THE EXPERIMENTAL ANALYSIS OF VARIOUS PARAMETER OF SHIELDED METAL ARC WELDING VALIDATION OF TAGUCHI METHOD

[1]Mr. Mane Sambhaji B., [2]Prof. Shitole J.S., Prof. Rajput A.D.

[1]PG Student, [2, 3]Assistant Professor

Dattakala Group of Institutions Faculty of Engineering, Maharashtra, India

ABSTRACT

This project is developed Shielded metal arc welding (SMAW) by using Taguchi method. Welding process parameters can plays a important role in determining the quality products of the welded joint in Shielded metal arc welding (SMAW) welding operation. To accomplish the target an endeavour has been made to choose significant welding boundaries like welding current, welding speed, root hole and position of terminal dependent on field master's ideas, accessible writing and on logical reasons. Taguchi Technique shall be used to conduct the experiments: - The Taguchi method has become an influential tool for improving output during research and development, items can be created rapidly and at least expense

Keyword: **-** *Taguchi Method, Shielded metal arc welding, UTM, Minitab 17*

1. INTRODUCTION

Shielded metal arc welding (SMAW), or than called manual metal welding (MMA or MMAW), transition protected curve welding or casually as stick welding, is a manual curve welding measure that utilizes a consumable anode covered with a motion to lay the weld .

An electric flow, as either exchanging flow or direct flow from a welding power supply, is utilized to frame an electric circular segment between the anode and the metals to be joined. The work piece and the cathode softens shaping a pool of liquid metal (weld pool) that cools to frame a joint. As the weld is laid, the transition covering of the anode crumbles, emitting fumes that fill in as a safeguarding gas and giving a layer of slag, the two of which shield the weld region from barometrical tainting.

As a result of the flexibility of the interaction and the straightforwardness of its gear and activity, safeguarded metal curve welding is one of the world's first and most mainstream welding measures. It rules other welding measures in the upkeep and fix industry, and however motion cored curve welding is filling in notoriety, SMAW keeps on being utilized broadly in the development of substantial steel structures and in modern creation. The cycle is utilized essentially to weld iron and prepares (counting tempered steel) however aluminium, nickel and copper compounds can likewise be welded with this strategy.

Welding current, arc voltage, welding speed, type of electrode, diameter of electrode etc. are the important control parameters of Shielded metal arc welding process. They influence the weld quality as far as mechanical properties and weld dot calculation. The worth of profundity of entrance expanded by expanding the benefit of welding current and the grain limits of the microstructure are shifted when the welding boundaries are changed

Taguchi Technique shall be used to conduct the experiments: - The Taguchi method has become an influential tool for improving output during research and development,. So that products better quality can be produced fast and at very low cast. Dr. Taguchi Telephones and Telegraph Company, Japan has authorize a method based on "ORTHOGONAL ARRAY" experiments which gives much reduced "variance" for the experiment with "optimum settings" of control variables. Consequently the marriage of Design of Experiments with improvement of control boundaries to discover best outcomes is achieved in the Taguchi Method. "Symmetrical Arrays" (OA) gives a bunch of even (least) tests and Dr. Taguchi's Signal-to-Noise proportions (S/N), which are log elements of wanted yield, fill in as target capacities in improvement, help in information examination and The reason for the investigation of fluctuation (ANOVA) is to analyze which plan boundaries altogether influence the quality trademark and assessment of ideal outcomes. The Factorial Design, Taguchi Method, Response surface strategy can be applied as the DOE (Design of Experiment). What's more, we can likewise utilize Optimization procedures like, fake neural organization, Gray connection examination, Genetic calculation, S/N proportion and so forth MINITAB programming is a valuable guide for the above reason.

A.SMAW can be done in three different ways:

Semi-automatic welding- tools controls just the electrode wire taking care of. Improvement of welding weapon is obliged physically. This might be called hand-held welding.

Machine Welding - Machine Welding - utilizes a weapon that is associated with a controller or the like (not hand-held) an administrator needs to continually set and change controls that move the controller.

Automatic Welding - utilizes hardware which welds without the steady changing of controls by a welder or administrator. On some gear, programmed detecting gadgets control the right firearm arrangement in a weld joint.

