Journal of Mines, Metals and Fuels, *71(12A): 137-143; 2023. DOI: 10.18311/jmmf/2023/43186*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Study of Tribological Behaviour of T6 Heat Treated Al7075-AlN Metal Matrix Composites

T. L. Annapoorna[1], Batluri Tilak Chandra[1]*, and H. S. Shivashankar[2]

[1]Department of Mechanical Engineering, Sri Sidhartha Institute of Techanology, Tumkur - 572102, Karnataka, India; annapoornatl@ssit.edu.in, batluritilakchandra@ssit.edu.in

[2]Department of Mechanical Engineering, Siddaganga Institute of Technology, Tumkur - 572103, Karnataka, India

Abstract

Metal matrix composite of aluminium was developed because of excellent properties like high level of strength, light weight, stiffness, and wear resistance. An effort is made to investigate the impact of reinforcement particles namely aluminium nitride on Tribological behaviour of aluminium 7075 alloy matrices. The percentage weight of aluminium nitride particulate considered here is 2wt% to 10wt% in a step of 2wt%. Stir casting process liquid metallurgy method is used to manufacture of composites. The as-cast aluminium alloy and composites specimens are prepared by lathe machine and prepared for heat treatment by subjecting to a temperature of 470ºC for 2-hour solutionizing treatment followed by ice medium quenching, next the specimens are subjecting to artificial ageing for duration of 8 hour with temperature of 120°C. Through a pin and disc test machine, the Tribological characteristics of as cast and composite alloys were investigated both before and after heat treatment. The wear rate was examined as a function of sliding velocity and applied load. Using a scanning electron microscope, the wear surface morphology and pin wear behavior were examined.

Keywords: *Heat Treated, SEM, Solutionizing, Wear Analysis.*

1.0 Introduction

The most adaptable and innovative engineering materials are Composite materials, which find applications in aerospace, medicine, automobile, defense and infrastructure. The composite material can provide unique and superior mechanical and physical properties as it combines the most desirable behaviour of its constituent. Now a day, the composite materials marketplace is becoming widespread[1,2].

Composites can be developed by many different techniques, Based on the type of morphology and reinforcement. The metal matrix composites are fabricated by different methods such as powder metallurgy, squeeze casting, stir casting, spray deposition, liquid infiltration etc[3]. In the stir casting process, reinforcement such as metal borides, nitrides, carbides and oxides are dispersed under atmospheric pressure within molten alloy matrix[4].

Recent days, liquid metallurgical method is used to develop to make metal matrix composites with higher volume fraction of reinforcement under lower pressure. In accordance to reports from the latest investigations, the homogenous mixture can be produced by adopting the right processing parameters, such as the molten metal's temperature, speed, and stirring duration; the mould preheating temperature; and the uniform feed rate of the particles. The selection of suitable engineering process depends on the desired quantity and distribution of reinforcement materials, the matrix alloy and its application. Among various aluminium alloys, 7075 and 6061 are more popular choices as matrix materials to prepare metal matrix composites due to its better formability characteristics and the option of modification

**Author for correspondence*

of strength of composite through heat treatment[7]. The Al7075 matrix improves in the wear resistance due to the addition of AlN and heat treatment process.in particulate reinforced aluminium matrix composites; reinforcement is added to the matrix of the bulk material to increase its strength and stiffness. The addition of ceramic particles like AlN, sic, Al_2O_3, B_4C etc., results in increasing wear resistance and ratio of strength to weight than the conventional alloys[8,12]. From the Basis of above considerations, the study is aimed to investigation of the effect of heat treatment on the wear behavior of aluminum 7075 composites reinforced Aluminium nitride particles.

2.0 Experimentation Procedure

2.1 Preparation of Composite Materials

Composite materials were manufactured using aluminum nitride as reinforcing material and aluminum 7075 alloy material as matrix. Table 1 illustrates the chemical composition of matrix material.

Aluminium nitride had better compatibility with aluminium, good thermal and physical behaviour, and proper interfacial adherence without any interfacial reaction. Aluminium nitride of average particle size 90-150 μ is used as reinforcement.

For the preparation of composite material, the Stir casting method is adopted. The different percentages of weight of Aluminium nitride particulates are chosen, i.e. From 0wt% to 10wt%, in incremental of 2wt%. The Al7075 alloy is melted in electrical resistance furnace up to 750° C and continuously stirred at 550 rpm. The Aluminium nitride particulates are preheated at 400° C and added to molten metal of Al7075 alloy. Finally, continuous stirring is done for better wetting between matrix and reinforcement. The T6 heat treatment technique is carried in a muffle furnace for two hours at a solutionizing temperature of 470° C. After that, the material is quenched in ice and artificially aged for eight hours at a temperature of 120° C.

