EXPERIMENTAL ANALYSIS OF MICROSTRUCTURE AND MECHANICAL PROPERTIES OF MIG WELDED AA 7075-T6 OF 10MM THICKNESS

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Abstract : *An attempt has been made in this paper to weld 7075 alloy using GTAW and GMAW with argon as a shielding gas. MIG is a welding process in which an electric arc forms between a consumable wire. Electrode and the work piece which heats the metal(s) causing them to melt and join. It is preferred over other fabrication process because of its higher deposition rates, higher welding speed and positional welding offers no problems. Mechanical properties (joint strength, hardness variation along weld joint) and microstructures (Grain sizes, material composition) were analyzed to study the behavior of AA 7075-T6 material for three different weld butt joint configurations.*
i.e V-60^o ,V-90^o and X-60^o.

Keywords: AA 7075 aluminium alloy, Gas tungsten arc welding (GTAW), Gas metal arc welding(GMAW), Mechanical properties, Micro structural characterization.

1. INTRODUCTION

Today's aluminium alloys together with their various tempers, comprise a wide welding procedure development, It is important to understand the differences between the many alloys available and their various performances and weld ability characteristics. When developing arc weld procedures for these alloys, consideration alloy are usually the Gas Tungsten Arc Welding (GTAW) process and the Gas Metal Arc Welding (GMAW) process, due to their comparatively easier applicability and better economy. The weld Fusion Zone (FZ) typically exhibits coarse columnar grains because of the prevailing thermal conditions during the weld metal solidification must be given to the specific alloy being welded. It is often said that arc welding of aluminium is not difficult, it is just different It is believed that an important part of understanding in differences is to become familiar with the various alloys, this series incorporates alloys which are considered unsuitable for arc welding. The preferred welding processes for fabricating the AA7075

2. RESEARCH FIELD ON MIG

Many investigators have suggested various methods to explain the effect of process parameter on hardness and tensile strength.
T. Senthil Kumar, V. Balasubramanian , M.Y.
Sanavullah [1] was worked on Influences of pulsed current tungsten inert gas welding parameters on the tensile properties of AA 6061 aluminum alloyWith the use of full factorial method and ANOVA. Medium strength aluminum alloy (Al–Mg–Si alloy)has gathered wide acceptance in the fabrication of light weight
Erdal Karadeniz, Ugur Ozsarac , Ceyhan Yildiz[2] was worked on The effect of process parameters on penetration in gas metal arc welding Processes. In this study, the effects of various welding parameters on welding penetration in Erdemir 6842 steel having2.5 mm thickness welded by robotic gas metal arc welding were investigated.
A.M. Torbatia, R.M. Mirandab, L. Quintinoc, S.Williamsa, D. Yappa [3] was investigated on Optimization procedures for GMAW of bimetal pipes. Autogenous gas tungsten arc welding (GTAW) and pulse rapid arc gas metal arc welding (GMAW) of butting bimetal (Bubi) pipelines were studied. GMAW was carried out from the outside of the pipe while GTAW was done from the inside to prevent lack of penetration and to promote a smooth internal weld bead surface

3. EXPERIMENT SETUP

3.1 Material

High strength precipitation hardening 7xxx series aluminium alloys, such as 7075 are used extensively in aerospace industry. 7xxx series alloys are Heat treatable with ultimate tensile strength of 32 to 88 psi. These are the highest strength aluminium alloys. These alloys are often used in high performance applications such as aircraft, aerospace and competitive sport equipment. The commonly welded alloys in this series such as 7075

Process parameters	Values
Current	180 amp
Voltage	30 volts
Welding speed	80 mm/sec
Gas flow rate	10 Lit/hr
Root gap	2mm
Electrode diameter	2.5 mm
Mode of Metal Transfer	Spray Transfer
Butt Joint Groove Angle	V 60
	V 90
	X 60

are predominantly welded with the 5xxx series filler alloys.composition of the base metal and the filler wire was determined using a vacuum optical emission spectrometer, manufactured by Quantron, Magellan, Germany. The composition is presented in Table 1 and 2.

