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INFLUENCE OF WELDING CURRENT AND WELDING SPEED ON TIG WELDING OF ALUMINIUM PLATE

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***Abstract*— To improve welding quality of Aluminum (Al) plate an automated TIG welding system has been developed, by which welding speed can be control during welding process. Welding of Al plate has been performed in two phases. During 1st phase of welding, single side welding performed over Al plate and during 2nd phase both side welding performed for Al plate by changing different welding parameters. Effect of T- welding speed T and welding T current on the tensile strength T of the weld joint has T been investigated for both T type of T weld T joint. Optical microscopic analysis has been T done on T the weld zone to evaluate the effect of welding T parameters on welding quality. Micro-hardness T value of the welded zone has been measured at the cross section to understand the change in mechanical property of T the welded zone.**

***Index Terms*— Automated TIG Welding System, Micro hardness Test, Tensile Test.**

I. INTRODUCTION

Unlike manufacturing processes that generate a single component, joining techniques combine multiple parts to produce the desired complicated configuration. Obtaining such a complicated shape using solely industrial methods is either too difficult or impossible. The connection of various pieces can be temporary or permanent. Furthermore, the bonding process can be mechanical or atomic. The atomic bonding arc of a permanent character is present in all joining processes. Welding, brazing, soldering, adhesive bonding, and mechanical fastening are all procedures that are included in the word "joining." These procedures are an important part of the manufacturing process.

Welding is the process of joining similar or dissimilar metals with or without applying heat and pressure. The bonding force between the two metallic atoms decreases sharply with the interatomic distance. But the pressure increases sharply and attains a tremendous value when the distance is reduced. Weldability of a material depends upon various factors like the metallurgical changes that occur due to welding, changes in hardness in and around the weld, the extent of oxidation, and time of cracking tendency of the joint.

A. DIFFERENT TYPES OF WELDING PROCESSES

Based on the type of heat source welding process is characterized as

a) Arc Welding
b) Resistance welding
c) Solid-State Welding
d) Radiant Energy Welding
e) Thermit welding
f) Allied Process
g) Gas welding

B. GAS WELDING

This process is also known as oxy-acetylene welding. Heat is supplied by the combustion of acetylene in a stream of oxygen. Oxygen and acetylene areprovided by the torch having flexible hoses. The heat from this torch is less concentrated than the electric arc.[2]

C. TIG WELDING

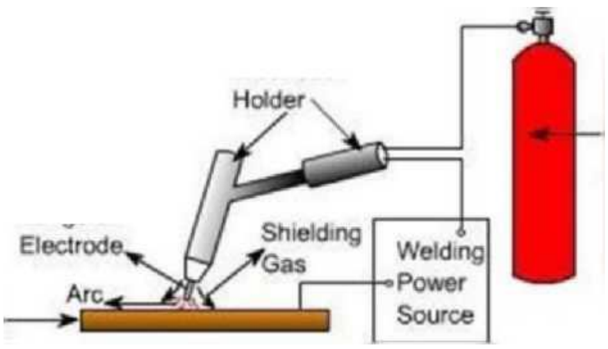

Figure 1: TIG WELDING SYSTEM (Reference 1)

Tungsten Inert Gas Welding is an arc welding process in which a tungsten electrode is non-consumable to produce the weld. An inert shielding gas such as argon or helium and filler metal is used to protect the weld area from the atmosphere. A rectifier is used as a power source from which power is supplied, with the help of a welding torch or a handpiece. This power is delivered to the tungsten electrode, already fitted into the handpiece. An electric arc is created between the base metal and the tungsten electrode with the help of a constant-current welding power supply from which energy is produced, and this energy is conducted throughout the arc with a column of highly ionized gas and metal vapors [2|. The inert gas protects the tungsten electrode and weld zone from the atmospheric air. The temperature produced by an electric arc is approximately 20000"C, and this heat is concentrated on a particular area for melting and joining the different parts of the material. The weld area is used to enter the work piece with or without filler material. Figure I &2 shows the mechanism and working of TIG Welding, respectively.

Manual. The tungsten electrode diameter generally varies from 0.5-6.5 mm, whereas the length of the tungsten electrode ranges from 150 to 200 mm. The current carrying capacity of the tungsten electrode is based on its size. It depends on whether the electrode is connected to the positive or negative terminal of the DC power source.

When the length of the arc varies over many millimeters, the power source required to sustain the arc has a constant c, from which stable current charitable current output is generated. The welding current is only a little affected by the size variation of the arc created during the welding operation. When the electrode is short-circuited over the workpiece, the ability to change the current to the desired value is critical. In another situation, an excessively high current will flow, resulting in electrode damage. The power source's open-circuit voltage ranges from 60 to 80 volts.

