Türk Mühendislik Araştırma ve Eğitimi Dergisi
Turkish Journal of Engineering Research and Education

1(2), 120-128, (2022)

REVIEW ARTICLE

Investigation of the Effects of Different Welding Methods Applied on Aluminum 7075 Material on the Mechanical and Microstructure Structure Properties of the Joint Zone

Alüminyum 7075 Malzemesine Uygulanan Farklı Kaynak Metotlarının Birleşme Bölgesinin Mekanik ve İçyapı Özelliklerine Etkisinin İncelenmesi

H.Sercan Çubuk[1], Gökhan Kurt[1] , Uğur Çavdar[2,*]
[1]İzmir Demokrasi University, Graduate School of Natural and Applied Sciences, Mechanical Engineering Program, 35580 İzmir, Turkey
[2]İzmir Demokrasi University, Faculty of Engineering, Mechanical Engineering Department, 35580 İzmir, Turkey

Received / Geliş : 14.09.2022
Accepted / Kabul : 21.10.2022
***Sorumlu Yazar (Corresponding Author): Uğur Çavdar, ugur.cavdar@idu.edu.tr**

ABSTRACT: The use of aluminum, one of the three most commonly used metals in the world, is increasing. This requires a closer investigation at aluminum and research for the production of new techniques. These studies are particularly important in 7xxx series aluminum. Due to the properties of 7075 Al such as strength/weight, corrosion resistance, alloy metallicity and etc 7075 Al is used vary of welding techniques. This study examines the structure and mechanical properties of the 7075 aluminum metals through different types of welding, but also compares the important mechanical and strength outcomes, such as rigidity, tensile stress and yield stress.

Keywords: Aluminum 7075, microstructure, welding, haz, aging

ÖZ: Dünya üzerinde önemi giderek artan ve çok kullanılan 3 metalden biri olan alüminyumun kullanımı artmaktadır. Bu durum alüminyumu daha yakından incelemeye ve yeni üretim teknikleriyle imal edilmesi için araştırılmaya gerekli kılmaktadır. Özellikle 7xxx serisi alüminyumlarda bu araştırmalar önemli bir yer tutar. Sahip olduğu özellikler ile 7075 alüminyum, mukavemet/ağırlık, korozyon direnci, alaşım metalliğine uyumluluğu vb. sebeplerle çeşitli kaynak metotlarında kullanımını arttımaktadır. Bu çalışmada, 7075 alüminyum metallerine farklı tipte kaynaklama işlemi yapılmasıyla elde edilen içyapı ve mekanik özellikleri incelenmekte, bununla beraber sertlik, akma gerilmesi ve çekme gerilmesi gibi önemli mekanik ve mukavemet sonuçları kendi aralarında kıyaslanmaktadır.

Anahtar Kelimeler: Alüminyum 7075, içyapı, kaynak, ıeb, yaşlandırma

1. INTRODUCTION

Aluminum is one of the metals with the highest amount of reserves in the world. The melting temperature of aluminum (Al) is 660°C. Since it can bond with various elements, it can be used in different industrial products. It is often used in materials. In addition, it can be produced by mixing with titanium and composite materials. Aluminum alloys, which have a wide range of uses from automotive to industry, are preferred because of their specific strength and low weight [1-3]. However, Aluminum is a metal which difficult to machine in production methods such as welding and machining [3-7].

Aluminum series from 2xxx to 8xxx are frequently used in the aerospace and transportation vehicle manufacturing industries. This makes it necessary to combine the material with welding methods [8-10]. In aluminum welding ; Thermal and electrical

H. Sercan Çubuk, Orcid: 0000-0001-6598-351X / Gökhan Kurt, Orcid: 0000-0001-6008-7812 / Uğur Çavdar, Orcid: 0000-0002-3434-6670

conductivity, refractory aluminum oxide (Al2 O3) formation tendency, high thermal expansion coefficient make this welding more difficult than steel welding [11-17]. This is because to its precipitation hardening. Low specific density, strong strength [18-21], good mechanical and natural aging properties [19] of 7075 Al (Al-Zn-Mg-Cu) metal increases its use in the mentioned sectors [22-25].

