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Study and Investigation of Welding Parameters of Electrodes

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ABSTRACT

In this project, the study and investigation of welding parameters of electrodes is to be carry out. The variation of flux material of electrodes cause changes in the depth of penetration, length of heat affected zone is to be recorded by a high-resolution camera, and the depths of penetration of specimen is measured by an optical microscope and hardness is measured by Brinell Hardness Tester after welding. Properties of different flux composition of same ISO configuration-E6013 electrode leads to different tensile strength and breaking load for same current condition. The arc turned more concentrated and the depth of penetration increased obviously as the welding current increased and arc turned less concentrated and the depth of penetration became shallow as current is decreased. But along with this, our project shows as chemical composition of flux changes Depth of penetration, Hardness, tensile strength, breaking load, length of heat affected zone significantly affected. Different types of electrodes leads to different chemical compositions and it affects on mechanical properties of metals like tensile strength, hardness, depth penetration. Also by varying voltage and current along with electrode size there is some change in mechanical properties. Hence we have selected Mangalam electrode of E6013 category and welding with it by varying current, voltage and electrode size. In this study by getting the results and analysis the selection of electrodes in shielded metal arc welding or manual metal arc welding is to be investigated.

Keyword: Input:-Current, Voltage, Electrode Size, Hardness, Tensile Strength, Depth of Penetration

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I. INTRODUCTION

Welding

Welding is the process of permanent joining two or more similar or dissimilar metals with or without the application of heat, with or without the application of pressure, with or without the application of filler material. Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion, which is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet, etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized.

Arc Shielding

However, joining metals requires more than moving an electrode along a joint. Metals at high temperatures tend to react chemically with elements in the air - oxygen and nitrogen. When metal in the molten pool comes into contact with air, oxides and nitrides form which destroy the strength and toughness of the weld joint. Therefore, many arc-welding processes provide some means of covering the arc and the molten pool with a protective shield of gas, vapor, or slag. This is called arc shielding. This shielding prevents or minimizes contact of the molten metal with air. Shielding also may improve the weld. An example is a granular flux, which actually adds deoxidizers to the weld.

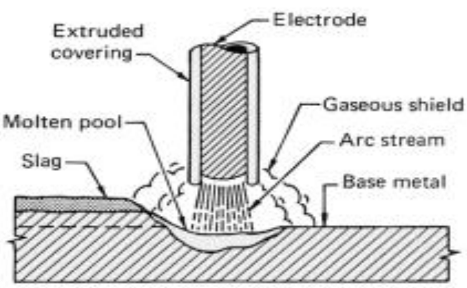

Figure 1:-Arc shielding

Shielded Metal Arc Welding

This chapter describes the factors to be considered for selection of suitable type of welding current and polarity. Further, the coating factor and its influences of quality of weld metal have also been elaborated. Mode of metal transfer in shielded metal arc welding and factor affecting the same have been presented.

Shielded Metal Arc Welding (SMAW) is an arc welding process in which coalescence of metals is produced by heat from an electric arc that is maintained between the tip of a consumable covered electrode and the surface of the base metal in the joint being welded.

An arc is generated between two conductors of electricity cathode and anode, they are touch to establish the flow of current and then separated by small distance. Because of very high velocity of electrons, the kinetic energy possessed by electrons is very high.

II. LITERATURE SURVEY

2.1 Saman Karami, Hamidreza Jafarian, Ali Reza Eivani, Shahram Kheirandish. Year: 4 Jun 2016

It can be proposed that transvers welding speed brought about decrease of heat input as the result flow ability would be decreases. Microscopic analysis demonstrated that in lower rotation speed or higher welding speed, probability of welding defect formation is relatively higher owing to the fact that the amount of heat input is not sufficient to provide enough flow ability hence tunnel or void formation are inevitable.

2.2 HR Ghazvinloo, A. Honarbakhsh-Raouf & N. Shadfar. Year:2 Feb. 2010

Increasing the voltage 20-26V & welding current from 110-150A decreases the fatigue life of weld metal but fatigue life gradually increasing with increasing welding speed.

The maximum fatigue life were obtain as 221, 360 & 476 Cycle. There welding speed is 70cm & voltage 20V & current 110A.

III. PROBLEM STATEMENT

In conventional welding process only current is adjustable because of that welding joints cannot maintaining their welding properties for a long time hence fatigue life and other mechanical properties are getting affected.