B.Working principle of SMAW welding:

SMAW is completed intently similarly as other bend welding measures. It additionally utilizes an AC or DC power supply that moves current to the terminal holder to deliver a circular segment prompting extreme warmth to liquefy the tip of the cathode and the joining piece of the workpiece with the curve. This bend length is kept up with by the welder by holding a steady space between the cathode and the weld pool that is a structure on the work piece. This workpiece bonds when the bend is taken off it. Then, at that point the joint is acquired.

C.SMAW welding applications:

Electrodes for Welding Low Carbon Steels: ...

Electrodes for Welding High Tensile Steels and Low Alloy...

Manufacturing plants, Shipbuilding, Industrial piping, Railroads, Maintenance and repair.

D.SMAW Welding effecting parameters:

Weld quality and weld statement rate both are impacted especially by the different welding boundaries and joint calculation. Basically a welded joint can be created by different blends of welding boundaries just as joint calculations. These boundaries are the cycle factors which control the weld affidavit rate and weld quality. The weld dot calculation, profundity of infiltration and by and large weld quality relies upon the accompanying working factors

- Electrode size, Welding current, Arc voltage
- Arc travel speed, welding position
- Gas Flow rate, Shielding Gas composition
- Electrode extension (length of stick out)

1. Electrode size:

The electrode measurement impacts the weld globule setup (like the size), the profundity of infiltration, dab width and consequently affects the movement speed of welding. When in doubt, for the same welding current the arc becomes more penetrating as the electrode diameter decreases. To get the greatest affidavit rate at a given current, one ought to have the littlest wire conceivable that gives the essential entrance of the weld. The bigger anode measurements make weld with less entrance yet welder in width. The decision of the wire anode width relies upon the thickness of the work piece to be welded, the necessary weld entrance, the ideal weld profile and statement rate, the situation of welding and the expense of terminal wire. Generally utilized cathode sizes are (mm): 2, 2.5, 3.18, 4, 5 and 6 mm. Each size has a usable current reach contingent upon wire piece and splash type bend or short-circuiting circular segment is utilized.

2. Welding current:

The value of welding current used in SMAW has the greatest effect on the deposition rate, the weld bead size, shape and penetration. In SMAW welding, metals are generally welded with direct current polarity electrode positive because it provides the maximum heat input to the work and therefore a relatively deep penetration can be obtained. At the point when the wide range of various welding boundaries are held consistent, expanding the current will build the profundity and the width of the weld entrance and the size of the weld dot.

3. Welding voltage:

The arc length (arc voltage) is one of the most important variables in SMAW that must be held under control. When all the variables such as the electrode composition and sizes, and the welding technique are held constant, the arc length is directly related to the arc voltage. High and low voltages cause an unsound circular segment. Exorbitant voltage causes the development of inordinate splash and porosity, in filet welds it builds undercut and creates smaller dabs with more noteworthy convexity, yet an unnecessary low voltage might cause porosity and covering at the edges of the weld dab. Also, with consistent voltage power source, the welding current increment when the anode taking care of rate is expanded and diminished as the cathode speed is diminished, different components staying steady. This is a very important variable in SMAW welding, mainly because it determines the type o metal transfer by influencing the rate of droplet transfer across the arc.

E. Problem statement:

To study the various process specification of SMAW

Find optimum values of process parameters from various sets of process parameter using DOE and experimentally.

F. Objectives

Identification of Optimum process parameters of SMAW.

