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# Experimental Investigation of Tensile Strength & Micro Hardness Behavior on Aluminium Plate Subjected to GTAW Welding Process

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**Abstract:** To enhance the nature of welding in Aluminium (Al) plate mechanized welding via TIG framework had been created, in which welding pace can be controlled all through welding procedure. Welding of Al plate had been performed out in the single stage. In this stage of welding, one side weld performed over Aluminium (Al) plate by changing distinctive parameters of welding. Rate of welding effect and welding current on the tensile strength of the joint of weld had been analyzed for butt sort of joint in the weld. Micro-hardness estimation of the welded zone had been estimated at the area of the cross-section to comprehend the variation in mechanical property of the zone that is welded. Uniform welding of Aluminium plate is conceivable by the use of the system of automated welding. Quality of welding or strength based on tensile for the joint of weld relies upon the parameters of welding like current and speed of welding. The welded joint tensile strength improves with rising in current. The hardness value of the zone of weld changes with the distance from the center of weld because of variation of microstructure. At a lower speed of welding, since more power of current available the strength of weld increases.

**Keywords:** TIG welding, Butt joint, Micro-hardness, Welding Current, Tensile Strength.

## I. INTRODUCTION

Welding is one of the most important and versatile means of fabrication available to industry. Welding is used to join hundreds of different commercial alloys in many different shapes. Actually, many products could not even be made without the use of welding, for example, guided missiles, nuclear power plants, jet aircraft, pressure vessels, chemical processing equipment, transportation vehicle and literally thousands of others.

Many of the problems that are inherent to welding can be avoided by proper consideration of the particular characteristics and requirements of the process. Proper design of the joint is critical. Selection of the specific process requires an understanding of the large number of available options, the variety of possible joint configurations, and the numerous variables that must be specified for each operation. If the potential benefits of welding are to be obtained and harmful side effects are to be avoided, proper consideration should be given to the selection of the process and the design of the joint. Generally, the quality of a weld joint is strongly influenced by process parameters during the welding process.

In order to achieve high quality welds a good selection of the process variables should be utilized, which in turn results in optimizing the bead geometry. In this study an attempt is made to investigate the effect of welding speed and joint design parameters on tensile strength of the welded joint. With this objective, several test specimens were welded with varying welding speed (by using adjustable speed motor) and variety of possible joint configurations (bevel angle and bevel height). Results of these studies indicated that numerous process variables of GTAW and variety of possible joint configuration have profound effect on tensile strength of the weld joint.

Norman et. al [1] had researched on autogenous microstructures, tungsten inert gas composites are welded Al-Mg-Cu-Mn with the huge opportunity of welding conditions. Welding speed was 420-1500 mm/min and the current was flowing with 100-195 A approx. Center in weld created due to high cooling speed and microstructures are viewed at the center. At the focal length cooling rate increases which lead in delivering dendrite in structure. Wang et. al [2] contemplated Ni-base super-composites for impacts of tungsten inert gas welding processes on microstructure, cracks in weld joint and tensile behavior of metal. For welding plate 55-90 A welding current range, width in limits of 1.2-1.5 mm, with 2100-2900 mm/min variable welding speed was utilized. From the exploratory outcome, it has been observed that increments in the input heat occur when welding current increases and welding speed decreases.

Literature review provides the information about welding of Al is tough & time taking task using traditional arc welding processes. The quality of welding relies upon various parameters like-welding current, welding speed etc. This presented research paper deals

with welding of Aluminium plate of 0.003 m thickness, using a mechanized TIG welding setup. The observations were recorded by varying process parameters like- welding pace & welding current. Better strength can be obtained by welding on both side of the joint. The micro hardness of the weld joint is also explored.

## II. METHODOLOGY

### A. Automated TIG welding development

An in-house automated welding setup has been created for the welding purpose with accurate results and to control the speed of welding as well as other factors. Fig. 1 depicts a mechanized TIG welding setup along with its major components.



