TIG WELDING PROCESS PARAMETERS OPTIMIZATION FOR STAINLESS STEEL MATERIALS USING REGRESSION ANALYSIS

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ABSTRACT:

In today's manufacturing market, mainly quality and productivity play a significant role. Every manufacturing firm aims at producing a larger number of units within a short time. The experiments have been planned using the design of experiments and followed by regression analysis. The welding parameters used are Weld Current (I amps), Gas flow rate (FR L/min), and Root Gap (G mm). The effect of welding parameters, distortion (mm), and tensile strength (N/mm^2) can be calculate, and the optimum welding condition can be determined to mitigate distortion and tensile strength. An L4 orthogonal array was taken for an experimental layout to analyze each parameter's effect on the welding characteristics and predict each weld parameter's optimal choice, such as weld current, Gas flow rate, and root gap. The impact of this parameter in Distortion (D) and Tensile Strength (TS) is analyzed. Optimization of welding parameters is valuable in terms of providing high precision and efficient welding for massive structures. Optimization of welding parameters is essential for a manufacturing unit to respond effectively to fierce competitiveness and increasing demand for quality products in the market. In the welding process, the optimization of weld process parameters is considered a vital tool for improving the output quality and reducing the overall production time.

Keywords*:* *Universal testing machine, TIG welding, Annova, etc.*

1. INTRODUCTION

Welding is the powerful metal joining techniques used in the industrial sector. Even after evaluating several modern manufacturing techniques, welding still

plays a vital role on the shop floor.GTAW is flexible and can be used in both welding positions on ferrous and nonferrous metals and, depending on the base metal. The technique may be used with or without filler metal to weld thin or dense materials. Filler metals are not used for welding thinner materials, edge joints, and flanges. For thicker fabrics, an externally fed filler wire is generally used. The type of filler metal wire used is based on the chemical analysis of the base metal. The filler metal wire size depends on the base metal's thickness, Which typically determines the current of welding. The process methods can be manual or automatic for GTAW. Which typically determines the current of welding. The process methods can be manual or automatic for GTAW.

2. LITERATURE REVIEW

DS. Nagesh, G.L. Datta. et.al.., Presents welding procedure variables that control the welding process and the quality of the welds produced. The joint configuration is determined by the weldment design, the metallurgical analysis, and the process and procedure required by the weldment[1].J.Tusek, M. Suban, et al. studied the influence of the chemical composition of flux and microstructure and tensile properties of welding joint. The metallurgical advantage of pulsed current welding is frequently reported in the literature. Parameters like weld current, Arc length, and root gap may affect the weld bead geometry, heat-affected zone, and mechanical properties of weldment [2]. Mohandas T, Madhusudhana .et. al. describes the area of Gas Tungsten Arc Welding indicates the necessity of systematic investigation of the process parameters on Bead Width, Bead Height, Heat Input, Transverse Shrinkage, Area of Penetration, and Tensile Strength[3]. Few reachers like T Mohandas, G Madhusudhan Reddy, Mohammad Naveed .et.al.,.He worked on the optimization of weld bead geometry on the Tig welding process. But very few investigations were carried at optimizing the process parameter of SMAW[4]. User Esme, Melih Bayramoglu, Yugut Kazancoglu, Sueda Ozgun, .et.al. presents that the Taguchi method is a powerful statistical tool that yields optimized parameter values

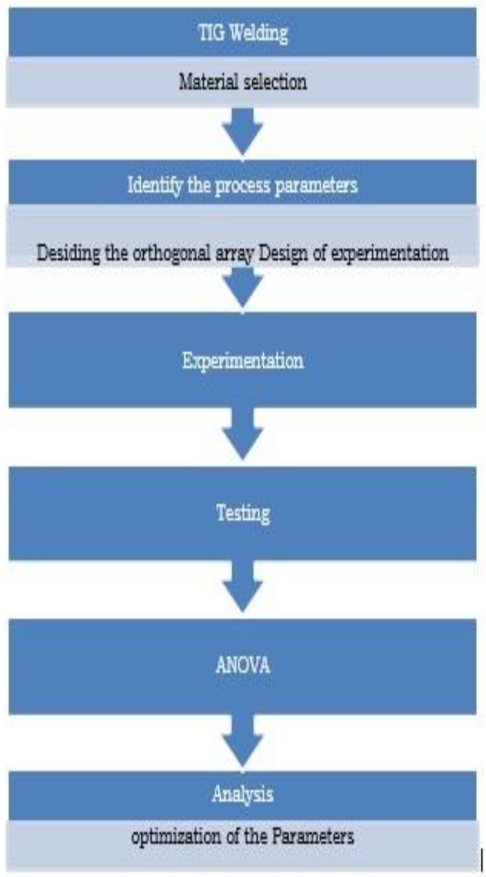
For features of the design response. Using Orthogonal array coupled with Meticulous experimental design a standard or S/N analysis of results using Taguchi techniques gives optimum parameters with the minimum amount of experimentation [5]. The purpose of regression testing is to ensure that changes such as those mentioned above have not introduced new faults. One of the main reasons for regression testing is to determine whether a change in one part of the software affects other software parts. Standard regression testing methods include re-running previously completed tests and checking whether program behavior has changed and whether fixed faults have re-emerged. Regression testing can be performed to test a system efficiently by systematically selecting the appropriate minimum set of tests needed to cover a particular adequately. Therefore, in most software development situations, it is considered good coding practice. When a bug is located and fixed, record a test that exposes the bug and re-run that test regularly after subsequent changes to the program

