European Journal of Technique

journal homepage: https://dergipark.org.tr/en/pub/ejt

Vol.12, No.1, 2022

Investigation of Mechanical Properties of Composite Al6061/Ni-Al_2O_3 Produced by Stir Casting Process

Oktay Adıyaman[1*]

[1*]Batman University, Faculty of Technology, Mechanical and Manufacturing Engineering, Batman, Turkey. (e-mail: adiyamanoktay@gmail.com).

ARTICLE INFO

Received: Dec., 28. 2021
Revised: Apr., 18. 2022
Accepted: May, 01. 2022

Keywords:
Composite
Al_2O_3
Microhardness
Al6061
Mechanical Properties
Stir Casting

Corresponding author: *Oktay Adıyaman*

ISSN: *2536-5010* | e-ISSN: *2536-5134*

DOI: https://doi.org/10.36222/ejt.1049835

ABSTRACT

Composites are widely used material types today, and it is known that matrices and additives in composites improve the mechanical properties of the material. In this study, Al6061 matrix and Ni-Al_2O_3 reinforced composite material was produced by stir casting method and the effect of Ni- Al_2O_3 mixture reinforcement on the hardness and tensile properties of the produced composite material was investigated. The determination of the mechanical properties of the samples obtained after the casting process was determined by the results of microhardness analysis and tensile test, and the internal structure of the material was examined by XRD analysis. According to the results of XRD analysis, it was determined that Ni and Al_2O_3 phases were formed together with the matrix element Al. The results of the tensile analyzes showed that the amount of strain in the composite material changed depending on the ratio of the reinforcement element, and the highest strain value occurred in the Ni-Al_2O_3 reinforced sample with Al matrix. However, it was observed that the brittle fracture mechanism was effective in all samples. While the highest microhardness value was obtained in sample 4 (Al6061+ (wt. 15%) Ni+ Al_2O_3) with 89.6 $HV_{0.5}$ value, the lowest microhardness value was obtained from pure Al sample with 66.7 $HV_{0.5}$ value. As a result, it was determined that the Ni-Al_2O_3 reinforcement element increased the microhardness value in the Al matrix composite material.

1. INTRODUCTION

With today's developing technology, it is demanded that the materials should possess more than one properties in themselves at the same time. It is possible that a material is expected to be not only resistant to high wear and corrosion but also light and aesthetic at the same time. For this aim, the composite materials developed in recent years have come forefront. The main material composite materials defined as materials fulfilling more than one function at the same time using the advantageous properties of two or more materials brought together [1-3] is defined as matrix and the materials added into this are called additives. Composite materials are sorted out as metal matrix composites (MMC), ceramics matrix composites (CMC) and polymer matrix composites (PMC) [3]. The interest in MMC has increased due to properties such as high thermal resistance, hardness, resistance to corrosion and wear, ability to resist to tensions steadily in high temperatures together with lightness in industrial applications. Thanks to these advantages, MMCs have been started to be used widely in many sectors such as automotive, aviation and defence industry [3-7]. While the engineering materials, Al, Mg, Zn, Cu, Ti, Ni, Fe, and Co elements and alloys are used as matrix materials in MMC materials, ceramics such as SiC, Al_2O_3 (Alumina), WC, TiC and B_4C are added to MMC as reinforcement materials [2, 8-9].

After steel; Aluminium, one of the materials possessing a wide usage in industry, comes into prominence because of the properties such as high resistance to corrosion, high electric conductivity, low density and recyclability; and owing to these advantages, it is highly preferred in MMCs [10,11].

In this study, Al 6061 serial materials used as matrix are highly preferred materials in especially automotive sector due to their properties such as being casted easily, appropriateness for serial production, easy machinability and low density [12,13].

In addition, aluminium based aluminium metal matrix composites (AMMC), taking place among MMC material types, are materials having the potential to be used in aviation, marine, defence and automotive sectors thanks to their advantages such as low weight, high flexibility, low toughness and excellent resistance in especially low wear and low heat working conditions, though they have low wear resistance and heat performance [14-16].

The resistance of AMMC materials to wear and corrosion is reinforced by adding ceramics as reinforcement elements such as SiC, Al_2O_3 and B_4C in the matrix [17, 18].

Since Al_2O_3 ceramics, which take place among reinforcement elements and relatively have high melting point, offer advantageous properties such as high hardness, resistance to corrosion and wear besides providing compressive strength; therefore, AMMC composites reinforced with Al_2O_3 are widely used in the sectors mentioned above [9, 19, 21].

