ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 10, Issue 1, January 2023

Exploration of Mechanical Properties of Al 6061 - TiB_2 Composites

R. Arunkumar[1], P V Arun Prakash[2]

[1]Assistant Professor, Department of Mechanical Engineering, MRK Institute of Technology, Kattumannarkoil, Tamilnadu, India.

[2]Assistant Professor, Department of Mechanical Engineering, MRK Institute of Technology, Kattumannarkoil, Tamilnadu, India.

Abstract: The present research work focuses on the production of aluminum matrix composites reinforced with various weight percentages of titanium diboride (TiB_2) particles by the stir casting technique. The percentage of reinforcement is varied from 0 wt.% to 10 wt.% in a stage of 2.5%. The mechanical properties of the fabricated aluminum matrix composites are investigated. The test results demonstrated that the tensile strength and hardness rise with the increase in TiB_2 percentage, whereas the percentage of elongation decreases as the TiB_2 percentage increases.

Keywords: Al 6061, Titanium diboride, Mechanical properties, Tensile strength, Percentage elongation & Hardness.

I. INTRODUCTION

The need for advanced technology materials in important fields such as automobile, aerospace, defence, nuclear applications, and maritime is increasing. Single-component materials do not meet the needs of advanced engineering applications such as resistance to high temperatures associated with the melting point of the material, high strength, high elastic modulus, high fracture toughness, high fatigue strength, high wear resistance and low density. Therefore, the need for composite materials with superior properties is increasing day by day.

Composite materials consist of a mixture of two or more elements to combine their superior properties in a single material. They are classified as metal, ceramic and polymer matrix composites according to matrix materials. Metal matrix composites, which combine soft base metal with hard refining material, have recently attracted attention due to their unique strength and stiffness. Now a day, in the majority of metal matrix composites aluminum is frequently employed as a matrix. Aluminum matrix composites have superior properties such as high modulus of elasticity, high strength, high fatigue resistance, high abrasion resistance, high rigidity, stability at high temperatures, high strength-to-weight ratio, low density and low coefficient of thermal expansion. Aluminum matrix composites are produced using various techniques, such as powder metallurgy, squeeze casting, spray casting, ball milling, stir casting, and friction stir processing, depending on the kind, size, and morphology of the reinforcing particles. Due to its low cost and ease of use, the stir casting method is one of the most widely used liquid phase production methods. Metal carbides (SiC, TiC, B_4C), metal borides (TiB_2, ZrB_2), metal oxides (Al_2O_3, TiO_2, ZrO_2), and metal nitrides (Si_3N_4, TiN) are reinforced in the aluminum matrix's melt at atmospheric pressure during the casting process.

II. LITERATURE REVIEW

Pravin Vyavahare et al [1] investigated the mechanical properties of a new composite, which was manufactured by a stir casting process where a matrix as Al 356 was used and reinforced with B4C. In the processing of composites, B4C particles have been used as reinforcement materials with different weight percentages (3, 6, 9, and 12). The

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 10, Issue 1, January 2023

evaluation of mechanical properties viz; tensile strength, compressive strength, density and hardness were carried out. It was found that the tensile strength, compressive strength and hardness of the metal matrix composite increase as weight fractions of the B4C particles increase.

S. Krishna Prasad et al [2] have used aluminum 7075 as the matrix material and titanium carbide with weight percentages (0, 3 & 6%) as the reinforcement to produce the composite by stir casting. Aluminum matrix composites are studied in depth to learn more about their microstructures and mechanical properties. The result shows that as the amount of TiB_2 particles in the aluminum matrix increases, the material's mechanical properties, such as ultimate tensile strength and hardness, increase at the expense of ductility.

Mahesh L et al [3] have chosen aluminum as the matrix material and 5 to 15wt% of titanium oxide as the reinforcement to produce the composite by powder metallurgy process. The effect of reinforcement on the density, porosity, hardness, strength and microstructure of composites was investigated. The density, porosity, hardness and compressive strength of Al-TiO_2 composites were found to increase with an increase in the weight % TiO_2 from 5 to 15 weight percent.

G.B.Veeresh Kumar et al [4] investigated the effect of the addition of zirconium dioxide particulates with Al 6061 at various proportions. Four casts of different percentages of reinforcement from 0 to 6 wt.% in step 2 are fabricated using the liquid metallurgy technique. The prepared composites were subjected to various physical, and mechanical tests. The researchers observed that the density, hardness and tensile strength increased significantly with the increase in the percentage of reinforcement in the matrix alloy, while the percentage elongation was found to be decreased.

