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Mechanical Characterization of LM 6 Metal Matrix Composite (MMC) with SiC and $CuSO_4$ as Reinforcement

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ABSTRACT: In recent review paper we have observed that, the manufacturing and automotive sectors, a metal matrix use was increased. Owing to its strong metal thermal conductivity and weak thermal expansion coefficient in ceramics. In this paper, wearing behavior, in different proportions as 10:20, 15:15 and 20:10 respectively, of aluminum (Al) reinforced with Copper Sulphate and Silicon Carbide, based upon its mass fraction. The MMC was produced by the sintering method in the above mentioned proportions. The temperature and the furnace pressure are 540^{o}C and 150N during the sintering cycle. M2 inch, or so. In the finance, the maintained heating average was 20^{o}C / min. The 0.9% to 1.0% lubrication of Copper Sulphate stearate means the ceramic and metal remain tightly connected. The fit of MMCs was checked on specific forms of fabric, stiffness or fit (Rockwell). Study of SEM according to requirements of ASTM [7]. The wear strength and hardness have been decreased and the ceramic composition has been increased for the 20:10 metal respectively. The micro structure of MMC is demonstrated in the SEM analysis.
Keywords: Coefficient, reinforcement, MMC, SEM, Manufacturing.

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I. INTRODUCTION

Due to their improved properties such as high strength, high stiffness and good wear resistance, hybrid composite materials become more and more common in the manufacturing and automotive industries, advanced composite materials are used to obtain high hardness and tensile strength at room temperature [1 to 3^{0}C]. The gradual loss of material because of the relative motion of the surface to the contact substance is wear. The wear damage may be micro cracks or locally deformed plastics. The tribological parameter that governs wear and friction, material properties and test parameters, such as the pressure applied, sliding speed, atmosphere and this form of sliding contact. The Low-Level Particulate Relief Reinforcement (LLRR) variant is a very important in terms of the hardness of MMC < whisker MMC < particle dispersed MMC fiber reinforcement. The wear resistance is influenced by the volume fraction of the upgrades.

The wear properties are affected by including rough particles in the composite material matrix. Hard ceramic part like Al_2O_3, SiC, Tic and so on [4]. The loss of wear relative to the base alloy has shown to be reduced in the matrix of the mixed composite content [10]. The studies showed that wear loss usually decreases as the volume fraction and particle size increases in the hard phase. Wear tests of composite content have found that the wear intensity of improved Al_2O_3 composites is two times greater, as particle size increases between 5 and 142μm. At the fraction of the set number. During sliding at higher wear rates, the sliding develops a high temperature, which makes this specimen soft and plastic. It interacts with the oxygen and the oxides. A thickness and continuity of the hard brittle oxide formed on the surface of the specimen will cover the entire area. The mechanical mixing layer formed and was partly responsible for increasing the wear resistance of composites as insulator form of thermal conductivity.

The mixed layer had micro structural characteristics which compared a combination of a finest seeded framework where the components relied on the loads of sliding. Through formation and separation of the matrix layer, the wear rate would be influenced in the burden. The main objective of this research is to evaluate the wear behavior of Al matrix, which has been reinforced continuously by two different types of particles like SiC and Al_2O_3. For the development of hybrid metal matrix composite goods, the vacuum sintering oven is used. A pin on the disc wear tester examines the effects of Al_2O_3 & SiC adding on the reinforcement and the load used in the dry slider metal wear of composite [7]. The particle distribution is examined for the micro structure of the specimen, and the worm surface has been examined by SEM.

It is necessary to uni formalize the distribution of the strengthening material in the matrix and to maximize the solder ability or bond between these substances. Industrial technology is growing fast and the need for materials is growing. For the production of AMCs with aluminum as a matrix and silicon Carbide as an enforcement, the current study uses stir casting method [8].

II. LITERATURE SURVEY

A. M. S. Hamouda et.al. Review provides on "Making and characterization of particulate enhanced Aluminum silicon composite matrix" [5] and the quartz particulate enhanced LM6 alloy composite value was calculated, and it was found to be that slowly by that the enhancement step. They found that with the addition of quartz particulates the tensile strength of the composites decreases. The article is also well featured in the joining of the particulate matrix and design studies performed to explain the mechanical activity and the fractograms used (SEM) in the treated composite materials.