Raghavendra et al. coated the surface of Al 6061 with Ni-Al_2O_3 material by means of electrodepositing method; and they investigated the effect of this coat material. At the end of the study, they found that the nano-Al_2O_3 particles in Ni matrix gained higher micro hardness and wear resistance [22]. In the study they conducted, Cooke et al. coated the surface of Al 6061 with Ni- Al_2O_3 at 600 °C by means of temporary liquid phase diffusion bond (TLP). They stated that in their study results, using TLP diffusion in Al_2O_3 of Ni coatings containing nano-dispersion, they showed successfully the binding property of the composite. [23]. As a result of literature research, it was established that the studies related to Ni- Al_2O_3 reinforced Al 6061 were mainly based on coating of these materials and the performance of the coating materials; however, it was found out that there were not adequate studies on obtaining Al_2O_3 reinforced Al 6061 material through stir casting process.

In this study, adding the reinforcement materials such as Ni, Al_2O_3 and Ni-Al_2O_3 into Al6061 aluminum serial material, the composites were produced through stir casting method. After manufacturing, the effects of Ni-Al_2O_3 reinforcement material on mechanical (hardness and tensile strength) and microstructure properties of metal matrix composite were studied.

2. MATERIALS and METHOD

Al6061 used as AMMC matrix material in casting process was obtained from Sekoç Aluminum Company. The chemical composition of Al6061is presented in Table 1.

TABLE I
CHEMICAL COMPOSITION OF AL6061

Fe	Si	Cu	Mg	Mn
0,7	0,40-0,8	0,15-0,40	0,8-1,2	0,15
Cr	Ti	Zn	Other	Al
0,04-0,35	0,15	0,25	0,15	Remaining

Reinforcement materials Ni powder (-325 mesh dimension) and Al_2O_3 powder (approximately 1.5 μm) were obtained from the importer company Alfa Easer via Elista Company. General properties of AMMC reinforcement powders are given in Table 2.

TABLE II
PROPERTIES OF THE POWDERS USED IN EXPERIMENTS

Material	Degree of Purity by weight (%)	Powder Dimension (mesh)	Melting Point (ºC)	Specific Weight (gr/cm^3)	Atomic mass (gr/mol)
Nickel	99,5	-325	1453	8.908	58.71
Al_2O_3	96.21	1.5 μm	2.072	3,95	101,96

Before melting process, Al6061 matrices material cut in 15 mm x 15 mm dimensions so that the pieces could go into melting pot, then these pieces were cleaned from oil and impurities on them by submerging them into alcohol. Before casting process, the matrix material, Al6061, weighed in a precise balance and put into the melting pot. The powders used as reinforcement materials added into the matrix material were added in matrix being prepared at a rate of wt. 15% of matrix weight (Table 3)

TABLE III
CASTING PARAMETERS

Sample	Casting Sample
N1	Al6061
N2	Al6061+ (wt. 15%)Al_2O_3
N3	Al6061+(wt. 15%)Ni
N4	Al6061+(wt. 15%)Ni+Al_2O_3

Ni-Al_2O_3, the mixture powder, was mixed with the help of a mixer at 300 rpm/min for 3 hours to obtain a homogenous mixture. After the powders were mixed, Al6061 matrix material and reinforcement material were put in a 10 kg melting pot, and they were melted in this pot (Figure 1).

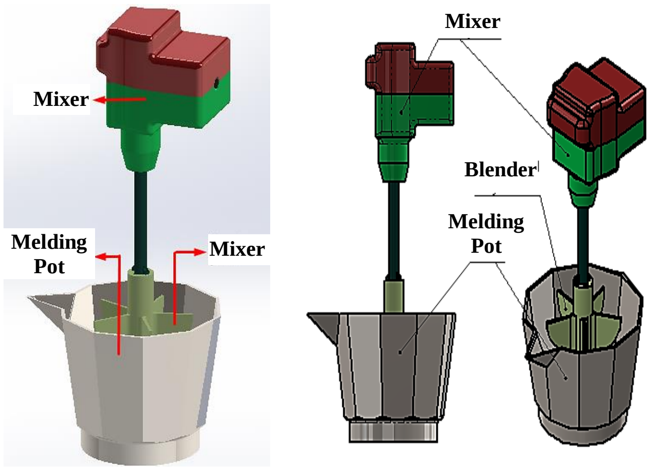

Figure 1. Mixture Preparation Figure for Composite Mixture

In order to melt the matrix material in the melting pot, a heat source was formed out of propane. After waiting about 90 min., the slag layer forming on the melted and liquefied matrix material was taken then mixing process was carried out; and then the reinforcement materials were added in the molten material. After mixing process was completed, the casting of melted mixture into the sample space prepared in dimensions of 15*25*200 mm in a sand mould with a system of sprue at room temperature as presented in the schematic picture in Figure 2.

