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Investigation of The Mechanical and Microstructure Properties of The TIG Welded Joining of Aluminum Alloy

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In this study, 6xxx series aluminum alloy is joined with TIG welding method. Welds were used as additional metal (5356 AlMg type additional wire) was in the joints. Tensile tests were applied to samples prepared in two different standard sizes in order to determine the strengths of welded joints. In addition, hardness measurements of welded samples were obtained from welding zone, HAZ and base material.

Keywords; Aluminum alloy, TIG welding, Fracture, SEM.

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1. Introduction

Aluminum alloys with high specific strength are widely used in industry. One of the most important reason is the low density. Density of aluminum is 2.7 g / cm^3 [1]. Using aluminum alloys in many constructions provides an advantage like decraeasing weight. Also aluminum and its alloys have very good corrosion resistance in the air, water, oil and many chemicals. Its thin refractory oxide layer (Al_2O_3) fulfil to provide corrosion resistance against to atmosphere effects [2].

Nowadays aluminum and aluminum alloys have wide usage area in many industries such as food, chemical, automotive, ship building, vehicle construction, aircraft building, machinery due to its low density, good thermal and electrical conductivity, increased strength properties and anti-corrosion properties. Moreover it becomes the preferred materials for engineers and designers. [3-7].

Welding is one of the most effective manufacturing processes employed in wide range of industrial application for joining of materials. Welding is an important method to join plates. Gas tungsten arc welding (GTAW)—commonly known as tungsten inert gas (TIG) welding—is an arc welding process that uses a nonconsumable tungsten electrode to produce the weld [8, 9]. An arc is generated between the electrode and the workpiece which produces heat at the temperatures necessary to weld the material. Gas tungsten arc welding as the name suggests is kind of arc welding process and it comes under the category of liquid state welding/fusion welding. Temperatures of the weld pool during.

GTAW can reach 2500 °C. Furthermore, atmospheric contamination of the weld area is inhibited by a shield of inert gas (argon or helium). The TIG arc welding method has found wide application range in the industry. GTAW is used extensively for welding stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys [10]. While aluminum and its alloys, gas melting welding and covered electrode can be welded limited when using arc welding methods, the emergence of under gas welding methods has allowed the creation of better quality joints.

In this study, 6xxx series aluminum alloy was joined with TIG welding method and its effects were investigated.

2. Experimental Procedure

In this study, two plates of 120 mm x 350 mm dimensions and 3 mm thick aluminum material were used and welded. Aluminum filler wire with AlMg 5356 composition is used. The chemical compositions obtained as a result of spectral analysis of the plates are given in the table.

Table 1. Chemical composition (wt%).

Steel	Mg	Fe	Si	Ti	Mn	Al
6xxx	0,526	0,22	0,16	0,019	0,05	Ba.
5356	5,0	0,4	0,25	0,2	0,2	Ba.

The plates are joined by TIG welding machine in the Fig.1, which will be a butt welding (Fig.2). Welding parameters are given below:

Current Type : AC
Wire : AlMg 5356
Wire diameter : 3,2 mm
Ampere : 130 Amper
Voltage : 14 - 16 V
Using Gas : Pure argon
Distance of plates: 2 mm

Figure 1. *Welding Machine*

Figure 2. *Welding process.*

After welding, the drawing was cut with the help of wire erosion in Fig.3. Tensile tests were carried out at a speed of 1mm / min on a Zwick 5-ton tensile machine. The side surface of the welded samples was sanded with 600, 800, 1000, 1200 and 2500 grit. Sanding, polishing and etching was done respectively. material surfaces are etched with Dix - Keller etchers, which are special to aluminum material, to obtain micro images (SEM and EDX). After the test samples were prepared for hardness measurement, they were made with a micro hardness device using a 500 gr load.

