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Analysis on Mechanical Properties of Gas Tungsten Arc Welded Dissimilar Aluminium Alloy (Al2024 & Al6063)

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Abstract: In this project dissimilar aluminium alloys (Al2024 & Al6063) are welded using tungsten inert gas welding in the butt joint with single V edge preparation. The welding is carried out with modifying three set of parameters such as current, gas flow rate and root gap.Welded materials is then subjected to various mechanical behaviour analyses such as tensile strength, hardness, corrosion test and microstructure analyze also carried out using scanning electron microscope for metallurgical study purpose. The main aim is to analyze how welding process parameters changes affect the mechanical behaviour of the aluminium alloys.
Keywords: Aluminium alloys (Al 6063 & Al 2024), Gas tungsten arc welding, (GTAW)Tensile, Hardness and corrosion test, Scanning electron microscopy (SEM)

I. INTRODUCTION

Aluminum combinations are notable for their applications in manufacturing industries Al6063 is an aluminum alloy with magnesium and silicon as the alloying components. It has commonly great mechanical properties and is heat treatable and weld able too. Al2024 aluminum compound is an aluminum amalgam with copper as the essential alloying component. It is utilized in application requiring high solidarity to weight proportion just as great exhaustion obstruction.

Welding is a joining process used to join different materials like metals, composites or plastics, together at their achieving surfaces by usage of warmth or possibly weight.

Weld limit of a material depends upon different segments like the metallurgical changes that occur in the midst of welding, changes in hardness in weld zone in light of speedy solidifying, level of oxidation on account of reaction of materials with natural oxygen and tendency of split game plan in the joint position. In TIG welding, the electric arc is produced between a non-consumable tungsten electrode and the work piece.

There electrode holder in which the nonconsumable tungsten electrode is fixed. By supplying the electric power between the electrode and the work piece, the insert gas from the cylinder passes through the nozzle of the welding head around the electrode. The insert gas surrounds the arc and protects the weld from atmospheric effects and hence defect free joints are electrode. The insert gas (argon) surrounds the arc and protects the weld from atmospheric effects and hence defect free joints are made. This process is also called as Gas Tungsten – Arc welding (GTAW).

A. Tungsten Inert Gas Welding

Welding utilizes the warmth created by an electric bend struck between a nonconsumable tungsten terminal and the work piece to combine metal in the joint region and produce a liquid weld pool. The bend zone is covered in an inactive or diminishing gas shield to ensure the weld pool and the non-consumable cathode. The procedure might be worked autogenously, that is, without filler, or filler might be included by bolstering a consumable wire or bar into the built up weld pool. TIG create

extremely top notch welds over a wide scope of materials with thicknesses up to around 8 or 10 mm. It is especially appropriate to sheet material.

The strength of the welding depends on following factors

1) The decision of selecting inert gas
2) Tungsten electrode
3) Current and voltage
4) Root gap between the work piece

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B. Process Parameters

There are a lot of welding parameters to consider when using gas tungsten arc welded as a machining process. It's important to examine these factors to determine their importance and get a good weld.

1) Current
2) Gas
3) Flow Rate
4) Root Gap

II. METHODOLOGY

A. Methodology Of The Project Work

The various literature survey is done. After studying the literature the Methodology has been made

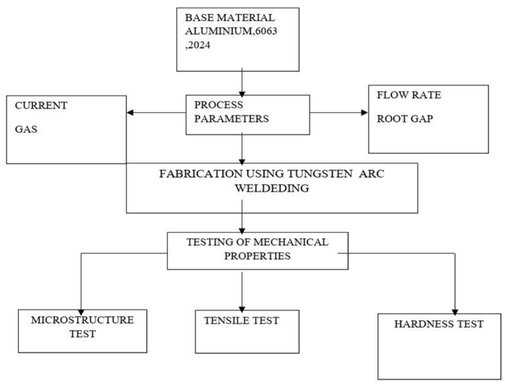

Fig. 1 Flow chart of project work

III. EXPERIMENTAL PROCEDURE

A. Material Selection

1) Base Metal Al2024 And Al6063

a) Aluminium 6063 is generally have good mechanical properties and is heat treatable and weld able. The Alloying composition of Aluminium 6063 is shown in (Table 41)

b) Aluminum 2024 contains copper as primary alloying agent.