Find optimum values of process parameters by using design of experiment

G. Methodology:

To strike the electric bend, the anode is carried into contact with the work piece by an extremely light hint of the cathode to the base metal. The anode is then pulled back somewhat. This starts the circular segment and consequently the dissolving of the work piece and the consumable anode, and makes beads of the cathode be passed from the terminal to the weld pool. Striking an arc, which varies widely based upon electrode and work piece composition, can be the hardest skill for beginners. The orientation of the electrode to work piece is where most stumble, if the electrode is held at a perpendicular angle to the work piece the tip will likely stick to the metal which will meld the anode to the work piece which will make it heat up quickly. The tip of the electrode needs to be at a lower angle to the work piece, which allows the weld pool to flow out of the arc. As the anode liquefies, the transition covering crumbles, radiating safeguarding gases that shield the weld region from oxygen and other atmospheric gases. What's more, the motion gives liquid slag which covers the filler metal as it ventures out from the terminal to the weld pool. When portion of the weld pool, the slag buoys to the surface and shields the weld from defilement as it hardens. Once solidified, it should be chipped away to uncover the completed weld. As welding advances and the cathode softens, the welder should occasionally quit welding to eliminate the leftover anode stub and supplement another terminal into the cathode holder. In this association utilizing the idea of misfortune work, signal-to-commotion proportions for torsional inflexibility was used and in view of this the ideal levels for input welding not set in stone. The strategy introduced in this investigation is a trial configuration measure called the Taguchi plan technique. Taguchi configuration, created by Dr. Genichi Taguchi, is a bunch of procedures by which the inborn inconstancy of materials and assembling measures has been considered at the plan stage. Albeit like plan of trial (DOE), the Taguchi configuration just leads the fair (symmetrical) trial blends, which makes the Taguchi plan considerably more powerful than a partial factorial plan. By utilizing the Taguchi procedures, businesses can significantly decrease item improvement process duration for both plan and creation, hence diminishing expenses and expanding benefit.

Taguchi recommended that designing enhancement of a cycle or item ought to be completed in a three-venture approach: framework plan, boundary plan, and resilience plan. In framework plan, the designer applies logical and designing information to create a fundamental useful model plan. The goal of the boundary configuration is to improve

The settings of the interaction boundary esteems for further developing execution qualities and to recognize the item boundary esteems under the ideal cycle boundary esteems. The boundary configuration is the critical stage in the Taguchi technique to accomplishing superior grade without expanding cost. The means remembered for the Taguchi boundary configuration are: choosing the legitimate symmetrical exhibit (OA) as indicated by the quantities of controllable components (boundaries); running analyses dependent on the OA; investigating information; distinguishing the ideal condition; and leading affirmation runs with the ideal levels of the relative multitude of boundaries

2. DESIGN OF EXPERIMENT

Design of Experiments (DOE) is statistical technique establish by R.A.Fisher in England in the 1920's to study the effect of multiple variables simultaneously. The DOE utilizing Taguchi approach can financially fulfill the requirements of critical thinking and item/measure plan streamlining projects. By learning and applying this technique, engineers, scientists, and researchers can significantly reduce the time required for experimental investigations. DOE is a procedure of characterizing and putting all potential blends in a test including different components and to recognize the best mix. In this, different factors and their levels are identified.

2.1 The advantages of design of experiments are as follows:

- Numbers of trials is significantly reduced.
- Significant choice factors which control and work on the exhibition of the item or the cycle can be recognized optimal setting of the parameters can be found out.
- Experimental error can be estimated.

2.2 DOE for Study of process parameter effects in welding

Following are the DOE techniques used in optimization work

- Full factorial technique
- Fractional factorial technique
- Taguchi orthogonal array
- Response Surface method (Central Composite design)

Mathematical models are used to establish the relationship between the input and output parameters in welding processes. "MINITAB" and "Design Expert" are the software used for DOE techniques and ANOVA

3. Material used for specimen:

Mild steel material is used for specimen, which is made for testing process. Properties and composition of selected material as follows.

Table 3.1 Chemical properties of work piece material

Material	**Percentage composition (%)**
C	0.08
MN	2
P	0.045
S	0.03
SI	1
AL	0.016
CR	0.006

Table 3.2 Mechanical properties of work piece material

Material properties	**Value**
Yield strength (Mpa)	275.00
Ultimate Tensile strength (Mpa)	462.00
% Elongation	34.00
Reduction in Area	59.00

3.2 Specimen:

Fig 3.2 Specimen

- Specimen diameter at welding section : 12 mm
- Specimen diameter at knurling section : 16mm
- Specimen length: 220 mm

3.3 Welding setup:

- Filler metal: Electrode -3.15,4,5 mm dia.
- Voltage range of SMAW welding machine : 0-100 V
- Current range of SMAW welding machine : 0-240 A

3.4 Process Parameter For Optimization:

1. Welding Voltage
2. Welding Current
3. Welding rod diameter

3.5 Setup used for testing process:

Universal testing machine is used for calculating ultimate tensile strength of welding joint. A universal testing machine (UTM) is also known as a material testing machine, universal tester is most used to test the tensile strength and compressive strength of material.