Fig. 1:- Mechanized TIG welding setup

Set-up of welding contains mainly the following parts:-

SCU (speed controlling unit) which is a mobile tractor is utilized here as a speed controlling unit which keeps running with a preset speed ideal for welding, Rail tracks which is straight line way on which tractor moves with a specific speed when already in motion, Torch of TIG Welding was made to fit the tractor unit while motioning. Also, an electrode made with tungsten is embedded on torch due to this Ar flows as gas, Machine for TIG welding it is Machine setup is the main branch of the assembly of TIG welding setup through which all the parameters are controlled such as speed and current flow in the system. Range of current and voltage of welding are 10.5-180.5 A and 232 V respectively, current contingent utilized properly; Cylinder of Ar gas is used to form an inert surrounding at a specific rate of flow in TIG welding for creating a steady arc. Regulator and valve are utilized to control the gas stream. Work holding table is made to hold the work piece so that separation can be created between work pieces and welding electrode. For holding the work piece firm appropriate clamping has been utilized.

### B. Speed Calibration

Prior to starting with the investigation, to get a desirable welding speed the movable tractor speed was calibrated and different speed values were found and organized as in table 1.

Table 1: Speed controlled tractor with speed value

Equipment numbers	Speed in mm/s
1.01	2.55
1.6	3.02
2.06	3.56
2.6	4.1
3.09	4.48
3.44	5.04
4.3	5.3
4.3	6.2

*C. Experimental Procedure And Planning*

The experiment was completed in single stage in the current work. The first period of analysis, welding with butt joints of Al plate (thick- 0.03 m) performed at a single face with varying welding pace along with current settings.

*D. Procedure Of The Experiment*

A plate taken as work piece to perform the investigation, this plate is made with Aluminium of 0.03 m thickness. The band-saw was utilized to cut Al plate with measurement of 120 mm x 50 mm and at the edges grinding activity was done to smooth the surface to be consolidated. For evacuating any sort of outer material surfaces were cleaned with emery paper. After the arrangement of a test, Aluminium plate's held with flexible clamp on the working table and welding task was performed as such as to get a butt joint. To concentrate the heat in the welding zone, an Alternating Current (AC) was utilized in the experiment of TIG welding. Zirconiated tungsten electrode with a diameter of 3.44 mm was taken in this trial.

To set up the end point of the electrode grinding activity was done to lessen the diameter of the tip is 2/3 of the main diameter which creates an arc for striking on the raw material. A ball is formed toward the end of the electrode. Small electrode during welding will form an unwanted extensive ball, while a big electrode won't frame palatable ball by any means.

The first period of trial welding factors chosen is appeared in table 2. Various preliminary tests have been performed before performing out the real investigation in order to obtain the proper factors range where welding might be conceivable and zero detectable imperfections such as porosity and undercutting happens.

Table 2: Welding parameters for experiment

Parameters	Range
Welding current	(100-140) A
Voltage	50 v
Speed	(3.5-4) mm/s
Tip distance from the centre	3 mm
Rate of gas flow	(8.1-10.1) l/min.
Current type	Alternating current
Dimension	120 mm*50 mm*3 mm

Now for the tensile test, the welded sample was cut into the element of 100 mm. X 25 mm. furthermore, cut into I shape. A universal tensile testing machine was utilized to perform tensile test which is having a maximum load conveying limit of 600,000 N. Now to carry out micro structural study and micro hardness measurement for each sample a cut 10 mm x5 mm x3 mm specimens were performed on the job. Now utilizing a polishing paper of 220.0 and 600.0 grit size the welded specimen was polished and mounted at cross section before carrying out micro hardness measurement test. Vickers micro-hardness tester was utilized to gauge the micro hardness.

Table 3: Experimental planning

Sr. No.	Work piece & electrode Distance (mm)	Flow of Argon Gas (l/min)	Voltage (V)	Speed of welding (mm/s)	Current (A)
1.0	3.01	8.5-10.5	50.3	3.60	102
2.0	3.01	8.5-10.5	50.3	3.60	112
3.0	3.01	8.5-10.5	50.3	3.60	122
4.0	3.01	8.5-10.5	50.3	3.60	132
5.0	3.01	8.5-10.5	50.3	3.60	142
6.0	3.01	8.5-10.5	50.3	4.01	102
7.0	3.01	8.5-10.5	50.3	4.01	112
8.0	3.01	8.5-10.5	50.3	4.01	122
9.0	3.01	8.5-10.5	50.3	4.01	132
10.0	3.01	8.5-10.5	50.3	4.01	142

### III. RESULT AND DISCUSSION

The breath of the weld is calculated and measured for the given samples and then average widths of welding are tabulated in table 4. Fig. 5 shows the plot of an average value of welding width with the applied welding current for various welding speed. It is seen that with the increase of welding current welding width also increases linearly. Fig.4 illustrates a specimen of a welded butt joint in which welding was done using the different current setting and varying welding speed as detailed in table 3.