Table- 1: Chemical Compositions (wt %) of the base metal

Cu	Si	Fe	Mn	Mg	Ti	Ni	Zn	Cr	Vd	Al
0.25	0.38	1.30	0.15	5.03	0.10	0.01	5.83	0.14	0.01	89.96

Table -2: Chemical Compositions (wt %) of the filler wire used in GMAW (ER-5183)

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.40	0.40	0.10	0.50	5.10	0.07	4.65	0.14	93.04

3.2 Experimental Procedure

Gas Metal arc welding GMAW welding is widely used for welding aluminium and it produces welds of good appearance and quality. A constant current AC power Source with a continuous high frequency is used with water or air-cooled GMAW torch and an externally supplied inert shielding gas. The AC process is used to provide a degree of cleaning of the aluminium surface during the electrode positive cycle though this is not a substitute for proper cleaning of the base material. The tungsten electrode diameter is usually about 2-4 mm and the method can be used with or without filler metal. The filler material is fed into the weld bead from outside. GMAW Welding gives the welder very good control, but welding speed is normally slower than for MIG and requires higher welder competence. The choice of torch cooling depends upon welding parameters and duty cycle. They are usually water-cooled. Air-cooled torches can be used at up to about 100 amps, and of the correct diameter for the current, are used The end of the electrode is prepared by reducing the tip diameter to 2/3 of the original diameter and then striking an arc on a piece of scrap material. This creates a ball on the end of the electrode. The ball must not be larger than 11/2 times the electrode diameter.A good indication that the electrode diameter is suitable for the welding current is to observe the ball diameter and the ease with which it forms. An electrode that is too small for the welding current will form an excessively large ball, whereas too large an electrode will not form a satisfactory ball at all. The torch must be maintained at an angle of close to 90° to the work piece surface and the filler material must enter the weld poolatan angle of typically 5°. As well as the work piece being properly clean it is important that the filler rod is also clean. If the rod has been exposed to air for a long time it is advisable to clean it by pulling the rod through a 'Scotchbrite' type of abrasive pad or through stainless steel wool in order to remove the oxide layer.

Figure-1: Experimental Setup

Table -3 : Process parameters

Serial number	Grove angle	Yield Strength	Ultimate Strength	Elongation
1	V60	177.968	204.624	9..5
2	V90	166.992	192.864	10
3	X60	137.984	165.424	12

3.3 Selected Process Parameters:

3.3.1 Tensile Testing

The rolled plates of AA7075 aluminium alloy were machined to the required dimensions (300mm×150mm) .Single'V'but joint configuration, as shown in Fig. , was prepared to fabricate GMAW welded joints. The initial joint configuration was obtained by securing the plates in position using tack welding for GMAW welds. The direction of welding was normal to the rolling direction. All necessary care was taken to avoid joint distortion, and the joints were made with suitable clamps Single pass welding was used to fabricate the joints .AA (Al-5%Si) grade filler rod and wire were used for GMAW welding processes, respectively. High purity (99.99%) argon gas was the shielding gas. Square butt joint configuration as shown in Figure.1 was prepared to fabricate GMAW Butt joints. After the GMAW Weld Butt joint model were completed on AA7075aluminium Base weld metal was metal were prepared for the tensile specimen according to ASTM E8M-04 standard ,AA7075 aluminium alloy the tensile specimen were prepared for as per Fig. 2, ASTM E8M-04 standard for the tensile test was carried out using universal testing machine(UTM). The results are noted that Tensile strength is 549.86N/mm, yield strength 413.66 N/mm and the elongation on 10.65m

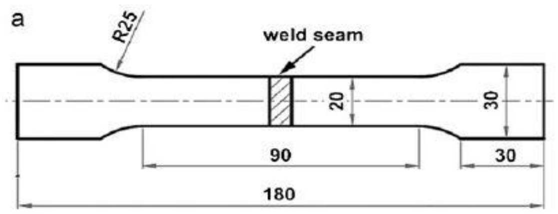

Figure -2: Specimen for Tensile testing

3.3.2 Hardness Testing

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.

