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Microstructure and Wear Behavior of Al2218-B_4C Nano Composites

[1]*Vidyadhar Pujar*, [2]*Srinivas H K*, [3]*Sahadeva G N*, [4]*Mamunuri Sailender*, [5]*Madeva Nagaral*

[1]Research Scholar, Department of Mechanical Engineering, Don Bosco Institute of Technology, Bangalore, Karnataka, India & Assistant Professor, Department of Mechanical Engineering, Oxford College of Engineering, Bangalore, Karnataka

[2]Professor, Department of Mechanical Engineering, SJBIT, Bangalore, Karnataka

[3]Professor, Department of Mechanical Engineering, EPCET, Bangalore, Karnataka

[4]Manager, ARDC, Hindustan Aeronautics Limited, Bangalore, Karnataka

[5]Deputy Manager, ARDC, Hindustan Aeronautics Limited, Bangalore, Karnataka

Email: v8123340411@gmail.com

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ABSTRACT

The effect of nano B_4C particle addition on the wear behaviour of Al2218 alloy composites has been investigated. Al2218 combination with 2 to 8 wt. % of nano B_4C composites were manufactured by stir technique. Microstructural study was completed by utilizing SEM and EDS. A pin-on-disc machine was used to evaluate the wear loss of examples, in which a set EN32 steel plate was used as the counter face. Wear tests were went with on Al2218 compound with nano B_4C particles strengthened composites at different loads of 9.8 N, 19.6 N, 29.4 N and 39.2 N with steady sliding rate of 2.8 m/sec and 2000 m sliding separation. Also, Wear tests were went with on Al2218 amalgam with nano B_4C particles strengthened composites at different paces of 1.4 m/sec, 1.8 m/sec, 2.3 m/sec and 2.8 m/sec with consistent load of 39.2 N and 2000 m sliding separation. The wear opposition of Al2218 compound improved with the gathering of B_4C particulates. Further, worn surface morphology and wear debris of prepared composites were studied to know the different wear phenomena.

1. Introduction

The normal name being composite material or basically a composite is mix of at least two materials with non-indistinguishable physical or substance properties, when intermixed delivers completely extraordinary item with unique attributes when contrasted and the individual material trademark. The mixing of the material is normally done at a perceptible level. These materials

are intermixed in such a proportion that its specific properties get improved. The proportions of two materials are advanced dependent on their applications. The subsequent composite material has an equilibrium of its properties that is greatly improved to any of the constituent materials [1, 2]. These composites are utilized for their extemporized mechanical properties, yet in addition for warm, electrical and ecological applications. These materials are commonly favoured for various applications like cements, strengthened plastics, for example, fiber fortified polymers, metal composites, clay composites. Artistic lattice composites and metal grid composites are commonly utilized for structures, extensions and structures, for example, boat shelter, pool boards, race vehicle bodies, baths, stockpiling tanks and likewise progressed materials in shuttle's and airplanes building which are sought after [3, 4].
The metal matrix composite (MMC) is the one in which metals are matrix phase & the reinforcing phase may be a metal other than base metal/matrix metal or another material like organic compound or a ceramic. The reinforcing material may be in the form of particles or whiskers or fibers and the properties of the MMC's can be varied with variation of size of reinforcing material [5]. Though MMC's are not widely used as the PMC's, but the properties like stiffness, high strength & fracture toughness are creating the trend towards MMC's. The MMC's can withstand high temperature, corrosive environment better than that of the composites made of PMC's. Most metals and alloys can be used as matrices which require reinforcement materials that are to be stable at high temperatures and are to be non-reactive too. It has to be kept in mind that if MMC's have to offer good strength then the reinforcing material used should have high modulus & high tensile strength.
In the current work an exertion has been made to know the impact of nano B_4C support expansion on the wear conduct of Al2218 aluminum composite. Al2218 composite with 2 to 8 wt. % of nano composites were created. Further, these readied tests were assessed for dry sliding wear conduct at different loads and sliding rates according to ASTM G99 norms.

