International Journal of Advanced Research in Technology, Engineering and Science (A Bimonthly Open Access Online Journal) Volume2, Issue2, March-April, 2015. ISSN: 2349-7173(Online)

Influence of Process Parameters on AA7075 in TIG Welding

M.Nagaaravindaraj[1*], J.Ragavan[1], B.Muthuselvam[1], K.Chandarasekaran[1]

ABSTRACT: ***Aluminium Alloy is containing high strength, light weight and good Corrosion resistance. Then Gas tungsten arc welding (GTAW) is an important joining method for high strength aluminium alloys using applications in transport applications like that marine, aerospace, bicycle components, marine Engine components, External throw away tanks for military aircrafts and other industries. Gas tungsten arc welding have been used to investigate the Weldability of high strength aluminium alloys. Some important GTAW process parameters and their effects on weld quality are discussed. Mechanical properties of welds such as tensile strength and hardness properties are discussed. The aim of the report is to investigation in GTAW of high strength aluminium alloy 7075 and to provide a basis for follow-on research.***

Keywords: GTAW System, AA7075 plate, Rockwell hardness test, tensile test.

1. INTRODUCTION

The 7075alloy contain zinc in amounts between 4 and 8 % and magnesium in amounts between 1 and 3 %. Both have high solid solubility in aluminum. The addition of magnesium produces a marked increase in precipitation hardening characteristics. Copper additions between 1 and 2 % increase the strength by solid solution hardening, and form the basis of high strength aircraft alloys. The addition of chromium, typically up to 0.3 %, improves stress corrosion cracking resistance. The 7075 alloy is used predominantly in aerospace applications, 7075 being the principal high strength aircraft alloy [1].

Authors Address: [1]Department of Mechanical Engineering, Nadar Saraswathi College of Engineering and Technology, Theni, Tamilnadu, India.

Aluminium alloys can be joined by most fusion and solid-state welding processes as well as by brazing and soldering, but inert gas tungsten arc welding (GTAW or TIG) and inert gas metal arc welding (GMAW or MIG) are the two most commonly used welding processes. The welding of As a matter of fact, many difficulties are associated to this kind of joining process, mainly related to the presence of a tenacious oxide layer, high thermal conductivity, and high coefficient of thermal expansion, solidification shrinkage, improper microstructure due to filler material, and above all high solubility of Hydrogen and other gases, in a molten state. A literature review has been done to study important GTAW processing parameters and their effects on weld quality. Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium), and a filler metal is normally used, though some welds, known as autogenously welds, do not require it.

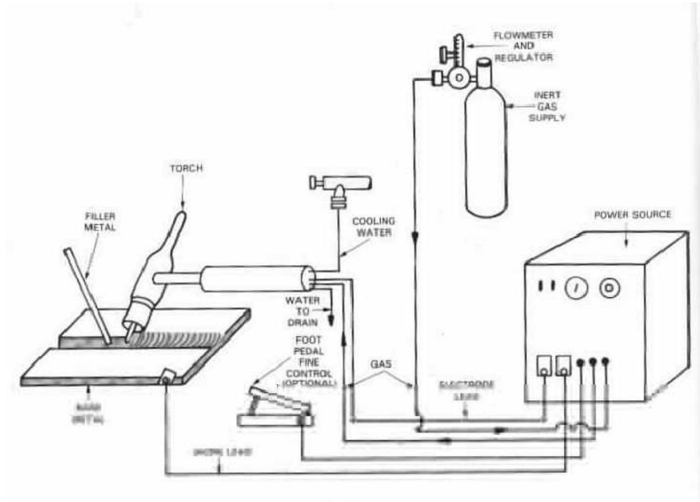


Fig.1. Schematic Diagram of GTAW System

1.1 Conventional fusion welding methods for Aluminum alloys

There are many different types of conventional welding. These include oxyacetylene welding, shielded metal arc welding, gas-tungsten arc welding, plasma arc welding, gas-metal arc welding, flux-core arc welding, submerged arc welding, electroslag welding, electron beam welding, and resistance spot welding. Of these techniques the most popular are oxyacetylene welding (OAW), gas-tungsten arc welding (GTAW), and gas-metal arc welding (GMAW). GTAW is a process that melts and joins metals by heating them with an arc established between a non-consumable tungsten electrode and the metals. These welding processes use inert gases such as argon and helium to provide shielding of the arc and the molten weld pool. This is why GTAW and GMAW are also called tungsten-inert gas (TIG) and metal-inert gas (MIG) welding processes, respectively. The conventional welding techniques are usually desirable due to their simplicity, low cost, portability and are generally used in maintenance, repair and field construction sites [2].