4. RESULT AND DISCUSSION

4.1 Tensile Properties

The transverse tensile properties such as yield strength, tensile strength, percentage of elongation of AA7075 aluminium alloy joints were evaluated. In each condition, three specimens were tested, and the average of the three results is presented in Table 4(a). The yield strength and tensile strength of un welded parent metal are 537MPa and 570MPa, respectively. However, the yield strength and tensile strength of GMAW butt joint with groove angle V-60^{o} are 177.968MPa and 204.464MPa, respectively. Yield strength and ultimate tensile strength of GMAW butt joint with groove angle V-90^{o} are observed to be 166.992MPa and 192.864 respectively and for the butt joint with groove angle X-60 are found to be 137.984MPa and 165.424MPa respectively.

Table -4(a): Experimental Data after Tensile Test Table

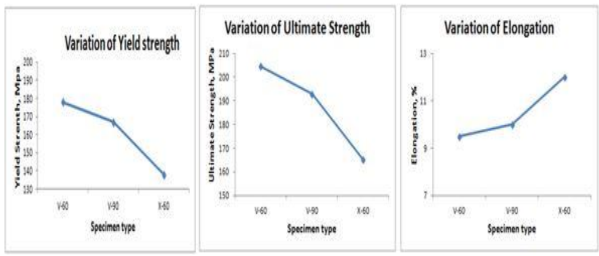

Figure -3: Variation Graphs

4.2 Hardness results

Hardness profile indicates a decrease in the weld hardness in the weld region as shown fig4(b), and this has been a Hardness measurement of the various weld regions were performed using a Rockwell diamond indenter. Favour nucleation and growth of all precipitates .The transition region indicates a reduction in hardness because of coarsening precipitates. The average hardness at different areas of the welded work piece are as given below.

Sample weld groove angle	Distance from the weld centre				
	Advanced Side		Weld centre	Retreating Side	
	8 mm	16 mm	0	8 mm	16 mm
V-60°	92	93.5	73	92.5	93
V-90°	89	89.5	71	89.5	89.5
X-60°	88.5	88	70.5	88.5	88

Table- 4(b): Experimental values after Hardness Test

Basemetal	Weld Region	Heat Effeted Zone
87 RHN	71.5RHN	90.08 RHN

Table -4(c): Average of Hardness values at various zones

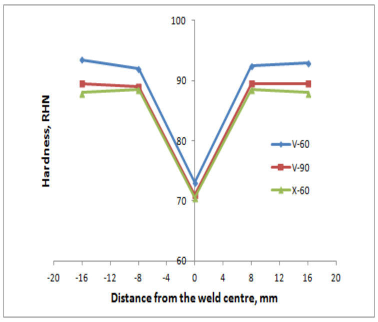

Figure -4: Variation of Hardness along the specimen

4.3 Microstructure of Weld Zone For Different Specimens :

The grain size in the welded zone is found to be quite non-uniform. Often elongated grains, dendrite structures remelting resulting in spherical morphology and in somewhat thicker can be observed in the welded zones of all the three structures .It can be observed that about 20% of the grains were found to be of larger size. Some porosity can also be seen in the weld.

4.3.1 Microstructure Of The Base Metal:

Microstructure of the parent metal has revealed spheroidal particles of $MgZn_2$ (black precipitates) and light grey particles of $FeAl_3$ present in the Aluminium solid solution as shown in Figure.