Fig. 3 Tungsten arc welding

c) It is used in application where high strength to weight ratio and good fatigue resistance is needed It is difficult to weld through gas tungsten arc welding so that it is joined with aluminium 6063 to test its welding ability. The alloying element of Al2024 is shown in (Table.3)

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B. Chemical Composition

Table 1 Chemical composition of Al6063

Elements	% of composition
Silicon	0.2–0.6
Iron	0.35
Copper	0.10
Manganese	0.45–0.9
Magnesium	0.10
Chromium	0.10
Zinc	0.10
Titanium	0.10
Aluminium	Remaining

Table 2 Chemical composition of Al2024

Elements	% of composition
Silicon	<0.5
Iron	<0.5
Copper	4.3–4.5
Manganese	0.5–0.6
Magnesium	1.3–1.5
Chromium	<0.5
Zinc	<0.5
Titanium	<0.5
Aluminium	Remaining

The detailed experiment procedure followed in this analyze is first the aluminium alloy of different series Al2024 and Al6063 with size of (10*6*1) cm shown in (Fig. 4) has been taken and made a single V edge preparation on it for butt joint. The gas tungsten arc welding is carried out by using argon as a inert gas with changing the root gap of 0.5 mm, 1 mm and 1.5 mm, inert gas flow rate, voltage and current applied. After the welding process carried out, the welded sample is carried out with different mechanical behaviour and microscopic structure analysis such as hardness test, tensile test, impact, corrosion test and scanning electron microscopic analysis.

Fig. 4 Welded Aluminium alloy

The above welded samples are made by changing the various welding process parameters. For each samples different root gap, current, voltage and inert gas flow rate to be maintained. The various changes for each sample is shown in (Table 3)

Table 3 Welded samples process parameter

Sample	Voltage (V) Volt	Current (I) Amps	Root gap (R) mm	Gas flow rate (G) litre/mins
1	30	60	0.5	16
2	40	70	1	18
3	50	80	1.5	20

C. Experimental Test On Welded Dissimilar Aluminium Alloy

In this work various weld parameters of TIG welded Aluminum alloy are examined by conducting the following tests.

1) Hardness Test with Vickers Hardness Testing Machine.
2) Tensile test by using UTM.
3) Corrosion Test
4) Microstructure analysis using SEM.

a) *Hardness Test On The Welded Specimen (Vickers hardness test):* Hardness is the property of a material that empowers it to stand up to plastic disfigurement, for the most part by entrance. Be that as it may, the term hardness may likewise allude to protection from bowing, scratching, scraped spot or cutting. The Vickers hardness test technique, likewise alluded as a smaller scale hardness test strategy, is for the most part utilized for little parts, slender Segments, or case profundity work [7]. The Vickers strategy depends on an optical estimation system. The Vickers hardness test technique comprises of indenting the test material with a precious stone indenter, as a correct pyramid with a square base and a point of 136 degrees between inverse faces exposed to a heap of 1 to 100 kgf. The full burden is typically connected for 10–15 s. The two diagonals of the space left in the outside of the material after expulsion of the heap are estimated utilizing a magnifying instrument and their normal determined. The zone of the inclining surface of the space is determined. The Vickers hardness is the remainder gotten by separating the kgf load by the square mm territory of space. Hardness Test is finished with Vickers Hardness Testing machine for inspecting the Variation of hardness of Gas tungsten arc Welded Aluminum alloy with various root holes and at various process parameter changes.

b) *Tensile Test:* Tensile test is performed on welded sample as shown (Figs. 5 and 6). The after effects of malleable tests are utilized in choosing materials for designing applications. Malleable properties much of the time are incorporated into material details to guarantee quality. Ductile properties frequently are estimated amid advancement of new materials and forms, with the goal that various materials and procedures can be looked at. At last, elastic properties regularly are utilized to foresee the conduct of a material under types of stacking other than uniaxial strain [8]. These proportions of solidarity are utilized, with suitable alert (as security factors), in designing structure. Likewise, of intrigue is the material's pliability,which is a proportion of the amount it very well may be twisted before it cracks

Fig. 5 Welded sample before tensile test.

