Retraction

Retraction: Study on Tribological Properties Of Aluminium Hybrid Composites For Automotive Applications (IOP Conf. Ser.: Mater. Sci. Eng. 1145 012104)

Published 23 February 2022

This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

Retraction published: 23 February 2022
Study on Tribological Properties Of Aluminium Hybrid Composites For Automotive Applications

K Kaviyaranan¹, A Saaron², K M Rahuram², A Ranjithvel² and S Selvakumar²

¹Assistant Professor, Department of Mechanical Engineering, Sri Krishna College of Technology, Coimbatore - 641 042, India.
²Students, Department of Mechanical Engineering, Sri Krishna College of Technology, Coimbatore - 641 042, India.

Abstract. Aluminium metal matrix hybrid composites are refined through stir casting method. Aluminium A-356 is reinforced with ceramic particles like Zirconium diboride (ZrB₂) and Tungsten carbide (WC) in varying weight percentages (ie. 2.5% and 5%). (The purpose is to compare the properties like of the different composite specimens). This work aims to develop aluminium metal hybrid composites for automotive applications and studying its wear characteristics. Due to low density, aluminium metal was chosen. Of the several alloys, A356 is chosen as the matrix material since it has good castability and good strength and low cost. Among the reinforcements, WC possess high durability and good wear support. Stir casting technique embraced to fabricate specimens. Then the casted specimens were machined and subjected to wear testing to examine the tribological properties through Pin on disc tribometer apparatus. The pin specimens were tested under different sliding conditions. Then the specimens were investigate under the (SEM) which is Scanning electron microscope to study the wear structure that occurred in sliding condition.

Keywords: Metal matrix, Tensile, Wear

1. Introduction
Aluminium composite were reinforcement of ceramic particles that have been the subjected to research scholars. Hybrid MMC’s is defined as the when the reinforcement of more than two is combined and it will achieved its expected property. It have the low melting point, thermal conductivity, low density, high specific strength of aluminium metal alloys. A356 have a good surface finish, high corrosion resistance. Composite is defined as combination of two phases namely matrix phase and reinforcement phase, the combination of both will improve the mechanical properties. These Aluminium base metal alloys and their composite its to be found their application in different building products, automotive engine parts, architectural and window frames. It is used in pistons an many engine parts. There are several approaches to synthesize the hybrid composite. [1], studied on Hybrid Al MMC’s application in the automotive industries for the production of engines, piston rings, & sockets were studied. The utilization of Hybrid aluminium metal lattice composites rather than solid or metal network composites brings about decrease of weight improves the decline in fuel utilization of car vehicles. [2], investigated on a study it was made on impacts of support on aluminium metal network composites. The reinforcements are ceramics materials like Silicon Carbide, Aluminium-di-oxide, Boron Carbide & Tungsten Carbide which are supported with aluminium & their properties were
examined. The review results the ceramic support materials improves their properties like hardness and tensile strength. [3], investigated on various blend of reinforcement utilized the creation of Hybrid Al metal composites and contemplated the tribological attributes. Correlation of Hybrid Aluminium metal grid composites with single support composite is done which showed the improvement in their properties like mechanical and tribology as expansion in the weight part of support of the base metal. [4] explored the impact of ZrB2 particles on mechanical properties and microstructure of A356/ZrB2 AMC. They detailed that the presence of ZrB2 support particles overhauled the mechanical conduct to the composite. The A356 aluminum metal was built up with an alternate weight part of zirconium diboride (ZrB2) particles weight in rates of 0%, 5% and 10% to set up the composite and look at the mechanical properties and microstructure”. [5] investigated the contribution of tungsten carbide for improvement of mechanical behaviour. Addition of WC increases the impact resistance of reinforced aluminium by reducing the cracks. [6-10] fabricate the Aluminium metal composite with WC particles usage of stir casting technique. The mechanical property of the created material is assessed and afterward the SEM picture is to examine the dissemination. The AMC where reinforced that has the improved hardness and strength. The materials malleability was decreased with the increments of WC particles.