3.0 Specimen Preparation

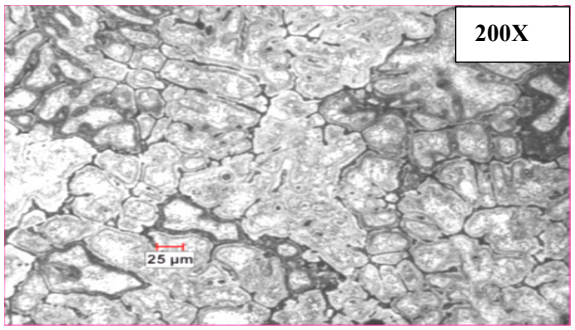
The specimens of T6 heat treated is prepared as per ASTM G99-95 standards; the testing specimens is machined to the pin size with diameter 8mm and height 30mm and specimens are polished metallographically.

4.0 Microstructure Analysis

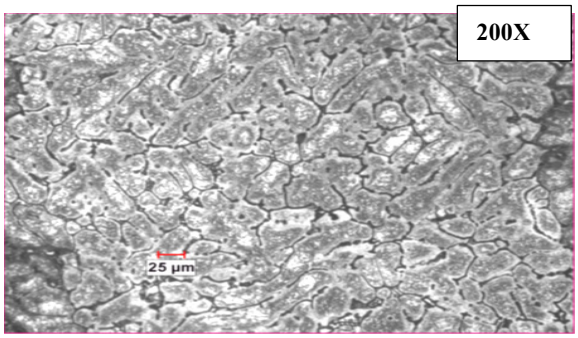
The microstructural analysis is carried out by standard metallographic procedure by etched with killer's agent.

Table 1. Chemical composition of matrix material

Name of the elements	Cu	Mg	Si	Fe	Mn	Cr	Zn	Ti	Al
Standard requirements %	1.2-2.0	2.1-2.9	0.5 max	0.5 max	0.3 max	0.18-0.28	5.1-6.1	0.2 max	Bal.
Observed value %	1.539	2.191	1.783	0.290	0.275	0.117	4.416	0.047	89.3



(a)



(b)

