Study of TIG welding of AZ31 B Magnesium alloy

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Abstract - *Magnesium alloys have gradually used for lightweight structural and functional parts in the bike, automotive and electronic industries because of their high specific strength, light specific weight, excellent damping capacity, recyclability, and ability to shield electromagnetic shocks. Magnesium alloys have the potential to replace aluminum alloy and steel in many structural applications since it is 35% and 77% less dense than aluminum alloy and steel, respectively. However, the lightweight structural and functional parts of magnesium alloys may be joined using mechanical fasteners as well as a variety of welding methods including tungsten-arc inert gas (TIG), metal-arc inert gas (MIG), plasma arc, electron, laser friction, adhesive, explosion, stud, ultrasonic and resistance spot welding. In this study AZ31 B magnesium alloy is used with 3mm thickness as well as filler is of same composition and 3mm diameter. Parameters used for process are peak current 75A bottom current 50A. Pulse mode 0.3-0.1, gas flow rate 15-20 lit/min, pre flow of gas 7.5 lit/min, post flow 11.6 lit/min (Argon gas) filler wire has manually feed. Base metal has strength of 273.37 MPa after welding sample 1 and sample 2 have strength of 193.70 MPa and 231.13 MPa respectively. Reduction in strength is 22.29%. It is observed that due to fine welding weld samples are broken from welded zone instead of heat affected zone.*

Key Words: AZ31 B Magnesium alloy, TIG welding and strength.

1. INTRODUCTION

Magnesium alloys exhibit the attractive combination of low density and high specific strength (comparable or greater than that of precipitation strengthened Al alloys), along with good damping capacity, castability, weld ability, and machinability. Of the various commercial magnesium alloys, those developed from the Al−Zn ternary system (i.e. the as-named AZ alloys) have found the largest number of industrial applications. These applications include automotive, industrial, materials handling and aerospace equipment where lightweight materials are needed [5]. At present, fusion welding processes, such as gas metal arc welding, laser welding and gas tungsten arc welding, have been widely investigated to join magnesium alloys; however, it is still a challenge to achieve solid magnesium alloy welds with fusion welding processes because defects such as pores, cracks and slag inclusions often occur in the resultant weld. Especially, pores are often found in the weld during fusion welding of magnesium alloy [7].