The molten composite poured down into the sample cavity through sprue was let to solidify at room temperature for 15 min. then the sand moulds were broken and the cast samples were taken out of the mould. The excesses formed in the samples obtained after the casting process were cleaned and the samples were made ready for metallographic and mechanical examinations (Figure 3).

The casted samples were cut sensitively at the sensitive sample taking machine in vertical direction in accordance with the length of the sample for micro-structure and microhardness analyses. The cut samples were exposed to surface polishing process by means of SiC sandpaper within the mesh clearance ranging from 120 to 1200. After polishing process, the surfaces were applied final polishing process and for this, broadcloth was utilized, then the samples were polished with diamond solution with the dimensions of 1 μm and 3 μm. The samples whose polishing process were completed were submerged into Keller solution for cauterization before microstructure examinations. Tensile tests were carried (according to ASTM E8) out at SCHMADZU brand with 1 mm/min. constant feed rate and

250 kN load capacity by preparing the samples whose dimensions are given in Figure 4.

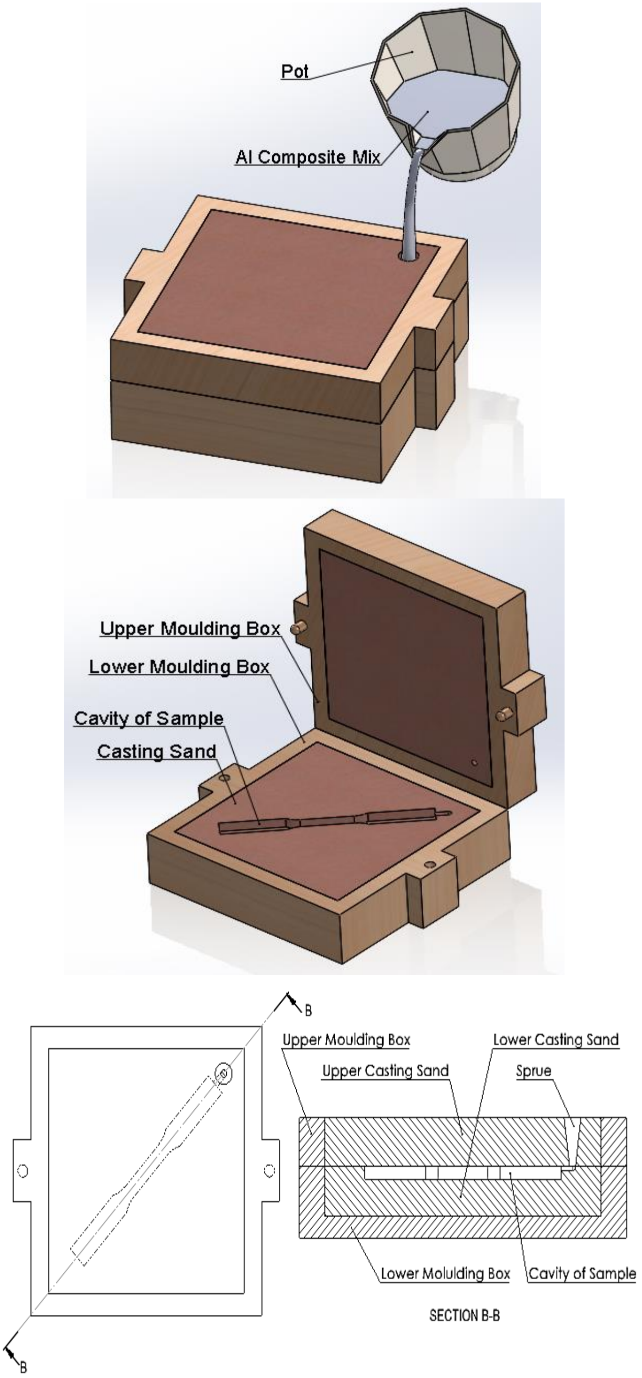

Figure 2. Shematic Picture and section of Sprue Gate

The microhardness analyses were performed by using Future Tech FM700 model digital hardness measurement device from seven different areas. After the cauterization process, the microstructure analyses of the samples were conducted with the help of Nicon optical microscope. In determination of phase components of the samples, X radiation diffraction (XRD) technique was utilized. The XRD analyses were conducted with the help of Rigaku RadB-DMax II diffractometer using cobalt target (λ=1.79026 A^0) and considering a 10° scanning speed per minute at 0.02° foot dimension and 20°-90° scanning intervals.

