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"A REVIEW ON STATISTICAL APPROACH FOR WELDING PROCESS PARAMETER OPTIMIZATION"

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ABSTRACT

One of the most common techniques for welding ferrous and non-ferrous metals is the gas tungsten arc weld (GTAW) or Tungsten inert gas weld (TIG). In the gas tungsten arc welding technique, a tungsten electrode that is not consumed is used to create the welding arc. An inert gas shield is used to remove air from the welding area throughout the welding cycle, protecting the electrode, weld puddle, and surrounding heat-affected zone from oxidation. A filler pole is managed into the pool at locations where additional weld metal is required. The purpose of this literature study is to gain an understanding of the impact of TIG welding parameters, such as stiffness of welding and twisting due to welding, on responsive yield parameters through the use of improvement techniques. The most often used welding parameters include welding current, gas flow rate, root gap, and bevel angle.

Key Words: *TIG welding, Process Parameters optimization, Taguchi method, Grey Relational Analysis.*

I. INTRODUCTION

The tungsten electrodes used in the gas tungsten arc welding technology are not consumed during the welding process. A distinct filler metal is used with an inert protective gas. An appropriate power source, an argon gas chamber, a welding lamp with an association connection for current stock, a tube for safeguarding the gas supply, and a cylinder of water were all required for the gas tungsten arc welding process. The ideal weld has the same characteristics as the base metal, hence the puddle of liquid must be protected from the atmosphere. Oxygen and nitrogen in the atmosphere quickly solidify with molten metal, resulting in weak weld dabs. Argon and helium are the two most common inert gases used. In Tungsten inert gas welding, the electrode is just used to create the arc and is not used up in the final weld. When welding dissimilar metals together, a filler metal or pole is inserted into the pool to provide the additional weld metal. Common brand names for this type of welding include "Heliarc" (Linde) and "Heliwelding" (Airco).

Power Supplies: There are three basics power supplies used in TIG welding process. They are a direct current straight polarity (DCSP) power supply, the direct current reverse polarity (DCRP) power supply, & the alternating current high frequency (ACHF) modified power supply.

Filler Metal: The selection of proper filler metal is based primarily on the composition of the base metal which we are going to weld. Filler metals usually are matched as closely as possible on the base metal composition.

Shielding Gas: The choice of shielding gas can significantly affect weld quality as well as welding speed. Argon, helium and argon- helium mixtures do not react with tungsten or tungsten alloy electrodes and have no adverse effect on the quality of the weld. Argon is more widely preferred, because in addition to it being less expensive, it provides a

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softer arc, which is smooth and stable. Argon is better for welding aluminium alloy, magnesium alloy, and beryllium copper.

Electrodes: The use of non-consumable electrodes – an electrode that does not supply filler metal-constitutes the major difference between GTAW and other metal arc welding process. Tungsten, which has highest melting temp of all metals 6170º F, has proved to be the best materials for non-consumable electrodes. Three basic kinds of tungsten or tungsten alloys are used for electrode in TIG welding: pure tungsten, zirconiated tungsten & thoriated tungsten.

II. Optimization Method

These days, the Taguchi approach is one of the most effective optimization tools for boosting efficiency in R&D, allowing for the rapid, low-cost production of high-quality products. When it comes to selecting process parameters with the fewest possible tests, the Taguchi technique is one of the finest options. Thus, Taguchi Technique combines experimental design with the ideal welding settings for maximum output. The Taguchi technique may be used to determine which of several parameters has the most impact on the final product. The Taguchi method employs a unique set or design known as a "Orthogonal array" to examine all of the process's parameters with a minimal number of tests. Dr. Taguchi's S/N ratios, which are log functions of the intended output, aid in data analysis and prediction by providing objective functions for optimization. To optimize a process, the Taguchi method uses the signal-to-noise ratio to determine which parameters of control have the least impact on the S/N and the greatest impact on bringing the mean closer to the desired value. How the answer deviates from the nominal or goal value is quantified by the S/N ratio in various noise conditions. The optimal signal-to-noise ratio for your experiment will depend on its purpose. Minitab has S/N calculations for static layout.
There are three Signal-to-Noise ratio of common interest for optimization:
Smaller-The-Better:
$n = -10 \, \mathrm{Log}_{10}$ [mean of squares of measured data]
Larger-The-Better:
$n = -10 \, \mathrm{Log}_{10}$ [mean of square of the reciprocal of measured data]
Nominal-The-Best:
$n = 10 \, \mathrm{Log}_{10}$ (square of mean/variance)

Grey Relational Analysis: In Grey relational analysis, the experimental data i.e. the measured features of quality characteristics are first normalized ranging from 0 to 1.Then, the Grey relational coefficient is calculated, based on normalized experimental data, to represent the correlation between the desired and actual experimental data. Then, the Grey relational grade is determined by averaging the Grey relational coefficient corresponding to selected responses. The overall evaluation of the multiple response process is based on grey relational grade. Hence, with this approach, optimization of the complicated multiple process responses can be converted into optimization of a single grey relational grade. Optimal parametric combination is then evaluated which would result highest Grey relational grade.