2. Experimental Details

Materials

In the present study Al2218 is used as the matrix material, most of the applications in areas such as aerospace, automobile, marine make use of 2xxx series, aluminium-copper alloys. Al2218 normally has 4.5% of copper and 1.8% of magnesium. The theoretical density of Al2218 alloy is taken as 2.80 g/cm^3.

Table 1: Chemical composition of Al2218 Alloy

Element	Si	Cu	Mg	Mn	Fe	Zn	Ni	Al
Wt. (%)	0.90	4.5	1.8	0.20	1.0	0.25	1.5	Balance

In the present work, nano B_4C particulates are used as the fortification materials, 500 nm particulates were used, which were obtained from Reinste

Nano Ventures Ltd., Delhi. The density of B_4C is smaller than the matrix material, which is 2.52 g/cm^3.

Methodology

The manufacture of Al2218-B_4C composites were completed by liquid metallurgy through stir cast method. Determined measure of the Al2218 compound ingots were kept into the heater for liquefying. The melting temperature of aluminum composite is 660°C. The Al2218 alloy melt was superheated to 750°C temperature. The temperature of the melt was recorded utilizing a chrome-alumel thermocouple. The molten metal is then degassed utilizing solid hexachloroethane (C_2Cl_6) for 3 min [6]. A hardened steel impeller covered with zirconium is utilized to mix the liquid metal to make a vortex. The stirrer will be turned at a speed of 300rpm and the profundity of drenching of the impeller was 60 percent of the height of the liquid metal from the outside of the liquefy. Further, the B_4C particulates were preheated in a heater upto 400°C will be brought into the vortex. Stirring was proceeded until interface connections between the fortification particulates and the Al matrix advances wetting. At that point, Al2218-2 wt. % nano B_4C melt was poured into the cast iron mold having measurements of 120mm length and 15mm width. Additionally, composites were set up for 4, 6 and 8 weight level of nano B_4C particles in the similar method.

Evaluation of Properties

The castings in this way got were sliced to a size of 15 mm diameter across and 5 mm thickness which is then exposed to various dimensions of cleaning to get required example piece for microstructure studies. At first, the cut examples were cleaned with emery paper up to 1000grit size pursued by cleaning with Al_2O_3 suspension on a cleaning disc utilizing velvet material. The cleaned surface of the examples etched with Keller's reagent lastly exposed to microstructure in an electron microscope.

The wear conduct of Al2218 compound and B_4C fortified composites were done by utilizing wear machine. The preliminaries were gone with according to ASTM G-99 wear testing standard [7] on 8 mm in measurement and 30 mm length roundabout example. The wear misfortune was determined in the wake of leading the dry sliding wear tests at 9.8 N to 39.2 N differing loads at 2.826 m/sec sliding velocity for 2000 m sliding separation in 90 mm distance across wear track. Likewise, one more arrangement of dry sliding wear conduct of Al2218 combination composites were dissected at different sliding velocities of 1.4 m/sec to 2.826 m/sec at 39.2 N load and 2000 m sliding separation. The wear misfortune was noted regarding stature misfortune and introduced in the work.

At the time of conducting wear tests utilizing wear machine, wear trash were gathered and these debris were read for the different wear instruments utilizing SEM micrographs. Further, worn surface morphology likewise done utilizing examining electron micrographs to know the different wear conduct associated with the Al2218 amalgam and Al2218 composite with 2 to 8 wt. % of nano B_4C composites.

