Experimental Investigation on Dissimilar Metals Welding of Aluminium 6063 & Aluminium 5754

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***Abstract*: -**

In all industries, including the manufacturing of automobiles, nuclear power plants, boilers, petrochemicals, and chemicals, different metals have been bonded or welded together are frequently used. Due to their less weight and improved mechanical and chemical properties when combined, two dissimilar metals are now used far more frequently than when they were used alone. This work focuses on investigating the microstructural-mechanical characteristics of dissimilar welding of Aluminium-6063 and Aluminium-5754 by using Gas-Tungsten Arc Welding (GTAW). The mechanical behavior has been assessed using microhardness profiles, tensile and bend tests, and the microstructure was assessed using optical microscopy. Finally, dissimilar welding Subjected to tensile test failed in the HAZ (59.46MPa), In the bend test, no cracks or openings were observed in the dissimilar metal welding, while cracks were observed in the similar metal welding, during hardness test it is observed that weld area is stronger than base metal and parent metal in dissimilar metal welding when compared to similar metal welding.

Keywords: GTAW, Alumninium-6063, Aluminium-5754, Hardness, Bending and Microstructure.

1. Introduction

Welding is a manufacturing or sculptural process that unites materials by inducing fusion, as opposed to lower-temperature metal-joining methods like brazing and soldering, which do not melt the base metal. These methods often involve combining metals or thermoplastics. A filler material is frequently added to the junction after the base metal has melted to create a pool of molten material (the weld pool), which cools to form a joint that is normally stronger than the base material. To create a weld, pressure can be employed alone, in combination with heat, or both. In order to prevent contamination or oxidation of the filler metals or molten metals during welding, a shield is also necessary. Different welding processes are used in the manufacturing of Automobiles bodies, structural work, tanks, and general machine repair work. In the industries, welding is used in refineries and pipeline fabrication. It may be called a secondary manufacturing process.

Basic Mechanism of TIG Welding

As previously mentioned, TIG welding is an arc welding technique that creates a weld using an inert tungsten electrode. An electric arc that burns between the work item and tungsten electrode generates the fusion energy. A shielding gas (such as argon or helium) is used during the welding process to protect the electrode, the arc, and the weld pool from the atmosphere's potentially harmful effects.

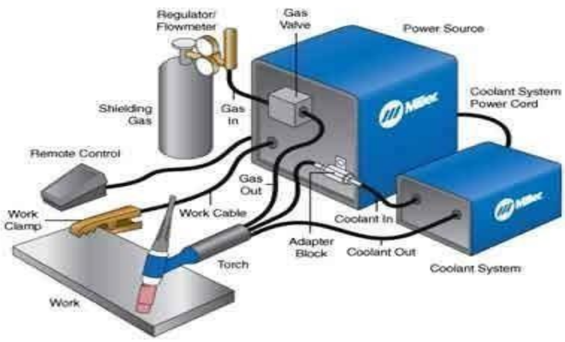


Fig 1.4 TIG Welding and Its Components

Standard tungsten electrode sizes range from 0.5 mm to 6.4 mm in diameter and 150-200 mm in length.

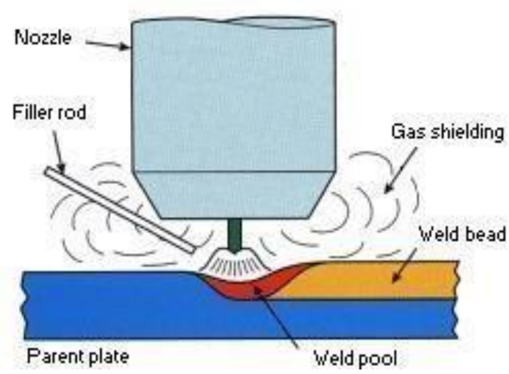


Fig 1.5 Basic Mechanism of TIG Welding

Whether an electrode is linked to the positive or negative terminal of a DC power source determines its ability to transport current.

TIG welding operations can be effectively performed with either argon or helium. Pureargon is used for welding extremely thin materials. When Argon is employed, arc penetration is lower than arc produced by Helium. Argon often produces an arc that runs more silently and smoothly. There are two major uses for the inert gas used in TIG welding. First of all, it aids in shielding the weld region from ambient pollution like oxygen and nitrogen, which might result in weld flaws. Second, it aids in the creation of an electrically steady arc, which is essential for making welds of superior quality. For these reasons, argon is favored in the majority of applications, with the exception of those where greater heat and penetration are needed to weld metals with high heat conductivity in thicker sections.

The welding of structural steels, low alloyed steels, stainless steels, aluminium, copper, titanium, and magnesium may all be done using pure argon. A combination of argon and hydrogen is used to weld certain grades of nickel alloys and stainless steels. High heat conductivity metals like aluminium and copper are examples of the kind of material that helium is useful for welding reasonably thick portions of. Copper and aluminium may both be filled with pure helium. Low alloy steel, aluminium, and copper may all be analyzed using helium-argon mixtures.

Gas tungsten arc welding (GTAW), commonly known as tungsten inert gas (TIG) welding, is a flexible welding technique that has a variety of applications, such as: Aerospace, Automotive, Medical, Fabrication, Pipe welding, Food and beverage industry. The challenges that occur in dissimilar welding have been the topic of significant investigation throughout the years, and many fascinating conclusions have been published. Dissimilar welding is utilized in the nuclear, petrochemical, electronic, and many other industrial sectors, thus this part considers the work of the pioneers in this field.

