Analysis of Welding Process Parameter by Taguchi Method

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ABSTRACT

In this paper project was carried out to study the weldability in different steel grades by their strength. The study reveals the influence on weldability of steel by varying composition of steel by mechanical characterization. The samples were welded together by metal inert gas welding process. In large steel fabrication industries such as ship making, and train guide way, the problem of residual stresses and overall distortion has been and continues to be a major issue. In the last few decades, various research efforts have been directed at the control of optimum material selection of steels for longer service life. Yet in actual practice, large amounts of resources are still being spent in reworking welds, which in turn increases the production cost and delays work completion.

Keywords-- Optimization, ANN, MINITAB 17, MATLAB

I. INTRODUCTION

Welding is a process of joining two similar or dissimilar metal by metal fusion, with or without the help of pressure and with or without the use of filler metal. The fusion of metal takes place by heat. That heat may be produced by chemically reaction, friction between two joining metal & resistance. In the end of the 19th century, the process of joining was forge welding in which blacksmith had used for to join metal by heating and hammering process. Arc welding were among the 1st processes to develop like - MIG welding, slag welding, flux welding and submerged welding etc. Development continued with introduced of beam (laser, Electric), welding, friction welding in the late half of 20th century.

II. METHODOLOGY

We prepare rod of 16 mm diameter for En 8, En 19, and EN 24 as a specimen. By conducting welding operation we prepare them for tensile test. In the present investigation Taguchi Methodology has been used to model tensile strength.

1. Identification of important input variables influencing the response tensile strength.
2. Reduced number of experimental trials.
3. Optimal setting of parameters.
5. Obtaining the inference regarding the effects of input parameters on the response/characteristics of the process.

A. Tensile Strength Test:

This type of physical weld testing is used to measure the strength of a welded joint. A portion of to locate the welded plate is locate the weld midway between the jaws of the testing machine. The width thickness of the test specimen are measured before testing, and the area in square inches is calculated by multiplying these before testing, and the area in square inches is calculated by multiplying these two figures. The tensile physical weld testing specimen is then mounted in a machine that will exert enough pull on the piece to break the specimen. The testing machining may be either a stationary or a portable type. A machine of the portable type, operating on the hydraulic principle and capable of pulling as well as bending test specimens, is shown in figure.

As the specimen is being tested in this machine, the load in pounds is registered on the gauge. In the stationary types, the load applied may be registered on a
The tensile strength, which is defined as stress in pounds per square inch, is calculated by dividing the breaking load of the test piece by the original cross section area of the specimen. The usual requirement for the tensile strength of welds is that the specimen shall pull not less than 90 percent of the base metal tensile strength.

The shearing strength of transverse and longitudinal fillet welds is determined by tensile stress on the test specimens. The width of the specimen is measured in inches. The specimen is ruptured under tensile load, and the maximum load in pounds is determined. The shearing strength of the weld in pounds per linear inch is determined by dividing the maximum load by the length of fillet weld that ruptured. The shearing strength in pounds per square inch is obtained by dividing the shearing strength in pounds per linear inch by the average throat dimension of the weld in inches. The test specimens are made wider than required and machined down to size.

III. PRIOR APPROACH

Thakur.et al. [1], focused to optimize tensile shear strength for galvanized steel using L27 orthogonal array method. On the basis of ANOVA, highly effective parameters are current and time, whereas force and diameter are less effective parameters. Using S/N ratio, tests indicate that tensile shear strength can be increased significantly (13.43%) by using the proposed statistical technique.

Niranjan Kumar Singh et al. [2] using Taguchi method conducted experiments in two phases on Austenition stainless steel grade 301 to find the effect of process parameters (welding current, weld cycle, hold time, cool cycle) on indentation as primary and initial parameter input parameters. They found that tensile shear strength can be increased significantly (13.43%) by using the proposed Taguchi method.

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Kadam. et al. [3] with the help of non-linear method like Genetic algorithm studied the effect of process parameters on nugget relation between responses and variable input parameters. They found that nugget dia.increases by by increasing the number of generation. According to them with the help of Genetic algorithm, maximum value of nugget dia. can be obtained.

Pradeep M. et al. [8] present an approach to find out the optimum weld parameters in spot welding dissimilar material thickness. Parameters for welding of dissimilar thickness material are not available beyond 4mm. Low carbon steel have been used by them having a composition of 0.8% C, 0.24% Mn, 0.01% S and 0.019% P (wt. %). Taguchi approach has been used for the optimization of welding current and time using L9 orthogonal array. There result indicate optimum current as 3.5KA and time 10 cycles.

Suresh R K et al [9] reported a systematic approach to determine the effect of process parameters on the force required for breaking of weld joints. They have used Taguchi approach for design of experiment. The input parameters used included welding current, welding time and electrode dia keeping squeezing time, hold time, electrode force, and sheet thickness as constant. L27 orthogonal array was selected for this study. A total of 27 experiment with
mixed combination of inputs were carried out. The results indicated maximum tensile strength at current level of 17.5A, weld time of 15 sec. and electrode diameter of 3mm. ANOVA results showed the % contribution of current as 63.7%, weld time 28.7% for maximum tensile shear strength.

Wuttipompun et al [10] has determined an optimum welding condition to reduce welding spatter. The author has selected four independent variable namely electrical supply, thickness of material, welding angle and welding position and used a full factorial experiment. The conclusion of the work showed that electrical supply, welding angle and welding position are variables that affect the number of defective parts due to spatter.

Balasubramaniam et al [11] has used regression analysis to optimize the welding current and weld time setting to achieve a minimum nugget diameter and a maximum tensile shear force. The work was carried out on the SPRC35 steel sheet. Subramaniam concluded the increase in welding current will lead to increase in nugget diameter and tensile shear strength.