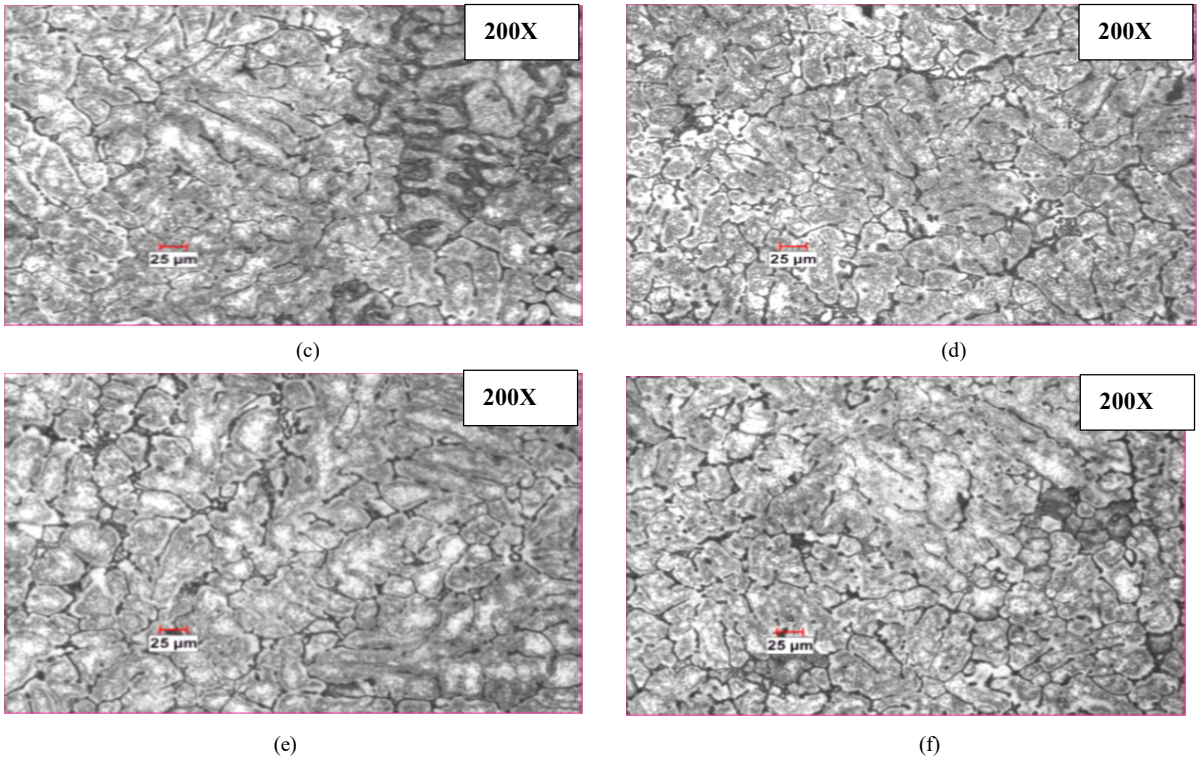


Figure 1. Micrograph of heat-treated Aluminium alloy (Al7075) – Aluminium nitride composites. (a) Micrograph of Al7075/ 0wt% AlN (b) Micrograph Al7075/ 2wt% AlN (c) Micrograph of Al7075/ 4wt% AlN (d) Micrograph of Al7075/ 6wt% AlN (e) Micrograph of Al7075/ 8wt% AlN (f) Micrograph of Al7075/ 10wt% AlN

The optical micrograph of Al7075-Aluminium nitride particulates of different weight percentage clearly indicates the uniform distribution of Aluminium nitride and minimum porosity particulates in the composite as shown in Figure 1.

5.0 Wear Characteristics

5.1 Effect of Reinforcement

Figure 2 shows the wear rate due to effect of reinforcement on as-cast, heat treated composites for varying weight

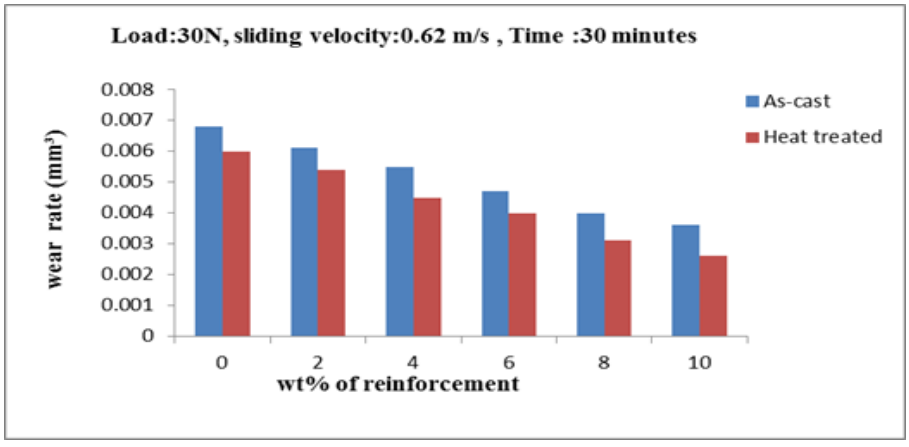


Figure 2. Effect of reinforcement of wear rate of Al7075 and its composites.

percentage of reinforcement carried with constant load of 30N, Sliding velocity of 0.62 m/s and a constant Sliding distance of 1500 m. It has been noticed that the increased reinforcement in the matrix reduces the composite's wear rate and also wear rate decreases due to heat treatment.

5.2 Effect of Applied Load

Figures 3 and 4 depict the trials under a range of load conditions, from 30 to 90 N, with a constant sliding distance of 1500 m and sliding velocity of 0.62 m/s for both as cast and heat-treated conditions. In both cast and heat-treated circumstances, the wear rate of composites increases with increased load. The wear rate is lowest at 30 N.

The alloy and its composites experienced precipitation formation as a result of heat treatment process, which lowered wear rate.

