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OPTIMIZATION OF PROCESS PARAMETERS IN CO_2 ROBOT WELDING

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ABSTRACT

This paper proposes a novel approach for optimization of process parameters in CO_2 robot welding. Quality of weld mainly depends on mechanical properties of the weld metal and heat affected zone (HAZ), which is in direct relation to the type of welding and its process parameters. Porosity, spatter and lack of fusion are greatly influenced by welding process parameters i.e. welding speed, welding current, shielding gas flow rate, voltage, contact tip, work distance, type of shielding gas etc. and also it plays a major role in determining the mechanical properties of the weld such as tensile strength, hardness etc. In this paper, effect of the various process parameters have been studied on welding of EDD513 (EN2) sheet using robot welding (MIG) process with copper coated mild steel wire of 1.2mmϕ. A set of experiments have been performed to collect the data using Taguchi's design of experiments approach. The mathematical models have been created based on the data recorded.

KEYWORDS

Taguchi design, CO2 robot welding, EDD513 (EN2) and ANOVA.

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INTRODUCTION

A welding process that melts and joins metal by heating them with an established arc between a continuously fed filler wire electrode and the metals is called as Gas Metal Arc Welding (GMAW). The process is used with a shielding provided externally as a flow of Argon (inert gas). In early 1900, the process GMAW was introduced, from 1950 it was used for the purpose of industrial welding processes[1]. Primarily it was used for the welding of aluminum because fundamentally at its introduction, it was a high current density, small diameter and bare metal electrode welding process using an inert gas for shielding. It is also called as Metal Inert Gas

(MIG) Welding. Further process advancement consisted of operation at low current densities and pulsed direct current, application to a broader range of materials and the use of reactive gases like CO2 and other gas mixtures. GMAWs are used as both automatic and semiautomatic operation modes. Nowadays all commercial metals and various types of alloys such as carbon steels, stainless steels, high strength low alloy steels, alloys of magnesium, copper, aluminum, titanium and nickel can be welded in all positions with this versatile process by choosing appropriate process parameters for the particular joint design and process variables[1]. Generally, input welding parameters are defined on the basis of some.

Traditional methods like process parameter charts, welder's experience and hand books. Later, with the help of some welding experts, advanced computer techniques were developed to help welding engineers to find out the suitable welding parameters[2]. Since the experimental investigation of the optimized process parameters are very costly and time consuming due to number of constraints and the above expert system is not reliable for choosing the welding parameters which gives the satisfactory result. To consider this particular problem, various methods have been developed to obtain the desired output variable through models which establishes a relation between input and output variables. A widely used method to find the welding process model is to use graphical methods, experimental design using regression analysis and response surface methodology[3,4,5]. Tarng and Yang found that the welding process parameters which obtained optimal weld bead geometry in the case of gas tungsten arc welding. They employed Taguchi method to formulate the experimental layout and analyzed the effect of each welding process parameters on the weld bead geometry as well as predicted an optimal setting for each process parameter[6].

Kim *et al*[5]. Developed an intelligent algorithm to understand the relation between the process parameters and bead height and used that relation to predict process parameters for an optimal bead height through a neural network and multi pass welding process previously mentioned statistical tools are accurate in terms of predicting the results from the process parameters. But the results are restricted to those points (anchor points) on which regression analysis is carried out. To find out a solution to this problem, Kumar and Debroy[7] presented that multiple sets of welding variables, capable of producing the target weld bead geometry, can be determined in realistic time frame by coupling real coded genetic algorithm with aneural network model.

A genetic algorithm does not require an objective mathematical function should be differential such that even if there is any bad data in the search space, the model does not get affected. This algorithm cannot produce a mathematical model between any process parameters and responses as output variables. To deal with this problem, response surface methodology uses the near optimal values as a reference point to obtain a model of the welding process and the suitable optimal values of the process variables. Dey *et al*[8]. Performed bead on plate weld on austenitic stainless steel using an electron beam welding machine and formed a constrained optimization problem to minimize weldment area after ensuring the condition of maximum depth of penetration. Sathiya *et al*[9]. Presented bead on plate welding of a super austenitic stainless steel AISI304L using a gas metal arc welding and optimized it with the help of genetic algorithm. They concluded the result after a comparision and confirmation test. T. Udayakumar *et al*[10]. Examined the microstructure and mechanical properties of friction welded super duplex stainless steel and finalized the results that weld transverse tensile failures repeatedly occurred away from the weld zone and shows more yield and ultimate tensile strengths, hardness with respect to the base metals.

