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EXPERIMENTAL INVESTIGATION OF WELDING SPEED ON TESILE STRENTH OF A TIG WELDED JOINT

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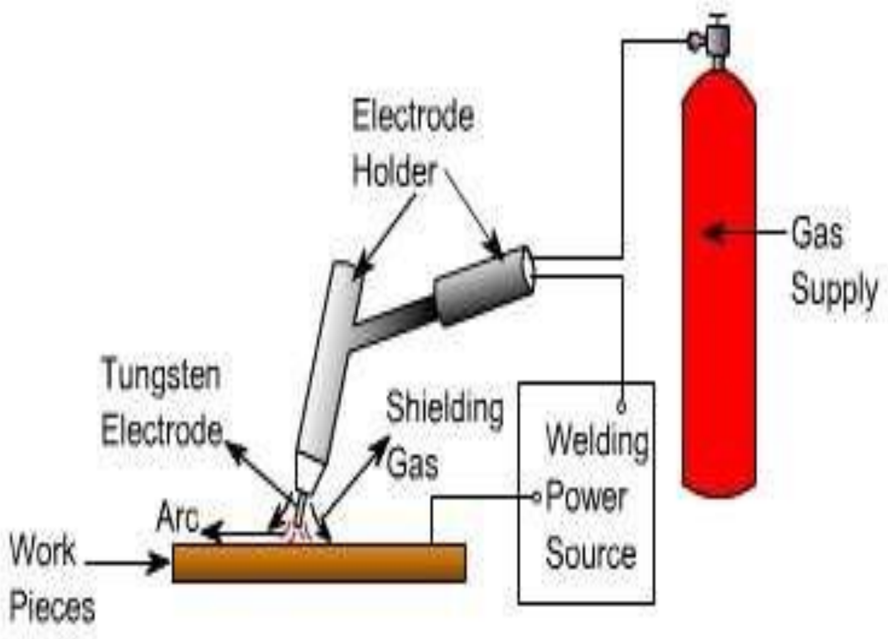
ABSTRACT: To advance the welding quality of Aluminium alloy plate an automated TIG welding arrangement has been developed, by which welding speed can be controller during welding procedure. Welding of Al alloy plate has been attained in two phases. During 1^st^ model of welding, one side welding is done over Aluminium alloy plate and during 2^nd^ phase both sides that is two sides welding is done for the aluminium alloy, by changing the welding parameters. Effect of the welding speed & current on tensile strength of the welded joint will be investigated for both weld types of joints. Here optical microscopic analysis is carried out on the weld zones to obtain the effect of welding parameters on welding quality. Even micro-hardness is also calculated at the cross section to understand the change of mechanical properties at the welded zones.

***Keywords*: Automated TIG Welding System, Micro hardness Test, Tensile Test**

INTRODUCTION

Welding is a stable connection process used to link dissimilar materials like metals, alloys or plastics, together at their contacting surfaces by use of heat and or pressure. Throughout the welding, the work piece has to be combined are melted at the interface and after solidification a permanent joint can be attained. Occasionally a filler material is additional added to the method, a weld pool of molten material which afterward solidification provides a strong bond amongst the materials. Weld ability of a material be contingent on different factors similar the metallurgical vagaries that occur during welding, Variations in hardness in weld zone due to rapid solidification, extent of oxidation due to response of materials with atmospheric oxygen & tendency of crack development in the joint position.
An sample schematic diagram of TIG welding is shown in the below



Schematic Diagram of TIG Welding System

Result and discussion

Welding width for all the samples were measured and calculated average welding width as shown in table 4. Average value of welding width then plotted against the applied welding current for different welding speed as shown in Fig. 5. From the plot it is clearly seen that welding width increases almost linearly with increase of welding current.

Fig.4 shows the welded butt joint specimen, where welding performed with different welding speed and current setting as described in table 3.