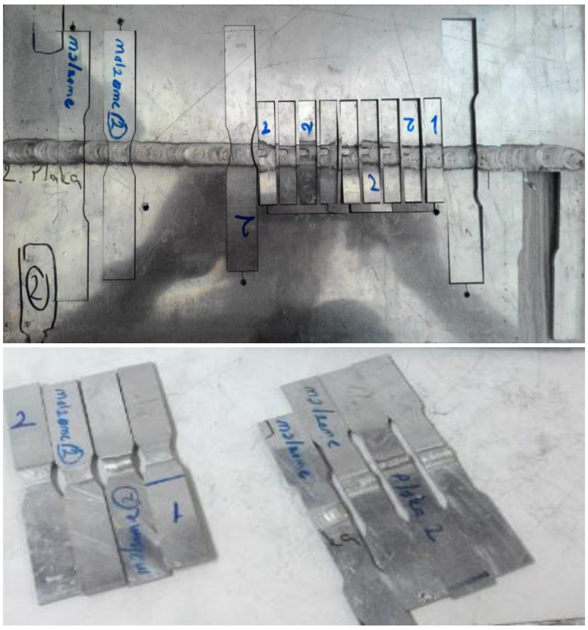


Figure 3. *Tensile strength test specimens*

In the cutting process, 2 types and different sizes of drawing samples were taken (Figure 4). The reason for this is the desire to fully analyze the mechanical properties of different regions during the tensile test. Samples will be expressed as standard A and standard B.

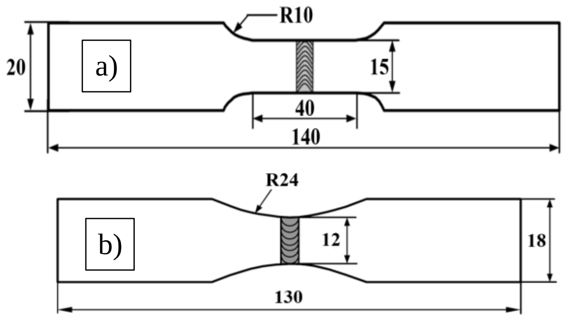
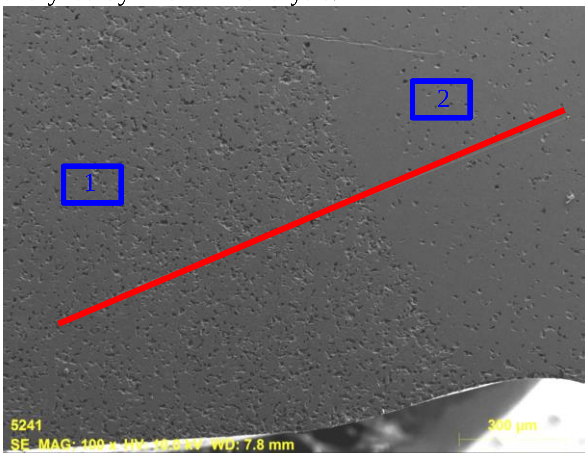


Figure 4. Measurements of the samples used in the tensile test; a) Standard A and b) Standard B.

1. Discussion

1.1. EDX Analyses

The elemental change in weld metal and HAZ was analyzed by line EDX analysis.



Mass percent (%)

Spectrum	Mg	Al
1	2.99	97.01
2	1.11	98.89
Mean value:	2.05	97.95
Sigma:	1.33	1.33
Sigma mean:	0.94	0.94

Figure 5. Linear EDX analysis.

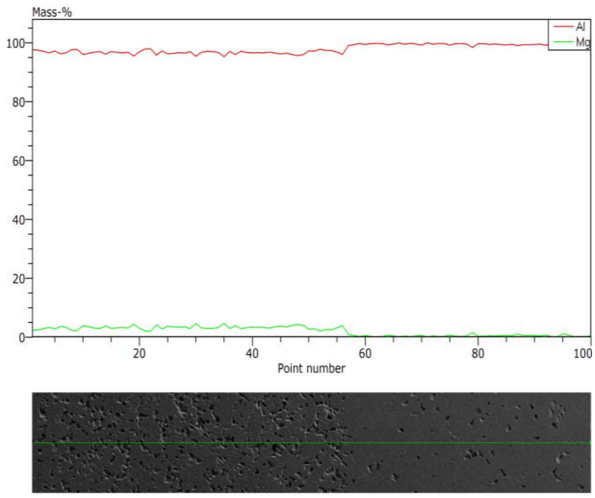


Figure 6. Graphic of EDX analysis

Magnesium and aluminum are the highest proportion of elements in the alloy. Therefore, two are taken into consideration. According to the results, the ratio of aluminum has decreased slightly as the welding metal has been increased and the magnesium ratio has increased.

