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STUDY OF SURFACE ROUGHNESS WITH THE VARIATION IN APPLIED LOAD OF RUTILE CERAMIC REINFORCED ALUMINIUM COMPOSITE

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ABSTRACT

The objective of this work is to study the surface roughness of LM13alloy composites with rutile particles .The fabrication route adopted for preparing the samples containing variable ratio of rutile reinforcement is simple vortex technique. The wear tests were carried out under different loading conditions from 9.8N to 49N. The pin specimen travelled a distance of 3000m at constant sliding speed on the hard steel disc. The addition of fine size rutile particles results in higher hardness and strength. The stress concentration at the voids due to weak interfaces leads to crack intitation, arising from the particle fracture .This can be avoided by providing more strength to the matrix which is achieved by introducing hard ceramic rutile particulates. As the soft matrix aluminium alloy is prone to scratches and indentation during the contact sliding conditions, study of surface roughness of composite after wear studies need significant attention.

KEYWORDS: Wear, Reinforcement, Rutile , SEM.

I. INTRODUCTION

Better mechanical and tribological properties of the aluminum composites are the major reason for the development and usage of such materials in various structural applications. Preparation of these materials is achieved by using different methods where in metallic alloys as base material and ceramics as reinforcement are chosen. Aluminum alloy as matrix and using natural minerals as reinforcement have lot of potential to be used as reinforcement for wear-resistant applications [1-5]. Rutile, a low cost mineral has good chemical and thermal stability .Thus the composite materials developed has high strength with higher wear-resistance qualifies them to be versatile material for the commercial applications in the industry [1].The literature studies predicted that the wear behavior of material depends on microstructural properties like shape, size, volume fraction, and distribution of the reinforcement and applied load [2-6]. A proper selection of a certain number of variable parameters for optimization of mechanical properties of the composite is required which are strongly determined by the microstructural parameters of the system matrix-reinforcement [3]. In present studies, the liquid metallurgy technique was used to prepare the composite by varying the fine size(50-75) rutile reinforcement from 5 % and 15 %. Hardness of the composite was measured with the fine particle size. Surface roughness of

the worn samples with the variation in applied load was observed in parallel and perpendicular to the sliding direction. Surface wear mechanism which is accountable for the abrasive action of the asperities and responsible for the wear of material studied in detail from the surface roughness of the wear tracks.

II. EXPERIMENTAL:

MATERIALS

LM13, a piston alloy as a base matrix and rutile mineral as reinforcement are chosen. It is obtained in the form of ingots. The chemical constituents of the LM13 alloy are given in Table 1.

Table 1: Chemical composition of the LM13 alloy.

Elements	**Si**	**Fe**	**Cu**	**Mn**	**Mg**	**Zn**	**Ni**	**Al**
Chemical Analysis (Wt.%)	12.0	0.4	1.2	0.4	1.00	0.2	1.0	Bal.

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DEVELOPMENT OF COMPOSITE:

The liquid metallurgy technique due to its cost, simplicity and easy to use is the conventional process for the fabrication of the composites in the industrial applications[5].This technique was used to fabricate the composites for the present studies. The required amount of LM13 alloy was measured and kept in a graphite crucible. It was melted in an electric furnace at 750ºC. The preheated rutile particles were charged into the crucible at a rate of 5-6gm/min with the help of funnel. The molten mixture was rotated with the help of an impeller at a frequency 630rps. Thereafter, the cast iron mould was used to solidify the melt at room temperature.

MATERIALS CHARACTERIZATION:

MICROHARDNESS

Microhardness of the specimen at different phases has been measured using Vickers hardness tester (model: MVK_HO, Mitutoyo, Japan). Each value of hardness is an average of the ten separate values taken from the different places of the samples at 100 gf load. There are three phases i.e., Al-matrix, reinforcement and interface between the matrix and reinforcement in the developed sample composite.

WEAR TEST

Wear test was done by using pin on disc machine. For this, cylindrical pins of 8 mm in diameter were machined from cast composite. To obtain an insight into the surface wear mechanism, roughness of wear tracks of composite materials were investigated.

