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DRY SLIDING WEAR STUDIES OF ZINC ALUMINIUM ALLOY CONTAINING MICRO AND NANO SOLID LUBRICANTS

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ABSTRACT

This paper has carried out characterization and dry sliding wear of ZA alloy composites reinforced with solid lubricants like graphite microparticles and zinc oxide nanoparticles to enhance the wear properties of ZA-Nano composite. ZA composite samples were fabricated using Nano ZnO and micro graphite particulates (50-60 microns) by stir casting technique. Microstructural examination were used to characterize the composite samples produced. The results show that hardness of the composite samples increased with an increase in weight percentage of graphite and ZnO nanoparticles. It was generally observed that composite sample containing 1 wt. % of reinforcement has the highest hardness values. Results obtained from the Microstructural examination using a Scanning Electron Microscope (SEM) show that the nanoparticles were well dispersed in the ZA alloy matrix. There is a scope to improve the wear properties of ZA alloy by reinforcing with hard/wear resistant material like hard nanoparticles and graphite. An attempt has been made to investigate the dry sliding properties of ZA/ZnO/Graphite composites

Key Words: *Nano materials, Scanning Electron Microscopy (SEM), EDS.*

1. INTRODUCTION

The study of friction, lubrication and wear is of profound importance, in functioning of many Engineering components In this regard, new materials are developed for tribological applications and one such materials are conventional Zinc based alloys used in bearing applications because of presence of hard zinc Aluminium-copper particles providing low friction bearing surface, while the softer zinc Aluminium material wears to provide better lubrication. These alloys possess low melting point, high strength, ease of casting and machining leading to low making cost. Among the Zinc based alloys, Zinc containing 27% wt Aluminium is having low density and high strength, corrosion resistance as well as better wear resistance. Its main shortcomings are loss of dimensional stability and inferior elevated temperature properties (up to 100^0C.)

In the past few decades researchers have attempted to improve the mechanical and tribological properties of ZA alloy at room temperature by i. alloying, with high melting point materials like, copper, nickel and silicon, ii. Heat treatment (T6 and T4) process and iii.adding suitable reinforcements to develop ZA based Metal ma-trix composite to overcome the short comings and improve wear resistance (2-5).The use of ceramic fillers (Al2O3,SiC,TiC,TiB2,B4C,Garnet)obtained synthetically, generated as industrial wastes like red mud, fly ash, stone dust ash and agro waste like rice husk ash with different weight percentage, particle size and shape as reinforcement and also using different fabrication techniques like stir casting, centrifugal casting(Functionally graded materials)squeeze casting, compo-casting, insi-tu, ultrasonic assisted casting and powder metallurgy had been reported in the literatures(6-9) by which the composite exhibited better strength, corrosion resistance and wear strength but difficulty in machining which is overcome by adding solid lubricants in the matrix.

Many researchers have also reported optimization of process parameters during wear test of ZA alloy based MMC using Taguchi experimental deign and ANOVA, containing the micro particle reinforcements (6-10).The use of micro particle reinforcement in ZA alloy matrix had received wide attention in literature but the combination of nano and micro solid lubricants has not been attempted. The size of reinforcement at nano scale increases the surface to volume ratio and hence increases the dislocation density there by improving the strength. The most commonly used solid lubricants with graphite, Molybdenum-disulphide (MoS2).

Synthesis of ZA-27 alloy MMC with Zinc oxide nanoparticles were carried out(1) and it predicted and found that strength, hardness and fracture toughness im-proved with increase in ZnO Nano particles as weight percentage increase in ZnO nanoparticles up to 5 wt%,which motivated to investigate the wear properties of ZA-27reinforced with both ZnO and graphite particulates.

2. PREPARATION OF ZINC OXIDE NANOPARTICLES BY SURFACE DIRECTING AGENT ASSISTED SOL-GEL METHOD

Surface directing agent assisted sol-gel method was used for synthesizing ZnO na-noparticles by the procedure which involves. A solution containing 130 mL of eth-anol and 30 mL of iso-propanol was mixed slowly with 25 mL (50 mmol) of ZnCl2 solution under sonication. The obtained mixture was slowly added to 80 mL of de-ionized water containing 2 g of N-Cetyl –NNN-Tri methyl ammonium bromide to form a white Precipitate. The system was kept under constant stirring at 80 °C for 4 h. Continuous stirring is carried out to remove excess water by evaporation.. The re-sultant precursor was then dried at 110 °C for 12 h and then calcinated at 400 °C for 4 h in high temperature muffle furnace.