2. LITERATURE REVIEW

Recently, few studies have been carried out to evaluate the tensile properties and metallurgical properties of gas tungsten arc welded magnesium alloys. The gas tungsten arc (GTA) welding for AZ91 magnesium alloy parameters used such as welding current 100/300 A and welding speed from 3.33/13.33 mm/s using such parameters the arc efficiency ranged from 0.63 to 0.88 melting efficiency was found to rise with both increasing welding current and speed [1]. The post weld heat treatment on the AZ31B magnesium alloy such as annealing and solution treatment annealing from 200°C to 450°C for 1hr (at a gap of 50°C) and solution treatment from 250°C to 450°C for 10 hr (at a gap of 50°C) the results obtained are annealing at 400°C for 1 hr fine grain structure and increase in tensile strength and elongation, tensile strength of 210 MPa equivalents to 1.5 times of welded joint and elongation of 11% for same condition [2]. The mathematical model the relationship between mechanical properties and tempering time for AZ80 magnesium alloy as soon as the tempering time increases the a-phase particles decreases and b-phase particles increases in $Mg_{17}Al_{12}$ grains, tensile strength and value of elongation increases as both the tempering time and temperature increases. The maximum value obtained for tempering at 375°C for 3 hr is 230 MPa and 2.10% elongation [3]. The characteristics of AZ31 magnesium alloy by using alternate current and pulsed current for welding. The results obtained are microstructure of the alternative current for the samples have been concluded to contain fewer finer grains than the pulsed current samples and for pulsed current strength increases with increase in current but in case of alternate current it does not happen [4]. The microstructure and characteristics of AZ31B magnesium alloy using pulsed current gas tungsten arc welding the welding speed from 105 mm/min to 145 mm/min (at a gap of 10 mm/min). It was found that among all 135 mm/min speed shows superior tensile properties than any other speed with a heat input of 369 J/mm [5]. The gas tungsten arc filler welding of AZ31 magnesium alloy with a filler AZ61 wire with automatic gas tungsten arc filler welding equipment the results showed that the microstructure of gas tungsten are filler welded joint revealed that the grain size in heat affected zone held significant variety compared with that of gas tungsten arc welded joint, which has changed the fracture location in tensile test and improved the ultimate tensile strength of welded joint [6]. Microstructure and mechanical properties of AZ31B magnesium alloy gas metal arc welded with AZ61A as a filler rod. He observed the pores generated in the welded joint are at the top of the welding and cracks generates due to the connection of the pores. Fracture happens in the heat affected zone or in base metal during tensile testing [7]. The comparative analysis on friction welded and gas tungsten arc welded AZ91 magnesium alloy butt joints the formation of fine, equiaxed grains and relatively higher hardness of weld region and heat affected zone are the reasons for higher micro hardness of friction stir welded joints. The Mg-alloy joints fabricated by friction stir welding revealed superior hardness values and the improvement in micro hardness was approximately 24% higher than gas tungsten arc welded joints [8]. The microstructure stability of cold drawn AZ31 magnesium alloy during annealing processes at 200°C to 450°C for 10 min to 166.66 min with areas of reduction 12.2% to 60.5% with initial diameter of 1.75 mm the results obtained are there are three stages of annealing processes recrystallization at 200-300°C, normal grain growth at 300-400°C and abnormal grain growth over 400°C which is significantly dependent on the prior cold drawn deformation [9]. The microstructure Evolution and Grain Growth Model of AZ31 magnesium alloy under condition of isothermal. Annealing of AZ31 magnesium alloy is done at a temperature range of 150°C to 450°C (at a gap of 50°C) and holding time from 15 min to 60 min (at a gap of 15 min). The results are there is first increase and then decrease in grain size at a temperature range of 150°C to 250°C and then gradual grain growth occurs [10]. The changes in hardness of magnesium alloys due to precipitation hardening for AZ31, AZ61 and AZ91 magnesium alloy the specimens were heated at 400°C for 22 hours to achieve solution annealing then specimens were cooled in water at 60°C to preserve supersaturated solid solution and then precipitation hardening alone at constant temperature of 250°C for different time intervals such as 15, 30, 60, 120, 240, 480, 690, 1920, 3840 and 7680 minutes. The results observed are there is no such change in hardness of AZ31 magnesium alloy as compared to AZ61 and AZ91 magnesium alloy [11]. The effect of heat treatment on microstructure and mechanical properties of the AZ31/WE43 bimetal composites casting of AZ31 and WE43 is made and T6 heat treatment refers to solid solution treatment at 673-793 K (399.85-519.85°C) for several hours followed by quenching and artificial ageing treatment. Solution treatment is designed at 698, 723, 748, 773 and 788 K with a fixed time 12 hours followed by water immersion then specimens were subjected to an artificial aging at 483 K for different times. The results obtained are at different temperature the hardness of AZ31 is almost same, no change in shear strength. Main crack can initialize in the WE43 material and then propagate along the interface zone [12]. The microstructure and mechanical properties of TIG/A-TIG welded AZ61/ZK60 magnesium alloy joints. The dissimilar joints of AZ61 and ZK60 magnesium alloys were obtained by tungsten inert gas welding and activating tungsten inert gas arc welding (A-TIG) processes varying welding currents are used from 60-100 A (at a gap of 10 A). For the TIG welded AZ61/ZK60 joints, a refined grain size of 19 μm and a maximum tensile strength of 207 MPa were achieved at a welding current of 80 A. The tensile strength of the AZ61/ZK60 joints was inversely correlated to the amount of TiO_2 in A-TIG welding. The TiO_2-coated samples (5 mg/cm^2) exhibited a maximum tensile strength of 156 MPa [13]. The effect of annealing process on microstructure and properties of roll-casting AZ31B Mg alloy sheet the experiment of general roll casting and combining energy field roll casting carried out with dimensions 200 mm width and 4.8 mm thick. Annealing heat treatment is done for both casting with various temperatures such as 250, 300, 400°C and holding time of 1-4 hours (at a gap of 1 hr). The results obtained are at 400°C the grain growth increases as time increases it is minimum at 1 hour (for general casting), at 300°C for holding time of 4 hours grain size is minimum for combination energy field casting. At 250°C no full recrystallization of roll casting occurred [14].

