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A Review on Optimization of MIG welding Process Parameters using different Method

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ABSTRACT: Metal inert gas welding (MIG) is used extensively in 25 years for joining and fabrication process due to its advantages such as production efficiency, low heat input, less arc, less heat effective zone. Different types of ferrous metals and non-ferrous metals can be join using MIG welding that cannot welded by non traditional welding processes.This paper represents the influence optimum values of process parameters like welding current, welding voltage, feed rate, gas flow rate, welding speed, etc. on the factors like weld strength, weld pool, tensile strength, DOP, microstructure of weld on different material by using different methods. Parameters can be optimized, and the best parameters are obtained for target quality.

KEYWORDS:MIGWelding, ANOVA, Medium Carbon Steel, RSM, GRA, Taguchi Method, Optimization.

I.INTRODUCTION

Metal Inert Gas Welding is arc welding process that make use of a continuous heated solid wire electrode and fed into the weld pool from the welding gun. Process is also known by Gas Metal Arc Welding (GMAW) or Metal Active Gas (MAG). Developed for welding of aluminium and other non ferrous material in the year 1940s, but as it takes lower welding time compared to other welding process. MIG welding was soon applied to steels. The process can be done with manual, semi-automatic and automatic welding process is flexible technique suitable for both thin and thick section component. In this an arc is struck between the end of a wire electrode and the workpiece, melting both of them to form a weld pool. The weld splash are guarded from contamination by atmosphere (i.e oxygen and nitrogen) using externally shielded gas of inert such as argon, helium, CO_2 or mixture of these. The wire serve as both filler metal for the welding joint and heat source (via the arc at the wire tip) so there is no external filler metal is needed. The wire is fed through a copper contact tube which conducts welding current into the wire. Wires may be solid (Simple drawn), or cored (composites formed from a metal sheath with powdered flux). Gas Metal Arc Welding can be effectively used in all positions.

WORKING PRINCIPLE OF MIG WELDING:

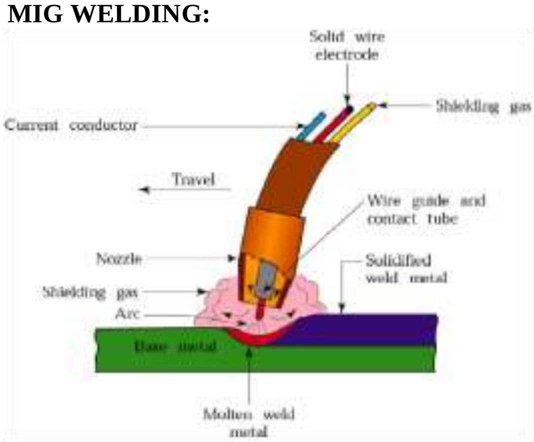

Fig. 1 Working of MIG Welding

As shown in the fig. the filler wire in this process is in the form of coil and continuously fed towards the work during the process, at the same time inert gases like (Argon, Helium, CO2) passes around the electrode. When gas is supplied, it gets ionized and an arc is initiated in between electrode and work piece. The heat is generated, electrode melts due to heat and molten filler metal is falls on heated joint. Continuous welding with coiled wire helps high metal depositions rate and high welding speed. The filler wire is electrode generally connected to positive polarity and workpiece is connected to negative polarity. The power source could be constant voltage DC power source. The gas shield around it prevents weld against atmospheric co contamination and surface oxidation. Filler metal is added manually is not required as it continuously fed through consumable wire pool.

Application of MIG

The MIG may be operated inautomatic or semi-automatic modes. All commercially applicable such as carbon steel, low alloy steel, stainless steel, aluminium, copper, titanium, and nickel alloys can be welded in all position by choosing appropriate shielding gas, electrode and welding variables. With advantage of minimum spatter, quality weld and welding of different metal MIG welding popular applications are

-Fabrication of steel structure and pressure vessel
-For most types of sheet metal welding
-Automotive industry

MIG welding process parameters

The weld deposition and weld quality is controlled by control variables in MIG welding. The Weld bead geometry, HAZ, depth of penetration and overall weld quality and weld deposition influence by following control variables.