Fig. 4–welded specimen performed with (a) welding speed 3.5 mm/sec & welding current 100, 110, 120, 130 and 140 A are taken for the sample no 1, 2,3,4,5 respectively (b) welding speed 4 mm/sec and welding current 100, 110, 120, 130 and 140 A are chosen for sample no 6,7,8,9,10 respectively

Table: Weld width

Sample no	Reading 1 (mm)	Reading 2 (mm)	Reading 3 (mm)	Avg. width (mm)
1	5.43	4.85	4.51	4.93
2	7.35	6.83	7.22	5.14
3	8.95	7.58	7.29	7.94
4	7.24	7.82	7.82	7.626
5	10.92	10.45	10.04	10.47
6	5.03	5.18	4.92	5.042
7	5.53	5.85	5.99	5.79
8	8.57	8.05	7.86	8.16
9	9.27	8.06	8.27	8.54
10	9.13	10.07	8.57	9.256

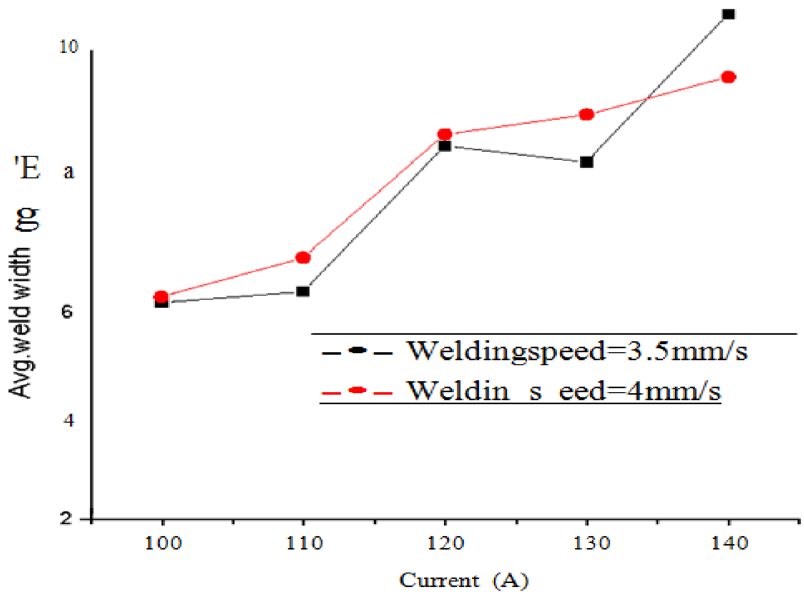


Fig : Welding width of the samples with different welding speed and welding current condition

Surface roughness of the weld zone for all the samples were measured and average surface roughness value was calculated from three reading which is tabulated in below table. Surface Roughness value initiates in the range of 1.1 to 3.5 micron is relatively low for a welded specimen. Therefore we can conclude that using an automated system and good quality of welding is probable which may not need in any additional finishing operation. These roughness values are over plotted against applied current. But there is no specific effect of applied current on the surface roughness value which has been pragmatic.

Table: Surface roughness value for different welded samples

Sample No	Readingl (-tm)	Reading2 (-tm)	Reading3 (-tm)	Avg. Value (-tm)
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