1.2 GTAW Process parameters and its effects

The gas tungsten arc welding (GTAW) process originally was created in the 1940s to weld magnesium and aluminum alloys for aircraft applications. It was developed because a welding method was needed that performed better on these materials than did shielded metal arc welding (SMAW). Today, many precision parts are gas tungsten arc welded, including batteries, metal bellows, pacemakers, medical components, and surgical tools [3].

Originally, helium was used as the shielding gas, and the process became known as arc welding. Argon gas soon became the most widely used shield gas because of its lower cost and smoother arc. In the GTAW process, an electrical arc is established between a tungsten electrode and the part to be welded. To start the arc, a high voltage is used to break down the insulating gas between the electrode and the part. Current is then transferred through the electrode to create an electrode arc. The metal to be welded is melted by the intense heat of the arc and fuses together either with or without a filler material. The arc zone is filled with an inert gas to protect the tungsten electrode and molten material from oxidation and to provide a conducting path for the arc current. Shield gases used are argon, helium, mixtures, of argon and helium, or small percentages of hydrogen mixed with argon. The shield gas usually is chosen according to the material to be welded [4].

Some welding equipment suppliers offer a series of pre calculated weld programs for a variety of part diameters, materials, and thicknesses. Welders should always follow an equipment supplier's suggested procedures first because the suppliers usually have performed a significant amount of qualifying and troubleshooting work [3]. As per the previous experimentation following are the different weld parameter that mainly determines quality of the weld.

a. Current. b. Welding gun speed c .Gas flow rate.

1.2.1 Current

Current has direct influence on weld bead shape, welding speed and quality of the weld. Most GTAW welds employ direct current on electrode negative (DCEN) (straight polarity) because it produces higher weld penetration depth and higher travel speed than on electrode positive (DCEP) (reverse polarity).Besides, reverse polarity produces rapid heating and degradation of the electrode tip, because anode is more heated than cathode in gas tungsten electric arc [5]. Reverse polarity may be of interest in welding aluminum alloys because of the cathodic cleaning action of negative pole in the work-piece, that is the removal of the refractory aluminum oxide layer. However alternating current is better adapted to welding of aluminum and magnesium alloys, because it allows balancing electrode heating and work-piece cleaning effects.

When using alternating current sine waves for welding, the terms electrode positive and electrode negative which were applied to the work piece and electrode lose their significance. There is no control over the half cycles and you have to use what the power source provides. The current is now alternating or changing its direction of flow at a predetermined set frequency and with no control over time or independent amplitude. During a complete cycle of alternating current, there is theoretically one half cycle of electrode negative and one half cycle of electrode positive. Therefore, during a cycle there is a time when the work is positive and the electrode is negative. And there‘s a time when the work is negative and the electrode is positive [5].

1.2.2 Welding gun speed

The effect of increasing the welding speed for the same current and voltage is to reduce the heat input. The welding speed does not influence the electromagnetic force and the arc pressure because they are dependent on the current. The weld speed increase produces a decrease in the weld cross section area, and consequently penetration depth (*D*) and weld width (*W*) also decrease, but the D/W ratio has a weak dependence on travel speed. These results suggest that the travel speed does not influence the mechanisms involved in the weld pool formation, it only influences the volume of melted material. Normal welding speeds are from 100 to 500 mm/min depending on current, material type and plate thickness [5].

In TIG welding of aluminum alloy AA7075, the depth of penetration of weld bead decreases with increase in bevel height of V butt joint. Maximum Tensile strength of 230 Mpa was observed at weld speed of 0.6 cm/sec and tensile strength is higher with lower weld speed. This indicates that lower range of weld speed is suitable for achieving maximum tensile strength. Bevel angle of the weld joint has profound effect on the tensile strength of weldment**.** Bevel angles between 300 to 450 are suitable for maximum strength. The heat affected zone, strength increased with decreasing heat input rate [6].

1.2.3 Gas flow rate

Argan is the most used GTAW shilding gas. Argon is used in welding of carbon and stainless steels and low thickness aluminium alloys components. Gas flow rate influence the welding speed and improves process tolerance.

Heat input rate=60VI/v J/mm

V=arc voltage in volts

I=welding current in ampere,

v =speed of welding in mm/min.