Figure 1: Welded specimen performed with (a) welding speed 3.50 mm/s and welding current 100, 110, 120, 130 and 140 A for sample no 1, 2, 3, 4, 5 respectively (b) welding speed 4 mm/s and welding current 100, 110, 120, 130 and 140 A for sample no. 6, 7, 8, 9, 10 respective.

Table 4: Width of weld

Number of samples	Reading 1 (mm)	Reading 2 (mm)	Reading 3 (mm)	Avg. width (mm)
1.0	5.44	4.89	4.533	4.94
2.0	7.36	6.86	7.24	5.17
3.0	8.97	7.6	7.3	7.92
4.0	7.22	7.8	7.8	7.627
5.0	10.89	10.5	10.1	10.42
6.0	5.07	5.2	4.9	5.042
7.0	5.58	5.89	6.0	5.76
8.0	8.6	8.08	7.9	8.12
9.0	9.3	8.1	8.3	8.55
10.0	9.15	10.1	8.6	9.258

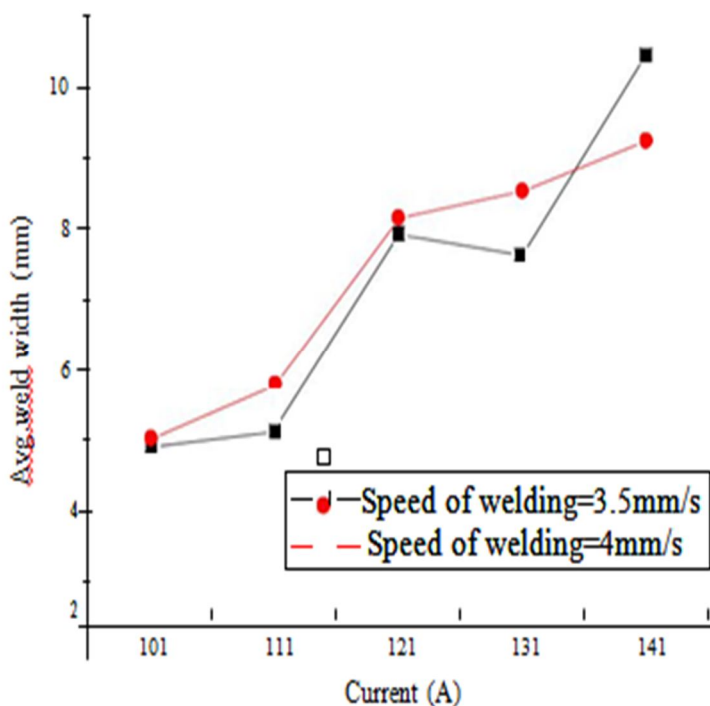


Figure 2: Width of welding samples with different welding current and welding speed condition

Samples were collected to calculate surface roughness of the weld zone and an average value in the roughness of surface was obtained and calculated with three sets of readings which are shown in Table 5. For this welded specimen the value of roughness found in the order of 1.11 to 3.51 micron, which is very low. Therefore it can be concluded that a good quality welding can be done by making use of an automated system which further may not require any finishing operation. In fig. 6 the roughness values are marked against the applied current. No specific impact on surface roughness value of applied current is seen.

Table 5: Value of surface roughness for different welded samples

Sample No	Reading1 (μm)	Reading2 (μm)	Reading3 (μm)	Avg. Value (μm)
1	3.411	3.358	3.034	3.145
2	1.929	1.190	1.189	1.436
3	1.720	1.381	1.376	1.492
4	0.704	1.382	1.395	1.160
5	2.812	2.791	1.220	2.274
6	1.900	4.615	3.258	3.258
7	2.363	2.192	2.174	2.243
8	3.563	3.575	3.583	3.574
9	3.248	3.311	4.151	3.57
10	1.311	1.236	1.210	1.252

