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Research paper

Effects of Zn Interlayer and Welding Current on the Mechanical Properties of TIG Welded 7075 Al Alloy

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Abstract

Gas tungsten arc welding of AA7075 Al alloy with ER4043 filler metal and Zn interlayer was carried out. The Zn foil was added to the fusion zone to improve the mechanical properties of the weld and minimise the difficulties associated with fusion welding of AA7075 Al alloy. The tensile shear property and the hardness of the weld were investigated as a function of welding current. Results show that a free-crack weld was obtained in the whole samples. Welding current of 90A showed the highest weld shear strength and hardness. Generally, the weld shear strength recorded a 76% to 86% from the tensile strength of the base metal and the highest hardness reached 75% from the base metal. This study aims to improve the capability of cheaper and more versatile fusion welding of Al alloy over the solid-state welding.

Keywords: *TIG Welding, Al alloy, Tensile Shear Strength Micro hardness*

1. Introduction

The Al 7XXX series alloys are known for their excellent high strength and age hardening properties. They have been used in structures such as transportation equipment, including aircraft, where a relatively high strength is necessary [1-3].Despite that the alloying elements such as Zn and Mg and Cu are the key in increasing the strength of this type of Al alloys, they are producing low-melting-point compounds. Consequently, in fusion welding many problems may exist such as considerable loss in strength and high crack sensitivity[4, 5]. Thus, solid state welding, e.g. friction stir welding and adhesive bonding, are often used to avoid these problems[6, 7].These joining techniques can be performed while the material remains in solid state, which can minimize the difficulties associated with a fusion welding. However, they cannot be used in high temperature applications and some of them require assembly to be applied such as friction stir welding[8, 9].Such limitations of solid state welding are the motivation for continuing the scientific research toward developing the fusion welding of 7XXX Al alloys. Tungsten Inert Gas (TIG) is one of the most fusion welding method for welding Al alloys. It is known for its relatively low heat input, versatility and high weld quality[10, 11].Zinc is one of the principal alloying elements that added to the Al to significantly increase strength through permitting precipitation hardening by combination with magnesium and copper [7, 12].

In this work, zinc has been added to the joint as an intermediate layer to assist in recovering some of the lost strength during welding, which is considered the main problem in welding AA7075 Al alloy. The weld metal (WM)was also supported with the addition of Al alloy filler metal. Tensile shear strength and hardness has been measured as a function of welding current to evaluate the mechanical properties of the joint.

2. Experimental procedure

TIG welding was carried out on plates of a standard AA7075 Al alloy with dimensions of 100× 30 × 3 mm. Welding was undertaken with ER4043 filler wire and 0.2 mm thickness Zninterlayer as a transition layer between the Al alloy plates. Lap joint was used and the Zn interlayer was embedded between the Al plates as shown schematically in Figure 1. The aluminum plates were cleaned by acetone and a stainless steel scratch brush prior to welding. The weld was performed using single welding pass with the aid of argon gas to protect the weld area during welding. Five different welding currents between 60 and 100 A was applied, in which the welding current was changed every 10 A as listed in Table 1.

Mechanical property of the weld was evaluated using tensile-shear and micro hardness tests. Tensile shear specimens were machined from transverse section containing the weld at the centre of the gauge length. The tensile tests were performed using a ZheJiang Geotechnical machine with a 50KN load cell and a crosshead speed of 0.2 mm/s at room temperature. The Vickers hardness measurements were undertaken using a micro hardness tester equipment and several hardness readings were performed to find the average hardness values. The test was done at 200 g and conducted through the centre of the welded joints across the base metal (BM), heat affected zone (HAZ) and WM using 0.5 mm spacing between indents.

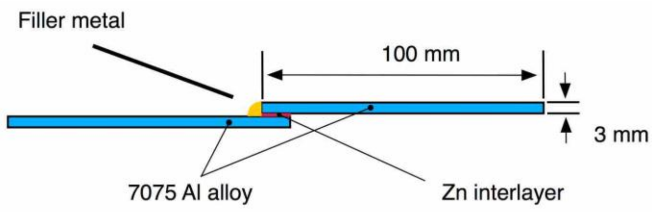

Fig 1: Schematic representation of the joint assembly

Table 1: Welding currentts used in weld manufacture

Weld sample	Welding current (A)
1	60
2	70
3	80
4	90
5	100

3. Results and discussion

Weld sample 4 with 90 A welding current showed the best weld profile in terms of the weld bead size and penetration as shown in Figure 2.

Regarding to the mechanical properties of the weld joints, all the tensile shear samples fractured at the HAZ after the tensile shear test as shown in Figure 3. The average ultimate tensile shear strength of the welded joints as a function of the welding current is shown in Figure 4. It can be clearly seen that the welding current has a significant effect on weld shear strength. The value of the shear strength increased with increasing of the welding current up to 90 A ands ample 4 with welding current 90 A showed the highest shear strength at 548 MPa, which reaches about 90% of the tensile strength of the BM, as illustrated in Figure 5.The increment in the welding current provided sufficient heat input for the weld joint that is probably enough to melt a part of the BM, the Zn foil and the ER4043 filler metal and provided the WM with sufficient alloying elements. However, at 100 A, the shear strength dropped, as shown in Figure 3, this probably due to the use of a relatively high heat input that generates a wide soft area and reduction[13].