Hamedi et.al [12] has used artificial neural network (ANN) and genetic algorithm (GA) to optimize spot welding parameters required to minimize dimensional deviations or gaps in subassemblies. The ANN was used to produce relationships between the welding parameters and their respective produced assembly gaps. GA was later used to select the optimum welding parameters which gave the smallest dimensional deviation.

Norasiah et.al [13] has looked into optimizing spot weld parameters in order to achieve a nominal weld diameter and smaller heat affected zone (HAZ) using Response Surface Methodology. Kim et.al [9] also has used Response Surface Methodology to determine the optimum spot weld parameters for TRIP steels. The work has developed a regression model to determine the response surface expressing the relationship between the input variables (welding current, welding time and welding force) and the output variables (shear strength and indentation).

Finally Lin et.al [14] has looked into spot weld parameter optimization using Taguchi Method and ANN. The Taguchi Method was used to identify the optimum settings for the four parameters; current, time, electrode force and electrode tip diameter. ANN was used in this work to model the welding process and predict the achieved weld strength for various welding schedules. The work reported above have used steels with the same type and thickness. Furthermore most work has only considered one weld characteristic; the weld strength except for Subramaniam [6] and Norasiah [8].

M.St. Weglowski et al [15] The Measurements of metal transfer are presented in the GMAW process in the range of welding wire speed from 150 inch/min to 240 inch/min. The measurement system is based on a high speed camera and it can measure the metal transfer at 3000 frames per second. Effect of welding current on the metal transfer are evaluated using dimensional and kinetic analysis.

E. Mahdi et al [16] the behaviour of MIG welded and un-welded AA 6061 T6 were investigated using a series of electrochemical measurements and mechanical tests. The Heat affected zone was more susceptible to corrosion showing severe pitting corrosion comparing to the base metal. The hardness of the welded specimens was increased as we moved away from the weld centre and Torsion welded specimens were broken at the heat affected zone suggesting softness of this area due to the impact of MIG welding.

G. Haragopal et al [17] they presented a method to design process parameters that optimize the mechanical properties of weld specimen for Al alloy, used for construction of aerospace wings. The process parameters considered for the study were gas pressure, current, groove angle and pre-heat temperature. Process parameters were assigned for each experiment. The experiments were conducted using the L9 orthogonal array. Optimal process parameter combination was obtained. Along with this, identification of the parameters which were influencing the most was also done.

Suresh Kumar et al [18] discuss about micro structural development during MIG welding of copper with iron filler. During the experimental work they consider voltage, current and travel speed as welding parameter. They investigate needle shaped morphology of iron matrix typical of marten site and at copper iron interface bended microstructure was observed which varied with travel speed.

Abbasi..K et al [18] MIG is carried on 144mm long x 31mm wide & 10mm thick bright drawn, mild steel. Increase in pressure of shielding gas is studied through variation of welding parameters like feed rate and arc voltage on penetration. The vessel was pressurized with argon-carbon dioxide mixture to absolute pressure of 7, 14, 29, 58, 115, & 230bars [7]. The metal transfer modes were controlled by changing the wire feed rates in the range of 3.81m/Min to 6.1mm/min. The result was found that along with increase in pressure the arc voltage must be increased in order to get good weld bead. Higher the pressure, density of fumes gets increases. MIG welding can be carried up to pressure of gas 230bar.

IV. OUR APPROACH

A. Planning Phase Input Parameter & There Levels.

<table>
<thead>
<tr>
<th>Parameters of the setting</th>
<th>Control factor</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Factor A</td>
<td></td>
</tr>
<tr>
<td>Welding Current</td>
<td>Factor B</td>
<td></td>
</tr>
</tbody>
</table>
Table 1: parameter of the setting

<table>
<thead>
<tr>
<th>Control Factor</th>
<th>Symbol</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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</thead>
<tbody>
<tr>
<td>A Material</td>
<td>EN</td>
<td>8</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>B Welding Current</td>
<td>E</td>
<td>50</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>C Weld Run</td>
<td>R</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2: Selected input parameter

V. RESULT

![Graph: Variation of Tensile Strength](image)

Fig 1 Variation of Tensile strength vs. Input parameters

Taguchi Orthogonal Array Design L9 (Factors: 3, Runs: 9)

Taguchi Analysis: Tensile Strength versus Material, welding Current, Weld Run

<table>
<thead>
<tr>
<th>Level</th>
<th>Material</th>
<th>Welding Current</th>
<th>Weld Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46.72</td>
<td>48.32</td>
<td>47.24</td>
</tr>
<tr>
<td>2</td>
<td>48.92</td>
<td>43.72</td>
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</tr>
<tr>
<td>3</td>
<td>47.17</td>
<td>50.77</td>
<td>48.32</td>
</tr>
<tr>
<td>Delta</td>
<td>2.2</td>
<td>7.06</td>
<td>1.08</td>
</tr>
<tr>
<td>Rank</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3 Response Table for Signal to Noise Ratios (Larger is better)

Table 3 shows welding current producing much impact as compare to material and weld run.

V. CONCLUSION

In this study the optimal welding condition was selected by varying welding parameters through the Taguchi parameter design method. With the L(9) orthogonal array, a total of 9 experimental runs, covering three main factors each at three levels indicated that the Taguchi parameter design was an efficient way of Determining the optimal cutting parameters for weld characteristics.

REFERENCES

[9] X. Sun, E.V. Stephens and M. A. Khaleel: “Effects of fusion zone size and failure mode on peak load and energy