3. FABRICATION OF COMPOSITE

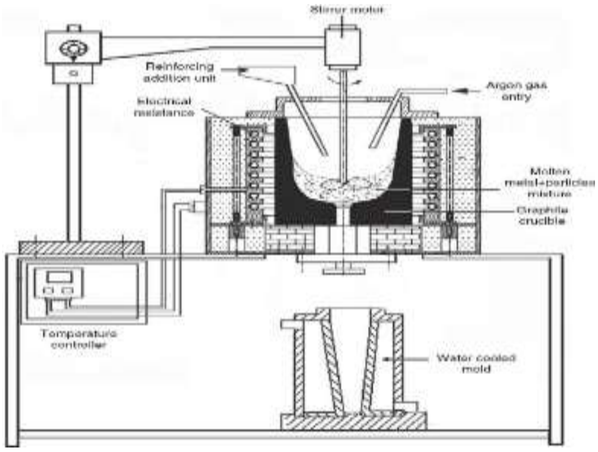

Figure 1. Stir casting with bottom pouring

Liquid metallurgy route has been widely used in the fabrication of ZA-MMC apart from powder metallurgy and squeeze casting. In the present work stir cast-ing with bottom pouring is used to fabricate the ZA MMC.

In this work known weight of ZA-27 alloy and reinforcement are weighed as per the desired composition and kept ready for melting. ZA-27 alloy ingot is melted in the crucible and heated to the temperature of 6000C. micro particles of 1%wt graphite (50-60 microns, Courtesy: Graphite India Ltd Bangalore) and 0.5%wt Zinc oxide nanoparticles (100nm, Courtesy: Synthesized in the Chemistry Lab, Global Academy of Technology Bangalore) were preheated and poured in the mould.5g of magnesium was added to improve wettability and stirring of the slur-ry containing reinforcements was carried out using stirrer rotating of 350rpm.immediately the composite was cast into metallic dies for solidification using bottom pouring stir casting equipment as shown in the Figure 1.

4. PHYSICAL PROPERTIES AND COMPOSITION OF THE MATERIALS

Table 1. Composition of matrix

Al	27
Cu	2.248
Mg	0.017
Zn	Reminder

Table 2. Physical properties of matrix and rein-forcement Composition

Details	ZA-27(matrix)	Graphite micro particles	Nano Zinc powder
Density(g/cc)	5.2	1.5	5.6
Melting point(0C)	431	4489	1975

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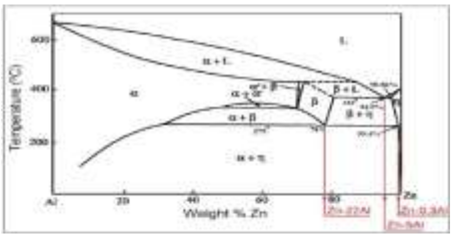
4.1 Hardness test

Table 3: Brinell hardness number

Specimen type	BHN
ZA-27 alloy	85
ZA-27+0.5%ZnO+1%graphite	92
ZA + 1% ZnO+ 2% graphite	106

The hardness was found to increase with the addition of reinforcement which is encouraging sign for wear applications.

4.2 Microstructural Examination



(a) (b)

Figure 2. (a)Microstructure of ZA-27 alloy reinforced with ZnO and graphite particles (b) phase diagram of the base alloy

When the Zinc alloy is cooled from molten state to room temperature results in formation of various phases like, α+L, β, α+β and α+η as shown in fig (2b). The microstructure in fig(2a)of ZA-27 alloy reveals the Aluminium rich matrix (α FCC) and inter dendritic Zinc rich phase (η HCP), CuZnO4 at 3820C and Al4Cu3Zn at 2750C.The light etching constituent is the Aluminium rich (α-phase) whereas the regions in dark are Zinc-rich (η-phase) and the surrounding Zinc oxide and graph-ite particulates.

4.3 Scanning Electron Micrographs

SEM examination was also carried out on the ZA-27 composites using high reso-lution FEG-SEM with EDS attachment. Fig 3 reveals the presence of well dis-persed ZnO Nano particles in the ZA alloy matrix.