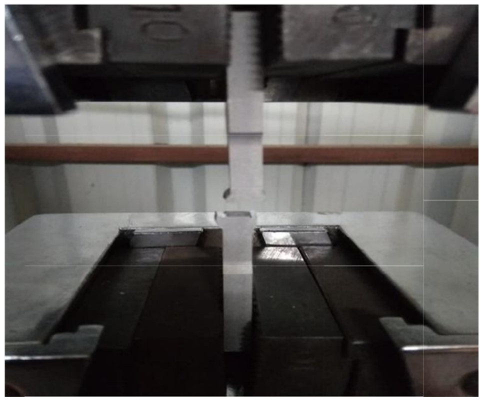

Fig. 6 Welded sample after tensile test

c) Corrosion Test: The salt shower test is an institutionalized and prominent corrosion test strategy shown in (Figs. 7 and 8), used to check consumption opposition of materials and surface coatings. Normally the materials to be tried are metallic completed with a surface covering which is expected to give a level of consumption assurance to the basic metal. Salt shower testing is a quickened erosion test that delivers a destructive assault to covered examples so as to assess the appropriateness of the covering for use as a defensive completion [9]. Test term relies upon the erosion obstruction of the covering, by and large the more consumption safe the covering is, the more drawn out the time of testing before the presence of erosion rust.

Fig. 7 Salt spray test chamber.

Fig. 8 Corrosion test arrangement

IV. RESULTS AND DISCUSSION

A. Vickers Hardness Test Values

The TIG welding test samples are subjected to Hardness test using Wilson Wolpert Micro hardness tester [10]. Each sample was tested at four locations with the test specimen being ssubjected

Table 4 to a load of 0.5 kg for a dwell time of 10 s for each location and the Hardness test results. Results are shown in (Table 4). The specifications of the test are

Given below:

Machine Name: Micro Vickers Hardness Tester

Testing load range: 10 g to 1 Kg Load

Make: Wilson Wolpert – Germany

Vernier caliper least count: 0.01 mm

Available Hardness testing Scale: HV, HRA, HRC, 15 N, 30 N etc.

Table 4 Hardness test result.

Properties	Location	Sample 1	Sample 2	Sample 3
H.V @0.5 kg load	1	31.8	37.2	34.1
	2	32.6	37	35.2
	3	33.1	36.4	33.9
	4	31.5	36.8	34.5
Average		32.3	36.9	34.5

1) Corrosion Test Result

Sample id: Hi-tensile aluminium –TIG welding 3 Nos.

History: Three aluminium welding specimen was subjected to salt spray corrosion test as per ASTM B 117-14. The sample was loaded in the chamber for 24 h and the details are given below in (Table 5).

Humidity 98% as measured by hygrometer during the test. Temperature of the test is 33 Degrees centigrade.

Pressure of Air for atomizing was 2–3 bar continuously by pressure regulator. Composition of the salt solution for 1 L of solution, 5% of Sodium chloride, 1% of Magnesium chloride, 94% of Deionized water pH of the solution maintained at 7.2 by addition of buffer solution. Determined by calibrated by pH meter with standard buffer solution. Measurement of pH, measured once in 8 h [11]. Type of loading of castings is tied with plastic wire and hung in the hangers.

Corrosion observation & measurements: The tool after cleaning with organic solvents and degreasing solution washed with D.M. water dried and weighed [12]. The initial weight before loading and the final weight after 24 h exposure were measured and given below. The casting surfaces were periodically observed and the images of the surfaces were captured after 24 h

Table 5 Corrosion test result

Sample	Initial weight(gm)	Final weight (gm)	Weight loss (gm)
1	5.960	5.940	0.02
2	5.982	5.966	0.016
3	5.976	5.965	0.011

2) Tensile Test Result

a) The tensile result and stress strain curve for sample 1 with 0.5 mm root gap is shown in (Fig. 9).

b) The tensile result and stress strain curve for sample 2 with 1 mm root gap is shown in (Fig. 10).

c) The tensile result and stress strain curve for sample 3 with 1.5 mm root gap is shown in (Fig. 11).