Welding Current, Welding Voltage, Gas Flow Rate, Electrode Size, Arc Travel Speed, Shielding Gas, wire feed rate.

1) Electrode Size:

The diameter of electrode influences the weld bead configuration (such as the size), bead width, the depth of penetration and has a consequent effect on the travel speed of welding. A common rule, for the same welding current the electrode diameter decreases then arc becomes more penetrating. One should have the smallest wire possible that provides the necessary penetration of the weld to get the maximum deposition rate at a given current. The larger electrode diameters create weld with less penetration but welder in width. The selection of the wire electrode diameter depends on the thickness of the work piece to be welded, the weld penetration required, the position of welding, the desired weld profile and the cost of electrode wire.Frequently used electrode sizes are (mm): 0.8, 1.0, 1.2, 1.6 and 2.4. Each size has a usable current range depending on wire composition and spray- type arc or short-circuiting arc is used.[7]

2) Shielding Gas:

To protect the arc and molten weld, pool from atmosphere oxygen and nitrogen is the primary function of shielding gas. If not properly protected it forms oxides and nitrites and result in weld deficiencies such as slag inclusion, porosity and weld embrittlement. So the shielding gas and its flow rate have a substantial effect on the following: Arc characteristics, speed of welding, penetration Mode of metal transfer, weld bead profile, cleaning of action and weld metal mechanical properties. Argon, helium and argon-helium mixtures are used in many applications for welding non-ferrous metals and alloys. Argon, Carbon dioxide and mixture of these are used in Carbon steel.[7]

3) Arc Travel Speed:

The rate at which the arc travels along the work- piece is known as the travel speed. It is controlled by the machine in automatic welding and by the welder in semiautomatic welding. The effects of the travel speed are just about similar to the effects of the arc voltage. The penetration is maximum at a certain value and decreases as the arc speed is varied. For a constant given current, slower travel speeds proportionally provide larger bead and higher input to the base metal because of the longer heating time. The high input increases the weld penetration and the weld metal deposit per unit length and consequently results in a wider bead contour. If the travel speed is too slow, unusual weld build-up occurs, which causes lower penetration, porosity, slag inclusions, poor fusion and a rough uneven bead.

The travel speed, which is an important variable in MIG, just like the wire speed (current) and the arc voltage, is selected by the operator according to the thickness of the metal being welded, the joint fit-up and welding position.[7]

4) Welding Current:

The value of welding current used in MIG has the greatest effect on the deposition rate, the weld bead size, shape and penetration.

In MIG welding, metals are generally welded with direct current polarity electrode positive (DCEP, opposite to TIG welding), because it provides the maximum heat input to the work and therefore a relatively deep penetration can be obtained. When all the other welding parameters are held constant, increasing the current will increase the depth and the width of the weld penetration and the size of the weld bead.[7]

5) Welding Voltage:

The welding arc voltage is one of the most important variables in MIG that must be held under control. The arc length is directly related to the arc voltage when all the other variables such as the electrode sizes, the welding technique and the shielding gas held constant. High and low voltages cause an unstable arc. The formation of excessive spatter and porosity, in fillet welds it increases undercut and produces narrower beads with greater convexity which causes due to excessive voltage, but an excessive low voltage may causes porosity and overlapping at the edges of the weld bead. The welding current increase when the electrode feeding rate is increased and decreased as the electrode speed is decreased with constant voltage power source, other factors remaining constant. The arc voltage to be used depends on base metal thickness, welding position, type of weld, electrode composition and size, type of joint, shielding gas composition and other factors.[7]

6)Weld Geometry:

Weld geometry has a direct influence upon weld quality.Weld geometry is used for the selecting welding process. There can be various joints such as butt joint, lap, fillet or T-joint. Bevel may be single- V, double-V or U shape. There can be various Welding positions such as flat, horizontal, vertical, or overhead, etc. Vertical and horizontal welding positions are most commonly used. If the welding position is difficult, then itincreases the problems in achieving the required weld quality.

