

Analysis of Welding Process Parameter

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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.

Key words: 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 black smith had used for to join metal by heating and hammering process. Arc welding were among the 1st processes to develop late in 19th century and resistance welding after this. In 20th century during World War I and World War II increase the demand for reliable and expensive process of joining technique. During world war many welding process were developed it also including manual techniques for example-shielded metal arc welding .many energy sources are used for welding process like: - flame, beam (electron), laser beam and friction of two joining metals during process etc. Welding arc are performed in different - different environment. It may be used in open place and can be under water. Many precautions are necessary for welding process. These precautions to avoid burs, electricity shock, vision damage and from harmful flames and gases .Now days semi-automatic , full automatic welding are very most popular in industries work 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.

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 balancing beam. In either case, the load at the point of breaking is recorded. Test specimens broken by the tensile strength test are shown in figure.

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.

II. LITERATURE REVIEW

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 tha 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 measure of weld quality including tensile strength, nugget diameter and penetration.L32 orthogonal array and minitab 14 software was used for analysis. They found that the average indentation was 0.87mm and data followed normal distribution but after conducting Taguchi method, residuals followed normal distribution without any pattern with time and fitted value. The validity of Taguchi method was confirmed.

Pandey et al.[2] used taguchi method on low carbon cold rolled 0.9mm thick mild steel sheets to find the effect of parameters on quality of weld strength. According to the results, current contribute 61%, holding time 28.7% and

pressure 4% on tensile strength. For optimum result, current should be 6.8KA, pressure 0.79KPa, and holding time of 5 sec.

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 increasing the number of generation. According to them with the help of Genetic algorithm, maximum value of nugget dia. can be obtained.

Panchakshari. et al. [4] carried out a comparative study of responses on low carbon steel using three methods- Genetic algorithm, Design of experiment and Response surface method and cross validated the results by using D-optimal method. The results shows that weld cycle and welding current should be 12 cycles and 11.2KA respectively. Other parameters such as hold cycle, squeeze cycle, nugget dia., and weld strength must lie at range of 12 cycles, 30 cycles, 5.4mm and 290N/mm² respectively.

Arvinder Singh. et al. [5] used Taguchi L9 orthogonal array method to find the effect of process parameters (pressure, weld time, and welding current) on tensile strength of austenitic stainless steel AISI 316L. They found maximum tensile strength of 789.46N/mm² at pressure 3.1KN, welding time 4ms and current 15KA

Darshan Shah. et al. [6] used neural network-based systems to find the optimum process parameters for resistance spot welding and weld quality assessment. Input parameters used includes are welding current, sheet thickness and cycle time. Parametric analysis is carried out for the quality of the resistance spot welding, i.e. weld strength. This parametric analysis (ANOVA) using weld strength as quality indicator shows the percentage contribution of parameters individually, i.e. welding current as 49.81 %, thickness of 37.94 % and cycle time of 2.61 % and the error is of 9.62 %. It has been found that weld strength increases as welding current increases and weld strength decreases as thickness of the material increases.

Hamed Pashazadeh. et al. [7] used full factorial design of experiments on AISI 1008 commercial steel sheets parameters (welding current, weld time, pressure) on nugget diameter and height. Best nugget size was achieved by using hybrid combination of artificial neural network and multi objective genetic algorithm. The result shows that range of 591 to 615 spot welds can be done for tip dressing operation in studied welding operation.

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 0.8mm thick metal strips of cross-section 10 and 5 mm having a composition of 0.101 C, 0.33 Mg, 0.011 S and 0.019 P (wt.%). Taguchi approach has been used for the optimization of welding current and time using L9 orthogonal array. Their 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 variable (welding current, time, electrode size) on tensile shear strength properties using mild steel 1 mm thick, 18mm wide and 150mm long sheets and copper electrodes. He used taguchi approach for

design of optimization experiment. The input parameters used included welding current, welding time and electrode dia keeping squeezing time, hold time, electrode force, 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.

Wuttipornpun 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.