2.Materials and Methods:

2.1Materials used:
In this study, Aluminum 356 is named as metal matrix and is appeared in figure 1a. The distribution and alloying components of Aluminum are appeared in the down table 1. A few particles of reinforcement are available, among them WC is chosen because it has high wear safe, high dissolving point and it is appeared in figure 1c. In a weight of 2.5% and 5% WC with other particle as ZrB2 figure 1b of 5% and2.5% respectively.

![Image](image1.png)

**Figure 1 a. A356 billets**  **1 b. Zirconium diboride (ZrB2) Powder**  **1 c. Tungsten Carbide (WC) Powder**

|        | Si  | Fe  | Cu  | Mn  | Mg  | Zn  | Al  |
|--------|-----|-----|-----|-----|-----|-----|-----|
|        | 6.6 | 0.25| 0.11| 0.002| 0.14| 0.026| Bal |

Table 1. Chemical Composition of A356.
2.2 Manufacturing:
Stir casting method is selected in this work because to fabricate the Aluminium hybrid composites and it have cost-efficient and also in manufacturing process. [11-15] In this technique the casting setup where consists of stirrer which is connected to the motor and the electricity were generated and the preheating furnace is also shown in Figures 2 a and b. In amount of 800gms of aluminium A356 is separated into formation of chips and it is inserted to the furnace for 60 minutes to reach the temperature of 720°C. The reinforced particles of Zirconium diboride and Tungsten Carbide were kept in crucibles and they were placed in the preheating furnace for 30 minutes to attain the temperature of 250°C. After that the base metal A356 reached its molten state and then the reinforced particles of ZrB₂ and WC were added and it will stirred well at a speed of 250 rpm for 10 minutes when it mixed well. The molten metal mixture is discharged into the die to attain the required shape.

2.3 Composition of specimen:
Three specimens were fabricated with different composition of varying weight percentages and it will shown in the below table 2. In this Specimen 1 contains of 100% Aluminium A356alloy, Specimen 2 contains 92.5% Aluminium A356, 2.5%WC and 5% ZrB₂. Specimen 3 contains 90% Aluminium A356, 5% ZrB₂ and 5% WC. The specimens were casted and it is shown in Figure 2 c.

![Figure 2. a. Furnace for Stir casting 2b. Furnace for Preheating 2c. Fabricated Specimen](image_url)

Table 2. Specimen Composition.

| S.NO | Identification of Specimen | Composition               |
|------|-----------------------------|---------------------------|
| 1    | Specimen S1                 | S1 [A -356 (100%) ]       |
| 2    | Specimen S2                 | S2 [A- 356 (92.5%) ZrB₂ (5%) WC (2.5%) ] |
| 3    | Specimen S3                 | S3 [A-356 (90%) ZrB₂ (5%) WC (5%) ] |
3. Results and Discussion:

3.1. Tensile Test

It is subjected to controlled the tension failure. This testing is regularly conveyed for the laboratory for material testing. [15-19] The ASTM D638 is the most used tensile testing machine. It estimates the elastic properties including the elongation, Poisson’s ratio, yield strength and tensile strength and it is estimated through the tensile test and it area to be reduced. The standardized cross section of the sample is shown in the Figure 4. The most widely recognized testing machine for tensile is the universal testing machine and it is shown in Figure 5 and 6.

The tensile strength and elongation is shown in figure 7 and 8. Table 5 shows the result of tensile test.

Figure 4. ASTM E8 Specimen Cross Section

Figure 5. ASTM E8 UTM Machine

Figure 6. Fractured Specimen

Figure 7. Tensile Strength

Figure 8. Elongation
Table 5. Results for Tensile Test

| S.NO | SPECIMEN NO               | TENSILE STRENGTH (in Mpa) | ELONGATION (%) |
|------|---------------------------|---------------------------|----------------|
| 1    | S1 A -356 (100%)          | 130.82                    | 7.56           |
| 2    | S2 A- 356 (92.5%) ZrB₂ (5%) WC (2.5%) | 166.67                  | 5.24           |
| 3    | S3 A-356 (90%) ZrB₂ (5%) WC (5%) | 180.08                  | 4.80           |

3.2 Wear Test:

Table 6 shows the result of Wear test is carried out the wear performance and to investigated the wear mechanism by the pin on disc apparatus. The stationary pin is pressed in the rotating disk under the applied load. The pin can be of any shape [20-24]. At the start of the test, the Wear rate and the coefficient of friction (COF) is measured. This can be performed several times during the test to measure the coefficient of friction (COF) and wear rate for the samples. During this test, friction force and wear rate are continuously monitored and noted. Through this wear test, we get the result of the sample specimens as shown in figure 8-12.