3. Results And Discussion

Microstructural Study

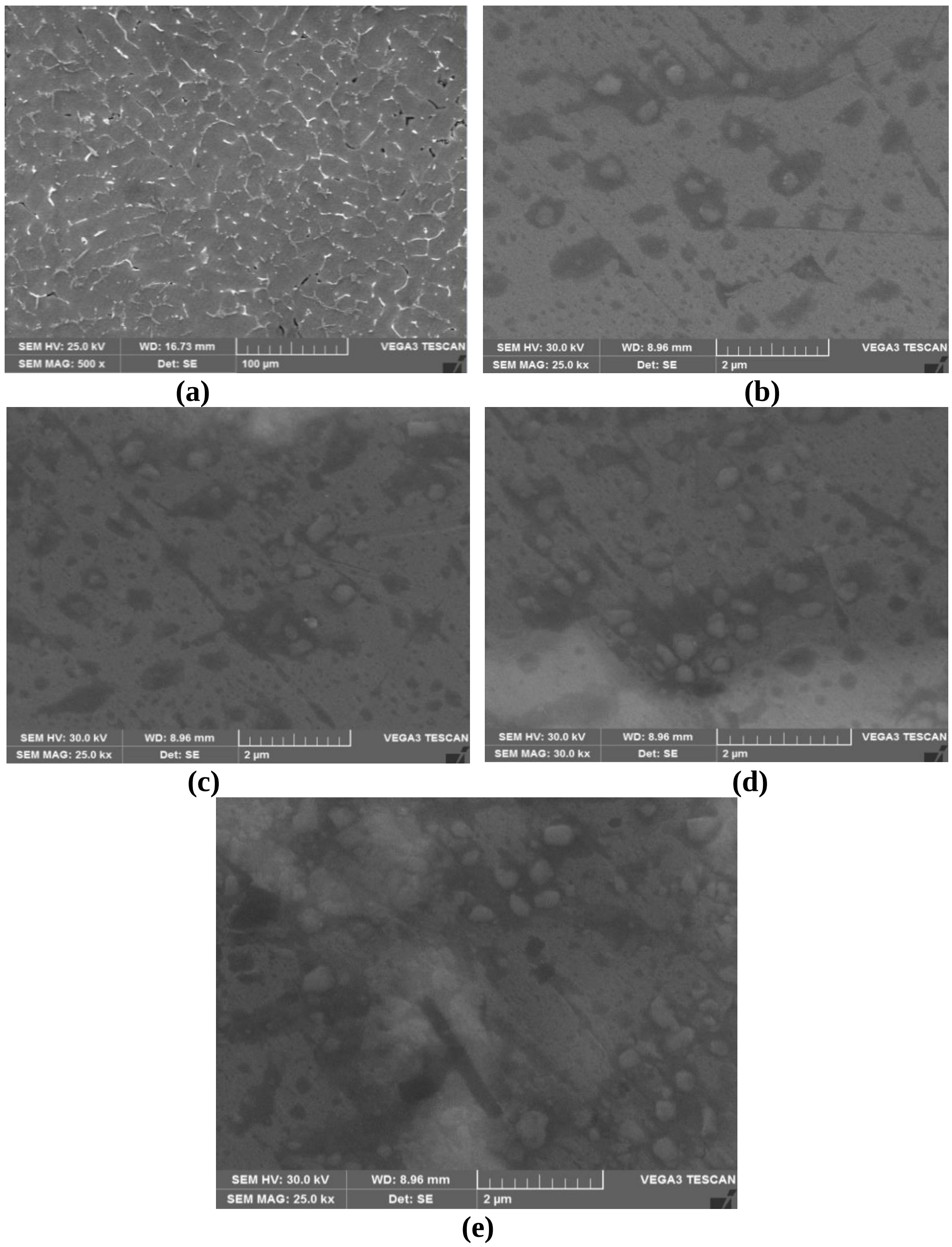
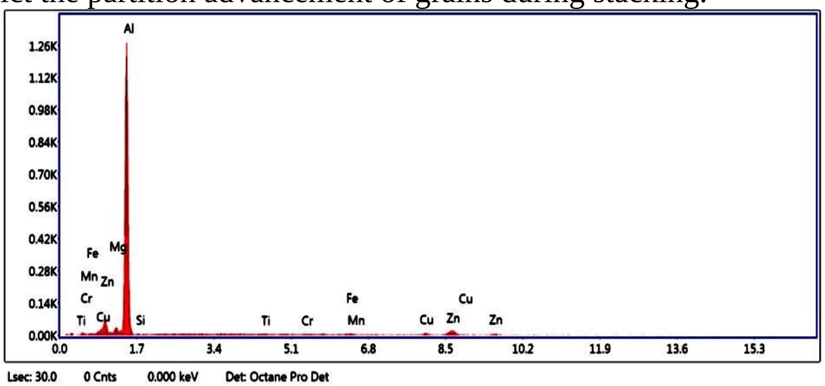