The effect of welding parameters, such as current, voltage, and welding speed, on the tensile strength and microstructure of T-joints made of dissimilar aluminum and steel alloys. The results showed that an increase in current and welding speed led to higher tensile strength, but excessive heat input caused microstructural defects [1]. The effect of different filler materials, such as AA4043 and AA5356, on the mechanical properties of dissimilar aluminum joints made using TIG welding. The results showed that AA5356 filler material provided higher strength and ductility compared to AA4043 filler material. [2]. The dissimilar joining of aluminum to steel using TIG welding with the addition of a nickel-based alloy as a filler material. The addition of a nickel-based alloy improved the tensile strength and ductility of the joint, and the joint failed in the aluminum base metal, indicating good metallurgical bonding. [3]. Microstructure and mechanical properties of dissimilar aluminum alloys AA6061-T6 and AA5083-H116 welded using TIG welding. The results showed that the joint made using AA4043 filler material exhibited higher strength and ductility than the joint made using AA5356 filler material. [4]. Effect of laser surface texturing on the dissimilar welding of aluminum and copper using TIG welding. The results showed that laser surface texturing improved the wettability and interfacial bonding between the aluminum and copper metals, resulting in a stronger joint with higher ductility. [5]. The effect of process parameters such as welding current, welding speed, and gas flow rate on the microstructure and mechanical properties of dissimilar joints between AA1050 and AA5083 alloys. They found that increasing the welding current and speed resulted in an increase in joint strength, but also led to a coarser grain structure. [6] [13]. Microstructure and mechanical properties of dissimilar joints between AA2024 and AA6061 alloys. They found that using a filler wire with a higher silicon content improved the strength of the joint, and that higher welding speeds resulted in a finer grain structure. [7][14].

Methodology:

Fig 3.1 Experimentation Procedure

2. Objectives

- To Find the characteristics of dissimilar metal welding by joining two or more metals of different chemical compositions in a way that ensures a strong and durable bond, while also preventing corrosion and other forms of degradation.
- To improve welding of dissimilar metal which also involve making sure the resulting joint meets all applicable environmental and sustainability criteria, has the appropriate aesthetic look, and is simple to check and repair.

3. Weld Plates Preparation & Welding Procedure

The basic metals employed in this investigation are Aluminium 6063 and Aluminium 5754 plates with dimensions of 100 mm x 60 mm x 4 mm. To explore how grain formation behaves at the weld zone and HAZ, the welding process has been performed in three distinct combinations, as illustrated in figure 3.2.

Before welding, the joining area of the base metals was properly cleaned to remove any foreign contaminants, such as dirt or grit, so that we could obtain a perfect weld fusion. Later, the joints were prepared for butt joining (with a 60° included angle and a 1mm rootgap).

Al-5356(Filler Wire)Al-5356(Filler Wire)

Fig 3.2 Weld Plates Preparation and Welding Procedure

Fig 3.3 TIG Welding Process

The work was then held in position with a g-clamp to avoid distortions and bending while maintaining its

alignment. These fixtures were designed after determining correct welding characteristics such as root gap, gas flow rate, welding current, and so on, and after selecting those values, which are listed in table 3.1 was completed by a review of open literature as well as trial and error.

MACHINE DESCRIPTION

Model: AC/DC315 BP 3 PHASE

TIG - Stainless Steel, Mild Steel, Brass, Copper, Aluminium, Titanium (1.6 mm- 3.2mm)

Table 3.1 Welding Parameters

After completing all of the steps, the welding was completed with present parameters using the GTAW technique. Figure 3.3 shows a LINCOLN JS machine used to create these weldments. A number of trials and errors were carried out in order to get a satisfactory defect-free weld connection.

Fig 3.4 LINCOLN 375 welding machine

Finally, the weld joint (shown in figures 3.4,3.5,3.6) was found to be free from porosity, fractures, and undercutting faults.

Fig 3 Sam 1 (Al-6063 & Al-6063) Fig 3.6 Sam 2 (Al-5754 & Al-5754) Fig 3.7 Sam 3 (Al-6063 & Al-5754)

COMPOSITION

The composition of the metals used in this simulation of the welding joint is given below

Aluminium 6063

Aluminium 6063 is an alloy of aluminium that is primarily composed of magnesium and silicon. It is commonly referred to as an architectural alloy because of its excellent ability to form complex shapes and its attractive finish.

A high strength-to-weight ratio, superior corrosion resistance, and great machinability are a few of aluminium 6063's important characteristics. Due to these qualities, it is frequently used for a range of applications, such as window and door frames, furniture, and structural elements. Aluminium 6063 is also suited for heat sinks and other applications where heat dispersion is crucial because of its strong thermal conductivity. Additionally, it may be readily welded and finished using a variety of methods, including anodizing, powder coating, and painting. Aluminium 6063 has good corrosion resistance and can be used in both indoor and outdoor applications. It is resistant to most atmospheric conditions, as well as to many chemicals. Aluminium 6063 is commonly used for architectural applications such as window frames, door frames, and curtain walls, as well as for decorative purposes. It is also used in the manufacture of furniture, electronic components, and heat sinks. There are several variations of the Aluminium 6063 alloy, including 6060, 6061, and 6082. These alloys have slightly different chemical compositions and mechanical properties, but are all generally suitable for similar applications.