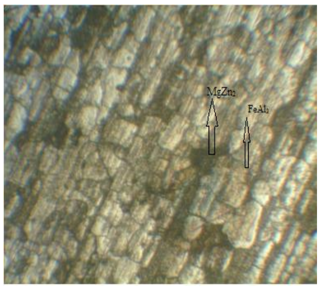

Figure- 5: Microstructure of Base Metal AA7075-T6

4.3.2 Microstructure Of The Weld Joints:

The weld microstructure consists of slightly elongated grains. Some porosity can also be seen in the weld

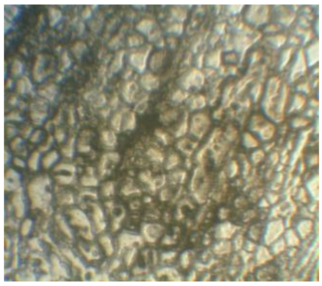

Figure- 6(a): Microstructure of weld joint for butt joint with groove angle v-60°

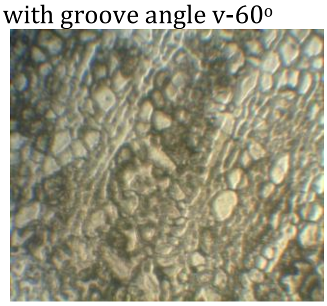

Figure- 6(b): Microstructure of the weld joint for butt joint with butt angle v-90°

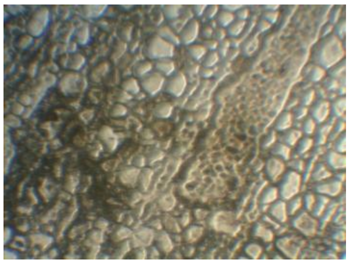

figure -6(c): Microstructure of the weld joint for butt joint with butt angle x-60°

4.3.3 Microstructure Of Heat Affected Zone:

The HAZ consists of a coarse grain structure can be seen.

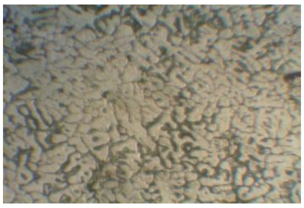

figure -7(a): Microstructure of the HAZ of the butt joint with groove angle v-60°

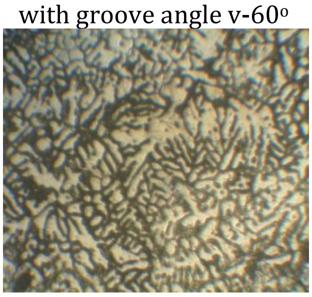

Figure- 7(b) : Microstructure of the HAZ of the butt joint with groove angle v-90°

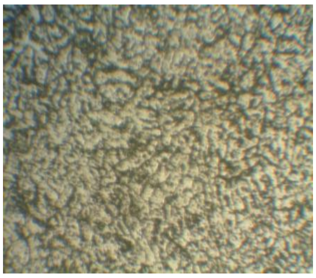

Figure -7(c): Microstructure of the HAZ of the butt joint with groove angle x-60°

Table -5 : Results Of Microstructure Analysis:

Sample Number	Groove Angle	Zone	Grain Size
1	V-60°	Base metal	5.5
		Weld zone	5.5
		Heat affected zone	5
2	V-90°	Base metal	5.5
		Weld zone	5.5
		Heat affected zone	5
3	X-60°	Base metal	5.5
		Weld zone	5.5
		Heat affected zone	5

5. CONCLUSIONS

- Hardness is lower in the weld metal (WM) region compared to the HAZ and BM regions. High hardness is recorded in the GMAW (HAZ) and the maximum Hardness of 93.5RHN was observed in the HAZ. In the parent metal 100.5 RHN is recorded.
- Hardness decrease has been observed both in HAZ and the weld centre due to softening and larger grain number compared to the Base metal which can be revealed by Micro structural Examinations
- Strength of joint is highly influenced design of butt joint. Ultimate Tensile strength and yield strength of V butt joint greater than X butt joint. Hence in Welding operation V butt joint is preferable than X butt joint.
- For V joint design, as the Groove angle increase Ultimate tensile and Yield strength were decreasing continuously. V butt joint with 60° has more strength than that of 90°
- As the Groove angle increase % of elongation increases in V butt joint but X butt joint the %of elongation is more than V butt joint .
- Low tensile strength is due to reduction in pre-existing dislocations and the elimination of the very fine hardening precipitates.
- In MIG welding, grains show a tendency of having greater grain size number in the HAZ and weld region compared to the base metal due to high heat input to the material.

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