II.LITERATURE REVIEW

Vijaya Sankar B[1], Daniel Lawrence I[2], Jayabal S[3] work on AISI 310 metal which is one of the most popular boiler and pressure vessel grade of steel plate which widely used in industry for the high temperature application. The factor that were studied are welding current, welding voltage, gas flow rate on the weld joints were studied. AISI 310 was butt-welded by using metal inert gas welding with filler material AISI 310 used with wire diameter 0.8 mm. The study focuses analysis of welding parameter by GRA on MIG welding on AISI310 metal. The significant effect of weld parameter were studied by grey relational analysis.The factor are consider as design factor by L9 orthogonal design to design the plan of the experiment.

Transverse Tensile Test

Identification	Welding Current(A)	Welding Voltage(V)	Gas Flow rate(L/min)	TS (N/mm^2)
1	130	23	13	268.28
2	130	25	15	289.82
3	130	27	17	327.20
4	150	23	17	273.78
5	150	25	13	268.34
6	150	27	15	266.85
7	170	23	15	237.57
8	170	25	17	254.23
9	170	27	13	293.27

Fig. 2 Tensile Strength Results

Identification	Welding Current (A)	Welding Voltage (V)	Gas Flow rate (L/min)	Avg Hardness value in HRB
1	130	23	13	95.0
2	130	25	15	90.3
3	130	27	17	87.0
4	150	23	17	89.7
5	150	25	13	90.0
6	150	27	15	84.3
7	170	23	15	85.1
8	170	25	17	86.3
9	170	27	13	83.7

Fig. 3 Hardness Results

Fig. 2 and 3 shows effect of process parameter in MIG welding process which shows that as voltage value increases, tensile strength increases but hardness decreases and increase in value of gas flow rate increases tensile strength but decreases hardness value. Welding current 130(Amp), welding voltage (27 V) and gas flow rate 17(lit/min) with electrode diameter of 0.8 mm is optimal value. As a result the increasing value of the Voltage and Gas flow rate improves the effectiveness of the process variables such as tensile strength and Hardness while the decreasing value of Electric current. The value of the tensile strength and hardness are widely depends on the factor of Weld current. The effects of Weld voltage, Current and Gas flow rate on the weld joints were determined. Experimental procedure derived by DOE and effects are identified through Grey relational analysis.[1]

Amit Ratan Biswasa[1], Sadananda Chakrabortya[2], ParthaSarathi Ghosha[3], Dipankar Bosea[4] was worked carried out on plate welds stainless steel AISI 304 and medium carbon steel 45C8 using gas metal arc welding (GMAW) process. The input process variables considered for experimentation are include welding current, welding voltage, speed and gas flow rate. yield strength, ultimate tensile strength, weld zone hardness, weld bead thickness, reinforcement of welded joint have been reported.Taguchi's Method has been employed for design of experiment. Based on ANOVA and S/N ratio analysis, result shows the process parameter which significantly affects the responses is welding current also it has been observed that inthe welded zone, the hardness decreases with increasing welding current. It has been observed that with the increase of welding current, weld bead thickness increases and reinforcement decreases. The investigation of both HAZ and weldedzone microstructure have been done, result shows grain structure change from base metal to HAZ and HAZ to weld zone. The grain size is become more compact in the welded zone.
Minitab 17 has been used to determine the number of runs required to get optimal values. L27 OA was used. Optimal values of variable used are welding current is 150Amp, welding voltage 25 Volt, speed 5mm/sec and gas flow rate 8 l/min. [2]

Ajit Hooda[1*], Ashwani Dhingra[2] and Satpal Sharma[2]studied process parameters such as welding voltage, current, wire speed and gas flow rate.develop a response surface model to predict tensile strength at MIG welding of AISI 1040. Response Surface Methodology (RSM) was applied to optimizing the MIG welding process parameters to attain the maximum yield strength of the joint. Experiments were conducted based on face centred composite design matrix, three-level and four-factor. The test specimens were composed of two pieces each, and each piece was 300 mm × 150 mm × 8 mm in size. AISI 1040. ER70S-6 filler wire with diameter of 1.2mm was used as consumable electrode.

