REVIEW ON WELDING PARAMETER EFFECTS ON TIG WELDING OF ALUMINIUM ALLOY.

Pankaj C. Patil, Prof. R. D. Shelke

Department of Mechanical Engineering, Everest Educational Society`s College of Engineering & Technology, Aurangabad (Maharashtra) India.

(patilcpankaj@gmail.com, 9860669107).

Abstract— Aluminium alloys are alloys in which aluminium is the predominant metal. The typical alloying elements copper, magnesium, magnese, silicon, tin and zinc. Al and aluminium alloys plays an important role in engineering and metallurgy field because of fabrication and formability.TIG welding technique is one of the precise and fastest processes used in aerospace industries, ship industries, automobile industries, nuclear industries and marine industries.

TIG welding process is used to analyzed the data and evaluate the influence of input parameters on tensile strength and hardness of aluminium specimen .Welding current , gas flow rate and welding speed are the input parameters which affect output responses of aluminium welded joints . To improve welding quality of aluminum plate pre and post welding precautions must be taken during welding process. TIG welding is a high quality welding process used to weld the aluminium. Welding of AL plate by varying input parameters, the output parameters get studied optimized so that better quality of welded joints will develop.

7005 AL alloy are alloy are alloyed with zinc and have highest strength of any easy weldable aluminium alloy. 7005 aluminium alloy is relatively soft, easily machined, durable, recycle, light weight, ductile and malleable metal with appearance silvery. It is non magnetic and does not easily ignite. Al has about one third density and stiffness of steel. 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.

Keywords— AA7005, filler rod, welding current, welding speed, gas flow rate, strength, hardness.

INTRODUCTION

In the earth crust, aluminium is the most abundant (8.3% by weight) metallic elements and third most abundant of all elements (after oxygen and silicon). Almost all metallic aluminium is produced from ore bauxite ($AloOx(OH)_{3-2x}$). Bauxite occurs as a weathering product of low iron and silica bedrock in tropical climate condition. Large deposits of bauxite and mining areas occur in Australia, Brazil, Jamaica, Indonesia and china. High strength 7xxxseries weldable aluminium alloys such as 7005 are used extensively in bicycles industry. 7005 Al alloys often used in high performance application such as automation industries, aerospace industries, automobile industries etc.

TIG Welding:

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 was, like MIG/MAG developed during 1940 at the start of the Second World War. TIG's development came about to help in the welding of difficult types of material, eg aluminium and magnesium. The use of TIG today has spread to a variety of metals like stainless mild and high tensile steels. GTAW is most commonly called TIG (Tungsten Inert Gas).The development of TIG welding has added a lot in the ability to make products that before the 1940's were only thought of. Like other forms of welding, TIG power sources have, over the years, gone from basic transformer types to the highly electronic power source of the world today.

The properties of aluminium alloy are as follow

Table 1: Chemical properties of 7005 AA.:

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	Al
7005	<=0.35	<=0.40	<=0.10	0.20-0.70	1.0-1.8	0.06-0.20	4.0-5.0	0.010-0.060	0.080-0.20	Remainder

Table 2: Physical properties of 7005 AA.

Alloy	Phase	Atomic Number	Standard atomic weight of Al	Appearance	Melting point	Boiling point	Density	Specific mass
7005	solid	13	26.9815	silvery	532^{o}C to 635^{o}C	2470^{o}C	2.375 gm/cm3	960 J/Kg-K

Table 3: Chemical properties of filler material.

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
5356	0.25	0.40	0.10	0.050-0.20	4.50-5.50	0.050-0.20	0.10	0.060-0.20	Remainder

The mechanical properties of 7005 aluminium alloys are as follow:

I. Lightness: -

7005 Aluminium alloy is the lightest of all ordinary metals, nearly three times as light as steel. Removing weight from products is an effective response to environmental concerns (energy efficiency, smaller carbon footprint) and economics (profitability of production and use). Lightness benefits not only the applications but also operations on the shop floor and working conditions, and means lower expenditures on material handling equipment.

II. Corrosion resistance: -

Aluminium and its alloys provide excellent resistance to atmospheric corrosion in marine, urban and industrial settings. This high resistance extends the life of equipment, significantly reduces maintenance costs and preserves outward appearances. These properties are especially desired in industrial vehicles, street furniture and traffic signals.

III. Suitability for surface treatments: -

Aluminium and its alloys lend themselves to a huge variety of surface treatments, which enhances its intrinsic qualities. For example an anodization of a few micrometers is enough to preserve the optical or decorative properties of the materials, while improving resistance, especially to corrosion and stress.

IV. Ease of use: -

Aluminium alloys are used in all the customary processes of forming, bending, vessel-making, stamping and machining where other metals are used.

V. Recycling: -

Aluminium can be recycled indefinitely without losing any of its intrinsic qualities. This is a considerable advantage in modern metallurgical industry. For the past 20 years the proportion of metal consumed that is recycled has grown steadily and today stands at something like 30% of primary metal production.

