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Parametric Optimization of MIG Welding Parameters of EN-31

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***Abstract:** The present investigation for optimization of MIG welding of EN-31 is conducted to establish the influence of MIG welding process parameters on hardness and surface roughness. From the experimental results it is concluded that welding speed is the main influencing parameter for hardness while welding current is least influencing for it. For the case of surface roughness, welding current has major dominance while other parameters were less effective.*
***Keywords:** MIG, EN-31, Hardness, Surface Roughness*

I. INTRODUCTION

Throughout the World, welding is a major fabrication technology that is used extensively for the construction of structures, buildings and bridges and in the civil, automotive, aircraft, aerospace, petroleum, shipbuilding, and electronic industries. Although welding is an addition technique, it is seen by many as a primitive science. During last several years, it has evolved as an interdisciplinary activity that requires synthesis of knowledge from different disciplines and incorporates the most advanced equipments of various basic engineering and applied sciences. Researchers from different disciplines such as arc and plasma physics, thermodynamics materials science, manufacturing, transport phenomena, modeling, robotics, economics, and from various engineering fields that includes mechanical, chemical, and electrical engineering are currently making new innovations.

Major studies have been under research by various researchers in the domain of welding technology. The researchers have performed investigations giving depth knowledge and insight knowledge of present welding technology.

Sindiri Mahesh and Velamala.Appalaraju [1] through their experimentations concluded that with increase in the levels of the selected parameters for MIG welding of AISI 1050, the strength of welded joint is enhanced and all the selected parameters have impact on the strength of the joint. Manoj Singla et al [2] by their study concluded that the Welding current was found to be most influencing variable to WDA. When a constant heat input is provided, and the welds are made using electrode negative polarity having a small diameter electrode and low voltage with low welding speed, it produce large bead area. Most effective design was found for two level fractional half area fractional designs to quantify to main and interaction influences of variable on the weld bead area.

Pushpendra Kumar Sharma et al [3] through their investigation found that the Tensile strength of weld increase in proportion to the weld bead width, because of the higher MIG parameters we observe wider weld head during the construction weld bead hardness. Hardness values are similar in both of them. Biswajit Das, B. Debbarma et al [4] through their research concluded that the higher voltage (> 26.5 V) causes abrupt rise in penetration depth value, whereas very high current (> 150 A) also causes the same. Very high welding speed (> 0.16 m/min) cause a decrease in penetration depth. S.Sivakumar et al.[5] through their study investigated the influence of different factors on welding penetration, micro structural and measurement of hardness for mild steel of 6mm thickness by using MIG welding.

S.Utkarsh et al. [6] in their investigation studied the influence of input parameter such as welding current, welding voltage, gas flow rate in l/min and welding speed in m/min so as to study the Ultimate Tensile Strength(UTS) of st-37 low alloy steel material in MIG Welding (GMAW). Experiments were carried out by using L9 orthogonal array. Srivani Valluru et al [7] in their investigation reveals that Weld Area Hardness is much higher than parent metal hardness and less than Heat affected zone Hardness. Kanwal et al. [8] investigated for optimization of MIG welding parameters for Hardness using Taguchi method. Welding speed, current and voltage were taken as welding parameters. Aluminum alloys of grades 6061 and 5083 were the materials taken into consideration for their study.

II. EXPERIMENTAL DETAILS

1) *Work piece:* The material used for the present work is EN-31 with specification of 25mm×25mm×4mm.
2) *Machine:* ESAB MIGMATIC MIG welding machine available at Punjab Body Builders, Lucknow.

The present investigation is performed by varying welding voltage, welding current and welding speed so as to analyze the hardness and surface roughness.

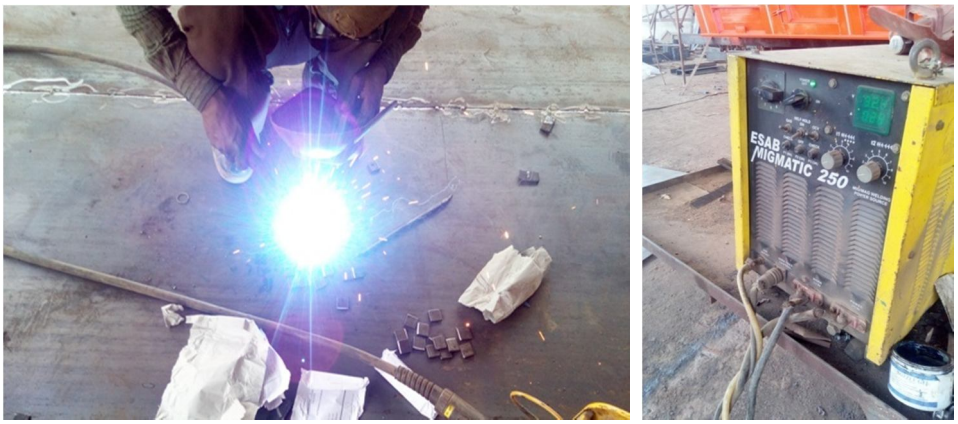

Fig. 1: MIG wedling setup for experiments

TABLE I: SHOWING PARAMETERS USED FOR EXPERIMENTATION ON MIG WELDING MACHINE

S.No.	Parameters	Units	Level 1	Level 2	Level 3
1	Welding Voltage	V	16	20	24
2	Welding Current	A	100	150	200
3	Welding Speed	mm/sec	5	10	15