Figure 3. Separating the excesses and sprues of produced cast samples

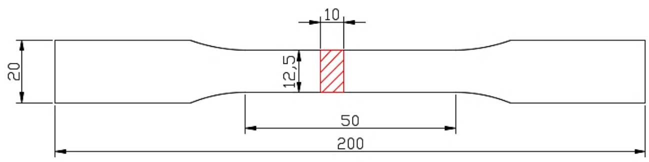

Figure 4. Technical drawing of tensile sample

3. DISCUSSION

The macro-photographs belonging to samples produced after casting process are given place in Figure 5a-d. The samples were produced as mass and tensile samples. Tensile samples were produced considering chip processing shares. It was observed that the amount of pores and spaces were in great number (Figure 5d); after some preventive measures, the samples could be produced properly in a nonporous structure (Figure 5a-c). To produce the samples in nonporous form, it was determined that performing pressured casting of the melted mixture in the mould cavity and adjustment of binding ratios added into the sand prepared for the mould in appropriate portions and improvement of mould design were effective.

In Figure 6, XRD graphic of Al matrix Ni-Al_2O_3 reinforced sample is given place. As can be seen in peak values in the graphic, it was determined that Al element was dense, yet Ni and Al_2O_3 elements were formed low peaks. That Al_2O_3 and Ni were not dense is considered that the reinforcement elements do not provide a proper dispersion in the molten liquid during mixture.

The images of the samples and rupture areas after the tensile test are shown in Figure 7 and the physical properties of the cast samples are given in Table 4. When the surfaces in the rupture regions are examined, it is observed that the samples exhibited a brittle fracture mechanism. It is seen that this result is compatible with previous studies. Karabulut et al. stated that the composite material produced with ceramic reinforcement elements used as reinforcement in aluminium matrix composites is harder and more brittle than pure aluminium material [24]. At this point, it is possible to explain the two reasons why necking region is not formed in the middle of the test samples. The first one was the selection of the tips of test samples as the melt entry point in the casting (Figure 3, 5a-d). This causes different cooling rates to occur in different parts of the material. As a result, it is inevitable that very small amount of irregularities in the lattice structure and grain density will occur. When the fracture regions are examined (Figure 7), it is seen that all test samples fracture from the same region. This situation supports our opinion. The second reason is thought that the irregularities that may occur in the material mixture may cause the fracture zone not to occur in the middle of the sample.

