Analysis of TIG Welding Process on Mechanical Properties and Microstructure of Aa6063 Aluminum Alloy Joints

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Abstract: Present work pertains to testing of mechanical properties and microstructure of AA 6063 Aluminium alloy joints by Tungsten inert gas (TIG) welding. By varying weld current and maintaining all parameters constant hardness, impact and tensile strength of the welded joints are tested and finally, microstructure details are analyzed. The results showed mechanical properties linearly varies with increase in weld current.

Keywords**:** TIG Welding , Microstructures , Welded Joints , Mechanical Properties , Alluminium alloy , varying current

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1. Introduction:

TIG stands for Tungsten Inert Gas .Gas tungsten arc welding GTAW is frequently referred as TIG welding. Tungsten inert gas is an arc welding method involving electric arc heat being maintained in between a fixed non-consumable tungsten electrode and the specific component being welded. The arc produces the required heat to melt the work and the shielding gas (pure argon), fed through the torch, keeps oxygen in the air away from the molten weld pool and the hot tungsten. Tungsten is used for the electrode both because of its high melting temperature and good electrical characteristics. When filler metal becomes necessary, a separate filler rod is fed into the arc stream either manually or mechanically. Since no flux is required, the weld joint is clean and free of voids. Tungsten Inert Gas is one of the widely used techniques for joining ferrous and non ferrous metals.TIG welding process offers several advantages like joining of dissimilar metals of 0.5mm thickness with low HAZ (heat affected zone), absence of slag etc., Compared to other process like MIG welding. Welding input parameters play a very significant role in determining the quality of a weld joint. The joint quality can be defined in terms of properties such as weld-bead geometry, mechanical properties, and distortion. Generally, all welding processes are used with the aim of obtaining a welded joint with the desired weld-bead parameters, excellent mechanical properties with minimum distortion. A lot of research work has been done on TIG Welding process for various materials to obtain the optimal mechanical properties. Jun Yan, Ming Gao , Xiaoyan Zeng [1] published a paper on Study on micro structure and mechanical properties of 304stainless steel joints by TIG , Laser and Laser-TIG hybrid welding. S.C. Juang , Y.S. Tarng [2] published a paper on selection of process parameters in TIG Welding to optimize the weld pool geometry on Stainless Steel material. A. Kumar & S. Sundarrajan [3] published a paper on the effect of welding parameters on mechanical properties of Al-Mg-Si alloy in TIG Welding by using Taguchi Method. Pawan Kumar, Kishor Purushottamrao Kolhe, Sashikant Janardan Morey, Chanchal Kumar Datta [4] published a paper on optimization of process parameters of an Alluminium Alloy with Pulsed Gas Tungsten Arc Welding using Gas Mixtures. P Sreeraj, T Kannan, Subhasis Maji [5] published a paper on Optimization of Process Parameters of Stainless Steel Clad Bead Geometry Deposited by GMAW Using Integrated Genetic Algorithm and Simulated Annealing. R.Sathish, B.Naveen, P.Nijanthan, K.Arun Vasantha Geethan, Vaddi Seshagiri Rao [6] published a paper on Weldability and Process Parameter Optimization of Dissimilar Pipe Joints using GTAW. ER Raghuvir Singh, Dr. N.M Suri, Prof. Jagjit Randhawa [7] published a paper on Optimization of Process Parameters for TIG Welding of 304l Stainless Steel using Response Surface Methodology. The main objective of the present study is to know the effect of TIG welding process parameter i.e., Current on mechanical properties and micro structure of Aluminium Alloy 6063 L weld joints. Tests were conducted to determine the mechanical properties tensile strength, impact strength, hardness of welded joints. The microstructure of the welded joints are observed under the microscope (20x, 50x and 200x magnification) and the results are discussed to know the effect of process parameter i.e., current on the mechanical properties and micro structures of welded joints on the TIG welding process.

2. Experimental Procedures

2.1 Welding Process

In this experiment, Plates of AA6063 aluminum alloy are machined in dimensions of 150mmx50mmx6mm. Two plates of same dimensions are joined as a square butt joint giving the resultant dimensions of 150mmx100mmx6mm.welding is done in forward direction using pulsed AC current. A non- consumable tungsten electrode of 2.4mm diameter shielded by argon gas is used to strike the arc with base metal, while distance between plates and tungsten electrode tip was 3mm in welding process with a root gap of 3.5mm and root face of 2mm. The chemical composition (wt%)of material was Al97.9,Si 0.51,Fe0.33,Cr0.06,Mn0.08,Mg0.76,Cu0.06,Zn 0.03,Ti0.05.The surface of the plates was cleaned, degreased and dried before welding.

By varying the weld current in between 300A-400A and maintaining all other parameters constantly microstructure and mechanical properties of welded joints are tested. To observe the microstructure under the metallurgical microscope specimens were cut from the weld beads, and are prepared according to the standard procedures. To study mechanical properties, abrasive cutters are used to cut joints and then machined into the required dimensions.

3. Experimental Results

3.1 Mechanical properties

3.1.1 Tensile strength

The welded samples were tested for tensile strength using the universal tensile machine (UTM). The edges of the test samples were fitted into the jaws of the testing machine and subjected to tensile stresses until the sample fractured. During the test, the various stress-strain diagrams were drawn for each of the sample from where the tensile load is determined.

