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Optimization of Multi-layer Welding of Titanium Alloy

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Abstract: Gas Tungsten Arc Welding GTAW process is a multi-input and output process in which the resultant joint strength is governed by both independent and combination of process parameters. The identification of suitable combination parameter is crucial to get desired quality of welded joint and hence, there is need for optimization of GTAW process to achieve a best result. The present work is based on the GTAW process parameters on multilayer welding of titanium alloy (Ti-6Al-4V). The design of experiment is done by response surface method to find the desired welding conditions for joining similar plates alloy material. Analysis of variance methods were applied to understand the GTAW process parameter. The considered parameters are filler diameter, welding current, welding speed and welding speed, while the desired output responses are heat input. From the results of the experiments, optimization is done to find optimum welding conditions of welded specimen to minimize the heat input by four welding pass is (5570 J/mm) and the total net heat input during welding for a GTAW procedure by four welding layers (3342 J/mm). In order to prevent structure changes especially for thick plates.

Keywords: GTAW, optimization, titanium alloy

INTRODUCTION

Titanium (Ti-6Al-4V) alloy is the most widely used material; it features good machinability and excellent mechanical properties. (Ti-6Al-4V) offers the best all-round performance for a variety of weight reduction applications in aerospace, automotive and marine equipment. This alloy is used at a minimum tensile strength of 1,193 MPa; it is used in the replacement of high-strength low alloy steel, 4340 M, at 1,930 MPa. This substitution resulted in a weight savings of over 580 kg (Boyer, 2003). The use of titanium in landing gear structure should also significantly reduce the landing gear maintenance costs due to its corrosion resistance. The low density and high strength make it very attractive for reciprocating parts, such as connecting rods for automotive applications. The structure in the engine and exhaust areas operates at elevated temperature, so the primary options are titanium-or nickel-base alloys however the latter would add significant weight. Titanium engine alloys are used up to about 600°C. Titanium alloys are considered one of the most difficult materials to machining. They possess very strong characteristics and cutting them involves a lot of problem. Followed by the problem reversible transformation of the crystal structure due to high temperatures during welding which were studied with Design of Experiments (DoE) of RSM. The heat input of welding process has a lot of problems which can occur. Heat affected zone, distortions, changes at the mechanical properties and microstructures which effect on the metals, leading to failure of the product and consequently loss of effort, cost, time and even sometimes live of people.

Heavy thickness uses: Given titanium's lightness, strength and resistance to corrosion and high temperatures, its most common use is in alloys with other metals for constructing aircraft, jet engines and missiles. Its alloys also make excellent armor plates for tanks and warships. It is the primary metal used for constructing stealth aircraft which are difficult to detect by radar (Krebs, 2006). The completed molds are then embedded on a casting table for centrifugal casting. Cast components of up to 2750 kg have already been successfully produced. Even larger structures are likely, but can also be manufactured by welding together two or more castings (Leyens and Peters, 2003). In addition, forging is one of process using to produce titanium productions for large ingots. Forging of large titanium ingots began/was undertaken in the early 1990s and the forging process it can produces up to 600 mm or 4500 kg (Leyens and Peters, 2003).

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