Akshay B R et al [5] fabricated aluminum 6061 - boron nitride surface composite by friction stir processing and studied its mechanical properties. The percentage of boron nitride was varied from 0 to 6wt% in steps of 3 wt %. Results show that composite exhibited higher hardness & tensile strength when compared to unreinforced ones.

K S Madhu et al [6] have prepared hybrid metal matrix composites by using aluminum 7029 as the matrix material and boron carbide (B_4C) and graphite (Gr) as the reinforcing material. The composite is produced by conventional stir casting in which the weight fraction of the boron carbide is varied (from 2%, 4%, 6% and 8%) by fixing the graphite weight fraction (2%). The samples are prepared according to ASTM standards and tested to find the various mechanical properties like tensile, hardness and impact. They determined that the hybrid composite tensile strength was increased, with a decrease in the elongation rate of unreinforced aluminum alloy. The impact strength and hardness property of a hybrid composite was increased compared to the base alloy.

Pardeep Sharma et al [7] investigated the effect of the addition of silicon nitride (Si_3N_4) particles with aluminum (AA6082-T6) at various proportions such as 0%, 3%, 6%, 9% and 12%. Mechanical properties of the fabricated aluminum matrix composites are investigated. They stated that the tensile strength and hardness increased with the increase in the percentage of reinforcement in the matrix alloy, while the percentage elongation was found to be decreased.

The objective of the work

In this study, experimental analysis is carried out by altering the weight percentage of TiB_2 in the Al6061 composite to determine tensile strength, percentage of elongation, and hardness.

III. MATERIAL AND METHODS

Materials

Al 6061 alloy is used as the most 6xxx series aluminum alloy offering a range of good mechanical properties, good surface finish, excellent corrosion resistance and high workability. Table-I displays the parent material's chemical composition. The properties of titanium diboride (TiB_2), which include its comparatively high melting point,

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 10, Issue 1, January 2023

strength-to-density ratio, hardness and wear resistance, are well known as those of a ceramic material with relatively high strength and endurance.

Table – I: Chemical composition of Al6061

Element	Weight %	
	Minimum	Maximum
Mg	0.8	1.2
Si	0.4	0.8
Fe	0.0	0.7
Cu	0.15	0.40
Cr	0.04	0.35
Zn	0.0	0.25
Ti	0.0	0.25
Mn	0.0	0.15
Al	95.85	98.56

Fabrication of Composites

The most widely used commercial method for making aluminum-based composites is stir casting. Particles of titanium diboride were initially preheated separately at 850°C. A sufficient quantity of aluminum alloy has been placed in a crucible and left inside the muffle furnace until it completely melts. Preheated titanium diboride particles are then added into the crucible having molten matrix material. The reinforcement particles have been mixed. After that, the reinforced particles and melted matrix are poured into the mold that has been preheated.

Mechanical test

The aluminum alloy 6061 and composite specimens are further subjected to mechanical tests like tensile and hardness.

IV. RESULTS AND DISCUSSION

Table - II lists the composite specimens' mechanical characteristics.

Table - II: Mechanical properties of composites.

S. No	Wt. % of TiB_2	Tensile strength (MPa)	Percentage Elongation	Hardness
1	0.0	178.1	8.1	41
2	2.5	194.4	7.7	54
3	5.0	203.8	5.9	63
4	7.5	213.3	4.5	71
5	10.0	220.7	3.7	81

