A Review on - Investigation & Optimization of Tig Welding Parameters And Their Effect on Aluminum Plate (AL 5052)

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Abstract - To improve welding quality of Aluminum (Al) plate an automated TIG welding system has been developed, by which welding speed can be control during welding process. Welding of Al plate has been performed in two phases. During 1st phase of welding, single side welding performed over Al plate and during 2nd phase both side welding performed for Al plate by changing different welding parameters on different composition of Aluminum (Al). Effect of welding speed and welding current on the tensile strength of the weld joint has been investigated for both type of weld joint. Optical microscopic analysis has been done on the weld zone to evaluate the effect of welding parameters on welding quality. Micro-hardness value of the welded zone has been measured at the cross section to understand the change in mechanical property of the welded zone.

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

I. INTRODUCTION

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification; a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material, which after solidification gives a strong bond between the materials. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position.

TIG welding is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere by an inert shielding gas (argon or helium), and a filler metal is normally used. The power is supplied from the power source (rectifier), through a hand-piece or welding torch and is delivered to a tungsten electrode, which is fitted into the hand piece. An electric arc is then created between the tungsten electrode and the work piece using a constant-current welding power supply that produces energy and conducted across the arc through a column of highly ionized gas and metal vapors. The tungsten electrode and the welding zone are protected from the surrounding air by inert gas. The electric arc can produce temperatures of up to 20,000oC and this heat can be focused to melt and join two different part of material. The weld pool can be used to join the base metal with or without filler material. Schematic diagram of TIG welding

and mechanism of TIG welding are shown in fig. 1 & fig. 2 respectively.

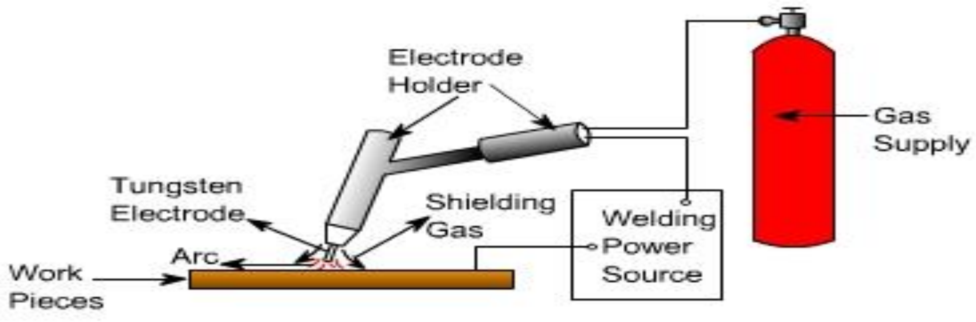

Figure 2: Schematic Diagram of TIG Welding System

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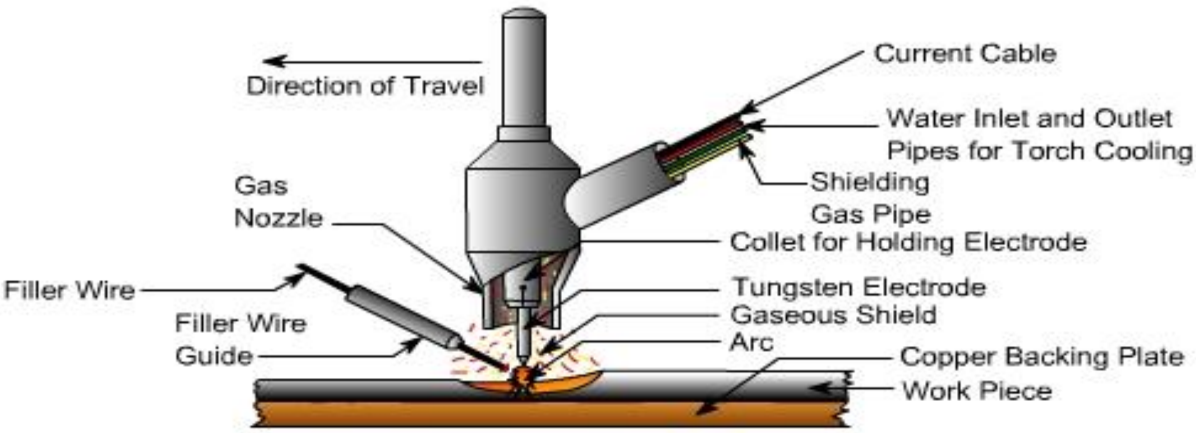