H. S. Arora, H. Singh & B. K. Dhindaw, presented a Report on "Major impetus of FSP technology for Aluminum and Magnesium alloys, Composite Manufacturing using friction stir Processing [6]," which outlined FSP's current status in composite production. He has said that FSP 's effective use of the methodology in surface and bulk composites development strongly confirms it in the composite manufacturing sector. He also acknowledges that more research in this field and a deeper understanding of the process characteristics will also pave the way for this technology's commercial success.

R. Ramesh, N. Murugan, submitted the paper "Aluminum 7075 – T651 alloy / B4C 4 percent volume micro-structure and material characteristics. Surface composite through friction stir processing" [7] and found that, using three passes, the composite surface manufactured at a rotation rate of 500 rpm has produced a good processed surface composite at a speed of 60 mm / min. In addition, the amount of grain in the nugget zone decreases with increased rotational velocity at a particular traverse velocity. Furthermore, he found that the average friction stir hardness was 1.5 times higher than that of base metal Aluminum 7075 – T651.

K.L. Meena et al. presented with a paper titled "An examining mechanical properties of Al / SiC MMC's Developed" [8], which showed that SiC particles were relatively uniformly distributed in Optical micrographs. With the growth of reinforced size and weight fraction of SiC particles, tensile strength increases. An rise in the improved particulate size and weight fraction of SiC particles often increases the field extension and percentage reduction. With increasing reinforced particle size and weight portion of SiC particles, hardness (HRB) and density increases. Impact Strength decreases when the particle size is strengthened and increases when the SiC particle size is increased.

N. Altinkok, Ozsert & F. Findik, presenting a paper on Al_2O_3 / SiC Aluminum reinforced MMCs produced by stir casting processes for dry sliding wear'[9], hybrid and bimodal particle reinforcement found that weight loss decreased particularly when SiC powder with wide grain sizes was used. She has done a fine alumina part reinforcement phase within the Aluminum matrix (A332) in addition to the coarse SiC particle reinforcement. He also stated that combining hybrid and bimodal particles improves the composite’s strength with respect to the smaller composite.

Dharmpal Deepak, Ripandeep Singh Sidhu, V.K Gupta, presentation of the paper on "Preparing 5083 Al SiC composite surface by friction stir processing with its mechanical characterization" [10] reveals the substantial increase in hardness of the surface composite developed in FSPed sample layer resulting from doping of 5083 Al with solid SiC particles by FSP. Given its greater strength, the wear tolerance of the FSPed sample is less than that of 5083Al. Low friction levels and higher friction intensity during wear testing of the FSPed sample can be due to this effect.

M. L. Ted Guo & C.Y.A.Tsao, presented in a paper on 'Semisolide powder-densification method tribologies of the self lubrifying Aluminum / SiC / graphite hybrid composites'[11], hardness decreases monotonously with the amount of the added graphite fracture energy decreases with increasing amounts of the addition of graphite. Co-efficient of friction. Decreases with the increase in percent of the added graphite. As the percentage of graphite addition increases, the amount of graphite released on a wear surface increases [3]. Graphite released from composites bonded the counter parts on the wear surfaces but the volume is small and the amount bonded for different graphite is not significantly differentiated.

M. Asif, K. Chandra & P.S. Misra, presented the paper "Development of composites for heavy duty Aluminum-based metal matrix composites" [4] and the dry sliding wear behaviour, enhanced by carbide silicone particles and by graphite, of Aluminum alloy based components. The results show that hybrid composite wear rate is lower than binary composite usage. With increased load and distance, the wear rate decreased. It also compares the results of the composites proposed with composites based on the iron metal matrix with corresponding test parameter values. The comparative analysis indicates that the composites introduced have a decreased stress, lower temperature increase and a small degree of noise.

Farshad Akhlaghi, S.Mahdavi, submitted a paper on "The Effect of SiC Content on the Tribological Properties for Hybrid Al / Gr./SiC Metallurgical Compounds"[10], in which graphite acts as a solid lubricant and reduced the friction coefficient. However, it decreases the composite's mechanical properties. In such hybrid composites, the strong siC particles improve stiffness and strength to compensate for the impact of graphite that are reduced. Powdered metallurgy (P / M) is an effective manufacturing technique for such MMCs, although it takes a fairly long mixing period to obtain a consistent graphite and SiC particle distribution in the matrix alloy [2]. The al / gr / sic compacts were made by cold pressing various pudding mixtures and the effects of sic contents were investigated after the sintering of the resulting hybrid composites on their density, microstructure, hardness and wear properties.