Aluminium 5754

Aluminium 5754 is an alloy of aluminium in which magnesium serves as the main alloying component. Excellent corrosion resistance, outstanding formability, and great weldability characterize this medium-strength alloy. In many different applications, aluminium 5754 is often utilized, especially in the automotive and transportation sectors. Aluminium 5754 has a density of 2.68 g/cm3, a melting point of 600-638 °C (1112-1180°F), and a thermal expansion coefficient of 23.2 x 10-6/K at 20-100 °C (68-212 °F). Depending on the temper, it has a tensile strength range of 190–260 MPa (28,000–38,000 psi) and a yield strength range of 80–220 MPa (12,000–32,000 psi).

Table 3.2 Chemical Composition of Aluminium 6063

Components	Amount (Wt.)
Aluminum	Balance
Magnesium	0.45-0.9
Silicon	0.2-0.6
Iron	Max. 0.35
Conner	0.10
Zinc	Max 0.10
Titanium	Max 0.10
Manganese	Max 0.10
Chromium	0.10

Others	0.05

Table 3.3 Mechanical properties of Aluminium 6063

Properties	Values
Density	2.7 gm/cc
Melting point	600°C
Poisson's ratio	0.3
Modulus of elasticity	70 GPa
Tensile strength	195 MPa
Shear strength	150 MPa
Proof stress	0.2%

Cold and hotworking techniques such as forming, bending, and deep drawing make it simple to deal with aluminium 5754. Diverse methods can be used to weld it and finish it.

Table 3.4 Chemical Composition of Aluminium 5754

Element	Si	Fe	**Mg**	Cu	**Mn**	Cr	**Zn**	**Al**
Wt. 0/o	0.25	0.31	3.2	0.02	0.38	0.23	0.18	Balance

Table 3.5 Mechanical Properties of Aluminium 5754

Property	**Value**	**Units**
Elastic Modulus	7e+10	N/m2 2
Poisson's Ratio	0.3897	N/A
Shear Modulus	2.7e+10	N/m2
Mass Density	2660	kg/m3
Tensile Strength	290000000	N/m2
Yield Strength	250000000	N/m2
Thermal Expansion Coefficient	2.4e-05	/K

Aluminium 5356 (Filler Material)

Aluminium alloys are frequently joined together using the filler metal aluminium 5356. With 5% magnesium and trace quantities of other components, it is an aluminum- magnesium alloy.

Additionally, the aluminium 5356 filler material is well recognized for having a high weldability and strong corrosion resistance. It is often used for welding aluminium alloys including 5083, 5086, 5754, and 6063 in the marine, automotive, and aerospace sectors. Because of its excellent toughness, aluminium 5356 filler material is appropriate for use in situations where the welded joint may be subjected to rapid impacts or other types of mechanical stress.

Table 3.6 Chemical Composition of Aluminium 5356 (Filler Material)

Element	Weight %
Si	0.25
Fe	0.40
Cu	0.10
Mn	0.05 - 0.20
Mg	4.5 - 5.5
Zn	0.10
Cr	0.05 - 0.20
Ti	0.06 – 0.20
Al min.	Rem

Table 3.7 Mechanical Properties of Aluminium 5356 (Filler Material)

Properties	Values
Tensile Strength	215MPa
Hardness	105HR
Melting Point	571°C
Elongation	12%
Thermal Conductivity	116W /mK
Tensile	215MPa

Tensile Testing Procedure

Tensile testing is a method of determining the mechanical properties of materials such as metals, polymers, ceramics, and composites. A sample of the material is subjected to an increasing tensile force in a tensile test until it breaks or fractures. The test analyses the material's resistance to applied force, and the results can be used to compute several mechanical properties of the material, including ultimate tensile strength, yield strength, modulus of elasticity, and elongation at break.

A stress-strain curve is produced after the test by measuring the material's stress and strain. The connection between the applied stress and the resulting strain is depicted by the stress-strain curve, which also offers crucial details about the material's mechanical properties. For instance, the ultimate tensile strength is the highest stress that a material can endure before it breaks, whereas the yield strength is the stress at which the material starts to deform plastically. In the industrial sector, tensile testing is frequently performed to make sure that materials fulfil the necessary requirements and standards for strength and durability. In order to create novel materials with better mechanical characteristics, it is also used in research and development to examine the mechanical behavior of materials. After the welding was done successfully the samples were made ready for studying the mechanical properties through tensile testing of the specimen. All the three welded specimens were cut precisely into dimensions of 200 mm x 20 mm by using milling machining process and later tensile test was performed on the universal testing machine. The standards were sized based upon the ASTM E646 standards for carrying out the tensile studies on the welded joints as shown in figure 3.8. The universal testing machine used to test the tensile strength with a maximum load capacity of 2000 KN.

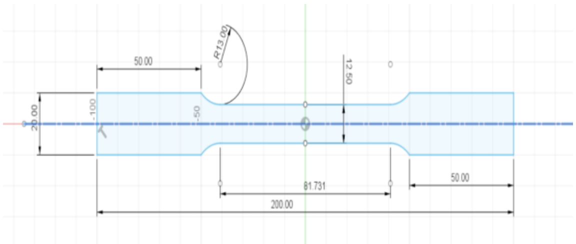


Figure 3.8 ASTM E646 Tensile Specimen Standard

Microhardness Testing

Testing for hardness is a method for determining a material's resistance to deformation or penetration. It is a crucial mechanical characteristic of materials and is frequently applied in production, quality assurance, and research and development settings.

Hardness may be determined in a number of ways, such as by indentation, scratch, and rebound tests. Indentation tests entail applying a known load to the material's surface and calculating the depth or size of the resulting indentation. In scratch testing, a controlled scratch is made on the material's surface, and the force needed to cause the scratch is measured. In rebound testing, a tiny mass is placed onto the surface of the material, and the rebound velocity is measured.

