A Review on Parameters Optimization of Tungsten Inert Gas Welding using Taguchi's Design of Experiment Method

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Abstract: *Tungsten Inert Gas welding is an important component in many industrial operations. The TIG welding parameters are the most important factors for the quality, productivity and cost of welding. This paper presents the influence of welding parameters like welding current, Gas Flow on strength of Aluminum material during welding. A plan of experiments and papers are based on Taguchi's Design of Experiments technique (DOE). An Orthogonal array, signal to noise ratio and analysis of variance (ANOVA) are to investigate the welding characteristics of joint and optimize the welding parameters. Finally the conformations tests have been carried out to compare the predicted values with the experimental values to confirm its effectiveness in the analysis of strength. The main objective of industries reveal with producing better quality product at minimum cost and increase productivity. In the present paper an attempt is made to* understand the effect of TIG welding parameters such as welding current , gas flow rate ,welding speed that are influences on responsive output parameters such as hardness of welding, tensile strength of welding, by using optimization philosophy.

Keywords: Current, Gas Flow, Tungsten Inert Gas, ANOVA, DOE

1. Introduction

Welding is a joining process usually metals or alloy by causing coalescence. In which process coalescence of materials is produced by heating to recrystallization temperatures with or without use of pressure and with or without the use of filler material. Welding is used for permanent joints of metals. TIG welding is a part of welding process and it can be wildly used in modern industries for joining either similar or dissimilar materials. Tungsten inert gas (TIG) welding is also called the gas tungsten arc welding (GTAW). TIG welding advantages like joining of similar and dissimilar metals at very high quality weld, low heat affected zone, absence of slag etc. Gas tungsten arc welding wildly uses a non consumable tungsten electrode to produce the weld because it created a very high temperature to weld the metals. Weld zone is protected by a shielding gas (usually inert gas such as argon) from atmospheric air or gases and a filler material is normally used for fill the gap of metal.

The tungsten electrodes carry high currents and are more desirable because they can strike and maintain a stable arc with relative ease. The zirconia added tungsten electrode is better than pure tungsten but inferior to normal tungsten electrodes. We know that TIG welding has several advantage like joining of dissimilar metals, the absence of slag, low heat affected zone and etc. Since input parameters play a major role in determining the quality of a welded sample. So, welding parameters those are affecting the arc should be calculated and their variable conditions during the process must be known before, in order to get good or optimum results, in order to get a perfect arc, we have achieved stable parameters. We also know that the properties of the welded sample are affected by a greater number of welding parameters. Properties are Hardness, Impact force, Tensile strength etc.

2. Process Parameters

Although TIG welding gives high quality welds, proper execution of the process and control of a number of parameters is required for a successful outcome. Recent experimental works can provide insight into how process parameters influence material flow in TIG welding process. Most of the material flow occurs through the retreating side and the transport of material beings forms the welded joint. Process parameters, such as Welding speed, Gas flow rate, Welding current acting on the working material during welding and the heat input during the process, are found to exert significant effects on the material and the temperature distribution by implication these factors inevitably influence the micro structural evolution and mechanical properties of the materials being joined.

3. Existing Research Efforts

A. Ravisankar, et.al [1], evaluated the temperature distribution and residual stresses for a GTAW circumferential butt joint of AISI 304 stainless steel using numerical simulation. For evaluation of weld induced residual stresses, the analysis of heat source fitting was carried out with heat inputs ranging from 200 to 500 J/mm to arrive at optimal heat input for obtaining proper weld penetration and heat affected zone (HAZ). For this chosen heat input, the influence of different weld speeds and powers on the temperature distribution and the residual stresses is studied. The heat source analysis revealed the best choice of heat input as 300 J/mm. The residual stresses on the inner and outer surfaces, and along the radial direction were computed. Increase in temperature distribution as well as longitudinal and circumferential residual stresses was observed with the increase in weld speed and power. The

validity of the results obtained from numerical simulation is demonstrated with full scale shop floor welding experiments.

Fei Liu, et.al [2], Gas tungsten arc butt welding of Mg– Al filling with Zn filler metal without and with Al foils in different thicknesses was carried out. Additional Al element was introduced into the fusion zone to accurately adapt microstructure and composition of the welding seam. Microstructures and mechanical properties of the welded joints were examined. Results show that the addition of appropriate quantity of Al element increases the substance of Al-based solid solution in the fusion zone near the Mg base metal. The solid solution can remove the stress concentration and hinder crack propagation, so the tensile strengths of the joints are improved. However, the flattering quantity of Al element will lead to the formation of partially Al-rich zones and deteriorate the mechanical property of the joints

T. Senthil Kumar, et.al [3], describes the influence of pulsed current TIG welding parameters on tensile properties of AA 6061 aluminium alloy weldments. . In the case of single pass TIG welding of thinner section of this alloy, the pulsed current has been found beneficial due to its advantages over the conventional continuous current process. The use of pulsed current parameters has been found to improve the mechanical properties of the welds compared to those of continuous current welds of this alloy due to grain refinement occurring in the fusion zone.