Ehsan Azarsa and Amir Mostafapour[11] investigated the effect of friction stir welding parameters on flexural strength of high density polyethylene sheets by using response surface methodology and found on the basis of experimental and analytical results that the welding performed at high rotational speed and less travel speed greatly increases flexural strength by lowering defects. Sen M, *et al*[12]. Made an attempt to perfect the DP-GMAW process parameters i.e. mean current, pulse frequency, thermal pulse frequency and standard arc voltage by developing three second order regression model and using response surface methodology[12]. In this paper mainly focus on the company has a problem of rejection rate of 16-18%, due to porosity, spatter and lack of fusion in welding finish. So rejection value is Rs.45, 270 per day. It leads tore work and delay in on time delivery.

Objectives

Following were the objective of the research being reported here.

To optimize the factors affecting weld to reduce rejection rate.

To improve quality

To reduces crap

To achieve on time delivery

To improve customer satisfaction

METHODS

The research being reported here has carried out in three phase. The activities carried out under these phase are described in this section

Design of experiment

In order to achieve the desired goal, the current study has been made in the following sequence:

To find the important GMAW welding parameters that will have a maximum influence on weld defects.

To find out the lower and upper limits of the considered parameters.

To develop an experimental design matrix

To conduct the set of experiments according to the designed matrix.

To recording of responses

To developing the mathematical models

To check the adequacy of the developed model B. Identification of parameters

Here the significant influence on bead geometry of gas metal arc welding process have been identified, these factors have been considered in this study i.e., voltage, current, speed etc. A number of trial runs were performed on EDD513 (EN2) 4mm thick to find out the effective and feasible working limits of the gas metal arc welding parameters included in this study as per the conditions given in Table No.1. Different sets of MIG process parameters have been used to process and carry out the trial runs.

Nine sets of experiments have been designed by Taguchi method. The experiments were arranged in three levels of voltage (19, 20.5 and 22 volt), three levels of current (127, 125 and 122Amp) and three levels of speed (20, 22 and 25cm/min). Since interactions of all process parameter used in this study is considered therefore in trial runs while varying one parameter to find the suitable limits.

Experimental setup

Based on Taguchi design, experiments have been conducted as shown below Figure No.1.

With interaction

TS = 619905-7362.4 AMP-101828 VOLTAGE+ 80979.4 SPEED+954.773 A*V-739.033 V*S-527.865 S*A..(1)

Without interaction

TS = -96076.6+1034.08 AMP+1926.74 VOLTAGE-769.36 SPEED..............................(2)

Based on the ANOVA method, if the calculated F-ratio of the developed model is less than the value of F-ratio from the F-table for a given confidence level (95%), then the model is said to be adequate. According to table ANOVA predicts that most affecting parameters are current (A) and voltage (V) there is no effect of speed.

Based on signal to noise (SN) ratio the optimum parameters are shown in Figure No.2 the combined effects of current, voltage and speed.

Interaction Plot

Current and voltage: Both panels indicate that these two factors interact. The interaction plots are shown below in Figure No.3.

