Research Article

Study on metallurgical properties of semi-solid metal aluminium alloy 5083 welding by gas metal arc welding

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Abstract

The study was aimed to investigate the metallurgical properties of semi-solid metal aluminium alloy 5083 welding using gas metal arc welding, with the variation of 5, 10 mm, and one-sided lap joint. The weld is characterized by a complete melting, and macro structure had no twist and cracks caused by the residual stresses in the weld. The small amounts of porosity were observed throughout the weld area. From the two-way lap joint at 10 mm, the penetration depth is better, and the porosity is less than the 5 mm lap joint. The microstructure of the base metal is composed of spheroidal grain structure (α), mixed with eutectic phase (Mg + Si). The pore size is 5 to 20 microns. It has a uniform distribution of Mg_2Al_3, which is smaller than the structure of the heat affected area. From the inspection does not show the crease of the weld. It showed that 5083 semi-solid aluminum alloys can lap joint with the gas metal arc welding.

Keywords: Gas metal arc welding, semi-solid state aluminium alloy 5083, lap joint

Introduction

Currently, aluminum shipbuilding industry in Thailand is a minor industry. Therefore, aluminum for construction or repairing ship was limited while these undertakings need are on the opposite side. Welding is the main process in doing, and aluminum alloy 5083, casting by GISS (gas induced semi-solid), is used in the procedure. [1] The method is the semi-solid metal casting process for forming spheroidal grain which is more durable and resisted to erode than the regular aluminum drawn. The new production process is widely interested and the material will probably replace the existing aluminum in the future. Welding aluminum has many limitations after welding which there were the possibility in occurring of crack and spongy. Consequently, selecting welding process is very important and gas metal arc welding (GMAW) is vital in welding aluminum material. GMAW has an effect on products quality and capital cost of welding which consists of electric current in welding, electromotive force, welding speed, torch angle, arc apace, position and direction of welding and rating of gas flown [2] and after welding, welding joint was flawless and complete.

Generally, the lap joint is applied in aluminum ship welding since cover welding in fracture is not widely used in the procedure of repairing. Additionally, aluminum piece was firstly brought to cover the

broken area then lap joint welding was applied in overlapping one side and two sides. The lap joint helps for adding durable and protects abrasion from cracking area. [3] After welding, the study on metallurgy comparison in applicable welding joints were applied because of the spheroidal grain manner which it was melt from heat, its phase was changed and residual welding stress was in a large amount and this caused crack in welding jointor unable to join weld completely. [4]

Material and Method

Semi-solid Aluminum alloy 5083 (with Manganese - Mg 3.95 of weight) was applied in the study. [5] Working piece 100 x 50 x 8 mm, lap joint space 5 mm and 10 mm, lap joint welding in one side and two side which the characteristics of lap joint will effect to weld bead, imperfection and durable of welding joint.

GMAW method had been examined 3 times, 6 working pieces, with welding rods A5.10 ER356, DCRP current, 20-23 Voltage, shielding gas 100% AR, gas flow rate at 13 liters/minute, welding speed 8.6 – 9 x 10^{-3} m/s. [6]

Metallurgical structure was examined by metal polishing machine and milling working piece with Keller's reagent (which consisted of nitric acid, hydrochloric acid and hydrofluoric acid), 3 to 5 seconds, dry blowing with heat air. After that, the results were examined using the digital camera which recorded welding surface of macro-structure to examine error in welding and light microscope was applied to find the micro-structure in weld zone (WZ) and heat affected zone (HAZ)

Results

The welding surface from lap joint variable of 5, 10 millimeters from alloy aluminum 5083 with GMAW were stable fusion. The heat effects to welding joint surface became oxide, and made aluminum melt two materials together without crack and spongy on welding surface.

There were no twisted characteristics of working pieces and no crack from residual stress. From welding one side lap joint, there was much porosity with diameter 0.1 to 0.5 millimeters around the welding joint area. From welding two side joint, at the connecting space 10 mm: the weld bead is better and the occurrence of porosity is less than at the connecting space 5 mm as in **Figure 1**. However, semi-solid aluminum alloy 5083 was able to weld with GMAW without the occurrence of crack.

