Effect of ER4043 and ER4047 Filler Rods on Tungsten Inert Gas Welding of AA5083-H111 and AA6061-T6 Aluminum Alloys

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ABSTRACT

The hull and superstructure made of 5083 and 6061 aluminum alloys are gaining popularity. The joining of the two materials by using Low and High Silicon content Al-Si alloy fillers is experimented in this paper and the observations are listed out. The comparative investigations of the chemical compositions after welding, softening occurred in the weld and changes happened in the hardness pattern are also done. The softening at the weld was due to formation of precipitates during welding.

KEY WORDS: Filler Rods ER4043 and ER4047, Tungsten Inert Gas welding, AA5083-H111, AA6061-T6, Chemical Composition, and Properties.

1. INTRODUCTION

Wrought Al–Mg alloys are used as structural materials in marine, automotive, aircraft and cryogenic applications. These materials exhibit their strength mainly from solid solution strengthening by Mg, which has a substantial solid solubility in aluminium. Al–Mg–Si alloy, one of the widely used heat-treatable alloys, is choice for medium-to-high-strength requirements and has good toughness characteristics. The major alloying elements magnesium (Mg) and silicon (Si) increase the strength of the alloy through precipitation hardening. These types of alloys are also age hardenable and usually heat-treated to T4 (natural ageing) and T6 (artificially ageing) temper conditions to develop required strength. Al–Mg–Si alloys are widely used in transportation components, machinery equipments, recreational products and consumer durables.

For aluminium alloy, the most common joining method is fusion welding. Generally, 5xxx and 6xxx alloys are easily welded by conventional arc welding processes, metal inert gas (MIG) welding and tungsten inert gas (TIG) welding. However, some important characteristics, such as solidification cracking, porosity, heat-affected zone (HAZ) degradation and so on must be considered during welding, due to the greater amount of alloying elements used in commercial alloys. The alloys of the 6xxx series alloys are, for instance, more sensitive to hot cracking than the alloys of the 5xxx series (Okamura, 2004; Leitao 2009; Subbaiah, 2012; Hakan Cetinel, 2014; Jannet, 2014).

2. EXPERIMENTAL PROCEDURE

Plates of 5mm in thickness were cut into strips of 300x150mm. The surfaces of the plates were cleaned. TIG welds on the AA5083-H111 and AA6061-T6 alloy plates were autogenously using alternating current TIG welding with a standard 2% Thoriated tungsten electrode. The electrode tip configuration was a blunt point with a 90degree included angle, the diameter of the electrode is 2mm. The argon shielding gas flow rate was $40Lmin^{-1}$.

The properties of welds were measured in an UTM with a cross head speed of $0.03175mms^{-1}$. In the tensile test sample, the weld was oriented perpendicular to the tensile stress axis and was in the middle of the gauge length. The configuration and the size of transverse tensile specimens were prepared with reference to the ASTM-E8 standard. The tensile tests were carried out at room temperatures.

Prior to the tensile tests, Vickers hardness profiles across the weld, HAZ and partial base metal were measured under the load of 1kgf for 15 Salong the centerlines of the cross-section of the tensile specimens using an automatic micro hardness tester, and the Vickers indents with a spacing of 1mm were used to determine the fracture locations of the joints. The welding parameters shown in Table.1

Table.1. Welding parameters

Welding parameter			
Current, Amps	200	Travel Speed, mm/min	150
Voltage, Volt	16		

The chemical composition of the base metals AA5083-H111and AA6061-T6 are given in Table.2. The chemical composition of filler rod ER4043 and ER 4047 is shown in Table.3.

Table.2. Chemical Composition of Base metals

Base Metal	Mg	Mn	Fe	Si	Cu	Cr	Zn	Ti	Zr	Al
AA5083-H111	4.254	0.525	0.259	0.980	0.346	0.113	0.103	0.019	0.002	93.31
AA6061-T6	0.812	0.061	0.323	3.01	1.142	0.184	0.072	0.02		94.31

Table.3. Filler Rod Chemical Composition

Filler Rod	Mg	Mn	Fe	Si	Cr	Cu	Zn	Ti	Al
ER4043	0.05	0.05	0.8	4.5 ~ 6	-	0.3	0.1	0.2	Rest
ER4047	<0.10	<0.15	<0.8	11-13		<0.30	<0.2		

3. RESULTS AND DISCUSSIONS

Chemical Compositions of the TIG welded joints: AA5083 alloy contains 4.254wt% of magnesium which is the major alloying element and 0.525wt% of manganese. The alloy may contain 0.4wt% of Iron and silica composition may vary. On the other hand AA6061 contains 3.01wt% of silicon and 0.812wt% of magnesium. Strengthening precipitate in AA6061 is magnesium silicide (Mg_2Si). ER 4043 contains silica 4.5-6wt% of silica and 0.05wt% of magnesium and ER 4047 contains 11-13wt% of silica and less than 0.01wt% of magnesium. Both fillers contain around 0.8wt% of iron. TIG welded joints made with ER4043 contains 2.994wt% of Si and 1.364wt% of magnesium. TIG welded joints with ER4047 Contains 6.503wt% of silica and 0.489wt% of magnesium. Both welded joints contain around 0.4-0.5wt% of iron.

