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Review Article

A Review On Optimization Of Process Parameters Of Weld Bead Using Taguchi Analysis For Steel 2062

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Article Info

Abstract

Submerged arc welding is a type of welding process; it is mostly used in industry applications. Because of its efficiency and consistency in high production quality for welding. In this paper the optimization of process parameters for welding bead using Taguchi analysis, basically focusing on steel 2062. In this paper, the investigation on various parameters such as arc voltage, welding current, welding speed, wire diameter and granular flux, which are, affect weld quality and its properties. The complete review of literature related to submerged arc welding and its process parameters and optimization techniques. This review includes study of Taguchi method, fuzzy logic, artificial neural network and other optimization approaches that are used to enhance weld quality, characteristics and its mechanical properties. After optimizing process parameters, submerged arc welding shows advantages like high production rate, automation abilities and best qualities production. Form the conclusion highlights of submerged arc welding parameters to achieve desired mechanical properties and weld bead geometry, therefore, it is required to improve the efficiency of submerged arc welding for various industrial applications.

Keywords - Submerged Arc Welding (Saw), Welding Process, Taguchi Analysis, Process Parameters

1. INTRODUCTION

Submerged arc welding (SAW) is an arc welding process in which electric arc submerging by Granular flux. It is widely used in industries because of its high productivity and high-quality welding. Granular flux provides a protective shield for the work piece during welding. This process is suitable for applications when required deep penetration, smooth finishing and high productivity like structural members in ships, pressure vessels and bridge beams. Submerged arc welding is preferred for its ability like high quality welding production, excellent mechanical properties. It is achieved by it's optimal process parameters like current, voltage, speed and wire diameter. This process is characterized for high deposition rate, it makes best for joining thick steel and making long welds.

2. PRINCIPLE OF SUBMERGED ARC WELDING

The principle of submerged arc welding includes generating a welded joint by submerging an electric arc beneath a coating of granular flux, shielding the arc and weld pool from atmospheric pollution. This process is normally used for butt-welding and fillet welding in many applications such as structural members in ships, pressure vessels, and bridge beams. The filler material, an uncoated wire electrode is continuous fed along with a flow of fine-grained flux to enable high-current welding. The arc burns in a void filled with gas and metal vapour, defined by unmated basic material and molten weld. The hardened weld and flux are then formed, with excess flux being recyclable. Submerged arc welding is capable for deep penetration, smooth finishes, and high productivity.

3. IMPORTANT PARAMETERS IN SUBMERGED ARC WELDING

ARC VOLTAGE

The arc voltage in submerged arc welding is an important parameter, it is responsible for making shape, width and penetration of the weld. It affects the weld bead geometry, heat transfer and energy transfer on the time of welding process. In submerged arc welding, the arc voltage, along with welding current and welding speed are affects the quality and features of weld, like hardness and penetration depth. Therefore, by controlling and optimizing of arc voltage is easy to achieve desired output welding and ensuring the welding quality.

WELDING CURRENT

In submerged arc welding, welding current plays an important role to determine depth of penetration on the time of welding process. It is difficult to select a perfect welding current parameters on basis of metal thickness and the type of joined to avoid problems like burn-through or incomplete penetration. As well as it is necessary to adjust welding current while changing the welding speed to maintain steady penetration levels. The proper welding current can affect the quality and mechanical properties of weld.

WELDING SPEED

Welding speed is an important parameter in welding processes, because it affects penetration and weld width. By increasing welding speed reduces penetration and result is thinner weld. When decreasing speed increase penetration. However, extremely low speed can delay energy transfer to the parent metal and reducing penetration. It is necessary to maintain constant penetration while varying speed, it can be with the help of adjusting welding current.

GRANULAR FLUX

Granular flux plays an important role in submerged arc welding for shielding the arc and protecting weld pool. The regular melting of flux forms a protective slag on the weld pool, preventing direct contact with atmospheric gases and reduce heat loos. By the result, the high thermal efficiency about 95% for submerged arc welding.

