Effect of Submerged Arc Welding on High Temperature Tensile Properties of P91 Type Steel

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Abstract

There have been research efforts to increase the efficiency of power plants by improving creep-resistant steels having stable mechanical properties at elevated temperatures. The components operating at temperatures between 575°C and 650°C are usually made of P91 (9Cr-1Mo) steel. The application of welding techniques creates a risk of reduction in high-temperature strength and creep resistance, particularly in the heat-affected zone of the weldments. In this study, the effect of the shielded metal arc welding (SMAW) on the high temperature tensile properties of P91 type steel plates was investigated.

Keywords: P91 steel, shielded metal arc welding, high temperature tensile properties

1. Introduction

P91 steels with optimum addition of some precipitate forming elements such as B, Mn, Ni, N, Nb, V, Cr, and Al have the excellent potential to provide higher strength at elevated temperatures [1]. To obtain the better mechanical properties, P91 steels undergo the normalizing and tempering [2]. Welding is a major joining process for the fabrication of steam generator components made of P91 type steels. Formation of heterogeneous microstructure in the heat affected zone during weld thermal cycle leads to a strength gradient across the weld joints. It is known that the fine grain heat affected zone attains the most weakened region in the weldments. Since evaluation of elevated temperature tensile properties is a preliminary step towards characterization of materials performance for high temperature applications [3], the effect of SMAW on the high temperature tensile properties of P91 type steel plates was investigated in this study.

2. Materials and Methods

The 30mm x 70mm plates, extracted from the P91 pipes having 186 mm outside diameter, were joined by SMAW using the E9015-B91H4R electrode in accordance with the AWS A5.5/A5.5M; and then, post-weld heat treatment (780°C/2h) was applied. The specimens were prepared by cutting the weld in the transverse direction. Following radiographic inspection, metallographic investigation and hardness measurement, tensile tests were performed at 20°C, 660°C, and 700°C.

3. Results and Conclusions

The initial material has a tempered-martensite microstructure with an average hardness of 336 HV0.1. The results of the tensile tests at 20°C, 660°C, and 700°C give UTS values of 728 MPa, 208 MPa, and 160 MPa; and % elongation in length values of 21, 25, and 28. The failure mode of all specimens is purely ductile, as characterized by the occurrence of dimples with voids. Fracture surface of the 700°C-tensile test specimen shows the existence of some secondary cracks.

Acknowledgment: The authors acknowledge the Magmaweld for the support of welding consumables.

References

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