Table.4. TIG Welded Joints Chemical Composition

Welded Joints	Mg	Mn	Fe	Si	Cr	Cu	Zn	Ti	Al
ER4043	1.364	0.163	0.431	2.994	0.080	0.100	0.018	0.014	Rest
ER4047	0.489	0.074	0.482	6.503	0.040	0.044	0.394	0.019	Rest

Microstructure of TIG welded AA5083-H111 and AA6061-T6 with ER4043 & ER4047 Filler Rods: The optical microstructure of TIG welded dissimilar joints of AA5083-H111 and AA6061-T6 with ER4043 and ER4047 filler rods are shown in Figures.1 to 6. The weld microstructures of ER4043 and ER4047 filler rods are shown in figures.1, 3 and 5 and 2, 4 and 6 respectively. The presence of casting defects and porosities were observed to be more in the ER4043 filler rod welded joints compared to ER4047 filler rod welded joints.

Figure.1. Weld at Top ER4043

Figure.2. Weld at Top ER4047

Figure.3. Weld at Middle ER4043

Figure.4. Weld at Middle ER4047

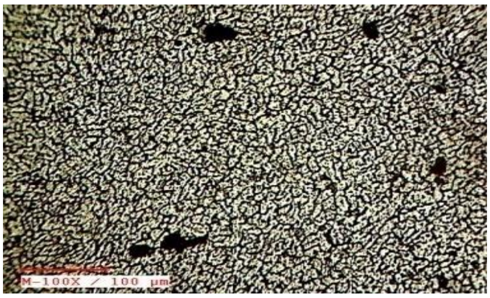

Figure.5. Weld at Bottom ER4043

Figure.6. Weld at Bottom ER4047

Tensile Properties of the AA5083-H111 and AA6061-T6 aluminium alloy plates with ER4047 filler rod: The tensile properties of the AA5083-H111 and AA6061-T6 aluminium alloy plates with ER4043 and ER4047 filler rod was found out and listed in Table 5.The ER4043 filler rod welded joint ultimate tensile strength is around 136 MPa. The percentage elongation of the welded joints is 4.45 %.The welded joint efficiency is (136/325) x100 = 41.85%. The ER4047 filler rod welded joint ultimate tensile strength is around 115 MPa. The percentage elongation of the welded joints is 3.09 %.The welded joint efficiency is (115/325) x100 = 35.38 %.

Table.5. Tensile Properties of AA5083-H111 welded joints

Material	Yield Stress, MPa	Tensile Strength, MPa	Elongation, %
Base Metal- AA5083-H111	197.39	321.34	22.26
Base Metal-AA6061-T6	265.99	325.08	15.93
Welded Joint with ER4043 Filler rod	-	135.879	4.45
Welded Joint with ER4047 Filler rod	-	115.628	3.09

Hardness Survey of the welded joints: The hardness survey of TIG welded joints of AA5083 and AA6061 dissimilar alloy plates shows that the hardness on AA6061 side of ER4047 filler rod is above 120HV1 and of ER4043 filler rod its above 110HV1. The hardness value of the welded joint on the AA5083 side is more or less equal to hardness value of AA5083 for both filler rods. The hardness of the welded joint on the AA6061 side is more than hardness of the base metal AA6061-T6. This may be due to the Magnesium silicon precipitates formed on the AA6061 side.

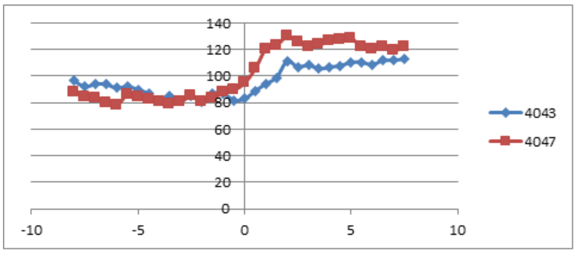

Figure.7. Hardness Survey of TIG welded joints of AA5083-H111 Aluminum Alloy

4. CONCLUSIONS

The AA5083-H111 and AA6061-T6 aluminum alloy plates were TIG welded with Two filler rods, Viz., ER4043 and ER4047. The Mechanical and Microstructural characterization of the welded joints have has yielded the following conclusions.

ER4043 filler rod TIG welded joints have produced best tensile properties compared to ER4047. The weld microstructure of TIG welded joints with ER4047 filler rod were fine compared to the weld microstructure of the other joints with the remaining filler rods.

The High Si-content (11%) ER4047 Filler rod produced the best Hardness profiles compared to the Less Si-content (5.5%) Filler rod, viz., ER4043.

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