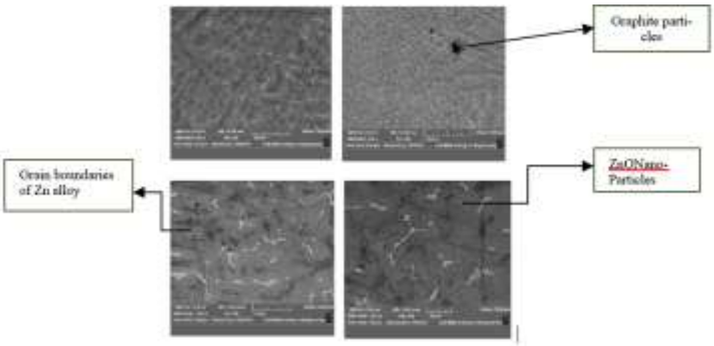


Figure 3: SEM Images Of .5%Wt Nano Zinc Oxide and 1% Graphite Particulate

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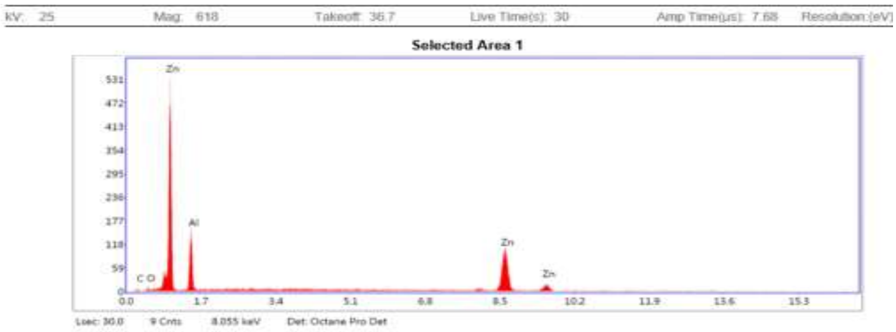

Figure 4. EDX spectrum of the composite with ZnO nano particles and graphite microparticles.

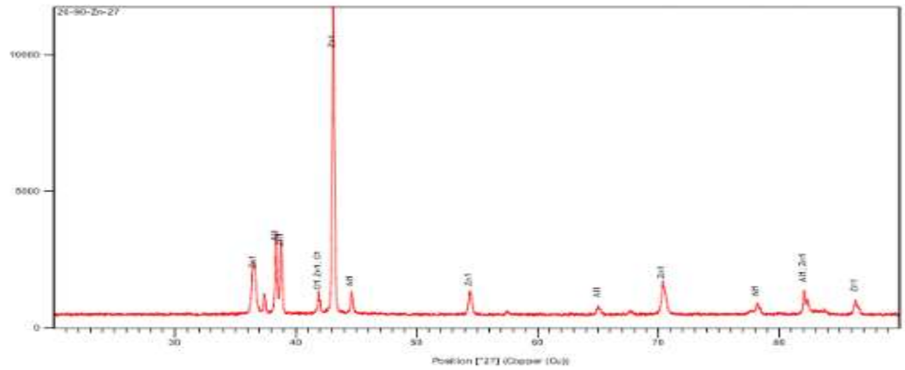

Figure 5.XRD of the ZA-27 composite containing ZnO and graphite particles.

Based on the XRD and EDAX results the ZnO and graphite particles reinforcements has dissolved completely in the ZA-27 matrix also EDS identified the composition of the sample and the relative quantity of each atoms is measured and the sharp peaks are noticed with the crystalline parts of the sample.

5. WEAR TEST

Dry sliding wear tests for ZA-27 alloy with different percentage of ZnO and graph-ite particulates was performed using a pin-on disc machine (Model: Wear & Fric-tion Monitor TR-20) as per ASTM G99: supplied by DUCOM is as shown in Fig.5. The linear wear of the pin is measured as wear loss recorded by LVDT with an ac-curacy of 0.01µm.wear test was carried out at room temperature. The wear test for the composite was carried out under the applied loads of 10N, 20N and 30N at sliding velocity of 2.61and 3.92m/s.

Table 4: Parameters taken during sliding wear test.