Aluminum alloys are prone to structural deformation. Welding deformations, which is called hot cracking or hot tearing, are observed in various heat-treated aluminum [20]. In the heat treated 7xxx series aluminum; Alloys 7075, 7079 and 7078 can be welded. However, the heat affected zone: HAZ (Isıdan Etkilenmiş Bölge: IEB) of the material are more brittle than the other regions [23, 26-33]. Especially 7XXX series Aluminum is extremely sensitive to weld cracking due to the high amount of copper it contains [24]. Since the solidification temperature is low in this alloy and the melting range is wide [24,25], the difference in solidification rate at the material interface can cause cracks due to shrinkage stress. The way to prevent solidification cracking is to improve the grain structure of the fusion region.

7075 aluminum alloy is strengthened by precipitation hardening. The aim here is to increase its strength. The strength of this material is obtained by aging heat treatments such as T6. The material, which is taken into solution by heat treatments such as T6, is stress relieving with controlled amount of stretching and artificially or naturally aged and used [24,25]. Precipitation hardening causes the temperature of the alloy to be raised to the single-phase region where all the precipitates are dissolved [26-29]. To form a saturated solution in the alloy, a process called quenching is applied. Natural aging and artificial aging are observed at the temperature of the sediments. This may occur slowly or rapidly. For example, the T6 temper condition is achieved by aging for 24 hours at 120 °C or 10 hours at 140 °C. [30-37]. A major challenge with this type of material is the availability of fusion welding , as the weld is susceptible to solidification cracking, porosity. Therefore, improved welding methods are desired at IEB [38 -40].

Laser beam welding is preferred because of its high thermal and electrical conductivity [41]. It is a IEB joining method for high speed and quality production in aluminum alloys. Some aluminum series have problems such as porosity due to solidification cracking [41,42].

TIG welding is one of the processes frequently used in industry to fuse the materials with high quality [43]. It allows to combine the metals with arc welding application. The material is welded by applying the heat of an electric arc between the tungsten sieve and metals [44,45].

FSW (Friction Stir Welding) friction heating interface deformation results in a junction formed by heat and solid-state diffusion [46,47].

The purpose of this review is to examine the applicability, limitations, advantages and disadvantages of laser beam. TIG welding applied to 7075 aluminum alloys, which are used in advanced technology systems where high strength aluminum is needed and draws conclusions about hardness, yield and tensile stresses.

2. MATERIALS AND METHODS

In this review, 8 different experiments were examined, the properties found in laser beam, TIG and FSW welding applied to 7075 Aluminum material are given in Table 1.

Table 1: Different types of welding methods applied to 7075 Al material.

No	*Welding Method*	*Base Material*	*Results*	*Ref.*
1	Laser Beam Base	*Aluminum 7075 *D6AC Structural Steel	The max tensile strength of the sample was measured as 94 MPa and the aluminum fusion line in the Steel/Aluminum joint was broken.	[2]
2	Laser Beam Base	*Al 7075-T6	A hardness of 125 HV was observed in the IEB.	[19]
3	Laser Beam and TIG Welding	*Al 7075-T6	The tensile strength of the welded joint was 365 MPa. Softening was observed according to the base material.	[52]
4	TIG Welding	*Al 7075	The highest tensile strength after the first welding cycle was measured as 176 MPa.	[49]
5	TIG Welding	*Aluminum 7075-T6	The yield strength of the welded part was measured as 200 MPa.	[53]
6	FSW	*Al 2024 *Al 7075	The yield stress after welding was measured as 325MPa.	[48]
7	FSW	*Al 7075-T651 *Al 5083-H111	Originating from each other AS 7075–RS 5083 tensile strength was measured as 367 MPa.	[50]
8	FSW	*Al AA7075-T651	The lowest hardness value in the microstructure was seen at 100 mm/min welding speed. Was seen on IEB at 106 HV.	[51]