Table 6. Result on Wear Test

| S.NO | COMPOSITION               | WEAR RATE (10⁻⁶) | COF |
|------|---------------------------|-----------------|-----|
|      |                           | 20N          | 40N | 20N  | 40N  |
| 1    | S1 A -356 (100%)          | 5.6           | 7.2 | 0.19 | 0.70 |
| 2    | S2 A- 356 (92.5%) ZrB₂ (5%) WC (2.5%) | 4.2          | 5.90 | 0.24 | 0.79 |
| 3    | S3 A-356 (90%) ZrB₂ (5%) WC (5%) | 3.0           | 4.80 | 0.29 | 0.89 |
3.3 SEM test:

Scanning Electron Microscope (SEM) is a test process that can scan the images with electron beam to produce the image for analysis. It is utilized in microanalysis and failure analysis of strong materials. It produces high resolution images and measures very small features and objects.

3.3.1 SEM Test on Tensile Test:

![Figure 13. Sem image on Fractured Surface (a)PURE AL A356) 100% (b) A-356 (92.5%) ZrB2 (5%) WC (2.5%) (c) A-356 (90%) ZrB2 (5%) WC (5%)](image)

Figures 13 a shows that the broken surfaces were examined by electron microscope acquired in the tensile test. The presence of voids and dimples on the break appeared of as-gotten Al combination
affirming pliable crack (figure 13 a). The SEM image of 13 b shows that the S2 composites specimen which have the tensile fracture surface. It is clearly identified that the composites were different in the appearances of the fracture surface. For the Al A356, more tearing edges and brittle areas were noticed, and as a part of little dimples were seen. When the amount of dimples were increased then the brittle areas are decreased. This dimple-fracture character were exhibits. The SEM pictures of the fractured surface of the materials are correspondence with the varieties of mechanical properties. Figure 13 b and c separately show dimples in composites. As this stage, reinforcement is fragile and has high strength. During twisting, two kinds of the microcracks will be started by the particles. The interfacial attachment between the clay particles and lattice is solid, the particles will break to nucleate microcracks when its strain and separation thickness arrive at the basic qualities by high pressure fixation, as demonstrated on account of the micro composites in Figure13 b and c, set apart with white bolts. Figure 13 b portrays the consolidation of ZrB$_2$ particles broadly lessens the voids on the crack surface. The ZrB$_2$ particles were connected to the grain refinement.

Figure 13 c portrays how the levelness of the cracked surface increments with the upgraded weight part of ZrB$_2$, WC molecule content. There are no voids around the particles, in solid interfacial holding between the grid and the reinforcement. The break surface shows that the composite encountered a bendable nature of crack at the infinitesimal level and fragile nature of break at the plainly visible level.

The crack morphology (Figure 13 c) is shows that greater and consistently dispersed voids which demonstrate a bendable break.

3.3.2 SEM Test on Wear Test:

![Figure 14](image-url)

**Figure 14.** Worn out Semi image of (a) (PURE AL A356) 100% (b) A- 356 (92.5%) ZrB$_2$ (5%) WC (2.5%) (c) A- 356 (90%) ZrB$_2$ (5%) WC (5%)

Figure 14 shows the worn out in surface parent alloy composite pin at a sliding condition of 20N for a velocity of sliding in 2m/s at 1000m constant distance.

From sliding, Figure 14(a) A few breaks and small harms were recognized. When the wear particles where arranged towards sliding of wear track is processed with the arrangement of section were solidified. From this state of morphology, it is seen that they have some little air pockets were arrangement on its layer. The nearby contact shave been broken. Simultaneously, the break arrangement it will harms because of sliding wear.