As we know that welders doesn't have enough technical knowledge to select the electrode as per the requirement hence they are not able to maintain the mechanical properties like tensile strength, depth of penetration and hardness.

IV. METHODOLOGY

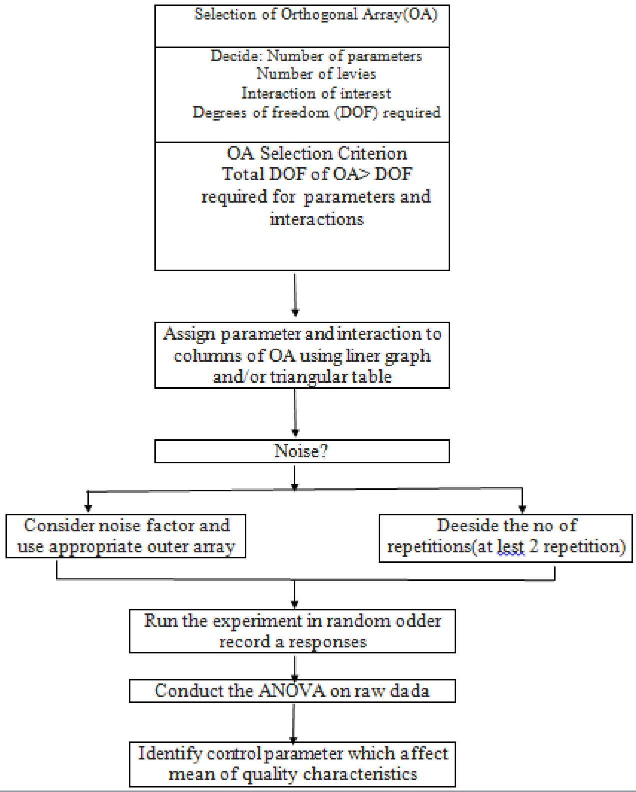

Figure2: Flow diagram of design methodology

V. RESULTS AND DISCUSSIONS

The present chapter gives the application of the experimental design method. The scheme of carrying out experiments was selected and the experiments were conducted to investigate the effect of process parameters on the output parameters e g, hardness. The experimental results are discussed subsequently in the following sections.

Selection of Orthogonal Array and Parameter Assignment

For the present experimental work the three process parameters each at three levels have been decided. It is desirable to have three minimum levels of process parameters to reflect the true behaviour of output parameters of study. The process parameters are renamed as factors and they are given in the adjacent column. The levels of the individual process parameters/factors are given in Table

Table 1 Process Parameters and their Levels Factors Parameters Levels

Factor	Parameter	L1	L2	L3
A	Currant	110	130	150
B	Voltage	20	23	26
C	Electrode Size	2.5	3.15	4

To test the sensitivity of a set of response variables to a set of control parameters (or independent variables) by considering experiments in "orthogonal array" with an aim o attain the optimum setting of the control parameters. Orthogonal arrays provide a best set of well balanced (minimum) experiment In general; the number of degrees of freedom associated with a factor (control variable) is equal to the number of levels for that factor minus one. In this study have three factors (A, B, & C) with each with 3 level". Array L9, has nine rows and four"3 level" columns The number of columns of an array represents the maximum number of factors that can be studied using that array

Experimental Results

1) Factorial designs

Factorial designs are widely used in experiments involving several factors where it is necessary to study the joint effect of the factors on a response. For simplicity and easy understanding, in the present section the design matrix of the 3^5 factorial designs is presented with subsequent explanation on the calculation of the main effects and the sum of squares. The three level design matrices are very famous and used in the daily life engineering applications very frequently

The 3^5 design

The 3^5 design is the design in the 3^k factorial design. This involves three factors (A, B,& C), each run at three levels. Table 5.2 depicts the 3^5 design matrix, where -l's refers to the low level and I's refers to the high level. These are also called as non- dimensional or coded values of the process parameters.

The SMAW experiments were conducted to study the effect of process parameters over the output response characteristics with the process parameters and interactions assigned to columns as given in Table 5.2. The experimental results for Hardness and products welding given in Table 5.3. 9 experiments were conducted using experimental design methodology and each experiment was simply repeated three times for minimizing the error. In the present study all the designs, plots and analysis have been carried out using Minitab statistical software.