Several frequently employed techniques for hardness testing include:

- Rockwell hardness test: The Rockwell hardness test measures how deeply an indenter penetrates a material under a given stress using a steel ball or diamond cone. The material's resistance to being indented is indicated by its Rockwell hardness rating.

- Brinell hardness test: This entails utilising a hardened steel ball indenter to apply a known load to the material's surface and measuring the diameter of the resultant indentation. Divide the weight by the indentation's surface area to get the Brinell hardness value.

- Vickers hardness test: It measures the depth of penetration of the indenter into the material under a certain force using a diamond pyramid indenter. Based on the indentation's surface area, the Vickers hardness value is determined.

3.5.1 Rockwell Hardness Test

The Rockwell hardness test is a popular indentation hardness test for metallic materials shown in fig 3.10. It bears Stanley P. Rockwell's name, who created the test in the early 1900s. A numerical number that depicts the hardness of the material is obtained from the test by measuring the depth to which a diamond or spherical ball indenter penetrates the surface of the material under a certain stress. To determine a material's hardness, a variety of Rockwell scales are employed, each of which employs a unique arrangement of indenter type and load. The most widely used scales are the Rockwell B and C scales, which employ a diamond cone indenter and a steel ball with a diameter of 1/16-inch, respectively. Aluminium, copper, and brass are examples of softer materials that are normally measured using the Rockwell B scale. Steel and hardened steel are examples of tougher materials that are often measured using the Rockwell C scale.

Fig 3.9 Rockwell Hardness Testing Machine

In order to set the depth reference for the Rockwell hardness test, the indenter mustfirst be lightly loaded and driven into the material's surface. Following the application of a significant load, the indenter's depth of penetration is measured and converted to a numerical hardness value using a dial or digital display.

Bend Test

A bend test is a type of mechanical test used to evaluate the ductility and soundness of a material by bending it to a specific angle without causing it to crack or fail. The bend test is commonly used to determine the suitability of a material for a particular application, such as in structural or construction projects. During the bend test, a specimen of the material is placed in a testing machine and bent to a specific angle, usually 90 degrees or more. The material is then examined for any signs of cracking or other damage. If the material does not crack or show any other signs of damage, it passes the bend test. Depending on the type of material being tested and the test criteria, there are a variety of techniques to conduct the bend test. For instance, the four-point bend test is often used for thicker materials whereas the three-point bend test is frequently used for materials that are relatively thin or have a limited cross- sectional area. The bend test is a useful tool for determining a material's ductility and soundness as well as other mechanical characteristics including the elastic modulus, yield strength, and elongation.

Testing Machine is of hydraulic type also known as universal testing machine. Bend test is rid out to obtain the maximum load up to which weld can with stand on bending and car to assess the welder capability.

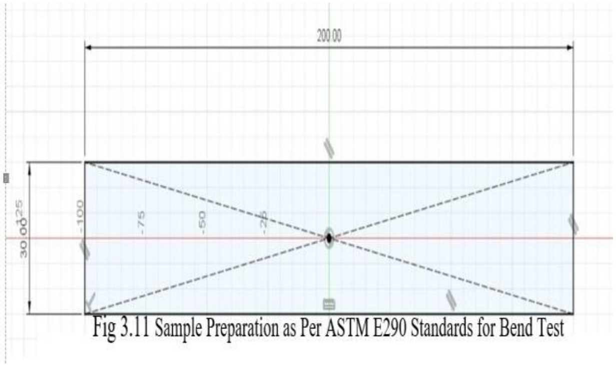


Fig 3.10 Bend Test

Metallurgical Microscope

A Metallurgical Microscope is a specialized type of microscope used to examine the microstructure of metallic materials. It is typically used in materials science, metallurgy, and engineering fields to analyze the structure and properties of metallic materials, including metals, alloys, and composites. In order to improve the contrast and resolution of the sample being seen, metallurgical microscopes frequently feature high magnification capabilities, generally ranging from 50x to 1000x or greater. Additionally, they could feature specialized objective lenses, including extended working distance lenses, to handle bigger samples or intricate geometries.

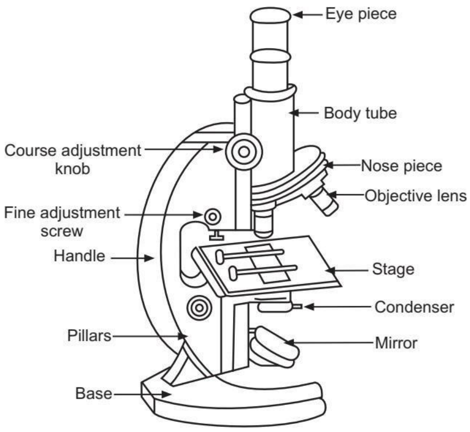


Fig 3.12 Metallurgical Microscope

In order to examine the microstructure of metallic materials, which might include grain size, grain orientation, phase morphology, and any imperfections or inclusions present, metallurgical microscopes are frequently utilized. Metallurgical microscopes can be used for a variety of other tasks in addition to observing the microstructure of metallic materials, such as measuring grain size, examining fracture surfaces, and determining how heat treatment or other processing conditions affect a material's microstructure.

The samples obtained after polishing and etching were undertaken microstructural study by using light microscope under 100x magnification.