LITERATURE REVIEWS

Indira Rani [1] Investigated the mechanical properties of the weldments of AA6351 during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. Experiment carried out with plate dimension 300mm X 150mm X 6mm, welding was performed with current 70-74 A, arc travel speed 700-760 mm/min, and pulse frequency 3 and 7 Hz. From the experimental results it was concluded that the tensile strength and YS of the weldments is closer to base metal. Failure location of weldments occurred at HAZ and from this we said that weldments have better weld joint strength.

CHEN [2] Investigated the influence of welding parameters on mechanical properties and microstructure of the welds of laser-TIG double-side welded 5A06 aluminum alloy. Experiment carried out successfully with plate dimension 150mm X 50mm X 4mm.The results show that the weld cross-sectional shape has an intimate relation with the mechanical properties and microstructure of the welds. The good weld profiles and free defects are responsible for the improvement of tensile properties. Due to low hardness of the fusion zone, this region is the weakest area in the tensile test and much easier to fracture. The loss of Mg element is responsible for the decrease of mechanical properties of the joints.

WANG [3] 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.

S.C. JUANG [4] Performed experiment by the use of neural networks to model tungsten inert gas (TIG) welding. Both the back-propagation and counter-propagation networks are used to associate the welding process parameters with the features of the weld-pool geometry. Experiment carried out on Al plate with welding current 80A-110A, welding speed 24 cm/min -35 cm/min and arc length 2.4 mm-3.2mm. It is shown that both the back-propagation and counter-propagation networks can model the TIG welding process with reasonable accuracy. A neural network approach for the modeling of TIG welding process. Both the back-propagation and counter-propagation networks were used to construct the complicated relationships between the welding process parameters and the weld pool features. Various network configurations for the modeling of the TIG welding process have been studied. The experimental results show that the counter propagation network has better learning ability for the TIG welding process than the back-propagation network. However, the back-propagation network has better generalization ability for the TIG welding process than the counter-propagation network.

LIU [7] 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.

WANG [8] Investigated the dynamic progress and residual distortion of out-of-plane of aluminum alloy 5A12, under different welding conditions of TIG welding. Experiment carried out with plate dimension 200mm X 160mm X (2.5mm, 4mm, 5mm, 6mm) welding was performed with gas flow rate 9.5 lit/min, welding speed 8 cm/min-14 cm/min, welding current 60A-100A and welding voltage 14 V. Out-of-plane distortion mechanism and the effecting parameters on distortion process were analyzed, and the effect of plate thickness and welding heat input on distortion was discussed. 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.

FAHMIDA [9] Performed systematic investigation on TIG welding of aluminium alloy to improve the structure property relationship of weldment by controlling heat input. Aluminium plates of 1xxx series were welded with filler metal 4043 and with different current settings 145 A, 175 A and 195 A. Experiment carried out with plate dimension 35mm X 16mm X 11mm. The welded samples were examined under optical and scanning electron microscopes and mechanical tests were performed to determine hardness, tensile and impact strengths. An eutectic was found to form. At the highest current setting that is at the highest heat input the eutectic mixture was coarsest and largest in size and tend to form a continuous network. On the other hand at low heat inputs the eutectic mixture did not get sufficient time to grow or to form any continuous network. The change in microstructure with heat input is also supported by the hardness, tensile and impact strength values of these plates. High heat input created more dilution in the weld structure and higher welding current decreased the difference in hardness values at different locations of the weld. The impact energy and tensile strength improved with increase in current content.

G VEN [10] 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.

LAKS [11] Performed TIG welding process to analyze the data and evaluate the influence of input parameters on tensile strength of 5083 Al-alloy specimens with dimensions of 100mm long x 15mm wide x 5mm thick. Welding current (I), gas flow rate (G) and welding speed (S) are the input parameters which effect tensile strength of 5083 Al-alloy welded joints. As welding speed increased, tensile strength increases first till optimum value and after that both decreases by increasing welding speed further. Results of the study show that maximum tensile strength of 129 MPa of weld joint are obtained at welding current of 240 Amps, gas flow rate of 7 lit/min and welding speed of 98 mm/min. These values are the optimum values of input parameters which help to produce efficient weld joint that have good mechanical properties as a tensile strength.

DONG [12] 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.

PARM [13] 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.

SANJ [14] 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.

MAY [15] 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.

DIN [19] Performed pulsed TIG welding of 304L stainless steel and compare the weld bead profiles for constant current and pulsed current setting. Experiment 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.

Acknowledgment

I am thankful to Prof. R. D. Shelke, my guide and Prof. S. K. Biradar for his constant encouragement, guidance and valuable support. I am also thankful to all other teaching and non-teaching faculties for their support and suggestions. I take this opportunity to express my deep sense of gratitude towards those, who have helped me in various ways for preparing this paper.

At the last but not least, I am thankful to my parent, who had encouraged and inspired me with their blessings and to my friends who helped me directly or indirectly in endeavour and infused their help for the success of publishing this paper.