III. RESULTS AND DISCUSSION

STRUCTURE ANALYSIS

The uniform distribution of dispersed particles having different compositions in the matrix was observed using optical microscope as shown in Figure 1.The fair distribution of rutile particles in the alloy is achieved by constant stirring of the melt with the help of graphite impeller which prevents the particle settling tendency due to normal shear strain [1].

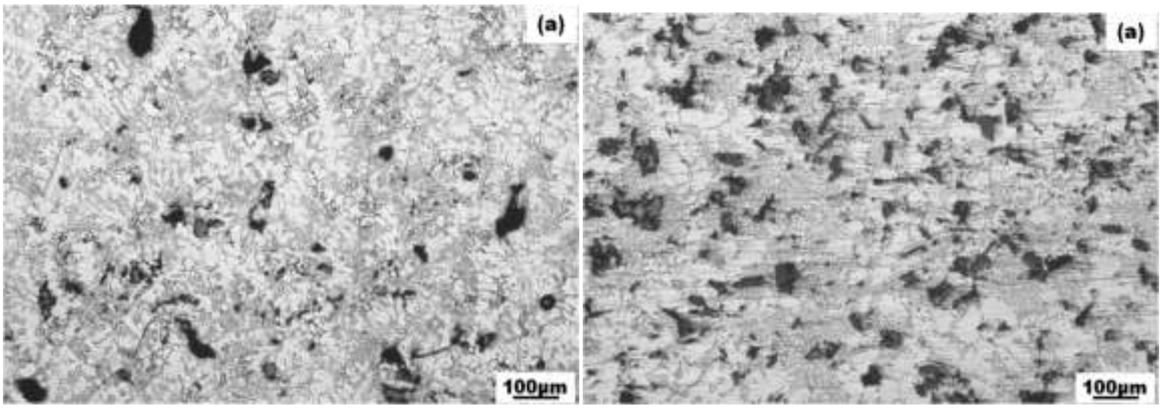

Fig. 1: The optical micrograph of composites with fine size rutile reinforced (a) 5wt.%, (b) 15 wt.% .

During solidification of the melt, the reinforced particles occupy the space in the inter-dendritic regions as they are pushed by the solid liquid interface regions which results in refinement in surface morphology. The inter-dendritic regions is decreased with increases wt.% of rutile particles. The acicular eutectic morphology of silicon is observed in the neighborhood of the particles. The particles offer preferential sites for the effective nucleation of eutectic silicon and also the mismatch of thermal conductivity between the particle and the matrix creates a thermal gradient at the interface. Delayed cooling in the vicinity of the particle accelerates the nucleation of α-Al away from the particles. The growth of α-Al has led to the enrichment of Si in the remaining melt zone surrounding the particles[5]. The heterogeneous nucleation of silicon due to the low thermal conductivity of reinforced particles leads to a change in silicon morphology from needle shaped to non-acicular**.**

MICROHARDNESS:

The rutile particles bonding with the matrix affect the mechanical behavior of the composite by enhancing its strength at the new interface regions resulting from the increased thermal and chemical reactivity. According to Arora et al. [7], the difference in coefficient of thermal expansion of the base matrix and rutile reinforcement generates higher dislocation density in the matrix which is the possible cause of the increased hardness of the composite.

Table 2: Variation of hardness at different phases in composites:

Composite	At interface	At particle
Composite- $^{5}\mathbf{C}_{\mathbf{fine}}$	121±0.5	706±0.5
Composite- $^{10}\mathbf{C}_{\mathbf{fine}}$	127±0.5	711±0.5
Composite- $^{15}\mathbf{C}_{\mathbf{fine}}$	138±0.5	718±0.65