4. Results And Discussions

Tensile strength of the specimens:

The tensile strength experimentation of the listed specimens was carried out as previously mentioned based on the ASTM E646 procedure to study the behavior of welded joints under tension. The results are shown in figure 4.5. It was found that all three specimens' weld joints were strong enough and that there was no rupture found at that specific area of the joint. The testing showed that the fracture happened after the HAZ, thus we may infer from this that the rupture was caused by a ductile fracture. With the use of a load vs. displacement graph, the graphs below demonstrate how the specimens responded under various loads that resulted in various displacements.

Cycle 1: Tensile Test of Al-6063 & Al-6063 Welded Plate

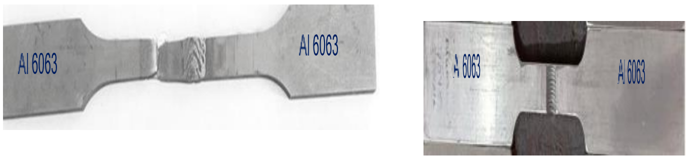


Fig 4.1.1 Tensile Test Specimens after testing on UTM of Al -6063 & Al-6063

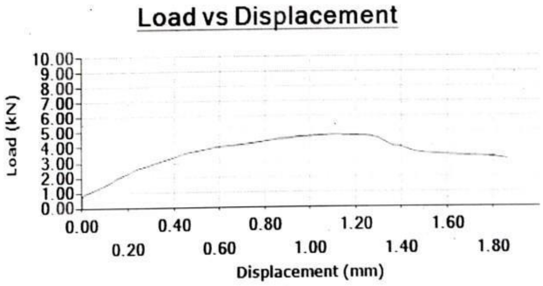


Fig 4.1.2 Load vs Displacement Graph of specimen Al -6063 & Al-6063

Cycle 2: Tensile Test of Al-5754 & Al-5754 Welded Plate

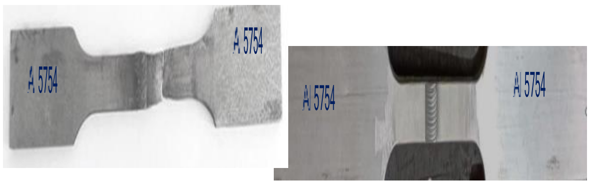


Fig 4.1.3 Tensile Test Specimens after testing on UTM of Al -5754 & Al-5754

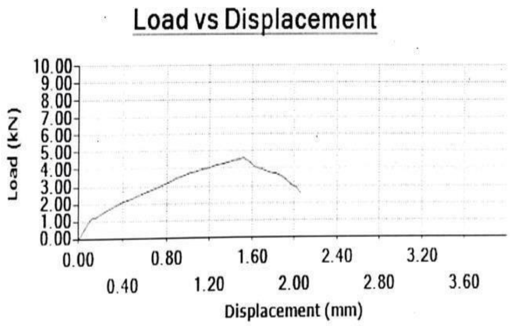


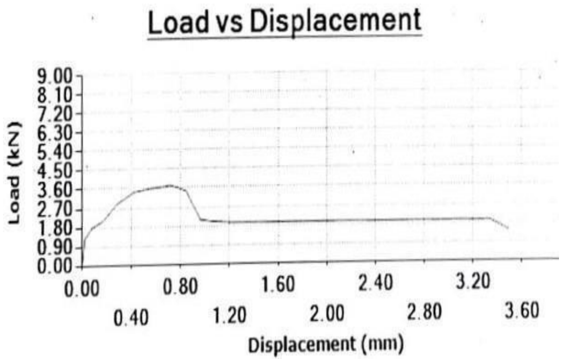
Fig 4.1.4 Load vs Displacement Graph of specimen Al -5754 & Al-5754

Cycle 3: Tensile Test of Al-6063 & Al-5754 Welded Plate

Fig 4.1.5 Tensile Test Specimens after testing on UTM of Al -5754 & Al-6063

Fig 4.1.6 Load vs Displacement Graph of specimen Al -6063 & Al-5754

The UTS (Ultimate Tensile Strength), as well as the ultimate load of various specimens, are listed in the



following table based on the results of tensile tests conducted on them.

Table 4.1 Tensile Strength values of Weldments

Specimen Name	Specimen type	Initial Width in (mm)	Specimen Thickness(mm)	Cross sectional area(mm)	Ultimate load (KN)	UTS (MPa)
Al-6063 & Al- 6063	Flat	19.25	4.12	79.31	3.75	47.28
Al-5754 & Al- 5754	Flat	19.02	4.25	80.84	4.62	57.15
Al-6063 & Al- 5754	Flat	19.34	4.20	81.23	4.83	59.46

Microhardness

The resistance of a metal to deformation against indentation, abrasion, or cutting is known as hardness. A Rockwell hardness test was carried out across the weldment to evaluate the hardness of the three weld samples. This hardness test is carried out to ascertain the various hardness values at various points of the samples, such as close to the base metal, the HAZ, and the weld zone. The indenter used in the Rockwell hardness is the Ball indenter which is 1/12 inch or 2.11 mm. The maximum load applied is 150kg.

Table 4.2 Microhardness values of Weldments

The hardness of the Base metal is greater than the Heat Affected Zone (HAZ) and Weld Zone. The above table 4.2 and figure 4.2.2 ,4.2.4 and 4.2.6 shows the hardness valueof weldments at Base metal, HAZ and weld zone.