5.3 Effect of Sliding Velocity

A combination of a 50 N applied load and constant sliding distance of 1500 m maintained, Figures 5 and 6 exhibit how wear rate of Al7075 alloy and its composites in as-cast conditions decreases as increase in sliding velocity from 0.21 m/s to 1.26 m/s. Additionally, wear rate in as-cast conditions is higher than that of solutionized

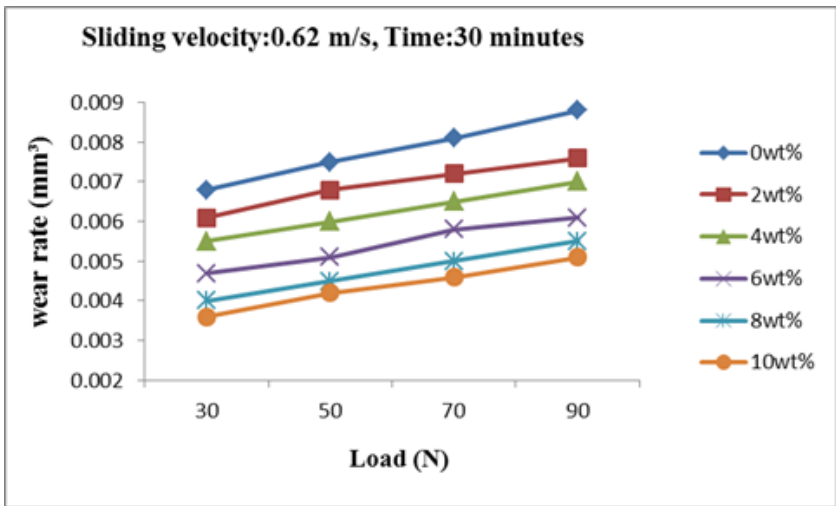


Figure 3. Wear rate variation of Al7075 and its composites with different load and unheated conditions.

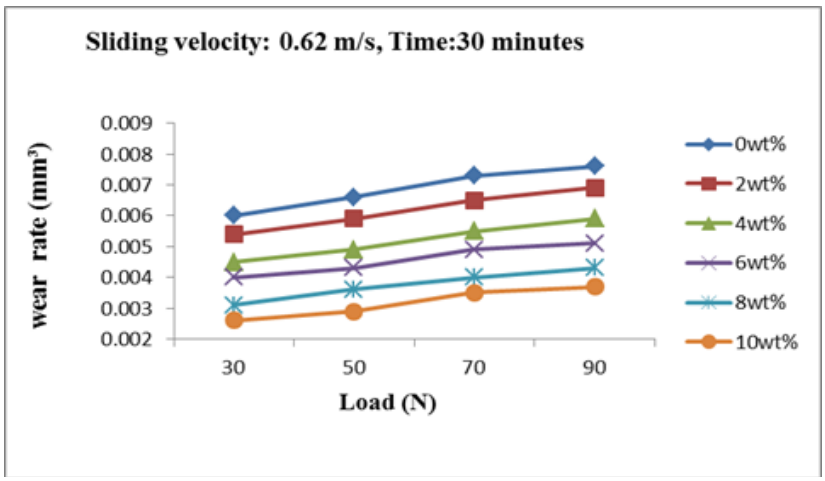


Figure 4. Wear rate variation of Al7075 and its composites with different load and heat-treated conditions.

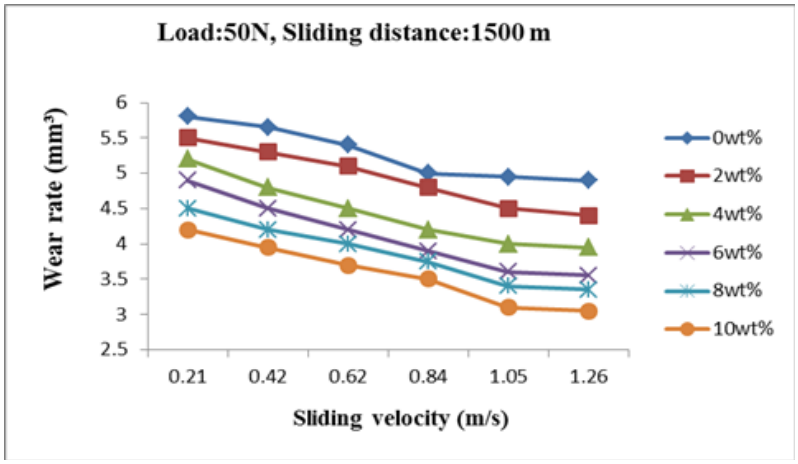


Figure 5. Variation of Al7075 alloy and its composites' wear rate with varying sliding velocities during as-cast.