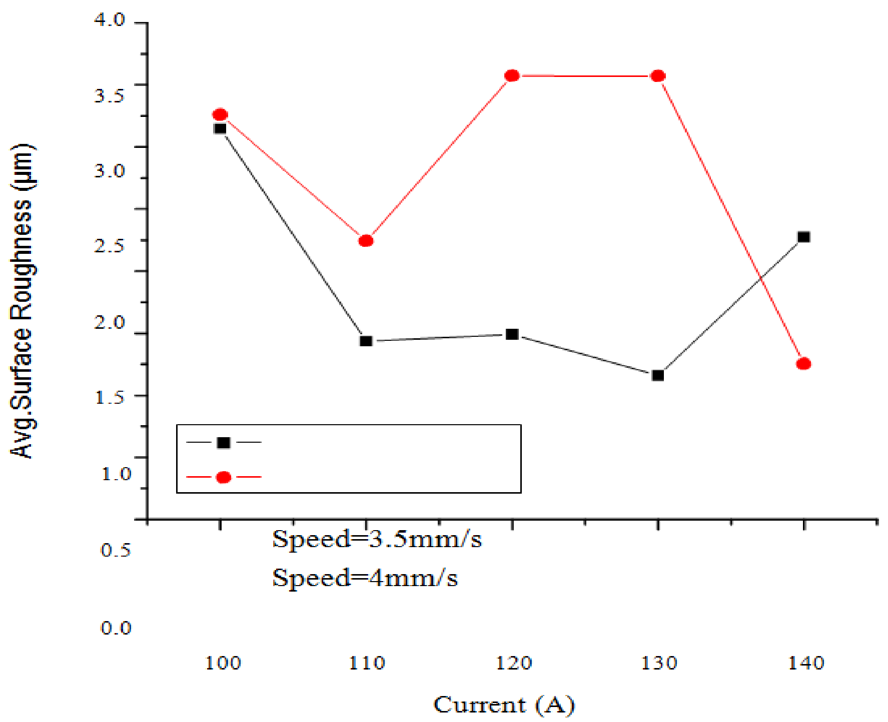


Fig. : Avg. surface roughness of the sample thru dissimilar welding current and welding speed condition

Optical microscopy imageries of the weld zone at the cross section:

current	Welding speed= 3.50 mm/s	Welding speed=4 mm/s
100 (A)		
110 (A)		
120 (A)		
130 (A)		
140 (A)		

Fig. : Optical microscopy photograph at the cross section of the welding done with different current setting and welding speed

Fig. 7 shows the optical image of the welded zone at the cross section for the specimen prepared with different welding speed and current setting. From the images no specific change could be observed for the weld specimen. However, cross section of the weld zone shows a clear effect of the welding parameters like applied current and welding speed. Fig. 7

shows the optical photograph at the cross section of the welding performed with different current setting and welding speed. It can be say from the observation of the figure that as welding current increases welding depth also increases for fixed value of welding speed. Again for a particular value of welding current welding depth found decreases as the welding speed increases.

From Fig. 8 and 9 shows the micro-hardness value at the welded zone taken from the centre of the welding zone towards the base material for different samples performed with different welding speed and welding current. From the graph it is found that for almost all the sample micro hardness value increases in the welding zone than the base material and these values are in the choice of 40 to 80 HV in the welded zone. After a certain distance these value reduces to the hardness of the base material for the sample processed with welding speed 3.5 mm/s and different current setting as shown in Fig. 8. However for the welding done with welding speed 4 mm/s and different current setting micro-hardness value reaches
to micro hardness of the base material after 5-6mm.