II. LITERATURE REVIEW

Kumar and Sundarrajan [6]used the Taguchi approach to analyze pulsed TIG welding process parameters and constructed regression models to see how they may be adjusted to improve the mechanical qualities of the weld. This strategy is used to plan and assess experiments to improve quality. The Taguchi technique assesses the effects of different parameters that are independent of one another, and quality attributes like ultimate tensile strength, yield strength, hardness, and so on are identified. The Taguchi technique is used because it is a procedure that improves output quality without raising the cost of the experiment. It also reduces the number of experiments that must be carried out.All of the welds' microstructures were examined and connected with their mechanical properties. The resultant welds are subsequently subjected to a cold planishing process, which relieves internal stresses and reforms grains, hence improving mechanical qualities.

Harmish Bhatt [71] investigated the effects of process parameters such as gas flow rate and welding current during TIG welding of aluminum alloy 7075. Heperformed the two sets of experiments.,He first set the mechanical properties such as Ultimate Tensile Strength and hardness. In 2 groups of the experiments, he tried to optimize the process parameters by limiting the values of gas flow rate and welding current to get maximum Ultimate Tensile Strength.

Ravindar and K Guru raj [8] adopted the pulsed current TIG welding method. Aluminum alloy 5053 sheets, with a thickness of 4mm, were employed. The final workpiece's dimensions must be 100x100x4 mm. Weld samples to variable circumstances by changing the process parameters, such as welding current, gas flow rate, and filler rods, and weld samples to varying conditions by changing the process parameters, such as welding current, gas flow rate, and filler rods. For process conditions such as a welding current of 180 A, a gas flow rate of 10/min, and a filler rod diameter of 1.6 mm, an impact test was performed, and a Vickers Hardness value was achieved. Due to a lack of fusion, the Vickers hardness value becomes very low, which is obtained suitable when the above process parameters values are modified, such as welding current 240A, gas flow rate 12/min, and filler rod diameter 3.2 mm. Due to a change in microstructure, the hardness value of the weld zone changed as the distance from the weld center increased. The refinement in fusion zone grain size achieved by pulsed current welding is the fundamental reason for enhancing Vickers Hardness and microhardness characteristics.

Surendhiran. S et al. [9] The AA 5456 is used to TIG weld sheets with dimensions of 250x150x2.4 mm. Microhardness was determined at 0.5 mm intervals throughout the weld, 1 mm intervals across the HAZ, and 1.5 mm intervals across the undamaged base metal. With a peak current of 80 A, a base current of 4 A, a welding speed of 230tnm/minute, and a pulse frequency of 2 Hz r, a coarse grain structure is achieved. The value of this study is that the mechanical properties improve as a result of the obtained optimum circumstances, and the regression models developed are useful for process automation.

Yashwant Thakur et al. [10] investigated the welding parameters for TIG welding of AA 7005 as it possesses good welding characteristics and corrosion resistance. He observed that the strength and profile of the welded joint are greatly influenced by the material and technique to be selected for welding. Experiment design is determined by the Taguchi method. The study of microstructure at different zones of weldment gives a comparative outcome between TIG welding and the base material to differentiate the effect of temperature distribution.

Lakshmi and Singh [11] investigated the effects of welding parameters on the weld bead geometry. The experiment is conducted on specimens with dimensions 50x30x5 mm for each welding input parameter. The process parameters used are welding current 25OA. Gas flow rate one l//min and speed 81 mm/min. The welding current range is selected for constant gas flow rate 5 mm thickness of the workpiece. The operating range of shielding gas flow rate at continuous content of 23OA and similarly the operating range of welding speed at a constant current of 230 A is selected for experimenting. He found a linear increment in the values of the front and back width of weld bead for the different values of welding current when the gas flow rate was kept constant. Similarly, when the welding wind is steady, there is an alternative increase and decrease in front and back width. Again with the continuous current when welding speed increases, the front arid back width decreases linearly with the penetration in depth increment.

Fahmida [12] investigated the TIG welding of aluminum alloy and enhanced the structure-property and weldments by controlling heat input. She used Ixxx series of Aluminium plates for welding and filler metal of 043 grade. The different current settings used were I45A. 175A. I95A. The vessels having dimensions 35mmX 16mmX 11 mm are used for the experimenting. After welding, the samples are examined and scanned under electron microscopes, and some mechanical tests are performed to determine the hardness, tensile, and impact strength. A eutectic was formed, and when the current is set at the highest value, i.e., at the maximum heat input, the catchy mixture was the coarsest network to create. The values of hardness, tensile strength, and impact strength of these plates support the change seen in the microstructure with the heat input. The effect of high heat input is that more dilution is created in the weld structure. Higher welding current reduces the variation in hardness values at different weld locations. The impact energy and tensile strength improved with an increase in client content.