M. Balasubramanian, et.al [4], created scientific models to anticipate grain size and hardness of argon tungsten beat current bend welded titanium composite weldments. Four elements, five level, focal composite, rotatable outline grid is utilized to improve the required number of investigations. The numerical models were created by reaction surface technique (RSM). The sufficiency of the models was checked by ANOVA system. By utilizing the created scientific models, grain size and hardness of the joints can be anticipated with 99% certainty level.

S. Mishra, et.al [5], report an experimental and modeling investigation of gas tungsten arc butt welding of stainless steel plates containing different sulfur concentrations. The main variables studied were sulfur concentrations in the two plates, welding current and welding speed. The results show significant shift of the fusion zone toward the low sulfur steel.

A.Kumar, et.al [6], depicted the change of mechanical properties of AA 5456 Aluminum amalgam welds through beat tungsten idle gas (TIG) welding procedure. Taguchi strategy was utilized to streamline the beat TIG welding procedure parameters of AA 5456 Aluminum composite welds for expanding the mechanical properties. Examination of change was utilized to check the ampleness of the created models. Microstructures of the considerable number of welds were concentrated on and corresponded with the mechanical properties.

D.S. Nagesh, et.al [7], clarified an incorporated strategy with another methodology utilizing test outline lattice of test plans system on the exploratory information accessible from ordinary experimentation, use of neural system for foreseeing the weld globule geometric descriptors and utilization of hereditary calculation for advancement of procedure parameters. An endeavor has been made to foresee the dot shape parameters utilizing backengendering neural system. To improve the procedure parameters for the fancied front tallness to front width proportion and back stature to back width proportion, hereditary algorithmic methodology has been connected.

Cristiene Vasconcelos Gonçalves, et.al [8], describes a technique used to estimate the heat flux is based on solution of an inverse three-dimensional transient heat conduction model with moving heat sources. The thermal fields at any region of the plate or at any instant are determined from the estimation of the heat rate delivered to the workpiece. The direct problem is solved by an implicit finite difference method. The system of linear algebraic equations is solved by Successive Over Relaxation method (SOR) and the inverse problem is solved using the Golden Section technique. The golden section technique minimizes an error square function based on the difference of theoretical and experimental temperature. The temperature measurements are obtained using thermocouples at accessible regions of the workpiece surface while the theoretical temperatures.

Palani.P.K, Saju.M et.al [9] researched the effect of TIG welding process parameters on welding of Aluminium-65032. Response Surface Methodology was used to conduct the experiments. The parameters selected for controlling the process are welding speed, current and gas flow rate. Strength of welded joints were tested by a UTM.

G.Haragopal, P.V.R.Ravindra reddy et.al [10] researched Taguchi method to study the effect of gas pressure, current, groove angle and preheat on MIG welding of Aluminium alloy (Al- 65032). They indicated that welding current has more effect ultimate tensile strength whereas gas pressure is the most significant parameter for proof stress, elongation and impact energy.

G.Padmanaban V.Balasubramanian et.al [11] researched the effect of optimization of pulsed current gas tungsten arc welding process parameters on tensile strength in AZ31B magnesium alloy. Result showed that maximum tensile strength of 188Mpa was obtained under the welding condition of peak current of 210 A, base current of 80A, pulse frequency of 6 Hz and pulse on time of 50%.

R.Satish, B.Naveen et.al [12] researched the weldability and process parameter optimization of dissimilar pipe joints using GTAW. Taguchi method was used to formulate the experimental layout to rank the welding input parameters which affects quality of weld. Results showed that lower heat input resulted in lower tensile strength and too high heat input also resulted in reduced tensile strength.

Joshi J, Thakkar M, et.al [13] researched the weldability and process parameter optimization of Aluminum using TIG. Taguchi method was used to formulate the experimental layout to rank the welding input parameters which affects quality of weld. Results showed that lower Ampere resulted

in lower tensile strength and results were investigated for metal Inert gas welding.

4. Conclusion

In the present works, various optimization techniques used for TIG process parameters are studied and effects of these parameters on the output parameters have been reviewed. The aim of this work is to study the output of various conventional and nonconventional optimization techniques on TIG welding process so as to allow choose the most suitable approach for a particular application. The summary of research work performed shows that conventional techniques like Taguchi , ANOVA, RSM and nonconventional techniques like ANN, GA, simulated annealing are successfully used in optimization of TIG process parameters for Stainless steel, carbon steel, magnesium alloy, Aluminum alloy, Titanium Alloy etc. The above observations can be utilized as a guideline document for further research in carrying out optimization of TIG welding parameters. It is conclude that the welding current is most significant parameter for TIG welding. Welding current is found to have effect on most of desired output parameter. As well as the Gas flow of shielding Gas is not so effective on output parameter.