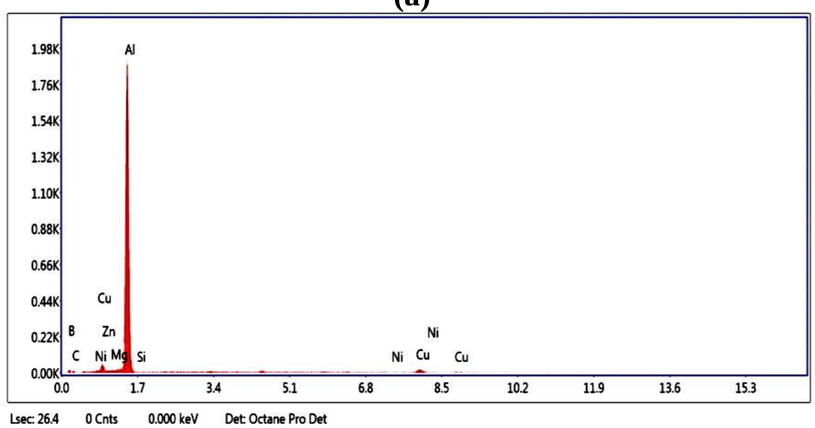
Figure 2: SEM of (a) as cast Al2218 alloy (b) Al2218-2 wt. % B_4C (c) Al2218-4 wt. % B_4C (d) Al2218-6 wt. % B_4C and (e) Al2218-8 wt. % B_4C composites

Figure 1a-e shows the SEM micrographs of as cast alloy Al2218 and the composites of 2 to 8 wt. % of nano B_4C reinforced with Al2218 alloy composites. The microstructure of as cast Al2218 alloy comprises of fine grains of aluminium solid solution with an enough dispersion of inter-metallic precipitates.

It also exhibits the incredible bonding between the matrix system and the nano particles so uniform homogenous dissemination of nano evaluated B_4C particulates with no agglomeration and clustering in the composites. This is basically a direct result of the suitable mixing action achieved all through the extension of the fortress by two stages. The nano particles wherever all through the grain furthest reaches of the cross section hinder the grain improvement and contradict the partition advancement of grains during stacking.



(a)



(b)

Figure 2: EDS images of (a) as cast Al2218 alloy (b) Al2218-8 wt. % B_4C composites

Figure 2 (a-b) represents the EDS spectrum of as cast Al2218 alloy and Al2218 alloy with 8 wt. % of nano B_4C reinforced composites. As cast Al2218 alloy EDS spectrum is showing the major elements like Al, Cu, Si, Mg, Mn and Fe in the Al2218 alloy matrix. Further, Al2218 with 8 wt. % of B4C composites EDS spectrum is indicating boron (B) and carbon (C) elements in the prepared composites and confirms the presence of B_4C reinforcement in the Al2218 alloy composites.

Wear Properties

The wear misfortune was determined in the wake of directing the dry sliding wear tests at 9.8 N to 39.2 N differing loads at 2.826 m/sec sliding pace for 2000 m sliding distance in 90 mm width wear track. Likewise, one more arrangement of dry sliding wear conduct of Al2218 combination composites were investigated at different sliding paces of 1.4 m/sec to 2.826 m/sec at 39.2 N load and 2000 m sliding separation. The wear misfortune was noted regarding height loss and introduced in the work.

Effect of Load on Wear Rate

Fig. 3 is indicating the correlation of wear conduct Al2218 amalgam and Al2218 composite with 2 to 8 wt. % of nano B4C composites at different loads of 9.8 N to 39.2 N fluctuating loads at 2.826 m/sec sliding rate for 2000 m sliding separation in 90 mm wear track. From the diagram it is obvious that as the load increment from 9.8 N to 39.2 N, there is an increment in wear misfortune in Al2218 combination and Al2218-B_4C particles fortified composites. The load influenced the wear conduct of both as cast and B_4C strengthened examples. The expanded wear misfortune as load increments from 9.8 N to 39.2 N is chiefly because of the improved contact territory between the example and the steel plate. This expanded region of contact during wear test creates more warmth, which causes the delamination in the compound and composites [8].