SURFACE ROUGHNESS ANALYSIS

All composites have shown similar nature ofwear behavior under the applied loading conditions. It is found that the wear rate goes on decreasing with the increase in ceramic rutile particle content for all the applied loads. Initial stages of run have shown the remarkable decrease in wear rate in all the samples. The addition of mineral rutile particles into the matrix reduces the wear rate[8]. Hard asperities of the prepared material protect the matrix from the scratching action of the asperities of steel disc [7]. Therefore, initial run in wear was found to decrease by adding more amount of mineral rutile in the samples(Fig. 3). Steady state wear have also shown significant improvement in wear rate. As per Archard's equation [9], V = (KWS)/H, where K is wear coefficient, W is the applied load in Newton, where V is the volume loss in mm^3, H is the bulk hardness, S is the sliding distance in meter.

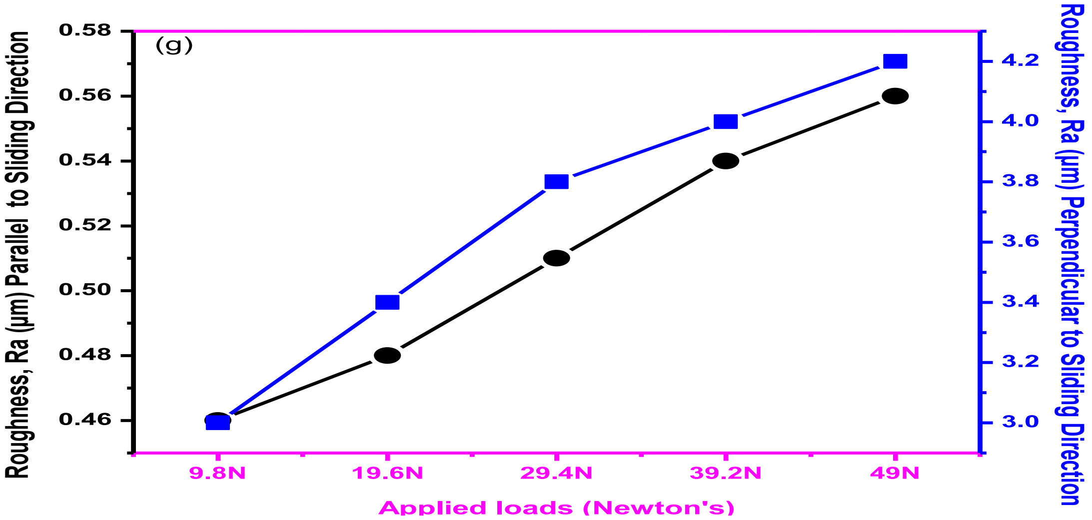

Figure 2: Roughness of wear tracks of 5% rutile composite at different loads.

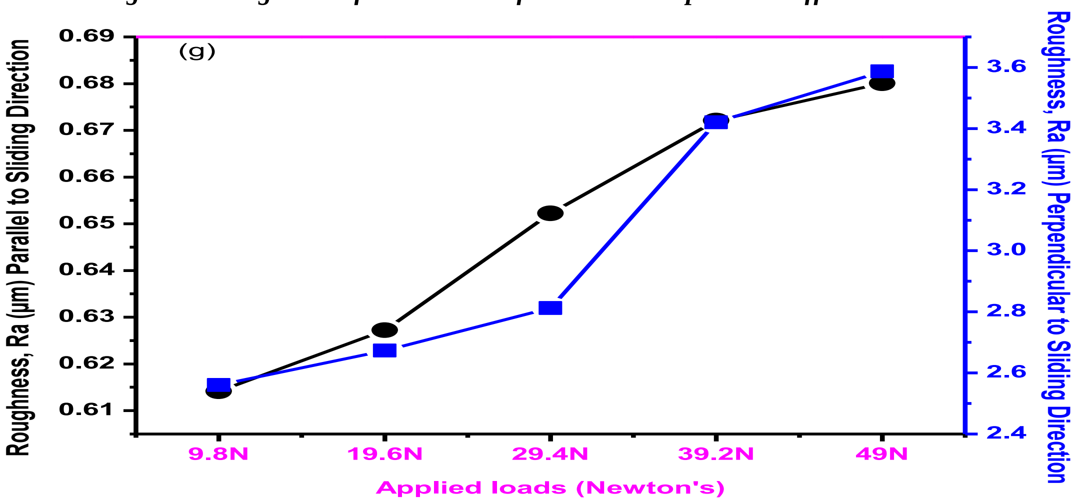

Figure 3: Roughness of wear tracks of 15% rutile composite at different loads.