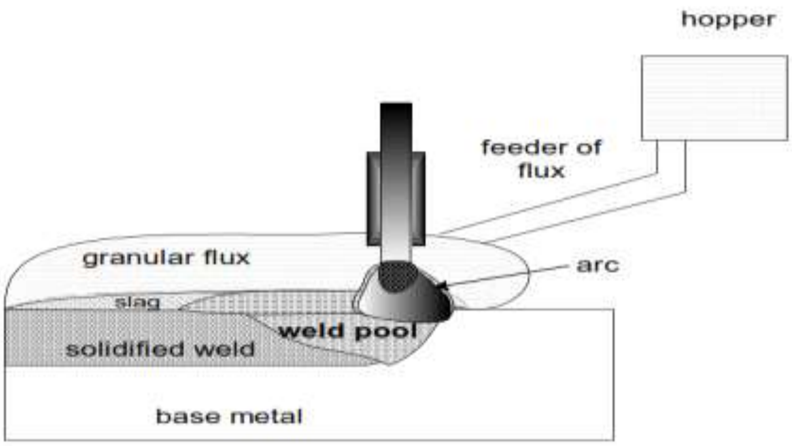

Fig-Schematic View of SAW

LITERATURE REVIEW

1. **Edwin Raja Dhas and Jenkins Hexley Dhas (2012)** this review focuses on various aspects of research topic. In this paper, process measurement in welding and process control in welding are discussed. In the process measurement there are many technique are used like, Design of Experiments, Taguchi method and FEA Simulation are discussed, and also in process control, Multiple Regression Analysis, Response surface modelling and Artificial Neural Network are discussed.[1]

2. **Harsh Sharma et al. (2020)** this review paper is focusing on submerged arc welding parameters and their effect on weld quality. It is based on analysis of 28 research papers on welding process parameters. Basically this paper focus on welding parameters, quality of weld, and future research scope.[2]

3. **Sameer Vishwakarma and Vijay kumar Dwivedi (2021)** this review paper focusing to optimize tensile strength and hardness with welding efficiency and low cost on optimization through Taguchi method and Mathematical models. It focused on improving process efficiency and reducing wastage in manufacturing.[3]

4. **Y. S. Tang et al. (2000)** used fuzzy logic in Taguchi method to optimize submerged arc welding process. It is focus on multiple performance characteristics like deposition rate and dilution. The experimental result confirm the effectiveness of the fuzzy logic approach.[4]

5. **Jin Zhang et al. (2022)** reviewed on flux design and thermodynamics in submerged arc welding. In this paper, thermodynamic principles for fluxes, Calphad technology applications, flux functions, metallurgical operations and refining processes are discussed, Welding industry needs new fluxes to meet demands in SAW quality, especially in thermodynamics, is crucial for flux development.[5]

6. **Zuhair Issa Ahmed and Ali Malik Saadoon (2015)** are focus on optimizing SAW process for ASTM A516 Grade 70 steel using Taguchi method. The study focused on ANOVA analysis for welding performance characteristics. The welding process parameters and effects on weld quality. In this process experiment result analysed using Minitab 16 software.[6]

7. **Ankush Batta et al. (2015)** used various welding processes aim for desired weld bead parameters and properties. In this paper focused on submerged arc welding process optimization and parameters. In this review covers welding processes optimizations techniques and quality assessment. In this process Taguchi method used to predicting and optimizing submerged arc welding.[7]

8. **Meenu Sharma and Dr M. I. Khan (2014)** used Grey-based Taguchi approach optimizes submerged arc welding process parameters. The significance of welding voltage in controlling penetration. Welding voltage significantly controls bead penetration compared to other parameters. [8]

9. **Sanjay Kumar Verma and Rupendra Kumar Marre (2022)** evaluate the study of optimal process parameters for submerged arc welding mild steel, weld bead geometry crucial for determining weld and strength. In this review investigates weld bead geometry and tensile strength using Taguchi method. In this experiment utilizes design of experiment with four parameters and five levels.[9]

10. **S Kumanan et al. (2007)** this paper applies Taguchi method and regression analysis for welding optimization. Taguchi's design of experiment used to determine optimal process parameters. To validates factor contributions through ANOVA technique are used and MRA builds mathematical model for predictions.[10]

11. **K. Srinivasulu Reddy et al. (2013)** used Taguchi technique to determine optimal process parameters, prediction of bead geometry and SAW process parameters using ANOVA and training various ANN models to find the best-suited modular network. The review paper focused to reduce cost by using non-traditional method for optimization.[11]

12. **Ankush Choudhary (2018)** in this paper investigated submerged arc welding parameters effects on weld bead characteristics by using Jaya algorithm for multi-objective optimization of the SAW process. In this, paper the focus on submerged arc welding of AISI 1023 steel. Aims to establish models for practical use in steel fabrication.[12]

13. **Kishor Purushottam et al. (2020)** evaluates the study discusses submerged arc welding process variables and their influence. In this investigation, the mathematical models developed using regression analysis for welding process control variables. The focus of the study is weld bead characteristics, mechanical properties and HAZ dimensions. Reduces cost of weld procedure developed by minimizing trial runs.[13]