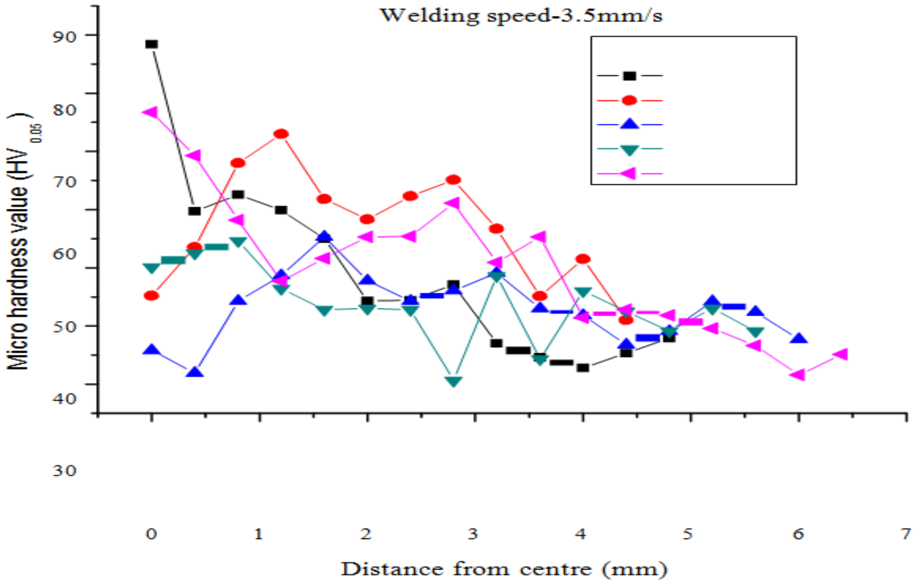


Fig.: Micro-hardness value from the centre of the weld zone towards the base material for welding done with welding speed 3.5 mm/s and different welding current

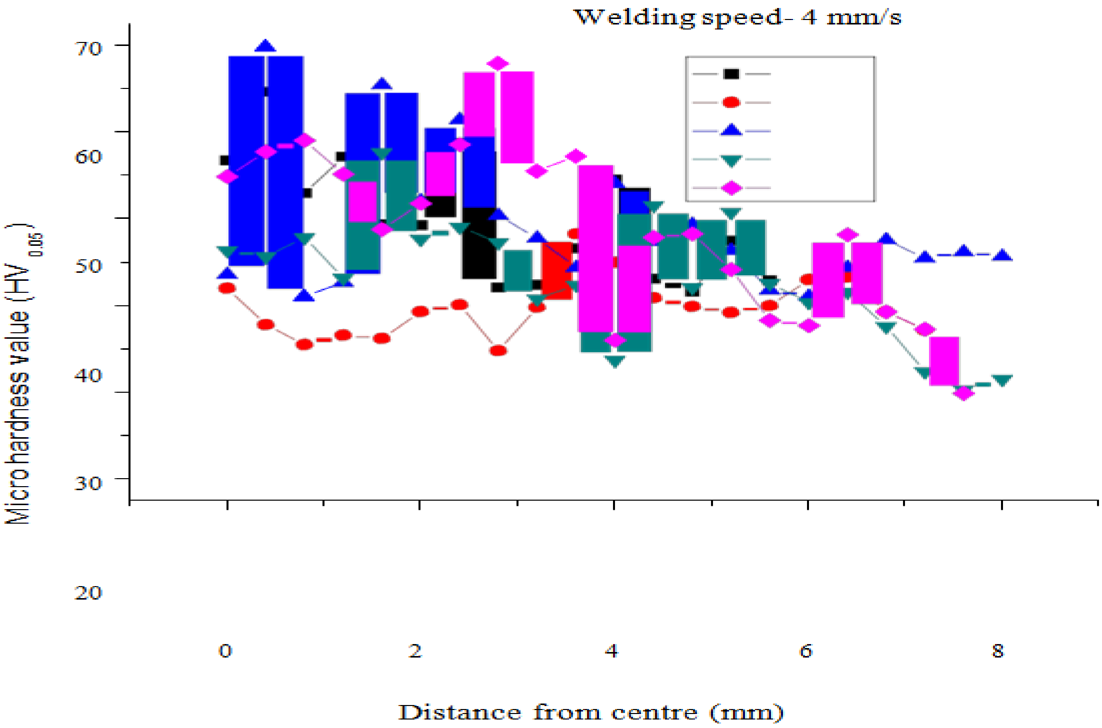


Fig. : Micro-hardness value from the centre of the weld zone towards the base material for welding done with welding speed 4 mm/s and different welding current

Tensile test:

Table 6 shows the tensile strength value for all the welded joints produced at different welding speed and current setting. Here the values are much lesser than the tensile strength of the pure aluminium. The received tensile strength of the aluminium is found to be 132MPa. In the figure 10 tensile strength of the welded joints are plotted against applied current for welding speed of 3.5 mm/s. From the it is also found that tensile strength value almost increasing for increasing current setting when welding speed is 3.5 mm/s (except for welding current form

120 A to 130 A). Similarly in Fig. 11 tensile strength of the welded joints are plotted against applied current for welding speed of 4 mm/s. From this graph it is found that, welding done with 4 mm/s there is no specific trend in change of tensile strength due to change in current. Initially with increase current tensile strength of the welding increases upto 120 A and then this value decreases.