A. Micro-Hardness Test

At the cross-section of the welded specimen to find out changes in mechanical properties of the welded zone, hardness at the micro level of the welded zone was calculated. Fig. 8 and 9 show for different samples the value of micro-hardness taken towards the base material from the welded zone with varying current and speed of welding. The graph depicts that for all the samples the value of hardness at the micro level increases in the welded zone as compared to the base metal with a range of 41 to 80.5 HV in the welded zone. As shown in Fig. 8 the sample treated with a stable welding speed of 3.5 mm/s and varying current setting after a certain space these values start to reduce equivalent to the hardness of base material. However, when welding is done with a speed of 4.05 mm/s with fluctuating current setting, hardness value will be equivalent with base metal values only after 5.05 to 6.05 mm.

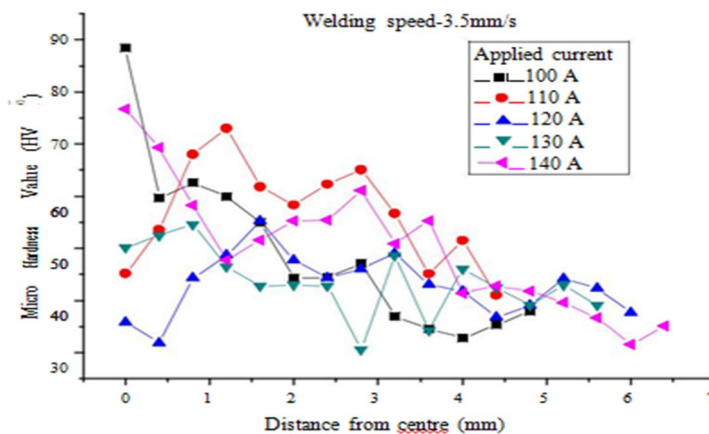


Figure 3: Micro-hardness value from the center of the weld zone towards the base material for welding done with welding speed 3.5 mm/s and different welding current.

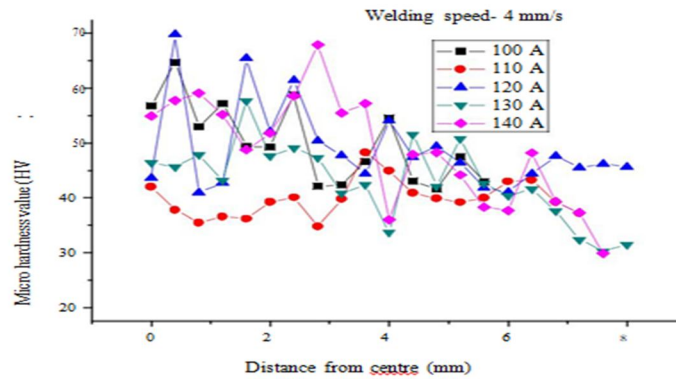


Figure 4: Micro-hardness value from the centre of the weld zone towards the base material for welding done with welding speed 4.1 mm/s and different welding current

### B. Tensile Test

The tensile test had been carried out using a UTM machine (Instron) having load carrying capacity of 600,000 N. Load is supplied at 1 mm/min speed. For different current and welding speed, the value of tensile strength for micro-welded joints is shown in Table 6. The values so obtained of tensile strength much lesser as compared to that of the pure Aluminium. The tensile strength was found to be 132 MPa for the standard tested Aluminum. For a constant speed of welding i.e. 3.5 mm/s a plot of tensile strength with that of applied current for the welded joint was framed in fig. 10. It is conceived that when welding is done at a speed range of 3.55 mm/s the value tensile strength increases with the rise in the current setting (exception for a range of 122 A to 132 A). In Fig. 11 the plot of joints with tensile strength against the applied current with constant weld pace of 4.5 mm/s. The graph concluded that there is no trend in change in tensile strength because of changing current when the welding is done at a speed of 4 mm/s. Primarily the tensile strength value increases till 120 A and then this value drops down. On comparison of fig. 10 and 11 it can be found out that welding is done at 3.5 mm/s the tensile strength value is larger for the current setting (exclude 122 A current setting) then values of tensile strength for joint at a range of speed of 4 mm/s for welded joint.