Cycle 1: Hardness of Al-6063 & Al-6063 Welded Plate

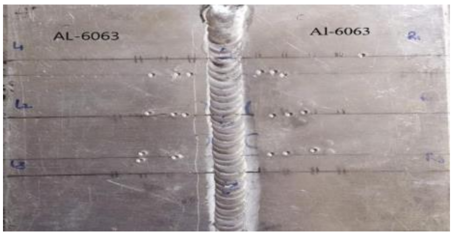


Fig 4.2.1 Rockwell Hardness Test on Weldment AL-6063 & Al-6063

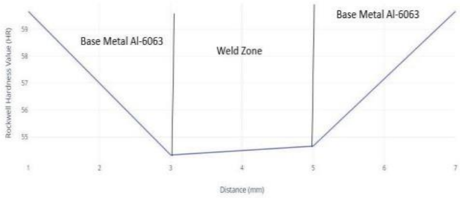


Fig 4.2.2 Rockwell Hardness Value Graph for AL-6063 & Al-6063

Cycle 2: Hardness of Al-5754 & Al-5754 Welded Plate

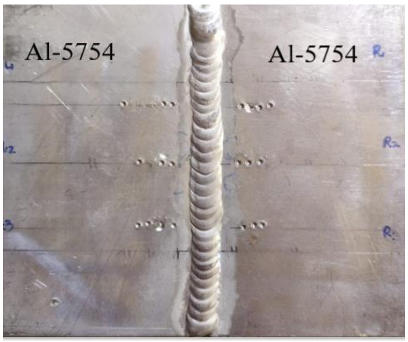


Fig 4.2.3 Rockwell Hardness Test on Weldment AL-5754 & Al-5754

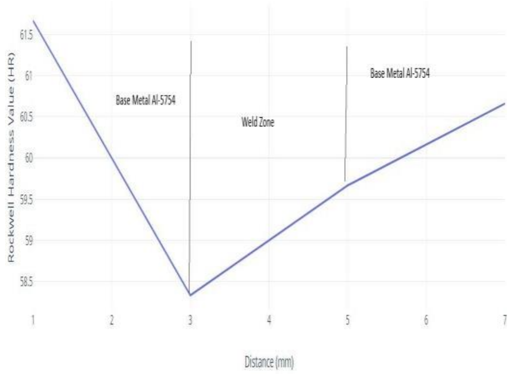


Fig 4.2.4 Rockwell Hardness Value Graph for AL-5754 & Al-5754

4.1.1 Cycle 3: Hardness of Al-6063 & Al-5754 Welded Plate

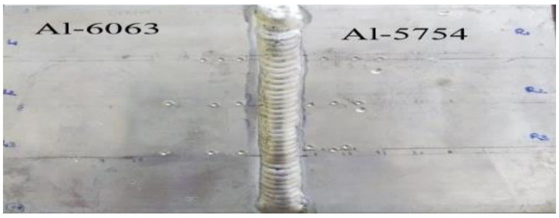


Fig 4.2.5 Rockwell Hardness Test on Weldment AL-6063 & Al-5754

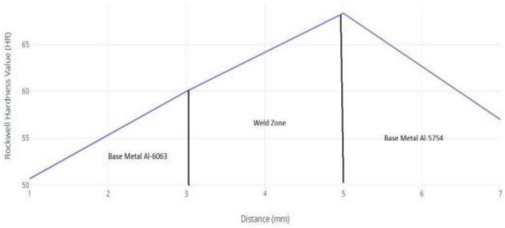


Fig 4.2.6 Rockwell Hardness Value Graph for AL-6063 & Al-5754

4.2 Bend Test

The test involves bending a sample of the material at a specific angle until it fractures. The procedure for performing a bend test can vary depending on the material being tested and the testing standards being followed. The guided bend tests are used to assess the ductility and robustness of welded joints and to find signs of delamination, cracking, and insufficient fusion. The quality of welds can be evaluated as a function of ductility to resist cracking during bending. Two specimens are tested for root bend. The specimen has been bended to 180˚ for bending test.

Table 4.3 Bend Test Values of Weldments

Specimen Name	Sample identification	Radius of Bend	Specimen Dimensions (mm) (TXWX L)	Results
Al-6063 & Al-6063	Root Bend - 01	4T/180°	4X30x200	Cracks are Observed
Al-5754 & Al-5754	Root Bend - 02	4T/180°	4X30x200	Cracks are Observed
Al-6063 & Al-5754	Root Bend - 03	4T/180°	4X30x200	NO Cracks are Observed

Fig 4.3.1 Bend Test of AL-6063 & Al-6063 (Sample 1)

Fig 4.3.2 Bend Test of AL-5754 & Al-5754 (Sample 2)

Fig 4.3.3 Bend Test of AL-6063 & Al-5754 (Sample 3)

The sample 1 and sample 2 did not pass the bend test according to the ASME SEC- IX-19 standards due to the presence of cracks and openings on the bend surface. This indicates that these samples have low ductility and are more prone to failure when subjected to mechanical stress. On the other hand, sample 3 passed the bend test as no cracks or openings were observed on the bend surface, indicating that it has good ductility and can withstand mechanical stress without failure. The ASME SEC-IX-19 standards are widely recognized in the industry as they provide guidelines for the evaluation and qualification of welding procedures and welders. The results of the bend test are crucial in determining the mechanical properties of materials, which is important for ensuring the safety and reliability of various industrial applications. Therefore, the observation of cracks and openings on the bend surface for samples 1 and 2 highlights the importance of conducting mechanical testing to assess the quality and suitability of materials for specific applications.

Microstructure Examination

The weldments produced by the GTAW welding process were free of macroscopic and microscopic flaws, and the filler materials utilized demonstrated improved penetrations without any cracking.