Comparing the fig. 10 and 11 it is clearly seen that for almost all current setting condition (except 120 A current setting) tensile strength values of the welded joint performed with welding speed 3.5 mm/s are larger than the tensile stress values of the welded joint performed with welding speed 4 mm/s.

Table : Maximum load at tensile strength and tensile strength value of different welded

Samples

Sample no	Load at tensile strength (N)	Actual tensile strength (MPa)
1	1719.36415	22.92486
2	1964.57603	26.19435
3	2878.42769	38.37904
4	2311.58920	30.82119
5	2927.50737	39.03343
6	1311.63038	17.48841
7	1285.78716	17.14383
8	3307.39478	44.09860
9	2258.41971	30.11226
10	1386.81158	18.49082

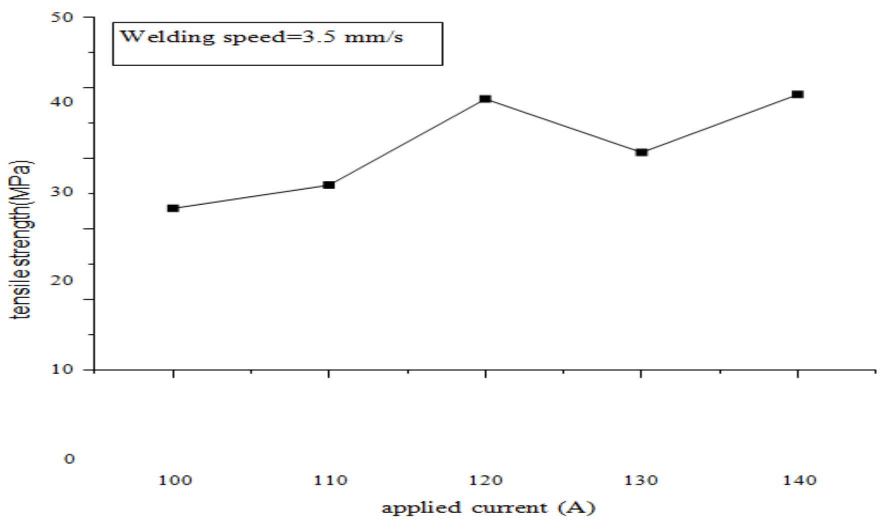


Fig: Tensile strength of the welded joint against applied current for welding speed of 3.5 mm/s.