Bao et al. [2], 7075 aluminum and D6AC alloy steel are used. Required laser power is 1.20 kW for welding. In steel/aluminum joints, the contact surfaces were milled. 396 W laser beam power and 650 mm/min welding speed parameters were taken for welding. Hayat [19] used 2 mm thick aluminum sheets in his study. It was carried out under a vacuum of 70 bar. The welding current was set to 20–25mA. 7075 weld specimen etched with Keller fluid. Hardness measurements was made in two sequential repetitions. First SEM, then EDS was used. The microstructure of stress was investigated. Song et al. [52] used 7075-T6 aluminum. Sample plates for welding have dimensions of 200 mm x 100 mm x 1 mm. 1.2 mm diameter welding wires were used as filler metal. 7075-T6 Al sheet was forehead welded on one side with one pass using the laser-TIG hybrid welding method. The micro hardness distribution was examined using a with a load of 300 g. Prathan et al. [49] used AA 7075 aluminum material in their studies. The size of the 6 mm thick sheet metal was 300 mm x 200 mm. TIG welding was performed after the sheet material was cut. They used nine base parameters in their experiments. The diameter of the filler rod to be used during welding was measured as 2 mm. A total of 9 welds with double V forehead joints were prepared using TIG welding parameters. Welded at a current of 130 Amps at 15 L/min. After the Rockwell hardness test, tensile tests were performed on all welds. Temmar et al. [53] used 7075-T6 aluminum alloy in their studies. Welding was carried out at 100–140 Amps, 12.5 Volts and 12.7 mm/sec. They used argon gas as shielding gas. Aging process was carried out after welding. Hardness was measured with a Vickers micro hardness device under 500 g load. Investigations for surfaces such as IEB were made. Cavailere et al. [48] used the FSW welding method in their work. The boards were 2.5 mm thick. The welding tool was fixed clockwise to the rotating axle. Weld cross section was measured with an instrument with a load of 200 gf for 15 seconds. Tensile tests were performed to evaluate the static properties of welded joints. The mechanical results during fatigue fracture were analyzed with a microscopic view of the welded joints. In their study, according to Kalemba Rec et al. [50] performed friction stir welding of Al 7075-T651 and Al 5083-H111 alloys.

The test pieces were 200 x 75 x 6 mm and combined with two different forehead welds. Xu et al. In their work [51], 6 mm thick AA7075-T651 aluminum alloy rolled sheets were used for experiments. FSW was performed from 100 mm/min to 400 mm/min. It was carried out along the rolling direction with welding speeds. Sections of samples taken perpendicular to the basee direction were used in microstructure studies. SEM was used for microstructural characterization analysis. Vickers micro hardness was measured at 1, 3 and 5 mm from the bottom surface of the samples using a computerized hardness tester with a load of 200 g and a loading time of 20 s.

3. FINDINGS AND DISCUSSION

3.1 Hardness Findings

The hardness results of the welding joint of the Al 7075 base material was given in Table 2. When the hardness results were examined, in study number 2 [19], it was found that the hardest region in the welded 7075 alloy joint was the phase region. For TIG welding, the hardness was measured as 175 HV. In study number 3 [52], the micro hardness gmicroradually increases with respect to the base material as one moves from the fusion zone towards the edge. HV hardness results were obtained from a maximum distance of 2 mm from the center of the fusion zone. The hardness rised up to 150 HV. The hardness increased according to distance from the welding point and eventually reached the base material value (approximately 185 HV). In study 5 [53], the stiffness of the fusion zone was found to be a minimum of 84 HV near the weld centerline. It was observed that there was 95 HV near the border of the fusion zone, giving variable result. In study number 6 [48] the first observation was made at a 4 mm aperture from the IEB point. In this region, mostly parent material grains were observed. This region, in addition to corresponding to the heat affected region, infers that the hardness is lower than the base metal. The highest hardness was measured as 170 HV. In the study number 7 [50], 145 HV hardness was found for Al 7075 – 5083 weld. They measured 85 HV for AS 5083–RS 7075 welding. In addition, the highest hardness value was observed on the Al 7075 side (approximately 150 HV). It was observed that the hardness decreased in IEB for both welding tests. It is understood that when there is a 4 mm wide structure in the IEB region on the 7075 side of the weld and the hardness is reduced by approximately 25%. In study number 8 [51], welded at 100 mm/min. The hardness was found to be 106 HV. The hardness in IEB was lower than the different type of material applied to 7075 Aluminum material.

Table 2: Hardness results of different types of welding methods applied to 7075 aluminum material.