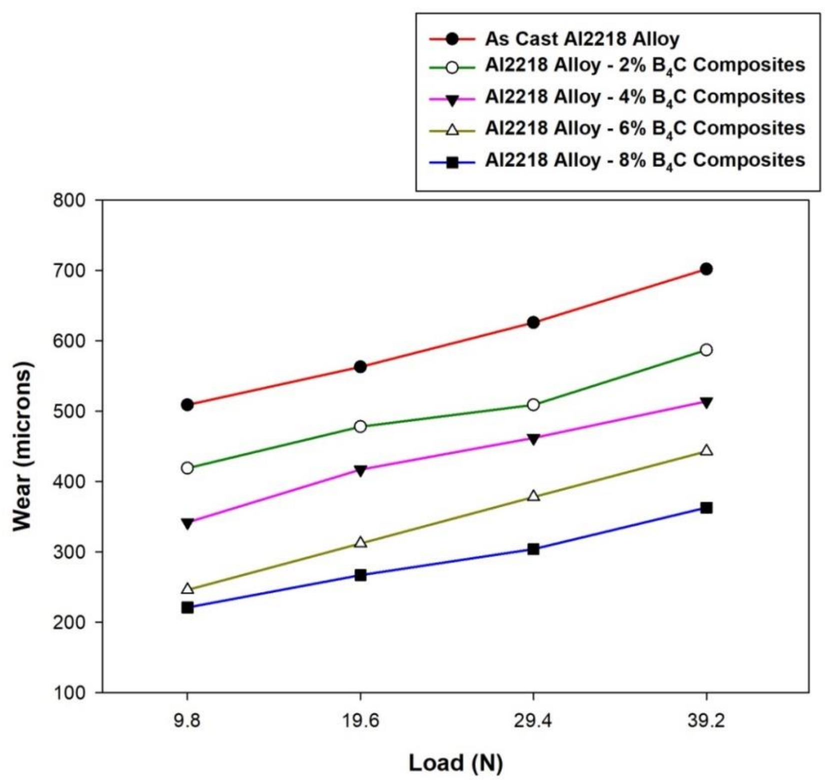


Figure 3 Wear loss of Al2218 alloy with nano B4C reinforced composites at varying loads and constant velocity

Effect of Sliding Speed on Wear Rate

Fig. 4 shows the wear misfortune with the variety of speed for a several samples with varying content of B_4C. The test is directed with differing speed of 1.4 m/sec, 1.8 m/sec, 2.3 m/sec and 2.8 m/sec by holding load of 39.2 N. From the Fig. 4, it is presumed that wear misfortune increments with the speeding up. For base Al2218 amalgam the impact of sliding velocity is more when contrasted with B_4C fortified nano composites.

From the graph 4 as the speed increases from 1.4 m/sec to 2.8 m/sec, there is an increase in wear of Al2218 alloy and Al2218 alloy with 2 to 8 wt. % of nano B_4C reinforced composites. Further, from the plot it is evident that the nano B_4C particles reinforced composites shown more wear resistance as compared to Al2218 alloy. The addition of nano B4C particles improves the hardness of Al2218 alloy with strong bonding between the matrix and reinforcement. This enhanced bonding helps in improving wear resistance of Al2218 alloy by acting these particles as barrier for the deformation during wear process [9].