2. LITERATURE SURVEY

Rong-Hua Yeh et al [7] (2003) have investigated the temperature distribution of aluminium plates welded by gas tungsten arc. The heat of fusion, the size and distribution of heat source, the travel speed, the heat conduction in the welding direction and the surface heat loss during welding were considered. A numerical scheme was developed to solve the three dimensional problem. With the help of a mathematical model, the effect of welding parameters such as heat input of the weld, preheating of the work piece and moving velocity of heat source on weld penetration in moderately thick plates were discussed. **Brickstad and Josefson[8] (1998**) have modeled a set of butt welds, in stainless steel pipes, with a varying number of weld passes, ranging from 4 to 36. They have conducted a parametric investigation considering the effects of pipe size (pipe thickness and number of weld passes), net line energy, ratio of inner radius to thickness, weld yield stress and inter pass temperature. The resulting axial and hoop stresses at the weld centre line and HAZ are plotted in groups to indicate the effects of each of the investigated parameters on the two types of stress. Based on this, they have proposed recommendations on how to use residual stresses in assessing the growth of surface flaws at circumferential butt welds in nuclear piping systems.

D.S.Nageshaet.al [9] explained an integrated method with a new approach using experimental design matrix of experimental designs technique on the experimental data available from conventional experimentation, application of neural network for predicting the weld bead geometric descriptors and use of genetic algorithm for optimization of process parameters. **Y.Cho.et.al.[10]** studied the effects of various process conditions on weld quality for aluminum using resistance spot welding, mathematical models were established, based on which the influences of the welding parameters were studied.

3. MATERIAL &METHODOLOGY

Aluminium alloy AA-7075 (Composition shown in Table 1) plates of the dimension 75*50* mm were taken for TIG welding technique. These plates are cleaned from dirt, grease and other foreign materials by using cleansing agents, dirt remover's another re-agents. Edge preparation is carried out where double V edge is prepared for an angle of 37^0. The Aluminium plates are placed on welding table where the welding process is carried out.

Table 1 Chemical Composition of AA7075 & filler material

Alloy	Al	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti
7075 min	Rem	-	-	1.2	-	2.1	0.18	5.1	-
7075 max	Rem	0.4	0.5	2.0	0.30	2.9	0.28	6.1	0.2
ER4043	Rem	6.0	0.8	0.30	0.05	0.05	-	0.10	0.2

In this process, all the various welding parameters such as the welding speed, flow rate, inert gas used and the number of passes is kept constant for all the trails and the welding current is used as varying parameter to study the effect of welding current on the structural and mechanical properties of weldments. The inert gas used in this investigation is 99.9% pure argon keeping the flow rate constant**.** The filler metal selected for the process is er4043which is the standard filler rod to be used for AA-7075 alloy (According to AWS Standards). In this study, TIG welding technique was adopted with three different welding currents for the Aluminum plates i.e., 50A, 70A and 90A respectively and these welded joints were further subjected to the following mechanical tests and metallographic analysis. Vickers's micro hardness test was conducted by applying load of 100kg. The hardness is measured at an interval of 10mm from the welded zone and 4 readings were taken on either side of the welded zone. The tests were conducted according to Indian standards 1501 - 2002**.** AA-7075 plates were subjected to tensile test following ASTM E-08 standards.

4. EXPERIMENTAL DETAILS

For the research purpose on GTAW welding we have chosen the aluminum alloy material which is wrought and heat treatable alloy. We fabricate 20 pieces into a dimension of 150x50x6mm by hydraulic cutting machine. We fabricate 20 pieces into a dimension of 75x50x6mm by hydraulic cutting machine .Then we have made all the work pieces in to flate plate standard form with angle of 37^0. Then we had took two

pieces and set it with maintaining a 1.5mm root gap and then we had started penetration process with desired or selected current, voltage, gas flow rate readings and done the experiment. In the present study, in order to identify
the process parameters with the maximum stress distribution in the GTAW for aluminum alloy 7075. Factors affecting the GTAW welding and their levels are given in table 2 and the experimental layout using L9 orthogonal array are given in table 3.

Table 2 Level of GTAW welding process variable.

variables	**unit**	**Level-1**	**Level-2**	**Level-3**
Current (A)	Amp	50	70	90
Speed (N)	Rpm	2:28	1:23	1:05
Gas flow rate (C)	Lit/min	10	12	15

Table 3 Experimental layout using L9 orthogonal array

S.NO	**CURRENT(Amp)**	**Speed (N)**	**Gas flow rate (C)**
1	50	2:28	10
2	50	2:80	12
3	50	1:52	15
4	70	1:23	12
5	70	1:26	15
6	70	1:26	10
7	90	1:05	15
8	90	1:08	10
9	90	1:05	12

5. RESULT AND DISCUSSION

In this research work the effect of input parameters on the Tensile test and hardness test were determined.

