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AN INVESTIGATION INTO THE OPTIMIZATION OF PROCESS VARIABLES AND THEIR EFFECTS IN ARC WELDING

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Abstract

Welding is a method used to join materials often metals or thermoplastics by applying intense heat to melt them and create a fused bond. Welding differs from lower-temperature metal-joining methods like brazing and soldering, as those processes do not melt the base metal. Arc welding stands out as a highly promising joining method due to its broad industrial use, enabling the rapid fusion of both similar and dissimilar materials. Arc welding is a widely used joining method, typically defined by its bead dimensions and mechanical properties. Manufacturers face the challenge of controlling process input parameters to achieve a high-quality weld with the desired weld integrity. In the past, it has been essential to analyze the weld input parameters for welded products to achieve a joint meeting the desired quality standard. It demands a lengthy, iterative process of testing and adjusting. This study aims to introduce a method for determining the optimal settings of welding process parameters.

Keywords: *Arc Welding; Process Parameter, Response; Optimization.*

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1. Introduction

Welding offers the most cost-effective and efficient method for permanently joining metals. It is crucial in the production and maintenance of steel. It is likewise employed in the building of spacecraft, fighter jets, submarines, and nuclear power plants. Welding holds a leading position among industrial methods and incorporates more scientific principles and variables than any other industrial process. Welds come in a variety of types. Certain processes produce sparks, while others don't need extra heating. Welding can be performed in various locations indoors or outdoors, above water or beneath it. A variety of welding methods and techniques are widely employed across numerous applications. The quality of welding is crucial, as it enhances the product's strength, hardness, and durability. The quality of a welded product is assessed using multiple criteria, including the shape of the weld bead, the speed of material deposition, and its hardness. These characteristics are influenced by various welding parameters including welding current, speed, arc voltage, and electrode output and to achieve high-quality results, it's essential to set these parameters correctly within the welding process. Welding is a permanent bond between two or more similar or different materials by applying filler to them at a certain temperature with or without pressure or with / without filling only.

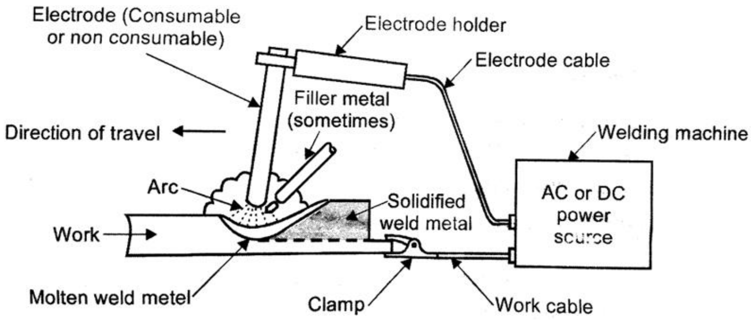

Figure 1. Basic circuit diagram of arc welding process

2. Literature Review

Osayi et al. (2015) conducted studies employing the Taguchi method within the framework of design of experiments (DOE), evaluating four welding parameters: welding current, welding speed, inertial separation, and electrode angle. An L9 orthogonal array was used in the experimental design, and the ultimate tensile strength was assessed for each run. Tensile tests were conducted on both welded and unwelded specimens using a universal testing machine (UTM). The microstructure of the welded specimens was analyzed. ANOVA and signal-to-noise ratio were employed to assess the significant impact of input parameters on ultimate tensile strength and to identify optimal process conditions, respectively.

Moradpour et al. (2015) investigated the welding of such structures and found that the selection parameters significantly impact the geometry of the weld bead, thereby influencing the overall weld quality. A novel method for predicting weld bead geometry and optimizing process parameters was introduced, leveraging fuzzy logic alongside the NSGA-II algorithma genetic algorithm for non-dominated sorting of class II. Initially, a range of welding parameterssuch as voltage, current, and welding speedwere set to conduct SAW under different conditions on API X65 steel plates. Then, the developed fuzzy model was applied to forecast the weld bead geometry and simulate the process. Average error percentage derived from the penetration depth, width, and height of the weld bead using the proposed fuzzy model.

