WELD ANALYSIS OF AL-5083-O & AL-6061 T6 JOINED USING GTAW

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

PRODUCTION ENGINEERING

SUBMITTED BY

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(2K20/PIE/05)

UNDER THE GUIDANCE OF

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CANDIDATE'S DECLARATION

I, **Harsh vardhan kirar,** Roll No. **2K20/PIE/05** of M. Tech (Production Engineering), hereby certify that the project Dissertation titled "**WELD ANALYSIS OF AL-5083-O & AL-6061 T6 JOINED USING GTAW**" which is submitted by me to the Department of Mechanical Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of the Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled **"WELD ANALYSIS OF AL-5083-O & AL-6061 T6 JOINED USING GTAW"** which is submitted by **Harsh vardhan kirar**, 2K20/PIE/05, Mechanical Engineering Department, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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ASTRACT

Newer automobile sector, rail-coach & shipbuilding industries aimed to design their vehicle to reduce the weight without compromising the strength and safety standards. One of the metals which comes in lights of metallurgist is aluminium due to its weight to strength ratio and its availability on earth.

As the use of aluminium grows in industries new challenges arrives, one of them is joining of two different grades of aluminium alloy due to their wide range of alloys and high mechanical properties.

The weld-analysis of AL-5083-O & AL-6061-T6 has been done at 9 samples or plates at different parameters. According to the design matrix of Taguchi L9 orthogonal array method. Effect of welding current, shielding gas-flow and filler material on the tensile properties of the weld joint has been investigated. Residual-stress analysis has been done on the sample at 5 different points on the welded-specimen; microstructure of the specimen has been obtained on the weld bead, heat-effected zone &base-metal to evaluate the effect of thermal cycle of GTAW and different welding process parameters on welding quality and grain structure of material. Micro-hardness value of Vickers indenter in the fusion zone, effected zone and base metal has been measured at the junction of weld bead to understand the change in mechanical property of the welded material.

Keywords: TIG Welding System, Micro hardness Test, Tensile Test, Residual stress, Micro-structure, Taguchi analysis

CHAPTER ONE

1. INTRODUCTION

Utilization of lightweight materials such as aluminium alloys has emerged with the aimed to decrease weight and improve the fuel economy without compromising with standard of safety in automobile and defence sector.

AA 5083 is used in many fields, such as storage tanks, ships panels, automobile parts and high-pressure vessels, due to its high strength with good corrosion resistivity, whereas AA 6061 is used in high-strength structures and automobile parts due to its high toughness and belongs to the tempered hardening alloy series. For welding dissimilar aluminium alloys belong to different grades of aluminium many new welding methods are developed which includes friction-stir welding, laser beam welding etc. But these modern methods required high initial cost for the equipment and this process also required the pre-treatment for welding and welding cost is on the higher side.

GTAW process is the one which provide comparable mechanical properties in simple and portable system at low cost with high precision. In TIG-welding and arc is formed in between the non-consumable tungsten electrode and the specimen. The arc is shielded by the argon, helium, carbon dioxide or sometimes mixture or these gases is used.

Weldability or fusibility of a material depends upon many factors few of them like the thermal conductivity of material, metallurgical changes occur at the time of welding, melting range of material and fillers etc.

Aluminium and its alloys are generally are insulated by the layer of aluminium oxide which has higher melting point as compare to metal and due to high solubility of impurities in molten state of metal increases the chances of impurities such as porosity and blow holes.

1.1. Classification of Aluminium Alloys

On the basis of the chemical composition of the alloying elements such as copper, manganese, tin, silicon and titanium they classify in different series of aluminium alloys: Based on the composition of typical alloying elements like copper, magnesium, manganese, silicon, tin and zinc they are designated as:

1. 1xxx(series-1): These series of alloys refer to pure aluminium and contains 99% of aluminium and have high thermal and electrical conductivity and use in rotor of big electrical motors.

2. 2xxx(series-2): These series of alloy belong to copper(major) and magnesium(minor) these alloys have good strength but low corrosion resistivity. These materials are used in automobile parts such as bearings, cylinder head of engine etc.

3. 3xxx(series-3): Silicon, copper, magnesium is major alloying element in these series and generally offers good strength and high wear resistance to due to which use in many structures and motor parts.

4. 4xxx(series-4): Silicon is major alloying element due to which these series offer moderate strength, high ductility and good impact resistance. Use in cookware and dental equipment.

5. 5xxx(series-5): Magnesium is major alloying element in this series offers moderate strength with good machinability and attractive appearance due to which used in ornament casting and welding assemblies.

6. 6xxx(series-6): This series belong to silicon as alloying element and offers good strength and the series is capable for the heat treatable alloys and offers high toughness after tempering of material.

7. 7xxx(series-7): The alloys in this series are offer good finish with good strength as well due to presence of zinc in this series of alloys and use in automotive parts and casting and brazing equipment.

8. 8xxx(series-8): the series of alloys belong to the Tin as alloying element due to which has low resistance to offer and use in bearing and bushing application.

1.2. Heat-treatable and non-heat-treatable alloys

Wrought aluminium alloys offers less defect as compare to cast aluminium with the aluminium as major element. Rolling, forging, and extrusion are some of the most common applications for these alloys. Wrought aluminium alloys can be classified into two types:

- Heat-treatable alloys
- non-heat-treatable alloys

Heat treatable alloys: When aluminium atoms and alloy element toms combine during a natural ageing process at room temperature, heat-treatable aluminium develop. Artificial ageing in a low-temperature furnace was also used to achieve this. Alloys such as 2xxx, 6xxx, 7xxx, 8xxx are known as heat treatment capable alloys.

Non Heat treatable alloy: AA-alloys that have been mixed with alloying elements prior to heat treatment are classified into non heat-treatable alloys. The toughness of such alloys is initially achieved by adding other elements. Non-heat-treatable alloy include pure aluminium, manganese alloys, silicon alloys, and magnesium alloys, among others. 1xxx, 3xxx, 4xxx, and 5xxx series of aluminium alloys are known as non-heat treatable alloys.

1.3. Aluminium Alloys selected for study

Aluminium alloys are known for their light weight with good mechanical properties. In 5xxx (5-series) AA- alloys magnesium is the major alloying component due to that they offer good mechanical properties and high corrosion resistance where as in 6xxx series of aluminium due to presence of silicon in major composition offers high machinability and weldability and also capable for the heat treatment. Due to these properties these alloys are used in many structural and automobile applications. Other factors that were taken into account while deciding these two grades of aluminium include:

- Availability of material in market in desired shape and thickness.
- Desired properties of material for some applications.
- Durability of material.
- Reliability of material supply in market.
- Appearance of material and surface finish.

1.3.1. AA-5083 Aluminium alloy

Aluminium alloy 5083-O belong to 5-series of aluminium alloy where Mg is major alloying element. Where the O represent the annealed condition of material. AA-5083(O) belong to non-heat treatable alloy.

I. Application of AA-5083

- Pressure storage tanks/vessels
- Automobile parts
- Rail coach structures
- Mining industries

Fig1: Aluminum peressure vessels use in beverage industries.(Holloway america)

Fig2: Aluninium body frames made for perfomace cars.(AutoGuide.com)

Fig3: Aluminium coach frames used in metros and LHB coaches. (MCF Indian railways)

1.3.2. AA-6061 Aluminium alloy

Aluminium alloy 6061-T6 belong to 6-series of aluminium alloy where Mg and Si is major alloying element. Due to presence of these element a compound is formed which enable them for the heat treatment namely magnesium silicate. T6 refer to the temper condition of level 6.

I. Application of AA-6061

- Aircraft and aerospace
- Bicycle frames
- Automobile parts
- Brake callipers

Fig4: Ultra-light weight chopper air frame. (AMAG Austria)

Fig.5: Bicycles frames made up of aluminium alloys. (Bike Europe)

Fi6: Brake callipers made of forged aluminium alloys. (Willwood disc brakes)

1.4. Requirement to weld different grades of aluminium

Aluminium and its alloys seem to become extremely important in industrial applications. As the use of aluminium grows, the requirement for diverse characteristics from different portions of the same weldment arises. A part may be required to have good resistance to corrosion in one location while on other location may need to have great temperature resistance in another. In the same way some application of aluminium alloys requires good toughness in particular zone and on same weldment require good strength and ductility there the use of welding of different grades if aluminium required to deliver the desired properties at desired location. Some application which required these characteristics are listed below.