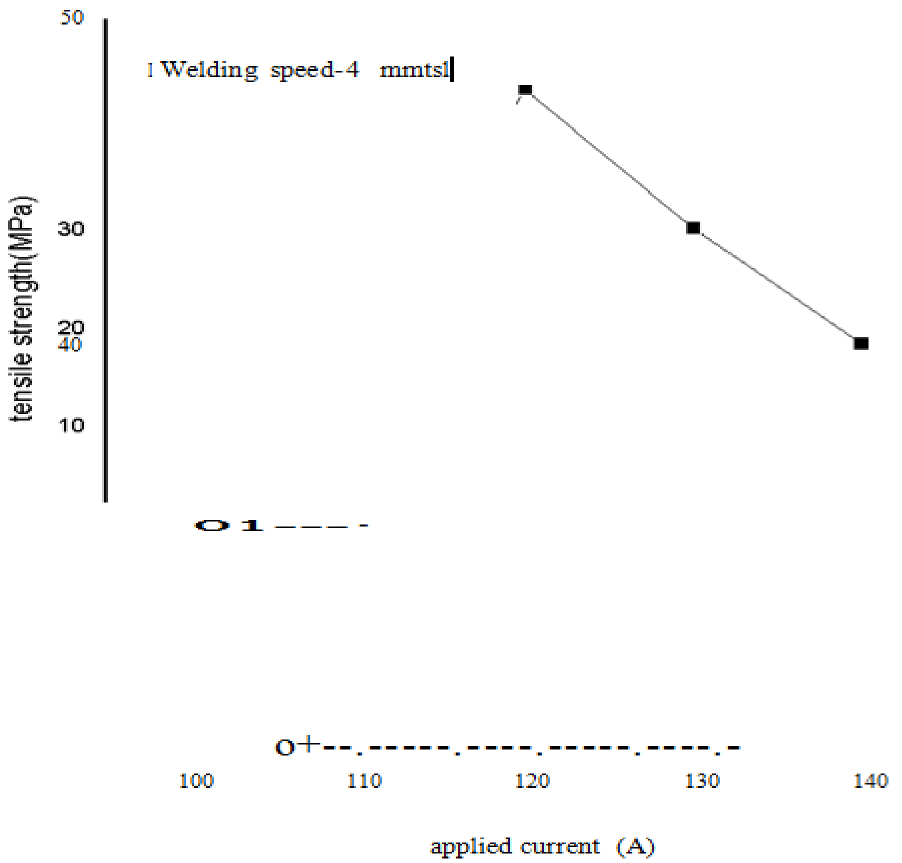


Fig: Tensile strength of the welded joint against applied current for welding speed of 4mm/s.

2"d phase of experiment (both side joint):

After performing the 1st stage of experiments it was revealed that tensile strength of the weld joint is quite low and only part of the plate thickness got welded for the applied parameter setting.

Table: Experimental parameters for both sides welding by TIG welding

Exp. No.	Electrode Workpiece Distance (mm)	Argon Gas flow rate (1/min)	Voltage (V)	Current (A)	Welding Speed (mm/s)
1	3	8-10	50	150	3.5
2	3	8-10	50	150	4
3	3	8-10	50	150	4.5
4	3	8-10	50	150	5
5	3	8-10	50	180	4.5
6	3	8-10	50	180	5
7	3	8-10	50	180	5.5
8	3	8-10	50	180	6

For all the experiments, distance between electrode and work-piece kept constant at 3 mm, Ar gas flow rate was 8-10 l/min and applied voltage was 50 V. Welding is been done by changing the welding current and welding speed.

Fig : Tensile test specimen

Fig: Tensile test machine during performing test

Table : Maximum load at tensile strength and tensile strength value of different welded samples (Both side welding)

Sample No	Load at tensile strength(N)	Tensile strength (MPa) UTS
1	6711.35578	111.8559
2	5538.17376	92.3029
3	4835.23384	80.58724
4	4517.39766	75.28996
5	5962.58473	99.37641
6	5752.48897	95.87498
7	6289.73264	104.8289
8	5994.42478	99.90709

The tensile strength value of the welded specimen plotted against welding speed for applied welding current of 150 A. Form the figure it is clear that tensile strength value of the welded joint decreases from approximately 110 MPa to 75 MPa for increasing welding speed form 3.5 mm/s to 5 mm/s. However, welding is done with the current setting 180 A (Fig. 18) it is found that tensile strength value of the welded joint are in the range of 95-105 MPa and no specific trend in change of tensile strength for the change of welding speed has observed.

