The Influence of PWHT on Mechanical Properties of Welded Joint of Alloy800H with Alloy625 Filler Metal

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1. Introduction

Fe-Ni-Cr alloy, UNS N08810 (Alloy800H) with excellent creep strength has been employed as a main material of the pressure vessel, which should be operated above the design temperature of 538°C. The welding of Alloy800H should be followed by stress relieving heat treatment at a minimum of 885°C according to the requirement of ASME Pressure Vessel code. In case that filler metal of Alloy625 (ERNiCrMo-3) is adopted to weld Alloy800H, this temperature range of PWHT will have an influence on the microstructure and mechanical properties of Alloy625 weldmetal because it is widely known that several phases such as γ′, MC, M23C6 and δ-phase may be precipitated within a range of 700–950°C. In this study, the influence of PWHT on properties of welded joint of Alloy800H with Alloy625 weld consumable has been evaluated.

2. Experimental procedure

The base materials, Alloy800H plates of 56mm thickness, have been welded by SAW with Alloy625(ERNiCrMo-3) filler metal, followed by PWHT of three conditions that were 900°C, 950°C and 1000°C for 7hrs. 1000°C is the solution temperature of Alloy625. Mechanical properties such as tensile strength, charpy impact toughness, hardness and bending ductility have been evaluated. Microstructural examination with SEM and EDX has been carried out to discover the change of mechanical properties by PWHT.

3. Result and discussion

On the PWHT conditions of 900°C, 950°C and 1000°C for 7hrs, the mechanical properties of weldmetal have been changed as Fig.1. Tensile strength was not significantly influenced by PWHT, but slightly increase at 900°C and 950°C. Yield strength decreased as PWHT temperature increased. Other properties showed a marked trend at 900°C and 950°C. A reduction of ductility and impact toughness, and a rise of hardness were observed. Accordingly, bending test was failed through weldmetal by these PWHT conditions as shown in Fig.2. Microstructural examination on each PWHT condition is shown in Fig. 3. A large quantities of needle like δ-phases have been precipitated in a row along the dendrite arm space at 900°C and 950°C to induce reduction of ductility. δ-phase is a (Nb, Mo)-rich compound that precipitated during heat treatment between 700–950°C[1]. On the stage of weldmetal solidification, excessive Nb and Mo have been segregated from dendrite core, and then promote formation of δ-phase at dendrite arm space during heat treatment. When welded specimen was heat treated at 1000°C for 7hrs, bending ductility, impact toughness and hardness were recovered due to resolution of δ-phases.

4. Conclusion

In case of using Alloy625 consumable for welding Alloy800H, PWHT temperature should be 1000°C or higher to prevent precipitate of δ-phases that induce degradation of properties.
Fig. 1 Change of mechanical properties of Alloy625 weldmetal by PWHT condition

Fig. 2 Failed bending specimen at 900°C & 950°C x 7hrs

Fig. 3 Change of microstructure of weldmetal by PWHT condition

References