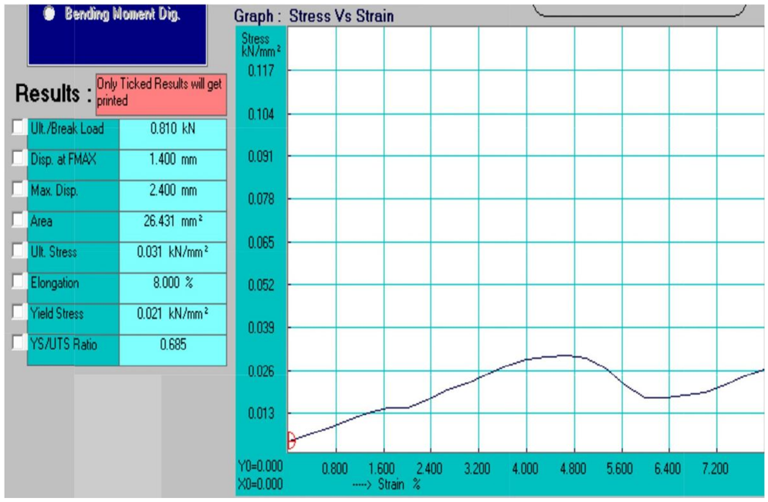

Fig. 9.Tensile test result for sample 1 (0.5 mm root gap).

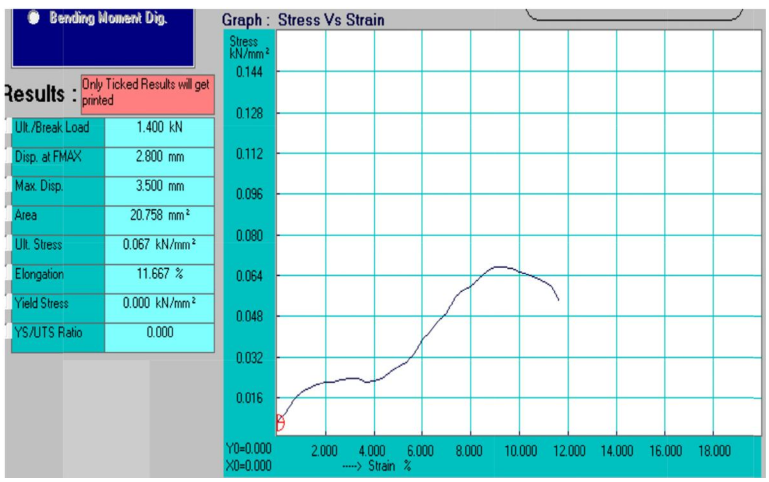

Fig. 10 Tensile test specimen for sample 2 (1 mm root gap).

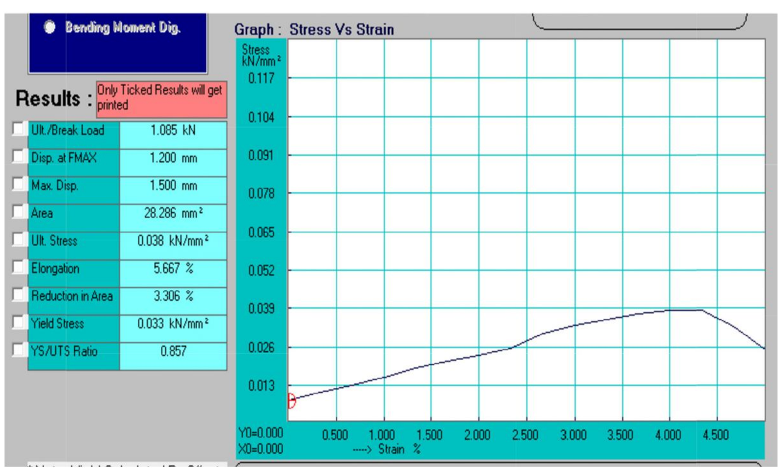

Fig. 11 Tensile test specimen for sample 3 (1.5 mm root gap).

