the ERNiCrMo-3(Inconel 625) filler metal resulted in an increase in nitrogen content up to 3 times, thus, an increase in their PRE_N value of the weld metal. However, the CPT of the weldments did not improved despite of their higher PRE_N values. This was attributed to the formation of fine precipitate in the weld metal, presumably Nb-nitride, which consumed most of the nitrogen in the weld metal. Therefore, unless the Nb content of the filler metal (~3%), is significantly reduced, this approach seems to be not effective in increasing the pitting resistance of the weldments.

References

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