Tensile strength

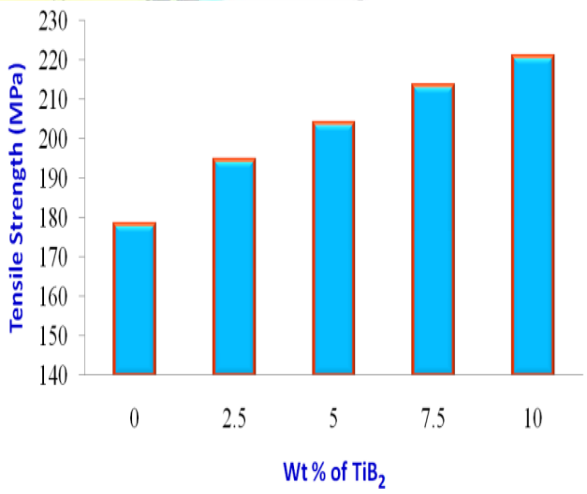

Figure-1: Tensile strength of composites

The effect of TiB_2 on the prepared composites and the AA6061 base matrix alloy's tensile strength is depicted in Figure 1. The tensile strength has been observed to increase with the increase in TiB_2 particles and it is notably greater than the tensile strength of the base matrix alloy. The composite with 10wt. % TiB_2 had a maximum tensile strength of 220.7 N/mm^2, which is 23.91% higher than the

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 10, Issue 1, January 2023

AA6061 matrix alloy. The tensile strength and load-bearing capacity of composites were improved by including a higher percentage of titanium diboride. The *titanium diboride* strengthening particles increased the tensile stress resistance in the composites. Jayasheel Harti et al [8] developed the TiC reinforced composites and study the effect of reinforcements on the mechanical properties. The aluminum (Al 2219) - TiC composites were fabricated by the stir casting process with different particulate weight percentages (0%, 2%, 4%, and 6%). The results showed that when the weight percent of reinforcement in the matrix grew, the composite's tensile strength increased. M. S. Sukumar et al [9] produced Al / Al_2O_3 composites and analyzed their mechanical properties. The stir casting method is used to fabricate the aluminum metal matrix composites, with the reinforcement volume percentages ranging from 0 to 10 wt.%. The analysis reveals that as the weight percentage of Al_2O_3 particles rises, so does the composite's tensile strength. Senthilkumar Packirisamy et al [10] fabricated an aluminum-silicon carbide composite and investigated the effect of reinforcement on the mechanical properties of aluminum metal matrix composite. The reinforcing particles in the Al6063 alloy varied from 0% to 9% by weight. The results of this study showed that the tensile strength of the composites is higher than that of the unreinforced matrix metal, and the tensile strength of the composites increased with an increase in the amount of SiC in the matrix phase.

Percentage elongation

Figure 2 depicts the percentage elongation of the prepared composites and the matrix alloy AA6061. Figure 2 shows that the percentage of elongation decreases as the percentage of TiB_2 increases. The percentage of elongation of the composites is lower than that of the matrix alloy, as shown in the figure. Further, from the graph, the trends of the % elongation can be found to be decreased with an increase in alumina content in the composites.

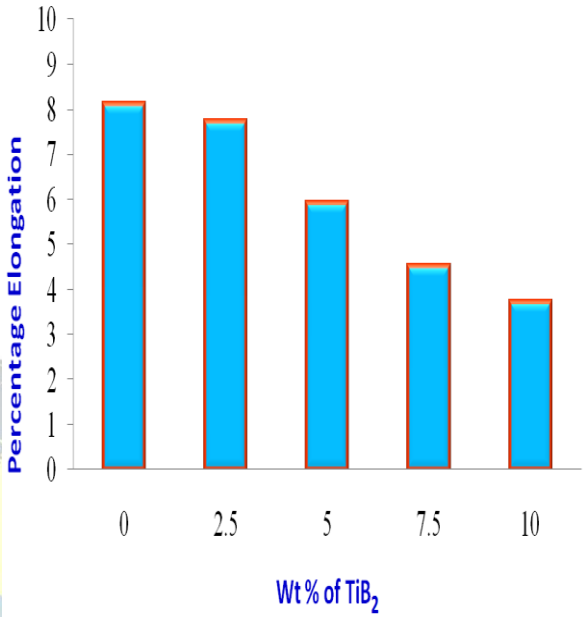

Figure-2: Percentage elongation of composites

The decrease in elongation of the composite may be due to an increase in the brittleness of the composite and the addition of harder TiB_2 particles. P. Senthilkumar [11], has produced composite material by reinforcing 0, 2.5, 5 and 7.5 wt% Al_2O_3 particles to Al 6061 aluminum alloy by using the stir casting method. It was determined that the elongation of composites decreased with an increase in the weight percentage of Al_2O_3 in the matrix material. J. Chandrasheker et al [12] created aluminum- boron carbide composite and researched its mechanical properties. Aluminum alloy (AA7050) is selected as the matrix material and boron carbide (B_4C) as reinforced particles are mixed in different weight percentages (0, 3, 6, 9, and 12 wt %). They found that the weight percentage of boron carbide in the matrix material decreased the elongation of composites. The elongation of composites is lower than that of un-reinforced Al alloy. The mechanical and wear properties of aluminum-based composites reinforced with Al_2O_3 were investigated by Madeva Nagaral et al [13]. A liquid metallurgy route was used to develop the Al 6061/ Al_2O_3 composites samples with various Al_2O_3 weight percentages produced (0, 3, 6, 9, and 12wt. percent). The

