Weldability of a Corrosion Resistant Ni-Cr-Mo-Cu Alloy

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Introduction

A Ni-Cr-Mo-Cu alloy, known commercially as HASTELLOY® C-2000® alloy (UNS N06200), was developed to maximize resistance to uniform corrosion in both oxidizing and reducing acids, while maintaining a level of resistance to pitting and stress corrosion cracking in chloride environments that is typical of the Ni-Cr-Mo alloys (Ref. 1). The modern corrosion resistant Ni-Cr-Mo alloys have been shown to exhibit good resistance to weld metal solidification cracking. Weldability testing has been carried out previously on Ni-Cr-Mo alloys with additions of tungsten and of titanium (Ref. 2), but there is currently no published information regarding the effect of copper on the weldability of Ni-Cr-Mo alloys. Information on mechanical properties of UNS N06200 alloy weldments and corrosion resistance of weld metal is also not available in the published literature.

Procedure

Both sub-scale and full-scale Varestraint tests were carried out on three production heats of UNS N06200 alloy along with other commercially available Ni-Cr-Mo, and Ni-Mo alloys for comparison. Varestraint specimens were tested in triplicate. Metallography and scanning electron microscopy were used to document solidification microstructures. Welded plates were prepared for mechanical testing using the GTAW, GMAW, and SMAW processes. The weldments were subjected to all-weld-metal and transverse tensile, bend, and charpy impact toughness tests. Immersion corrosion tests were performed on all-weld-metal coupons of UNS N06200 alloy in various environments, including hydrochloric, hydrofluoric, and sulfuric acids, with other Ni-Cr-Mo alloys included for comparison.

Results and Discussion

The resistance of UNS N06200 alloy to solidification cracking was found to be similar to that of other Ni-Cr-Mo alloys, including UNS N06022 (HASTELLOY® C-22®) and UNS N10276 (HASTELLOY® C-276®) alloys. UNS N06200 alloy is unique among modern Ni-Cr-Mo alloys in that it contains approximately 1.6 wt. % copper; however, the addition of copper does not appear to have a detrimental effect on the resistance of the alloy to solidification cracking. UNS N06200 alloy weld metal met the minimum tensile strength requirements of the base metal and passed 2T and 1.5 T transverse bend tests. The corrosion rate of UNS N06200 alloy weld metal was lower than that of UNS N10276 alloy and UNS N06022 alloy in hydrochloric, hydrofluoric, and dilute sulfuric acids, similar to that of UNS N06022 alloy in ASTM G28A solution, and similar to that of UNS N10276 alloy in ASTM G28B solution and concentrated sulfuric acid.

Conclusions

UNS N06200 alloy weld metal exhibits good resistance to solidification cracking, which is typical of the modern wrought Ni-Cr-Mo alloys. In the as-welded condition, the weld metal provides mechanical properties that are comparable to the matching wrought material. UNS N06200 alloy weld metal exhibits lower uniform corrosion rates in hydrochloric, hydrofluoric, and dilute sulfuric acids compared to other Ni-Cr-Mo alloy weld metals, such as UNS N06022 and UNS N10276.

References

1. P. Crook, M. L. Caruso, and D. A. Kingseed. 1997. Corrosion Resistance of a New, Wrought Ni-Cr-Mo Alloy. *Materials Performance*, 36(3):49-52

2. M. J. Cieslack, T. J. Headley, and A. D. Romig. Jr. 1986. The Welding Metallurgy of HASTELLOY Alloys C-4, C-22, and C-276. *Metallurgical Transactions*, 17A(11):2035-2047.