3.2. Tensile Strength Test

A graph from the tensile test result of the basic metal without welding is given below.

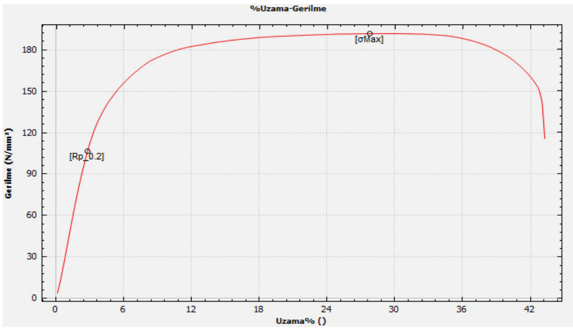
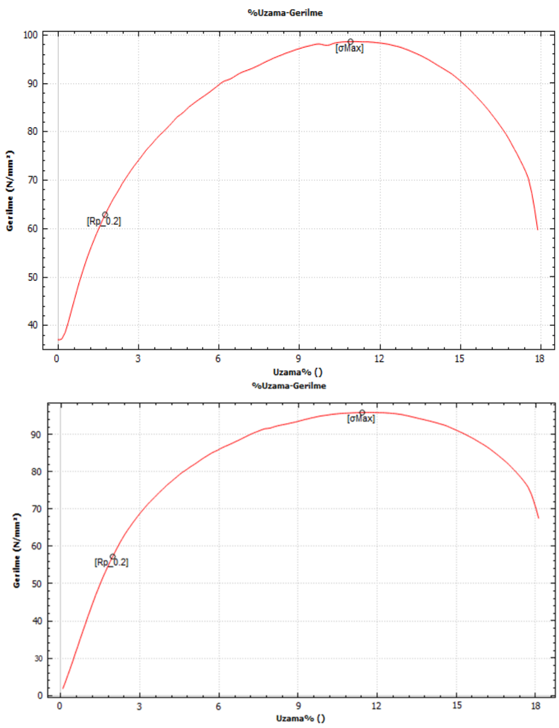


Figure 7. Tensile strength test (Stress-%Elongation)

Tensile strength was measured as 184 MPa, yield strength 103 MPa and elongation value of approximately 35%.

Tensile test graphs of welded samples are different from samples prepared in two standards. The short size sample chart is given in Figure 8. The tensile strength was measured as approximately 97 MPa (98.6, 97.8 and 93.2MPa), the yield strength was approximately 64 MPa (52.6, 59.4 and 64.0 MPa) and the elongation value was about 19.5%.



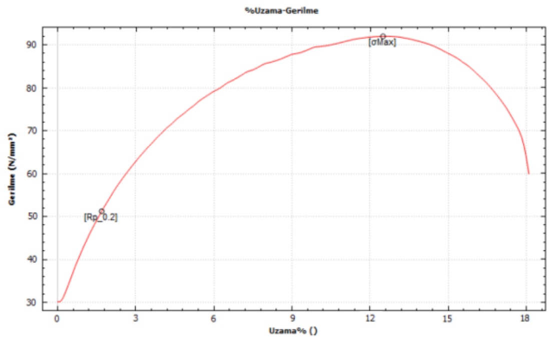


Figure 8. *Sample B test results.*

When the average tensile strength was taken, it was measured approximately 87 MPa (88.2, 87.4 and 87.7MPa), yield strength was approximately 64 MPa (66.5, 58.5, 68.7 MPa) and the elongation value was approximately 20%.

