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An Investigation of Tensile Strength and Surface Roughness during Gas Metal Arc Welding of Alloy Steel

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Abstract: ***The present investigation for optimization of MIG welding of Mild Steel is conducted to establish the influence of MIG welding process parameters on tensile strength and surface roughness. From the experimental results it is concluded that welding voltage is the main influencing parameter for tensile strength while welding speed is least influencing for it. In case of surface roughness, welding speed has major dominance while other parameters were less effective.***
Keywords: MIG, Mild Steel, Tensile Strength, 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.

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K. Abbasi [9] in their study found that when speed is taken as variable parameters, penetration depth increases with increase in speed upto an optimum value of 1450 mm/min, beyond that speed penetration starts decreasing. These researchers also found that when the heat input is considered, the depth of penetration will increase with heat input till 109 J/min. Beyond this value, the penetration depth will decrease. Patil et al. [10] during the investigation while finding the effect of welding current, welding voltage, welding on the ultimate tensile strength (UTS) of AISI 1030 mild steel material during welding process used Taguchi method for designing the experiments and analysis of variance was employed for studying the welding characteristics of material and optimize the welding parameters.

II. EXPERIMENTAL DETAILS

1) *Work piece:* The material used for the present work is Bright Mild Steel with specification of 4mm thickness, 203mm height 35mm width.
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 tensile strength and surface roughness.

Fig. 1: MIG wedling setup for experiments

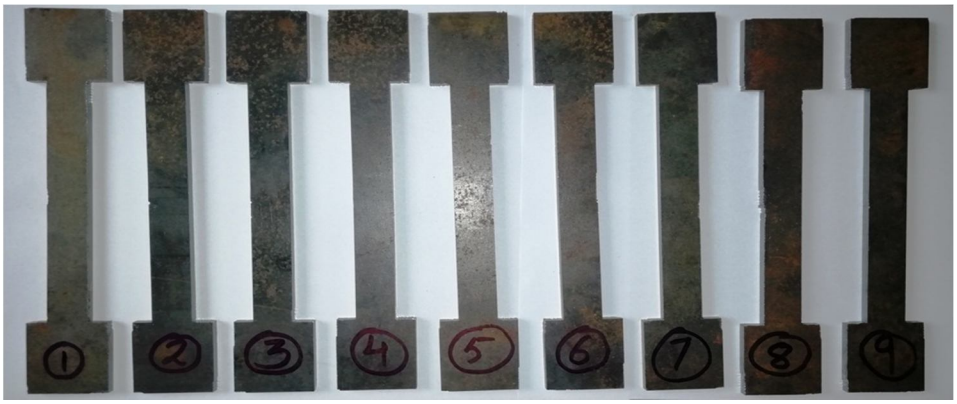

Fig. 2: I-shaped specimens

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

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Table III: Showing Experimental Values Of Hardness And Surface Roughness

Exp. No	Welding Voltage	Welding Current	Welding Speed	Tensile Strength(N/mm^2)	Surface Roughness (Ra
1	16	100	5	460.42	3.71
2	16	150	10	463.1	1.52
3	16	200	15	467.5	1.78
4	20	100	10	461.87	1.23
5	20	150	15	466.45	2.59
6	20	200	5	471.13	3.68
7	24	100	15	470.97	2.41
8	24	150	5	479.1	2.79
9	24	200	10	481.97	3.93

III.RESULTS AND DISCUSSION

A. Influence of parameters on Tensile Strength

The following table III shows ANOVA of Tensile Strength conducted on MINITAB 16.0. The result shows that the contribution of welding voltage is most and is 70.09%. Welding current is the second most influencing parameter for tensile strength with a contribution of 28.05% while welding speed is the least dominating parameter and has negligible influence on tensile strength having a contribution of only 1.26%.

Table IIIII: ANOVA Table Of Tensile Strength Of Welded Joint

Source	DOF	SS	Adj MS	F Value	Contribution
Welding Voltage	2	312.868	156.434	116.94	70.09%
Welding Current	2	125.237	62.618	46.81	28.05%
Welding Speed	2	5.631	2.815	2.10	1.26%
Error	2	2.675	1.338		0.60%
Total	8	446.411			100%

Following figure 3(a) shows THE main effect plot for Tensile Strength. It shows that the Tensile Strength increases with both welding voltage and welding current. Welding voltage has major influence on tensile strength followed by welding current similar to that obtained by Sindiri Mahesh [1]. An increasing trend is observed for tensile strength with welding voltage [1]. Moreover, with increase in the level of welding current, the tensile strength is observed to follow an increasing trend but reverse is observed by Sindiri [1].

Welding speed is the least influencing factor for tensile strength [1] and has negligible contribution of only 1.26.