Pin material	ZA-Composite
Sliding speed (rpm)	500 and 750
Normal load (N)	10, 20, 30
Velocity(m/s)	2.61 and 3.92
Sliding distance (m)	3000,1000

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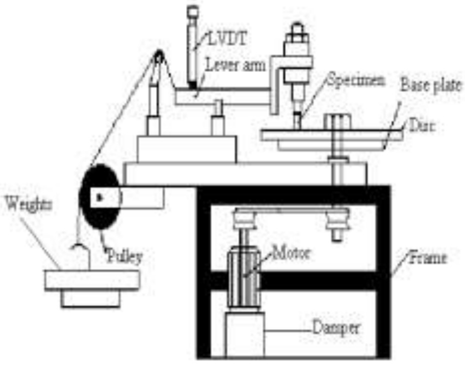


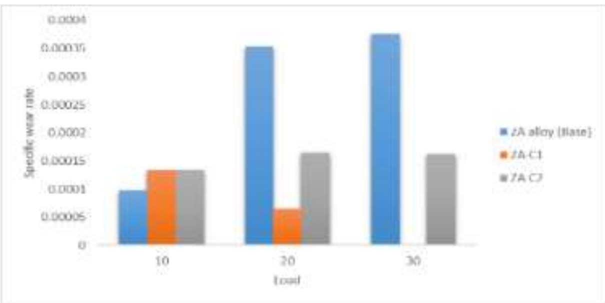
Figure 5. Wear testing machine

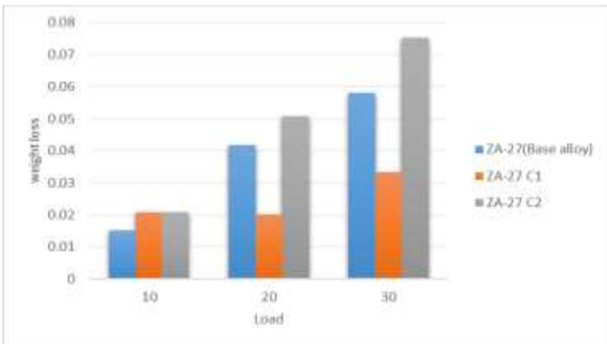
6. RESULTS AND DISCUSSIONS

Micro and Nano particulate metal matrix composites are being investigated in re-cent years due to their superior mechanical properties suitable for a number of engineering applications. The size of reinforcement is reduced to nanoscale so that interaction of particles with dislocations is of importance in addition to other strengthening effects like, Hall-petch strengthening, Orowan strengthening etc re-sulting in improvement of mechanical properties. The amount, size, shape, and distribution of hard/soft particles embedded into the matrix have effects on the wear and friction behaviour of the composites. During manufacturing processes of metal matrix composites, different types of defects may originate like voids and porosities. These defects lead to the reduction of both mechanical and tribo-logical properties of composites. In addition to, tribological testing parameters such as sliding speed, applied load, sliding time, and surface roughness affect the wear and friction behaviour of MMCs.

6.1 Effect of applied load and sliding speed on the weight loss

The addition of graphite and ZnO oxide particles to ZA-27 alloy improves the sliding wear resistance in when compared to ZA-27 matrix alloy. The test results depicts the effect of both the applied load and sliding speed for the base alloy and composite. The histogram in fig6 reveals the weight loss of the composites as well as base alloy at a sliding speed of 2.61m/s and 3.92m/s. The weight loss increases with increase in the applied load and observed that the weight loss of composite is less when compared with base alloy. When the load is less the wear loss is small but increase with the increase in load which is obvious. With increase in load there is a increase in wear of both base and reinforced alloy





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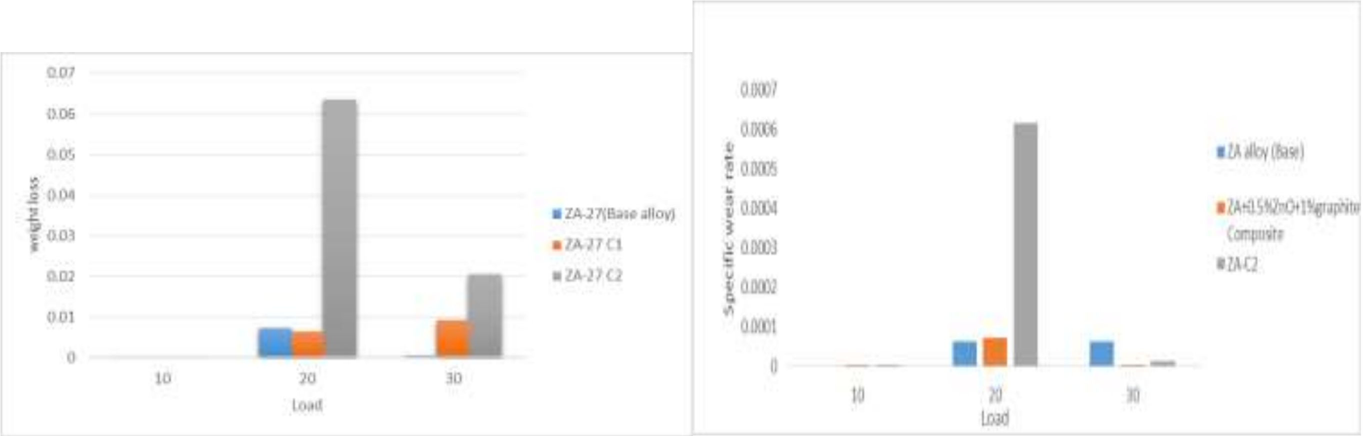

