ISSN: 2455-1600

OPTIMISATION OF GAS TUNGSTEN ARC WELDING ON STEEL –A REVIEW

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Abstract

Modernisation of GTAW process is going on day by day and it produces perfect, precise welds. TIG is the preferrable choice in most of the intricate works, where shape of each and every weld joint counts.Stainless steel 347 has slightly improved corrosion resistance over type 321 stainless steel in strongly oxidizing environments.Type 347 should be considered for applications requiring intermittent heating between427c to 899c, or for welding under conditions which prevent a post weld anneal.It has application in Aircraft collector rings; Aircraft exhaust stacks; Boiler casings In this paper work related to optimisation of TIG welding parameters of various researchers using optimisation methods like analysis of variance (ANOVA) ,Response surface methodology (RSM) etc. have been reviewed and categorised under three categories i.e optimisation on TIG welding,optimisation on steel and optimisation on RSM. Process parameters namely arc voltage, current and shielding gas flow rate is optimized using various optimisation method After applying RSM simultanious effect of welding parameters on tensile strength and hardness will be parameters to achieve desired mechanical properties was evaluated. It is found that at lower welding speeds strength is more due to more intensity of current. and With the increase in current, tensile strength of the weld joint increases.

Keywords: Gas Tun tungsten arc welding(GTAW); tensile strength, RSM method

1.Introduction

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenous welds, do not

ISSN: 2455-1600

require it. A constant-current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapors known as a plasma.

Stainless steel 347 has slightly improved corrosion resistance over type 321 stainless steel in strongly oxidizing environments.Alloy 347 is a columbium/tantalum stabillized austenitic chromium-nickel stainless steel. Alloy 347 has a slightly improved corrision resistance over other alloyes of stainless steels in strongly oxidizing environments as a result of addition of columbium and tantalum. Columbium- tantalum carbides precipitate within the grain boundaries. The most commonly used welding process is gas tungsten arc welding(GTAW). The quality and performance of welded parts highly depends upon welding parameters. Thus many researchers have focused on the optimization of welding process parameters to obtain favorable mechanical properties. Using RSM, it is possible to evaluate simultaneous effects of many parameters on weld mechanical properties and to optimized them to achieve suitable result. Although some researchers have already applied DOE to optimize welding parameters, but no effort is yet made to perform this optimization on gas tungsten arc welding of stainless steel grade 347. using RSM. This study is focused on the RSM optimization of some crucial welding parameters namely welding current, voltage and shielding gas flow rate to achieve most favourable results mechanical properties.

2.Optimisation methods

Optimization is defined as the process of finding the conditions that give the minimum or maximum value of a function, where the function represents the effort required or the desired benefit. We prefer RSM method over taguchi method because RSM involves more experimentation, however it can take you closer to global optimum.

Response surface methodology (RSM) is a collection of mathematical and statistical techniques for empirical model building. By careful design of experiments, the objective is to optimize a response (output variable) which is influenced by several independent variables (input variables). An experiment is a series of tests, called runs, in which changes are made in the input variables in order to identify the reasons for changes in the output response. Originally, RSM was developed to model experimental responses (Box and Draper, 1987), and then migrated into the modelling of numerical experiments. The difference is in the type of error generated by the response.

Response surface methodology uses statistical models, and therefore practitioners need to be aware that even the best statistical model is an approximation to reality. In practice, both the models and the parameter values are unknown, and subject to uncertainty on top of ignorance. Of course, an estimated optimum point need not be optimum in reality, because of the errors of the estimates and of the inadequacies of the model.

ISSN: 2455-1600

Nonetheless, response surface methodology has an effective track-record of helping researchers improve products and services: For example, Box's original response-surface modeling enabled chemical engineers to improve a process that had been stuck at a saddle-point for years. The engineers had not been able to afford to fit a cubic three-level design to estimate a quadratic model, and their biased linear-models estimated the gradient to be zero. Box's design reduced the costs of experimentation so that a quadratic model could be fit, which led to a (long-sought) ascent direction

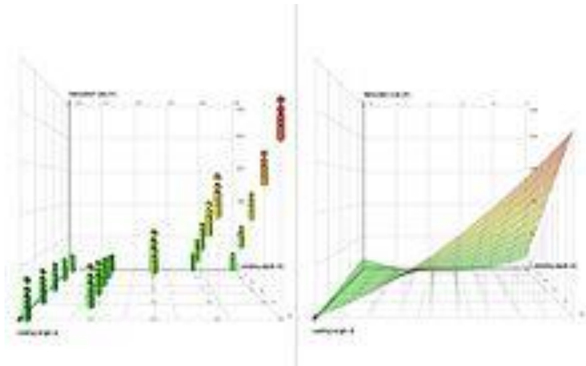

Fig Designed experiments with full factorial design (left), response surface with second-degree polynomial (right)

3.LITERATURE REVIEW

SHEN JUN et al. did work on effects of welding current on properties of A-TIG welded AZ31 magnesium alloy joints with TiO2 coating. The effects of welding current on the macro-morphology, microstructure and mechanical properties of tungsten inert gas(TIG) welded AZ31 magnesium alloy joints with TiO2 coating were investigated. The results showed that the increase of welding current led to the increase in the depth/width ratio and deteriorated the surface appearance of the welded seams with TiO2 coating. When the welding current was less than 130 A, the ultimate tensile strength of the welded joints with TiO2 coating increased with the increase in welding current and then decreased when the welding current was greater than 130 A.