3.6 Steps in Taguchi Method:

1. Identify the main objective of the experiment.
2. Identify the output response and its system of measurement.
3. the experiments trials on the OA.
4. The data can be analyses by using the statistical techniques signal to noise ratio, the analysis of variance and factor effects to find the significance of process parameters.
5. Find out the optimal levels of variables.
6. Confirmatory experiments done for the verification of the optimal design parameter

3.7 Software used for Optimization Process:

Minitab 17 software we are using for optimization and analysis .Minitab is a statistics package developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972. It is compatible with other Minitab, Inc. software.

4 EXPERIMENTATION FOR OPTIMIZATION OF SMAW

4.1 Welding Parameters:

- Welding voltage : 21,23,25 V
- Welding current : 180,200,220 A
- Welding Rod Diameter: 3.15,4,5 mm

4.2 Levels of welding process parameter:

Table 4.2 Levels of process parameters

Welding parameters	Units	Level 1	Level2	Level3
Current(I)	Amp	180	200	220
Voltage(V)	Volt	21	23	25
Welding Rod Diameter (D)	mm	3.15	4	5

Number of Levels	Number of Parameters (P)																		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16	L16	L16	L16	L32	L32	L32	L32	L32
3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27	L27	L36	L36	L36	L36	L36	L36	L36
4	L'16	L'16	L'16	L'16	L'32	L'32	L'32	L'32	L'32										
5	L25	L25	L25	L25	L25	L50	L50	L50	L50	L50	L50								

.

Fig 4.1 Array Selector

4.2 Orthogonal array for Taguchi method:

Table 4.2 Orthogonal array L9

Sr.no.	Current	Voltage	Rod Dia.
1	180	21	3.15
2	180	23	4
3	180	25	5
4	200	21	4
5	200	23	5
6	200	25	3.15
7	220	21	5
8	220	23	3.15
9	220	25	4

4.2 Procedure of Experiment:

a) Preparing circular M.S. rod of size Diameter 12 mm and length of 220mm in shaping machine for performing SMAW welding.

b) Cleaning the work pieces for any oil or dust

c) Checking and preparing arc of SMAW for performing the SMAW welding operation.

d) Carrying out SMAW welding operation as per orthogonal array combination for each experiment

e) Checking and preparing the tensile testing machine ready for performing the tensile testing operation.

f) Placing the specimens in the jaws correctly

g) Applying the load.

h) Measuring the ultimate tensile strength of each specime

Table 4.3 Ultimate Tensile strength for L9 orthogonal array

Exp No.	Current	Voltage	Rod Dia.	UTS (MPa)
1	180	21	3.15	380
2	180	23	4	400
3	180	25	5	450
4	200	21	4	395
5	200	23	5	439
6	200	25	3.15	360
7	220	21	5	430
8	220	23	3.15	356
9	220	25	4	370

5. SOFWARE ANALYSIS OF SMAW

5.1 Outcomes from project:

After calculating ultimate tensile strength from experiment that data is feeded into Minitab 17 software for further optimization. Minitab software is statical analysis software it provides statical data from software analysis. Results as follows:

Table 5.1 Analysis of Variance for S/N ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
I	2	0.44771	0.44771	0.22386	48.51	0.020
V	2	0.06926	0.06926	0.03463	7.50	0.118
Dia.	2	4.04463	4.04463	2.02231	438.24	0.002
Residual Error	2	0.00923	0.00923	0.00461		
Total	8	4.57083				

Table 5.2 Response Table for Signal to Noise Ratios Larger is better

Level	I	V	Dia
1	44.00	47.28	47.10
2	50.38	46.61	46.85
3	49.05	49.55	49.48
Delta	6.38	2.94	2.63
Rank	1	2	3

Table 5.3 Response Table for Means

level	I	V	Dia.
1	168.8	247.6	244.6
2	331.1	234.2	240.2
3	284.7	302.7	299.8
Delta	262.3	68.5	59.6
Rank	1	2	3

