ISSN: 2581-3404 (Online) IF: 5.68 (SJIF)
IJIRTM, Volume-8, Issue-6, December-2024.

A Review on Optimization of Welding Process Parameters to Improve the Mechanical Strength of Weld Joints

Dinesh Kumar Vijay[1], Ashish Yadav[2]
[1]M.Tech. Scholar, Department of Mechanical Engineering, Maharana Pratap College of Technology, Gwalior, India.
[2] Assistant Professor, Department of Mechanical Engineering, Maharana Pratap College of Technology, Gwalior, India.

Abstract. Metal Inert Gas (MIG) welding, also known as Gas Metal Arc Welding (GMAW), is a versatile and widely used welding process that employs a continuous consumable wire electrode and an inert shielding gas to join metals. The process is known for its efficiency, precision, and adaptability to various materials, including steel, aluminum, and stainless steel. MIG welding is widely utilized in industries such as automotive, construction, and manufacturing due to its high-speed operation and ability to produce strong, clean welds with minimal post-weld cleanup. Its ease of automation and suitability for diverse applications make it a preferred choice for modern fabrication needs.

Keywords: **-** GMAW, Shielding, MIG, Welding Current, Welding ,Speed.

Introduction

Welding is a pivotal process in fabrication, offering speed and cost-efficiency unmatched by other methods. It finds extensive application across diverse sectors including shipbuilding, railway equipment, automotive manufacturing, boiler construction, nuclear power plants, pipeline infrastructure, aerospace, and automotive industries. Various welding techniques are available, including Tungsten Inert Gas (TIG), Metal Inert Gas (MIG), Shielded Metal Arc Welding (SMAW), Plasma Arc Welding (PAW), Flux Cored Arc Welding (FCAW), Submerged Arc Welding (SAW), Gas Metal Arc Welding (GMAW), Electro Slag Welding (ESW), and Oxyacetylene (OA) Welding.

Among these methods, TIG and MIG/MAG are widely adopted. TIG welding employs a non-consumable electrode, while MIG welding utilizes a fed wire to fuse metals. The MIG process includes an AC motor heat exchanger, a consumable electrode, and water cooling for both parent metals and fillers, serving as a temporary heat source to join materials.

Parameters like arc current, arc voltage, and welding speed significantly influence welding quality, productivity, and costs. Welding enables the permanent joining of materials, such as metals, alloys, or plastics, through heat and pressure. During welding, workpieces melt and solidify to form a durable bond. Fillers may be introduced to create a molten weld pool between workpieces, ensuring a robust connection. Challenges include rapid solidification leading to hardness changes, oxidation risks from atmospheric exposure, and the potential for weld defects like porosity The Taguchi process is a mathematical method developed by Genichi Taguchi to improve the performance and quality of products. Based on Taguchi, the main point just before the analysis was the establishment of the study. Only in this way, it is possible

to improve the quality of the process. This method can achieve the final output value and reduce the variance from the output value at a lower cost. He believes that the easiest way to improve quality is to build and build on the product. The main purpose of this method is to create a good product that is not expensive for the manufacturer. Taguchi has developed an experimental design approach to test how different parameters affect the meaning and variability of a process performance. The new layout that is easily designed by Taguchi includes the introduction of orthogonal layouts to develop guidelines that affect the path and the number at which it should be varied. Instead of tackling exploring all possible mixes as a true make-up, the real Taguchi method examines people for integration. The following will allow most of the facts needed to determine which variables are most likely to contribute to higher productivity using a low-volume trial, thus saving your time and resources. Taguchi arrangements are usually produced or tested small arrangements usually go slowly by hand; large-scale editing can be based on determination algorithms. Generally, the order can be purchased online. The setting is easily selected by the number of guidelines (variable) and the number of grades (levels).

II. Literature Review

Sudhir Kumar et al. (2023) research work, AISI 1018 steel samples are inserted into the V-butt by a combined arrangement using MIG welding. The test design is Taguchi based Orthogonal Array (L9). The effect of process parameters such as current temperatures, voltages and pre-temperature is studied and the welds are tested using X-ray radiographic examination. Weld quality is tested in terms of solid metal structures such as high strength and percentage elasticity. Process parameters are optimized using a Taguchi-based gray method.