- In case of food storage/ beverage industries the pressure and storage tanks required the high corrosion resistivity while the support members required the good strength to withstand with the load of storage tank.
- In automobile industries the outer shell or body panels required to be light weight and good corrosion resistivity while the frames members required to take the impact load while in accidents condition.

1.5. Applications of Dissimilar Aluminium Alloy welded component of AA5083-O and AA6061-T6

In shipbuilding and fabrication of yacht 5083 aluminium alloy sheets are use as the panels to cover the structure due to their less weight and corrosion resistivity. Where the frames and structure members are made up of aluminium 6061 or 6063.

Fig7: frames and body panes of yacht. (Coenen yachts America)

In automobile the heigh performance German cars axel assemblies are made by the combination of 5083 and 6061 aluminium alloys.

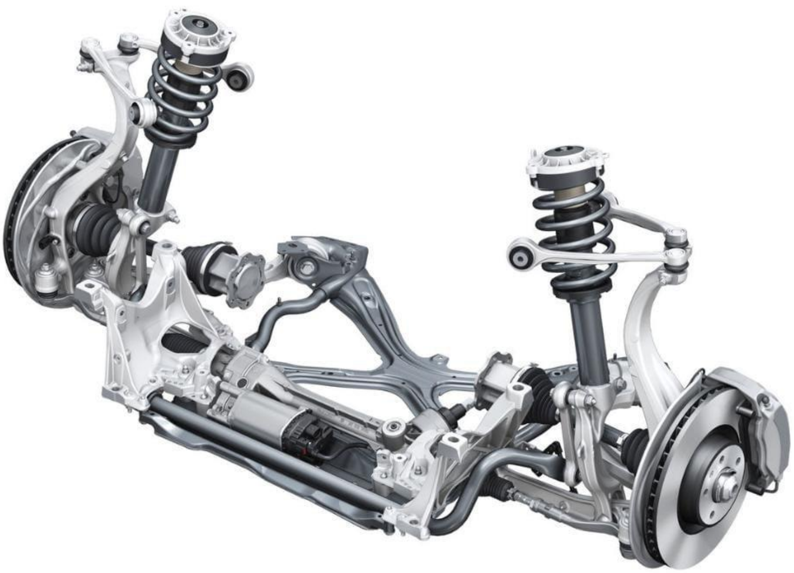

Fig8: Axel assembly of cars made by dissimilar aluminium alloys. (Audi-mediacenter)

1.6. Difficulties and defects faced in welding of dissimilar aluminium alloys

- Hydrogen solubility is major concerns in welding deferent grades of AA-alloys. hydrogen is very much dissolve in molten pool of aluminium. Due to dissimilar thermal properties of alloys, it causes high chance for trapping of hydrogen bubbles in weld pool cause porosity.

- Difference in thermal properties of different grades cause the overheating of material due which the area of heat effected zone increases.

- Due to large gap in thermal conductivity, over melting of one of the materials take place due to which the V-shape bud joint dimension changes occur and effect the properties of the joint.

1.7. Different welding processes

Welding techniques can be categorized according with the heat source used:

1.7.1. Arc Welding: as name suggested an arc is formed in between the electrode and specimen or material used to be welded with help of electric power supply. The arc produced is use to melt the bas material melt at the interface and after solidification a bond between the surfaced is obtained. The power supply used can be AC or DC type and the electrode use in arc welding could be consumable or non-consumable.

1.7.2. **Gas Welding**: A highly concentrated flame at very high temperature created by the ignition of gas or a gas-mixture is utilized to melt the components to be joined in the gas welding process. To get good welding, a filler material is used. Oxyacetylene gas welding is the most prevalent form of gas welding method, in which acetylene and oxygen combine to produce heat.

1.7.3. **Resistance welding**: This kind of welding generates heat by sending a large amount of current via the resistance created by the connection between different metal surfaces. Spot-welding, which uses a pointed electrode, is the most frequent kind of resistance welding. When a wheel-shaped electrode is used for seam welding, continuous pattern spot resistance welding can be employed.

1.7.4. **High Energy Beam Welding:** A high-intensity concentrated energy beam, such as a laser or an electron beam, is being utilized to melt the job components and fuse them in al plane in this kind of welding. These forms of welding are mostly used for precision weldments and modern material welding, and occasionally welding of different materials, which are not achievable with traditional welding methods.

1.7.5. **Solid-State Welding:** Solid-state welding relates to welding techniques which does not require the melting of parent materials' contact surfaces. Because pressure is necessary for a sound joint, it is also known as pressure welding. Ultrasonic welding, friction-stir welding, techniques are common.

1.8. Classification of Arc Welding:

Among all of these welding procedures, arc welding is the most extensively employed for various materials. The following are examples of arc welding processes:

1.8.1. **Shielded Metal Arc Welding (SMAW):** In SMAW flux-coated consumable electrode is required in this type of arc welding technique. The flux disintegrates as the electrode melts, providing shielding gas to protect the weld spot from ambient oxygen and other gases, as well as slag to cover the liquid filler rod as it goes from the electrode towards the weld area. As the weld hardens, the slag hovers to the surface of the pool, protecting the weld from the environment.

1.8.2. **Gas Metal Arc Welding (GMAW):** In MIG-welding a continuous consumable coil of electrode is utilized in this type of arc welding. A shielding gas, usually argon or a blend of argon plus carbon dioxide, is blasted into the weld zone by a welding gun.

1.8.3. **Gas Tungsten Arc Welding (GTAW):** A shielded arc is formed in between tungsten electrode and specimen during the TIG welding process. TIG welding is good for high welds because the arc created in between the electrode is intense. GTAW can be carried out manually or either with automated equipment, and it can be used for both production and maintenance welding. The electrode used is non-consumable electrode and shielded from the atmosphere by the mean of shielding gas, Argon, Helium and carbon dioxide are the common shielded gases used in tig welding.

1.9. Mechanism of TIG-welding

TIG welding is a shielded arc welding technology that produces welds joints with a non-consumable tungsten electrode. Usually inert shielding gas (argon or helium) protects the weld site from the environment, and a filler metal is commonly employed. The energy is generated from the power source to a non consumable tungsten electrode that is mounted into the hand torch through a touch. A power supply helps to formed an electric arc between tungsten electrode and the specimen. The electric arc could generate temperatures of approximately to 15000-20000 degree Celsius, which may be concentrated to melt and combine two distinct materials. The metal parts can be joined even without filler material using the weld pool.

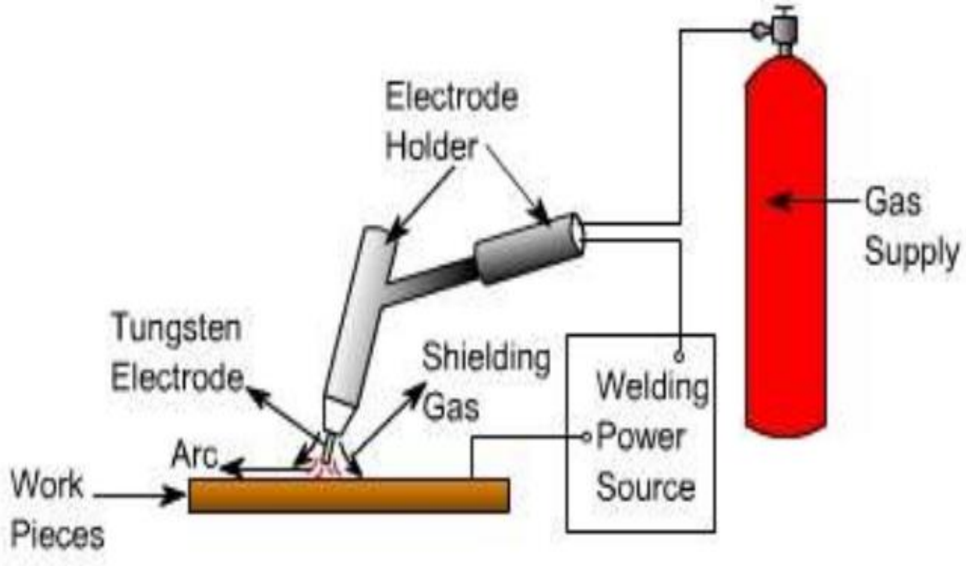

Fig9: Schematic diagram of TIG welding. (nptel.ac.in)

When tried to compare to other arc welding techniques, the TIG process offers high precision control of heat input, resulting in a small HAZ. This method may be used to join a variety of materials, including stainless steel, aluminium alloys, and magnesium. Furthermore, this method is capable of effectively welding dissimilar metals.