No	*Welding Method*	*Base Material*	*Results*	*Ref.*
2	Laser Beam Base	*Al 7075-T6	A hardness of 175 HV was observed in the IEB.	[19]
3	Laser Beam and TIG Hybrid Welding	*Al 7075-T6	It was observed that the micro hardness increased to 150 HV at a distance of IEB.	[52]
5	TIG Welding	*Al 7075-T6	It has been observed that there is 95 HV near the border of the fusion zone, giving variable results.	[53]
6	FSW	*Al 2024 *Al 7075	The highest hardness is 170 HV.	[48]
7	FSW	*Al 7075-T651 *Al 5083-H111	The highest hardness is 180 HV on the Aluminum 7075 side.	[50]
8	FSW	*Al AA7075- T651	The lowest hardness value in the microstructure was seen at 106 HV in the IEB.	[51]

3.2 Yield Stress Findings

The yield stress results of the weld joint made with Al 7075 were given in Table 3. When the yield stress was examined, in study number 2 [19], the yield strength at the weld at 20 mA was measured as 208 MPa. Material elongation varies between 6.7% and 11%. In study 5 [53], the yield strength of the non-welded part was measured to be 404 MPa, while the yield strength of the material after TIG welding was found to be 200 MPa. The yield of post-weld aged joints was measured as 216 MPa. Precipitate formation was observed in the sample. It was examined that there was a 9% increase in strength in the connection. In study number 6 [48], the base strengths of 2024 and 7075 metals were measured as 380 MPa and 503 MPa, respectively, and the yield stress after welding was 325 MPa. Good ductility was observed at the joints of the piece. When the yield stress evaluated, it is said that the results were at a good level. In study number 7 [50], the yield strength of the weld for AS 7075–RS 5083 was found to be 302 MPa with a standard deviation of 1.2%. For the AS 5083–RS 7075 sample, it was observed as 305 MPa. Fracture was observed in all samples where 5083 material was located.

Table 3: Yield stress results of different types of welding methods applied to 7075 aluminum material.

No	*Welding Method*	*Base Material*	*Results*	*Ref.*
2	Laser Beam Base	*Aluminum 7075-T6	Yield strength of 208 MPa at 20 mA was measured as 205 MPa at 25 mA.	[19]
5	TIG Welding	*Aluminum 7075-T6	The yield strength of the welded part was measured as 200 MPa.	[53]
6	FSW	*Aluminum 2024 *Aluminum 7075	The yield stress in the finished material after welding was measured as 325 MPa.	[48]
7	FSW	*Aluminum 7075-T651 *Al 5083-H111	In the AS 5083–RS 7075 specimen, the yield stress was observed as 305 MPa. The results for both samples are similar.	[50]

3.3 Tensile Stress Findings

The tensile stress results of the weld joint of Al 7075 base material was given in Table 4. When the tensile stress results are examined, it is observed that the tensile strength at 20 mA is 297 MPa in study number 2 [19]. In study number 3 [49], tensile strength was found to be 176 MPa. It understood that the maximum tensile strength increase was 183 MPa. In the study, in which 140 A and 17 L/min gas flow rate were included in the parameters, it was understood that it would give better tensile strength by narrowing the gap. In the experiment on 6 mm AA 7075 sheet material, it was observed that the gas flow rate and current made significant changes on the final tensile strength of the welds in TIG welding. In study number 4 [50], the tensile strength of the AS 7075–RS 5083 sample was found to be 367 MPa. The tensile strength of the other sample was 365 MPa with a standard deviation of 0.8%. It is concluded that the weld samples have an effect on the material composition but not the tensile properties. In study number 6 [52], the tensile strength of the piece after welding was measured as 365 MPa. It was published that the fusion region was the weakest region. It was observed that all welded regions were broken in this region. As a result of the study, it was examined that the whole rolled joint has a relatively good deformability. In study number 5 [51], plastic deformation occurred in the IEB. In the study, the maximum tensile stress for aluminum 7075 material was measured as 585 MPa. The final tensile strength of the parts produced at each welding speed was observed as 515 MPa. In the study number 7 [2], in the welding process, the heat conduction and tensile deformation of the material was affected, leaving a large residual stress on the end joints. The maximum tensile strength of the attachment point was measured as 94 MPa. In the study number 8 [53], it was observed that after aging process welding was applied to the material due to increase the tensile strength in the weld composition region. It also showed that the fusion zone of the weld of the 7075 aluminum alloy has a significant effect on reducing the impact energy. On welded 7075 aluminum sample, micro cracks are visible. It is published that this condition causes low tensile strength. The tensile strength of the welded part is 508 MPa. The tensile strength in the IEB region after welding found as 248 MPa with 9% elongation.