2) Analysis and Discussions of Results

The SMAW experiments were conducted by using the parametric approach. The effects d individual SMAW process parameters, on the selected quality characteristics hardness has been discussed in this section. The average value of the response characteristics for each variable at different levels were calculated from experimental data. The main effects of process variables for raw data were plotted. The response curves (main effects) are used for examining the parametric effects on the response characteristics. The analysis of variance (ANOVA) of raw data is carried out to identify the significant variables and to quantify their effects on the response characteristics. The most favourable values (optimal settings) of process variables in terms of mean response characteristics are established by analysing the response curves and the ANOVA tables.

3) Effect on hardness of SMAW products

In order to see the effect of process parameters on the surface roughness, experiments were conducted using L9 OA. The experimental data is given in Table. The average values of hardness for each parameter at levels -1 and 1 for raw data are plotted in Figure respectively. The points in the plot are the means at the various levels of factor with a reference line drawn at the grand mean of the response data.
It is seen from that hardness increases with the increase in melting temperature. Whereas the hardness reduces as decrease temp means the melting temperature and the welding works inversely proportional on hardness. As we all know that as the temperature increase the dope and heat affected zone because the dope of varies from the processing temperature to the ambient temp.

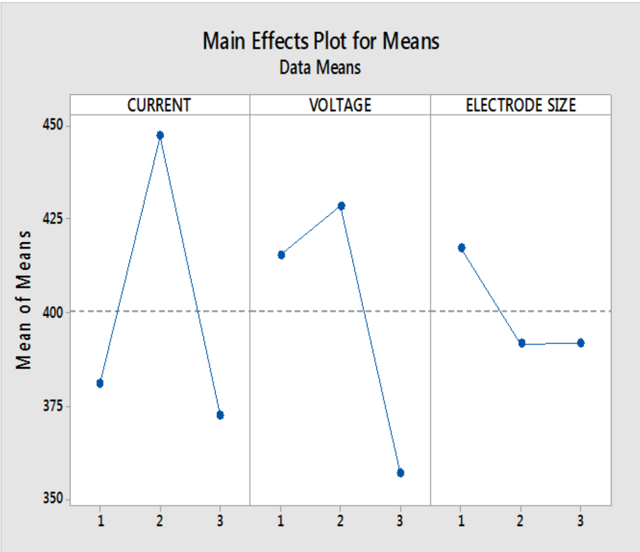

Figure3: Effect of process parameter on hardness

It is seen from the hardness reduces with increase in strength get reduces which affects on the hardness property as well as the hardness occurs temperature. The dope is mostly affected process parameter on the strength is lower.
So as the effect of first two level then decrease the value hardness so higher hardness tends to reduction hardness value. if the decrease the value drinking so higher packing pressure tends to reduction in hardness value. If hardness exceeds than dope as results is back pressure means heated material. so that heating material always less than cooling material and heating material tends to reduction in hardness.

It is noticed from that there is slight interaction between hardness and strength. hardness & strength also one of the important factors which effect on dope. The Hardness is generally decided on basic of the hardness. in the experimentation of hardness & strength parts, the generally said that to reduce hardness more time to cool the welding sample is preferred. but it also depend upon the which is used for industrial application.

Residual Plots show that there is normally distributed of data. The points on the plot above appear to be randomly scattered around zero, so assuming that the s have a mean of zero is reasonable. The vertical width of the scatter doesn't to increase or decrease across the fitted values, so we can assume that the variance in the error terms is constant.

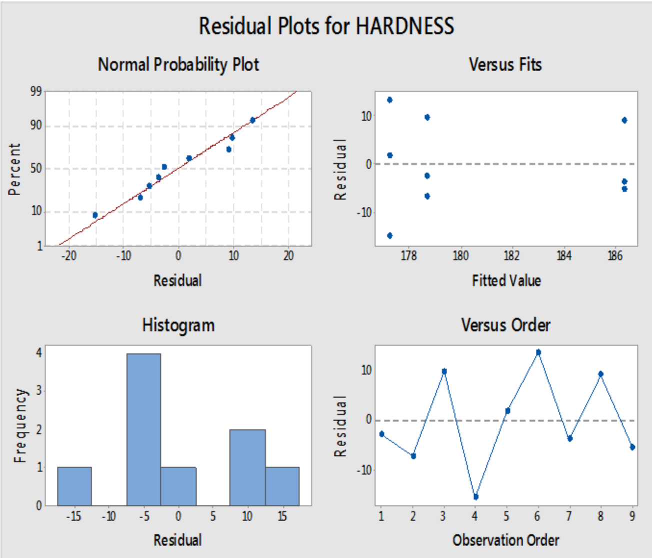

Figure4:-Residual Plot For Hardness

This layout can be useful for comparing the plots to determine whether your model meets the assumptions of the analysis. The following residual plots are included in the graph:

Histogram: Indicates whether the data are skewed or outliers exist in the data.