3) Microstructural Testing

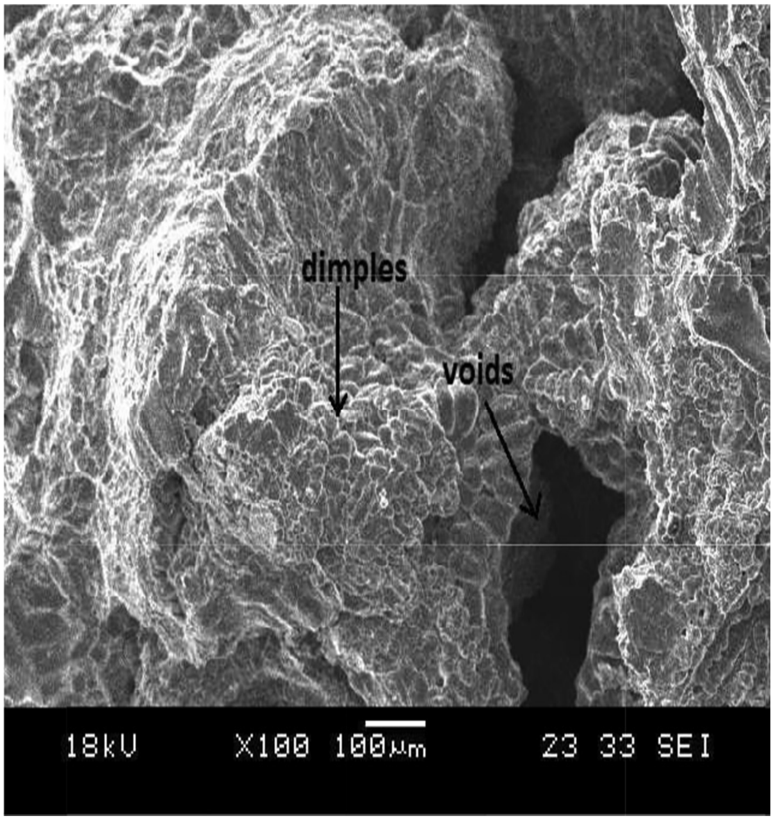

Fig. 12. SEM image of 0.5 mm root gap weld sample in polished stage

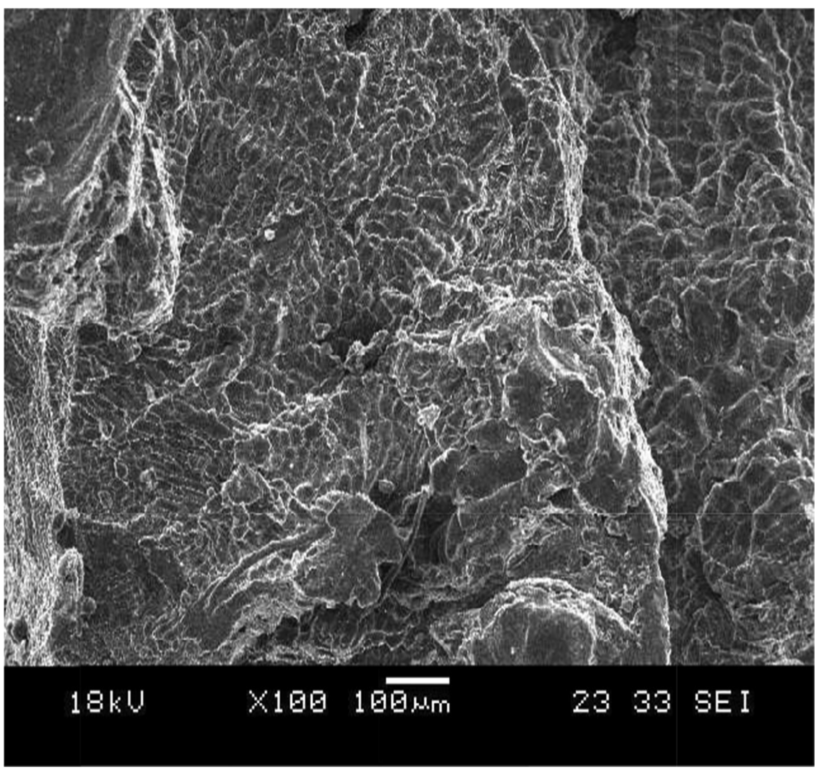

Fig. 13. SEM image of 0.5 mm root gap weld sample in Etched condition

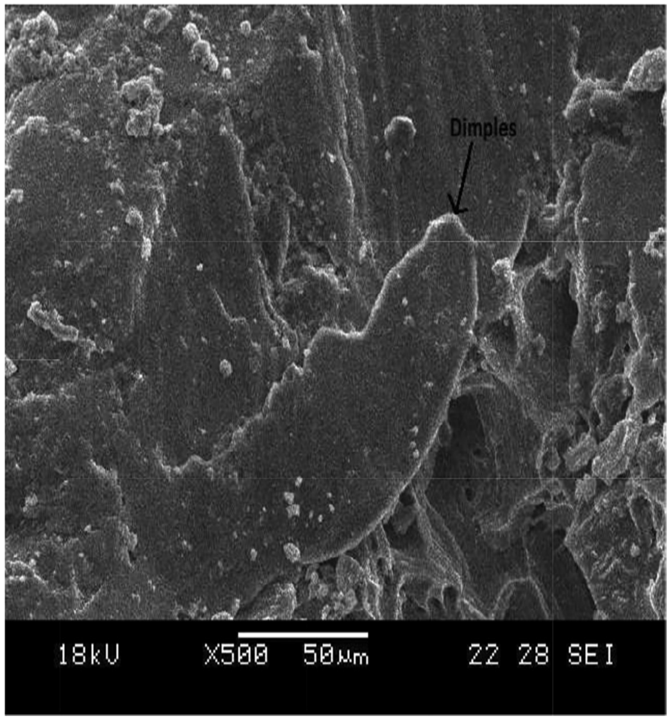