Srirangan kumar Arun et al. did work on multi-response optimization of process parameters for TIG welding of Incoloy 800HT by Taguchi grey relational analysis. The experiments were conducted according to L9 orthogonal array. The input parameter chosen were the welding current, Voltage and welding speed. The output response for quality targets chosen were the ultimate tensile strength and yield strength (at room temperature, 750 °C) and impact toughness. Grey relational analysis was applied to optimize the input parameters simultaneously considering multiple output variables. The optimal parameters combination was determined as A2B1C2 i.e. welding current at 110 A, voltage at 10 V and welding speed at 1.5 mm/s. ANOVA method was used to assess the significance of factors on the overall quality of the weldment

Kannan S. et al. did work on an investigation on compression strength analysis of commercial aluminium tube to aluminium 2025 tube plate by using TIG welding process. Taguchi L25 orthogonal array was used to identify the most influencing process parameter which affects the joint strength. The micro structural study was depicted the welding joints characterization in between tube to tube plate joints. The radiograph test was conducted to prove the welds are non-defective and no flaws are found during the welding process. The mechanical property of compression strength and hardness has been measured to obtain the optimal joint strength of the welded sample was about 174.846 MPa and 131.364 Hv respectively.

Zhangalloy Liang et al. did work on Comparison of microstructure and mechanical properties of TIG and laser welding joints of a new Al–Zn–Mg–Cu. Results show that the width of the fusion zone (FZ) and heat affected zone (HAZ) in laser joint is obviously smaller. The FZs in TIG and laser joints are both made up of dendritic equiaxed grains and lots of coarse particles, the mean grain size is 33.9 μm and 6.1 μm respectively, and the coarse particles are identified as the T (Al Zn Mg Cu) phase. The two factors of grain size and alloying elements distribution are combined to result in almost the same micro hardness of the two FZs. Moreover, the grain morphology, grain size and degree of recrystallization of the two HAZs are almost the same with base metal (BM).

Costa Josiane Dantas et al. did work on obtaining and characterization of Ni-Ti/Ti-Mo joints welded by TIG process. It was observed that the short time and lower heat treatment temperature favors the formation of Ni4Ti3 precipitate, which is responsible for the formation of stable passivation film. The longer the time and temperature of heat treatment more the decrease in the corrosion resistance and increase in the fragility of the obtained joints, and consequently the amount of the precipitated Ni4Ti3.

Buddu kumar Ramesh did work on mechanical properties and microstructural investigations of TIGwelded 40 mm and 60 mm thick SS 316L samples for fusion reactorvacuum vessel applications. The present paper reported characterization of welding joints of SS316L plates with higher thicknesses like 40 mm and 60 mm, prepared using multi-pass Tungsten Inert Gas (TIG) welding process. The weld quality has been evaluated with non-destructive tests by X-ray radiography and ultrasonic methods. The mechanical properties like tensile, bend tests, Vickers hardness and impact fracture tests have been carried out for the weld samples. Tensile property test results indicate sound weld joints with efficiencies over 100%. Hardening was observed in the weld zone in non-uniform manner. Macro and microstructure studies have been carried out

ISSN: 2455-1600

for Base Metal (BM), Heat Affected Zone (HAZ) and WeldZone (WZ). Scanning Electron Microscopy (SEM) analysis carried out for the impact fractured specimens show ductile fracture.

Tsai Te-Chang did work on modeling and analyzing the effects of heat treatment on the characteristics of magnesium alloy joint welded by the tungsten-arc inert gas welding.The objective of the paper was to present the mathematical models for modeling and analysis of the effects of heat treatment on the characteristics of magnesium alloy joint welded by the tungsten-arc inert gas (TIG) welding. The process of heat treatment adopts the tempering process with varying processing parameters, including tempering temperature and tempering time. The microstructure and mechanical properties of the welded joint were considered in the characteristic evaluation and explored by experiment.

Sathish R. et al did work on 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 the quality of the weld and is influenced by the parameters like gas flow rate followed by current and bevel angle. The conclusions derived from the project was that Variation in heat input resulted in significant changes in the mechanical properties of the weld.Results showed that lower heat input resulted in lower tensile strength and too high heat input also resulted in reduced tensile strength.