Normal probability plot: Indicates whether the data are normally distributed, other variables are influencing the response, or outliers exist in the data. If batch is a random factor, and the final model includes the batch by time interaction, then the variance of the marginal residuals depends on the time variable and may not be constant. You can use the conditional residuals to check the normality of the error term in the model.

Residuals versus fitted values: Indicates whether the variance is constant, a non linear relationship exist, or outliers exist in the data.

Residuals versus order of the data: Indicates whether there are systematic effects in the data due to time or data collection order.

Table 2 Response Table For Means Of SMAW Part

Level	Current	voltage	Electrode size
1	0.3197	0.3606	0.2877
2	0.3943	0.3596	0.3962
3	0.3032	0.2970	0.3333
Delta	0.0911	0.0636	0.1085
Rank	2	3	1

It is observed from Table that there are three parameters and three levels which in experimentation of the parameters were optimized to optimize the v e value of hardness in products. All parameters are important and affects on welding specimen.

4) Effect On Tensile Of SMAW Products

Shows that the effect on tensile of SMAW products decreases with the increase of heat affected zone as well as at highest temperature level, it is at its least value. As piously discussed the welding pressure tends to reduction of HAZ because high pressure maintains dimensional stability of molten material in the WELD. SWAW is high temperature therefore the highest temperature level tends to reduction in tensile value in products. Whereas tensile gets reduces with decrease in the welding pressure and packing time. The cooling time need more to reduce tensile value. The effect of cooling time is very significant. Effects of Process Parameters on tensile of SMAW products Residual plots are used to evaluate the data for the problems like non normality, non AO variation, non constant variance, higher-order relationships, and outliers. I can be scene that the residuals follow an approximately straight line in normal probability plot and approximate symmetric nature of histogram random indicates that randomly around zero in residuals versus the fitted values Since residuals clear pattern, there is no error due to time or data collection order. the duals are normally distributed. Residuals possess constant variance as they are temperature, welding pressure and welding time are he melts the significant parameters which have the p value are less than 0.05. Similarly the cooling time having P values greater than 0.05, the reasons for the greater value is as same as mentioned for SMAW products. from Table that there are three parameters and three levels which were used in experimentation of SMAW parts, the parameters were optimized to optimize the value of tensile in products

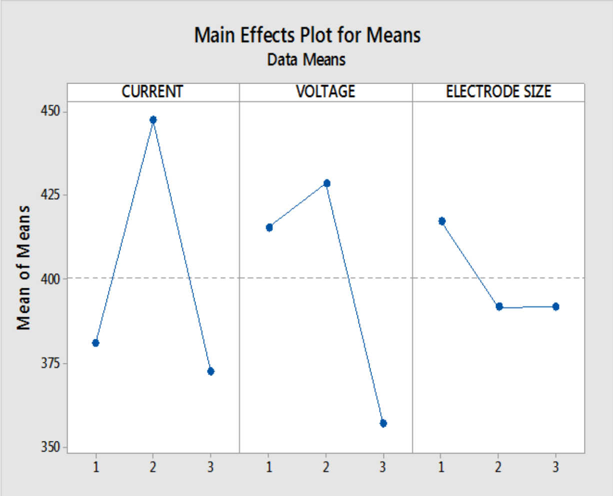

Figure 5 Effect of process parameter on tensile

All parameters are important and affects on SMAW but in that which is most affected and which is least, so it is necessary to study and set the ranking of the parameter as per their effect on SMAW. So from the experimentation we found that Tensile Strength is mostly affects the SMAW.