Table 4: Tensile stress results in different types of welding methods applied to 7075 aluminum material.

No	*Welding Method*	*Base Material*	*Results*	*Ref.*
1	Laser Beam Base	*Aluminum 7075 *D6AC Structural Steel	Max tensile strength was preferred as 94 MPa.	[2]
2	Laser Beam Base	*Aluminum 7075-T6	The tensile strength of welding at 20 mA was found to be 297 MPa, and at 25 mA it was found to be 256 MPa.	[19]
3	Laser Beam and TIG Hybrid Welding	*Aluminum 7075-T6	The strength of the sample after processing is 365 MPa. Softening was observed according to the base material.	[52]
4	TIG Welding	*Aluminum 7075	The highest tensile strength after the first welding cycle was measured as 176 MPa.	[49]
5	TIG Welding	*Aluminum 7075-T6	After welding, the tensile strength of the finished piece was found 248 MPa with an elongation of 9%	[53]
7	FSW	*Aluminum 7075-T651 *RS 5083-H111	Originating from each other AS 7075–RS 5083 tensile strength was measured as 367 MPa.	[50]
8	FSW	*Aluminum AA7075- T651	The tensile strength is 515 MPa.	[51]

3.4 *Other Findings and Discussion*

When the other findings of the welding joint made to the Al 7075 base material were examined, it is published. In study number 1 [2], max tensile strength was preferred as 94 MPa. In the heat affected area while the aluminum side is in dendrite structure with dense distribution, on the steel side, a structure consisting of coarse austenite grains is among the findings. In study number 2 [19], deposited phase formations were observed in the base area. When SEM images examined, the fusion region consists of thinner grains than the IES region. Average grain size varies between 5-48 microns. In addition, precipitation in the material can cause cracks in the fusion zone. In study 3 [52], it is observed that after rolling, the density increases in the IEB and phase region, respectively, in the laser-TIG hybrid welded joint. Four regions with distinctive microstructural features were seen after laser-TIG hybrid welding. Due to rapid heating and cooling production techniques, unstable crystalline microstructures are seen in the sample. This crystal structure was observed throughout the heat dissipation region. No significant structural changes were seen in the IES and fusion site. The coarse sedimented phases in this region were dispersed within the surface. In the study number 4 [49] that the presence of the FSW welding line reduces the fatigue behavior of the material. In study 5 [53], it was found that the reinforcement behavior of TIG welding in the IEB was related to the balance of the dissolution, reversal and precipitation processes throughout the IEB. However, it was understood that this situation will only occur when it is compared with the main material study number 7 [50], it was seen that the yield of the tensile strength of the weld is above 100% even in soft alloys (5083). In study number 8 [51], 15.9% elongation at break was observed for the base material. The long holding time and high temperature reached during FSW resulted in larger grains and intermetallic particles.

4. CONCLUSION

In this study, the mechanical and microstructure properties of the materials containing 7075 Aluminum metal when combined with laser, TIG and FSW welding methods were investigated. Obtained results were given below:

- The highest tensile strength is seen in study 5 using FSW welding. It is understood that the ultimate tensile strength is 515 MPa.
- It is seen that the aging treatments is applied to aluminum 7075 after FSW welding increase the hardness in the weld zone.
- In the examined welding methods, it is seen that the area under the influence of heat (IEB) is between 1.5 mm and 4 mm. It is examined for laser welding between 1.5 mm and 3 mm, for TIG welding between 2 mm and 4 mm, and for FSW welding between 2.5 mm and 4 mm.
- It is seen that the phase densities increase due to sudden temperature changes at the IEB.

- In TIG welding, when the gas flow rate and current increases, the final tensile strength of the weld increases.

