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PARAMETRIC OPTIMIZATION FOR TENSILE STRENGTH AND MICRO- HARDNESS OF MIG WELDING JOINT OF MILD STEEL 1090 AND STAINLESS STEEL 304 USING TAGUCHI TECHNIQUE

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Abstract - Customer satisfaction is now the main tasks and obligations of mgt. organizations. Organizations should thus attempt to establish if their employees need to maintain and improve the quality of service. In this we attempt to achieve the objective of the client. Welding is a manufacturing technique for connecting two different or equal materials by fusing using a wire electrode and also the use of protective gas to safeguard the welding region. Metal Inert Gas Welding may be carried out using optimizing methods and also utilizing process parameters and their levels in this experiment. In this study, we discover that welding joints optimized for maximum tensile strength and micro hardship of the welding joints are best suited to certain process parameters, such as welding current, welding voltage, gas flow rate, etc. Taguchi technique that minimizes process variance via experimental design. The primary aim of this technique is to offer the high quality product at reduced costs and also to save time during experiments. The purpose of the experimental design in Taguchi is to examine how different parameters influence the mean and analysis of variance in the process performance characteristics, which describe how the process works. Taguchi involves the experimental design that uses orthogonal arrays to arrange factors that influence the levels and process at which they vary. Taguchi method is excellent if a few factors make a substantial contribution. In this research, the optimum Gas Metal Arc Welding settings for improving the softening ability of Mild Steel1090 & Stainless Steel304 under different circumstances are shown. In Taguchi 'DOE' this method may be utilized effectively in the optimization strategy for the welding process parameter as well as in the production operations.

Key Words: Fusing, Wire electrode, Taguchi Technique, Orthogonal arrays, Gas metal arc welding, Steel 1090, Stainless Steel 304

1. INTRODUCTION

1.1 Welding

Welding is a Joining process of similar and dissimilar metals with the use of filler rod or with or without the use of application of pressure. The procedures of brazing and soldering are similar to welding processes. During welding process metals and thermoplastics are welded. The welding process is widely used in domestic and industrial purposes, such as joining of railway lines, ship building, roadways, bridges and machinery's parts.

1.2 HISTORY OF GAS METAL (MIG) ARC WELDING

The history of MIG welding, power supply and the continuous feed of electrode wire. And knowing how to mix the gases and produce the optimum protection method.

In 19th Century

The 'Humphrey Davy's discovered the arc welding in 1800s.and MIG welding was developed around 19thCentury. Firstly, carbon electrodes were used, after later1800s, 'N.G. Slavianoff' and 'C.L. Coffin 'invented the metal electrodes

Beginning of 20th Century

In 1920s,'P.O. Nobel' was invented the predecessor of GMAW. During this process direct current, bare electrode wire and arc voltage was used to regulate the continuous feed rate. A shielding gas was not used to protect the weld area.

In 1926's

Another forerunner of Gas Metal arc welding was released in 1926s. During practical work this process was not suitable.

In 1970's

Additional power source was created in the 1970s. And the GMAW-P and GMAW processes continue to be improved. GMAW's work was finished at the "Welding Institute of the UK." This establishes the linear connection between pulsed frequency and wire feeding speed.?

In 1990's

'Lincoln Electric' develops the arc power source surface tension transfer (STT). 'Lincoln' comprises digital circuits and arc welding software. The waveform generator, technology which requires no consistent voltage and current sources, produced electricity throughout this procedure.

Today, GMAW is the most economical welding process, used in sheet metal, automobiles industries. And today's GMAW is using for a wide variety of a materials type and thickness. And selection of electrodes based on the material thickness and current ranges.

1.3 METAL INERT GAS (MIG) WELDING

MIG welding is an arc welding technique in which solid consumable wire electrode is supplied between the work pieces by use of a welding flame. Properly connecting the two materials. Or electric arcs are formed in this process between the work piece and the wire electrode, which heats and melt and connect metals. A shielding gas also serves to protect the welding region from external conditions and supply the soldering flask or gun, such gases as argon, helium, carbon dioxide, nitrogen, etc. Mostly CO2 is widely used in MIG welding, because it is least expensive and used for deeper penetration etc. This type of welding process can be automatic and semi-automatic. For MIG welding

thickness of metal should be more than 3mm. The most commonly power source of MIG welding are constant voltage and direct current are used. There are some following metals are used for MIG welding such as, Mild steel, Stainless steel and Aluminum etc.