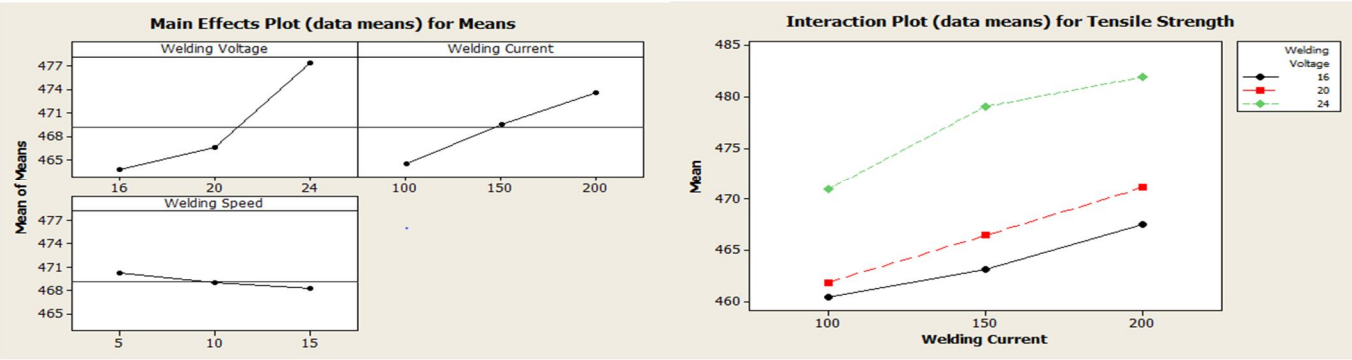

Fig. 3: (a) Main effect plot for Tensile Strength; (b) Interaction plot for Tensile Strength with parameters

The above figure 3(b) depicts the interaction plot between tensile strength and welding current at different levels of welding voltage. The plot depicts that the tensile strength increases with MIG welding parameters at all levels. The tensile strength increases with welding current at every level of welding voltage.

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B. Influence of Parameters on Surface Roughness

The following table IV shows the analysis of variance for surface roughness. The result shows that the contribution of welding speed is most and is 33.29%. Welding current is the second most influencing parameter for tensile strength with a contribution of 14.77% while welding voltage is the least dominating parameter and has a contribution of only 10.32%.

Table IVV: ANOVA Table Of Surface Roughness

Source	DOF	SS	Adj MS	F Value	Contribution
Welding Voltage	2	0.821	0.411	0.25	10.32%
Welding Current	2	1.174	0.587	0.35	14.77%
Welding Speed	2	2.647	1.323	0.80	33.29%
Error	2	3.307	1.654		41.62%
Total	8	7.949			100%

Following figure 4(a) shows the main effect plot of parameters for surface roughness. It illustrates that the 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, the surface roughness first improves but with further increase in the value of welding current the surface gets degraded. Welding speed is the most dominating parameter for surface roughness of MIG welded joint for the present set of parameters. 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.

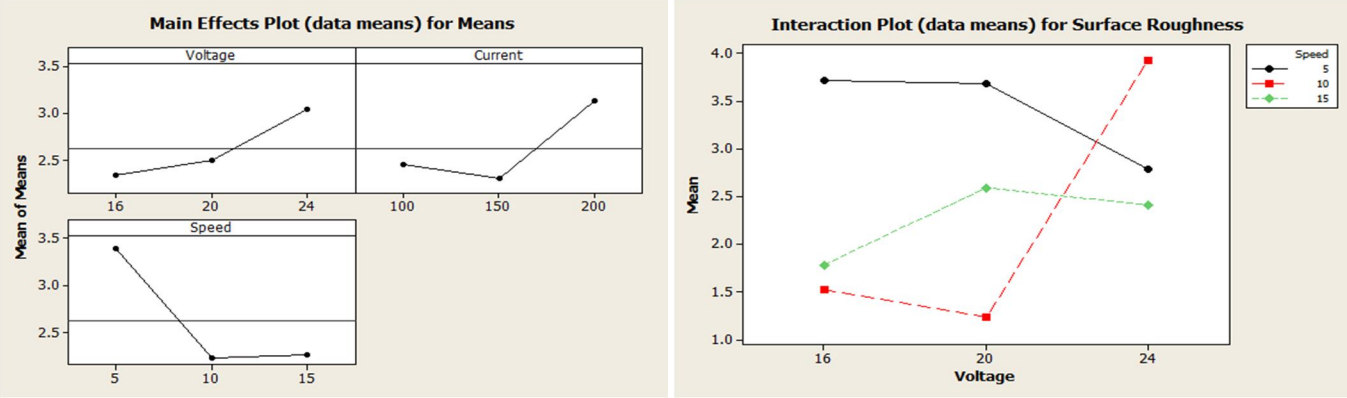

Fig. 4: (a) Main effect plot for Surface Roughness; (b) Interaction plot for Surface Roughness with parameters

The above figure 4(b) shows the interaction plot between surface roughness and welding voltage at different levels of welding speed. It depicts that at lower level of welding speed, the surface roughness is higher. When the welding voltage value is increased at lower level of speed, the surface roughness get improved. At middle level of welding speed (10 mm/sec), the surface roughness obtained is lower. With increase in level of voltage at medium speed, the surface degrades. When it comes to higher welding speed, medium value surface roughness is achieved.