III. Literature Review

Saini [1] investigate that the angular distortion is a major problem in butt weld plates. Restriction of this distortion by restraint may lead to higher residual stress. In initially angular distortion in (–ve) direction is provided to reduce the angular distortion if the magnitude of distortion is predictable. For optimizing the weld parameter control ANOVA is applied. In these paper the transverse direction of TIG, welding process was evaluated using following as main input parameter welding current, filler rod diameter, length of plate and time gap between passes. Experiment was carried out with SS 302 & MS samples of varying length, 50mm width and 6mm thick. The stainless steel and mild steel plates were prepared with V grove design and butt weld type. With single pass filler metal, the distortion is measured with dial gauge fitted to a height gauge. 70 to 100 Amps was used as a current variation. A carbon steel filler rod of 1.5 to 2.5 used as a filler metal in these cases In this L9 orthogonal array was selected for design of experiments towards the distortion optimization caused by welding. MATLAB 16 software is used to developed a source code to do optimization. Direct and interaction effect of the process parameters were analyzed & presented in graphical form. At

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the end conclusion was explain that the highest effect on angular distortion is found of diameter of electrode. The least effect on angular distortion is found of time between successive passes.

Patel [2] in these paper welding parameter were analysed to determine their significance on thin plate of 304L SS of 4mm thickness by Design of experiments with using Taguchi method designto have output response (Tensile strength & Distortion). The result get experimentally were analysed using ANOVA and significance of effects for all the tested parameters upon performance measure was determined. Experiment were carried out with work piece 304L is cut in size of 4mm thick & size 300mm x 250mm. In analysis of Experiments, observe that the root gap is most significant parameter for weld strength & current is most significant parameter for distortion. Error associated with weld strength for Stainless Steel 304L varies from .410 to .295% which is under acceptable range and the error associated with distortion for Stainless Steel 304L varies from .056 to .078%.

Sueda Ozgun [3] were carried out investigated the multi-response optimization of tungsten inert gas welding (TIG) welding process for an optimal parametric combination to yield favorable bead geometry of welded joints using the Grey relational analysis and Taguchi method. Sixteen experimental runs based on an orthogonal array of Taguchi method were performed to derive objective functions to be optimized within experiment. The objective functions have been selected in relation to parameters of TIG welding area of penetration, bead geometry; bead width, bead height, penetration, as well as tensile load and width of heat affected zone. The Taguchi approach followed by Grey relational analysis to solve the multi-response optimization problem. And also, the significance of the factors on overall quality characteristics of the weldment has also been evaluated quantitatively by the analysis of variance method (ANOVA). Optimal results have been verified through additional experiments. It shows application feasibility of the Grey relation analysis in combination with Taguchi technique for continuous improvement in product quality in manufacturing industry.
Experiments were performed on 1.2mm AISI 304 thin stainless steel plate with size (25 x 240mm). 4 factor and 4 level is used i.e L16 Orthogonal array is used. Welding parameters were taken is travel speed, current, gas flow rate, Gap distance. Result of ANOVA indicates that the welding speed 52.14% contribution is most effective parameter on the responses under the multi criteria optimization (higher tensile load, penetration area, area of penetration & lower heat affected zone, bead width, bead height). The % contribution of other parameters are gap distance 20.12%, current 15.40%, shielding gas flow rate is 9.09%.

Mukesh [4] these paper discuss the influence of different input parameters such as welding current, gas flow rate and welding speed on the mechanical properties in TIG. The output response such as microstructure, hardness, and tensile strength of weld specimens are investigated in this study. In this L9 orthogonal array is used, which consist of 3 input parameters. Analysis was done by the application of Taguchi design using Minitab 16. Austenitic stainless steel 202 grade size 100 x 50 x 6 mm with square edge butt joints were prepared in this experiments. ANOVA analysis was performed for the analysis purpose which show that the current is the most significant parameters that influenced the tensile strength and micro-hardness of the weld. The delta ferrite in matrix of austenite SS 202 Microstructure of weld metal structure shows. The highest tensile strength is 0.595 KN/mm2 is obtained at a welding current of 210 amp, gas flow rate 14 l/min and welding speed of 190 mm/s. At a welding current of 210 amp, gas flow rate 12 l/min and welding speed of 180 mm/s obtained maximum micro hardness.