Table 6: Tensile strength value and maximum load at that point of different welded samples

Sample No.	Load at tensile strength (N)	Actual tensile Strength (MPa)
1.0	1719.364123	22.92477
2.0	1964.576045	26.19444
3.0	2878.427689	38.37935
4.0	2311.589278	30.82196
5.0	2927.507345	39.033645
6.0	1311.630355	17.48855
7.0	1285.787116	17.14349
8.0	3307.394775	44.09879
9.0	2258.419723	30.11256
10.0	1386.811889	18.49018



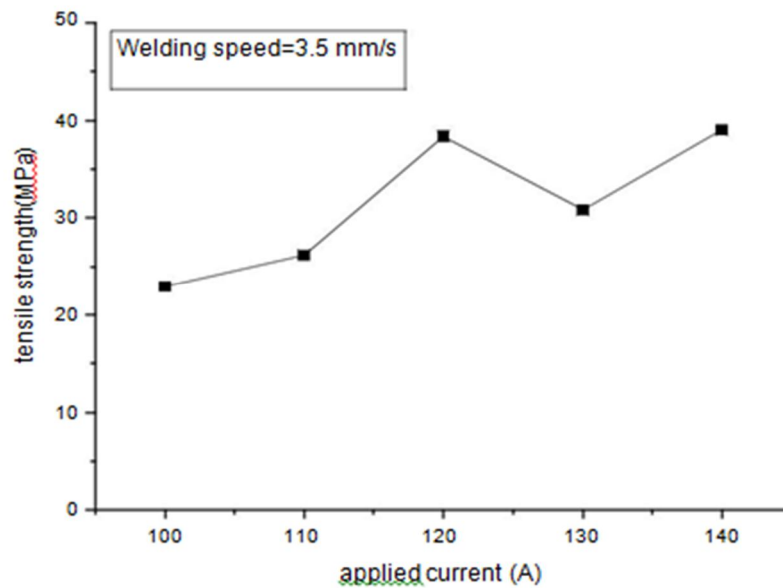


Figure 5: Tensile strength of the welded joint against applied current for welding speed of 3.5 mm/s.

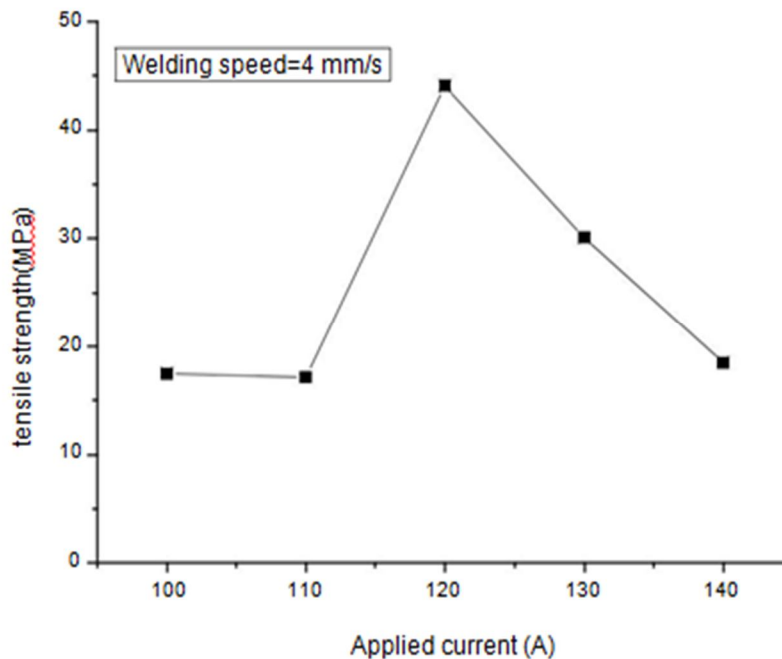


Figure 6: Tensile strength of the welded joint against applied current for welding speed of 4.1 mm/s.

#### IV. CONCLUSION

By the examination of welding via TIG for the plate of Aluminium, the following below results could be observed.

With the automated welding system uniform welding of Aluminium plate can be possible. The welding strength or tensile strength of the weld joint depends on the welding parameters like welding speed and welding current. With the increase in current, tensile strength of the weld joint increases. Hardness value of the weld zone change with the distance from weld centre due to change of microstructure. At lower welding speeds strength is more due to more intensity of current.



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