There is no evidence of cracks or interconnected defects such as porosity, inclusions in a tested material. This is a positive result as these defects can significantly reduce the strength and ductility of a material, making it more prone to failure when subjected to mechanical stress. Porosity refers to the presence of voids or gas pockets within the material, while inclusions are foreign particles embedded within the material. The absence of these defects suggests that the tested material has good quality and is suitable for use in various applications. This importance of conducting quality control and inspection processes to ensure the integrity of materials. Such processes can involve various techniques such as visual inspection, non-destructive testing, and mechanical testing, depending on the specific requirements and standards of the application. In summary, the absence of cracks and interconnected defects in the tested material is a positive result that indicates good quality and suitability for use in various industrial applications.

Cycle 1: Microstructure of Al-6063 & Al-6063 Welded Plate

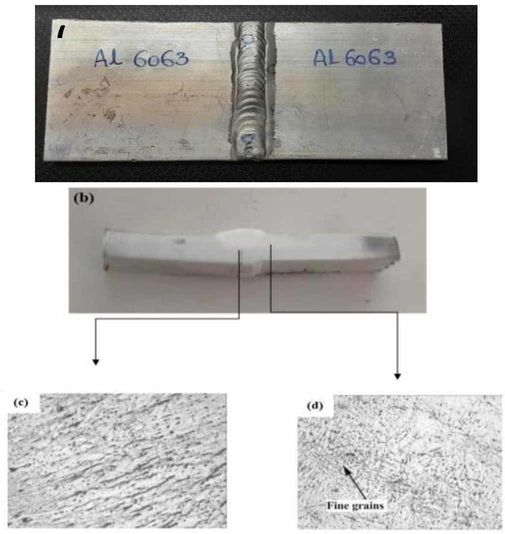
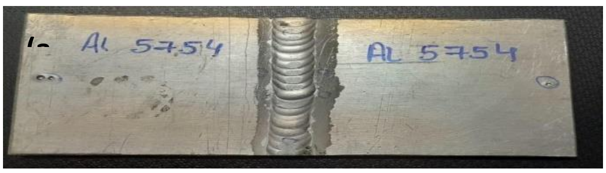


Fig 4.4.1 (a) Weldments of Al-6063 & AL-6063(c) Side View of Weldments of Al-6063 & AL-6063 (c) Microscopic view of Al-6063 HAZ. (d)Microscopic view of weld zone of Al-6063 & Al-6063 with Fine grain structure.

Cycle 2: Microstructure of Al-5754 & Al-5754 Welded Plate



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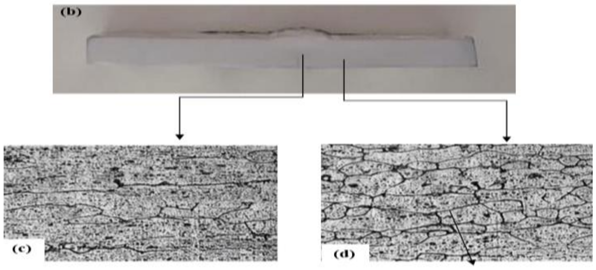

Fig 4.4.2 (a) Weldments of Al-5754 & AL-5754 (b) Side View Weldments of Al-5754 & AL-5754 (c) Microscopic view of Al-5754 HAZ. (d)Microscopic view of weld zone of Al-5754 & Al-5754

Cycle 3: Microstructure of Al-6063 & Al-5754 Welded Plate

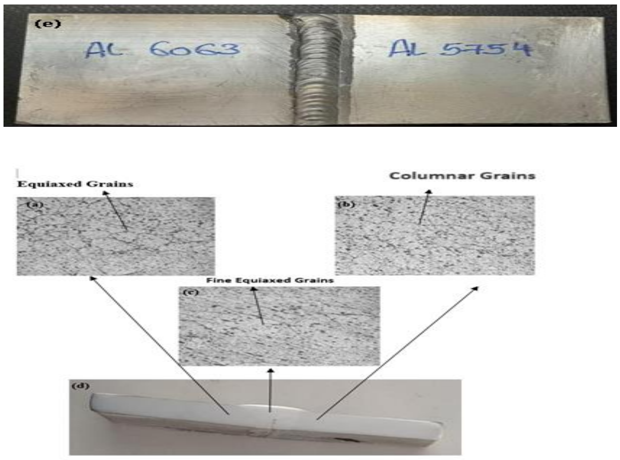

Fig 4.4.3 (a)Microscopic view of HAZ at Al-6063 as Base Metal. (b) Microscopic view of

HAZ at Al-5754 as Base Metal. (C)Microscopic view of weld zone of Al-5754 & Al-5754. (d)Side View Weldments of Al-6063 & AL-5754. (e) Weldments of Al-6063 & AL-5754

When using 100x/Poulton's reagent, the etching process reveals the material's microstructure, allowing the inspector to evaluate the quality of the weld or casting. If there are no evident cracks or interconnected defects like porosity and inclusions, this indicates that the material has a sound microstructure and is free from defects that could compromise its integrity. This information is crucial for ensuring that the material is suitable for its intended application, whether it be structural or non-structural. By following standardized procedures like ASTM E340 and ASTM A604, inspectors can ensure that the quality of the material is consistent and meets the necessary standards.

5. Conclusions

Finally, we would like to state that the mechanical characteristics of dissimilar metal weldings of Aluminium-6063 & Aluminium-5754 weld joints have been investigated and reported in this experimental investigation.