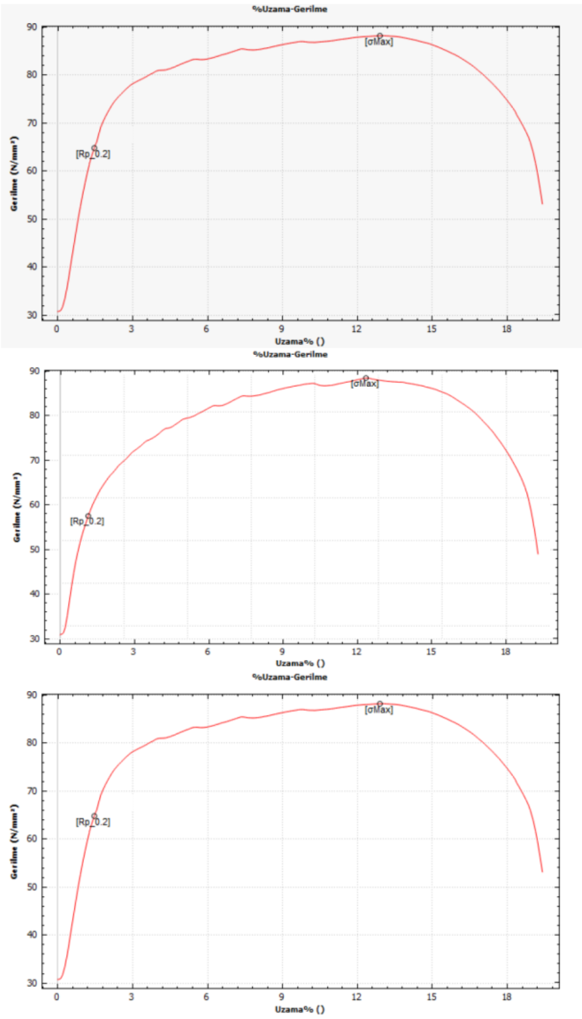


Figure 9. *Sample B test results*

1.2. Hardness

Hardness values are given in table 2.

Table 2. Hardness values

Measurment	**Base Metal**	**HAZ**	**Welding Zone**
1.	26.7 HV	61.7 HV	63.6 HV
2.	27.0 HV	62.8 HV	63.8 HV
3.	25.5 HV	62.5 HV	63.5 HV
Average	26.4 HV	62.33 HV	63.63 HV

According to the hardness values, the base metal was measured as 26.4 HV, HAZ 62.33 HV and the weld metal as 63.63 HV. The highest hardness value was in the weld metal.

Gurmeet Singh et al. [11] reported that the 6082-T6 alloy was around 60HV in the weld metal, where a result of TIG welding was achieved by 95 HV in HAZ. Hayat [12] measured the hardness values of the alloy of the 6xx series as a result of the point resistance welding at approximately 40HV. He reported that there were no regional changes and similar results occurred in each region. Ibrahim Sevim et al. [13] reported that the hardness values of the 6061-T6 alloy, which is about 40 HV in the base metal in MIG welding, increased in HAZ and reached the highest value in the weld metal above 60HV.

1.3. Fracture Samples

Welded parts were subjected to tensile testing and rupture sites were determined. In figures 10 and 11, rupture photos are given for two groups of samples.

Figure 10. Sample B fracture speciments.

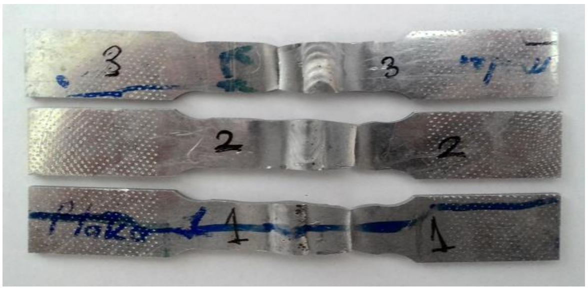


Figure 11. *Sample A fracture speciments.*

After tensile strength test, it is desired to investigate where the rupture came from. It was determined that the tensile fraction from HAZ was cut on the short tensile samples cut in the design, in which the narrowest part was the weld metal.