1.9.1. Components of GTAW welding

TIG welding requires a power source, a welding torch, an inert gas supply, a supply of filler wire, and a suitable temperature controller. Power Source: Drooping type attributes are used as a power source. For aluminium welding, the direct current electrode positive or reverse polarity is employed.

Regulator: flow gauges are the sorts of regulators which are employed in GTAW. The gas pressure is controlled by the regulator, which is determined by the kind of gas used, the size of the weld pool, specimen orientation and types of material.

Torch: In tig-welding deferent welding touches are used depending upon the manual or automatic process in welding operation and also depends on the type of cooing used. In light weight or where the penetration is less required air-cooled system is used in welding torch. In heavy duty work where the heat requirement is high to penetrate up larger depth there the water-cooled system may impowered.

Shielding Gases: Inert stable gases such as argon and helium are used to shield the arc from the atmosphere sometimes Co2 or mixture or these gases can be used in the shielding operation.

The GTAW system can be seen in the figure below and the parts uses in touches to regulate process is also seen in figure below.

Fig10: GTAW welding system

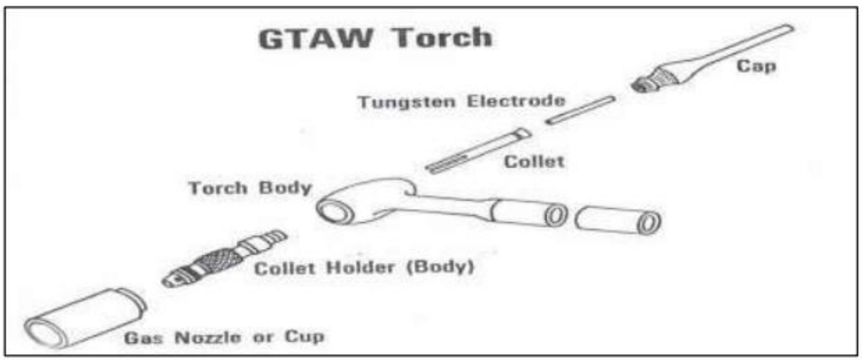

Fig11: parts associated with welding torch (nptl.ac.in)

1.9.2. Process parameter of GTAW

The process parameter that are responsible for the cause and reduction of weld-defects are discussed below:

1. Welding current: the welding current is one of major parameter which describe the properties of welded joint. In tig-welding if the welding current on the lower side cause the less penetration in the specimen and sticking of filler rod may also see and if the welding current is on higher side the splatter of weld bead and specimen may also get effected. In case of fixed current, the change in voltage take place due to stability of arc which need to be maintain during the welding process.

2. Welding voltage: The welding voltage able to impact the arc stability. In case of higher voltage helps in quick initiation of arc generation and also help to increase the gap between the electrode and work-piece but due to that the they impact the quality of weld formed.

3. Shielding gas and gas flow: In GTAW the shielding gas is use to cover the arc and act as the barrier between the arc and the atmosphere. Inert gas is ideally used in welding operation, argon, helium are the common gases use in welding operation. The type of gases use is depended upon the type of material use in welding and desired properties from the operation. Sometimes Co2 is also use in tig welding and sometime mixture of gases are also used. The gas flow rate of the shielded gas also effects the weld formation lower gas flow led to cause of porosity in weld region where the higher gas flow effects the geometry of weld bead and other defects.

4. Welding speed: TIG welding speed is indeed a major factor. When welding speed is raised, power intake per unit length the weld drops, resulting in less weld reinforcement and welding penetration on workpiece. Welding speed, also known as travel speed of welding is used to control weld bead size and penetration. It is linked with the current. Unnecessary fast welding speeds reduce wetting action may increase the chances of undercut, porosity, and other defects whereas low welding speeds lessen the likelihood of porosity.

1.9.3. Advantages of TIG-welding:

2. High precision on heat input in weld region.
3. Pinpoint accuracy can be achieved in the operation.
4. Due controlled heat input and high concentration lower region for effected zone.
5. No sparks are generated.
6. No smoke and fumes are extracted during process.
7. No slag formation take place.

1.9.4. Disadvantages of TIG-welding:

II. The filler deposition rate is on lower side.
III. Bright UV rays are extracted during process.
IV. Traveling speed or welding speed is less.
V. A high skilled operator is required.
VI. Good hand-eye coordination required.

1.9.5. Application of GTAW process:

The use of GTAW welding is seen in may place and different industries in different form due to its capability to weld variety of materials and their alloys such as aluminium, copper, brass and different types of steels.

- GTAW is used in aerospace to weld the magnesium alloys and other parts which required high precision in welding.
- It also uses to fabrication of automobile parts and other joining operations.
- It also used in fabrication of aluminium extruded pipes and members use in windows and other construction sides.

CHAPTER TWO

2. LITRATURE REVIEW AND OBJECTIVE OF THIS WORK

The demand and supply for alloys are rapidly growing as compared to its pure metal in present time as the properties of the alloys are vast and mostly being augmented in contrast to their base parent metal, as they can be easily tweaked as and when need arises during machining the component.

Due to its attractive characteristics which including light weight, high strength, and good corrosion resistance, dissimilar Aluminium Alloys are widely used in aircraft, shipbuilding, automotive, and frames and constructions, among others.

Welding different aluminium alloys is difficult due to insufficient heating caused by thermal conductivity differences. As a result, appropriate welding parameters and the selection of a suitable welding procedure are essential to achieve higher quality welds.

Sanjeev Kumar used TIG welding to investigate the feasibility of welding thicker plates. Pulsed Tungsten Inert Gas Welding was used to weld aluminium plates (3-5mm thickness) with a welding current of 48-112 A and a gas flow rate of 7-15 l/min. Weld metal has a lower shear strength (73MPa) than parent metal (85 MPa). Weld deposits create co-axial dendritic micro-structure in direction of fusion line, and tensile failure occurs near the fusion line of weld deposit, according to photomicrographs of welded specimens.

Maamar hakem uses GTAW process to weld the AA5083 pipe use to transport the liquifies natural gages in his research they perform 4 passes of GTAW welding using argon as shielding gas and perform optical Metallographic studies and mechanical testing and finds the optimum parameters and concludes that he finds coarse structure in HAZ and hardness value vary from 80-100HV.

J. Shore works on the effect of porosity on high strength aluminium alloys and says that hydrogen is major cause of defects(porosity) in aluminium alloys welded specimens and gases such as oxygen, nitrogen have less solubility in weld pool of molten aluminium as compared to hydrogen.

T. Luijendijk who works on GTAW welding of different grades of AA-alloys of different thermal conductivity and he found that to obtain the optimal results the welding torch should has to be placed above the material having higher thermal conductivity.

Infante et al. performed the FSW on different grades of aluminium alloys and stated that dissimilar AL-joint have lower fatigue strength than base metal joint.

Indira Rani et. Al in her studies the mechanical characteristics of AA6351 welded joints were investigated during TIG welding using non-pulsed and pulsed current with various frequencies. Welding was done at 70-74 A current, 700-760 mm/min arc travel speed, and 3 and 7 Hz pulse frequency. The tensile strength and YS of the weldments are closer to base metal, as per the experimental results. Weldment failure occurs at HAZ, and we discovered that weldments had better weld bond strength.

Çömez and Durmus joined the 5xxx and 6xxx series of Al-alloys by CMT-MIG, in his works they find the effect of heat cycle on microstructure and other mechanical properties

I. Magnabosco perform the electron beam welding of dissimilar materials created three separate welded connections. Copper plates and three separate stainless steels plates were used to create the connectors. Depending on the thickness of the samples, different welding settings were applied. The weld bead was evaluated morphologically, microstructurally, and mechanically (micro-hardness test). The findings revealed complicated heterogeneous fusion zone microstructures caused by rapid cooling and poor mixing of materials containing mutually insoluble major components. Porosity and micro cracks were among the faults discovered.