J.Jenix Rino, D.Chandramohan, K.S.Sucitharan, a paper on the "Information on the development of hybrid-reinforced composites in metal-aluminum metal material"[14] shows that the stir casting method allows for a successful synthesis of composites in aluminum alloy matrix strengthened with hybrid. The important process parameter are the synthesis & characterization of the hybrid composite by stir casting, the design and location of the mixer, speed and time of mixing, the temperature of melting and filling, the temperature of particle preheating, the incorporation rate, the type and size of mold and the reinforcement part. The compound hardness, toughness, strength, corrosivity and wear resistance will be increased further by added hybrid enhancement instead of single enhancement.

III. RAW MATERIAL

1. ALUMINUM MATRIX MATERIAL

The name aluminum comes from the former name of alum (potassium aluminum sulphate), which was aluminum. Aluminum is the most common element on the globe, containing well over 8 per cent of the earth's surface. After oxygen and silicone, it is the third most common element. Aluminum is lightweight, strong, recyclable, resistant to corrosion and essential to everyday life. Aluminum goods are just as common in our lives and developed ecosystems. Aluminum has been the preferred commodity for a wide variety of products and services since its industrial development started just over a hundred years ago [9]. A smooth, lightweight metal is aluminum. It's dull silvery, due to a thin oxidizing layer that quickly forms when exposed to air. Non-magnetic, non-sparking aluminum (as metal).

It is very sensitive such that a thin yet similarly safe oxide film occurs easily in the atmosphere. That's why it is highly corrosion resistant. Anodization with a special procedure, i. e. The oxide protected surface of aluminum, even reinforced and made more resistant to corrosion, can be an electrolytic oxidation process. It's soft, silver and white metal. Aluminum is the third highest in the Earth's crust, following the oxygen and silicon, and the richest in metal. It constitutes the solid surface of the Earth about 8 percent by weight. Aluminum has a unique and unsuperb combination of characteristics which make the structural material versatile, highly usable and attractive. The light of aluminum is one-third the steel density, 2.700 kg / m3. Depending on alloying and processing methods, aluminum is solid with a tensile strength of 70 to 700MPa. The correct alloy and material extrusions are as durable as structural steel.

The Young's aluminum module is a third of steel module (E = 70,000 MPa). In order for an aluminum extrusion to achieve the same deflection as a stain profile, the moment of inertia must be three times greater. In air interaction, a thin layer of oxide has been developed, offering excellent corrosion safety even in corrosive environments. The surface treatments such as anodizing or powder coating can further strengthen this layer. Even when compared to copper, thermal and electrical conductance are very good [7]. For comparison, about half the weight of an equal copper conductor is on an aluminum conductor. Together with other metals, aluminum has a relatively small linear expansion coefficient. At design stage, this should be considered in order to compensate for expansion differences.

2. ALUMINUM MATRIX SELECTION

MMC materials have numerous superior characteristics, which are unreinforced,: improved power, greater elastic frame, better service temperature, better wear resistance, weak electrical and thermal conductivity, low thermal expansion coefficients and a strong vacuum environmental resistance. The best matrix and reinforcement preference will accomplish these properties.

3. SILICON CARBIDE REINFORCEMENT ELECTION

Silicium carbide particles are added in total 5-25% by weight. The physical and mechanical properties measured includes: densities, porosity, ultimate tensile strength, yield strength, durability values, and energy impact were then examined for the alloy particulate-composite microstructure. The results revealed that, addition of silicon carbide reinforcement, increased the hardness values and apparent porosity by 75 and 39 percent , respectively, and decreased the density and impact energy by 1.08 and 15 percent , respectively, as the weight percent of silicon carbide increases in the alloy [8]. The yield strength and final strength of the tensile increases respectively by 26.25 and 25% to a maximum 20% added silicone carbide. The distribution of strong and weak ceramic phases in the ductile metal matrix is the cause of these changes in intensity and hardness ratios.