5. REFERENCES

[1] D. Bakavos, P.B. Prangnell, Mechanisms of joint and microstructure formation in high power ultrasonic spot welding 6111 aluminium automotive sheet, Mater. Sci. Eng. A 527 (23) (2012) 6320–6334, https://doi.org/10.1016/j. msea.2010.06.038.

[2] Bao, Y., Zhou, J., Zhang, Y., Xu, Y., & Liu, H. (2021). Microstructural and mechanical characteristics of direct laser welding 7075 super hard aluminum alloy/D6AC ultra-high strength alloy structural steel. Materials Letters, 287, 129312.

[3] Georgantzia, E., Gkantou, M., & Kamaris, G. S. (2021). Aluminium alloys as structural material: A review of research. Engineering Structures, 227, 111372.

[4] Yildiz, D. E., Kocyigit, A., Erdal, M. O., & Yildirim, M. (2021). Dielectric characterization of Al/PCBM: ZnO/p-Si structures for wide-range frequency. Bulletin of Materials Science, 44(1), 1-7.

[5] Salur, E. , Acarer, M. & Nazik, C. (2021). Mekanik Alaşımlama Süresinin Toz Metalurjisi ile Üretilen AA7075 Matrisli Nanokompozit Malzemelerinin Sertliklerine Etkisi . Journal of the Institute of Science and Technology , 11 (3) , 2218-2231 . DOI: 10.21597/jist.829529

[6] Seymen, Y. (2009). Alüminyum (Al7075) Elmas Benzeri Karbon (Dlc) kaplanmış Parmak Freze Ile işlenmesinin Deneysel Incelenmesi (Doctoral dissertation, Marmara Universitesi (Turkey)).

[7] Tokatlı, M., Saydam, F. , Hal, M., Koşatepe, A. , Çolak, M. & Yüksel, Ç. (2022). Alüminyum Alaşımlarının Dökümünde Yaygınca Kullanılan Sıvı Metal Temizleme Yöntemlerinin İncelenmesi . Journal of the Institute of Science and Technology , 12 (1) , 423-434 . DOI: 10.21597/jist.940414

[8] Çevik, B., Özçatalbaş, Y., & Uygur, İ. (2012). 7075 Alüminyum Alaşımının Sürtünme Karıştırma Kaynağı ile Birleştirilmesi. In International Conference on Welding Technologies (pp. 369-376).

[9] Niu, P. L., Li, W. Y., Li, N., Xu, Y. X., & Chen, D. L. (2019). Exfoliation corrosion of friction stir welded dissimilar 2024-to-7075 aluminum alloys. Materials Characterization, 147, 93-100.

[10] Anton Savio Lewise, K., Raja Dhas, J. E., & Pandiyarajan, R. (2022). Optimising aluminium 2024/7075 friction stir welded joints. Advances in Materials and Processing Technologies, 1-19.

[11] Langebeck, A., Bohlen, A., Freisse, H., & Vollertsen, F. (2020). Additive manufacturing with the lightweight material aluminium alloy EN AW-7075. Welding in the World, 64(3), 429-436.

[12] Imran, M., & Khan, A. A. (2019). Characterization of Al-7075 metal matrix composites: a review. Journal of Materials Research and Technology, 8(3), 3347-3356.

[13] Sajadifar, S. V., Moeini, G., Scharifi, E., Lauhoff, C., Böhm, S., & Niendorf, T. (2019). On the effect of quenching on postweld heat treatment of friction-stir-welded aluminum 7075 alloy. Journal of Materials Engineering and Performance, 28(8), 5255-5265.

[14] Niu, P., Li, W., Yang, C., Chen, Y., & Chen, D. (2022). Low cycle fatigue properties of friction stir welded dissimilar 2024-to-7075 aluminum alloy joints. Materials Science and Engineering: A, 832, 142423.

[15] Singh, K., Singh, H., Vardhan, S., & Mohan, S. (2021). Mechanical study of Al 7050 and Al 7075 based metal matrix composites: a review. Materials Today: Proceedings, 43, 673-677.

[16] Arcieri, E. V., Baragetti, S., & Borzini, E. (2018). Bending fatigue behavior of 7075-aluminum alloy. In Key Engineering Materials (Vol. 774, pp. 1-6). Trans Tech Publications Ltd.