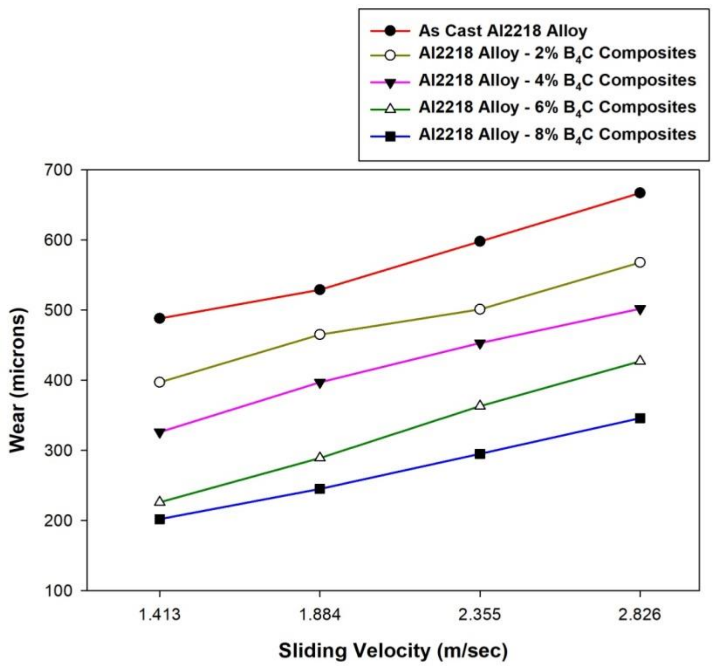
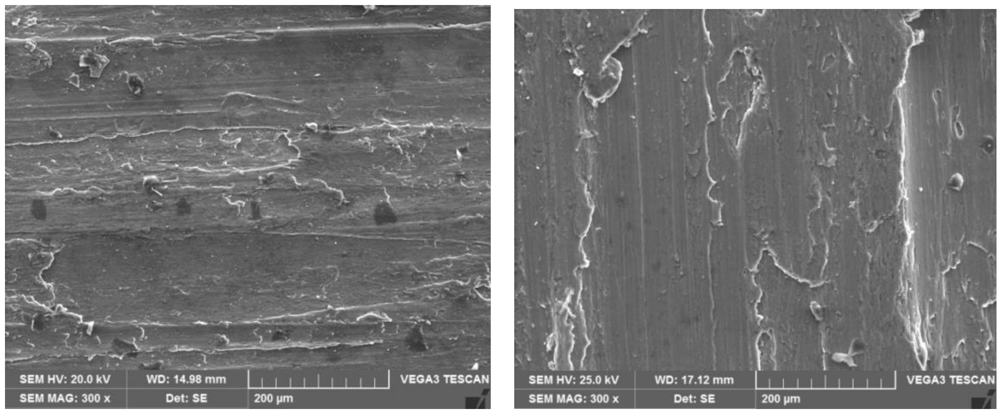


Figure 4 Wear loss of Al2218 alloy with nano B_4C reinforced composites at varying speeds and constant load

Worn Surface morphology and Wear Debris

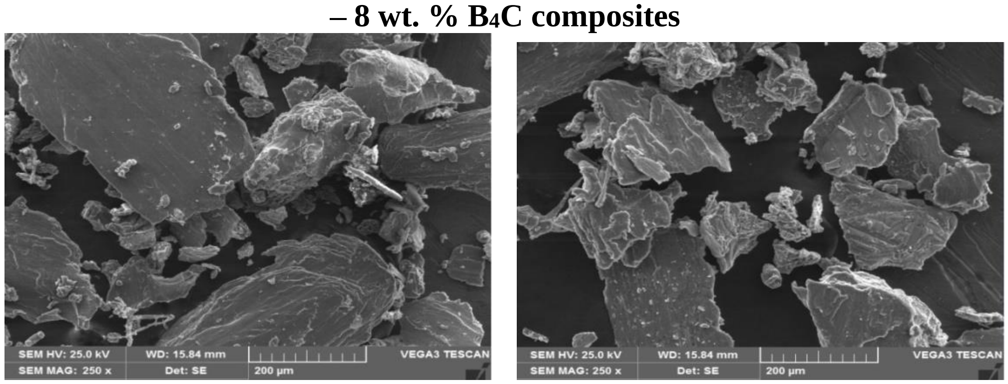
It's significant to study the worn-out surface morphology of Al2218 alloy and its nano composites as it shows the type of wear the materials with different composition have undergone. During sliding the Al2218 matrix is softer than the rubbing disk material and hence shows viscous flow in Al2218 matrix, which is in the form of pin causing plastic deformation of the specimen surface, resulting in very high material loss. The worn surface of Al2218 alloy shows presence of grooves, micro-pits and fractured oxide layer as shown in Fig. 5 (a), which would have caused the increase of wear loss. Whereas 8 wt. %