4. ALUMINA

Aluminum oxide, with a chemical formula Al_2O_3, is a chemical compound of aluminum and oxygen. The most common occurrence is the occurrence of several oxides of aluminum and aluminium (III) oxide. It is generally called alumina and may, depending on certain shapes or applications, also be called aloxide, aloxite, or alund. The mineral corundum, which are precied by ruby and saphir type, typically forms in its crystalline polymorphic form α-Al_2O_3. Applying strong ionic interatomical connection, Aluminum Oxide, commonly known as alumina, has its desirable material properties. It can exist in several crystalline phases all of which revert at high temperatures to the most stable hexagonal alpha phase.

In order to improve the specific desired material properties, the composition of the ceramic body can be changed. An example could be added to improve hardness and color by adding chrome oxide or manganese oxide [11]. Additional additions can also be made to improve the facility and consistency for the brushed and welded assembly of the metal films fired into the ceramic. In the family of electronics ceramics aluminum is one of the cheapest and most common stuff. The raw materials from which this high-performance technical grade ceramic is produced are readily available and affordable, which means that the manufactured alumina forms cost good value. It is not surprising that fine grain technical grade alumina has a wide range of applications with an excellent combination of properties with an attractive price.

5. ALUMINA REINFORCEMENT SELECTION

Under reducing, inert and high vacuum conditions, highly pure alumina can withstand very high temperature. They remain strong chemical tolerance and wear and abrasion immune to high temperatures. The products of alumina can endure a temperature of up to 1750° C.

PHASE	SOLID	SOLID	SOLID
MOLECULAR FORMULA	Al	SiC	Al_2O_3
APPEARANCE	WHITE POWDER	BLACK POWDER	WHITE POWDER
DENSITY	2.8 g/cm^3	3.22 g/cm^3	3.76 g/cm^3
MELTING POINT	934K, 7 60^{0}C 1220^{0}F	2731^{0}C, 4 49^{0}C 51^{0}F	2097^{0}C 2370 K 3805^{0}F
BOILING POINT	2500^{0}C 2774K 4551^{0}F	3581^{0}C 854K, 64 54^{0}F	2978^{0}C 51K, 5391 F
QUANTITY	501 g	251 g	251 g
SIZE	401 mesh	401 mesh	401 mesh
PURITY	99.6 % (Metal Basis)	99.6 % (Metal Basis)	99.6 % (Metal Basis)

TABLE No. 1: PHYSICAL COMPOSITION OF RAW MATERIAL

Sl No	Al %	SiC%	Al_2O_3 %	% q	Wt of Al(g)	Wt of SiC(g)	Wt of Al_2O_3 (g)	Total Mass (g)
1	71	19	11	96	11.98	3.43	1.73	17.15
2	71	15	16	96	12.71	2.58	2.59	17.26
3	71	10	20	96	12.16	1.74	3.48	17.37

TABLE No. 2 : WEIGHT COMPOSITION OF SAMPLES

PREPARATION OF HYBRID METAL MATRIX COMPOSITE MATERIAL

Sintering processes are used in the preparation of aluminum metal matrix (Al+SiC) and aluminum metal hybrid metal composite (Al+Sic+Al2O3). Powder metallurgy consists of three main production phases, shaping and producing techniques. Physically, the primary material is powdered into numerous small individual particles. The powder then produces a cohesive structure on a weekly basis. The pressure of 10 to 50 tons per square inch is usually used quite similar to the measurements of the item eventually to be produced [5]. In addition, in order to achieve the same compression ratio for more complicated materials, the usage of lower pouches and upper punch is always required, and the final element consists of heat, high temperature and longer setting times.

The technique of metal sintering used for the composite production. Powder must be properly mixed after sintering to achieve the necessary properties. The powder and blender are very finely mixed in this process. The pressure is often minimized by a lubricant and a thinner mixture is obtained [10]. The metal powder is usually mixed to make a uniform blend of 0.5% to 1.5% of the lubricant and of optical alloying element, and metal stearate is usually added to the mix. The compaction is due to the powder shaping in the necessary form. The pressures on the powder will be controlled strictly as low pressure on the component created is very sensitive in nature. The pressure is very high [4]. If the applied pressure is more tit, it could be deformed. Pressure from 1 to 150 Nm^2 in general.