- Using Aluminium-5356 filler, the GTAW method has been effectively used to combine the dissimilar metals of different cycles of Al-6063 & Al-6063 as cycle 1, Al-5754 & Al-5754 as cycle 2, and Al-6063 & Al-5754 as the cycle 3.
- It can be claimed that appropriate dilution between the base metals and filler wires of cycle 1 was observed because the fracture occurred outside of the HAZ zone in tensile testing.
- The tensile test results showed that the dissimilar metal welding of Al-6063 and Al- 5754 using Al-5356 filler had a higher tensile strength compared to same-metal weldings. Specifically, the weldments Al-6063 and Al-5754 exhibited a tensile strength of 59.46 MPa at an ultimate load of 4.83 KN. The results suggest that cycle3 of the welding process was the most effective in producing strong weldments, while cycles 1 and 2 were satisfactory. The findings highlight the importance of selecting appropriate welding parameters to achieve optimal results in terms of strength and reliability. Overall, the study provides valuable insights into the potential of dissimilar metal welding to improve the mechanical properties of aluminium alloys.

- The maximum hardness value was found in dissimilar weldment Al-6063 & AL- 5754 when compared with similar weldment for same Al-5356 filler.
- Welding same-metal aluminium alloys like Al-6063 and Al-6063 and Al-5754 and Al-5754 can cause cracks and reduced strength in bending tests due to thermal expansion differences and residual stress. However, different-metal aluminium alloys like Al-6063 and Al-5754 exhibit improved ductility and fewer residual stresses, resulting in a more reliable welded joint. Thus, when selecting welding processes for aluminium alloys, consider specific alloys and their potential impact on product performance.
- The absence of cracks and defects in the tested material indicates good quality and suitability for use in various industrial applications. Quality control and inspection processes are important to ensure the integrity of materials. By using techniques such as visual inspection, non-destructive testing, and mechanical testing, inspectors can ensure that the quality of the material meets the necessary standards. The microstructure of the material can also be evaluated through etching processeslike 100x or Poulton's reagent, which can help ensure that the material is suitable for its intended application.

6. References

[1] R. R. Prakash and S. V. K. Murthy, "Effect of Welding Parameters on the Mechanical Properties of Dissimilar Aluminum Alloys AA6061-T6 and AA7075- T6 Welded by TIG Welding," Journal of Materials Engineering and Performance, vol. 27, pp. 2954-2964, 2018.

[2] S. S. Sundar, V. Raghuraman, and N. B. Prasad, "Dissimilar Welding of Aluminium Alloys AA6061-T6 and AA5083-H116 using TIG Welding with AA4043 Filler Metal," Transactions of the Indian Institute of Metals, vol. 71, pp. 711-718, 2018.

[3] M. G. K. Prasad, P. V. Sivaprasad, and K. Srinivasa Rao, "Influence of Post-Weld Heat Treatment on the Mechanical Properties of Dissimilar Aluminum Alloys AA6061-T6 and AA5052-H32 Joined by TIG Welding," Journal of Materials Engineering and Performance, vol. 27, pp. 5532-5542, 2018.

[4] S. S. Thakur, S. Kumar, and M. Singh, "Effect of Laser Surface Texturing on the Dissimilar Welding of Aluminium and Copper using TIG Welding," Materials Today: Proceedings, vol. 5, pp. 12986-12993, 2018.

[5] S. Rajakumar, R. Sivasubramanian, and R. Narayanasamy, "Effect of Filler Material on the Properties of Dissimilar Friction Stir Welded Aluminium Alloys," Journal of Materials Engineering and Performance, vol. 26, pp. 4466-4475, 2017.

[6] M. Khodabakhshi, E. Jafari, and M. Shamanian, "Effect of Post-Weld Heat Treatment on Mechanical and Microstructural Properties of Dissimilar Friction Stir Welded AA5083-H321 and AA6061-T6 Alloys," Journal of Manufacturing Processes, vol. 25, pp. 25-35, 2017.

[7] Prakash Mohan, " Study on the effects of welding parameters on TIG welding of Aluminium Plate"

[8] "Dissimilar Aluminum Welding" by J.F. Lancaster and S.A. David, Welding Journal, Vol. 81, No. 12, December 2002.

[9] "Dissimilar Metal Welding of Aluminum Alloys" by M.J. Krajewski and M.G. Smith, Welding Journal, Vol. 93, No. 4, April 2014.

[10] "Welding of Dissimilar Aluminum Alloys" by Y. Zhou, L. Li, and F. Huang, Welding Journal, Vol. 95, No. 8, August 2016.

[11] "Dissimilar Metal Welding of Aluminum Alloys" by L. Cui, J. Zhang, and Y. Zhou, Journal of Materials Science and Technology, Vol. 33, No. 6, June 2017.

[12] "Welding of dissimilar aluminium alloys using TIG welding process" by J. Bala Murali Krishna and G. Madhusudhan Reddy, Materials Today: Proceedings, Vol. 5, No. 11, 2018, pp. 23879-23886.

[13] Rikka, S., & Malkapuram, D. (2019). Mechanical Properties of Similar and Dissimilar Metals of Monel 400 and SS 321 by Using Gas Tungsten Arc Welding (GTAW) Process (No. 2019-28-0141). SAE Technical Paper.

[14] Sudarshan, R., Venkatesh, S., Balasubramanian, K., & purnapu Rupa, P. K. (2019, March). Plasma current effects on the microstructure of solution precursor plasma spray YSZ coatings. In Journal of Physics: Conference Series (Vol. 1172, No. 1, p. 012021). IOP Publishing.