1. Mild steel is easily weld and have less amount of problems.
2. Aluminum is difficult to weld with MIG welding due to oxides are deposited during welding process. But easily weld with TIG welding.
3. Stainless steel is easily welded but requires more skill than mild steel.

MIG welding can be easily done with ferrous and non-ferrous metals. And has great role in industries due to flexibility, and higher deposition rates etc.

Gas metal arc welding (GMAW) can be done in three ways:

Automatic welding- In this process equipment's are used which welds without adjusting the controls by an operator. This type of welding controls the alignment of gun in a welding joint.

Machine welding- It uses gun which is connected with manipulator. An operator which set sand adjusts the controls that move the manipulator.

Semi-automatic welding- In this process equipment which controls the electrode wire feed. Welding gun's movement is controlled by hand. It is also known as hand-held welding.

1.4 VARIOUS TYPES OF WELDING JOINTS

In welding joint, two or more piece of metals is combined to each other. Materials of welding either metal or plastic which depends on the materials too. Welding joint is said to be when two pieces of materials are joined. e.g. when two pieces are combined to each other's, Then welding is used. There are many types of welding joints, which are following:-

- Butt joint
- Corner joint
- Edge joint
- Lap joint
- Tee joint

2. LITERATURE REVIEW

The optimization of tensile strength and micro-hardness characteristics of several MIG soldering metals was discussed in this literature. The literature review on MIG welding was collected from research papers, books and articles on MIG welding. The following abstract has been discussed by many writers. They are linked to the optimization of MIG welding settings for different metals.

LITERATURE SURVEY

- **Wei-Chih Chug et al. (Jan. 2009)** in this literature Chung, describe the heat input on stress corrosion cracking on the heat affected zone with steel A508. On round bar tensile specimen on constant extension rate were conducted. In multi-pass welding operation, low heat input is better than high heat input which results in the SCCresistance.
- **K. Kishore et al. (Jan 2010)** carried out a study of AISI 1040 Gas Shielding Arc Welding (MIG and TIG) flaws. The orthogonal array was described using taguchi methods. The ANOVA can get the data. Parameters optimizing minimal faults in this research. Ultrasonic testing equipment gathers current working data in which angle beam techniques were used for the testing of welded materials.
- **Honarbakhsh-Raouf et al. (May 2010)** This literature showed that the impact of FCAW welding hardness and microstructure is up to 5 mm thick.In this method, author studies the impact of soldering speed, wire feed rate, etc. in three factors, such as soldering speed, wire feed rate and temperature. Hardness tests were conducted after the welding procedure. And the development of the microstructure has also been done. After this procedure, the outcome was changed and the grain size, hardness etc. was affected.
- **Abbasi. K et al (Nov. 2010)** this author, shows the effect of increasing the pressure on the MIG welding. Shielding gas is used as a mixture of argon and co2. During welding process study of three parameters are also done. And also study on the variation changes with pressure at the different wire feeds.
- **Mr. L. Suresh kumar et al. (Feb. 2011)** in this literature review author discuss on the AISI 304 and AISI316 for the MIG and TIG welding process. Three parameters are involved in this study such as, current, root and angle gap and weldingspeed.TaguchitechniqueisusedforL9orthogonalarray.Also studied on the tensile strength, hardness, grain structure, elasticity and ductility. in this literature, the author shows the comparison between TIG and MIG welding process. Where the MIG welding specimen has higher ductility than TIG welding specimen, TIG welding specimen has higher tensile strength than MIG welding specimen.

3. TAGUCHI OPTIMIZATION APPROACH

Taguchi technology is a methodology of quality engineering which was created by a Japanese engineer, Genichi Taguchi, in the 20th century. Taguchi techniques use factorial designs of two, three and mixed levels. This approach focuses on the use of engineering rather than the sophisticated statistical methodology. Taguchi's primary goal is to improve quality at a minimal cost. Taguchi technology develops experimental design techniques to examine how the various factors influence the variance and mean process parameters. In Taguchi technique design of experiments is proposed where 'OA' which to organize the input parameters and different levels at which varies. Taguchi technique is best and used when an intermediate no. of variances such as, 4 to 55 between some variables and few variables are contributing. Which refer the designs as "off-line quality control" because it ensuring the good quality performance in the design stage.

3.1 PHILOSOPHY OF TAGUCHI TECHNIQUE

Taguchi technique is used for both shop floor and upstream quality engineering. Shop floor is based on the cost, maintenance quality and real time for monitoring. And

upstream method is used for small scale and to reduce the cost, variability and market place. And also more improvement technique which reduces the time and cost etc. following three simple concept of Taguchi's philosophy such as;

- Quality of a product should be designed and not in specter.
- The quality which is best to achieving by the minimizing the deviation from the target.
- From the standards the cost of the quality must be measured as a function's deviations and losses must be measured the system wide.