14. **Mr. Mohit Sharma et al. (2019)** this paper focusing on process control factors and weld quality parameters in submerged arc welding, developing numerical models for various parameters. The study utilized a five-level factorial method to analyse welding voltage, wire feed rate, welding velocity and nozzle to plate distance.[14]
15. **Rudra Pratap Singh et al. (2020)** focus on submerged arc welding for optimal hardness of welds. Research uses artificial neural networks to predict optimal welding parameters. Sensitivity analysis conducted to assess input parameters impact on hardness.[15]

16. **Aman Singh and R. P. Singh et al. (2020)** Review of welding parameters affect mechanical properties in submerged arc welding. Various factors affect weld bead dimensions in submerged arc welding process, core wires increase deposition rate compared to equivalent solid wire.[16]

17. **V. Sengupta et al. (2019)** reviews physical phenomena in submerged arc welding over 100 years. In this paper explores metal transfer, arc length, chemical reactions and weld pool dynamics. In this paper,

several techniques include X-ray imaging, numerical simulation and creative experiments. Aims to bridge gaps in knowledge for further research awareness.[17]

18. **J. Deb Barma et al. (2012)** focused on optimal weld parameters using Taguchi method. Taguchi method is efficient for multi-response optimization problems. The research involves three process variables and response parameters. It considers wire feed rate, stick out and traverse speed variables. And response parameters include hardness, tensile strength, and toughness.[18]

19. **A Biswas et al. (2012)** focused on optimizing multiple bead geometry parameters in submerged arc weldment. Taguchi method's popularity in robust design but fails in multi-objective optimization. Various studies on welding process optimization using different methodologies. Taguchi method and principle component analysis are commonly used techniques.[19]

20. **P. V. Gopalkrishna et al. (2020)** this paper focus on submerged arc welding optimization using Cuckoo Algorithm. Edwin Raja and Kumanan optimized submerged arc weld parameters. Ajitanshu Vedrtnam used response surface methodology and genetic algorithm. Emphasis on improving weld bead width penetration, reinforcement, strength, and hardness.[20]
21. **Saurav Datta and Siba Sankar Mahapatra et. al. (2010)** this paper focuses on optimizing submerged arc welding process for quality improvement. Integrated approach combined desirability function, PCA, and grey-Taguchi method. Aims to solve multi-criteria optimization problems in SAW effectively. Previous works optimized SAW process parameters with one response. Taguchi method used for multi-objective optimization in various welding processes.[21]
22. **A. Sarkar et. al (2013)** AHP with Taguchi technique used to convert multiple response into one. Welding response parameters like penetration, bead width, and reinforcement determined. Taguchi method identified optimal response parameter setting within experimental domain. Confirmatory test validated parameters setting determined by AHP-based Taguchi method.[22]
23. **Y. S. Tarng el. al (2012)** Grey relational analysis simplifies optimization of multi performance characteristics. Taguchi method optimizes process parameters effectively for improved weld qualities. Multiple weld qualities in hard facing are improved simultaneously. Data pre-processing and normalization enhance analysis accuracy.[23]
24. **Saurav Datta et. al (2009)** This paper focusing on converting multiple objectives into a single objective function. Dual response approach for determining optimal process conditions. In this paper PCA-based hybrid Taguchi method efficient for multi-objective optimization. PCA eliminates responses into uncorrelated quality indices. Aims to optimize welding process for desired bead geometry parameters.[24]
25. **Saurav Datta et. al (2008)** this paper explored modeming, simulation, and process optimization in submerged arc welding. Previous studies used optimization, neural networks and regression analysis. Taguchi method coupled with Grey relational analysis for optimal parametric combination. Taguchi method provides well-balanced experimental design for optimization.[25]
26. **Sharma Umang Kumar et. al (2015)** this paper is focusing on SAW process, arc welding, and flux utilization. Taguchi method in used for process optimization and reduction in manufacturing time. Taguchi method enhances quality and reduces cost in manufacturing processes.[26]

CONCLUSION

The conclusion drawn from the data on optimization of submerged arc welding is that, it is a highly effective process with significant advantages like high production rate, automation capabilities and quality weld products. The process is suitable for wide range applications, including but welding, fillet welding, cladding and surfacing. Form the optimization welding parameters like current, speed and wire diameter the weld joints can be enhanced. Submerged arc welding offers high thermal efficiency, fast welding rate and it can work on various wire size and currents. Form the optimization techniques like Taguchi methods, the process parameters can be fine-turned to achieve the desired mechanical properties and weld bead geometry.

FUTURE SCOPE

1. Little work reported on optimization of process parameters of SAW using Taguchi technique.
2. Since, it is the least researched field, transient analysis of process parameters in submerged arc welding demands more work.

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