Figure 14 b which shows the presence of furrowing component in this system. The wear surface of A356 compound tried at greatest burden shows a particular example of furrows and edges running corresponding to each other, a common place of the sliding wear. Likewise, it is clear from the SEM images that the sections are a lot better and firmly divided in A356--5.% TiB$_2$ because of the sliding activity of a bigger number of hard particles and trash.
The SEM images shows that the picture of wear debris and their worn surface of composite at 20 N. Figure 14 b shows that they have thin line grooves in the worn surfaces and the compelling of grease particles were consequenced. When compared to the composite the size of wear groove is more modest. Figure 14 b shows the fine wear garbage were divided. They might actually diminish to twisting of the surface of the pin.

The Sem image of Fig 14 c shows that the composites of sliding speed which attains in higher conditions in the worn surfaces. Figure 14 c Shows the surface were used and exceptionally thought half and half composites. The all around utilized surface of the SEM pictures shows the scars and pits for insignificant degree of composites under the higher condition of the wear ascribes measure boundaries. High seriousness of wear, chipping of the lattice, surface furrowing which have less fortifications were found in the material composite. It is cleared that the rough wear system in the hardly cracked particles in the work surface.

4. Conclusion

From this present study, we have done the process under stir casting using aluminium A356 alloy with the reinforcement of ZrB2 and WC. After that casting, machining process is done. The machined specimen is tested in methods of Tensile test and wear test.

(i) While comparing the tensile test, the tensile strength of parent specimen is lesser than the hybrid specimen and its elongation of parent specimen is higher than the hybrid specimen.

(ii) When comparing the pin on disc test, the wear rate at different load of 20N and 40N of the parent specimen is higher than the hybrid specimen.

(iii) The coefficient of friction is tested under varying loads of 20N and 40N the parent specimen is lesser than hybrid specimen.

(iv) After this above testing, the SEM images are taken. The fractured specimen is gives the difference in cracked surfaces. The worn surfaces gives the parent specimen is worned when compared to other specimen.

References:

[1] Mandal, A., Murty, B.S. and Chakraborty, M., 2009. Sliding wear behaviour of T6 treated A356–TiB2 in-situ composites. Wear, 266(7-8), pp.865-872.

[2] Karuna, G.S. and Babu, P.S., 2019. Morphological Studies and Mechanical Characteristics of Aluminium Hybrid Composite Reinforced with Fly Ash and Nano Red Mud. i-Manager's Journal on Material Science, 6(4), p.1.

[3] Akbari, M.K., Baharvandi, H.R. and Shirvanimoghaddam, K., 2015. Tensile and fracture behavior of nanomicro TiB2 particle reinforced casting A356 aluminium alloy composites. Materials & Design (1980-2015), 66, pp.150-161.

[4] Kumar, N., Gautam, G., Mohan, A. and Mohan, S., 2018. High Temperature Tensile and Strain Hardening Behaviour of AA5052/9 vol.% ZrB2 insitu Composite. Materials Research, 21(5).

[5] Pydi, H.P.R., Adhithan, B. and Bakrudeen, A.S.B., 2013. Microstructure exploration of the aluminum-tungsten carbide composite with different manufacturing circumstances. International Journal of soft computing and engineering, 2

[6] Kumar, N.M. and Kumaraswamidhas, L.A., 2019. Characterization and tribological analysis on AA 6061 reinforced with AlN and ZrB2 in situ composites. Journal of Materials Research and Technology, 8(1), pp.969-980.

[7] Loganathan, P., Gnanavelbabu, A. and Rajkumar, K., 2021. Influence of ZrB2/hBN particles on the wear behaviour of AA7075 composites fabricated through stir followed by squeeze cast technique. Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 235(1), pp.149-160.
[8] Huang, G., Hou, W. and Shen, Y., 2018. Evaluation of the microstructure and mechanical properties of WC particle reinforced aluminum matrix composites fabricated by friction stir processing. Materials Characterization, 138, pp.26-37.