of B_4C particles in Al2218 alloy composites restrict the viscous flow of the matrix as shown in Fig .5 (b), it is observed that the grooves or erosion have reduced with increase in B_4C particles means there is more and more resistance to wear loss [10]. Meanwhile, the stress seems to be transferred on B_4C particles and strain concentration occurs around these B_4C particles and worn surface area shows less and less cracks and grooves with increasing B_4C particles.



(a) (b)

Figure 5 Worn surfaces SEM micrographs of (a) Al2218 Alloy (b) Al2218 – 8 wt. % B_4C composites



(a) (b)

Figure 6 Wear debris SEM micrographs of (a) Al2218 Alloy (b) Al2218 – 8 wt. % B_4C composites

The byproducts obtained in the form of particles after wear test are called wear debris. During the course of rubbing action always the softer material wears out. In wear debris analysis the worn-out particles are observed in SEM to understand type of wear the material has undergone. The various images obtained from SEM are shown in above Fig. 6 (a-b).

Fig. 6 (a) shows image of debris resulted from wear of Al2218 aluminium alloy. The size of the debris due to wear mechanism shows the extent of wear, Al2218 alloy has under gone. The long layers formed from wear surface were not able to withstand the high load and hence the layers were pulled and thrown away in the form of thin plate, these thin long mechanical layers resulted due to the ductility of test sample. Fig. 6 (b) shows wear debris of

Al2218-8 wt. % of B_4C composites, the debris can be seen in the form of fragments which are crushed between test piece & rotating disc. The wear debris of B_4C based composites exhibits less wear with small particles like fragments pulled out from the pin.

4. Conclusions

Al2218 alloy with nano B_4C composites have been manufactured by stir casting technique by taking 2 to 8 wt. % of B_4C particles. The microstructure and wear practices of Al2218 compound nano composites were analyzed. SEM microphotographs uncovered the even circulation of B_4C particles in the Al2218 compound. Further, nano support particles were eminent by the EDS examination. The impact of load and the sliding velocity was seen on the Al2218 amalgam and its B_4C particles fortified composites. As the load and speed improved, there was enhanced wear loss of Al2218 amalgam and nano composites. The improved wear opposition was seen on account of Al2218 amalgam with 8 wt. % of nano B_4C composites.

References

Mohammed Imran, A. R. Anwar Khan, JMRT, 8 (3), 2019, pp. 3347-3356.

R. Devanathan, J. Ravikumar, Materials Today Proceedings, 22, 2020, pp. 3136-3144.

V. Bharath, V. Auradi, Madeva Nagaral, Satish Babu Bopanna, JurnalTribologi, 25, 2020, pp. 29-44.

NosaIdusuyi, John I. Olayinka, JMRT, 8 (3), 2019, pp. 3338-3346.

V. Bharath, V. Auradi, Madeva Nagaral, Satish Babu Bopanna, Journal of Bio and Tribo Corrosion, 6, 45, 2020.

Madeva Nagaral, V Auradi, SAKori, Vijayakumar Hiremath, JMES, 13, 1, 2019, pp. 4623-4635.

Zhang Mei Juan, Transactions of Nonferrous Metals Society of China, 20, 2010, pp. 471-475.

C. S. Ramesh, R. Keshavmurthy, B. H. Channabasappa, S. Pramod, Materials and Design, 30, 2009, pp. 3713-3722.

Madeva Nagaral, Applied Mechanics and Materials, Vol. 592-594, 2014, pp.170-174.

C. Mallikarjuna, Materials and Desig=n, 32, 2011, pp. 3554-3559.