K. Nageswara Rao, perform the TIG welding with Aluma-Steel welding rods produces a dissimilar welding across SUS304 stainless steel and A6061-T6 alloys. Weld strength and micro structural properties were studied. In his research work they try to restrict the weld defects in dissimilar metal welds, the percentage of Ti with 0.15 control the thermal caused defect in aluminium and the temperature should be down to 30to 600 c after one layer of tig welding each layers makes to reduce thermal cracking for upcoming addition.

V. D Prabhu, done the experimental Investigation of Aluminium 6061 Alloy by GTAW Process in this experiment 6mm plate of AA6061 is welded at different parameter with filler ER5183 and performs different mechanical test and conclude that in his work at 190A welding current, material tensile strength is at its peak. Shielding flowrate 8 L/min, filler rod diameter 2mm. The tensile strength of 6061 aluminium alloy welded metal will be reduced as welding current is increased.

Ishteyaque Ahmad, perform the GTAW welding of AA-6061 alloy plate of thickness 6mm in this study they selected the welding current as the process parameter which they vary for different sample with filler rod of ER4047 which has high fluidity due to high silicon content. In his experiment he performs surface and mechanical test has been performed for optimal values of current.

Michinori had performed energy Beams Arc and friction stir welding methods were used to evaluate the mechanical characteristics of aluminium-based dissimilar alloy junctions. A1050-H24, A2017-T3, A5083-O, A6061-T6, and A7075-T651 were the metals involved in the experiment. The specimen was made of various aluminium alloys with a thickness of 3 mm. In comparison to other fusion welding techniques, friction stir welding of aluminium alloy A5083/A6061 has the highest hardness value in the stir zone through the weld metal. The aluminium alloy A2017/A7075 age-hardening aluminium joint has the maximum tensile strength thanks to friction stir welding. Fusion and crystallisation zones are particularly tiny in Power Beam welding processes like EBW and LBW. As a result, when comparison to MIG and TIG welding, the heat input is minimal.

Krzysztof in their study performing MIG welding, the mechanical characteristics of the aluminium alloy AA-7020 were compared to those of the aluminium alloys AA-5083 and AA-5059. The flat specimens are sliced in the opposite direction of the rolling motion. The experiment was carried out at a temperature of +20°C. When compared to the aluminium alloys AA-5059 and AA-5083, the junctions welded by MIG welding of the aluminium alloy AA-7020 have a larger yield stress. The aluminium alloy AA-7020 has the worst plastic characteristics. When compared to alloys AA-5083 and AA-5059, the welded joints of aluminium alloy AA7020 have a higher strength.

Qinglei et. al measured Some mechanical properties of AA6351 welded joints were investigated during TIG welding using non-pulsed & pulsed current with various frequencies. Welding was done at 70-74 A current, 700-760 mm/min arc travel speed, and 3 and 7 Hz pulse frequency. The tensile strength and YS of the weldments are closer to base metal, as per the experimental results. Weldment failure occurs at HAZ, and we discovered that weldments had better weld bond strength.

Mustapha Arab Mokhtar Zemri in their study friction Stir Welding (FSW) was used on Aluminium 6082-T6 sheets with measurements of 200 x 70 x 2 mm for their research. To investigate the most critical elements that impact both Ultimate Tensile Strength (UTS) & Hardness (HV) in AA 6082-T6 joints formed by Friction Stir Welding, a Design of Experiment (DOE) was used (FSW). The effect of two components, tool rotating speed and welding speed, on (UTS, HV) was explored using the Taguchi technique and a L9 orthogonal array to determine the best process parameters.

Lakshman uses the TIG welding to evaluated the influence of welding parameters such as welding current, shielding gas frate, and welding speed on the tensile property of the aluminium alloy AA-5083. The aluminium alloy AA-5083 specimen dimension in the experiment is 100 mm x 15 mm x 5 mm. When the welding current is 240 amps and the gas flow rate is 7 Lt/min, the maximum strength of 129 MPa is attained. The welding speed was set at 98 mm/min for high tensile strength.

Venugopal in his study finds the influence of M2-Hss tool pin profile on the mechanical characteristics of aluminium alloy AA-7075-T6 in friction stir welding was investigated. The joints were built using three distinct tools (Taper Threaded, Cylindrical, and Square) at varied rotating speeds. The mechanical parameters of the joint, including as tensile, impact, and micro hardness, were determined, and the creation of the FSP zone was examined microscopically. Friction stirs welding and plastic flow have resulted in grain refining. At 800 rpm, the threaded cylindrical profile provides high-strength welds.

Casalino et al. used laser welding to join AA5754 Al alloy sheets. They employed the ANN approach to predict geometrical properties of the weld seam for these lasers welded Al connections, and they demonstrated that ANN helped them establish a relationship between process factors and weld seam characteristic.

Zhang et al. used laser welding to create a welding method for dissimilar Al alloys AA5754 and AA6013, and they evaluated the influence of process parameters on the development of hot cracking joints. When the laser strength is increased for the building of AA6013 up and AA5754 down, the hot cracking sensitivity decreases.

Rayeset et al. looked at the effects of increasing the feed rate while keeping the rotating speed constant on the microstructural and mechanical characteristics of the FSW of the AA5754 aluminium alloy. They discovered that the mechanical characteristics of the FSW joints are affected by rotating speed.

2.1. Research gap and motivation

1. In welding of dissimilar aluminium alloys most of the researchers follow the FSW and LBW to weld the weldments due to their higher mechanical properties and small heat effected area. But the cost of these setup is much high and sometimes in multiples as compare to fusion welding methods.

2. In GTAW of aluminium alloys most research is done on the same material very few works are done in dissimilar aluminium alloys due to difficulty to control the welding defects because of difference in thermal conductivity of deferent series of aluminium alloys.

3. Most of the work in study of aluminium alloys are limited to tensile testing very few of researchers works on the microhardness test, microstructures and residual stress test of the welded specimen.

4. In 5xxx and 6xxx series of most of the work is done on the other alloys such as 5456 from 5series and 6063 and 6082 in 6 series of aluminium alloys.

5. In case dissimilar aluminium alloys most of the researchers use less thickness of the material limited to 3mm due to easier to penetrates up to 3mm and few of them done on 6mm and very few done on V-shape bud joint with root of 2mm.

6. The most important factor or research gap found was the use of filler material. Very less researchers on 2 different filler materials. In this project 3 different filler material have been used which are ER4043, ER4047, ER5356.

2.3. OBJECTIVES

- The aim of this project is to optimise the GTAW process parameters in order to identify the effect of process parameter on mechanical properties of specimen.
- To identify the limits of process parameters under which the variation in mechanical properties is seen with the peak and low values.
- Development of design matrix using Taguchi method.
- Performing tests as per the design matrix results.
- Fabricating the specimens for tensile test, hardness test and micro-structure test.
- To make relation between the various selected influencing process parameters in to evaluate the percentage of contribution in each of them in case of the tensile test and micro hardness test.

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CHAPTER THREE

3. METHODOLOGY

3.1. BASE MATERIAL SELECTION

The base material employed in this investigation for welding dissimilar aluminium alloys are two dissimilar alloys, one belongs to 5xxx series and the other from the 6xxx series. specimen of 5 mm thick annealed aluminium alloy 5083-O plate, while the other is a 5 mm thick artificially aged aluminium alloy 6061-T651. They were chosen because of their widespread use in the automotive, food & beverage, and aerospace sectors.

The lightweight properties of AA-5083 and AA-6061 aluminium alloys, as well as their good machinability, weldability, and corrosion resistance, were the key reasons for their selection. It is more commonly accessible than other aluminium grades and, because of its excellent strength-to-weight ratio, it is a feasible alternative to steel alloys. The chemical composition of these alloys is listed below in table.

Table1: Chemical composition of AA-5083 and AA-6061.

COMPONENTS	AA5083	AA6061
Mg	4.2500	0.9450
Si	0.3120	0.4660
Mn	0.5100	0.0690
Cu	0.0340	0.3450
Cr	0.1080	0.1700
Zn	0.0500	0.2000
Ti	0.0120	0.0950
Fe	0.0190	0.4550
Al	BALANCE	BALANCE

Table2: Mechanical properties of AA5083-AA6061.