TABLE IIi: SHOWING EXPERIMENTAL VALUES OF HARDNESS AND SURFACE ROUGHNESS

Exp. No	Welding Voltage	Welding Current	Welding Speed	Rockwell Hardness HRC	Surface Roughness (Ra
1	16	100	5	60.5	3.71
2	16	150	10	62	1.52
3	16	200	15	61	1.78
4	20	100	10	62	1.23
5	20	150	15	59.7	2.59
6	20	200	5	62	3.68
7	24	100	15	58	2.41
8	24	150	5	61	2.79
9	24	200	10	60	3.93

III.RESULTS AND DISCUSSION

A. Influence of parameters on Hardness

The following table III shows the analysis of variance for hardness of welded joint. From the table it's clear that the major dominating factor for hardness is welding speed that yields a contribution of 40.57% followed by welding voltage with a contribution of 33.47%. Welding current have almost negligible influence on hardness of welded joint.

TABLE IIIII: ANOVA TABLE OF HARDNESS OF WELDED JOINT

Source	DOF	SS	Adj MS	F Value	Contribution
Welding Voltage	2	4.709	2.354	1.95	33.47%
Welding Current	2	1.242	0.621	0.52	8.83%
Welding Speed	2	5.709	2.854	2.37	40.57%
Error	2	2.409	1.204		17.13%
Total	8	14.069			100%

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The Hardness initially had negligible influence with both welding voltage and welding speed but with further increase in their levels, hardness tends to decrease. Both these parameters have major influence on Hardness. Moreover, with increase in weld current, initially hardness increase at a faster pace but with further increase in weld current the hardness increases at a slower pace. Following figure 2(a) shows the main effect plot of parameters for Hardness. The optimum parameters were found to be 200A welding current, 20V welding voltage and 10mm/sec welding speed.

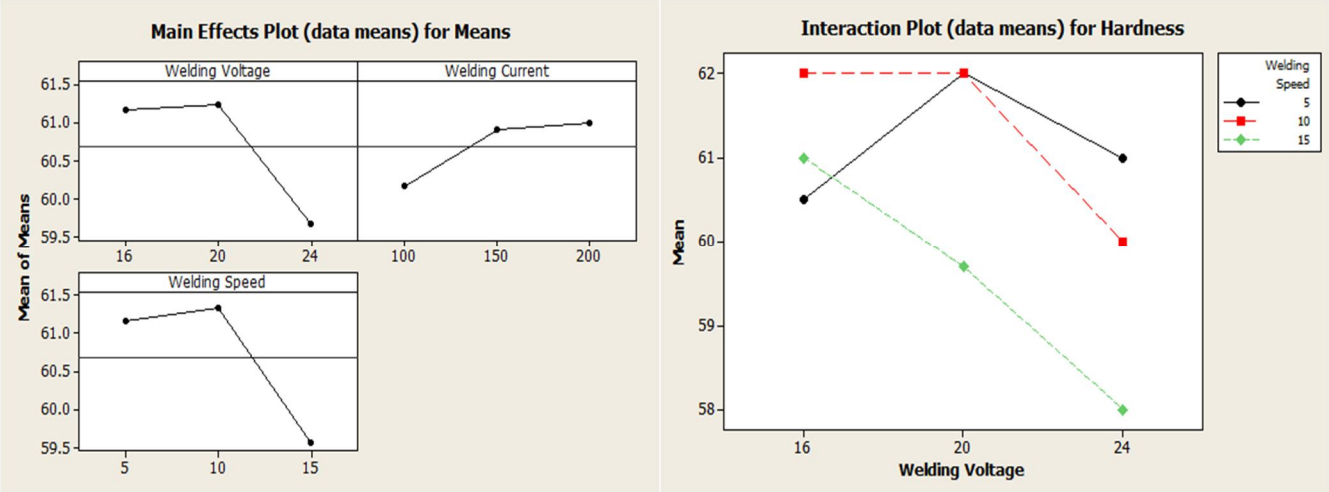

Fig. 2: (a) Main effect plot for Hardness; (b) Interaction plot for Hardness with parameters

The above figure 2(b) shows an interaction plot between Hardness of welded joint and welding voltage at different levels of welding speed. The plot elucidates that the Hardness initially increases and then decreases with welding voltage at lower level of welding speed. With increase in welding speed level, the hardness obtained is higher but it decreases with increase in welding voltage. At higher level of welding speed, the hardness obtained decreases with increase in welding voltage.