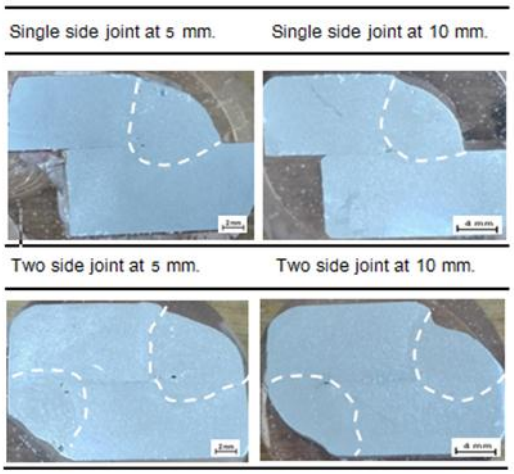

Figure 1 Macro-structure examination

The micro-structure of base metal (BM) consisted of phase aluminum (α=white) mixed with Eutectic phase (Mg + Si = Black + Gray) steadily dispersing which the structure of phase aluminum mixing with semi solid metal was spheroidal grain (α) from welding variable lap joint 5, 10 millimeters and from lap joint one side, two sides, there were porosity with diameter 5-20 micron in the WZ. As in **Table 1**, spheroidal phase structure was changed to dendrite structure with smooth dispersion of Mg_2Al_3 as in **Figure 2 (A)** and **(B).**

Table 1 Porosity size on weld zone

Variable	Welding test		
	1 micron	2 micron	3 micron
Lap joint at 5 mm.	6-18	5-18	5-20
Lap joint at 10 mm.	5-12	7-15	6-10

The micro-structure that was affected from HAZ **Figure 2 (C), (D)** and were one sided lap joint welding and **(E), (F)** were two sided lap joint welding. In this area, it was the most noticeable point because of the residual stress which was risk to occur the crack or other error. From examination, there was no crack but the porosity of 1-30 micron was occurred from two side lap joint welding at the phase of lap joint 5 millimeters which take place in the cooling down period of welding. The elaborated structure with tiny particle similar to dendrite structure was from the cooling process of fusion on welding joint zone with smooth dispersion of Mg_2Al_3 and the grain structure was rougher than the welding joint area.

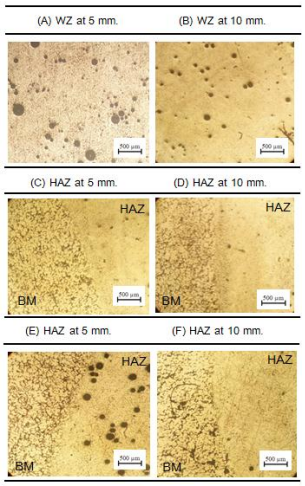

Figure 2 Micro-structure examination

Discussion

Heat temperature factor of Semi-Solid Aluminum alloy 5083 welding was effected to porosity occurrence especially in lap joint welding at 5 millimeters because the lap space was narrow and it made less heat accumulation in welding joint and Hydrogen cannot drain out before cooling down period. Since aluminum material was quickly reaction to hydrogen, the method to decrease porosity was to warm the working piece after welding at 573 kelvins for 30 minutes. [6]

From the examination, there was no crack in welding joint [7,8] which show that Semi-Solid Aluminum alloy 5083 are able to do GMAW lap joint welding. The best variable for welding is two side lap joint welding with lap joint space at 10 millimeters because the wide lap joint space make the large amount of heat accumulation and while welding in the second side was as warming the working piece after the first welding joint which effected to the less amount of hydrogen from the cooling process of fusion on welding joint zone [6] with smooth dispersion of Mg_2Al_3.

In the micro-structure of heat affected zone was the most noticeable point because it is the most residual stress zone which is risk to occur crack or other error from cooling period while welding. [9] However, welding with Semi-Solid Aluminum alloy 5083 were able to do with GMAW process without effecting to be crank of welding joint.

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