Dheeraj Singh, Vedansh Chaturvedi, Jyoti Vimal [5] this research paper discuss the optimum welding parameters for Gas tungsten arc welding. Taguchi method with an L16 orthogonal array (4-level and 4-factor) based on 16 experiment run were performed. Parameters namely used is current, gas flow rate, welding speed & gun angle is taken as a process parameters. The objective function have been chosen in relation to parameter of TIG welding bead geometry i.e. area of penetration, tensile load, , bead width, bead height, and penetration for quality target. Experiment were perform on a specimen of1.2mm 304 stainless steel plate (30 x 250 mm). The paper presented the optimization of the TIG welding process of stainless steel work piece by the grey relational theory. The optimal process parameters that have been identified the best combination of process variables for S.S are current at 40 A, gas flow rate at 5 l/min, welding speed 12m/min and gun angle at a 80 ^{o}. After the predicted optimal parameter setting with the help of (ANOVA) the most significant factor also found in this case gun angle is having max % contribution.

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J.Pasupathy, V.Ravisankar [6] this paper presents the influence of welding parameters like welding speed, current on strength of low carbon steel on AA1050 materials during welding. A Taguchi method has been used to obtain the data. An analysis of variance (ANOVA), orthogonal array and S/N ratio are used to investigate the welding characteristics of dissimilar welding joint and to optimize the process parameters. Experimentally work us carried with 1mm thick low carbon steel & 2mm AA1050 aluminium alloy were used, size is (150mm width & 300mm length). In this study L9 orthogonal array is used. The experiment value that is observed from optimal welding parameters, strength is 61.37 MPa & S/N ratio is 16.45.

Mallikarjun Kallimath, G.Rajendra, S,Sathish [7] this paper discuss the TIG welding is used extensively in industry to join similar metals and dissimilar metal as requirement. It can also be used for hard facing and surfacing of metal. The main thing should be considered in the TIG welding process is the selection of the optimum combination of input variables (welding parameters) for achieving the required qualities of welding. This problem can be solved by the development of mathematical models through effective and strategic planning and the execution of experiments by Taguchi techniques and ANOVA. This paper use the Taguchi method by designing a 3-factor and 2-level orthogonal array with full replication. Experiment is carried out with specimens of AA6160 base metal with filler metal of 4043. Input parameters used is current, voltage and gas flow rate. The Gas flow rate is found to be a major contributing factor. The interactions of current and voltage greatly influences the tensile strength of the material.

S.Akella, B.Ramesh Kumar [8] this research paper discuss about the distortion is one of the major constraints in TIG welding which cannot be completely avoided irrespective of types of material & thickness of material is used. This paper discuss about the optimization welding parameter of TIG welding along with Taguchi method and ANOVA for the transverse distortion control applied to mild steel plate. In this research paper the main welding parameters is used for the transverse distortion control is welding current, root gap, gas flow rate, and welding speed & weld voltage. In this study the paper is based on 2 level and 5 factor i.e. L8 orthogonal design is selected for optimizing process parameter of TIG welding. Experiment was perform with specimen of M.S. plate of 200mm x 50mm x 3mm in size & the final sample is of size 200mm x 100mm x 3mm. The sample is V butt weld with groove angle of 60°. In this research paper the output response distortion is calculated with the help of dial gauge fitted to a height gauge. The effect of each parameter of welding contribution for distortion control for MS structure have been resulted as: root gap contribution 43%, weld current contributes 37%, weld speed 14% and the error is about 6%.

IV. CONCLUSION

According to the aforementioned research, TIG welding is one of the most important joining methods for a wide range of alloys and materials. Pipes used in the offshore oil and gas, marine, construction, aerospace, and many other sectors are joined using tungsten welding methods. To determine mechanical qualities including tensile strength, hardness, and distortion control, etc., the Taguchi optimization approach has been used in a large number of published studies.As for the design of the experiment, you can use the likes of the factorial design, grey relational analysis, taguchi technique, and the response surface approach. Academics have been observed utilizing Minitab for the aforementioned purposes. Some of the most crucial inputs for TIG welding include the root gap, welding current, bevel angle, gas flow rate, welding speed, etc. Numerous studies have employed ferrous metals (SS202, SS304, etc.) and statistical techniques (Taguchi method, S/N ratio, ANOVA, etc.) to reach a conclusion.

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