2.1.DEFINITION OF PROBLEM

In this investigation, an attempt was made to determine the optimum process parameters TIG on SS316L plates. Process parameters considered are weld current, gas flow rate, and root gap. Each process parameter is assessed at two levels (with one trial on each specimen). Trails are

conducted, and the response characteristics are studied for distortion and tensile strength.

2.2.EXPERIMENTAL PLAN



3. EXPERIMENTAL WORK

3.1.WORKPIECE MATERIAL

AISI type 316l stainless steel is used in the current experiment, with many advantages such as low thermal conductivity, high corrosion resistance, and improved stability at elevated temperatures, and is also used in various industries, including electronics, medical equipment, home appliances, automotive, and advanced tube industry. It has excellent characteristics for shaping and welding

Tensile strength	Yield strength	Density
515 Mpa	290 Mpa	7.99 g/cm^3
Melting point	Thermal conductivity	% Elongation
1400-1450^{o}c	21.4 W/m^o K at 500^{o}c	20

Table-3.1 Properties of AISI 316l Steel

3.2. EXPERIMENTAL SET-UP

When selecting **a** TIG welding machine, you should know how much power and sophistication are needed for the job. It is also necessary to ascertain the volume of such jobs currently on hand and the projected business for TIG welding**.** The next question is - does one need an AC or DC power source. Professionals say that aluminum and magnesium are two metals that are best welded using the AC output from the power source. Steels and stainless steels are most often fused with DC output. To weld a variety of metals, use a combination AC/DC machine. If the power source is either moved around the shop or taken from one site to another, then a portable welder is needed. There are two basic ways to accomplish portability - inverters and engine-driven welders. Inverters are now available that weigh around 13 kg and come with handles for easy shifting around.

Figure 3.1: Tig Welding Experimental Set Up

TIG welding is mostly used for different welding kinds of alloys of aluminum and stainless steel, where quality is of importance. TIG welding is mainly used in aeronautical constructions and the chemical and nuclear power industry.

3.3. EXPERIMENTAL RESULTS AND ANALYSIS

Butt-welded joints are prepared as per the experimental plan given in Table 3.6. For each of the Butt-welded joints made, the responses are the Bead Width, Bead Height, Transverse Shrinkage, Heat Input, Area of Penetration, and Tensile Strength, which are experimentally determined. After getting the experimental results, the results are analyzed to arrive at optimum values of process parameters. Experimental results are given in Table 3.2.

S. No	Parameters/ Levels	Welding Current (Amp)	Root Gap (Mm)	Gas Flow Rate (L/Min)
1	Level-1	80	1	8
2	Level -2	90	2	10

Table 3.2 Process parameters for welding

Trial No	Welding parameter levels			Output	
	A	B	C	Distortion	Tensile strength
1	80	1	8	0.7	203
2	80	2	10	1.5	196
3	90	1	10	0.9	224
4	90	2	8	0.7	213

Table 3.3 Experimental results for the weld bead geometry

Fig 3.2: Welded samples as per the experiment plan

Fig 3.3 standard specimen for tensile test

4.RESULTS & DISCUSSIONS:

The experiment was performed on material grade SS 316L with experiment architecture (DOE). Using a dial gauge and the universal test unit, the output factors are absorbed.Table 3.3 the input parameters that are taken for experimentation and results. Fig 4.1 shows the tensile strength values, and in fig: 4.2 shows the distortion values of the experiments.