Obtaining a weld with relatively good strength using fusion arc welding forAA7075 Al alloy is very difficult due to the risk of the formation of low melting point compounds that lead to solidification cracking in WM and micro fissuring in the HAZ[14-16]. Zn interlayer with aid of the ER4043 filler wire fed the WM with alloying elements and redistributed the chemical composition of the WM that prevents the formation of the eutectic compounds and produce a solid solution strengthening and therefore raised the shear strength of the weld[13].

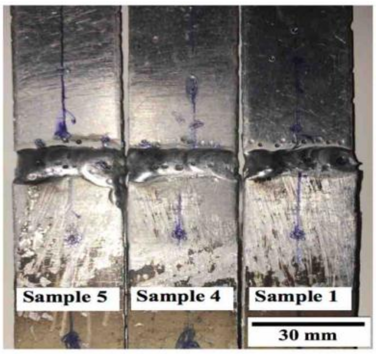

Fig 2 : Top view of weld samples 1, 2 and 4

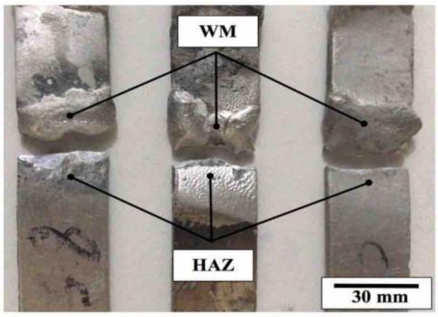

Fig 3: Top view of weld samples showing the fracture in the HAZ

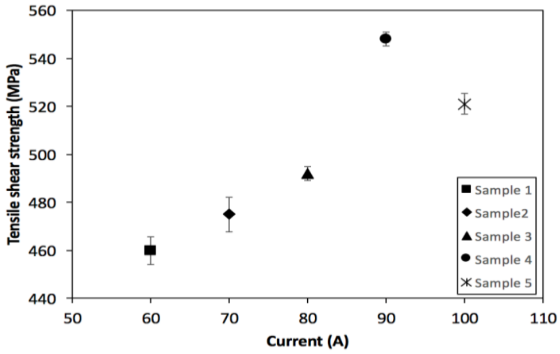

Fig 4 Tensile shear strength as a function of welding current

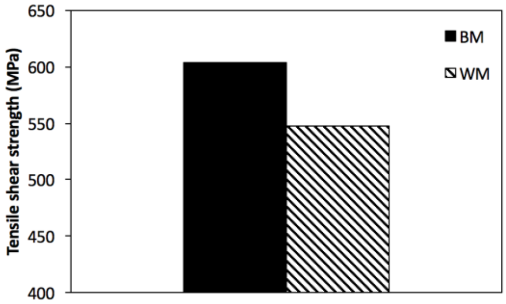

Fig 5: A comparison in tensile shear strength between the BM and the WM of sample 4

The micro hardness results were in line with the tensile shear strength. The WM was harder than the HAZ in the all samples. Sample 4 with 90 A welding current also showed the highest harness level as shown in Figure 6. It is observed that the HAZ is the weakest area in the all welds and this justifies why the failure to happen in this region during tensile test. This can be explained in terms of the effect of the grain size coarsening in HAZ after welding comparing to the BM[17]in addition to the precipitation in the partially melting zone in the HAZ that lead to reduction in the hardness[16, 18].However, WM and HAZ both have lower hardness than the BM as shown in Figure 7 since the AA7075 is high strength Al alloy and welding process soften it to some level[7].

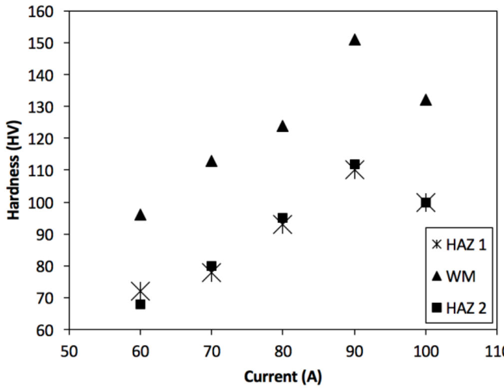

Fig 6: Micro hardness as a function of welding current

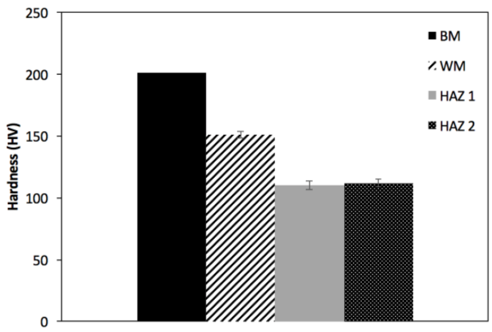

Fig 7: A comparison in micro hardness between the BM, WM and HAZ of sample 4

4. Conclusions

3 mm thickness AA7075 Al alloy plates welded by TIG welding process. A range of welding current was used to optimize the best heat input.

The weld was performed using Zn foil as an interlayer and ER4043 filler metal as strengthening agents for the WM.

The weld was feasible and the weld sample made with 90 A welding current displaced the best weld profile.

Tensile shear strength property of the welds was evaluated. The failure happened in the HAZ in the whole samples. Weld sample 4 with 90 A welding current showed the highest shear strength of 548 MPa, which reached about 86% from the tensile strength of the BM.

HV numbers of the WM was higher than the HAZ in the whole samples and weld sample 4 with 90 A welding current recorded the highest hardness with 151 HV that equals about 75% from the hardness of the BM.

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