III. OBJECTIVE OF WORK

Welding was done on a 3 mm thick aluminum plate using an auto ma led TIG welding system. To get a higher strength union, welding parameters such as welding speed and current are modified, and only welding is done on both sides of the aluminum plate. We investigated the tensile strength, microstructure, and microhardness of the weld pool by varying welding speed and currently used techniques.

IV. EXPERIMENTAL WORK AND METHODOLOGY

Figure 2: Automated TIG welding setup

The main components of a TIG welding setup are:-

A. Power Source

The power source in TIG welding can be DC or AC since the output obtained is of constant current characteristic in both cases. In TIG welding, arc length varies linearly with the arc voltage, and variation of 3-4 mm in arc length can alter the voltage up to 5V. DC power source is generally used for welding since it produces entire arc, but with metals like aluminum, AC power supply because it forms an oxide film over its surface. So, changing (the polarity from positive to negative the cleaning and the welding actions are performed alternately.Speed Control Unit* A speed control unit runs with the decided speed. The welding torch is also fixed with it with the help of a clamp at a particular angle to produce a stable arc during welding. The regulator is there to change the welding speed. An adjustableknow is There to maintain a constant distance between the tween torch and the workpiece.

B. Welding Torch

The welding Torch is connected with the speed control unit, the tungsten electrode is attached, and argon gas flows with this torch.

C. Gas Shielding

A gas lens is attached to the nozzle of the welding torch so that the flow of gas is laminar. The selection of the gas nozzle depends on the electrode diameter.

D. Gas Cylinder

A gas cylinder filled with t,he argon gas is supplied with welding torch at a fixed flow rate to fire inert atmosphere and stable arc. A regulator and a valve are there to control the gas flow rate.

E. Work Holding Table

A plate made of cast iron is used to hold the workpiece to maintain the proper gap between the tungsten electrode and the workpiece.

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CALIBRATION OF SPEED

To get the required welding speed, the speed of the control unit is calibrated before the start of the experiment.

Table 1: value of speed on the speed control unit

EQUIPMENT NUMBER	SPEED VALUE (MM/S)
1	2
1.5	3
2	4
2.5	5
3	6
3.5	7
4	8

EXPERIMENTAL PLANNING

The experiment is carried out in two phases. In the first phase,an aluminum plate of thickness ^nm is butt welded at one side by varying welding speed and welding current.Inthe second phase, butt welding of aluminum plate is done on both sides by changing the welding wind and speed as varied previously.

EXPERIMENTAL PROCEDURE

The three in the thick commercial aluminum plate are used for the experiment. It is cut in 120x50 mm dimensions with the help of a band saw. Grinding is done on the edges to make the surface smooth for joining. To remove the extra material, veneers are polished with every piece of paper.

In the working table, aluminum plates are fixed with (the help of a flexible clamp after the sample is prepared, and welding is done to forma butt joint.

Alternating Content is used for TIG welding since it concentrates the heat in the welding area. 3.5 inni diameter zirconate tungsten electrode is used in the experiment. Through grinding (the rip diameter at the end of the electrode is reduced 2/3 of the original diameter, and then the arc is struck on the scrap material piece. Due to this, a ball is created at the end of the electrode. Small electrodes for the welding current will form acolossal ball. On the other hand, large electrodes will not form good balls.

The welding parameters of the experiment's first phaseare shown in table 2. Several trials before the actual experiment arc were done to get the appropriate parameter range so that welding should be done without any recognized defects such as undercutting and porosity.

Table 2: Welding Parameters for one cycle of experiments

PARAMETERS	**RANGE**
Welding Current	100J30A
Speed	3-4mm/s
Voltage	45V
Gas Flow Rate	7.5-10//min
Distance of tip from weld center	3mm
Current type	AC
Dimension	120mmX50mmX

After the welding is done, welded specimens are cut in the dimension of 100mmX20mrn for tensile testing. These dimensions are further cut into I shape. The tensile test is performed with Universal Tensile Testing Machine with a maximum load-carrying capacity of 600kN.

Again 10mmX5mmX3mm specimen is cut at the cross-section for microstructural analysis and microhardness measurement of each sample. A cross-section of the welded model is polished sequentially with 220: 600 and 1200 grit size polishing paper. Microhardness was measured with a Vickers microhardness tester, and with the help of an optical microscope optical image of the cross-section at the welded zone was taken.