Yield Test	Yield Strength MPa	Voltage V	Current A	Wire Speed m/min	Gas Flow Rate l/min
Transverse	374.571	22.5	190	2.4	12
Longitudinal	398.907	22.5	210	2.4	12

Fig. 4 Optimized Values of Input variables

The maximum yield strength, at the optimum values of process variables-welding voltage, welding current, wire speed and gas flow rate was experimented. The longitudinal yield strength isgreater than the transverse yield strength.[3]

JigarShah[1], GauravPatel[2], Jatin Makwana[3]performed experiments and presents the influence of welding parameters like welding current, welding voltage, wire feed rate, Gas flow rate etc. on weld strength, ultimate tensile strength, and hardness of weld joint. The parameters are optimize using DOE method and having the best parameters combination for target quality. Analysis done using ANOVA, the optimization of variable done using GA and ANN. From the ANOVA result it is observed that the gas p0ressure and welding current are influencing parameter for tensile strength and these two parameters are highly influencing parameter compare to welding speed for hardness.

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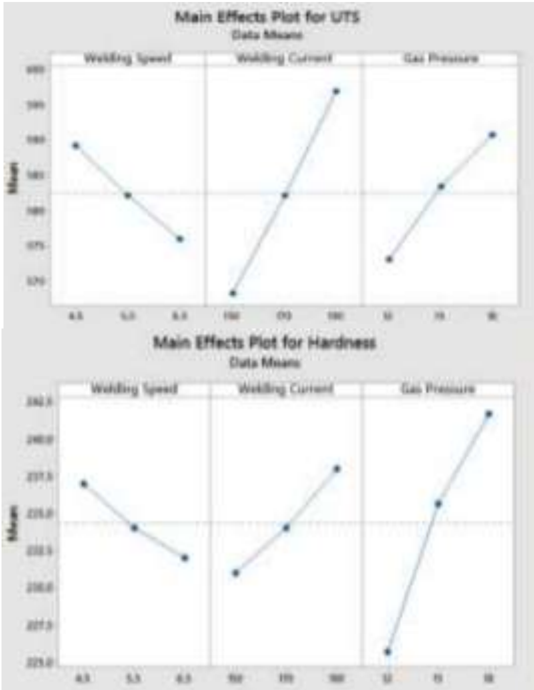

Fig. 5 Main effects plot

The graph generated by use of Minitab17 statistical software is useful to find out optimum parameter value for response variable. The figure of main effect plot shows that high tensile strength will meet at gas pressure 18psi, welding current 190A and welding speed 4.5 m/min. fig. shows that high haedness value will meet at 18psi, welding current 190A and welding speed 4.5m/min.[4]

Santosh J. Bardeskar[1],Shitole Jagdish[2] Studied influence of welding parameters like welding current, welding voltage, Gas pressure on UTS of two dissimilar material (AISI304 & IS2062) during welding. For plan of experimentation Taguchi technique has been used.OA,S/N ratio and ANOVA are applied to study the weld characteristics of material & optimize the welding parameters. The result shows optimal parameters for maximum tensile strength. The study done for effect of microstructure while welding of AISI 304 and IS 2062,it is observed that welding current and welding voltage are major influencing parameter on tensile strength of welded joint. The carbon steel wire with diameter of 1.2mm was used as filler material and 5mm of plate thickness.Singlepass on 150x35 mm plate with gas metal arc welding process and V-butt joint used with use of 100% argon gas was used as shielding gas.

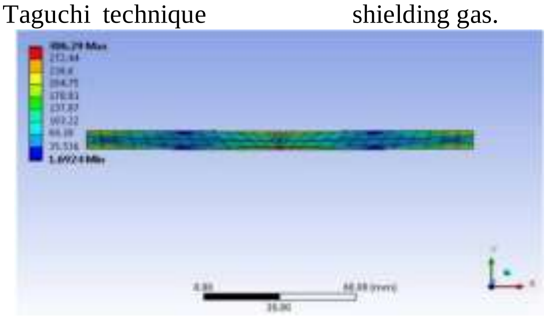

Fig. 6 Von – Misses stress of Welded joint

The value of von- misses stresses developed in the weld joint in the model is 272.44MPa of tensile nature and 168.22MPa of compressive nature. Optimization is done by GRA and ANOVA.