PROPERTIES	AA-6061-T6	AA-5083-O
Melting range	582-652ºC	591-638ºC
Modulus of elasticity	68.9 Gpa	71 Gpa
Density	2.7 g/cc	2.66 g/cc
Thermal Conductivity	167 W/m-k	117 W/m-k
Tensile strength	310 Mpa	280 Mpa
Yield strength	276 Mpa	248 Mpa
Shear strength	207 Mpa	172 Mpa
Hardness	107HV	87HV

The AA5083-AA6061 alloy lies under the wrought aluminium alloy whose having good strength at normal temperature, ductility, corrosion resistivity and weld ability. Along with its utility in aerospace, food and beverage industries, automobile and wide use in panel and structures of marine vehicles.

Fig12: AA5083(O)-AA6061(T6) plates.

3.2. FILLER MATERIAL SELECTION

Fillers are alloys or pure metal materials which on heated liquefy and transfer to the weld pool where they solidify and a joint is prepared. In aluminum different fillers are use according to the base metal, for 6xxx series alloys 4043 are commonly use in large scale and in case of 5xxx series alloys 5356 are commonly used. Between these two one newer fillers comes across which is 4047 which known for their crack-resistivity due to loss melting range as compare to other. The chemical composition of 4043,4047 & 5356 is listed in Table.

Table3: Chemical composition of ER4043, ER4047, ER5356.

COMPOSITION	ER4043	ER4047	ER5356
Mg	0.05	0.10	5.0
Si	4.5	12	0.23
Mn	0.05	0.15	0.12
Cu	0.30	0.30	0.05
Cr	-	-	0.9
Zn	0.10	0.20	-
Ti	0.20	0.15	0.13
Fe	0.80	0.80	-
Al	BALANCE	BALANCE	BALANCE

Fig13: ER4043, ER4047, ER5356 filler rods.

3.3. WELDING MACHINE SETUP

In this STUDY, TIG welding machine TRITON 220 AC/DC is USED in which the welding current can be varied from 5 Amp to 220 Amp, shielding gas flow can be regulate from the gas regulator placed on the gas cylinder which can vary from 0-20l/min.

The shielding gas used in welding machine is pure Argon (99.99%). Air cooled welding torch is used with ceramic nozzle and non-consumable tungsten electrode with 2.2 mm diameter.

Fig14: Triton 220 AC/DC GTAW machine.

I. Process parameter for TIG welding

The parameters available for TIG welding those effects the mechanical properties of welded specimen.

1. Welding current
2. Welding voltage
3. Welding speed
4. Shielding gas flow
5. Filler material
6. Material transfer rate

II. Identifying the Important Process Parameters

The microstructure, mechanical, and metallurgical characteristics of the weldment are influenced by the welding circumstances provided by various process factors. Identification of proper welding conditions is also critical for getting a sound and leak-proof welded connection free of weld flaws including hot cracking, porosity, and stress corrosion cracking, among others. Desired welding conditions can be obtained by carefully selecting the process variables or elements that impact weld quality that are independently controlled. Welding current, shielding gas flow, and filler material were chosen from among several independently controlled process variables or parameters impacting mechanical qualities to carry out the experimental work.

3.4. Experimentation

Plates of AA-5083 and AA-6061 were shear out from the material sheets in dimensions of 110*60*5 with help of shearing machine. FLOWMECH shearing machine is impowered to shear out the plates of identical dimensions from 5mm sheet of both grades of aluminium alloys.

Fig15: Flowmech shearing machine

Before begin the welding process between the aluminium plates a V-shape bud joint has been prepared using the grinder wheel. One side of each plate is buffed using the wheel grinder equally and maintain the angle of 60º. All the foreign particles of oils, grease and other surface sticking material is remover by using metal cleanser.

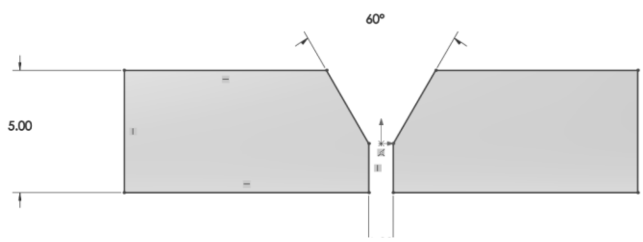


Fig16: Side view of weldments.

Fig17: wheel grinder

TIG welding (Triton 220 AC/DC) was employed to create butt connected with a weld size of 110mm X 60mm X 5mm of each. To construct a 60° groove weld connection, the material was chamfered from 2mm above the base. To remove oil/grease, dust, and oxides, the base plates were brushed and then cleaned with acetone. Welding is done with an automated setup. The tungsten electrode is 0.8 percent zirconated, and the shielding gas is pure argon.

3.5. Experiment trails use to get working range of process parameters

To determine the possible operating limits of each process parameter, many trial runs were conducted on 5mm sheets of AA5083-O and AA6061-T651 aluminium. The trial runs were carried out using various combinations of current parameters. Weld quality was assessed based on bead shape and appearance to determine the welding parameters' operating limitations.

From the trails analysis it was found that at 180A the less penetration takes place while at 200A a sound and leak proof joint found and at 220A over heated and spatter and undercuts is detected on weld bead. The weld bead at all 3 current can be seen below.

Fig18: Weld bead at deferent welding current

3.6. Taguchi design matrix

Welding current is major parameter in welding of aluminium alloys as the lower welding current cause less penetration in the weld profile due to which a sound weld is not prepared and if the welding current is more than the electrode may overheat and can cause undercutting. Shielding gas is use to protect the arc form the atmosphere too high and too low argon gas floe cause the porosity in the weld pool. high gas flow cause spattering of arc and spatter of weld pool and effect the weld bead geometry. Taguchi L9 orthogonal array has been applied on the operating range of process parameter. Taguchi L9 array has been shown in Table below.

Table4: Design matric of process parameters

WELDING CURRENT	FILLER MATERIAL	SHIELDING GAS FLOW
180	5356	10
180	4043	12
180	4047	14
200	5356	12
200	4043	14
200	4047	10
220	5356	14
220	4043	10
220	4047	12

Further the parameters are adjusted according to the table above and 9 welded sample are prepared.
These samples are prepared by 2passes of welding due to lower material transfer rate and 5mm thickness of plates. The welded plates can be seen in figure below.

Fig19: GTAW welded plates

3.7. Non-destructive Testing of Weld

Non-destructive testing is useful to ensure that defects in the welds bead and different zones can be detected before to place to use. Faulty welded weldments may provide way to problems, some of which may be disastrous depending on the items being welded and used.

The welded plates were visually examined to find out any surface defect, then the X-ray penetration helps to detect any sub-surface flaws.

I. Residual stress test

Residual stresses are locked in stress present in weld even when there is no external loading. Residual stresses develop in welded material due to differential volumetric change, and differential expansion and contraction. Residual stress of samples has been determined by non-destructive testing, X-ray diffraction technique. X-ray diffraction technique with the cosα method was employed in the present research because it makes the system small, portable, easy to handle, and stress can be obtained in a shorter time. PULSTEC micro-360n machine was employed in the examination, shown in figure below.

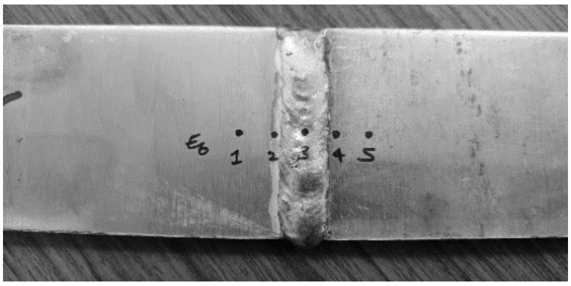


Fig20: Marking of location prior to testing

Fig21: PULSTEC micro-360n residual stress tester

3.8. Mechanical Testing of Welds

AA5083 is an aluminium alloy that cannot be heat treated, but AA6061 can. These alloys have a better strength-to-weight ratio, are ductile, and resist corrosion. Due to these characteristics these alloys are widely use in automobile, aerospace and food storage and beverage industries. The joints that constitute various structures should have specific service capabilities. Different kinds of testing were made to ensure that the desired function will be satisfied. The optimum evaluation includes real practise observation of the structure. Normally, this is not feasible. As a result, several mechanical tests on standard specimens are undertaken to determine the structural behaviour in service.