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 10, Issue 1, January 2023

results indicated that the expansion of a weight level of Al_2O_3 reinforcement decreases the percentage of elongation in the composites.

Hardness

Figure-3 shows the graph between the hardness versus the TiB_2 weight percent. It shows that adding TiB_2 particles to an aluminum 6061 alloy improves the hardness of the composites. The presence of harder titanium diboride reinforcement leads to the increase in constraint to plastic deformation of the matrix during the hardness test. [14] proposed a system, this fully automatic vehicle is equipped by micro controller, motor driving mechanism and battery. The power stored in the battery is used to drive the DC motor that causes the movement to AGV. The speed of rotation of DC motor i.e., velocity of AGV is controlled by the microprocessor controller. This is an era of automation where it is broadly defined as replacement of manual effort by mechanical power in all degrees of automation. The operation remains an essential part of the system although with changing demands on physical input as the degree of mechanization is increased..

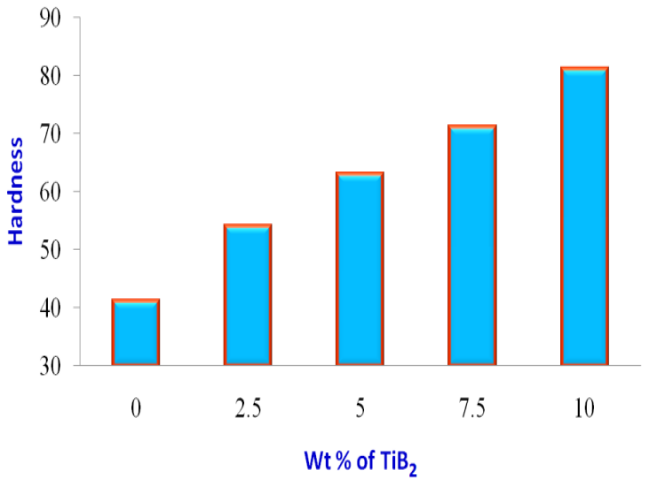

Figure-3: Hardness of composites

The result shows that the hardness of the composites is higher than the unreinforced matrix metal and the hardness of the composites increases linearly with increasing the weight percentage of zinc oxide. The mechanical properties of aluminum-based composites reinforced with silicon carbide were investigated by Senthilkumar Packirisamy and Suresh Ramachandran [10]. Stir casting was used to develop the Al6063-SiC composite samples with various silicon carbide weight percentages produced (0, 3, 6 and 9wt.%). The results showed that the expansion of a weight level of SiC reinforcement increases the hardness of the composites. Madeva Nagaral et al [15] investigated the mechanical properties of aluminum reinforced with TiB_2 particle composites, which were produced through the stir-casting method. Al2618 alloy was taken as the base matrix, in which TiB_2 particles were used as reinforcements. 3 and 6 wt.% particles of TiB_2 were added to the base matrix. Mechanical properties such as hardness, yield strength and tensile strength were evaluated according to ASTM standards. The result of this test showed that the hardness of the metal matrix composite increases as the weight percentages of the TiB_2 particles increase.

V. CONCLUSION

In this research work, the effects of reinforcement particles on the mechanical properties of composites made of the aluminum metal matrix were examined. The composites were made of Al 6061- TiB_2 using the stir casting method.

The experimental results led to the following conclusions.

- Al 6061-TiB_2 composites have demonstrated greater tensile strength in comparison to Al 6061 base alloy. Additionally, as the weight percentage of TiB_2 reinforcement rises, composites' tensile strength increases.
- The elongation of composites is lower than that of un-reinforced Al-alloy and the elongation of composites decreased with an increase in the weight percentage of TiB_2 in the matrix material.

The hardness of the composites is higher than the unreinforced matrix metal and the hardness of the composites increases with an increase in TiB_2 percentage.