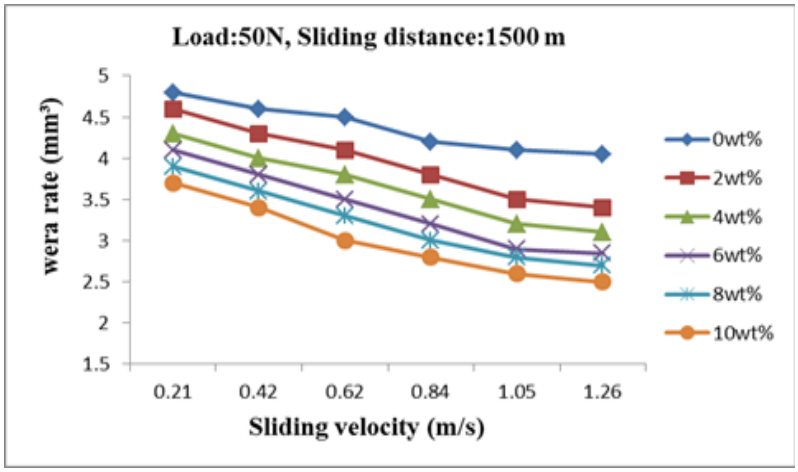


Figure 6. Variation of Al7075 alloy and its composites' wear rate with varying sliding velocities during heat treatment.

alloy and its composites. Furthermore, as sliding velocity increases, note the lowest wear rate.

6.0 SEM Analysis of Worn-Out Surface

The worn structure of as cast and Heat treated Al7075-AlN MMC are shown in Figure 7. The wear of as cast and heat treated Al7075 alloy is by plastic deformation. As compared to the as cast composite, the heat-treated composite had a reduced wear rate and the smaller grove formation during wear test in the heat-treated alloy is noticed from SEM.

7.0 Conclusion

- Al7075-aluminum nitride reinforced composites are developed successfully by stir casting method followed forging and T6 heat treatment process.
- The wear resistance of dry sliding increases, as the Aluminium nitride reinforcement particulate increased in Al7075 matrix alloy.