Fig. 14 SEM image of 1 mm root gap weld sample in polished stage.

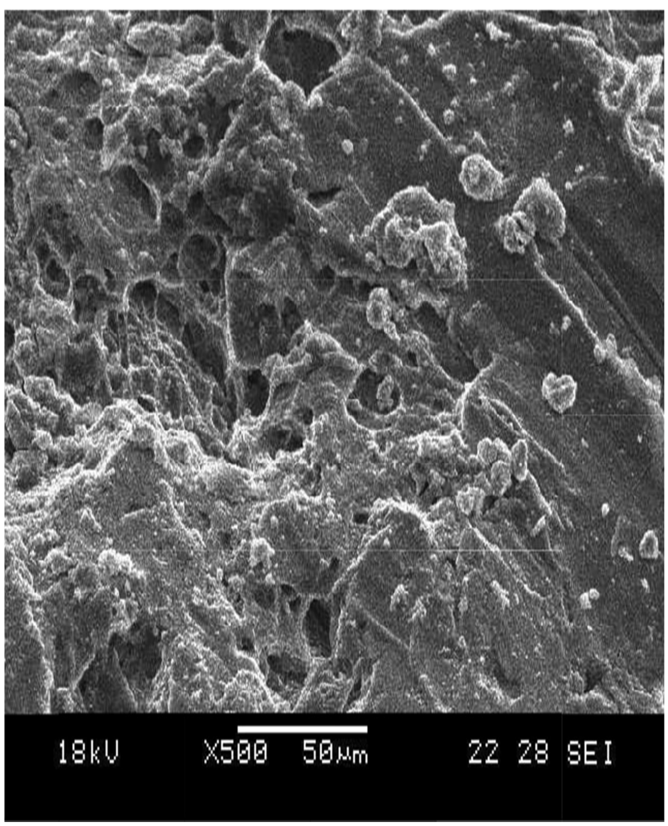

Fig. 16 SEM image of 1 mm root gap weld sample in Etched condition.

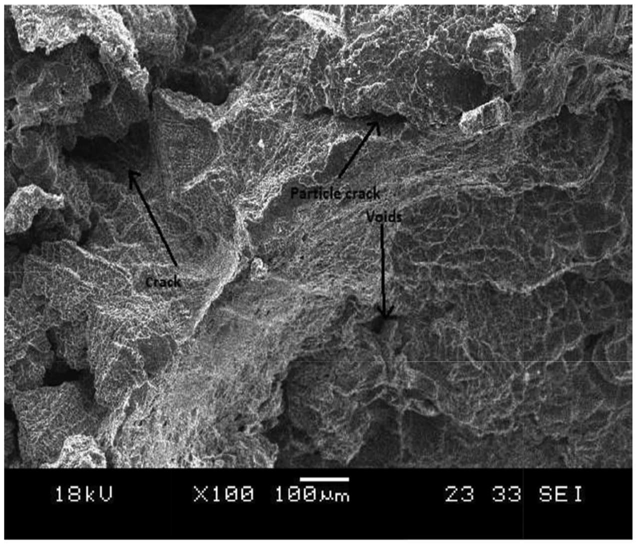

Fig. 17 SEM images of 1.5 mm root gap welded sample in polished stage.

