International Journal on Interactive Design and Manufacturing (IJIDeM)
https://doi.org/10.1007/s12008-024-01780-8

ORIGINAL ARTICLE

Application of metal cored filler wire for environmental-friendly welding of low alloy steel: experimental investigation and parametric optimization

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Received: 25 June 2023 / Accepted: 9 March 2024

Abstract
Motivated by the crescente demand for eco-friendly and worker-safe welding techniques, this study optimizes current (A), voltage (V), and gas flow rate (GFR) for regulated metal deposition (RMD) welding of ASME SA387 Gr.11 Cl.2 steel. Employing MEGAFIL 237 M metal cored filler wire and a Taguchi L_9 orthogonal array, bead-on-plate trials were conducted to evaluate heat-affected zone (HAZ), depth of penetration (DOP), and bead width (BW). A unique dual-pronged optimization approach was implemented. The utility function method, combined with Taguchi's signal-to-noise (S/N) ratio, maximized desirable and minimized undesirable responses. Additionally, TOPSIS with Taguchi S/N ratio identified the optimal process parameters. Both optimization strategies converged on identical. A = 135 A, V = 14 V, and GFR = 13 L/min. Notably, voltage emerged as the most influential factor in the mean S/N response table, highlighting its critical role in controlling weld quality. The proposed procedures offer a robust framework for determining optimal RMD welding conditions in pipeline applications. This not only enhances weld integrity and worker safety but also paves the way for sustainable manufacturing and continuous quality improvement in the field.

Keywords RMD welding · Weld bead geometry · Low alloy steel · TOPSIS · Utility function · Taguchi method

1 Introduction

Technology advancement in today's fast-paced world compels nearly all factories and engineering companies to produce long-lasting, high-quality goods at competitive prices. While many products are created independently as standalone pieces, they often need to be put together in order to function in their intended real-world contexts [1–4]. Welding is the method of choice in several sectors (including the automotive, aviation, hydrocarbon, pharmaceutical, power, and agricultural industries) for joining thick and thin, and often incompatible materials to easily produce efficient, durable, and cost-effective products [5–8]. Welding saves time and money when compared to other methods like adhesive bonding and mechanical fastening of joining materials. It creates a weld so strong and durable that it's nearly impossible to detach the joined pieces. The American Welding Society (AWS) recognizes 94 distinct welding methods, one of which is gas metal arc welding (GMAW) [9–11].

GMAW has been employed in a broad range of industries since its commercialization in the late 1950s, including shipyards, gasoline and oil pipelines, pressure vessels, boiler pipes, heat exchangers, coal conversion, and chemical parts. There are three ways in which metal can be transferred: globular arc transfer, spray arc transfer, and shortcircuiting arc transfer. Out of these three modes of metal transfer, the shortcircuiting mode of metal transfer is quite popular

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