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MODIFICATION OF AA 5083 WELD JOINT CHARACTERISTICS

Wajira Mirihanage and Nanda Munasinghe
Department of Materials Engineering, University of Moratuwa,
Moratuwa, Sri Lanka.

ABSTRACT

Aluminum Alloy 5083 [AA 5083] is commonly used in the manufacturing of pressure vessels, marine vessels, armored vehicles, aircraft cryogenics, drilling rigs, structures and even in missile components etc. This alloy is considered as a one of the best weldable aluminum alloys and exhibits a slight reduction of the strength of the Heat Affected Zone [HAZ], comparatively to the most of other Aluminum alloys. This decline in the strength has to be considered critically in the design stage and it can be considered as a major drawback in applications especially where a better weight to strength ratio is required. AA 5083 consider as a non heat treatable Aluminum alloy and therefore conventional post welding treatments are not used. In this research, AA 5083 Gas Metallic Arc welded [GMAW] samples were subjected to controlled heating procedures and their mechanical properties were measured. It was observed that there are certain differences of material properties in the test samples depending on heat treatment parameters. In addition to that the pattern of variation was not uniform along the entire cross section of the weldment. With those observations further studies were focused on to the potential improvements of the AA 5083 GMAW joint characteristics. This research paper will discuss the reasons for these observations on the basis of experimental out come and metallurgical principles like formation of precipitation in Aluminum alloys.

1. INTRODUCTION

Aluminum and its alloys show unique characteristics of light weight, high strength, high toughness, extreme temperature capability, versatility of extruding, and excellent corrosion resistance. Those make it the obvious choice of material by engineers and designers for the variety of engineering applications.

As an example Aluminum - Magnesium alloys have high Strength and show excellent corrosion resistance even in salt water, and high toughness even at cryogenic temperatures to near absolute zero. The marine industry has made use of its high-strength magnesium base Aluminum alloys such as AA 5083 to obtain the tensile strength requirements. GMAW [Gas Metallic Arc Welding] is widely used in Aluminum and its alloy fabrications, maintenance and repair of parts and structures.

Because arc welds consist of fused metal and a high peak-temperature heat affected zone, the properties of the theses regions may degrade and displayed inferior mechanical properties. Although AA 5083 considered as a one of the best weldable aluminum alloys and even it also exhibits a relatively slight reduction of the strength of the Heat Affected Zone [HAZ], comparatively to the most of other Aluminum alloys. In this research, AA 5083 GMAW samples were subjected to controlled heating conditions and their mechanical properties were measured. It was observed that there are certain differences of material properties in the test samples depending on heat treatment parameters. With those observations, studies were focused on to the potential improvements of the AA 5083 GMAW joint characteristics.

2. EXPERIMENTAL PROCEDURE

Table 1 contains the chemical composition (in weight percentage) of the investigated AA 5083-H321 and it was analyzed by using Spectrometry Methods. 6mm thick AA5083 plates were joining by GMAW process with using AA 5356 filler wire. Subsequently part of the welded samples were subjected to the temperatures of 473 K and 673 K for period of five minuets and then allow to cool in room temperature (302 K-305 K). Tensile tests were carried out for differently treated samples to obtain the stress – strain curves of thee weld metal zone as well as the HAZ. Micro-hardness values along the cross sections(transverse to weld direction) of samples was measured by using Vickers micro hardness testing machine and polished cross sections were etched by using Hydrofluoric and Hydrochloric and mixture for optical microscopy.

3. DISCUSSION

In steels a weld can be made as strong as the parent material, but this is not the same with aluminum. In almost all instances, the weld will be weaker than the parent material. To further understand why this occurs, the two classifications of aluminum alloys must have to be considered. Heat treatable and non-heat treatable. The latter category is generally hardened only by cold working which causes physical changes in the metal. The more the alloy is cold worked the stronger it gets. But, weld joint of alloy that has been cold worked, is almost similar to the locally anneal material around the weld so that it goes back to its 0 tempered (or annealed) condition and it becomes "soft". Therefore, the only time in the non-heat treatable alloys that can make a weld as strong as the parent material is when you start with 0 tempered materials.
With heat treatable aluminum alloys, the last heat treatment step heats the metal to approximately 200° C. But when welding, the material around the weld becomes much hotter than 200° C so the material tends to loose some of its mechanical properties. Therefore, if the operator doesn't perform post-weld heat treatments after welding, the area around the weld will become significantly weaker than the rest of the aluminum - by as much as 30 to 40 percent. If the operator does perform post weld heat treatments, the proprieties of a heat treatable aluminum alloy can be improved. /2/