In Taguchi technique poor quality cannot improve by the screening, inspection etc. in this process it involves the three parameters such as, parameters, system and tolerance design etc.

3.2 DESIGN OF EXPERIMENTS STRETAGY

Design of experiments uses Taguchi technique which satisfying the process and product design and optimization problems. DOE technique of investing and defining the possible combinations and to identifying the optimal combinations also identified the different factors and their levels. The main objectives of the DOE are that to determine the optimum levels for the various variables and to obtain the satisfactory outputs.

Following objectives of DOE are

- To investigate the optimum conditions for a process or products etc.
- To estimate the response under the various best or optimum conditions.
- To investigate the contribution of various interactions and parameters.

3.3 LOSS FUNCTION OF THE TAGUCHI METHODS

It is a graphical representation of various varieties of non-perfects parts that can be leads to the overall losses for a manufacturer etc. and developed by 'Genichi Taguchi'. It involved with poor quality and credit for increased focus on the continuous improvements. The Loss function of Taguchi maintains the growing loss both for society and the producers, which depends on the unpredictability of the process' goal value or design parameters. The more the departure from the goal, the bigger the loss. The loss notion depends on the variance and is linked to costs and benefits associated with reliability at system levels.

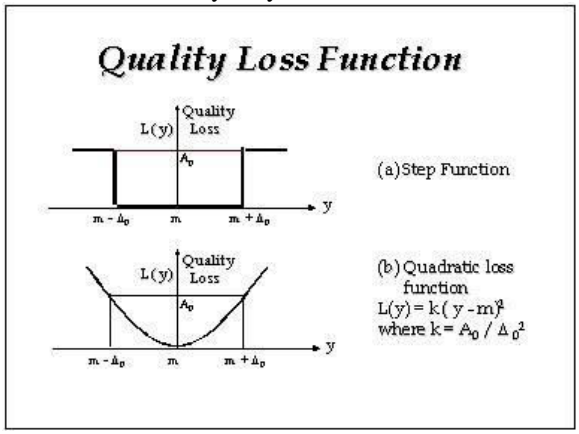

Figure 1 Taguchi Loss Function

3.4 SIGNAL- NOISE RATIO

Taguchi technique uses the S/N ratio and to minimize the quality of products variation due to various parameters. There are following three types of S/N ratio can be used such as;

1. Larger the better
2. Smaller the better
3. Nominal the best

3.5 ANALYSIS OF VARIANCE (ANOVA)

ANOVA's purpose is to study the design factors that influence the quality of the goods. This is shown by the overall variability of the S/N ratio assessed by a sum of square variance in design parameters from the total average S/N ratio. A total square deviation sum from the overall average S/N ratio may be computed. This may be determined by

$$SST = \Sigma(n_i - n_m)^2$$

Where,

n_i = S/N ratio of i^{th} run or experiment.

n_m = total mean of S/N ratio

4. METHODOLOGY

In this research there are mainly eight parameters are used. But during MIG Welding operation three parameters are used. This can optimize the strength and hardness of welding operation. The following processes parameters were selected for this experimentation work.

- Welding Current -A
- Welding Voltage -B
- Gas Flow Rate -C

TABLE 1: Selection of process parameters

Sr. No.	Symbols	Process Parameters	Unit
1	A	Welding Current	Amp
2	B	Welding Voltage	Volt
3	C	Gas Flow Rate	L/min

4.1SELECTION OF QUALITY CHARACTERSTICS OF MIG WELDING

Here 2nd procedure for the Taguchi technique is to determine the quality characteristics of MIG Weld Joint should be optimized. This type of quality characteristics which is one of the most important parameters whose variations effects on the product quality. It observes the o/p variation. For e.g.- wt, hardness, corrosion, radiation and strength of a structure etc.

Here, two quality characteristics of MIG Welding joints are selected in this research. They are:-

- Micro hardness
- Tensile Strength

4.2 SELECTION OF ORTHOGONAL ARRAY FOR TAGUCHI APPROACH

In this process where, selection of process parameters are decided by after studying the research paper before the selection of orthogonal array is used as a matrix for conducting the experiments, here there are two main following points were considered

1. No. of levels of the parameter of interest.
2. No. of parameters and interactions of interest.

If there is more than two levels are used for the process parameters then its behavior will be non-linear. Therefore, each parameter means how many parameters are used to analyze at the three levels. The selection of process parameters and their levels are given in table no.