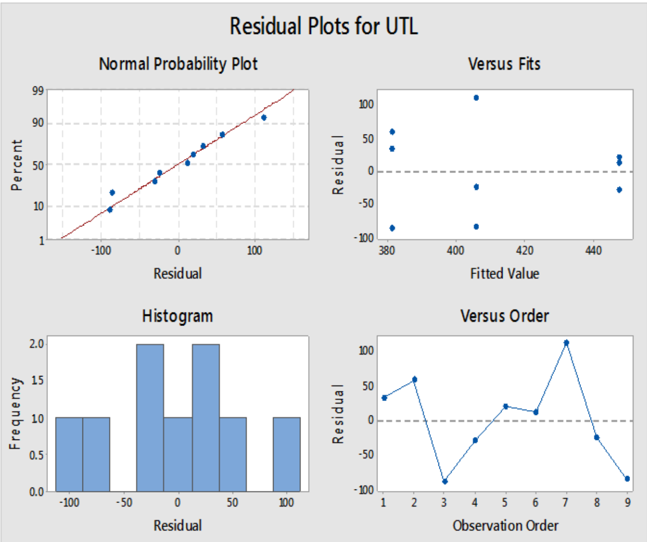

Figure 6 Residual Plot For tensile

Table 3 Response Table For Means Of SMAW Part

Level	current	voltage	Electrode size
1	0.2508	0.2682	0.2240
2	0.2797	0.2690	0.2898
3	0.2430	0.2363	0.2597
Delta	0.0367	0.0327	0.0657
Rank	2	3	1

5) Estimation of Optimum Response Characteristics

In this section, the optimal values of the response characteristics SMAW of hardness and tensile strength Parts along with their respective confidence intervals have been predicted. The results of confirmation experiments are also presented to validate the optimal results. The optimal levels of the process parameters for the selected response characteristics have already been identified. The optimal value of each response characteristic is predicted considering the effect of the significant parameters only. The average values of the response characteristics obtained through the confirmation experiments must lie within the 95 % confidence interval.

Table 4 Results obtained from hardness and tensile tests with their calculated S/N ratios

Experiment No.	Welding Current (Amp)	Welding voltage (volt)	Welding Electrode size (mm)	Hardness (HV)	S/N ratio for Hardness	Tensile N/mm^2	S/N ratio for Tensile
A	110	20	2.5	176	44.9083	412.74	52.1232
B	110	23	3.15	171.66	44.6913	438.58	52.8410
C	110	26	4	188.33	45.4946	292.30	49.3166
D	130	20	3.15	162	44.1893	416.81	52.3988
E	130	23	4	179	45.0729	466.54	53.3778
F	130	26	2	190.66	45.6040	458.93	53.2349
G	150	20	4	182.66	45.2289	517.19	54.2730
H	150	23	2	195.33	45.8145	380.73	51.6123
I	150	26	3.15	181	45.1536	319.81	50.0978

VI. CONCLUSION

The weld joints that had been welded at different level of voltage, current and welding Electrode size were mechanically tested. Minitab 17- software has been used to analyse the experimental data. The results obtained from the tensile and hardness tests at various welding conditions. The interaction effect between welding parameters is not been considered. The strength of the weld joint which is generally expected to be high is examined by equation.

The micro hardness testing as carried out on different welded specimens. That the most influencing factor for the hardness property is induced vibration at higher level of current. It has been observed that micro hardness of the weld metal/zone was found to increase in almost all the cases where vibratory conditions were applied. When mechanical vibrations are induced into the weld pool during welding, a disturbance is created which tends to pose a hindrance to the solidifying dendrites and forms a new nucleation sites causes a fine grain structure forms. The tensile specimens were prepared in accordance with ASTM E A 370-2017 standards. The displacement rate was 0.5 mm/min. is explaining the results obtained from the tensile test and the most influencing factor which affect the yield property of the welded joint. The yield strength of the welded joint is maximum when current is at 130Amp, welding electrode size 3.15mm and the voltage 23 v.

When the welding current is high and the welding electrode size is low then the metal deposition rate increases, the mentioned condition of the weld geometry lead to enhancement of the tensile property of the welded structure. We have found an interesting outcome from the results that when the applied voltage increases its yield strength also increases. This improvement in yield strength for vibratory weld specimen attributed to the favourable microstructure changes that impeded grain growth, resulting in relatively shorter dendrites in the depth of penetration.

Table 1 Concluded results from Taguchi's experiment and description of most significant value by ANOVA

Responses /Input parameters	Current (Amp)	Voltage (v)	Electrode size (mm)	ANOVA
Hardness	150	23	4	Frequency with 95 %
Tensile strength	130	20	3.15	Frequency with 95 %

It has been shown in this work that vibration applied into the DOP can be successfully enhanced the mechanical properties of welded joints. Thus the present research attempt provided an alternative for grain refinement of weld metal. The auxiliary vibrations induced into the weld pool resulted in increased micro hardness and the yield strength of the welded joints which indicates the orientation of the crystal and refinement of grain stock place.

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