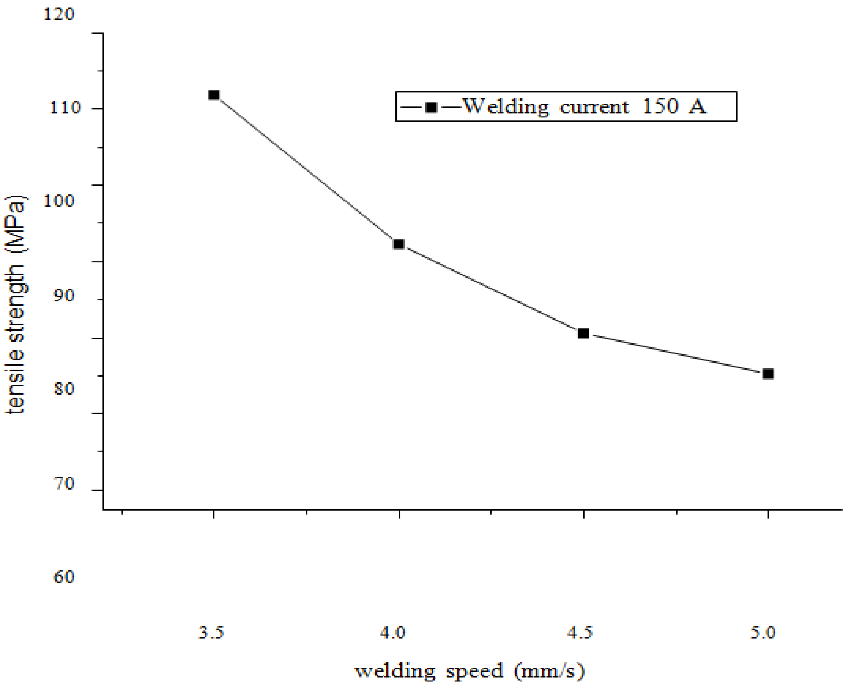


Fig: Tensile strength of the welded joint against different welding speed for Applied current of 150 A

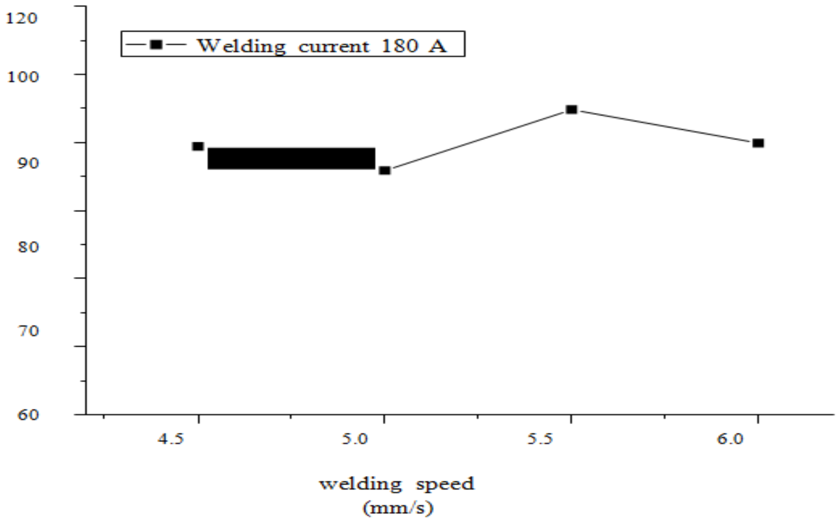


Fig: Tensile strength of the welded joint against different welding speed for applied current of 180 A

The tensile strength value of the welded specimen plotted against welding speed for applied welding current of 150 A. Form the figure it is clear that tensile strength value of the welded joint decreases from approximately 110 MPa to 75 MPa for increasing welding speed form 3.5 mm/s to 5 mm/s. However, welding done with current setting 180 A (Fig. 18) it is found that tensile strength value of the welded joint are in the range of 95-105 MPa and no specific trend in change of tensile strength for the change of welding speed has observed.
At relatively lower current setting i.e. 150 A when welding speed increase overall heat input for the welding decreases and corresponding welding penetration from both side also decreases and therefore tensile strength of the welded joint decreases. However, when welding perform with 180 A and different welding speed value heat input decreases with increase value of welding speed but with the minimum heat input maximum welding penetration is been obtained for the higher amount of current(180 A). Therefore for altering the welding speed no detailed variation in the welding speed has been experimental.