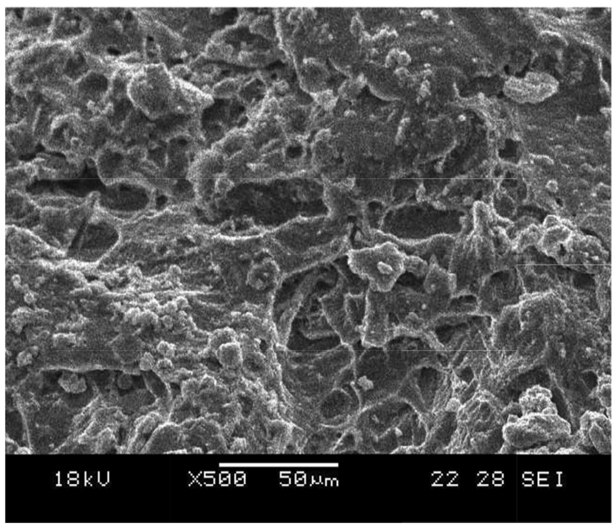

Fig. 18. SEM image of 1.5 mm root gap welded sample in Etched stage.

a) The scanning electron microscope (SEM) is one of the most versatile instrument available for the examination and analysis of the microstructural characteristics of solid objects.
b) It enables us to contemplate the dispersion of the aluminium 6063 phase in the Aluminium Alloy 2024 Metal Matrix by TIG welding. There must be a uniform distribution of the reinforcement materials in the Aluminum 6063 Matrix
c) The welding samples were polished metallographically prior to examination. Characterization is done in etched conditions.
d) Etching was accomplished using Keller’s reagent. Microscopic studies to examine the morphology, particle size and microstructure were done by a Philips XL 30 FEG scanning electron microscope (SEM) equipment.
e) Multiple Images were taken at different scaling sizes and volume fractions.
f) The Microstructure itself reveals the increased dispersion of Al6063 in the Al 2024 matrix with the increase in alpha phase.
g) The Bonding interface and multi-grain refinement enhances the mechanical properties of the welding material.
h) The below figures exhibits the SEM images of Aluminum 6063 alloy and Al2024 in different welding condition.
i) Polished and Etched SEM images of 0.5 mm root gap welded sample is shown in Figs.12 and 13 respectively.
j) Sample 2: Polished and Etched SEM images of 1 mm root gap welded sample is shown in Figs. 14 and 15 respectively.
k) Sample 3: Polished and Etched SEM images of 1.5 mm root gap welded sample is shown in Figs. 16 and 17 respectively.
l) From the above microstructure figures we can observe that with the increment in root gap from 0.5 mm to 1.5 mm the heat affected zone (HAZ) area

V. CONCLUSIONS

A. The tensile strength of the GTAW Al 6063 & Al 2024 sample (2) is increases with the increases the current and root gap.
B. Similarly the tensile strength of the GTAW Al 6063 & Al 2024 is increases with the increment of gas flow rate and voltage.
C. The hardness of the GTAW Al 6063 & Al 2024 is increases with the increment of root gap 1 mm to 1.5 mm and gas flow rate18–20 lit/min.
D. The corrosion test of the GTAW Al 6063 & Al 2024 sample (3) is having the minimum weight loss in the increment of the root gap and gas flow rate.
E. From the SEM analysis, with increment of current the heat affected zone area also increasing, affecting the grain size and microstructure of the Aluminium alloy.
F. From the above investigation we can conclude that increment of root gap between the weld specimens from above 1.5 mm is given low Weld ability.
G. Similarly the variation of current and gas flow rate in the specimen, current 70–80 amp and gas flow rate 18–20 lit/min can give the more Weld ability

From the above analysis, the augmentation in root gap between the weld samples from 0.5 to 1.5 mm, there is similarly less metal stream rate at weld partition and the combination zone will have a lot higher disengagement thickness, higher grouping of point absconds, which thus results the decrement in mechanical properties like rigidity, hardness and so forth.