Himanshu Yadav, et al. (2023) focuses on building performance of these frameworks to achieve the best parameter combination of targeted quality. In the fine-tuning of these parameters, the Taguchi method has emerged as the most widely accepted method by researchers for the across the globe.

Ravinder Kumar, et al. (2022) most widely studied Argon and Helium blend is preferred for improved welding quality because it does not respond to each other. Argon and Helium gases protect the welding area from the outside and help keep the arc stable due to low energy ionization. Aluminum is lightweight and is very effective in the aerospace, aviation, maritime, automotive, defense and other industries. TIG welding parameters such as current welding, flow rate and welding voltage are considered to affect the tensile strength, Hardness and Toughness of the aluminum weld joint. Welding parameters are controlled by electronic control units. The AC power supply prefers the use of aluminum as compared to DC electric power due to the melting of its aluminum melting point at lower levels.

Prakash BabuKanakavalli, et al. (2022) discussed the use of Taguchi and Gray-related analytical methods in determining the appropriate MIG Welding process criteria presented. The Taguchi method is widely used in constructing valid tests, while the gray relationship analysis assists decision-making when considering multiple approaches; this combination serves as an effective tool in determining the correct process parameters. In the current welding work current, voltage, speed, bevel angle were considered as the input parameters for combining two different metals (AISI1010 and AISI1018), as these influence the output characteristics such as tensile strength and stiffness, these parameters need to be adjusted.

Ashish Chafekar, in al. (2021) discussed the MIG semi-automatic welding machine according to the recurring L9 orthogonal array. Process parameters viz. welding voltage, wire feed rate and dynamic are important for a smart MIG welding machine that is considered flexible. Responses such as tensile

strength, hardness and thermal conductivity (HAZ) of AA6061-T6 aluminum alloy welded joints were investigated and adjusted using gray-related gray matter analysis. From this multi-purpose use, it has been found that current welding is the most important parameter followed by the supply chain level and the dynamic power of the smart welding machine under consideration.

Dharmendra et al. (2021) presented the effect of welding parameters such as current welding, welding voltage and flow rate at penetration depth and strength of the strength using the Taguchi process. Two types of oxides MgCO3 and Cr2O3 were used to test the effects of flow flow in the steel entry Fe 410 size 100 × 65 × 6 mm by GMAW with V-groove weld design combined. Cr2O3 was found to be the leading vehicle leading to high penetration. Nine Cr2O3 (L9) test runs are used based on orthogonal listing. The most important factor and the correct parameter estimates were identified using the ANOVA and S / N ratios. With the power of the tensile the dominant object was present, and then the rate of gas flow and electric power respectively. Results were obtained next to the expansion results after performing a confirmation test.

III. Methodology

Butt weld joints are arranged utilizing GTAW under changed interaction boundaries of welding as given by L9 symmetrical exhibit of Taguchi strategy under argon gas protecting. As the metal testimony rate if there should be an occurrence of gas tungsten curve welding is basically administered by welding current, gas stream rate, welding speed (welding time) and somewhat root face. In this way, these information boundaries have been thought about for the investigation and examination.

DESIGN OF EXPERIMENT (DOE) Design of Experiments, given by Ronald A. Fisher during the 1920s, is a well-built statistical technique to study the effect of numerous variables at the same time. By designing the experiments using Taguchi approach, one can fulfil the requirements of a problem and optimize the process or product design projects. Using this technique scientists, engineers and researchers can be time efficient in experimental investigations. In an experiment, DoE technique give all the possible combinations to detect the best combination. For this, various factors along with their levels are pinpointed. The main objective of a well-planned and designed experiment is to know in a process which combination of variables influencing the performance most so that one can find out the best level for that combination of those variables to get desired practical output in products. In the research papers considered for above literature review, following DoE techniques have been mostly used to study and optimize the effects of process variables in MIG welding:

a.) Taguchi Orthogonal Array
b.) Full Factorial technique
c.) Response Surface Methodology
d.) Fractional Factorial technique

Analysis of Variance ANOVA is used to learn the response of each process variable on the response parameter. Software mostly used are “MINITAB” and “Design Expert” for ANOVA and DoE. Through mathematical model the correlation between input and output.

