Abstract

Design and Optimization of a protection device for laser weld beads of metal alloys for aerospace applications

In the present thesis an automated laser welding apparatus was designed and developed in order to perform laser , that allows to achieve laser welding in a controlled, versatile, efficient, reliable, simple, and economical way. This system allows to shield not controlled from oxidation and nitriding process, both the melted pool and the material portion just after welding when the oxidation or nitriding critical temperatures, generally between 200 °C and 500 °C are still in place. Oxidation is even more serious when welding titanium, nickel superalloy, zirconium, molybdenum, stainless steel and other gas-reactive metals and alloys. Most of these materials are used for a wide range of applications in aerospace and biomedical fields as well as for piping in petrochemical, food, semiconductor, nuclear, and chemical industries. These metals can be used in contact with corrosive or sensitive materials without contaminating them, thus making them the number one choices for applications requiring long service life and non-contamination.

The resulting oxidized surfaces are not longer corrosion resistant and further treatment may be necessary. Removing the oxidation using mechanical means, such as grinding, also removes the metal's passive protective layer.

The automated laser welding apparatus (patent number: SA2012A000016) was tested with three different joints: butt welding of 3 mm thick Ti6Al4V plates; dissimilar butt welding of 1.5 mm thick of Haynes 188 and Inconel 718 and edge joint of 0.7 mm thick Inconel 625 sheets.

All of the tests were performed with automated laser welding apparatus; the bead quality was discussed in terms of geometrical features, porosity content, microstructure, hardness and strength. This work is divided in three parts.

In the first part, the principles of operation and the different types of laser are discussed, with mention to the advantages of a disk laser source, which is employed in the experimental part. Also, the types of laser welding, the influence of process parameters and the advantages compared to traditional welding techniques are explained.

The second part presents the issue of oxidation caused by welding and the relative solutions proposed in the literature for shielding the bead. Then, the development and the implementation of the automated laser welding apparatus with its components is described.

Finally, the capabilities of the automated laser welding apparatus on three different types of joint are discussed in the last part and the relative results are provided.