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The loss of material can be calculated from the known hardness and the load applied. This can also be concluded from the above equation that wear rate is determined by the number of parameters. The improved hardness of the material lowers the wear loss. Fig.2 clearly shows the increase in surface roughness with the increase in applied load in both the directions but the amount of surface roughness in parallel direction is about 20% of the roughness in perpendicular direction. This can be explained on the basis of material removal by the abrasive action of the protruded asperities during the dry sliding conditions[10]. The formation of grooves and ridges on the worn samples of composites supports the enhanced surface roughness in the perpendicular direction.Fig.3 depicts the roughness of 15 % of rutile particles samples of wear tracks with less roughness in parallel direction may be due to the filling of the machined grooves with the tribo oxide layer formed during the wear tests.

Surface wear mechanism is accountable due to the abrasive action of the asperities and formation of the hard tribo-oxide layer which safeguards the composite from the wear loss of material which can be observed from the surface roughness of the wear tracks.

IV. CONCLUSIONS

The presence of rutile particles significantly influences the heterogeneous nucleation of the strengthening phases hence improves the morphology of the composite.The role of reinforced rutile particles on the hardness improved with increased amount of rutile composites. The abrasive action of the asperities is responsible for the wear of material which is confirmedfrom the surface roughness studies of the wear tracks.

V. REFERENCES

[1] Singh, M, Mondal, DP, Jha, AK, Das, S, Yegneswaran, AH. “Preparation and properties of cast aluminium alloy-sillimanite particle composite”, Composites A-ApplSci Mfg., 2001; 32(6); 787-795.

[2] Sharma, A., Kumar, S, Singh, G, Pandey, OP. “Effect of particle size on wear behaviour of al-garnet composites,” Particulate Science and Technology, 2015; 33(3); 233-239.

[3] Hashim, J, Looney, L, Hashim, MSJ. “Metal matrix composites: production by the stir casting method”, J. Mater. Proces. Technol., 1999;92; 1-7.

[4] Arora and Kumar, Role of Different Range of Particle Size on Wear Characteristics of Al-Rutile Composites, Particulate Science and Technology An International Journal, Vol 33: 229-233, (2015).

[5] Cruz, KS, Meza, ES, Fernandes, FAP, Quaresma, JMV, Casteletti, LC, Garcia, A. “Dendritic arm spacing affectingmechanical properties and wear behavior of Al-Sn and Al-Si alloys directionally solidified under unsteady–state conditions”, Metall. Mater. Trans. A, 2010;41(4); 972-984.

[6] Kumar, S, Panwar, RS, Pandey, OP. “Wear behavior at high temperature of dual-particle size zircon-sand-reinforced aluminum alloy composite”, Metall. and Mater. Trans. A, 2013; 44(3);1548-1565.

[7] Arora, R, Kumar, S, Singh, G, Pandey, OP. “Influence of particle size and temperature on the wear properties of rutile reinforced aluminium metal matrix composite,” J Compos Mater, 2014; 49; 843-852.

[8] Sharma,A,Arora, R, Kumar,S. “Effect of Mineral Garnet Reinforced on the Tribological Properties of Composite at High Temperature",IJSRST.2017;3(7):211-215.

[9] Archard JF.Contact and rubbing of flat surfaces. J Appl. Phys. 1953; 24: 981-988.

[10] Das, S, Das, S, Das, K. “Abrasive wear of zircon sand and alumina reinforced Al-4.5 wt% Cu alloy matrix composites-a comparative study”. Compos. Sci. Technol., 2007; 67(3-4); 74-751.

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