Table No.1: Welding conditions

Welding robot	OTCFD-V6
Plate thick	4mm
Wire coilϕ	1.2mm
Gas used	co_2
Payload	6kg

Table No.2: Process Parameters and its Level

S.No	Factors	Units	Levels -1	0	+1
1	Current	Amp	122	125	127
2	Voltage	v	19	20.5	22
3	Speed	cm/min	20	22	25

Table No.3: DOE table with responses

Run	AMP (a)	Voltage (v)	Speed (cm/min)	TS (n)
1	122	19.0	20	51153.00
2	122	20.5	22	53701.33
3	122	22.0	25	51902.00
4	125	19.0	22	52153.33
5	125	20.5	25	55780.00
6	125	22.0	20	59650.00
7	127	19.0	25	51528.33
8	127	20.5	20	59898.67
9	127	22.0	22	60623.33

Mathematical models: regression analysis

Tensile strength (Ts) =f (current, voltage, speed) or. (Ts=f (I, V, S)

Table No.4: ANOVA table for tensile strength

S.No	Source	DF	Seq SS	F	P
1	Regression	3	113243328	17.7532	0.0042587
2	AMP	1	40634132	19.1107	0.0072113
3	Voltage	1	50116453	23.5704	0.0046537
4	Speed	1	22492742	10.5786	0.0226336
5	Error	5	10631236		
6	Total	8	123874564		

Figure No.1: Test specimen

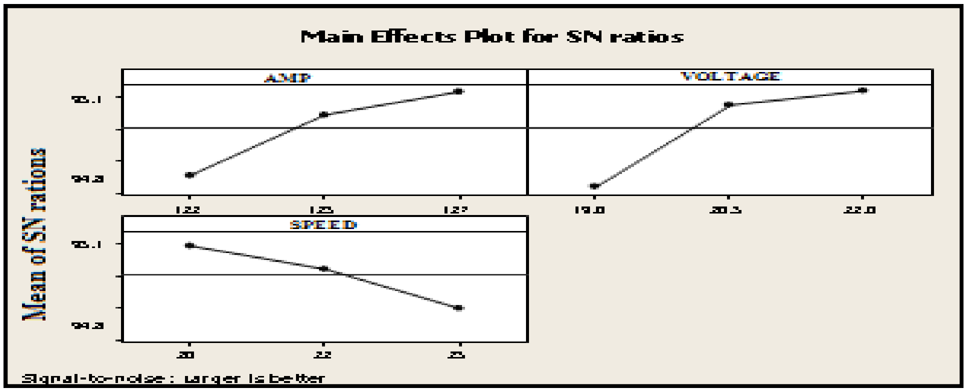

Figure No.2: Signal to noise (SN) ratio

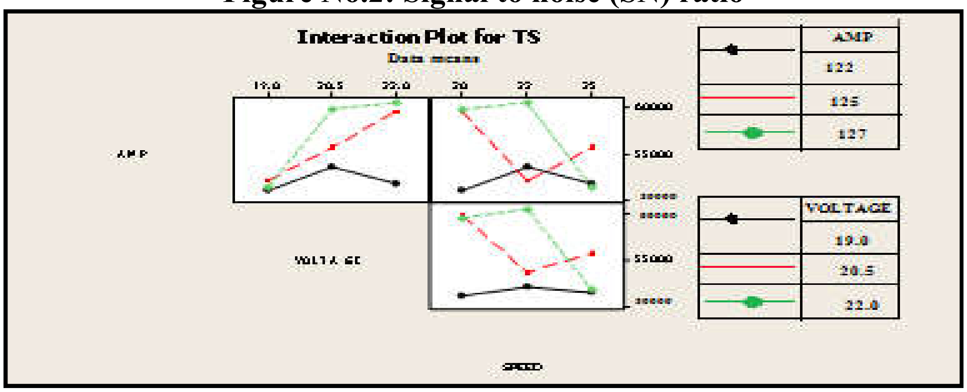

Figure No.3: Interaction plot for tensile strength

CONCLUSION

In this paper, butt joint weld runs had been conducted using gas metal arc welding process in CO_2 robot welding. Experiments were carried out on the basis of Taguchi design technique and recorded data were used to find out an optimal parameters of current, voltage and speed. As ANOVA predicts the significance of process parameters, tensile strength followed by voltage and current has been found as the sequence of effective parameter among all used in this study. Speed rate is least effective parameter. Optimized parameters for achieving high tensile strength are current127A, voltage 22V and speed 20cm/min.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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