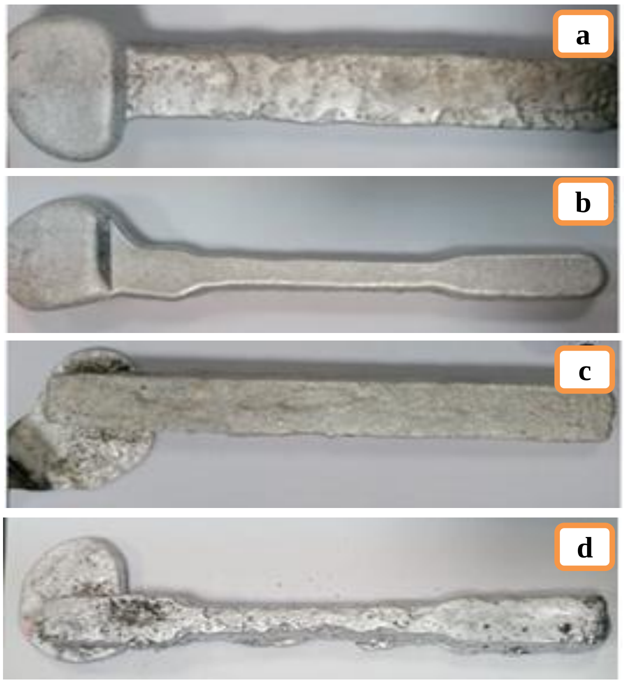

Figure 5. Samples produced after casting process

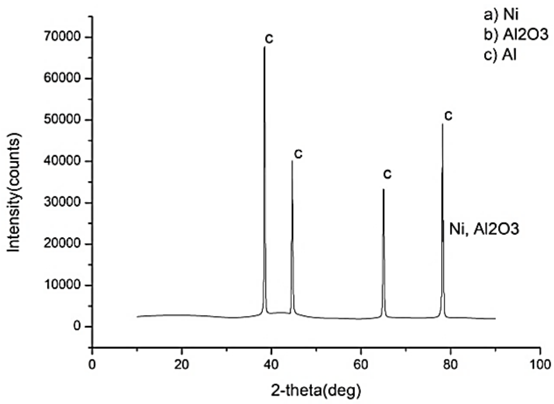

Figure 6. XRD analysis results of Al/Ni-Al_2O_3 sample

When Figure 7 is examined, it is seen that the other test samples (samples 1, 2, 3, excluding sample 4) broke off from the radius region, whereas in sample no. 4, the rupture region was in the region farther from the radius region. The tensile graph of the tensile test of the composite samples obtained is shown in Figure 9. According to this graph, it was observed that the lowest elongation value was in sample 2 and the highest elongation was in sample 4. When all the data obtained in Figure 7 and Figure 8 are examined, it is concluded that Ni-Al_2O_3 reinforcement material in the cast composite material has an effect on increasing the tensile strength of the composite material. Similarly, it is understood from the graph in Figure 8 that the tensile strength of sample 3 is better than samples 1 and 2. It is seen in most studies that the addition of Ni into aluminium alloys increases the density; and this increases the strength and hardness of the material. The high-density value of nickel, 8.9 g/cm^3, led to an increase in the density of aluminium alloys with the increase of nickel content [25-29].

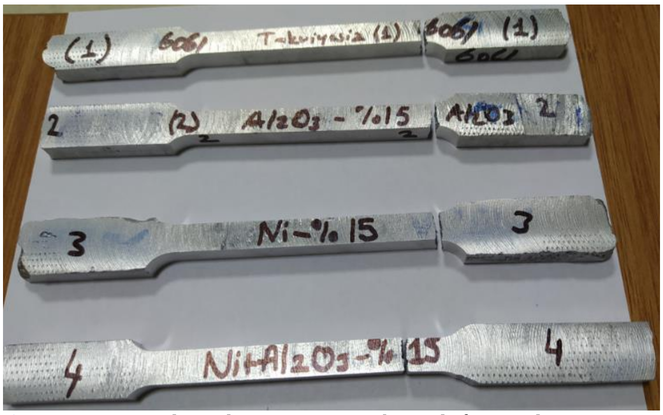

Figure 7. Test samples and rupture regions obtained after tensile test

TABLE IV
PHYSICAL PROPERTIES OF THE CAST SAMPLES

Material	Modulus of Elasticity (Gpa)	Density (MJ/m^3)
Al 6061	3,24	1,55
Al6061 (%15 Al_2O_3)	2,29	0,78
Al6061 (%15 Ni)	2,92	2,31
Al6061(%15 Ni+ Al_2O_3)	2,70	2,41

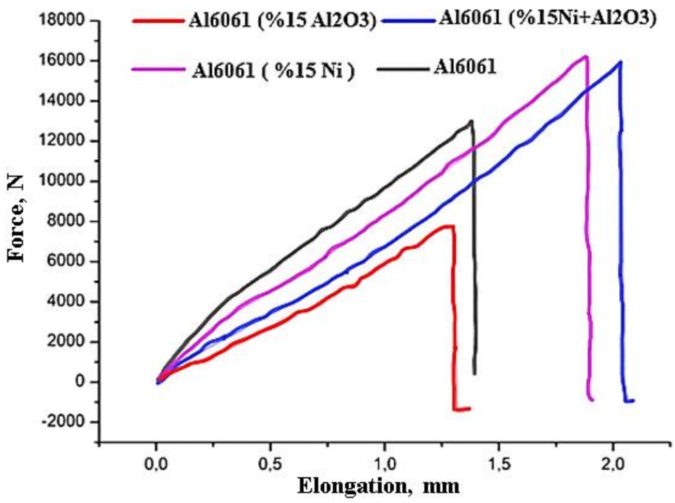

Figure 8. Result graph of tensile test

Microhardness measurements of the samples produced by stir casting method with Al6061 matrix and reinforced with wt.15% Al_2O_3, wt.15% Ni and wt.15% Al_2O_3+Ni by weight, respectively, were made. The average hardness values of these measurements are shown in Figure 9.