I. Tensile Testing of Welds

To perform the tensile test the specimen of tensile test is taken from the welded plates. The specimen was designed as per ASTM standard CAD is shown in figure below and EDM wire cutting machine was used to machine the tensile specimen. The uniaxial tensile testing was performed according to ASTM-E8M standard as shown in Fig.

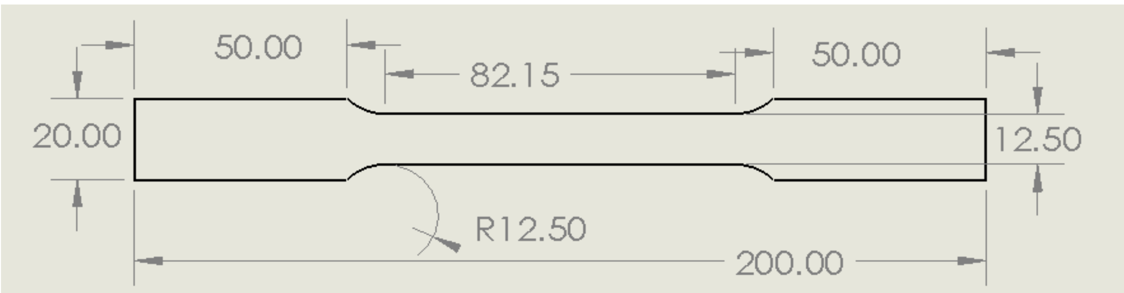


Fig22: Design of Tensile test specimen as per ASTM-E8m.

Fig23: Tensile test specimen

The tensile test was performed in a Tinius Olsen universal testing machine with a cross head speed of 2.5mm/min and a 50 KN electromechanical control. The maximum tensile strength and elongation % were measured. The tensile test is performed by grasping one end of a specimen in a tensile testing machine and pulling on it until it cracks.

II. Analysis of Tensile Testing

TIG welded junctions always ruptured at areas under HAZ on the weaker material side, according to investigations of welding different aluminium alloys. Those investigations, however, did not look into the influence of material location on tensile qualities. Under all welding circumstances, the failure site in HAZ also indicates flawless bonding between incompatible AA 5083-O and AA 6061-T651 alloys. The results show that the ultimate tensile strength of both the base metal and the welded specimens is greater, indicating significant work hardening beyond the yield limit. Solid solution strengthening caused by the growth of Mg2Si particles in the fusion zone may also improve weld metal strength.

Fig24: Tinius Olsen H50KS UTS machine.

III. Micro-hardness Test

For micro-hardness test specimen for testing is taken from the junction of welded plates and place them in the cold-mounting and polishing has been done to remove the scratches from surface for smooth indentation of diamond inventor.

Micro-indentation hardness analysis is a procedure for determining a material's hardness on a small scale. At weights ranging from a few grammes to one kg of, a precise diamond indenter is pressed into the material. A hardness value is calculated using the microscopically recorded imprint length and the test load. The acquired hardness values are good indications of a material's characteristics and predicted service lifetime.

The tester uses dead weights to apply the selected test load. With a light microscope or a video picture and computer software, overall length of a hardness imprints is precisely determined. The test load, imprint length, as well as a shape factor again for indenter type employed in the test are then processed to make a hardness number.

IV. Vickers Micro-hardness Test

Process that involves in the preparation of test specimen for micro hardness test.

- Cutting of workpiece from weld joint.
- Burring and placing of workpiece in mould for cold-mounting.
- Grinding of excess mountain material to get specimen material at planer position.
- Grinding of specimen from water proof sandpaper from 100 to 2500 grades.
- Wet polishing of the specimen for mirror like surface finish with less scratches.
- Etching of material to identify the base metal and workpiece.

Fig25: Grinding and polishing of specimen

For Vickers micro-hardness tester (DRAMIN-40 STRUERS microhardness testing machine) was used to measure the hardness across the transverse section of the joint with load of 500g dead weight of indenter and dwell time of 10 s was applied and reading was taken shown in figures below. The reading for the hardness test is taken at 5 places on specimen.

1. Base metal AA6061
2. AA6061 HAZ
3. Weld bead
4. AA5083 HAZ
5. Base metal AA5083

Fig26: DRAMIN-40 STRUERS microhardness testing machine

V. Analysis of Micro-hardness Test

In comparison to their corresponding base metals, both AA6061 and AA5083 alloys have shown a reduction in micro-hardness in the weld. This is because to TIG thermal cycle coarsening, dissolving, and reprecipitation of stronger precipitates in heat effected zone.

Both base metals have the high hardness value as compared to the weld bead and heat effected zone. For base metal AA6061 the value of Vickers hardness was observed 106HV0.5 at 500g of dead weight at indenter. In AA5083 the Vickers hardness value was measures as 92HV0.5 at 500g of weight on indenter. The micro-hardness profile can be seen in fig below.

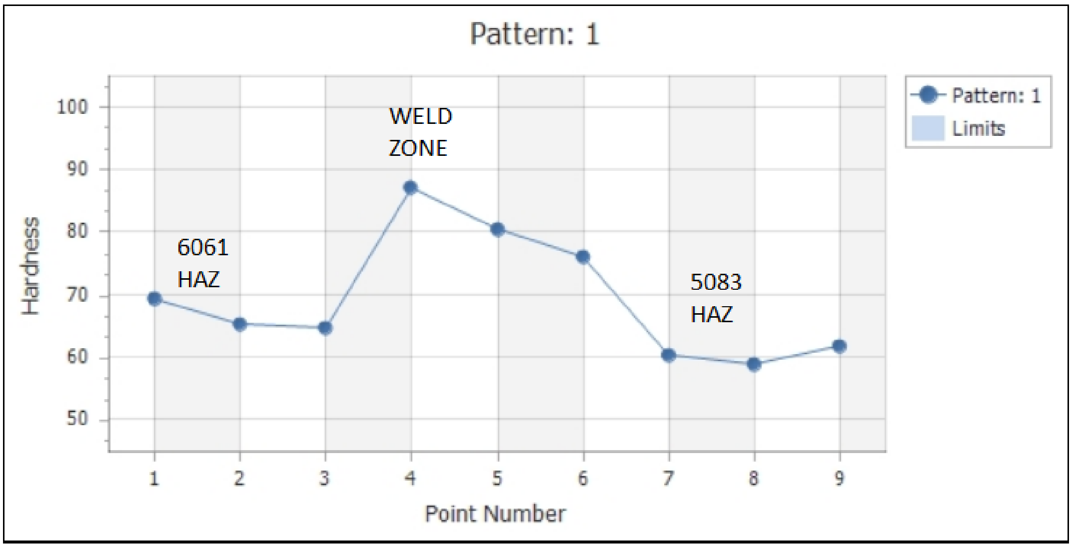


Fig27: Micro hardness profile of AA6061-AA5083.

VI. MICROSTRUCTURE TEST

Microstructure examination of samples welded at different process parameter has been taken place. For producing or fabricating the test specimens the rectangular piece of material is taken out from the junction of the welded plates. These rectangular pieces of metal contain the 3 zones.

- Base metal
- Heat effected zone
- Welded/fusion zone

This specimen is place in the mold and the cold mounting material is poured inside the mold and allow to settle and cool down and the test specimen in cold mounting is taken out from mold. These specimens are grinded on the grinding station using the water proof sandpaper of grades vary from 100 to 2500 grid size.
After grinding the wet-polishing of specimens are performed on polishing station after that the etching of specimens are done using etching solution and dry in hot air dryer due to etching solution the identification of 3 zone can be seen on naked eyes.

Fig:28 (a) Grinding station, (b) Polishing station

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. TENSILE TEST

The tensile test of all 9 TIG-welded AA5083(O)-AA6061(T6) was carried on the UTS machine with jaw speed of 2.5mm/min. The highest tensile strength is attained by sample 4 with process parameters are:

- filler material= ER5356
- welding current=200A
- shielding gas flow=12l/min

with UTS value of 182 MPa, compared to ER4047, which yields at 179 MPa, and ER4043, at 149 MPa. In the majority of tensile testing, the fracture occurs in the heat influenced zone, as shown in figure. Below is a stress-strain curve for welded specimens of maximum tensile strength from all filler materials.

Fig29: Fractured sample after tensile test.