5.1 TENSILE TESTING

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain hardening characteristics. Uni axial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic materials, such as composite materials and textiles, biaxial tensile testing is required.

Table4:Tensile test on AA7075

sample no	**Yield Load (KN)**	**Ultimate load(KN)**	**Breaking load(KN)**
1	100	163	141
2	105	167	145
3	102	172	140
4	106	162	142
5	105	160	148
6	101	170	150
7	105	171	149
8	104	170	148
9	103	172	146

Table 5 Hardness test (Rockwell)

Sample no	Major load (Kgf)	Scale	Welding Zone	Welding Affected Zone	Pallet Zone
1	100	D	84	70	68
2	100	D	85	57	63
3	100	D	79	52	57
4	100	D	78	27	98
5	100	D	79	30	96
6	100	D	83	38	91
7	100	D	88	48	96
8	100	D	73	31	95
9	100	D	75	39	97

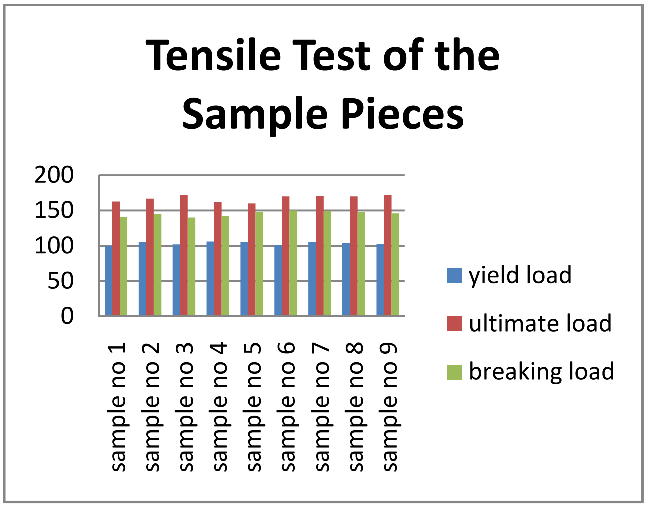
5.2 HARDNESS TEST

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

5.2.1 ROCKWELL HARDNESS

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter.

Fig 2 Effect of Tensile test on sample piece



6. CONCLUSION

In this study mechanical properties evaluated of AA-7075 alloy on Tungsten Inert Gas (TIG) welding were investigated to reveal the weld strength, hardness of welded joints by using weld current as varying parameter.

Reference:

[1].Alexander Grant Paleocrassas, (2009) ―Process Characterization of Low Speed, Fiber Laser Welding of AA 7075-T6 -Application to Fatigue Crack Repair‖ PhD thesis‘. North Carolina State University, Raleigh, North Carolina

[2].Deepa Reddy Akula, (2007) ―Characterization of Mechanical properties and study of microstructures of stir welded joint fabricated from similar and dissimilar alloys of aluminium‖ PhD thesis‘. University Of Missouri – Columbia.

[3]Article published in the July/August 1999 issue of Practical Welding Today.

[4]. Miller TIG HAND BOOK.

[5]. Welding Robots technology, system issues and application Pires J N, Lourerio,A Bolmsjo,G 2006 VIII 180p.88illsu.

[6]. I.S. Kim a, J.S. Son a, H.J. Kim b, B.A. Chin. ―Development of a mathematical model to study on variation of shielding gas in GTA welding‖. Journal of Achievements in Materials and Manufacturing Engineering. I.S. Kim, J. S. Son, H.J. Kim, B.A. Chin Volume 19 Issue 2 December 2006

[7]. Rong-Hua Yeh et al "Thermal analysis of welding on aluminum plates", Journal of Marine Science and Technology, Vol. 11, No. 4, pp. 213-220 (2003)

[8]. Tregelsky,V."The electric welder",Foregin languages publishing House,Moscow,1968.

[9]CemalMeran―Prediction of the optimized welding parameters for the joined brass plates using genetic algorithm‖ Materials and Design..27 (2006) 356–363.

[10]Y. Cho and S. J. Hu ―Design of Experiment Analysis and Weld Lobe Estimation for Aluminum Resistance Spot Welding‖ Weldingjournal, March 2006 American Welding Society and the Welding Research Council.

BIOGRAPHY

Nagaaravindaraj M . is a student in the Department of Mechanical Engineering, Nadar Saraswathi College Of Engineering & Technology, Theni.

Ragavan J . is a student in the Department of Mechanical Engineering, Nadar Saraswathi College Of Engineering & Technology, Theni.

Muthu selvam B . is a student in the Department of Mechanical Engineering, Nadar Saraswathi College Of Engineering & Technology, Theni