[17] Akkurt, O., Altıntaş, A., Çavdar, P., & Çavdar, U. Effect on the Mechanical Properties of Sintering Process of Aluminium Alloys. International Scientific and Vocational Studies Journal, 3(2), 85-91.

[18] Gökozan, H., Çavdar, P. S., Soy, G., & Çavdar, U. (2019). Analysis of artificial aging with induction and energy costs of 6082 Al and 7075 Al materials. Rev. Metal, 55(1), e137.

[19] Hayat, F. (2022). Electron beam welding of 7075 aluminum alloy: Microstructure and fracture properties. Engineering Science and Technology, an International Journal, 34, 101093.

[20] Hatamleh, O., Singh, P.M., Garmestani, H., "Corrosion susceptibility of peened friction stir

welded 7075 aluminum alloy joints", Corrosion Science, (51), 135-143, (2009).
[21] Sardar, S., Karmakar, S. K., & Das, D. (2018). High stress abrasive wear characteristics of Al 7075 alloy and 7075/Al2O3 composite. Measurement, 127, 42-62.
[22] Czerwinski, F. (2020). Thermal stability of aluminum alloys. Materials, 13(15), 3441.
[23] Akça, H. (2006). Tig yöntemiyle kaynak edilen alüminyum ve alaşımlarının mikroyapı ve mekanik özelliklerinin incelenmesi (Doctoral dissertation, Marmara Universitesi (Turkey)).
[24] Weman, K. (2011). Welding processes handbook. Elsevier.
[25] Kara, R. , Yıldırım, G. , Çolak, F. & Tınas, M. (2017). TIG ve Elektrik Ark Kaynağı ile Birleştirilen Alüminyum Plakaların Mekanik Özelliklerinin İncelenmesi . El-Cezeri , 4 (2) , 274-281 . DOI: 10.31202/ecjse.318221.
[26] Manladan, S. M., Yusof, F., Ramesh, S., Fadzil, M., Luo, Z., & Ao, S. (2017). A review on resistance spot welding of aluminum alloys. The International Journal of Advanced Manufacturing Technology, 90(1), 605-634.
[27] Mishra, A. (2020). Machine learning approach for defects identification in dissimilar friction stir welded aluminium alloys AA 7075-AA 1100 joints. Journal of Aircraft and Spacecraft Technology, 4(1), 88-95.
[28] Kumar, K. S., Karthikeyan, S., & Rahesh, R. G. (2020). Experimental investigation of wear characteristics of aluminium metal matrix composites. Materials Today: Proceedings, 33, 3139-3142.
[29] Mehdi, H., & Mishra, R. S. (2019). Study of the influence of friction stir processing on tungsten inert gas welding of different aluminum alloy. SN Applied Sciences, 1(7), 1-11.
[30] Mehdi, H., & Mishra, R. S. (2021). Effect of friction stir processing on mechanical properties and heat transfer of TIG welded joint of AA6061 and AA7075. Defence Technology, 17(3), 715-727.
[31] Kubit, A., Wydrzynski, D., & Trzepiecinski, T. (2018). Refill friction stir spot welding of 7075-T6 aluminium alloy single-lap joints with polymer sealant interlayer. Composite Structures, 201, 389-397.
[32] Mohammed, S. M. A. K., Jaya, Y. D., Albedah, A., Jiang, X. Q., Li, D. Y., & Chen, D. L. (2020). Ultrasonic spot welding of a clad 7075 aluminum alloy: Strength and fatigue life. International Journal of Fatigue, 141, 105869.
[33] Naafila, A., Purnowidodo, A., & Setyarini, P. H. (2019). Pengaruh waktu solution treatment terhadap kekuatan tarik aluminium paduan AA 7075-T6. Prosiding Seniati, 215-220.
[34] Evdokimov, A., Springer, K., Doynov, N., Ossenbrink, R., & Michailov, V. (2017). Heat source model for laser beam welding of steel-aluminum lap joints. The International Journal of Advanced Manufacturing Technology, 93(1), 709-716.
[35] Sato, Y. S., Kokawa, H., Enomoto, M., & Jogan, S. (1999). Microstructural evolution of 6063 aluminum during friction-stir welding. Metallurgical and Materials Transactions A, 30(9), 2429-2437.
[36] İpekoğlu, G. (2011). Kaynak sonrası ısıl işlemin sürtünme karıştırma kaynaklı AA6061 ve AA7075 alüminyum alaşımı levhalarda içyapı ve mekanik özelliklere etkisinin incelenmesi.
[37] Temmar, M., Hadji, M., & Sahraoui, T. (2011). Effect of post-weld aging treatment on mechanical properties of Tungsten Inert Gas welded low thickness 7075 aluminium alloy joints. Materials & Design, 32(6), 3532-3536.
[38] Sreenivasan, K. S., Kumar, S. S., & Katiravan, J. (2019). Genetic algorithm based optimization of friction welding process parameters on AA7075-SiC composite. Engineering Science and Technology, an International Journal, 22(4), 1136-1148.
[39] Abolusoro, O. P., & Akinlabi, E. T. (2020). Effects of processing parameters on mechanical, material flow and wear behaviour of friction stir welded 6101-T6 and 7075-T651 aluminium alloys. Manufacturing Review, 7, 1.
[40] Haghshenas, M., & Gerlich, A. P. (2018). Joining of automotive sheet materials by friction-based welding methods: A review. Engineering science and technology, an international journal, 21(1), 130-148.
[41] Pakdil, M., Çam, G., Koçak, M., & Erim, S. (2011). Microstructural and mechanical characterization of laser beam welded AA6056 Al-alloy. Materials Science and Engineering: A, 528(24), 7350-7356.
[42] Li, S., Xu, W., Xiao, G., & Chen, B. (2018). Weld formation in laser hot-wire welding of 7075 aluminum alloy. Metals, 8(11), 909.