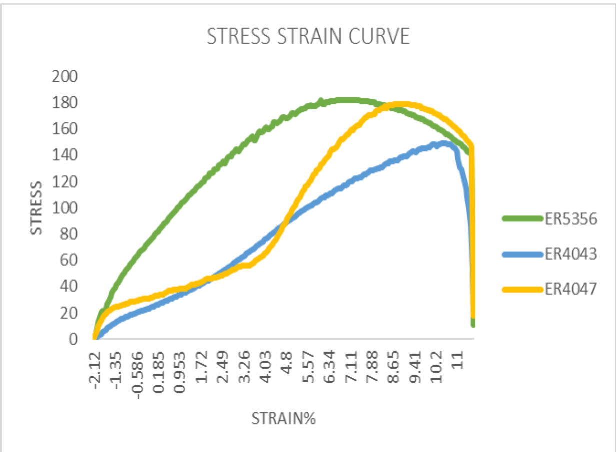


Fig30: Stress strain curve of specimens

4.2. MICROHARDNESS TEST

The Vickers indenter is used in microhardness of specimens with load of 500g on the indenter and dwell time of 10s. Three indentation is done in each region to get the mean of them for accurate results.

Understanding the behaviour of micro-hardness requires research into the effects of process variables. The influence of welding current, filler material and gas flow of inert gas and their interaction on micro-hardness on the specimen has been recorded.

The hardness value weld bead of each sample is compared and highest values of Vickers hardness is achieved on sample 4 with parameters are as follow:

- filler material= ER5356
- welding current=200A
- shielding gas flow=12l/min

The value of hardness is found to be similar in welding current of 180A and 200A but due to overheating and coarsening of grains the hardness value drops in the 220A welding current.

Understanding the behaviour of micro-hardness requires research into the effects of process variables. The influence of welding current, filler material and gas flow of inert gas and their interaction on micro-hardness on the specimen has been recorded.

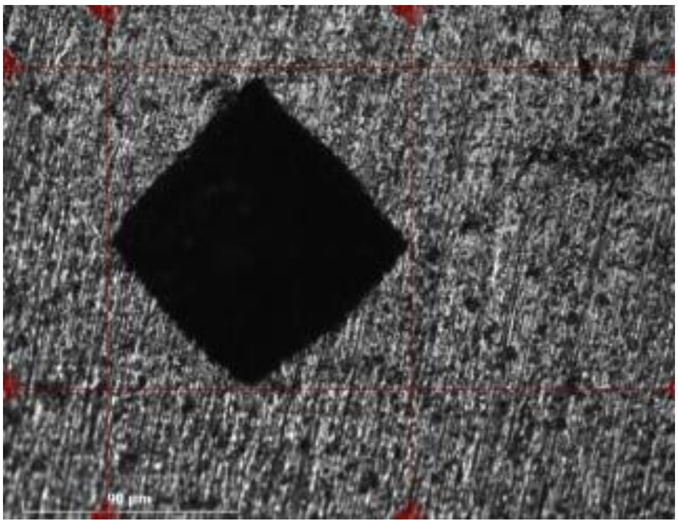


Fig31: Vickers indentation on specimen.

4.3. MICROSTRUCTUE TEST

Microstructure Examination is use to determine the effect of various fabrication and heat treatment on structure of aluminium that differs from the base metal or untreated aluminium alloy.

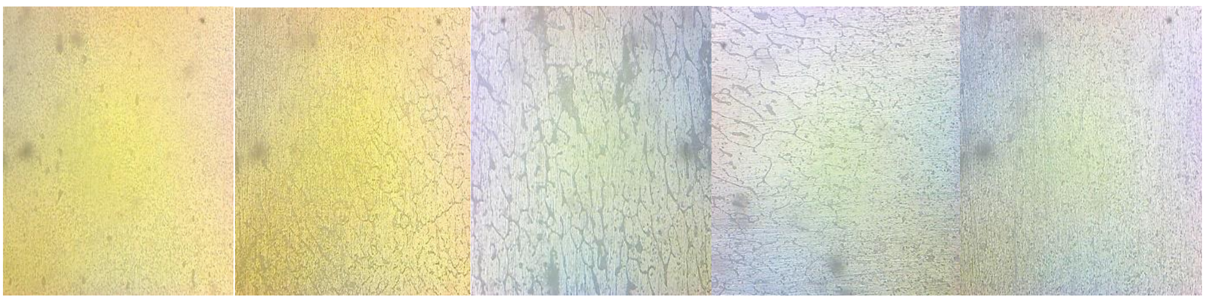
For examine the micro structure visually using test equipment the etching of the material has to been performed with etching solution for 10-15s.

FIG32: Etched specimen

The microstructure of specimen is taken at 5 different locations

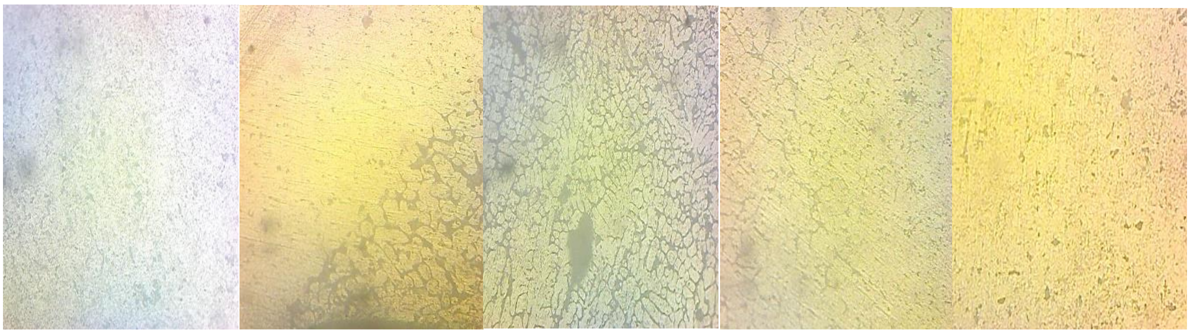
- AA5083
- AA5083(HAZ)
- FUSION ZONE
- AA6061(HAZ)
- AA6061

Specimen with ER4043 as a filler material.



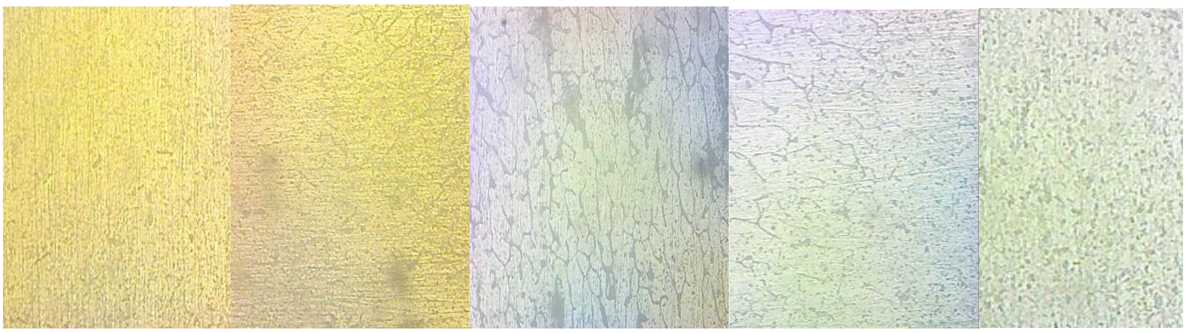
AA5083 AA5083(HAZ) ER4043(WB) AA6061(HAZ) AA6061

Specimen with ER4047 as filler material.



AA5083 AA5083(HAZ) ER4047(WB) AA6061(HAZ) AA6061

Specimen win ER5356 as filler material.



AA5083 AA5083(HAZ) ER5356(WB) AA6061(HAZ) AA6061

the grain structures of aluminum base metals 5083-O and 6061-T651, as well as the fusion zone of a dissimilar welded junction the dense interdimeric web of Mg eutectic in the matrix of aluminum crystalline phase forms the base metal of 5083-0. On aluminum 5083-O, the contact between both the base metal as well as the fusion zone reveals the presence of heat cycles during the welding process, which undergo disturbance in the grain boundary inside the aluminum matrix.

In case of ER-4047 filler wire, which is silicon rich as compare to other two. As a result, the microstructure is made up of an inter-dendritic network of aluminum silicon eutectic in an aluminum solid solution matrix.