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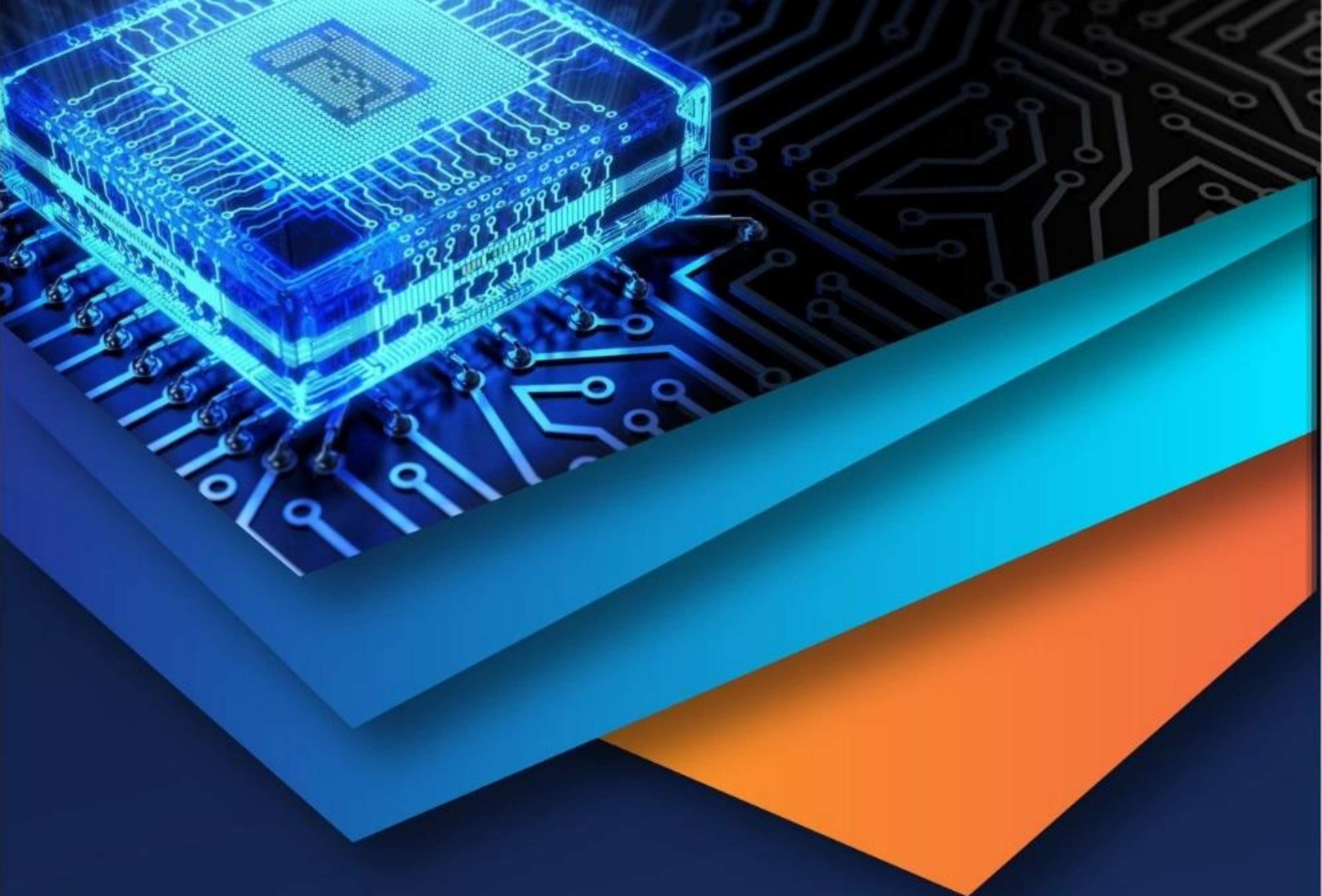

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