Rose Razal et al did work on Optimization of pulsed current tungsten inert gas welding parameters to attain maximum tensile strength in AZ61A magnesium alloy. A maximum tensile strength of 199.5MPa was exhibited by the PCTIG welded AZ61A magnesium alloy joints with the optimum welding parameters of peak current 165.6A, a base current of 83A ,pulsed frequency of 6.24hz and pulsed on time of 46.2

Malik Deepak did work on Effect of Process Parameters on Angular Distortion of Gas Tungsten Arc Welded SS 302 and MS Plate. ANOVA is applied for the optimization of weld parameters control..The conclusions derived from the investigation was that angular distortion had positive effect with increase in length of plates and diameter of electrode and angular distortion had negative effect with increase in current and time gap between passes. Within the design range of parameters, the highest effect on angular distortion was found of diameter of the electrode. Within the design range of parameters, the least effect on angular distortion was found of time between successive passes.

kumar Rajeev et al studied influence of welding current on bead shape, mechanical and structural property of tungsten inert gas welded stainless steel plate. The weld width and depth of weld penetration were found optimum at the welding current of 100 A. Both the weld width and depth of penetration was also found optimum at the welding speed of 90 mm/min. The micro hardness near to the top of the weld bead surface is high and was gradually decreases towards center of the fusion/weld zone. But it was minimum for the welding current of 100 A in comparisons with welding current of 80 A and 120 A.

ISSN: 2455-1600

SUDHAKARAN R. et al did work on optimization of process parameters to minimize angular distortion in gas tungsten arc welded stainless steel 202 grade plates using partical swarm optimization .The experiments were conducted using design of experiments technique with five factor five level central composite rotatable design with full replication technique. A mathematical model was developed correlating the process parameters with angular distortion. A source code was developed in MATLAB 7.6 to do the optimization. The optimal process parameters gave a value of 0.0305° for angular distortion which demonstrates the accuracy of the model developed. The results indicate that the optimized values for the process parameters are capable of producing weld with minimum distortion.

Simhachalam D. et al did work on experimental Evaluation of Mechanical Properties of Stainless Steel by TIG Welding at Weld Zone.In the work, it was observed that by keeping constant gas flow rate and welding current and by varying the filler rod diameter in increasing order the depth of penetration and impact strength decreases.

Liang Qin. Guo et al did work on high speed tandem gas tungsten arc welding process of thin stainless steel plate. A high speed tandem gas tungsten arc welding process involving an assistant arc following the main arc to suppress the formation of undercut and humping defects is proposed. The influences of assistant electrode parameters and welding current combinations on weld appearance were studied through statistical design-of-experiment. The welding speed of 1.5 mm thick 409 L stainless steel plate was increased to3 m/min without sacrificing weld appearance quality. Good mechanical properties and a fine microstructure of welded joint were obtained compared with the single arc weld at the equivalent heat input.

Qiang Zhung et al did work on microstructure and mechanical properties in TIG welding of CLAM steel.Tungsten insert gas (TIG) welding on China low activation martensitic (CLAM) steel under identical conditions was performed. Micro hardness test, tensile test, Charpy impact test and microstructure measurements were carried out on TIG welded joints after post weld heat-treatment. Hardening at WM and softening in HAZ is detected in the TIG weld joint. Micro hardness in WM decreased when the temperature of PWHT increased. The ultimate tensile stress of weld metal is higher than that of HAZ and BM.

Sathiya P. et al did work on optimization of laser welding process parameters for super austenitic stainless steel using artificial neural networks and genetic algorithm.

Full factorial design was used to carry out the experimental design. Artificial neural networks (ANNs) program was developed in Mat Lab software to establish the relationship between the laser welding input parameters like beam power, travel speed and focal position and the three responses DP, BW and TS in three different shielding gases (argon, helium and nitrogen). The established models were used for optimizing the process parameters using genetic algorithm (GA). Optimum solutions for the three different gases and their respective responses were obtained. Confirmation experiment has also been conducted to validate the optimized parameters obtained from GA.

kumar R et al did work on application of response surface methodology to optimize process parameters in friction welding of Ti−6Al−4V and SS304L rods.

A method to decide near optimal settings of the process parameters in friction welding was proposed. The success of the friction welding process is based on various input parameters like friction pressure, friction time, upset pressure and upset time and output parameters like tensile strength, hardness and material loss. Ti−6Al−4V and SS 304L (SS) materials were joined by friction welding process using interlayer techniques. The Box−Behnken design and response surface methodology (RSM) were applied to deciding the number of experiments to be performed and identify the optimum process parameters for obtaining better joint strength.