When non-heat-treatable alloys are welded, microstructural damage is incurred in the HAZ. Unlike the case of heat-treatable alloys, whose strengthening precipitates may dissolve or coarsen, the HAZ damage in non-heat-treatable alloys is limited. Thus, loss in strength in the HAZ is not nearly as severe as that experienced in heat-treatable alloys. For this reason, 5xxx-series alloys are popular for use in welded pressure vessels where reasonable joint strengths can be obtained in the as-welded condition without the need for post-weld heat treatment but it is not provided the material which have the mechanical properties nearly mach with the its originally designated values. This reflected in the micro hardness graph (Fig. 01) of the AA 5083 weld joint.

According the observations hardness is reduced at the weld metal region and maximum reduction occurs at the HAZ. This is compared with the experimentally heat treated GMAW joints. These test peaces are treated at 473 K and 673 K respectively. The changes are visible in the hardness profiles of the treated samples comparing with the initial sample which was not treated.

The sample which treated at 473K shows slight increment of the hardness in the parent metal region and the hardness values are less than the hardness of untreated welded joint in the region towards to the center of the weld. Sample which treated 673 k displays the inferior hardness values to both of other samples. (Fig. 02)

Stress – strain graph of the weld metal zone was displayed in the fig no.03. According to the results maximum strength figure was displayed by the sample which dose not subjected to the heat treatment and samples which treated at 673 K displayed the minimum tensile strength.

Stress – strain of the HAZ were displayed in the fig. no. 04 and highest strength in this zone were displayed by the sample which was treated at the 473 K for 5 minuets and the least strength again by the sample which treated at the 673 K for 5 minutes time . Basically those two regions have different chemical compositions and weld metal zone properties are based on the composition of the filler material. HAZ properties are basically not depending on only the weld (filler) meta compositionl. Commonly practicing filler materials for AA 5083 exhibit the strength variations in a narrow range.

The temperature around 475 k Aluminum alloys containing Silicon has a susceptibility formation of Mg_2Si precipitates. Constant temperature maintaining at 473 K for 5 minutes could be a significant to form Mg_2Si precipitates and that is the most probable cause for the improvement of the strength and the hardness. Above the temperatures of 500 K resulted to sperodising of the Mg_5Al_8 Sperodised Mg_5Al_8 can produce the declined of the alloy properties. Optical micrographs were displayed relative differences between the weld joint areas. Formation of different Mg_5Al_8 and Mg_2Si quantities and sizes/shapes of precipices could be the main reason for discussed behavior of the AA 5083-H321 weldments.

4. CONCLUSION

Potential of produce GMAW Joints of AA 5083 which has near equality of the properties of the base material was attempted at these investigations. In the weld metal zone this aim is more possible to attain by the alloy with deserve chemical composition and not focused in this investigation.. In the case of HAZ potential of fractional restore of the AA 5083 - H321 mechanical properties can be acquire through the heat treating at around the 473 K for approximately five minutes and heat treating at the higher temperatures does not make the improvements of hardness or ultimate tensile strengths.

5. REFERENCES

1. Paul J. Konkol, Kevin Colligan, James J. Fisher, and Joseph P. Pickens, *Friction Stir Welding of Structural Materials for Naval Combatants, Concurrent Technologies Corporation ,1998*

2. Frank Armao, *Frequently Asked Questions in Aluminum Welding, The Lincoln Electric Company, (January, 2000*

3. Hatch J.E., *Aluminum: Properties & Physical Metallurgy, 1983, TWI Publications, Weldability of Materials - Aluminum Alloys, Oct 1996*

4. Christian Fuller, Murray Mahoney, and William Bingel, *Friction Stir Processing of Aluminum Fusion WeldsRockwell Scientific Publications , 2003*