Kumar and colleagues (2016) link the application of grey relational analysis, grounded in Taguchi methods, to fine-tune parameters for gas arc welding. The multiple reaction optimization process utilizes an orthogonal matrix compatible with both the GRA and Taguchi methodologies. The best welding parameter settings simultaneously reduce bead width while increasing bead height, HAZ, and weld penetration. Research has demonstrated that the grey-based Taguchi method improves many reactions in gas metal arc welding.

Jadoun et al. (In 2016, the Taguchi method was employed to evaluate how each welding parameter influenced welding resistance, with the goal of identifying the optimal settings to achieve maximum resistance. The study involves selecting parameters via an orthogonal matrix, conducting experimental runs, analyzing the data, identifying optimal combinations, and concluding with experimental validation. The proposed approach is illustrated using experimental results.

Yan et al. (In 2017, it was concluded that an optimization method for arc welding process parameters is proposed to lower energy consumption and boost thermal efficiency. In the multi-objective optimization model for arc welding, minimizing total energy consumption and maximizing thermal efficiency serve as the optimization goals, while welding current and welding speed act as the independent variables. FSGA is employed to address the optimization problem, and a case study is conducted to verify the proposed model.

Patil (2017) centers on simulating multiple reactions and optimizing gas tungsten arc welding. Their goal is to attain particular tensile strength and stiffness following welding. 304 stainless steel, commonly employed across nearly all industrial sectors, was selected as a candidate material for investigating the tungsten inert gas welding process. To ensure a strong and dependable weld, the welding process must deliver consistent, high-performance results.

Shukla et al. (This document, from 2018, centers on analyzing parameters for armored metal arc welding to enhance penetration, employing the response surface method. Welding current, electrode polarity, and flashlight angle were designated as input parameters. The experiment was designed using a fully factual approach. The RSM-based model was created to assess the penetration depth resulting from different welding parameters. The quadratic model created via RSM demonstrates high accuracy and is suitable for making predictions within the range of the probe factor.

Ghosh et al. (The 2018 study presents research on AISI 316L stainless steel samples joined using MIG welding. He has been designated as a butt joint. The quality of welding was assessed based on the ultimate strength, elastic limit, and percentage elongation of the welded samples. Observed data has been interpreted, discussed, and analyzed using principal component analysis (PCA). The best parametric setup has also been calculated and confirmed. The experimental results and subsequent analyses have been interpreted fruitfully, leading to several key conclusions.

Sheikh and Kamble (2018) carried out experiments aimed at removing welding defects and enhancing welding quality. The study revealed that the welding defect impacts the visual appearance of the product. Welding defects on the sheet lower the product’s cost of sale. Extra repair costs were needed to fix the product defects. Taguchi methods are applied using DOE analysis. This was aimed at achieving improved outcomes specifically, reducing defects during sheet welding.

Kumar et al. (In 2018, a hybrid method was employed, and ANOVA was used to assess the significance of input parameters in order to enhance the degree of Gray's relationship.

Choudhary et al. (In 2019, the Jaya algorithm is employed for multi-objective optimization of the SAW process, with its optimization outcomes compared against those obtained using the traditional desirability approach and the genetic algorithm.

3. Noteworthy Contributions in the Field of Proposed Work

Manufacturers face the challenge of controlling process input parameters to achieve a high-quality weld with the desired weld integrity. In the past, determining the weld input parameters for a welded product has been essential to achieve a joint meeting the desired quality standard. It demands a lengthy process of trial and error for development. In arc welding, manufacturers face the primary challenge of selecting process input parameters that ensure a high-quality weld joint, superior welding performance, and optimal strength. Traditionally, setting the weld input parameters for newly welded products to achieve the desired joint specifications is a lengthy process that requires careful judgment and the expertise of either a welding engineer or operator to select the optimal parameters and attain the best results.

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