CONCLUSION

1) By using TIG welding process uniform welding of aluminium alloy possible.
2) The important parameters affecting the output responses have been identified as speed and current.
3) Selection and preparation of welding joint greatly affect the welding strength, microstructure etc.
4) To improve welding quality of aluminium pre and post welding precaution must be taken during welding process.
5) By optimizing and controlling welding parameters (like welding current, gas flow rate, welding speed) welding defects get totally avoided.

REFERENCES:

[1] Indira Rani, M., & Marpu, R. N. (2012). Effect of Pulsed Current Tig Welding Parameters on Mechanical Properties of J-Joint Strength of Aa6351. The International Journal of Engineering and Science (IJES), 1(1), 1-5.

[2] ZHANG Guang-jun, YAN Zhi-hong, WU Lin (2005). Visual sensing of weld pool in variable polarity TIG welding of aluminium alloy.Journals of Science Direct (SP), 522-526.

[3] Hong-tao ZHANG, Ji-hou LIU, Ji-cai FENG, (2014). Effect of auxiliary TIG arc on formation and microstructures of aluminum alloy/stainless steel joints made by MIG welding−brazing process. Journals of Science Direct (SP), 2831-2838.

[4] CHEN Yan-bin, MIAO Yu, (2008). Joint performance of laser-TIG double-side welded 5A06. Journals of Science Direct (SP), 26-31.

[5] Wang Xi-he*, Niu Ji-tai, Guan Shao-kang,Wang Le-jun, Cheng Dong feng,(2009). Investigation on TIG welding of SiCp-reinforced aluminum–matrix composite using mixed shielding gas and Al–Si filler. Journals of material science and engineering, A499, 106-110.

[6] S.C. Juang, Y.S. Tarng , H.R. Lii, (1996). A comparison between the back-propagation and counter-propagation networks in the modeling of the TIG welding process.Journal of materials processing technology, 75(1998) 54-92.

[7] LIU Xu-he1, GU Shi-hai1, WU Rui-zhi1, LENG Xue-song2, YAN Jiu-chun2, ZHANG Mi-li,(2010). Microstructure and mechanical properties of Mg-Li alloy after TIG welding, Journals of Science Direct (SP), 21(2011)477-481.

[8] Wang Rui, Liang Zhenxin, Zhang Jianxun, (2008). Experimental Investigation on Out-of-Plane Distortion of Aluminum Alloy 5A12 in TIG Welding, Journals of Science Direct (SP), 37(7)1264-1268.

[9] Fahmida Gulshan, Qumrul Ahsan,(2014). Effect of Heat Input on the Structure and Properties of Aluminium Weldment TIG Welded with 4043 Filler Rod.Journal of chemical and materials engineering, 2(2):25-32.

[10] G.Venkatasubramaniana*a*, ***A.SheikMideen, AbhayKJha, (2013).*** Microstructural characterization and corrosion behavior of top surface of TIG welded 2219-T87 Aluminium alloy,International journal of engineering science and technology,vol05,No-03.

[11] Lakshman Singh, Rajeshwar Singh, Naveen Kumar Singh, Davinder Singh, Pargat Singh,(2013). An Evaluation of TIG Welding Parametric Influence on Tensile Strength of 5083 Aluminium Alloy,International scholarly and scientific research and innovation,vol-7,no.-11.

[12] Dongjie Li, Shanping Lu*, Wenchao Dong, Dianzhong Li, Yiyi Li,(2012). Study of the law between the weld pool shape variations with the welding parameters under two TIG processes,Journal of material processing technology,212(2012) 128-136.

[13] Parminder Singh.S.K.Gandhi, (2012). Comparative Study of Friction Stir and Tig Welding for Aluminium 6063-T6, International journal of engineering research and technology, vol-0I.

[14] Sanjeev Kumar,(2010). Experimental invstigation on pulsed TIG welding of aluminium plate, International journal of advance engineering technology, vol-0I.

[15] Mayur.S1, Pavan.K.M1, Sachin.L.S1, Chandrashekar.A2 and B.S. Ajay Kumar3,(2013). Effect of Welding Current on the Mechanical and Structural Properties of TIG Welded Aluminium Alloy AA-5083, International journal of mechanical engineering and research, vol-03.

[16] Dinesh Kumar.R, Elangovan.S, Siva Shanmugam.N, (2014).Parametric optimization of pulsed –TIG welding process in butt joining of 304 L austenitic stainless steel sheets, International journal of engineering research and technology, vol-03.

[17] J.L. Song*, S.B. Lin, C.L. Yang, G.C. Ma, H. Liu,(2009). Spreading behavior and microstructure characteristics of dissimilar metals TIG welding–brazing of aluminum alloy to stainless steel, Journal of materials science and engineering, A 509 (2009) 31-40.

[18] American welding society.1980.Welding handbook, volume 03.

[19] Fundamentals of American welding society.1980.Welding handbook, volume 01