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Experimental Investigation of MIG Welding for ST-37 Using Design of Experiment

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Abstract: In this research work of Gas Metal Arc Welding(GMAW) show the effect of Current(A),Voltage(V),Gas Flow rate(L/Min) and Speed(M/Min) on Ultimate Tensile Strength(UTS) of st-37 low alloy steel material, In this Experiment we done Experiment by using L9 orthogonal Array to find out UTS and also perform confirmatory Experiment to find out optimal run set of current, voltage speed and gas flow rate.

Index Terms- MIG Welding,L9 Orthogonal Array ,S/N ratio,ST-37.

I. Introduction

MIG welding is also recognized by gas metal arc welding. It is a semi-automatic process by which the arc length and feeding of wire into the arc can be controlled automatically and operator skills required to positioning the gun at a correct angle and moving it along the seam at a controlled travel speed in the metal transfer depends upon modular and spray transfer. In the 1920's, the basic concept of GMAW was introduced but it was not commercially available until 1948. primarily it was considered to be, fundamentally, a high-current density, small diameter, bare metal electrode process using an inert gas for arc shielding. The application of this process was for welding aluminum and As a result, the term MIG (Metal Inert Gas) welding was used and till now a days. Subsequent process developments included operation at low-current densities and pulsed direct current, application to a broader range of materials, and the use of reactive gases(particularly CO2) and gas mixtures. The commercial metals like carbon steel low alloy and high alloy steels , stainless steels , aluminum , copper , titanium , zirconium , nickel alloys can be welded by nuclear welding. By this process 1-13mm thickness range weld joints can be possible in any welding positions.

In this process consumable flux cored continuous wire or metallic electrode of diameter 0.8-2.4mm wound in spool form is fed at a required present speed through a welding gun, it picks up electric current from copper contact tube which is electrically connected to the DC power source and a shielding gases like argon, helium, carbon dioxide, carbon dioxide-argon mixture, argon-helium mixture. shielding gases are also use to cooled down the gun. MIG welding is use to increase productivity and consistency of quality.

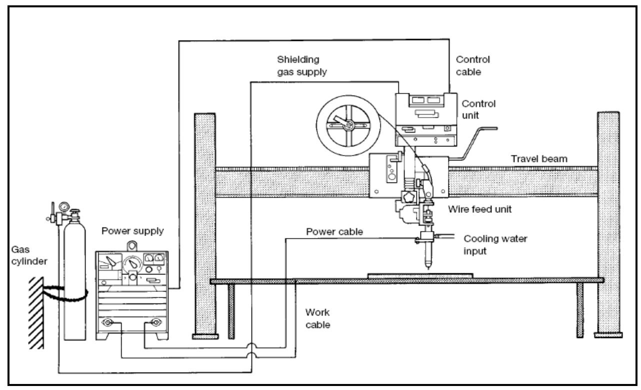

Fig.1. sample of automatic GMAW welding

II. LITERATURE REVIEW

M.Agka Khani et al. studied 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 where as increasing the nozzle to plate distance the welding speed results in decreases weld dilution and gas flow rate did not affect the weld dilution[1].

Gautam Kocher et al. studied for the material IS 2062 E250 Mild Steel and take input parameter as welding speed variable while arc voltage(V),welding current(A),Wire feed rate(W),Distance between the nozzle and the plates are fixed and the response was the effect of weld speed on penetration and reinforcement. This study was undertaken with the objective of determining the effects of weld speed on the weld profile and dilution analysis of the MIG butt welds of IS2062 E250 A mild steel plates at constant wire speed rate and constant arc voltage and welding current[2].

S.R.patil et al. studied for the material AISI 1030 Mild steel and take input parameter as welding current,voltage,weld speed. The response was the signal-to-noise(S\N) ratio and

ANOVA(analysis of Variance) were used for optimization and It was found that tensile strength depends on welding speed. And the result show that by increasing the welding speed and decreasing the current increases the UTS of welded joint while voltage do not affect the weld strength[3].