3. EXPERIMENTAL PROCEDURE

The material used for the experiment is AZ31 magnesium alloy. The initial size of the plate was 300mm × 300mm × 3mm the plates are first marked into the size of 90mm × 90mm as shown in fig 1. The two samples were taken from plates for strength test by marking the direction on the plate as along and across the rolling direction strength test conducted on these two samples after welding it is known that marked directions are wrong and directions are reversed by the expert opinion. The welding of the plates has done in across direction due to high tensile strength is obtained in across direction instead of along direction of rolling. Before going for welding the plates are cleaned by buffing. Tungsten inert gas welding is used to join the two plates filler metal used is same AZ31 magnesium alloy diameter 3mm. Argon gas is used to protect welding from atmosphere.

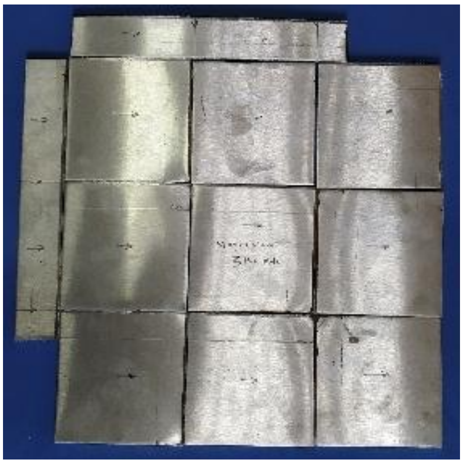

Fig 1: Plated marked in along and across direction.

During welding specifications are peak current 75A bottom current 50A. Pulse mode 0.3-0.1, gas flow rate 15-20 lit/min, pre flow of gas 7.5 lit/min, post flow 11.6 lit/min. Wire feeding during welding is done manually after welding samples are prepared for tensile as shown in figure 2a. From tensile test it is observed that samples are broken in welded zone instead of heat affected zone (HAZ) this proves that due to these welding specifications we can achieve fine welding and less heat affected zone figure 2b shows broken samples of welding. Tensile test is carried out on Universal testing machine of capacity 600 kN Tensile test is carried out according to IS 1608 (PART-1): 2018.

(a) (b)

Fig 2: a and b: welded samples and broken samples after welding.

4. RESULTS AND DISCUSSION

Strength obtained in the along direction is 251.5 MPa and across the direction is 273.3 MPa. For welding of base metal across rolling direction is selected for better results. After tensile test of two samples the result obtained are tensile test of weld sample 1 is 193.70 MPa and tensile test of weld sample 2 is 231.13 MPa average of two samples is 212.41 MPa by this reduction in tensile strength is 22.29%. From results it observed that welding is broken through welded zone, instead of heat affected zone. Generally it is observed in literature welding is broken through heat affected zone due to coarser grain structure. Due to welding parameters used in this study we obtained fine welding.

5. CONCLUSIONS

From experiment it is seen that magnesium welding can be done with various parameters but strength obtained after welding is less as compared to base metal.

1. With such parameters used in study we can obtain maximum strength for welded samples.
2. Weld samples are broken from welded zone instead of heat affected zone (generally observed in references).
3. Due to fine welding weld samples have strength 193.70 MPa and 231.12 MPa as an average 212.41 MPa strength is obtained.
4. Percentage in reduction of strength is 22.29% (Base metal strength 273.37 MPa).

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