M.AgkaKhani et al [19] This research show studies for the material IS 2062 ES250 Mild steel and take input parameter as wire feed rate (W), welding voltage (V), nozzle to plate distance (N), welding speed (s) and gas flow rate (g) and the response was the relationships between the weld dilution and the five controllable input welding parameters such as wire feed wire, welding voltage, nozzle-to-plate distance, welding speed, gas flow rate. And it was found that among main input welding parameters the effect of wire feed rate is significant. Increasing the wire feed rate and arc voltage increases the weld dilution whereas increasing the nozzle to plate distance the welding speed results in decreases weld dilution and gas flow rate did not affect the weld dilution

III. PROBLEM IDENTIFICATION

The term “weldability” has been used to describe a wide variety of characteristics when a material is subjected to welding. These include the physical and mechanical properties of the welded structure. The Weldability of any material/Steel Parts Depends on

- Welding Properties of the Alloy-- Chemical Composition, Metallurgical Properties and Physical Properties.
- Design and Service Requirements-- Design, Loading Condition.
- Welding Conditions-- Preparation for Welding, Welding Operations, and Post- Weld treatments.

A. Factors Affecting Weldability

- Melting point, thermal conductivity, reactivity, coefficient of thermal expansion, electrical resistance and surface condition of material are factor that affect weldability.
- Meting point of metal: Materials with medium melting point can be welded very easily.
- Thermal conductivity: Material with high thermal conductivity (K) are treated as difficult to weld materials.
- Reactivity: If the material reacts with air, water or surroundings it become difficult to weld.
- Coefficient of thermal expansion of metals: Material with high thermal expansion coefficient, it becomes difficult to weld.
- Electrical resistance: Higher the electrical resistance of the material, it becomes difficult because it requires lot of heat energy.
- Surface condition: The material with dirty surface it becomes difficult to weld. From the above mentioned factors whichever the material is influenced by maximum number of factors, the corresponding material is treated as very difficult to weld and whichever the material is influenced by least number of factors, the corresponding material is treated as very easy weld material

IV. EXPERIMENT & DATA COLLECTION

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.
- 4) Determination of experimental error.
- 5) Obtaining the inference regarding the effects of input parameters on the response/characteristics of the process.

In traditional experimental design procedures, a large number of experimental works have to be done when the number of process parameters increases that problem is solved with the help of Taguchi method, which uses design of experiment a special design of orthogonal arrays to study the entire parameter space with only a few number of experiments depend upon % accuracy. The greatest advantage of this method is the saving of effort in conducting experiments, saving experimental time, reducing the cost and discovering significant factors quickly. Therefore, the S/N ratio is the ratio of the mean to the SD. Taguchi uses the S/N ratio to measure the quality characteristic deviating from the desired value. Three type of S/N ratios available, depending

on the type of characteristic; lower the better (LB), nominal the best (NB) or higher the better (HB). The S/N ratio for the higher-the-better criterion is given by Taguchi as:

3. Larger the better (for making the system response as large as possible):

A. Planning Phase Input Parameter & There Levels.

Parameters of the setting	
Control factor	Symbol
Material	Factor A
Welding Current	Factor B
Weld Run	Factor C

Table 1: Parameter of the Setting

Table-1					
Control Factor	Symb ol	Level 1	Level 2	Level 3	
A	Material	EN	8	19	24
B	Welding Current	E	50	100	150
C	Weld Run	R	1	2	3

Table 2: Selected Input Parameter

V. RESULT

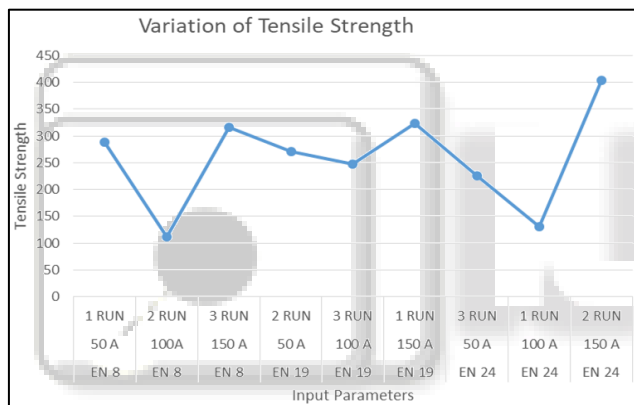


Fig. 5.1: Variation of Tensile Strength vs. Input Parameters

VI. 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.

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