Optimum welding condition for higher tensile strength obtain by taguchi are at pressure of 18Psi, welding current 150Amp and welding voltage 25 Volt. Other then this shielding gas, wire feed rate, diameter of electrode etc. are also

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important control parameter in metal inert gas welding process.[5]

Benazir Aftab[1],Yogesh Mishra[2]Studied MIG welding of mild steel of 5mm thickness with process variables welding current, gas flow rate, nozzle to plate distance to get high strength. The experimentation designed with Taguchi L9 Orthogonal Array(OA).After performing welding, welded specimen were cut for tensile test with dimension of 100mm x 25 mm, which further cut in to 'I' shape for tensile testing. The analysis of effect of welding current, gas flow rate and nozzle to plate distance on the tensile strength of weld joint, microstructure of the joint & micro hardness of weld pool.The tensile strength and hardness are mechanical properties which were consider for work. It was found that preheat temperature has also most significant effect on the hardness and tensile strength. After study it was fount that with optimum values of welding current 124A,gas flow rate 15l/min and preheat temperature 275°C, the higher value of hardness and tensile strength was achieved.

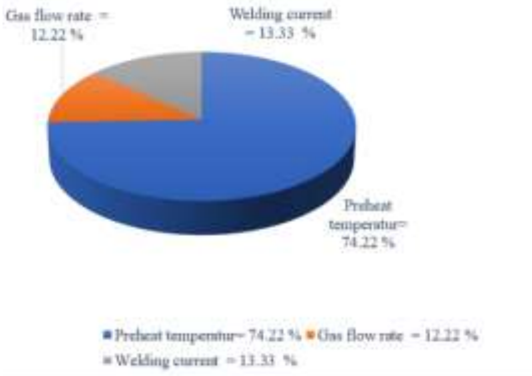

Fig. 7 Pie Chart of Percentage Contribution

The percentage contribution of process parameter for hardness and tensile strength as shown in chart. The preheat temperature contribute maximum which is 74.22%, gas flow rate contributes 13.33% which mainly responsible to affect tensile strength and the welding current having minimum contribute 12.22% which is minimum.[6]

III. DESIGN OF EXPERIMENT (DOE)

Design of Experiments, given by Ronald A. Fisher during the 1920s, is a well-built statistical technique to study the effect of numerous variables at the same time. By designing the experiments using Taguchi approach, one can fulfil the requirements of a problem and optimize the process or product design projects. Using this technique scientists, engineers and researchers can be time efficient in experimental investigations. In an experiment, DoE technique give all the possible combinations to detect the best combination. For this, various factors along with their levels are pinpointed. The main objective of a well-planned and designed experiment is to know in a process which combination of variables influencing the performance most so that one can find out the best level for that combination of those variables to get desired practical output in products. In the research papers considered for above literature review, following DoE techniques have been mostly used to study and optimize the effects of process variables in MIG welding:

a.) Taguchi Orthogonal Array
b.) Full Factorial technique
c.) Response Surface Methodology
d.) Fractional Factorial technique

Analysis of Variance ANOVA is used to learn the response of each process variable on the response parameter. Software mostly used are "MINITAB" and "Design Expert" for ANOVA and DoE. Through mathematical model the correlation between input and output variables in the welding process is established.

IV.CONCLUDING REMARK

In this literature survey have been concluded that current is as effective parameter in welding. After that welding speed and voltage can affect the welding.

It is found that from the review paper study when the welding current, voltage, gas flow rate increases, the tensile strength decreases, but when welding speed increases, the tensile strength also increases.

For Design of Experiments various methods are available but for more process parameters RSM is suitable for optimization.

The Study found that the control factors had varying effects on the response variables.

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L9, L27 orthogonal arrays, S/N ratio analysis of variance were used for study.

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