Figure 2: Principle of TIG Welding

Advantages of TIG Welding:-

TIG welding process has specific advantages over other arc welding process as follows -

1. Narrow concentrated arc
2. Able to weld ferrous and non-ferrous metals
3. Does not use flux or leave any slag (shielding gas is used to protect the weld-pool and tungsten electrode)
4. No spatter and fumes during TIG welding

Application of TIG Welding:-

The TIG welding process is extensively used in the so-called high-tech industry applications such as-

1. Nuclear industry
2. Aircraft
3. Food processing industry
4. Maintenance and repair work
5. Precision manufacturing industry
6. Automobile industry

Process parameters of TIG welding:-

The parameters that affect the quality and outcome of the TIG welding process are given below.

a) Welding Current

Higher current in TIG welding can lead to splatter and work piece become damage. Again lower current setting in TIG welding lead to sticking of the filler wire. Sometimes larger heat affected area can be found for lower welding current, as high temperatures need to applied for longer periods of time to deposit the same amount of filling materials. Fixed current mode will vary the voltage in order to maintain a constant arc current.

b) Welding Voltage

Welding Voltage can be fixed or adjustable depending on the TIG welding equipment. A high initial voltage allows for easy arc initiation and a greater range of working tip distance. Too high voltage, can lead to large variable in welding quality.

c) Inert Gases:

The choice of shielding gas is depends on the working metals and effects on the welding cost, weld temperature, arc stability, weld speed, splatter, electrode life etc. it also affects the finished weld penetration depth and surface profile, porosity, corrosion resistance, strength, hardness and brittleness of the weld material. Argon or Helium may be used successfully for TIG welding applications. For welding of extremely thin material pure argon is used. **Argon** generally provides an arc, which operates more smoothly and quietly.

Penetration of arc is less when Argon is used than the arc obtained by the use of Helium. For these reasons, argon is preferred for most of the applications, except where higher heat and penetration is required for welding metals of high heat conductivity in larger thicknesses. Aluminum and copper are metals of high heat conductivity and are examples of the type of material for which helium is advantageous in welding relatively thick sections. Pure argon can be used for welding of structural steels, low-alloyed steels, stainless steels, aluminum, copper, titanium and magnesium. Argon hydrogen mixture is used for welding of some grades of stainless steels and nickel alloys. Pure helium may be used for aluminum and copper. Helium argon mixtures may be used for low alloy steels, aluminum and copper.

d) Welding speed:

Welding speed is an important parameter for TIG welding. If the welding speed is increased, power or heat input per unit length of weld is decreases, therefore less weld reinforcement results and penetration of welding decreases. Welding speed or travel speed is primarily control the bead size and penetration of weld. It is interdependent with current. Excessive high welding speed decreases wetting action, increases tendency of undercut, porosity

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Welding was done with current in the range 100-190 A and welding speed 420-1500 mm/min. For the experimentation welding current in the range of 90-170 A and welding speed in the range of 100-220 mm/min, were used for 2-5 mm thick plate.

To reduce the welding challenges of aluminum, it is found always that welding of Aluminum is a big challenge by conventional arc welding process. Again, repeatability of welding depends on its control on welding speed and other processing parameters.

Properties and advantages of Al:

Aluminum is a very lightweight metal (specific weight of 2.7 g/cm3). Use of aluminum in automobile and aerospace reduces dead weight and energy consumption. Strength of Aluminum can be improved as per the required properties for various applications by modifying the composition of its alloys. Aluminum is a highly corrosion resistant material. Different types of surface treatment can further improve its corrosion resistance property. Aluminum is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum the most commonly used material in major power transmission lines.