IV. CONCLUSIONS

The current experimental investigation of MIG welding carried on mild steel 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 Tensile Strength of welded joint and its surface roughness. From the study following conclusions were derived:

A. Welding voltage is the most dominating parameter for tensile strength and has a contribution of 70.09%. Same was observed by Sindiri Mahesh [1].

B. Tensile strength increases with increase in welding voltage [1]. Similar trend is observed to follow in present investigation. Welding voltage has major influence on tensile strength.

C. Tensile Strength increases with welding current in this investigation which is opposite to that obtained by Sindiri [1]. With increase in the level of welding welding current, the tensile strength is observed to follow an increasing trend.

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D. Welding speed is the least influencing factor for tensile strength and has negligible contribution of only 1.26%. Same was observed by Sindiri Mahesh [1].

E. Welding speed is the major influencing parameter for surface roughness with a contribution of 33.29%.

F. As we increase the level of welding voltage poor surface finish is obtained. For welding current, the surface roughness first improves but with further increase in the value of welding current the surface gets degraded.

G. 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.

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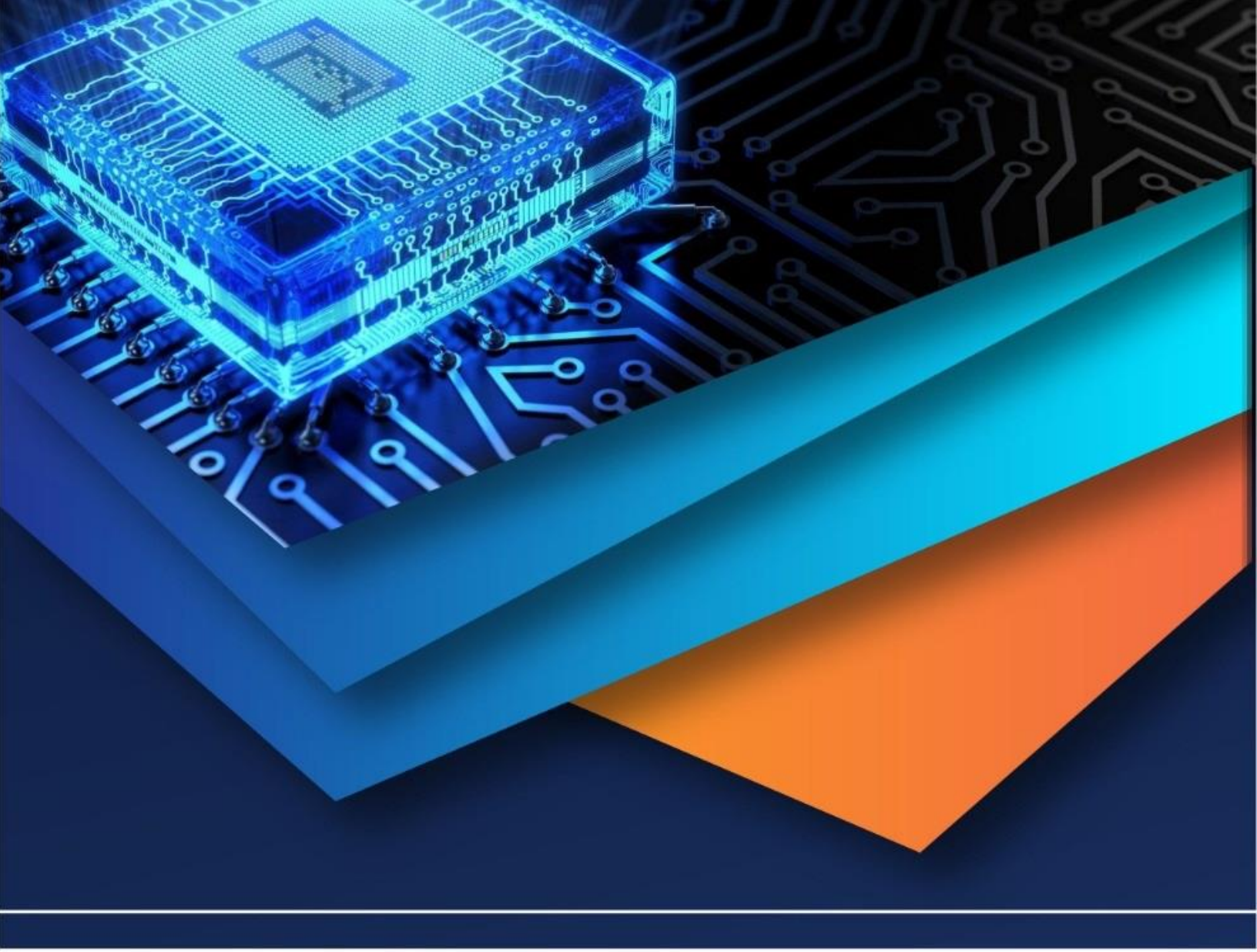

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