Figure 6: Effect of sliding speed and applied load on the weight loss

6.2 Effect of reinforcements on the wear

Zinc oxide and graphite are added as solid lubricant reinforcements in the ZA-alloy. the test results depicts the composite specimen exhibiting less weight loss compared to base alloy with increase in load and sliding speed as shown by the histograms. The literature says that the use of ceramic (hard) fillers as reinforce-ments in the matrix improves the mechanical strength and wear strength of metal matrix composites but, with the decrease in ductility of the composites. While, soft particles act as a solid lubricant and hence decrease the coefficient of friction of the composites. In this work there is a combination of soft (graphite) and hard (Zinc oxide) which is a solid lubricant are used as reinforcements exhibiting im-proved wear strength and reduction values of coefficient of friction.

6.3 Effect on coefficient of friction

The tests were performed at room temperatures and the histograms fig7 reveals the variation of coefficient of friction with the applied load and sliding speed of 2.61m/s. the amplitude of friction fluctuates were observed at 10N, 20N and 30N.There exists a stick slip phenomenon as observed in the frictional profiles of the experiment and found that coefficient of friction of both the base alloy and composite increased with increase in load. But with increase in sliding speed of 3.92 m/s and load the coefficient of friction of the base and composite material was low.

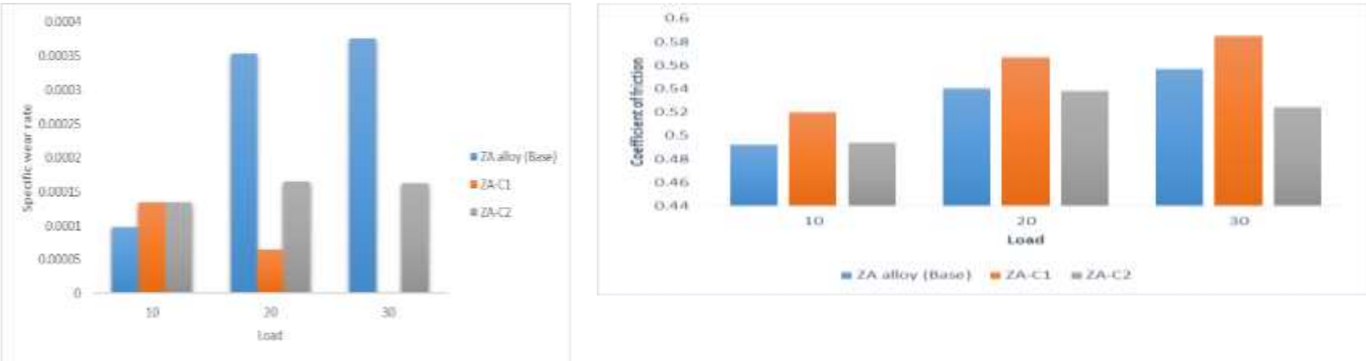

Figure 7: Effect of load on coefficient of friction

7. CONCLUSION

The ZA alloy and ZA Nano composite containing ZnO Nano particulates and graphite micro particulates were developed and its characterization was carried out using SEM, XRD and EDX along with that Dry sliding wear test was performed to identify the wear characteristics under 10N, 20N and 30N at sliding distance of 3000m and 1000m at a sliding velocities of 2.61m/s and 3.92 m/s.

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It was found that the reinforcement was very well distributed in the matrix of Zinc Aluminium with high zinc content and density was found to be close to the standard ZA base alloy.

From the above results since weight loss is the simple measure of wear it was found that minimum weight loss was found for ZA composite and at higher sliding velocity and at low load and maximum weight loss was found to be at for ZA base at low sliding velocity and high load.

This work is a preliminary study of dry sliding wear properties and thorough study of effect of reinforcements on hybrid ZA-Nano MMC is to be done.

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