Table 3 Experimental Planning

Experiment No.	Electrode Workpiece e distance	Argon gas flow rate (l/mm)	Voltage (V)	Welding Speed (mm/s)	Current (A)
1	3	7.5-10	45	3	1Ü0
2	3	7.5-10	45	3	105
3	3	7.5-10	45	3	11Ü
4	3	7.5-10	45	3	120
5	3	7.5-10	45	3	130
6	3	7.5-10	45	4	10Ü
7	3	7.5-10	45	4	105
8	3	7.5-10	45	4	110
9	3	7.5-10	45	4	120
10	3	7.5-10	45	4	130

V. RESULT AND DISCUSSION

The average value of welding width is calculated by measuring the welding width of all the samples and is shown in table 4. For different welding speeds, a graph is plotted between average welding width and the applied welding current as shown in figure 8, which shows that welding width increases in linear proportion with welding current. Figure 7 shows the welded butt joint specimen where welding is performed with varying welding speed and wind, whose details are in table 3.

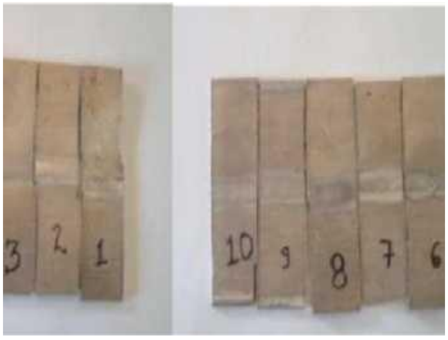


Figure 3 - a) Welded specimen performed with welding speed 105, 110. 120 and I30A for samples numbers 1 to 5.

b) welded specimen performed with welding speed 4mm/s and welding current 100. 105. 110120 and 130A for sample numbers 6-10, respectively.

Table 4- Weld Width to Current (A)

Sample no	Reading 1 (mm)	Reading 2 (mm)	Reading 3 (mm)	Avg. width (mm)
1	5.53	4.67	4.31	4.83
2	7.38	6,78	7.45	7.20
3		7.67	7.37	()5
4	7.36	7.75	7.85	7.65
5	10.87	10.59	10.09	10.51
6	5.12	5.08	4.88	5.026
7	5.67	5.76	5.88	5.77
8	8.43	8.17	7.79	8.13
9	9.38	8.03	8.78	8.73
10	9.19	10.09	8.52	9.26

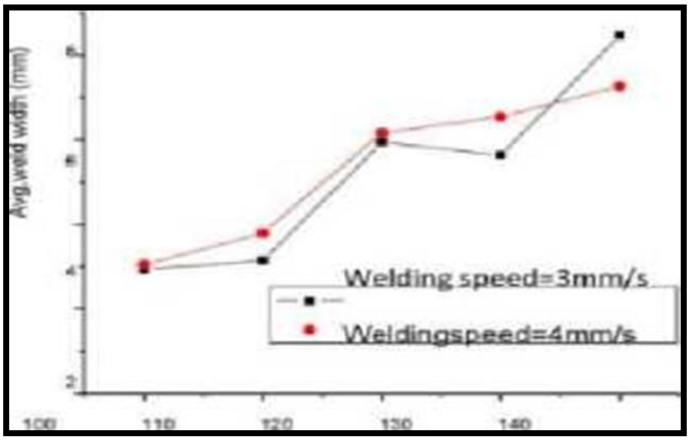


Figure 9 Specimens welding width with varying welding speed and current

The average surface roughness value for all the samples of weld zone was measured from the readings in Table 5; Roughness value ranges from I to 6 microns approximately, which is somewhat low for a welded specimen. Thus, we conclude that finishing operation is not required to use an automated system. The roughness values obtained are plotted against the applied current, and the same is shown in figure 6. But the wind does not have any effect on the surface roughness.