Harshal k chavan et al. studied single pass corner joint are evaluated by FMEA by ANSYS covers varying heat input, welding speed on thermo mechanical response of weld mint after cooling down to the room temperature. From Results shows that heat input, welding speed has significant impacts on the response[4].

Ajit Hooda et al. studied for the material AISI 1040 Medium carbon Steel and take input parameter as welding voltage,current,wire speed and gas flow rate and the response was RSM(Response Surface Methodology) for maximum yield strength of joint. The similar weld joint of AISI 1040 material was developed effectively with MIG welding with selected range of input variable parameters. The longitudinal yield strength is greater than the transverse yield strength[5].

J.pasupathy et al. studied for the material AA1050 low carbon steel and take input parameter as welding current, welding speed, Distance of electrode from work piece and the response was Signal to Noise(S\N),ANOVA(analysis of Variance) for strength. The experiment value that is observed from optimal welding parameters, the strength & S/N ratio[6].

Miss Nihau Bhadauria et al studied for Experiments were conducted based on central composite face centered cubic design and mathematical models were developed for GMAW process parameters like voltage(V),welding speed(s) and gas flow rate(G).Using these models the direct effect of the process parameters on weld bead penetration were studied. And results shows that as penetration increases the strength of the weld[7].

H.J.Park et al. studied for Experiment on optimizing the wire,feed,speed against the welding speed for lap joint fillet weld of 1.6 mm aluminum alloy which is used for light weight car body and the response was for the same welding speed has wire feed speed increases the bead becomes wider and the bead cross sectional area is increases. As wire feed speed increases the penetration changes from incomplete penetration to excessive melting. The objective function consist of the sum of the bead width, back bead width and bead cross section area for the objective function value 3 the weld quality is ideal[8].

A.R.Rahemanet et al. studied for Experiment on change in hardness, yield strength and UTS of welded joints produced in st37 grade steel his work focus on relationship between MIG welding variables and Mechanical Properties of st37 steel joint. The welding current and welding speed were fixed on 135 A and 50 cm/min and effect of arc voltage on mechanical properties of weld metal was investigated[9]

III. EXPERIMENTAL PROCEDURE

For the research purpose on MIG welding we have chosen the material ST37 after experiment work on different materials like MILD STEEL alloys, IS2062 E250, Low alloy steel etc. we get the our required material as st-37 which is low alloy steel. We fabricate 20 pieces into a dimensions of 100x75x6mm by laser cutting machine. Then we have made all the work pieces in to flate plate standard form with angle of 60^0 .

Then we had took two pieces and set it with maintaining a 1.5mm root gap and then we had started penetration process with desired or selected current,voltage,wire feed rate,gasflow rate readings and done the experiment with the skilled worker in **Truetzschler India pvt.ltd** with the permissions and guidelines of the manager.
Then we had done the all experiments and took readings and made the calculation and table

Table 1. Levels of process variables

Variables	Unit	Level1	Level2	Level3
Current(A)	Amp	110	120	130
Voltage(V)	Volt	21	22	23
Welding speed(G)	M/Min	4.5	5.5	6.5
Gas flow rate(L/Min)	L/Min	8	9	10

Table 2 Experimental layout using L_9 orthogonal array

Current(A)	GAS FLOW RATE(L/MIN)	VOLTAGE(V)	SPEED(M/MIN)
110	8	21	4.5
110	9	22	5.5
110	10	23	6.5
120	8	21	5.5
120	9	22	6.5
120	10	23	4.5
130	8	21	6.5
130	9	22	4.5
130	10	23	5.5

In the welding experiments, we are used ER70S-6 with 0.9 mm diameter. The work pieces consisted of ST-37 Low alloy steel with thickness of 6mm.The chemical composition (wt.%) of both base metal and electrode wire are given Table 3.