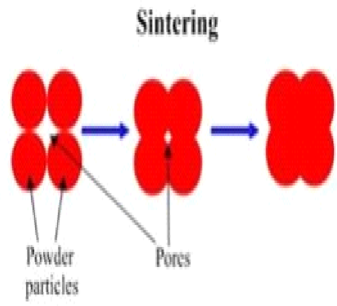

FIG No. 1: BONDING

FIG No. 2 : SINTERED COMPONENT

FIG No. 3 : DIE DESIGN

ELEMENT LINE	SAMPLE 1 70% Al – 20% SiC – 10% Al_2O_3 –		SAMPLE 2 70% Al – 15% SiC – 15% Al_2O_3 –		SAMPLE 3 70% Al – 10% SiC – 20% Al_2O_3 –	
	Weight	Formula	Weight	Formula	Weight	Formula
Al K	68.8	Al	69.4	Al	70.41	Al
SiC K	21.0	SiC	14.4	SiC	8.91	SiC
Al_2O_3 K	9.67	Al_2O_3	15.7	Al_2O_3	21.1	Al_2O_3
Mg K	0.61	Mg	0.71	Mg	0.51	Mg

TABLE NO. 3: MOLECULAR COMPOSITIONS AFTER SINTERING

IV. FINAL RESULT

1. *HARDNESS OF COMPOSITE MATERIAL*

Hardness, rather than fundamental physical quality, is the hallmark of a substance. It is defined as the indentation resistance, and it is measured by the permanent indentation depth. Simply put, the narrower the indentation, the harder is the substance when using a defined force (load) and a given indenter [5]. Rockwell's hardness testing method is the most commonly applied, as defined in ASTM E-18.

Sample No	Material Composition	Test 1	Test 2	Test 3
		HRC	HRC	HRC
1	70% Al – 20% SiC – 10% Al_2O_3 –	56.12	57.32	56.01
2	70% Al – 15% SiC – 15% Al_2O_3 –	55.21	54.10	55.61
3	70% Al – 10% SiC – 20% Al_2O_3 –	53.23	53.02	54.92

2. WEAR RESISTANCE OF COMPOSITES

Sliding tests are carried out in a pin on a wear test machine at room temperature. The pins are loaded by a dead loading system against the disk. The pins are spherically ended with low-free layers such as carbon coating on the valve train, for example with diamond. The user is typically able in the experiment to control and measure the normal load applied, undirected speed or frequency of oscillation and the environmental parameters, such as temperature, pressure, lubricant pressure. Using a profile meter, wear rates (wear per unit time) are calculated by loss of mass or volume [6]. Although ASTM G99-04 states that a spherical pin can be used to optimize the operation of an actual system with many different specimen geometries. This test is called a trio meter, the machines used to conduct this test.

The wear report indicates the rate of wear of
Sample 1: 70% Al – 20%SiC – 10%Al_2O_3 = 0.0018mg/sec for 2N
Sample 2: 70% Al – 15%SiC – 15%Al_2O_3 = 0.0021mg/sec for 2N
Sample 3: 70% Al – 10%SiC – 20%Al_2O_3 = 0.0022mg/sec for 2N

Since the Resistance of Sample 1: 70% Al – 20%SiC – 10%Al_2O_3 = 0.0018mg/sec for 2N. We can use sample-1 composites in engine components where the resistance to wear is of the utmost importance.

3. MICROSTRUCTURE ANALYSIS SEM & EDX OF SAMPLE.

EDX and SEM (Microstructure Analysis) of sample:

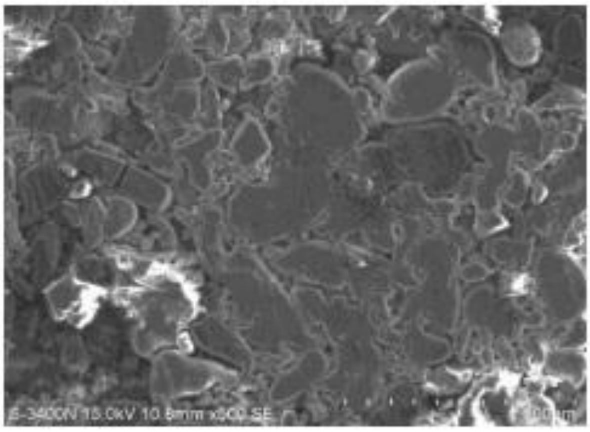

FIG No 4: SURFACE MORPHOLOGY THROUGH SEM OF SAMPLE 1

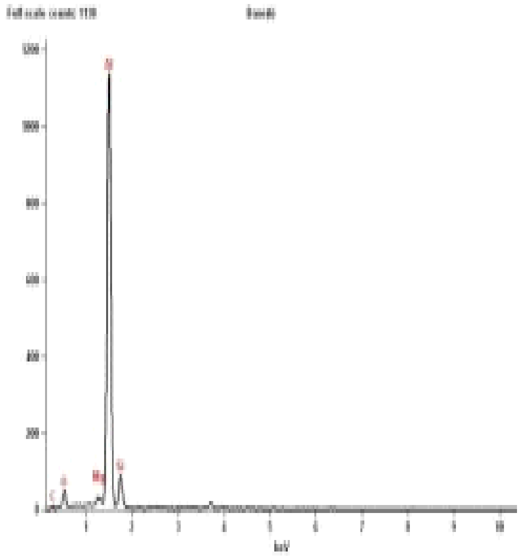

Fig No. 5: Sample 1 - EDX 70% Al –20%SiC – 10%Al_2O_3

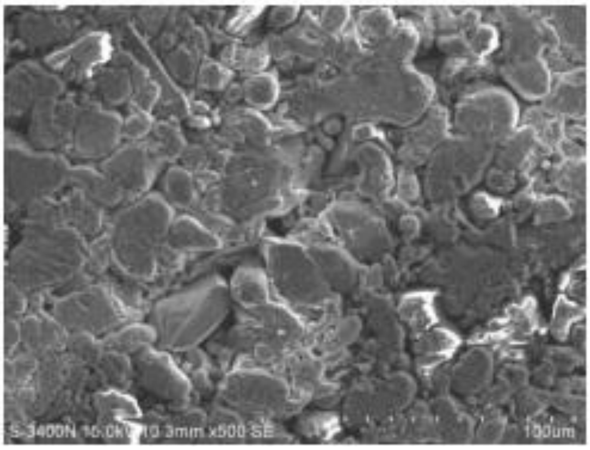

FIG No. 6: SURFACE MORPHOLOGY THROUGH SEM OF SAMPLE 2

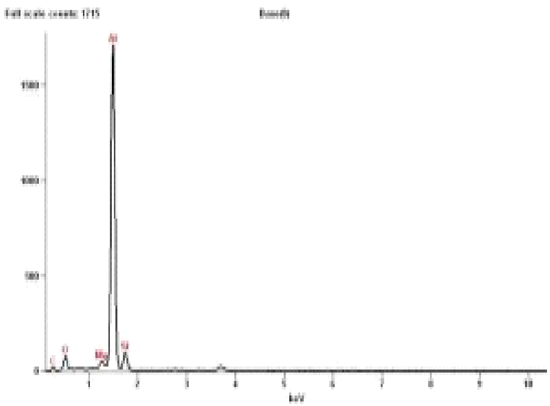

Fig No. 7: Sample 2 - 70% Al – 15%SiC – 15%Al_2O_3 = 0.0021mg/sec for 2N

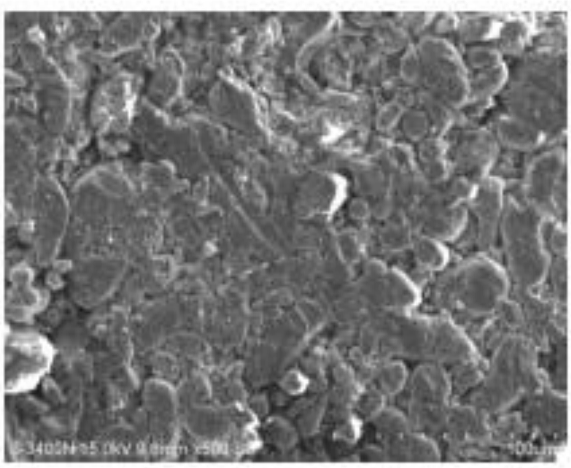

Fig No. 8: SURFACE MORPHOLOGY THROUGH SEM OF SAMPLE 3

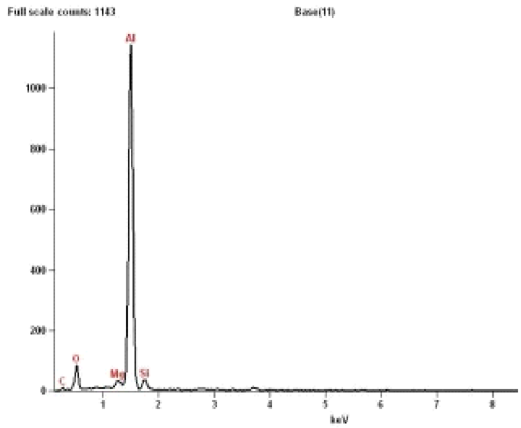

Fig No. 9: Sample 3 - 70% Al – 10%SiC – 20%Al_2O_3 = 0.0022mg/sec for 2N

Al – SiC – Al_2O_3 Product Matrix Compound was synthesized by powder metallurgy technique utilizing a vacuum sintering furnace at 540°C under vacuum atmosphere by adjusting the composition of SiC and Al_2O_3 by 10 percent, 15 percent, 20 percent (mass) at density (95 percent). This document aimed to highlight dry sliding wear of silicone carbide and alumina reinforcement composites. Compared to unreinforced alloy, the incorporation of SiC and Al_2O_3 particles into the Al improves sliding wear resistance. In comparison with the unreinforced alloy, also the hardness of the composite is increased [7]. This study assesses the sliding wearing behavior of 2N composites based on reinforced Al.

The wear of the composite is reduced as the proportion of SiC reinforcement increases. The microstructures analyzes SEM and EDAX were conducted using the Electron Scanning Microscope at the magnification level 100X, 50X & 20X and 10X.

In above Fig No. 4, The SEM confirms that the Sic and Al_2O_3 (strengthening) distribution through the Al matrix.

In above Fig No. 6, The EDX confirms the presence in the prepared specimens of the Al, SiC and Al_2O_3 elements.

In above Fig No. 8, The concentration of the elements & wt% of Al, SiC & Al_2O_3 in the prepared specimens was verified by EDX.

V. FUTURE SCOPE OF WORK