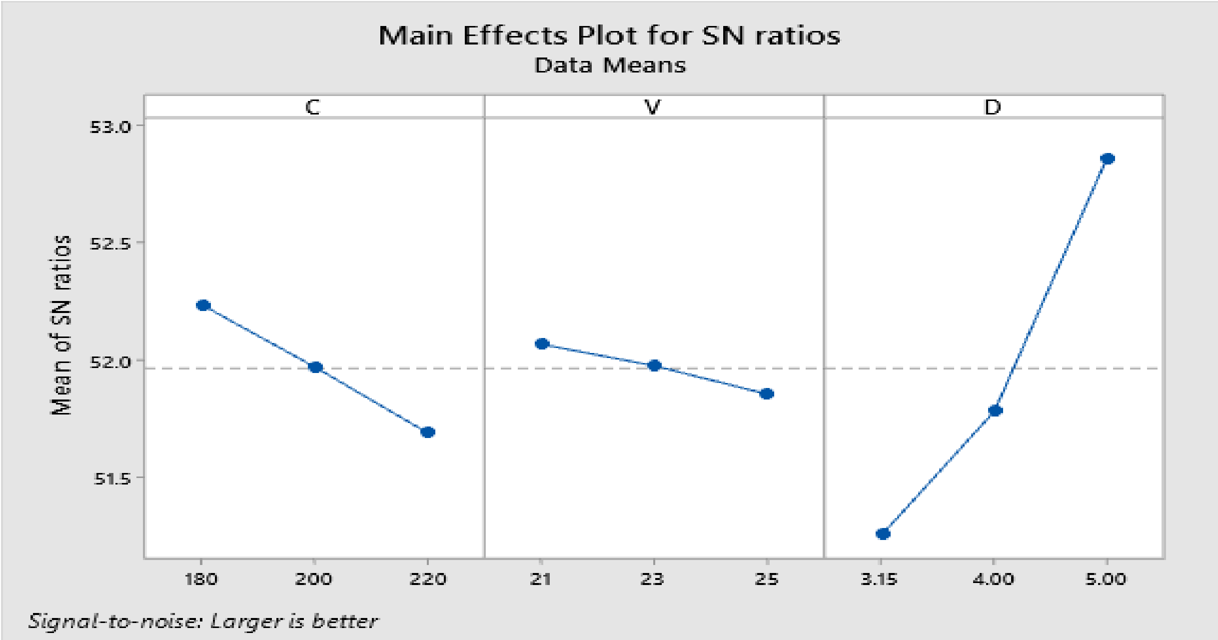

Fig 5.1 Graph from minitab S/N ratio vs process parameters

5.2 Result table

Table 5.1 S/N Ratios for the ultimate Tensile Strength Measurement

Current	Voltage	Rod Dia.	UTS (MPa)	S/N Ratio
180	21	3.15	380	61.13
180	23	4	400	61.58
180	25	5	450	62.60
200	21	4	395	61.47
200	23	5	439	62.39
200	25	3.15	360	60.66
220	21	5	430	62.21
220	23	3.15	356	60.57
220	25	4	370	60.90

6. Conclusion

The present research work describes the use of Taguchi method and statistical techniques for analyzing and optimizing the Process Parameters in SMAW welding of AISI 304.

From the study, the following conclusions are drawn:-

- Main effect plots reveal that voltage and current has significant influence on Tensile strength.
- The optimum welding condition obtained by Taguchi method for maximum strength is AISI 304 Mild steels (i.e. current = 180 ampere, voltage = 21 volts, Rod Diameter) .
- Maximum ultimate tensile strength found on maximum current, intermediate level voltage and low level gas flow rate. Minimum ultimate tensile strength found on low level voltage and intermediate level current and gas flow rate.
- Welding voltage and current affects output UTS more than Welding Rod Diameter.
- In this project varying noise parameters current, voltage, Welding Rod Diameter to get accurate signal parameter in this project UTS. We found high S/N ratio(62.60) at current = 180 ampere, voltage = 25 volts, Welding Rod Diameter= 5mm and minimum S/N ratio(60.57) current = 220 amperes, voltage = 23 volts, Welding Rod Diameter= 3.1

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