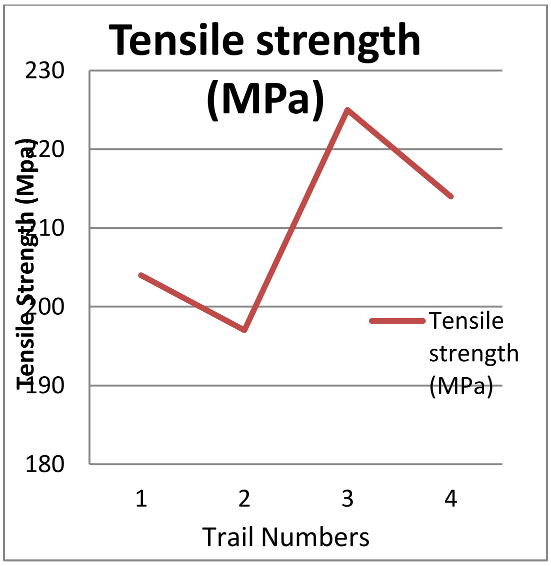


Fig: 4.1 shows the tensile strength vs. experimental trails

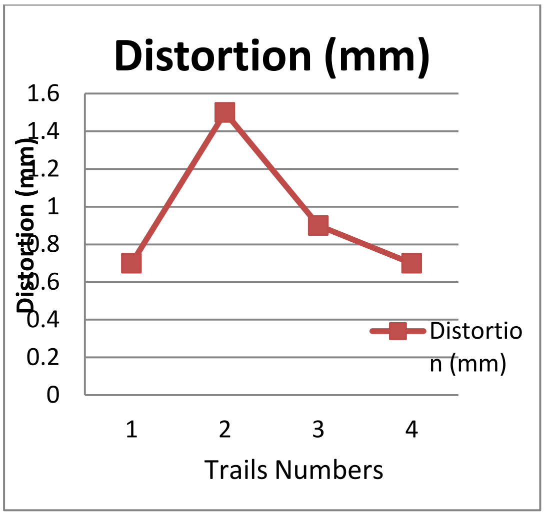


Fig: 4.2 shows the distortion vs. experimental trails

The Table 3.3 shows the values of the input parameters that were obtained as optimum experimental values. These values were used in the confirmation tests, and the error percentage was calculated by comparing them with the model experimental values.

Exp .No	Current (Amps)	Root Gap(Mm)	Gas Flow (L/Min)	Tensile Strength (Mpa)	Distortion (Mm)
3.	80	1	10	224	0.9
4.	90	2	8	213	0.7

Table 4.1 Optimum experimental values

The model equation used for the confirmation tests and correlation between input factors and the measured output parameters obtained by linear regression analysis is given below.

Tensile strength = Bo + B_1* I+ B_2 * RG + B_3* FR

Bo, B_1, B2, $B_3$are constants. I, RG, and FR are the input parameters.

The linear regression equation for tensile strength:

TS = 252.75 + (-0.65*80) + (0*1) + (1.75*10) = 217.5 Mpa
TS = 252.75 + (-0.65*90) + (0*2) + (1.75*8) = 208Mpa

Exp.No	Experimental Values	Model Eqn. Values	Error (%)
3	224	217.5	3.33
4	213	208	2.83

Table 4.2 Comparison of experimental and model equation for tensile strength

The linear regression equation for distortion:

Distortion = Bo + B_1* I+ B_2 * RG + B_3* FR

Bo, B_1, B2, $B_3$are constants. I, RG, and FR are the input parameters.

The linear regression equation for distortion:

D = (-2.65) + (0.02*80) + (0*1) + (0.02*10) = 1 mm
D = (-2.65) + (0.02*80) + (0*1) + (0.02*10) = 0.75 mm

Exp.No	Experimental Values	Model Eqn. Values	Error (%)
3	0.9	1	10
4	0.7	0.75	6.66

Table 4.3 Comparison of experimental and model equation for distortion

We can see from the results that the inert gas flow rate substantially affects tensile strength and impact the distortion. Gas flow rate affects the heat input by trying to spread over the region of the molten metal. This increases the heat addition over that small weld area to increase the penetration and decrease the metal deposition rate. Also, since the metal is in a liquid state for a more significant amount of time, it spreads over the base metal, and tensile strength increases. Welding current affects both tensile strength and distortion. This welding current increases the arc length and hence the heat input. This increase in heat input causes the spreading of the arc cone at its base, which leads to an increase in tensile strength. The interactions between current and voltage significantly affect the material's tensile strength. As evident from the error's effects within 10 percent, the confirmation tests demonstrated a closer agreement of prediction with experimental findings.It proves the selected regression analysis's effectiveness to better predict tensile strength and distortion.

Conclusions:

The following findings are made after performing the experiments and evaluating the experimental outcomes. The regression analysis has been successfully employed for optimizing the process parameters of Tungsten Inert Gas Welding of steel plates. It has been shown that the regression analysis provides a systematic and efficient methodology for searching the welding process parameters with optimal weld structures.

- Parameters of the welding process are chosen as study factors, such as welding current, root gap, and gas flow rate. Using DOE, the process parameters are selected.
- The effects on tensile strength and distortion of process parameters is discussed in the current analysis.
- The DOE method is used to do the numerical simulation of experiments, and experiments are carried out to determine Values for tensile strength and distortion.
- To achieve the optimal values Regression analysis is used, and the experimental values are compared with these values.
- The error percentage is found to be below 4 percent between experimental and regression values for tensile strength.
- The error percentage is found to be below 11 percent between experimental and regression values for tensile strength.

References:

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