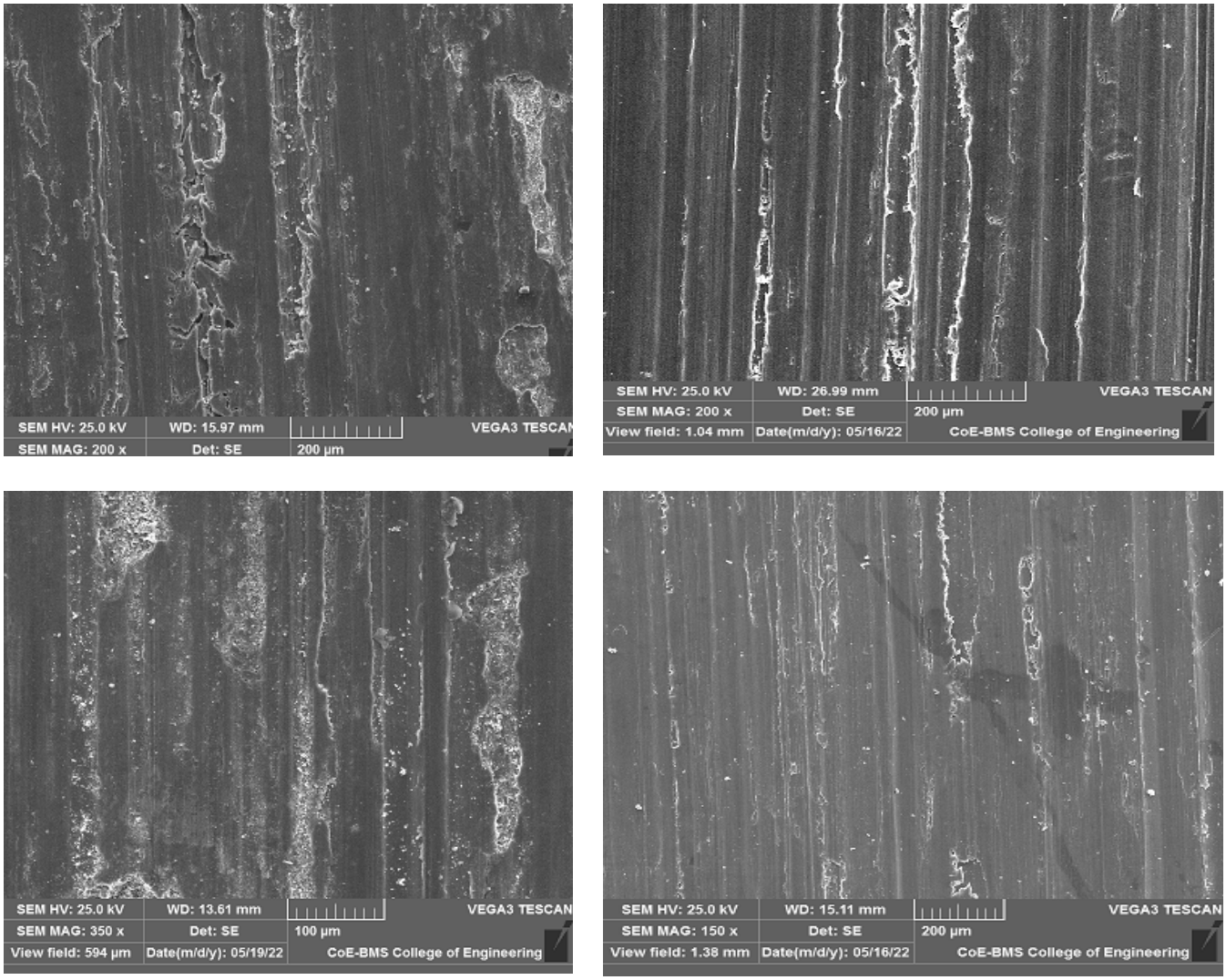


Figure 7. The worn surface SEM analysis of as cast and Heat treated Al7075-AlN MMCs. (a) SEM analysis of unheat treated Al7075/0wt% AlN (b) SEM analysis of unheat treated Al7075/8 wt% AlN (c) SEM analysis of heat treated Al7075/0wt% AlN (d) SEM analysis of heat treated Al7075/8wt% AlN

- The wear rate of the matrix alloy and its composites increases as the applied load increases. As compared to as-cast and its composites, the heat treatment procedure greatly reduces the wear rate.
- The heat-treated alloy's and its composite's rate of wear reduces as the sliding velocity increases.

8.0 References

1. Schwartz MM. Composite Materials Handbook. McGraw-Hill, Second Edition; 1992.
2. Vinoth Babu N, Moorthy TV. Synthesis and characterization of Al7075/Sic composite by stir casting. Applied Mechanics and Materials. 2014; 592-4. https://doi.org/10.4028/www.scientific.net/AMM.592-594.760
3. Saravanan C, Subramanian K. Effect of particulate reinforced aluminium metal matrix composite-a review. Mechanics and Mechanical Engineering. 2015; 19(1).
4. Sreedhar N, Balaguru S. Mechanical and tribological behaviour of Al 7075 hybrid MMC's using stir casting method. International Journal of Mechanical and Production Engineering Research and Development.

2020; 10(3):391-400. https://doi.org/10.24247/ijmperd-jun202036
5. Sharma SC, Pual Vizhian S, Shashishankar A, Krishna M. Influence of heat treatment on microstructural and tensile properties of Aluminium E-Glass short fiber composites. Journal of Mechanical Behaviors of Materials. 2011; 14(4-5). https://doi.org/10.1515/JMBM.2003.14.4-5.305
6. Wahab MN, Daud AR, Ghazali MJ. Preparation and characterization of stir cast-aluminium nitride reinforced aluminum metal matrix composites. IJMME. 2009; 4(2).
7. Ravindra Sagar CS, Chandra BT. Heat treatment effect on the hardness of aluminium LM13-MgO particulate composite. IJERAT. 2018; 4(1). https://doi.org/10.7324/IJERAT.2018.3180
8. Deaquino-Lara R, Soltani N, Bahrami A. Tribological characterizations of Al7075-graphite composites fabricated by mechanical alloying and hot extrusion. ELSEVIER, Materials and Design. 2015; 67:224-31. https://doi.org/10.1016/j.matdes.2014.11.045
9. kumar R, Dhiman S. A study of sliding wear behaviours of Al-7075 alloy and Al-7075 hybrid composite by response surface methodology analysis. ELSEVIER. 2013; 50:351-9. https://doi.org/10.1016/j.matdes.2013.02.038
10. Mukilan B, Arun Kumar J. Tribology studies in powder metallurgy Al-LM13 SiC-reinforced functionally graded composites. IJARTET. 2017; 4(19).
11. Vikash Kumar K, Tripathy SK, Mohanta GK. Mechanical and wear behavioral assessment of Al 7075-Al2o3 metal matrix composite. IJITEE. 2019; 8(11). https://doi.org/10.35940/ijitee.K2274.0981119
12. Sunil Kumar M, Sathisha N, Jagannatha N, *et al*. Tribological study on effect of chill casting on aluminium A356 reinforced with hematite paticulated composites. J Bio Tribo Corrosion. 2022; 52. https://doi.org/10.1007/s40735-022-00635-7