It has been observed that fracture ocuured at base metal rather than HAZ or fussion zone. According to this result, it was seen that the parameters were selected appropriately. It has also been determined that welded joints have higher mechanical properties than base metal. According to these results, it can be thought that the selection of wire and Welding parameters are appropriate and the welding process is successful.

4. Conclusion

In this study, 6XXX series (Al-Mg-Si) aluminum alloys were welded under shielding gas compositions (pure argon) with TIG welding method.

- Welding process has been done successfully.
- As a result of the tensile test, it was observed that the ruptures did not break from the weld metal in two different standard samples. These results show that welding seams are safe.
- As a result of the tensile experiment, it was observed that the referenceless (pure) tensile sample was extended longer than the welded tensile sample compared to the tensile sample of the non-reference (pure) tensile sample.
- According to the hardness test results, the highest hardness values were measured from the weld metal, followed by the HAZ and the main material, respectively.

References

[1]. Hatch Jhon E., 1984, Aluminum: Properties and Physical Metallurgy, American Society for Metals, Metal Park Ohio.

[2]. Onaran, K. 2003. Malzeme Bilimi, Bilim Teknik Yayınevi, İstanbul, s. 320-321.

[3]. Yinghui Zhou, Xin Lin, Nan Kang, Weidong Huang , Jiang Wang , Zhennan Wang, Influence of travel speed on microstructure and mechanical properties of wire + arc additively manufactured 2219 aluminum alloy, Journal of Materials Science & Technology Volume 37, 15 January 2020, Pages 143-153.

[4]. R. Sun, L. Li, Y. Zhu, W. Guo, P. Peng, B. Cong, J. Sun, Z. Che, B. Li, C. Guo, L. Liu J. Alloys. Compd., 747 (2018), pp. 255-265

[5]. F. Montevecchi, G. Venturini, N. Grossi, A. Scippa, G. Campatelli, Addit. Manuf., 21 (2018), pp. 479-486

[6]. J.V. Gordon, C.V. Haden, H.F. Nied, R.P. Vinci, D.G. Harlow Mater. Sci. Eng. A, 724 (2018), pp. 431-438.

[7]. G. Wang, Y. Zhao, Y. Hao J. Mater. Sci. Technol., 34 (2018), pp. 73-91

[8]. V. Vara Prasada, D. Lingaraju, Effect of Different Edge Preparations On The Tensile And Hardness Properties Of Gtaw Welded 6082 Aluminum Alloy, Materials Today: Proceedings 4 (2017) 157–165.

[9]. Hicken, G.K., 2005. Gas-tungsten arc welding. ASM Handbook 6, 190–194.

[10]. Yingyot Poo-arporn, Samrerng Duangnil, Denchay Bamrungkoh, Pheemphat Klangkaew, Channut Huasranoi, Piyawat Pruekthaisong, Supan Boonsuya, Jitrin Chaiprapa, Anuchit Ruangvittayanon, Chatree Saisombat Gas tungsten arc welding of copper to stainless steel for ultra-high vacuum applications, Journal of Materials Processing Tech. 277 (2020) 116490

[11]. Gurmeet Singh, Amardeep S.Kang, Kulwant Singh, Jagtar Singh, Gurmeet Singh ve arkadaşları, Experimental comparison of friction stir welding process and TIG welding process for 6082-T6 Aluminium alloy, Materials Today: Proceedings, Volume 4, Issue 2, Part A, 2017, Pages 3590-3600

[12]. Hayat Fatih (2012). Effect of aging treatment on the microstructure and mechanical properties of the similar and dissimilar 6061 T6 7075 T651 RSW joints. Materials Science and Engineering: A, 556, 834-843.

[13]. Ibrahim Sevim, Fatih Hayat, Yakup Kaya, Nizamettin Kahraman, Sadettin Şahin, The study of MIG weldability of heat-treated aluminum alloys, Int J Adv Manuf Technol (2013) 66:1825–1834.