Bharatha P. et al did work on optimization of 316 stainless steel weld joint characteristics using taguchi technique. It has been observed that current, speed, root gap has some influence on the tensile strength and the bending strength of the material. Based on Analysis of variance (ANOVA) it is found that welding speed (46.51% contribution) has greater influence on bend strength and current (96.75%) has highest influence on tensile strength. Further it has found that root gaps has some influence on both tensile and bend strengths. Micro structure study shows some inclusions near the heat affected zone due to change in weld material and also change in grain sizes that are developed during welding process.

Mourads A.H. et al did work on Gas tungsten arc and laser beam welding processes effects on duplex stainless steel 2205 properties.

The results achieved in the investigation disclosed that welding process play an important role in obtaining satisfactory weld properties. In comparison with GTAW, LBW had produced welded joint with a significant decrease in FZ size and acceptable weld profile. The ferrite–austenite balance of both weld metal WM and heat affected zone (HAZ) were influenced by heat input which was a function of welding process. In comparison with LBW, GTAW had resulted in ferrite–austenite balance close to that of base metal BM due to higher heat input in GTAW.

Rao V Anand et al did work on experimental Investigation for Welding Aspects of Stainless Steel 310 for the Process of TIG Welding .The parameters like current, filler materials, welding speed were the variables in the study. The mechanical properties and microstructure of 310 austenitic stainless steel welds were investigated, by using stainless steel filler material of different grades. Higher tensile strength was achieved with a current 120A and 309L filler rod and also the weld has fewer defects. Experiments were carried out with accuracy in order to keep the error minimum and determine the results appropriately.

Patil Mukundraj V et al did work on multi response simulation and optimization of gas tungsten arc welding . The key objective of the paper was to find the values of input and process variables responsible to yield the typical tensile strength and hardness.

kumar A. et al did work on optimization of pulsed TIG welding process parameters on mechanical properties of AA 5456 Aluminum alloy weldments. The influence of pulsed welding parameters such as peak current, base current, welding speed, and frequency on mechanical properties such as ultimate tensile strength (UTS), yield strength, percent elongation and

ISSN: 2455-1600

hardness of AA 5456 Aluminum alloy weldments have been studied and the following conclusions were obtained. The same optimum combination (i.e. P2B1S2F2) was observed in all the mechanical properties of welds.

Afshar M Reza et al did work on Optimization of tungsten leaching from low manganese wolframite concentrate using response surface methodology (RSM).In the study the effect of temperature , time and Na2Co3 weight ratio on optimization of tungsten leaching from low manganese wolframite concentrate was investigated using RSM. The optimal conditions for tungsten leaching process were identified to be temperature range of 202-208c,3-3.7 hours and 3.68-4.27 Na2Co3/Wo3 weight ratio which resulted in tungsten leaching efficiency of 96.57%.

Kiaee N. et al did work on Optimization of gas tungsten arc welding process by response surface methodology.Gas tungsten arc welding is widely used for connecting of boiler parts made of A516-Gr70 carbon steel. In the study important process parameters namely current, welding speed and shielding gas flow rate were optimized using response surface methodology (RSM). The simultaneous effects of these parameters on tensile strength and hardness were also evaluated. Desired tensile strength and hardness were achieved at optimum current of 130 A, welding speed of 9.4 cm/min and gas flow rate of 15.1 l/min.

Sudhakaran R et al did work on effect of Process Parameters on Depth of Penetration in Gas Tungsten Arc Welded (GTAW) 202 Grade Stainless Steel Plates Using Response Surface Methodology.

The maximum depth of penetration obtained from experimental studies was 1.77 mm when the process parameters such as welding current was maintained at 110 amps and welding speed, shielding gas flow rate and welding gun angle were maintained at 190 mm/min, 15 liter/min and 70° respectively. The minimum depth of penetration obtained from experimental studies was 0.33 mm when the process parameters such as welding current, welding speed, shielding gas flow rate, and welding gun angle were maintained at 80 amps, 200 mm/minute, 10 liter/min and 80°, respectively. Out of the four process parameters selected for investigation, welding current has the strongest effect on depth of penetration. Welding speed had negative effect on depth of penetration, and shielding gas flow rate has no significant effect on depth of penetration. The mathematical model developed in this work from the experimental data can be employed to control the process parameters and achieve the desired weld quality in butt welded plates.

4.Summary

This paper shows the efficient use efficient use of optimisation methods l(ike Response Surface Methodology,ANOVA,Finite Element Method etc) in order to optimise GTAW welding parameters like arc voltage, current and shielding gas flow rate.Based on the discussion made above it is very clear that current, speed, root gap has some influence on the tensile strength and the bendin hardness of the material. It is found that at lower welding speeds strength is more due

ISSN: 2455-1600

to more intensity of current. and With the increase in current, tensile strength of the weld joint increases.

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