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Table 3. chemical composition (wt.%) of work material and electrode wire used

Material	C	Si	Mn	P	S
ST-37	0.113	0.024	0.417	0.007	0.01
Electrode	C	Si	Mn	P	S
ER70S-6	0.10	1.00	1.70	0.010	0.015

3.1TAGUCHI'S DESIGN METHOD

Taguchi technique is used to increases the output and reduced the cost of the products. The Taguchi Design is based on orthogonal array. Taguchi design recognizes the control factors to minimize the effect of Noise factor. Orthogonal array helps to reduced the time and cost of the experiment. The Signal-to-Noise (S/N) Ratio which are log function of required output which is the objective function to be optimized.

larger is better

$$S/N=-10*\log(\sum(1/Y^2)/n)$$

smaller is better

$$S/N = -10*\log(\sum(Y^2)/n)$$

where y = responses for the given factor level combination
n= no of responses in the factor level combination

IV. RESULTS AND DISCUSSION

In this research work the effect of input parameters on the Tensile strength were determine.

Table 4. Experimental result for uts and s/n ratio

Expt.No	(I)	(V)	(S)	(G)	UTS(N/MM^2)	S/N Ratio
1	110	21	4.5	8	400.05	52.0423
2	110	22	5.5	9	454.25	53.1459
3	110	23	6.5	10	427.75	52.6238
4	120	21	5.5	10	437.16	52.8128
5	120	22	6.5	8	434.78	52.7654
6	120	23	4.5	9	434.33	52.7564
7	130	21	6.5	9	213.41	46.5843
8	130	22	4.5	10	420.33	52.4718
9	130	23	5.5	8	436.83	52.8062

The result show that among the input parameters the voltage affects the most and it was observed that gas flow rate do not affect the weld strength. Greater S/N ratio results to better Quality show the optimimum level of process variables.

Table 5. Response table for mean

Level	CURRENT (A)	VOLTAGE (V)	SPEED (M/MIN)	GAS FLOWRATE (L/MIN)
1	427.3	350.2	418.2	423.9
2	435.4	436.5	442.7	367.3
3	356.9	433	358.6	428.4
Delta	78.6	86.2	84.1	61.1
Rank	3	1	2	4

Effect of current : In this experiment the major effect is produced by current & voltage it is most significant parameter among four available. current at value of120A current we get the maximum s/n ratio of 52.8128 and ultimate tensile strength of 434.34(N/mm^2). when the current is too low the molten metal fails to wet the joint surface and cause lack of fusion. with increasing current the melting rate of the electrode is increases.

Effect of voltage: In this experiment the major effect is produced by voltage it is most significant parameter among four available. voltage at value of 22V we get the maximum s/n ratio of 52.8128 and ultimate tensile strength of 434.34(N/mm^2). this is a very important variable in MIG welding, mainly because it determines the type of metal transfer by influencing the rate of drop late transfer across the arc. the arc voltage to be used depends on the base metal thickness, type of joint, electro composition and size, shielding gas composition, welding position, type of weld and other factors

Effect of speed: In this experiment the major effect is produced by speed it is significant parameter among four available. speed at value of 5.5(M/Min) speed we got maximum signal to noise ratio as 52.81. and at same Speed 5.5(M/Min) we get maximum ultimate tensile strength of 434.34(N/mm^2). the linear rate (express in cm/min or mm/sec) at which the arc moves around along the joint ,termed arc travel speed, affects weld bed size and penetration. with other variables kept constant, there is a certain value of travel speed at which the weld penetration is maximum.

Effect of gas flow rate: At the value of gas flow rate of 10(L/Min) we get better signal to noise ratio as 52.62 and at 10(L/Min) Speed we get maximum ultimate tensile strength of 434.34(N/mm^2). It is a least affective variable among four of the parameters.

V. CONCLUSIONS

after the experiment we can say that the current and voltage as a input parameter create a significant effect .finally we got the confirmatory experiment at below range and got the optimum value of strength and s/n ratio.

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Table 6 Confirmatory Test Range

Current (A)	Voltage (V)	Speed (m/min)	Gas flow rate(L/min)
110	22	5.5	9

Table 7 Confirmatory Test Result

UTS(N/mm$^{2)}$	S/N ratio
454.25	53.1459

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