Table 2:- Aluminum alloy nominal composition (% weight) and applications

Alloy	Al Content	Alloying Elements	Uses
1100	99.0	Cu 0.1	Universal, Hallo ware
1060	99.6		Universal,
1420	92.9	Mg 5.0; Li 2.0; Zr 0.1	Aerospace
1421	92.9	Mg 5.0; Li 2.0; Mn 0.2; Sc 0.2; Zr 0.1	Aerospace

II. MATERIALS COMPOSITION AND PROPERTIES

The Experimental material will be select as 5052 Al-alloy of 100mmlong x 50mmwide x 3 mm thickness also thickness, which will weld by TIG welding after surface preparation. The chemical composition of 5052 Al alloy is shown in Table.

Table 3:- Chemical Composition of 5052Al-alloy

Chemical Composition % wt.									
Material	Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
5052 Al Alloy	0.6	0.5	0.1	0.5	2.6	0.2	0.1	0.25	Balance

5052 is readily wieldable by standard techniques. It is frequently welded with GTAW (TIG) or GMAW (MIG). Aluminum must be very dry & clean to avoid contamination & porosity of the weld. Filler metals 1100, 4043 or 4047 are used. 4043 and 5356 is the most crack tolerant. Best color match is obtained with 1188-filler metal. Shielding gas must be dry & free of hydrogen.

Physical Properties of Al 5052

Property	Value
Density	2.68 g/cm3
Melting Point	605 °C
Thermal Expansion	23.7 x10-6 /K
Modulus of Elasticity	70 GPa
Thermal Conductivity	138 W/m.K
Electrical Resistivity	0.0495 x10-6 Ω .m

Other Aluminum Alloys are- Aluminum-lithium alloy AlBeMet, Alclad, Alnico, AlSiC, Alumel, Aluminum granules, Alusil, Devarda's alloy, Duralumin, Hiduminium, Hydronium, Hypereutectic aluminum, Italma, Lo-Ex, Magnalium, Magnox (alloy), MKM steel, Nickel-aluminum alloy, R.R. alloys, Aluminium-scandium alloy, Silumin, Y alloy, Al/Ca composite.

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III. Literature Review

It is not always necessary that the selection of parameters can be optimal and will give same set of result for particular welding environment. In this study, a literature review has been made and attempts to analyze the effect of different parameters on the welding geometry.

[1]S.K. Marya (1996), developed a finite element model to predict the evolution of residual stress and distortion dependence on the yield stress-temp for 3.2 mm 2024 Al alloy by TIG welding.

[2]WU Rui-zhi, LENG Xue-song (2005), performed TIG welding of 2.5 mm thick Nickel based 718 alloys using welding current in the range of 44-115 A, voltage 13-15 V and welding speed 67 mm/min. The influence of magnetic arc oscillation on the fatigue behavior of the TIG weldments in two different post-weld heat treatment conditions was studied.

[3]CHEN Yan-bin, MIAO Yu (2008), investigated the microstructures of autogenous TIG welded Al-Mg-Cu-Mn alloy for a wide range of welding conditions. Welding was done with current in the range 100-190 A and welding speed 420-1500 mm/min. The fine microstructure was observed at the centre of the weld, which was form due to higher cooling rate at the weld centre compared to the fusion boundary. It was observed that as the welding speed increases, the cooling rate at the centre of the weld also increases, producing smaller size dendrite structure.

[4]WANG (2008), did the experiment Using He–Ar mixed gas as shielding gas, the tungsten inert gas (TIG) welding of SiCp/6061 Al composites was investigated without and with Al–Si filler. Experiment carried out with plate dimension 60mm X 30mm X 3mm, welding was performed with gas flow rate 115 ml/s, welding speed 18 cm/min and arc length 4 mm. Welded joint with filler were submitted to tensile tests. The microstructure and fracture morphology of the joint were examined. The results show that adding 50 vol.% helium in shielding gas improves the arc stability, and seams with high-quality appearance are obtained when the Al–Si filler is added. The microstructure of the welded joint displays non-uniformity with many SiC particles distributing in the weld center. The average tensile strength of weld joints with Al–Si filler is 70% above that of the matrix composites under annealed condition.