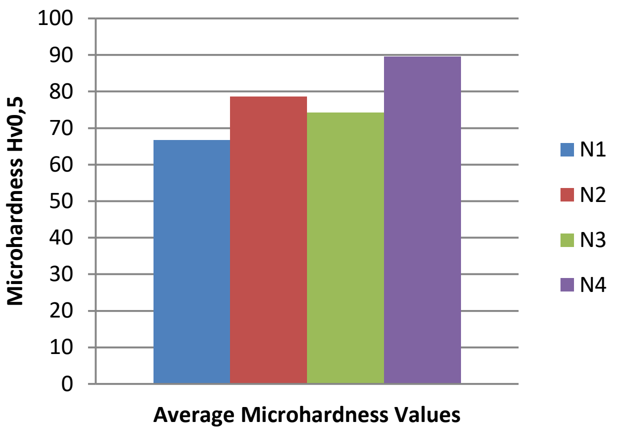

Figure 9. Microhardness values of samples

As a result of the hardness measurements, the highest average hardness value was obtained as 89.6 $HV_{0.5}$ in the sample reinforced with wt.15% Ni-Al_2O_3. The lowest hardness value was obtained as 66.7 $HV_{0.5}$ from the test sample no. 1 (Al) without reinforcement. The microhardness values obtained in other samples were measured as 78.6 $HV_{0.5}$ in Al_2O_3 reinforced test sample no. 2 and as 74.3 $HV_{0.5}$ in Ni added test sample no. 3, respectively.

Sivananthan et al. added Al_2O_3 at different rates as a reinforcement element into Al6061 by stir casting method. In their hardness measurements after the tests, they stated that they obtained 81 HV hardness values in the 4% by weight Al_2O_3 reinforced sample and an average of 75 HV hardness values in the 2% weight samples. In the light of these results, both in this study and in previous studies [29], it was observed that the microhardness of the Al6061 alloy increased with the increase in the amount of Al_2O_3 particles in the composite material.

It is known that the hard and brittle Al_2O_3 particles used as reinforcements cause dispersion hardening in the matrix. It was seen in previous studies that these particles act as the second phase in the matrix and contribute to the hardening of the composites by resisting the movement of the dislocations. [31,32]. In another study, Ni and Al_2O_3 were added as reinforcing elements into the Al matrix, and as a result, higher hardness obtained with the increase of nickel amount in the samples with 10% Ni-40% Al_2O_3-50% Al mixture ratios. It was stated that the decrease in the amount of Al used as a matrix element contributed to the high hardness value [25]. In another study, it was observed that the hardness value increased as B_4C grain reinforcement ratio increased. While the highest hardness value was obtained as 68.1 $HV_{0.5}$ from 16% reinforced B_4C and Al matrix composite, the lowest hardness value was obtained as 48.5 $HV_{0.5}$ from pure Al [33]. Kılıç stated that in the B_4C reinforced coating study, the hardness value of the coating layer was 2-2.5 times higher than the substrate [34]. Considering the previous studies, it is seen that the hardness of Al matrix composites varies depending on the added reinforcement element and its amount. In this study, it was determined from the results obtained that the results obtained increased due to the increase of the reinforcement element in parallel with the literature

4. CONCLUSION

In this study, Ni-Al_2O_3 composite material with Al6061 matrix was produced using the stir casting method. After production, the effect of the reinforcing element Ni-Al_2O_3 matrix on the hardness and tensile properties was investigated. After the analysis and evaluation of the data obtained after the evaluation, the following conclusions were reached;

- It was determined that the highest elongation value at which the tensile analyses changed depending on the reinforcement element occurred in Ni- Al_2O_3 reinforced sample with Al matrix.
- However, it was observed that the brittle fracture mechanism was effective in all samples.
- While the highest microhardness value was obtained in sample 4 with 89.6 $HV_{0.5}$ value, the lowest value was obtained from pure Al sample with 66.7 $HV_{0.5}$.
- In the light of the results obtained, it was determined that Ni-Al_2O_3 reinforcement element increased the Al matrices microhardness.
- As a result of XRD analysis, it was determined that Al element is dense, while Ni and Al_2O_3 elements also occur at low peaks.