[9] Manikandan, A., Omkumar, M.S. and Mohanavel, V., 2019. Influence of ZrB2 on The Microstructural Characteristics of AA6082/ZrB2 Composites. Materials in technologije, 53(3), pp.327-332.

[10] A. Haldorai and A. Ramu, Security and channel noise management in cognitive radio networks, Computers & Electrical Engineering, vol. 87, p.106784, Oct. 2020. doi:10.1016/j.compeleceng.2020.106784

[11] A. Haldorai and A. Ramu, Canonical Correlation Analysis Based Hyper Basis Feedforward Neural Network Classification for Urban Sustainability, Neural Processing Letters, Aug. 2020. doi:10.1007/s11063-020-10327-3

[12] Saleh, B., Jiang, J., Ma, A., Song, D. and Yang, D., 2019. Effect of main parameters on the mechanical and wear behaviour of functionally graded materials by centrifugal casting: a review. Metals and Materials International, 25(6), pp.1395-1409.

[13] Zhang, S.L., Yang, J., Zhang, B.R., Zhao, Y.T., Chen, G., Shi, X.X. and Liang, Z.P., 2015. A novel fabrication technology of in situ TiB2/6063Al composites: high energy ball milling and melt in situ reaction. Journal of Alloys and Compounds, 639, pp.215-223.

[14] Kaviyarasan, K., Pridhar, T., Sureshbabu, B., Boopathi, C. and Srinivasan, R., 2018. Fabrication of Al6061-Al2O3 composite through liquid metallurgy technique. In IOP Conference Series: Materials Science and Engineering (Vol. 402, No. 1, p. 012148). IOP Publishing.

[15] Shen, T., Dai, Y. and Lee, Y., 2016. Microstructure and tensile properties of tungsten at elevated temperatures. Journal of Nuclear Materials, 468, pp.348-354.

[16] Hillary, J.J.M., Ramamoorthi, R. and Chelladurai, S.J.S., 2020. Dry sliding wear behaviour of Al6061–5% SiC–TiB2 hybrid metal matrix composites synthesized by stir casting process. Materials Research Express, 7 (12), p.126519.

[17] Selvam, J.D.R., Smart, D.R. and Dinaharan, I., 2013. Microstructure and some mechanical properties of fly ash particulate reinforced AA6061 aluminum alloy composites prepared by compocasting. Materials & Design, 49, pp.28-34.

[18] Logesh, K., Hariharasakthisudhan, F., Moshi, A.A.M., Rajan, B.S. and Sathickbasha, K., 2019. Mechanical properties and microstructure of Al356 alloy reinforced AlN/MWCNT/graphite/Al composites fabricated by stir casting. Materials Research Express, 7(1), p.015004.

[19] Anilchandra, A.R., Ambere, L., Bonollo, F., Fiorese, E. and Timelli, G., 2017. Evaluating the tensile properties of aluminium foundry alloys through reference castings—a review. Materials, 10(9), p.101.

[20] Sivaraman, P., Nithyanandhan, T., Karthick, M., Kirivasan, S.M., Rajarajan, S. and Sundar, M.S., 2020. Analysis of tensile strength of AA 2014 and AA 7075 dissimilar metals using friction stir welding. Materials Today: Proceedings.

[21] Niranjan, K. and Lakshminarayanan, P.R., 2013. Dry sliding wear behaviour of in situ Al−TiB2 composites. Materials & Design, 47, pp.167-173.

[22] Desai, A.M., Paul, T.R. and Mallik, M., 2020. Mechanical properties and wear behavior of fly ash particle reinforced Al matrix composites. Materials Research Express, 7(1), p.016595.

[23] Prabhu, S.R., Shettigar, A.K. and Herbert, M.A., 2019. Microstructure and mechanical properties of cuttle-reinforced AA6061 matrix composites produced via stir casting process. Transactions of Nonferrous Metals Society of China, 29(11), pp.2229-2236.

[24] Kaviyarasan, K., Kumar, J.P., Anandh, S.K., Sivavishnu, M. and Gokul, S., 2020. Comparison of mechanical properties of Al6063 alloy with ceramic particles. Materials Today: Proceedings, 22, pp.3067-3074.