[5]LIU (2009), analyzed microstructure, element distribution, phase constituents and micro hardness for welding joint of Mg-Li composite plates of carried out by TIG welding process with Cr-Ni fillet wires. Experiment carried out with plate dimension 110mm X 10mm X 2mm, Welding has done with speed (30)mm/min, gas flow rate-13 l/min, and welding current 80 A. The results indicate that austenite and ferrite phases were obtained in the weld metal. The micro hardness near the fusion zone at Mg-Li composite side increased from weld metal to fusion zone, and the peak value appeared near the boundary between fusion zone and Mg-Li composite.

[6]VEN (2010), analysed the micro structural characterization and corrosion behavior of top surface of tungsten inert gas (TIG) welded 2219−T87 aluminium alloy (AA2219–T87) in 0.6 M NaCl solution was studied by optical microscopy, scanning electron microscopy (SEM), potentiodynamic polarization, and electrochemical impedance spectroscopy (EIS). The optical microscopy and SEM analyses revealed that the welding of base metal (BM) with ER2319 filler alloy caused the formation of micro pores and micro cracks on the surface of weld zone (WZ) while the welding heat caused the dissolution and segregation of CuAl2 intermetallic particles along the grain boundaries in the heat affected zone (HAZ).The decrease of charge transfer resistance of HAZ when compared to WZ and BM obtained by electrochemical impedance spectroscopy (EIS) further confirmed its higher corrosion rate in 0.6 M NaCl solution.

[7]DONG (2010), analyzed the A double-shielded TIG method to improve weld penetration and has been compared with the traditional TIG welding method under different welding parameters (i.e., speed, arc length and current). Experiment carried out on martensite stainless steel with plate dimension 100mm X 50mm X 10mm, welding was performed with welding speed 1.5 mm/sec-5mm/sec, welding current 100 A - 240 A and arc length 1 mm 7 mm. The strength of the Marangoni convection was calculated to estimate the influence of the welding parameters on the variations in weld pool shapes. The results show that the changes in the welding parameters directly impact the oxygen concentration in the weld pool and the temperature distribution on the pool surface.

[8]SANJ (2011), did TIG welding of 6 mm thick Al plate. They performed experiment in two phases in first case they used AC power supply of current (100 A, 150 A, 200 A), gas flow rate of (7 lit/min, 15 lit/min) and pulsed frequency of 4 HZ. In second case DC power supply of current (48 A, 64 A, 80 A, 96 A, 112A), gas flow rate (7 lit/min). Photomicrographs of welded specimens were taken and analyzed from the experiment it has been observed that shear strength varies with change of pulse current. This change in shear strength is due to lack of refined grain structure of weldments, responsible for poor strength. Maximum value of shear strength has been observed at pulse current of 250A, gas flow rate of 15 lit /min and base current 200 Amp. The microstructure, has been found to be very refined grain structure at pulse current 250A & gas flow rate of 15 lit/min. at base current of 200 A.

[9]DIN (2011), performed pulsed TIG welding of 304L stainless steel and compare the weld bead profiles for constant current and pulsed current setting. Experiment

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carried out with plate dimension 150mm X 30mm X 1.6mm, welding was performed with gas flow rate 10 lit/min. Effect of welding current on tensile strength, hardness profiles, microstructure and residual stress distribution of welding zone of steel samples were reported. For the experimentation welding current of 75-125 A, welding speed 125-375mm/min, pulse frequency 3 Hz have been considered. From the experimental result it was concluded that most important parameters affecting the responses have been identified as speed and current. Also found that there is good improvement in tensile strength after optimizing while comparing with parent metal and bend test result in no opening or crack formation. Hence a good quality weld is obtained from face to root, the optimized process parameters would definitely solve the problems of corrosion and fatigue faced by the material, by improving the weld quality at the same time, it increases the strength of the weld with minimum heat affected zone.