REFERENCES

[1] Senel M.C. et al., “The investigation on mechanical properties and microstucture of SiC reinforced aluminum matrix composites,” Technological Applied Sciences (NWSATAS), to be published. DOI:10.12739/NWSA.2018.13.2.2A0142.

[2] Oztop B, Gurbuz M, “Investigation of properties of composites produced by reinforcement graphene matrix obtained from waste aluminium,” International Journal of Multidisciplinary Studies and Innovative Technologies, vol. 1, no 2, pp 4 – 8, 2017.

[3] Rangrej S. et al., “Effects of reinforcement additions on properties of aluminum matrix composites – A review,” Materials Today: Proceedings, to be published. DOI: 10.1016/j.matpr.2020.10.604.

[4] O'Connor M.J., Wawner F.E., Jones C.C., “An investigation of the microstructure and mechanical properties of the macro-interface in selectively reinforced aluminium castings,” Journal of Materials Science, vol. 31, pp. 164-171, 1996.

[5] Shunmugasundaram M., Kumar A.P., Sankar L.P., Sivasankar S., “Experimental investigation and process parameters optimization of stir cast aluminium metal matrix composites to improve material removal rate,” Materials Today: Proceedings, vol. 27, pp. 883–888, 2020.

[6] Rao E.S., Ramanaiah N., “Influence of heat treatment on mechanical and corrosion properties of aluminium metal matrix composites (AA 6061 reinforced with MoS2),” Materials Today: Proceedings, vol. 4, pp. 11270–11278, 2017.

[7] Schneider Y., Soppa E., Kohler C., Mokso R., Roos E., “Numerical and experimental investigations of the global and local behaviour of an Al(6061)/Al2O3 metal matrix composite under low cycle fatigue,” Procedia Engineering, vol. 10, pp. 1515–1520, 2011.

[8] Karakoc H., Cıtak R., “Study on weldability of B_4C reinforced aluminium composite materials with TIG welding,” El-Cezerî Journal of Science and Engineering, vol. 4, no. 3, pp. 584-592, 2017.

[9] Senthil S. et al., “Manufacturing processes and recent applications of aluminium metal matrix composite materials: A review,” DOI: 10.1016/j.matpr.2020.08.792.

[10] Gokce A., Findik F., Kurt A.O., “Powder metallurgy processing of aluminum alloys,” Engineer and Machinery, vol. 58, no. 686, pp. 21-47, 2017.

[11] Venkata S. et al., “Investigation of SiC and AL_2O_3 – Reinforced with aluminium composites- A review,” DOI: 10.1016/j.matpr.2020.10.276.

[12] Prajulraj P. et al., “Experimental investigation on mechanical and morphological properties of AA 6061 reinforced with silicon carbide,” DOI: 10.1016/j.matpr.2020.07.501.

[13] Ramesh C.S., Keshavamurthy R., Channabasappa B.H., “Abrar Ahmed, Microstructure and mechanical properties of Ni–P coated Si3N4 reinforced Al6061 composites,” Materials Science and Engineering A, vol. 502, pp. 99–106, 2009.

[14] Su H., Gao W., Feng Z., Lu Z., "Processing, microstructure and tensile properties of nano-sized Al_2O_3 particle reinforced aluminum matrix composites," Materials and Design, vol. 36, pp. 590–596, 2012.

[15] Okumuş M., Bülbül B,. "Investigation of Thermal and Microstructural Properties of Al-4.5Cu/SiC Composite Produced by Mechanical Alloying Method," GU J Sci, Part C, vol. 8, no. 2, pp. 405-417, 2020.

[16] Panwar N., Chauhan A., "Fabrication methods of particulate reinforced Aluminium metal matrix composite-A review," Materials Today: Proceedings, vol. 5, pp. 5933–5939, 2018.

[17] Bayar H., Subasi M., Karatas C., "SiC takviyeli alüminyum alaşim matrisli kompozit malzemenin yüksek basinçli kalip dökümü ve mekanik özellikleri," Gazi University Journal of Science GU J Sci Part C, vol. 3, no. 4, pp. 603-612, 2015.

[18] Kalaiselvan K., Murugan N., Parameswaran S., "Production and characterization of AA6061–B4C stir cast compo," Materials and Design, vol. 32, pp. 4004–4009, 2011.

[19] Shang F., Cao Z., Zhang P., Qiao B., Li H., "Microstructure and properties of Ni/ Al_2O_3 composites prepared by powder injection molding," IOP Conf. Series: Materials Science and Engineering, vol. 389, pp. 012-022, 2018.