B. Influence of parameters on Surface Roughness

The following table IV shows the analysis of variance for surface roughness. From the table it's clear that the major dominating factor for surface roughness is welding current that yields a contribution of 82.82% while the other parameters have almost negligible influence on surface roughness.

TABLE IVV: ANOVA Table OF Surface Roughness

Source	DOF	SS	Adj MS	F Value	Contribution
Welding Voltage	2	0.8213	0.4106	51.12	10.33%
Welding Current	2	6.5835	3.2917	409.76	82.82%
Welding Speed	2	0.5282	0.2641	32.88	6.64%
Error	2	0.0161	0.0080		0.21%
Total	8	7.9490			100%

Surface starts to degrade with increase in levels of welding voltage. As we increase the level of welding voltage poor surface finish is obtained. For welding current, it also follows the same trend as the voltage and surface finish get poor with increase in the level of welding current. Welding current is the most dominating parameter for surface roughness for the present set of parameters. Welding speed is the least influencing parameter for surface roughness. The graph shows that the surface roughness first reduces with increase in the value of welding speed. But on further increase in level of welding speed above 10 mm/sec, the surface roughness slightly increases.

Following figure 3(a) shows the main effect plot of parameters for surface roughness. The optimum parameters were found to be 100A welding current, 16V welding voltage and 10 mm/sec welding speed.

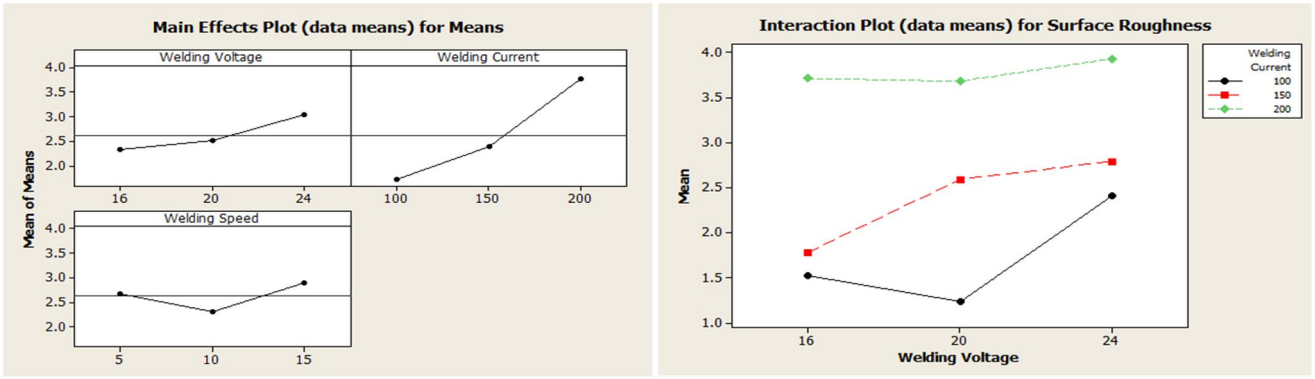

Fig. 3: (a) Main effect plot for Surface Roughness; (b) Interaction plot for Surface Roughness with parameters

The above figure 3(b) shows an interaction plot between surface roughness and welding voltage at different levels of welding current. It depicts that at higher level of welding current, the surface roughness is higher. When the welding voltage value is increased at lower level of current, the surface roughness first decreases and then get increased. At middle level of welding current (150A), the surface roughness obtained increases with welding voltages. With increase in level of voltage at medium speed, the surface degrades. When it comes to higher welding current, the surface roughness almost remains constant with increase in the value of voltage.

IV. CONCLUSIONS

The current experimental investigation of MIG welding carried on EN-31 studies the influence of MIG welding parameters for their optimization using L9 orthogonal array of Taguchi method. Factors like Welding Voltage, Welding Current and Welding Speed were chosen and their interactions were found. These results show the performance of parameters at different levels to optimize the hardness of welded joint and its surface roughness. Following conclusions are made during the investigation of MIG welding on EN-31:

A. Hardness initially had negligible influence with both welding voltage and welding speed but with further increase in their levels, hardness tends to decrease. Both these parameters have major influence on Hardness.
B. Moreover, with increase in weld current, initially hardness increase at a faster pace but with further increase in weld current the hardness increases at a slower pace. The hardness first increase with increase in voltage and further it get decreased.
C. Welding speed is the major influencing parameter for hardness of welded joint and yields a contribution of 40.57%.
D. Welding current is the major influencing parameter for surface roughness with a contribution of 82.82%.
E. As we increase the level of welding voltage poor surface finish is obtained. For welding current, it also follows the same trend as the voltage and surface finish get poor with increase in the level of welding current.
F. Welding speed is the least influencing parameter for surface roughness and has a contribution of only 6.64%.

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