[10]PARM (2012), an experimental investigation has been carried out on microstructure, hardness distribution and tensile properties of weld butt joints of 6063 T6 aluminum alloy. Experiment carried out with plate dimension 150mm X 75mm X 6mm, welding was performed with gas flow rate 20 lit/min, welding speed 120 mm/min and welding current 90 A. Two different welding processes have been considered: a conventional tungsten inert gas (TIG) process and an innovative solid state welding process known as friction stir welding (FSW) process. In this study, it has been found that heat-affected zone of FSW is narrower than TIG welding and mechanical properties like tensile strength etc. are within comfort zone and are better than TIG welding method. Microstructure results also favour FSW. Results showed a general decay of mechanical properties of TIG joints, mainly due to high temperature experienced by the material. Instead, in FSW joint, lower temperatures are involved in the process due to severe plastic deformation induced by the tool motion and lower decay of mechanical properties. Hence, from industrial perspectives, FSW process is very competitive as it saves energy, has higher tensile strength, lower residual stress values and prevents the joints from fusion related defects.

[11]Indira Rani (2012), investigated the effect of process parameters i.e. plate thickness, welding heat input on distortion of Al alloy 5A12 during TIG welding. For welding they used current (60-100) A, welding speed (800-1400) mm/min and thickness of w/p (2.5-6) mm. The results show that the plate thickness and welding heat input have great effect on the dynamic process and residual distortion of out-of-plane.

[12]Pankaj C. Patil, Prof. R. D. Shelke (2013), from the literature study, it is found that welding of aluminium is a big challenge by conventional arc welding process. Again repeatability of welding depends on its control on welding speed and other processing parameters. In this work to perform welding of 5 mm thickness 7005 aluminium alloy plate, TIG welding setup will use. Welding of the 7005 aluminium alloy plate will do by changing the welding parameters. Effect of welding parameters on the tensile strength and hardness of weld joint will analyze.

[13]G VEN (2013), analyzed the micro structural characterization and corrosion behavior of top surface of tungsten inert gas (TIG) welded 2219−T87 aluminum alloy (AA2219–T87) in 0.6 M NaCl solution was studied by optical microscopy, scanning electron microscopy (SEM), potentiodynamic polarization, and electrochemical impedance spectroscopy (EIS). The optical microscopy and SEM analyses revealed that the welding of base metal (BM) with ER2319 filler alloy caused the formation of micro pores and micro cracks on the surface of weld zone (WZ) while the welding heat caused the dissolution and segregation of $CuAl_2$ intermetallic particles along the grain boundaries in the heat affected zone (HAZ).The decrease of charge transfer resistance of HAZ when compared to WZ and BM obtained by electrochemical impedance spectroscopy (EIS) further confirmed its higher corrosion rate in 0.6 M NaCl solution.

[14]MAI (2015), analyzed structural and mechanical properties evaluation of AA-5083 alloy after single pass Tungsten Inert Gas (TIG). Experiment carried out with plate dimension 125mm X 60mm X 3mm, and welding current 70 A,75A,80A. Welding was investigated to reveal the weld strength, hardness of welded joints by using weld current as varying parameter. The tensile strength has been increased by an amount 34% and 37% at weld current 75A in comparison with weld carried out at 70A and 80A respectively

IV. GAP ANALYSIS

A gap analysis is a method of assessing the differences in performance between a existing systems or software applications to determine whether systems performance requirements are being met and, if not, what steps should be taken to ensure they are met successfully.

By study of several literature reviews, I found that:

- Investigation on the microstructures of autogenous TIG welded Al-Mg-Cu-Mn alloy for a wide range of welding conditions have taken.
- TIG welding on Al-SiC composite produces intermetallic brittle phase weakens weld strength.
- Arc length & welding speed has significant impact on weld profile and bead appearance.
- Aluminum extensively used as metal matrix composite.
- Increase in wt% of SiC increases the strength compromising with ductility

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- Active flux is mixed with acetone and coated to the base metal before welding
- Increase in weld preparation and reduction in number of passes leads to reduced heat input.
- Activated fluxes used are - SiO2, TiO2, MgO, CaO, MnO2, & Al2O3.

In our tenure of work, welding to different specimen of Al is big challenge and in this work to perform, we consider the welding of 2-5 mm Aluminium plate for different test and period

for more results, an automated TIG welding setup will be made. Welding of the Aluminum plate was done by changing the welding current and welding speed to get a high strength joint. To get better strength welding of the Aluminum plate also done from both side. Effect of welding speed and applied current on the tensile strength of weld joint, micro hardness of the weld pool and macrostructure of the joint will analyze.

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