IV. Conclusion

This study focuses on enhancing the parameters of gas tungsten arc welding to address weld distortion and depth of weld penetration as response variables. The following conclusions can be drawn for effective stainless steel plate welding using the gas tungsten arc welding process. In this literature survey have been concluded that current is as effective parameter in welding. After that welding speed and voltage can affect the welding. It is found that from the review paper study when the welding current, voltage, gas flow rate increases, the tensile strength decreases, but when welding speed increases, the tensile strength also increases. For Design of Experiments various methods are available but for more process parameters RSM is suitable for optimization

References

[1] Kumar, S., & Singh, R. (2019). Optimization of process parameters of metal inert gas welding with preheating on AISI 1018 mild steel using grey based Taguchi method. *Measurement*, *148*, 106924.

[2] Yadav, H., & Niranjan, M. S. (2019). A Review on Parametric Optimization of Aluminium Alloy 5754 for MIG Welding.

[3] Kumar, R., & Kumar, D. D. (2019). Optimization of Process Parameters on TIG Welding to Enhance Mechanical Properties of AA-6351 T6 Alloy. International Journal of Trend in Scientific Research and Development, 3, 505-509.

[4] Kanakavalli, P. B., Babu, B. N., & Sai, C. P. V. (2019). A hybrid methodology for optimizing MIG welding process parameters in joining of dissimilar metals. *Materials Today: Proceedings*.

[5] Chafekar, A., & Sapkal, S. (2020). Multi-objective Optimization of MIG Welding of Aluminum Alloy. In *Techno-Societal 2018* (pp. 523-530). Springer, Cham.

[6] Dharmendra, B. V., Kodali, S. P., & Boggarapu, N. R. (2019). Multi-objective optimization for optimum abrasive water jet machining process parameters of Inconel718 adopting the Taguchi approach. *Multidiscipline Modeling in Materials and Structures*.

[7] Shinde, P. D., & Madavi, K. R. (2018). Experimental Investigation for Parametric Optimization of Gas metal arc welding process by using Taguchi technique on mild steel Fe 410.

[8] Ghosh, N., Pal, P. K., & Nandi, G. (2018). Investigation on dissimilar welding of AISI 409 ferritic stainless steel to AISI 316L austenitic stainless steel by using grey based Taguchi method. *Advances in Materials and Processing Technologies*, *4*(3), 385-401.

[9] Khan, A., Agrawal, B. P., Siddique, A. N., & Satapathy, S. N. (2018). An Investigation on Cladding of Stainless Steel on Mild Steel using Pulse Current GMAW. *International Journal of Engineering Trends and Applications (IJETA)*, *5*(2).

[10] Rizvi, S. A., & Ali, W. (2018). Optimization of Welding Parameters and Microstructure and Fracture Mode Characterization of GMA Welding by Using Taguchi Method on SS304H Austenitic Steel. *Mechanics and Mechanical Engineering*, *22*(4), 1121-1131.

[11] Srivastava, S., & Garg, R. K. (2017). Process parameter optimization of gas metal arc welding on IS: 2062 mild steel using response surface methodology. *Journal of Manufacturing Processes*, *25*, 296-305.

[12] Ghosh, N., Pal, P. K., & Nandi, G. (2017). GMAW dissimilar welding of AISI 409 ferritic stainless steel to AISI 316L austenitic stainless steel by using AISI 308 filler wire. *Engineering science and technology, an international journal*, *20*(4), 1334-1341.

[13] Sivaraman, A., & Paulraj, S. (2017). Multi-Response Optimization of Process Parameters for MIG Welding of AA2219-T87 by Taguchi Grey Relational Analysis. *Materials Today: Proceedings*, *4*(8), 8892-8900.
[14] Anand, K. R., & Mittal, V. (2017). Parameteric Optimization Of Tig Welding On Joint Of Stainless Steel (316) & Mild Steel Using Taguchi Technique. *Int. Res. J. Eng. Technol*, 2395-56.
[15] Songsorn, K., Sriprateep, K., & Rittidech, S. (2017). Optimization of Metal Inert Gas Pulse Brazing Process on Galvanized Steel Sheets Based on Taguchi Method. *The Journal of Industrial Technology*, *13*(2), 78-95.