[43] Kumar, K., Kumar, C. S., Masanta, M., & Pradhan, S. (2022). A review on TIG welding technology variants and its effect on weld geometry. Materials Today: Proceedings, 50, 999-1004.

[44] Bhatt, H. (2018). Study of Effect of Process Parameters of Welding during TIG welding of AA 7075 and its optimization. Int. J. Appl. Eng. Res, 13(12), 10658-10663.

[45] Bindu, A. H., Chaitanya, B. S. K., Ajay, K., & Sudhakar, I. (2020). Investigation on feasibility of dissimilar welding of AA2124 and AA7075 aluminium alloy using tungsten inert gas welding. Materials Today: Proceedings, 26, 2283-2288.

[46] Rhodes, C. G., Mahoney, M. W., Bingel, W. H., Spurling, R. A., & Bampton, C. C. (1997). Effects of friction stir welding on microstructure of 7075 aluminum. Scripta materialia, 36(1), 69-75.

[47] Kawashima, T., Sano, T., Hirose, A., Tsutsumi, S., Masaki, K., Arakawa, K., & Hori, H. (2018). Femtosecond laser peening of friction stir welded 7075-T73 aluminum alloys. Journal of Materials Processing Technology, 262, 111-122.

[48] Cavaliere, P., Nobile, R., Panella, F. W., & Squillace, A. (2006). Mechanical and microstructural behaviour of 2024–7075 aluminium alloy sheets joined by friction stir welding. International Journal of Machine Tools and Manufacture, 46(6), 588-594.

[49] Pradhan, P. K., & Punyakanti, S. (2019). Study the effect of welding parameters during tig welding of aluminum plate and its optimization. International Journal of Engineering and Management Research, 9.

[50] Kalemba-Rec, I., Hamilton, C., Kopyściański, M., Miara, D., & Krasnowski, K. (2017). Microstructure and mechanical properties of friction stir welded 5083 and 7075 aluminum alloys. Journal of Materials Engineering and Performance, 26(3), 1032-1043.

[51] Xu, W., Li, Z., & Sun, X. (2017). Effect of welding speed on mechanical properties and the strain-hardening behavior of friction stir welded 7075 aluminum alloy joints. Journal of Materials Engineering and Performance, 26(4), 1938-1946.

[52] Song, G., Wang, Z., Liu, Z., & Liu, L. (2022). Effect of partial rolling on the microstructure and mechanical properties of laser-TIG hybrid welded joints of 7075-T6 aluminum alloy. The International Journal of Advanced Manufacturing Technology, 1-11.