TABLE 2: Taguchi L9 (L 3*3) orthogonal array matrix

No of Runs	Control Factors		
	A	B	C
1	L1	L1	L1
2	L1	L2	L2
3	L1	L3	L3
4	L2	L1	L2

4.3 SELECTION OF BASE MATERIAL FOR MIG WELDING OPERATION

Mild Steel1090 and Stainless Steel304 is selected as a base material for the experiment work. Here, the base material are in fig.2.

Fig. 2 Base Material (Left) Mild Steel1090, and (Right) Stainless Steel304

4.4 PROCEDURE FOR PREPARATION OF SPECIMEN OF MILD STEEL1090 AND STAINLESS STEEL304

To prepare the specimens of plates for mild and stainless steel with dimensions (150*75*6 mm) were used cutting of plates then V-joint with 60 degree angle will be made. Tracking will be done on the back sides of the both plates, to avoid the leveling mistake after tracking, specimen will be kept under the electron on the flat plate for welding operation as shown in fig no.4.2. of MIGMATIC Machines then clamp the specimen with base metal plate using clamped. Then by putting the different types of process parameters one by one will be done in V-groove for the 9plates.

Fig.3. Performing GMAW operation on plates

Fig4. Weld Specimen after GMAW operation

5. RESULTS AND CONCLUSION FOR MIGWELDIING

ANALYSIS OF TENSILE STRENGTH

Table 3 Tensile Strength Value & S/N ratio's Values

RUN	CURRENT (Amp)	VOLTAGE (Volt)	Gas Flow Rate (L/Min.)	TENSILE STRENGTH (MPa)
1	100	15	15	425.12
2	100	20	20	437.23
3	100	25	25	420.35
4	125	15	20	475.78
5	125	20	25	573.32
6	125	25	15	558.85
7	150	15	25	464.64
8	150	20	15	424.58
9	150	25	20	537.41

5.1 Results and Discussion of the tensile Strength

Every linear model analysis gives the low-level coefficient of each factor, p- and variance table analysis no. Uses the result to determine the factor in relation to the response data and the relative of each component in the mode is essential.

Absolute value that shows the relative significance of each component in the sequence and adjusted square sum of the ANOVA response The table shows the proportional significance of each element which has the largest effect on the square. These findings are shown in the answer tables. The response tables 5.2. reveal the average S/N ratio and mean of each response characteristics. For each degree of the individual variables. The table contains the rank based on the delta statistics and compares it with the relative size of impacts, Minitab that assigns the rank, 2nd and 3rd uses of levels in the answering table to find the optimal outcome of each of the variables.

These rankings are shown in our experimental work and have soldering current, with the greatest effect on the S/N ratio and the soldering voltage, followed by the gas flow rate. Our aim is thus to improve the tensile strength of MIG. We want to maximise the S/N ratio and also to see maximum means by joining various materials and also to factor levels, which create the greatest average of Taguchi method. At 150A, the voltage was 15V and the gas flow rate was 25 L/min.

Table4. Results of Optimum Parameter for Tensile Strength

Welding Current	Level 3	125
Welding Voltage	Level 3	25
Gas Flow Rate	Level 2	25

So, these results show the higher tensile strength of Mild Steel 1090 and Stainless Steel
304. When using the 125 amp Welding Current, the 25 Volt Welding Voltage and the 15L/min Gas Flow Rate. These are thus ideal welding conditions to achieve the greater tensile strength of Mild Steel 1090 and Stainless Steel 304.

6. CONCLUSION AND FUTURE SCOPE FOR THE MIGWELDING OF MS1090 & SS304

The conclusion for this study can be concluded in the following steps

- Design Of Experiments (DOE) tech. which is widely used and to optimize the MIG Welding parameters in welding operation.
- Optimum parameters levels for the tensile strength
- % Contribution by each parameter on the tensile strength

PARAMETER	% CONTRIBUTION
Welding Current	46.29%
Welding Voltage	25.08%
Gas Flow Rate	6.56%

- % Contribution by each parameter of the Hardness at Weld Area

PARAMETER	% CONTRIBUTION
Welding Current	31.14%
Welding Voltage	41.29%
Gas Flow Rate	24.61%

FUTURE SCOPE

- By using Taguchi technique we can optimize the other parameters.
- By using optimization approach we can reduced the cost of operations.
- During this operation means MIG Welding of MS 1090 AND SS 304, which increase the weld ability of the joints of two different materials.

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