4.4. RESIDUAL STRESS TEST

Residual stresses affect the fatigue life, deformation, corrosion resistance, and dimensional stability of welded joints, which is why residual stress study is valuable in this welding research. According to researchers, residual stress in welded material can be both tensile and compressive. Tensile residual tension stays in weld beads, while compressive residual stress stays in base metal. Distribution of residual stress at 3 different positions (weld bead; base metal-5083 and base metal-6061) are tabulated in table below for highest and lowest strength.

Table5: Residual stress distribution

S. No	Residual stress MPa (Weld-bead)	Residual stress MPa (5083)	Residual stress MPa (6061)
1	145	-28	-21
2	107	-41	-23

Fig33: specimen for residual stress analysis.

4.5. TAGUCHI ORTHOGONAL ARRAY DESIGN

In order to proceed this project, the first most important step is to create the Taguchi orthogonal array. For generating this Taguchi orthogonal array using MINITAB19 software we need to first identify the important process parameters and divide those parameters into three different levels from the available working ranges with regard to the material AA5083(O)-AA6061(T6) alloy used in this project work.

The range of each process parameter is selected by experiment trials and listed in the table below.

Table 6: Process parameter levels

SYMBOL	INPUT PARAMETERS	UNITS	LEVEL 1	LEVEL 2	LEVEL 3
WC	Welding current	Ampere(A)	180	200	220
SGF	Shielding gas flow	Litre/min	10	12	14
FM	Filler material	-	ER4043	ER4047	ER5356

The next step is to pick from the available number of runs L9 or L27 for three factors and three levels Taguchi design in order to produce the Taguchi orthogonal array using the above-mentioned input parameters and their various levels. The same may be seen in the picture below.

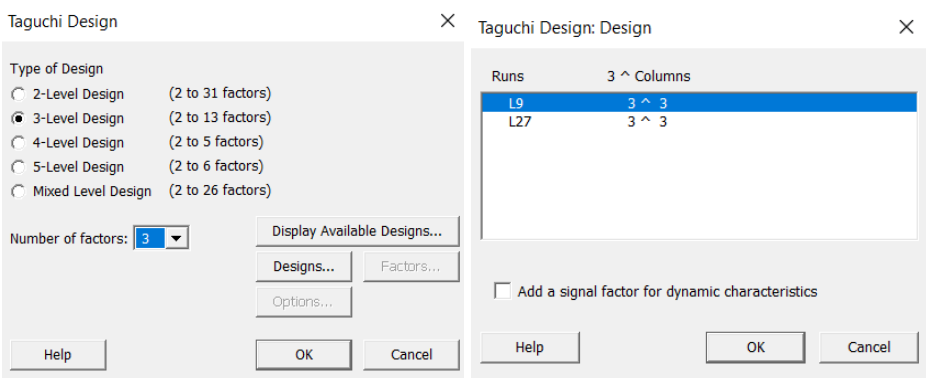


Fig34: Taguchi design and available runs for 3 factor and 3 level.

Due to limited quantity of the work material and wastage AA5083-AA6061 alloy, we used L9 orthogonal array design as it is more compact and provide precise results and will help us to do the requisite engineering experimental design in order to fulfil our goal with minimum number of experiments to perform. The standard Taguchi L9 orthogonal array design has been shown in the table below.

Table7: Design matrix by Taguchi L9 array

Run	Parameter A	Parameter B	Parameter C
1	L1	L1	L1
2	L1	L2	L2
3	L1	L3	L3
4	L2	L1	L2
5	L2	L2	L3
6	L2	L3	L1
7	L3	L1	L3
8	L3	L2	L1
9	L3	L3	L2

By substituting the values of various levels of input parameters associated with this project work, we will obtain the required L9 Taguchi orthogonal array as given in the table below.

Table8: Required Taguchi L9 orthogonal array

RUN	WC	FM	SGF
1	180	ER5356	10
2	180	ER4043	12
3	180	ER4047	14
4	200	ER5356	12
5	200	ER4043	14
6	200	ER4047	10
7	220	ER5356	14
8	220	ER4043	10
9	220	ER4047	12

I. Analysis of process parameter for tensile strength of welded specimens.

When making a TIG welded joint of AA5083-AA6061, the best process parameter is welding current at 200A, filler material ER5356, and gas flow at 12Lt/min. The maximum tensile strength has been calculated to be 182 MPa. Plot of S/N ratio against design factor is shown in figure below and response for the S/N ratio is illustrated in table.

Table9: Response for Signal to Noise Ratios

Level	WC	FM	SGF
1	40.23	40.59	42.32
2	43.92	43.01	42.64
3	43.05	43.61	42.24
Delta	3.70	3.02	0.40
Rank	1	2	3

The main effects plot for S/N ratios and the main effects plot for means have been used to support this response table for S/N ratios. This graphic, in combined with the response table, aids in estimating the needed input parameter levels. Figure shows the major effects graphs for S/N ratios and means.

Fig35: Main effects plot for S/N ratios

II. Analysis process parameter for Micro-hardness value of welded specimen

In TIG welded joint of AA5083-AA6061 the best process parameter which provides the best micro hardness indentation value and with less welding defects are welding current at 180A, filler material ER5356 and gas flow rate 12Lt/min. The maximin Vickers hardness value is 84.18HV0.5 at 500g of load at indenter. Plot of S/N ratio against design factor is shown in figure below and response for the S/N ratio is illustrated in table.

Table10: Table for Signal to Noise Ratios

Level	**WC**	**FR**	**G**
1	37.12	36.12	37.41
2	37.76	37.17	36.94
3	36.48	38.06	37.00
Delta	1.28	1.93	0.47
Rank	2	1	3

The main effects plot for S/N ratios and the main effects plot for means have been used to support this response table for S/N ratios. This graphic, in combined with the response table, aids in estimating the needed input parameter levels. Figure shows the major effects graphs for S/N ratios and means.

Fig36: Main effects plot for S/N ratios

CHAPTER 5

5. CONCLUSION

The purpose of this study was to investigate the effects of several TIG welding process parameters and to determine the best combination of parameters for improving the mechanical and metallurgical characteristics of TIG welded specimens of dissimilar aluminium alloys AA5083-O and AA6061-T651.

- The optimum value of current in tig-welding of AA-5083 and AA6061 of thickness 5mm is 200 Ampere in case V-shape bud-joint with root gape of 2mm and bead angle of 60 degree.

- Gas flow for shielding the arc from atmosphere also cause the impact on weld properties and weld geometry. In this study the ideal flow is observed to be 12l/min below it causes the risk of porosity and above it causes the distortion of weld geometry and effect the UTS of specimen.

- 3 different filler material has been used in this study among which ER5356 is ideal for welding dissimilar AL-alloys due to their high strength among 4043 and 4047 and high ductility as compare to other two.

- ER4043 is not a right choice to use in dissimilar alloys due to their large melting range which is main cause of hot -cracking in the weld pool where 2 or more passes of welding required.

- According to the Taguchi methods results, the welding current seems to be the most significant process parameter that has a substantial impact on the tensile strength of the weldment of AA 5083-AA 6061 alloy.

- According to the optimized result the residual stress analysis is performed on the specimens which shows the best tensile strength and specimen with lowest one. As the earlier studies states the weld bead has residual stress in tensile nature with 145Mpa and 107Mpa. The base-metal have compressive residual stress in nature with range of 22-41 MPa.

- Vickers hardness test were performed in which the sample which exhibits the highest hardness value is sample 4 with filler material ER5356 and welding current 200A.

- There is low significant change in hardness value at 180A and 200A but in sample of 220A the hardness value decreases due to overheating and coarsening of the precipitates and dendrites.

- In microstructure of welded specimen at 200x in case of ER5356 more fine grains are found in fusion zone and less coursed grains in heat effected zone.

- On high heat input in weld thermal cycle causes the coarsening of grain in heat effected zone and make them weaker section as compare to other zones.

FUTURE SCOPE OF WORK

- This project can be extended by using different grades of aluminum alloys and other alloys which are comparable and have high weldability and fusibility.

- Other welding process such as GMAW and CMT-MIG can be used to weld aluminium grades of deferent series.
- Other parameter such as filler rod diameter and different shielding gases can be study.

- Other new filler material and metal transfer processes can be used to increase metal transfer rate as compare to traditional method has less and uncontrolled metal transfer rate.

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