Micro hardness value for both side welding:

Fig. 19 shows the micro hardness profile from the centre of the weld zone towards the base material for welding done with welding speed (3.5 mm/s and 4mm/s) and welding current(150 A) while the welding is done from the both side.

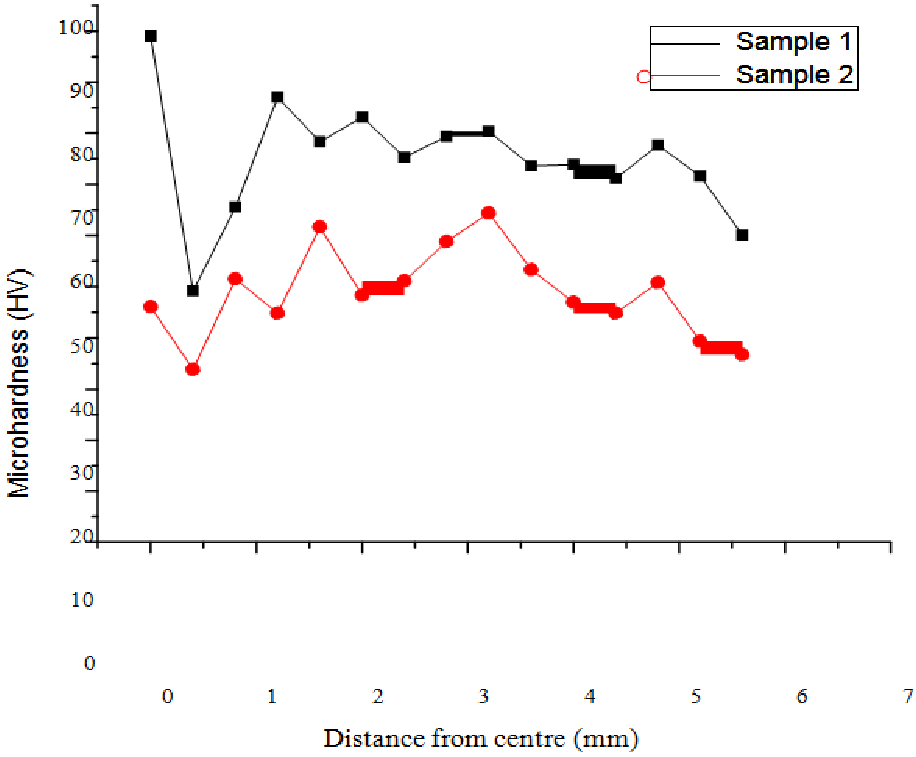


Fig : Micro-hardness value from the centre of the weld zone towards the base material for welding done with welding speed (3.5 mm/s and 4mm/s) and welding current(150 A)

CONCLUSION

From the experiment of TIG welding of Aluminium plate following conclusion can be made

- The automated welding system unvarying welding of Aluminium plate can be possible.
- Welding strength or tensile strength of the weld joint will depend up on the welding parameters chosen such as welding speed and welding current.
- With the increase in current, tensile strength of the welded joints will increase.
- Here the hardness of the weld zones changes with the distance from weld center due to the changes in the microstructure.
- At lower welding speeds strength is more due to more intensity of current.
- For both side welding tensile strength is found almost equivalent to the strength of base material.
- For both sided welding performed with high current (180 A), welding speed has no specific effect on the tensile strength on the welded joints.

Future scope

Here in this thesis welding has been performed without any filler materials. If a filler rod wire feeding system can also be included in this process by using filler rod wire thicker plate also can be welded. Welding setup can also be use for welding of some other materials.

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