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Optimizing pulsed GTAW process parameters for bead geometry of titanium alloy using taguchi method

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ABSTRACT

The selection of process parameters for obtaining optimal weld bead geometry of Ti-6Al-4V titanium alloy in the pulsed gas tungsten arc welding (GTAW) is presented. The bead geometry includes bead penetration, bead width and bead height. All these characteristics were considered together in the selection of process parameters using various Ar + He (Argon + Helium) mixtures as a shielding gas with sinusoidal AC wave and modified Taguchi method was used to analyze the effect of each welding process parameter on bead geometry properties. Experimental results were furnished to illustrate this approach.

Key words : Pulse parameter, Modified taguchi method, Ti Alloy, Gas mixtures, Bead geometry

INTRODUCTION

Titanium and its alloys have been considered as one of the best engineering metals for industrial applications such as in food processing industry. This is due to the excellent combination of properties such as elevated strength to weight ratio, high toughness, excellent resistance to corrosion and good fatigue properties make them attractive for many industrial applications (Balasubramanian *et al.*, 2008). Titanium alloy grade – 5 (Ti-Al-V alloy) has gathered wide acceptance in fabrication of vessels, blades, discs, airframes, rings, fasteners, forgings and biomedical implants. Basically, GTA welding is strongly characterized by the bead geometry. This is because the bead geometry plays an important role in determining the mechanical properties of the weld. On the other hand it is widely understood that the GTA welding of titanium alloy exhibits columnar grains in the weld pool, which often results in inferior mechanical properties and may lead to hot cracking. In recent past many researchers have investigated the effect of physically disturbing the arc and thereby disturbing the molten pool by incorporating many techniques. One such technique which has been used by many investigators is pulsing current. This technique has been investigated successfully by many researchers to great success, resulting in grain refinement of fusion zone (Balasubramanian *et al.*, 2008).

The important process parameters which affects the bead profile are pulse current, secondary current (back ground current), pulse frequency, pulse duty cycle, welding voltage welding speed and gas flow rate. The thermal behaviour of weld governed by arc characteristics and the behaviour of metal transfer significantly influences the geometry, chemistry, microstructure and stresses of weld. Deep penetration in pulsed current welding is produced mainly by arc pressure at peak duration and significantly long peak duration is needed for deep penetration (Ko and Yoo, 2001). Argon – helium mixtures is used to take advantages of optimum operating characteristics of each gas, superior arc ignition and stable arc characteristics of argon and higher thermal conductivity of helium. These mixtures are used to increase the heat input of the arc. Helium rich mixtures are preferred in order to achieve good cleaning action with high heat input and arc stability (Riechelt and Hoy, 1980). The linear relationship exists between the heat input of a weld and the maximum temperature at a given distance from weld centre line shows that pulsed arc welds would be cooler and therefore exhibit less thermal distortion than conventional GTA welds of the same penetration (Leitner *et al.*, 1973). The heat input is typically calculated as follows: H = [60EI] / 1000 S, Where H = Heat input (kJ/mm), E = Arc voltage (Volts), I = Current (Amps) and S = Travel speed (mm/min).

To study the entire process parameter with a small number of experiments, a Taguchi technique is used. In fact Taguchi technique has been designed to optimize a single quality characteristic. To consider the several quality characteristics together in the selection of process parameters, the modified Taguchi method (MTM) is used (Mohamed, 2001).

MATERIALS AND METHODS

The experiments were conducted on 2.5mm thick

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