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Effect of Post Weld Heat Treatment on Mechanical and Corrosion Behaviors of NiTi and Stainless Steel Laser-Welded Wires

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Effects of post weld heat treatment (PWHT) on mechanical properties and corrosion behavior of NiTi shape memory wire, laser welded to the 304 stainless steel wire were investigated. The results showed that PWHT at 200 °C increased corrosion resistance and tensile strength of the joint up to ~1.8 times that of the as-weld joint, with no heat treatment. On the contrary, precipitation of neoteric intermetallic compounds like Fe_2Ti, Cr_2Ti, FeNi, Ni_3Ti, and Ti_2Ni in the welded region deteriorated these properties, when PWHT was conducted at 400 °C. Due to the vital effects of the PWHT performed after the laser welding, careful control of the PWHT temperature was found to be a prerequisite for achievement of desirable properties in the dissimilar NiTi-304 stainless steel laser-welded wires.

Keywords corrosion behavior, laser welding, mechanical properties, NiTi shape memory alloy, post weld heat treatment, stainless steel

1. Introduction

By virtue of the unique shape memory effect, super-elasticity and good biocompatibility, NiTi alloys have been used for fabrication of various bio-medical instruments such as orthopedic implants, orthodontic wires, bone prostheses, and stents (Ref 1-4). As is well known, successful application of any advanced material hinges not only on inherent properties of the material, but also on development of the joining technologies.

During the last few years, several techniques such as friction welding (Ref 5, 6), tungsten inert gas welding (Ref 7), plasma welding (Ref 8), brazing (Ref 9, 10), and laser welding (Ref 11-13) have been examined for joining of the NiTi alloys. Among these diverse welding techniques, laser welding has been regarded as a suitable method for joining of the NiTi alloys. This method has been especially appropriate for fabrication of small medical devices with complicated shapes due to the low and precise heat input, small heat-affected zone (HAZ), low residual stress, minor weld distortion, and high welding speed (Ref 14).

Successful fusion welding and particularly similar laser-assisted welding of NiTi alloys has been well established, during the recent years (Ref 15-17). Few studies have, however, been conducted on welding of the NiTi alloys to other materials, such as stainless steel which has many diverse applications. Joining of the NiTi to this material is desirable for multiplication of its usage. Indeed, fabrication of the complex medical devices by joining NiTi to stainless steel is desirable for many medical applications. However, making dissimilar joints between these materials is a rather difficult procedure because of the large differences in their physical and chemical properties. It has been shown that the formation of intermetallic compounds such as Fe_2Ti and Cr_2Ti could make the welded region brittle (Ref 18). Several researchers have recently reported that properties of the dissimilar NiTi-stainless steel joints could be improved by using Ni (Ref 6, 19) and Co (Ref 20) interlayers and Ag-based fillers (Ref 21). However, based on author's knowledge, no attempt has been so far made to explore the effect of post weld heat treatment (PWHT) on properties of the dissimilar NiTi-stainless steel joints. The results of Chan et al. (Ref 22, 23) have shown that the PWHT remarkably improves the mechanical properties and corrosion behavior of the NiTi-NiTi similar joints. It is, therefore, expected that PWHT can improve properties of the dissimilar NiTi-stainless steel joints. It should be pointed out that the laser welding and the PWHT is a simpler and more cost-effective method for joining of the dissimilar wires when compared to the interlayer method.

This paper gives insight into the effect of PWHT on mechanical properties and corrosion behavior of the dissimilar laser-welded NiTi-stainless steel wires. The objective of the paper is to provide some foundation for improvement of the mechanical properties and corrosion behavior of the dissimilar joints produced by the laser welding technique.

2. Experimental Procedures

NiTi wires (containing B2 phase at room temperature) and AISI 304 stainless steel wires (containing γ-Fe and small amount of α-Fe phase) with 0.36 mm diameter were used in this experiment. Chemical compositions of the wires are listed

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