References

[1] A. Ravisankar, Satish Kumar Velaga, Gaurav Rajput, S. Venugopal, 2014, "Influence of welding speed and power on residual stress during gas tungsten arc welding (GTAW) of thin sections with constant heat input: A study using numerical simulation and experimental validation", Journal of Manufacturing Processes, Volume 16, Issue 2, April 2014, Pages 200-211

[2] Fei Liu, Daxin Ren, Liming Liu, 2013, " Effect of Al foils interlayer on microstructures and mechanical properties of Mg–Al butt joints welded by gas tungsten arc welding filling with Zn filler metal", Materials & Design, Volume 46, April 2013, Pages 419-425

[3] T. Senthil Kumar, V. Balasubramanian, M.Y. Sanavullah, 2007, "Influences of pulsed current tungsten inert gas welding parameters on the tensile properties of AA 6061 aluminium alloy", Materials & Design, Volume 28, Issue 7, 2007, Pages 2080-2092

[4] M.Balasubramanian, V. Jayabalan, V. Balasubramanian, 2008, "Developing mathematical models to predict grain size and hardness of argon tungsten pulse current arc welded titanium alloy", Journal of Materials Processing Technology, Volume 196, Issues 1–3, 21 January 2008, Pages 222-229

[5] S. Mishra, T.J. Lienert, M.Q. Johnson, T. DebRoy, 2008, „An experimental and theoretical study of gas tungsten arc welding of stainless steel plates with different sulfur concentrations", Acta Materialia, Volume 56, Issue 9, May 2008, Pages 2133-2146

[6] A. Kumar, S. Sundarrajan, 2009, "Optimization of pulsed TIG welding process parameters on mechanical properties of AA 5456 Aluminium alloy weldments",

Materials & Design, Volume 30, Issue 4, April 2009, Pages 1288-1297

[7] D.S. Nagesh, G.L. Datta, 2010, "Genetic algorithm for optimization of welding variables for height to width ratio and application of ANN for prediction of bead geometry for TIG welding process", Applied Soft Computing, Volume 10, Issue 3, June 2010, Pages 897-907

[8] Cristiene Vasconcelos Gonçalves, Solidonio Rodrigues Carvalho, Gilmar Guimarães,2010, "Application of optimization techniques and the enthalpy method to solve a 3D-inverse problem during a TIG welding process", Applied Thermal Engineering, Volume 30, Issue 16, November 2010, Pages 2396-2402

[9] Palani.P.K, Saju.M "Modeling And Optimization Of Process Parameters For Tig Welding Of Aluminium-65032 Using Response Surface Methodology" .2248-9622,Volume-3,Issue 2, 2013.

[10] G.Hargopal, P.V.R.Ravindra reddy, "Parameter design for MIG welding of Al- 65032 alloy using Taguchi technique", 0975-1084, Volume-70, 2011

[11] G.Padmanaban, V.Balasubramanian, "Optimization of pulsed current gas tungsten arc welding process parameters to attain maximum tensile strength in AZ31B magnesium alloy", Trans.Non ferrous Met.soc.china 21, 2011.

[12] R.Satish, B.Naveen, "Weldability and process parameter optimization of dissimilar pipe joints using GTAW".2525-2530, Volume-2, 2012.

[13] Joshi J, Thakkar M, Vora S. Parametric Optimization of Metal Inert Gas Welding and Tungsten Inert Gas Welding By Using Analysis of Variance and Grey Relational Analysis. Work.;240(8):77-48.

[14] KARTHIKEYAN M, NAIKAN VN, NARAYAN R, SUDHAKAR D. Orbital TIG Welding Process Parameter Optimization using Design of Experiment for Satellite Application. International Journal of Performability Engineering. 2016 Mar 1;12(2).

[15] Patel CN, Chaudhary PS. Parametric Optimization of Weld Strength of Metal Inert Gas Welding and Tungsten Inert Gas Welding By Using Analysis of Variance and Grey Relational Analysis. International Journal of Research in Modern Engineering and Emerging Technology. 2013 Apr;1(3).

[16] Prajapati NK, Patel SM. Optimization of Process Parameters for Surface Roughness and Material Removal Rate for SS 316 on CNC Turning Machine. International Journal of Research in Modern Engineering and Emerging Technology. 2013;1(3):40-7.

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