REFERENCES

[1] Pravin Vyavahare, Bharat Admile, and S G Kulkarni, "Mechanical Characterization of Stir Cast Al356-B_4C Composite," *International Journal of Engineering Research & Technology*, Vol. 10, Issue. 04, pp.522-525, April-2021.

[2] S. Krishna Prasad, Samuel Dayanand, M. Rajesh, Madeva Nagaral, V. Auradi and Rabin Selvaraj, "Preparation and Mechanical Characterization of TiC Particles Reinforced Al7075 Alloy Composites," *Advances in Materials Science and Engineering*, Volume 2022, 11 pages. https://doi.org/10.1155/2022/7105189.

[3] Mahesh L, J Sudheer Reddy, "Fabrication of TiO_2 Reinforced Aluminum Metal Matrix Composites Through P/M Process," *International Journal of Engineering Research & Technology*, Vol. 3, Issue. 17, NCERAME - 2015 Conference Proceedings.

[4] G.B.Veeresh Kumar, R. Pramod, Ch Guna Sekhar, G.Pradeep Kumar and T. Bhanumurthy, "Investigation of physical, mechanical and tribological properties of Al6061- ZrO2 nano-composites," *Heliyon* 5 (2019) e02858.

[5] Akshay B R, R Keshavamurthy, Prabhakar Kuppahalli and Madhu Sudhan. J, "Mechanical Properties of Friction Stir Processed Al6061-BN Surface Composite," *Materials Today: Proceedings*, 5 (2018) 24568–24577.

[6] K S Madhu, B N Sharath, C V Venkatesh and D G Pradeep, "Evaluation of Mechanical Properties of Ceramic Reinforced Aluminium-7029 Hybrid Composite," IOP Conf. Series: *Materials Science and Engineering* 1189 (2021) 012019.

[7] Pardeep Sharma, Satpal Sharm and Dinesh Khanduja, "Production and some properties of Si_3N_4 reinforced aluminum alloy composites," Journal of Asian Ceramic Societies, (2015), http://dx.doi.org/10.1016/j.jascer.2015.07.002

[8] Jayasheel Harti, T. B. Prasad, Madeva Nagaral and K. Niranjan Rao, "Hardness and Tensile Behavior of Al2219-TiC Metal Matrix Composites," *Journal of Mechanical Engineering and Automation*, 2016, 6(5A): 8-12.

[9] M. S. Sukumar, K. Anand Babu and P. Venkataramaiah, "Exploration of mechanical behavior of Al_2O_3 reinforced aluminium metal matrix composites," *Mechanical Engineering*, 72, pp.25462-25465, 2014.

[10] Senthilkumar Packirisamy and Suresh Ramachandran, "Investigation of mechanical properties of Al 6063-SiC composites," *World Journal of Advanced Engineering Technology and Sciences*, 07(02), pp.189–194, 2022.

[11] P. Senthilkumar, "Experimental Investigation on Mechanical Properties of Aluminium 6061-Al_2O_3 Composites," *International Journal of Advanced Research Trends in Engineering and Technology*, Vol. 1, Issue 4, pp.66-72, 2014.

[12] J. Chandrasheker and N. V. S. Raju, "Experimental Investigation on Mechanical Properties of AA7050/B_4C Composites," ARPN Journal of Engineering and Applied Sciences, Vol. 16, No. 23, pp.2470-2474, 2021.

[13] Madeva Nagaral, Bharath V and V Auradi, "Effect of Al_2O_3 Particles on Mechanical and Wear Properties of 6061al Alloy Metal Matrix Composites," Journal of Material Sciences & Engineering, Vol. 2, Issue. 1, pp.1-4, 2013.

[14] Christo Ananth, M.A.Fathima, M.Gnana Soundarya, M.L.Jothi Alphonsa Sundari, B.Gayathri, Praghash.K, "Fully Automatic Vehicle for Multipurpose Applications", International Journal Of Advanced Research in Biology, Engineering, Science and Technology (IJARBEST), Volume 1,Special Issue 2 - November 2015, pp.8-12.

[15] Madeva Nagaral, Samuel Dayanand, V.K.Basavaraj and V. Auradi, "Production and mechanical properties of Al2618-TiC composites," Proceeding of NCRIET-2015 & Indian J.Sci.Res. 12(1):055-059, 2015.