Fig 1 : UTS tested specimens

Sample no	Current(A)	Ultimate Tensile strength (Mpa)
1	300	78.186
2	325	62.618
3	350	94.124
4	375	96.554
5	400	96.474

Table 1: UTS of AA6063 joints

3.1.2 Impact Strength

The Charpy test sample has 55mm x10mm x6mm dimensions, a 45deg V notch of 5 mm depth and a 0.25 mm root radius will be hit by a pendulum at the opposite end of the notch. To perform the test, the pendulum set at a certain height is released and impact the specimen at the opposite end of the notch to produce a fractured sample. The absorbed energy required to produce two fresh fracture surfaces will be recorded in the unit of Joule.

Fig 2: Impact tested specimens

Sample no	Current (A)	Absorbed Energy (J)
1	300	9
2	325	19
3	350	3
4	375	11
5	400	12

Table 2: Impact strength of AA6063 joints

3.1.3 Hardness Test:

Toughness of welded samples are tested using Brinell hardness testing machine"75 HB 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter hardened steel with a 500 kilogram load applied for a period of 30 seconds.

Sample no	Current (A)	Hardness (BHN)
1	300	27.1286
2	325	26.53
3	350	38.12
4	375	40.198
5	400	53.43

Table 3: Hardness of AA 6063 Joints

Hardness is being increased gradually but at a certain point the hardness will become lesser than the previous reading obtained and then again the hardness is increased

3.2 MICROSTRUCTURE

The samples were cut to small pieces using metallographic cutter and put in a furnace at about 500°C for heat treatment. The base was made by using a hydro-press mounting machine and ground with emery paper of finer grade (180, 320, 600, 800 and 1000) and polished using the 6μ, 3μ and 1μ of diamond particles. The samples were etched with chemical solution that contained 190 ml distilled water, 5ml nitric acid, 3ml hydrochloric acid and 2ml hydrofluoric acid for about 80 seconds before being observed under the microscope (20x, 50x and 200x magnification).

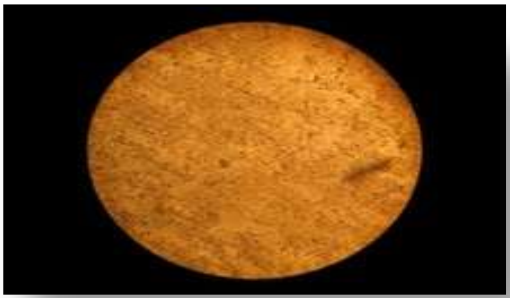

Fig 3: Sample 1(300A)

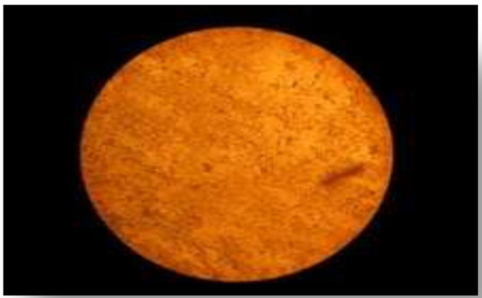

Fig 4: Sample 2 (325A)

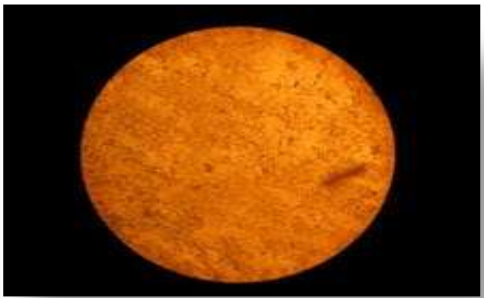

Fig 5: Sample 3 (350A)

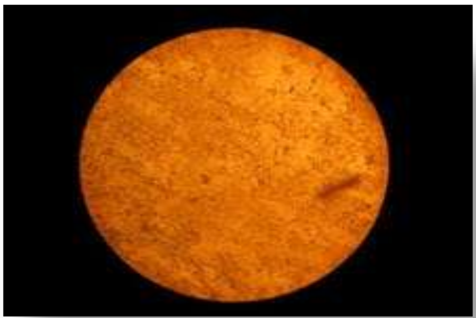

Fig 6: Sample 4 (375A)

In Sample 1, the micrograph of welded sample subjected to current 300A processing show fine grains of well diffused Mg2Si compound in the Al matrix. These fine particles are responsible for the high and improved ultimate tensile strength and hardness values obtained in Figures 3 and 5 above

From Sample 2, the micrographs of welded sample subjected to current 325A processing show well diffused equiaxed compound of Mg2Si in Al matrix. This structure also enhanced good mechanical properties for the sample in terms of the ultimate tensile strength and hardness values. These were shown in Figures 3 and 5 above.

In Sample 3 show high concentration of the Mg_2Si compound at different parts of the sample. There is no uniform diffusion of the precipitated compound and hence, the obtained ultimate tensile strength and hardness values. These were shown in Figures 3 and 5 above show the values.

The micrograph of the sample welded at current 375A revealed the deposition of the precipitate of Mg2Si in Al matrix at the grain boundaries with a cluster at a point close to the edge. This enhanced good ultimate tensile strength and hardness properties as obtained in Figures 3 and 5.

4. CONCLUSION

TIG welding is done on Aluminium 6063 plates. The effect of current on the mechanical properties of welded joints is studied. The increase of welding current in AA6063 aluminum alloy will increase the welding heat input. Accordingly, the chance of defect formation such burns in welded metal also increases. It affects on the mechanical properties and quality of welded metal badly. It is observed that by varying current, the diffused equi axed compound of Mg2Si in Al matrix varies linearly and the mechanical properties also varies according to the fineness of diffusion. Mechanical properties are directly proportional to the fineness in the grain diffusion of Mg2Si in Al matrix which depends on the process parameter i.e., Current of TIG Welding.

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