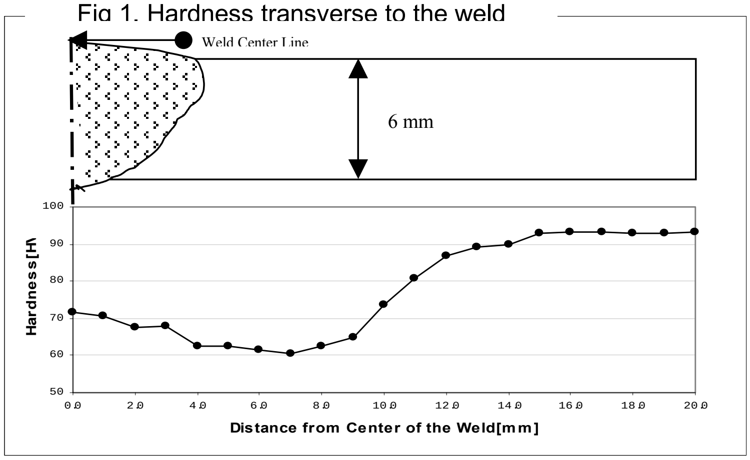
TABLES

Table 1. Chemical Composition of AA 5083 alloy by weight

Element	**Zn**	**Mg**	**Mn**	**Si**	**Cu**	**Fe**	**Cr**	**Al**
Percentage	0.20	4.60	0.60	0.40	0.10	0.40	0.10	Bal.

FIGURES

Fig 1. Hardness transverse to the weld



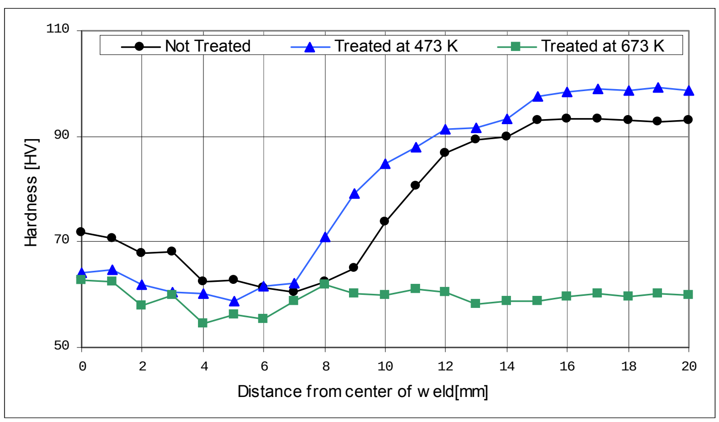


Figure 2 Average Micro-Hardness

Fig. 03 - Stress vs. Strain - Weld Metal

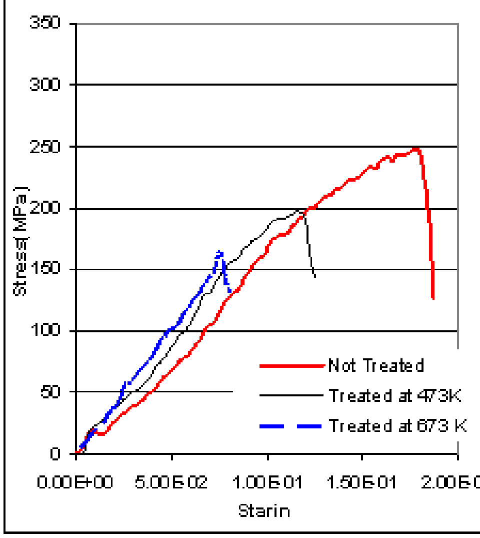


Fig. 04 - Stress vs Starin - HAZ

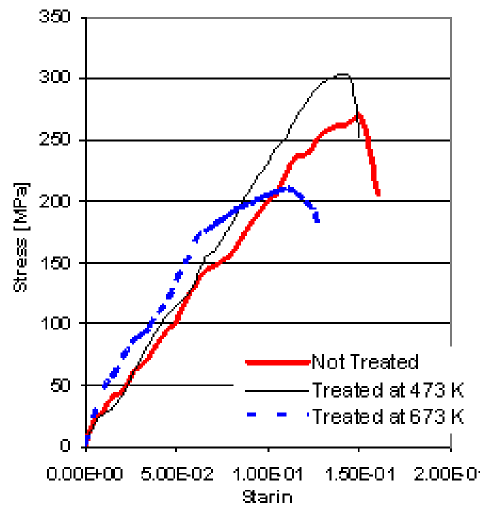
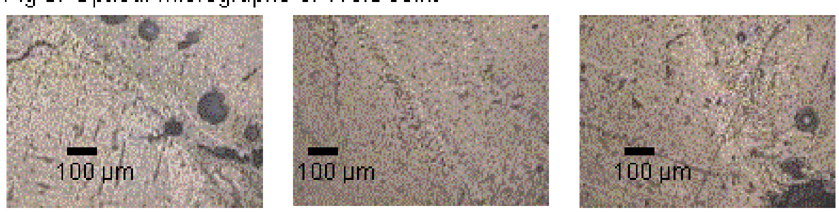


Fig 3. Optical Micrographs of Weld Joint



[3.a] Untreated [3.b]Treated at 473 K [3.c]Treated at 673 K