Table 5: Surface roughness value for different welded samples

Sample No	Reading 1 (μm)	Reading 2 (μm)	Reading 3 (μm)	Avg. Value (μm)
1	3.442	3.385	3.034	3.287
2	1.896	1.157	1.123	1.392
3	1.768	1.299	1.476	1.514
4	0.865	1.297	1.379	1.180
5	2.835	2.896	1.233	2.321
6	1.876	4.654	3.312	3.280
7	2.398	2.145	2.234	2.259
8	3.567	3.498	3.612	3.559
9	3.229	3.411	4.121	3.587
10	1.345	1.178	1.276	1.266

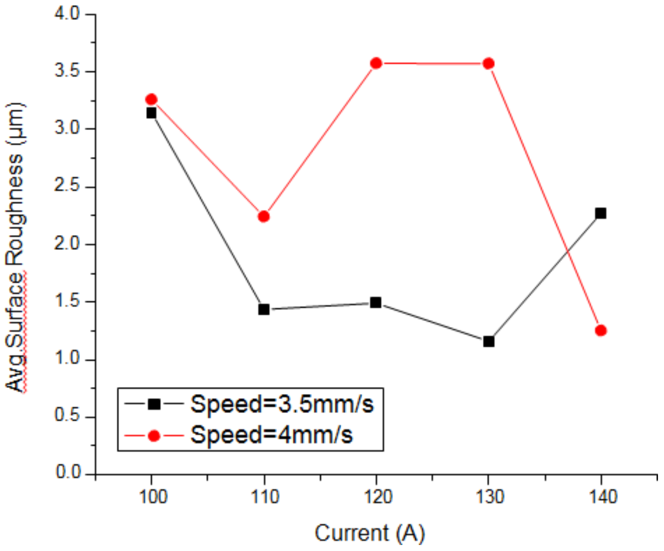


Figure 4 Surface roughness of samples with different current

TENSILE TEST

A universal tensile testing machine is used to perform the tensile test of the welded joint having a maximum load capacity of 600kN.

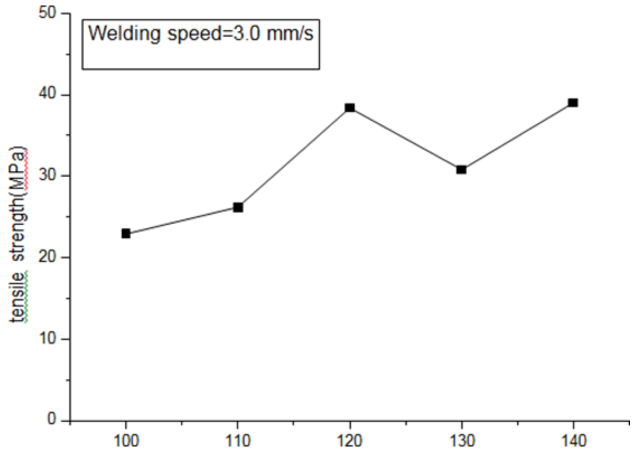
All of the welded joints' tensile strength values are acquired at various welding speeds and current settings, as shown in Arabic 6. These values are significantly lower than those of pure aluminum. The aluminum's tensile strength was discovered to be 132 Mpa. The tensile strength of welded joints is plotted versus the applied current for a welding speed of 3mm/s, as shown in figure 10. Except when welding current runs from 120 to 130 A, it can be stated that tensile strength increases in direct proportion to the increasing current setting.

Similarly, for the welding speed of 4mm/s, the tensile strength of welded joints is plotted against the welding speed of 4mm/s, shown in figure 11. The conclusion drawn from the graph is that there is no specific change observed in tensile strength when there Change in current settings. Initially, when there is an increment in contemporary locations, there is an increase in tensile strength,but this increase is only up to 120 A, and then these values decrease,

When we compare Figures 10 & 11, we can observe that for all current settings values except 120 A. tensile strength of welded joint when welding speed is 3mm/s are greater than tensile strength values when welding speed is 4 mm/s.

Table 6; Maximum load at tensile strength and tensile strength value at the different welded samples.

Sample no	Load at strength (N)	Actual tensile strength (MPa)
1	1718.31465	23.94286
2	1963.50763	25.19435
3	2877.47628	37.37904
4	2312.59820	31.81012
5	2927.53077	38.03435
6	1311.63805	18.41884
7	1285.71786	16.13438
8	3307.39748	45.06890
9	2258.41971	31.12126
10	1386.85181	19.42809



applied current(A)

VI. CONCLUSIONS

The following conclusions are made with the TIG welding to aluminum:

- It is possible to uniformly weld aluminum with automated TIG welding,
- Welding speed and welding current affect the parameters such as welding and the tensile strength,
- Strength of welded joint increases linearly to increase in welding current.
- Due to changes in microstructure, hardness value changes as the distance from weld centerchanges.
- For both side welding, Tensile strength is almost equal to the power of base material.
- For both sides of welding, welding speed does not have any notable effect on the tensile strength of the weld joint.

VII. FUTURE SCOPE

In the present study, the welding is performed without any filler material. So. in the future, welding can be done with a filler metal to weld some thicker plates. The same welding setup can also be used for some other material.

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