[20] Sajjadi S.A., Ezatpour H.R., Beygi H., "Microstructure and mechanical properties of Al– Al_2O_3 micro and nano composites fabricated by stir casting," Materials Science and Engineering A, vol. 528, pp. 8765–8771, 2011.

[21] Yang G., Song W., Lu J, Hao Y, Li Y, Ma Y,. "Microstructure of surface composite Al_2O_3/Ni on copper substrate produced by vacuum infiltration casting," Materials Science and Engineering A, vol. 418, pp. 223–228, 2006.

[22] Raghavendra C. R., Basavarajappa S., Sogalad I, "Influence of pin temperature on dry sliding wear behaviour of Ni– Al_2O_3 composite coating on Al6061 substrate," J. Inst. Eng. India Ser. C, vol. 101, no. 4, pp. 671–681, 2020.

[23] Cooke K O, Khan T I, Oliver G D,. "Effect of Ni– Al_2O_3 nanocomposite coating thickness on transient liquid phase bonding of Al 6061 MMC," Science and Technology of Welding and Joining, vol. 17, no. 1, pp. 22-31, 2012.

[24] Karabulut H., Citak R., Cinici H., "Effect of mechanical alloying duration on transverserupture stregth of Al+10% Al_2O_3 composites," Journal of the Faculty of Engineering and Architecture of Gazi University, vol. 28, no. 3, pp.635-643, 2013.

[25] Sak N., Zeren M., Yamanoglu R., "Characterization of properties in alumina doped and nickel alloyed aluminum based composites," Koc. Üni. Fen Bil. Der., vol. 1, no. 1, pp. 1-7, 2018.

[26] Bhattacharyya M., Kumar A. N., Kapuria S. "Synthesis and characterization of Al/SiC and Ni/Al_2O_3 functionally graded materials," Materials Science and Engineering: A, vol. 487, no. 1-2, pp. 524-535, 2008

[27] Fahrenholtz W. G., Ellerby D. T., Loehman R. E. "Al2O3–Ni composites with high strength and fracture toughness," Journal of the American Ceramic Society, vol. 83, no. 5, pp.1279-1280, 2000.

[28] Kilic M., "The Investigation of microstructures and fabrication of functionally graded intermetallic materials by self-propagating high-temperature synthesis," Batman University Journal of Life Sciences, vol. 5, no.2, pp. 87-98, 2015.

[29] Imak A., Kirik I., Kilic M., "Comparison of microstructure and wear behaviors of PTA coated AISI 304 with alumina, boron and ekaboron III powder," Materials Testing, vol. 64, no. 4, pp. 541-549, 2022.

[30] Sivananthan S., Reddy V.R., Samuel C.S.J., "Preparation and evaluation of mechanical properties of 6061Al- Al_2O_3 metal matrix composites by stir casting process," Materials Today: Proceedings, vol. 21, pp. 713–716, 2020.

[31] Baradeswaran A., Perumal A.E., "Study on mechanical and wear properties of Al 7075/ Al_2O_3/graphite hybrid composites," Composites: Part B, vol. 56, pp. 464–471, 2014.

[32] Pathak J.P., Singh J.K., Mohan S., "Synthesis and characterisation of aluminium– silicon–silicon carbide composites," Indian J Eng Mater., vol. 13, pp. 238–46, 2006.

[33] Celik Y.H., Secilmis K., "Investigation of wear behaviours of Al matrix composites reinforced with different B_4C rate produced by powder metallurgy method," Advanced Powder Technology, vol. 28, no. 9, pp. 2218-2224, 2017.

[34] Kilic M., "Microstructural Characterization of Ni-Based B_4C Reinforced Composite Coating Produced by Tungsten Inert Gas Method," Arch. Metall. Mater. Vol. 66, no. 3, pp. 917-924, DOI: 10.24425/amm.2021.136398.

BIOGRAPHIES

Oktay ADIYAMAN obtained his BSc degree in Mechanical Education from Gazi University in 1994. He received the BSc., and MSc. diploma in Mechanical Engineering from the Gazi University in 1998 and 2003 respectively, and PhD degrees in Graduate School of Science, Engineering and Technology of the Firat University in 2015. His research interests are machinebility, manufacturing and tribology. In 2016 he joined the Faculty of Technology, Batman University as a Assist Prof. where he is presently a professor.