Our study shows that Silicon Carbide and Copper Sulfate can be used to improve the manufacturing process in composites, to minimize component prices, and to recycle waste left as land fill. Further investigations on Silicon Carbide and Copper Sulfate help to optimize the processing parameter and help Silicon Carbide and Copper Sulfate enter composite manufacturers that are mass production.

Improved characteristics of alumina with the addition of SiC can prevent thermal shock-related failure of the developed cutting tools. This method can also be used for the development of biomedical implants due to the chemical stability of alumina – SiC nano composites. Carbon nanotube-alumina nano composites have been used to produce optical sensors.

VI. CONCLUSION

This review paper focus on characteristics of Silicon Sulphate and calcium carbide. SiC & Graphite are also found to be the most widely used materials for refraction. In cases where SiC is used for hardening and improving the mechanical properties, the wear rate increases, and graphite reduces the wear rate and even the wear rate.

If the content of SiC in the al matrix increases then density, tensile strength, sliding resistance to wear and composite slurry erosion resistance are increased, although ductility, tensile strength and friction coefficients are reduced. The density, porosity, hardness, tungsten strength, strength of impact, sliding resistance, slurry erosive wearing resistance of the composite increases if the particle size of SiC increases, but the ductility and strength of the fatigue decreases. Al MMCs are strengthened by extrusion in their density and impact power, but the compound porosity and cluster of SiC sections are that. During the point of delivery, the wear of equipment decreases as the feed volume rises. Improved surface quality at low speeds. Rigidity, hardness and resistance to wear increase linearly to 10wt. SiC improving rate. Al-MMCs have strong tensile strength relative to Al-MMCs improved by micro SiC. Maximum. Max. In alkaline condition and cold, wear in SiC-p-reinforced Al MMCs is obtained.

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