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Reinforcement Effect on Wear Behaviour of Different Al-Alloy Composites : A Review

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ABSTRACT

In recent years, Metal Matrix Composites (MMC) have received wider acceptance as material for components subjected to tribological applications. Therefore the use of different kind of Metal-matrix composite(MMC) material is in constant growing over the years, because MMC's have better physical, mechanical and tribological properties comparing to matrix material. Aluminium alloys are the most widely used material in engineering due to their alluring properties such as good ductility, high strength to weight ratio, availability and low cost and excellent corrosion resistance. Their applications have often been restricted because of their properties such as soft and poor wear resistance. These properties can be overcome by reinforcement of different particulates in aluminium and its alloys. After reinforcement, Aluminum Metal Matrix Composites (MMCs) have enhanced properties such as hardness, elastic modulus, improved wear resistance and tensile strength. Owing to their excellent improved properties, Aluminium Metal Matrix Composites (MMCs) are sought over other conventional materials in the field of aerospace, automotive and marine applications. Even if many developments in the tribological properties of the Metal Matrix Composites, some problems are still persist. Wear is one of the major problem in industrial applications and it needs further meticulous solutions. In this paper an attempt has been made to provide an extensive literature review on the wear behaviour of aluminum alloys on reinforcing with different reinforcements such as alumina oxide, silicon, magnesium, fibres and fly ash.

Keywords: Metal Matrix Composites, Wear, Reinforcement

I. INTRODUCTION

Material's tribological characterization is important for modern applications of engineering. Wear is one of the significant design parameters for common tribological components which are used in the industrial applications, include rolling and sliding contact bearings, gears, seals, tappets and cams, electrical brushes, piston rings, and forming and cutting tools. Abrasive and Adhesive wear are most common failure modes in components operating under the moderate contact stresses. Composite materials are widely used traditional engineering materials due to their advantages on to monolithic materials. The metal matrix composite's (MMC's) development has been major innovations in materials science field in the recent years [1]. A metal matrix composite (MMC) is fabricated using a ductile metal such as Al, Ti or Nickel as the base material, which is normally reinforced by the ceramic material such as graphite, alumina or Silicon Carbide (SiC). Composites which are having higher toughness, stiffness, specific strength and good wear resistance can be achieved by combining the metallic properties such as toughness and good ductility of the matrix with properties such as hardness, high strength and elastic modulus of a reinforcement of ceramic. Thus, because of increased applications of the composite materials in the tribological components their characterization having a major significance. Composite's wear resistance has got much more attention in recent years.

Aluminum is the most abundant metal and the third most abundant chemical element in the earth's crust, comprising over 8% of its weight. Aluminum alloys are broadly used as a main matrix element in Composite materials. Aluminum alloys for its light weight, has been in the net of researchers for enhancing the technology. The broad use of aluminum alloys is dictated by a very desirable combination of properties, combined with the ease with which they may be produced in a great variety of forms and shapes. Discontinuously reinforced aluminum matrix composites are fast emerging as engineering materials and competing with common metals and alloys. They are gaining significant acceptance because of higher specific strength, specific modulus and good wear resistance as compared to ordinary unreinforced alloys. Reinforcing particles used in this study are silicon carbide and fly ash particles which are added externally One of the main drawbacks of this material system is that they exhibit poor tribological properties. Hence the desire in the engineering community to develop a new material with greater wear resistance and better tribological properties, without much compromising on the strength to weight ratio led to the development of metal matrix composites. Aluminium is one of the most commonly used metal matrixes for production of MMCs. The reinforcements being used are fibers, whiskers and particulates. The advantages of particulate-reinforced composites over others are their formability with cost advantage. Further, they are inherent with heat and wear resistant properties. For MMCs SiC, Al_2O_3 and Gr are widely used particulate reinforcements.

Ceramic particles, such as oxides (Al_2O_3, MgO, TiO_2, etc.), carbides (SiC, TiC, B_4C, etc.), nitrides (AlN, BN, Si_3N_4, etc.), and borides (TiB_2, etc.) are the main reinforcement materials in the development of MMCs. SiC and Al_2O_3 particulate reinforced aluminium matrix composites have several advantages as they are less expensive, have lower density, possess excellent thermal conductivity, corrosion resistance, higher elastic modulus, yield strength, and good wear resistance, and can be fabricated using standard and cost-effective manufacturing processes. Consequently, for wear-resistant and weight critical applications such as brake drums, cylinder liners, pistons, cylinder blocks, connecting rods, etc., reinforcing materials such as SiC and Al_2O_3 appears to be a promising alternative.

Aluminium matrix composites have been appeared as advanced materials for several major applications in automobile, aerospace, defense and other engineering sectors [8] due to their stiffness and high specific strength, superior wear and seizure resistance as compared to the alloy irrespective of sliding speed and applied load. Forsooth, these promising new materials have found splay range of applications in automobile industries in last few years. Out of different automobile components, aluminium matrix composites have been found to be a much more promising material, in brake cylinder blocks, drums, connecting rods, cylinder liners, gears, pistons, drive shafts, valves, suspension components, etc. Attempts have been made to find out the effect of sliding velocity on the wear behaviour of the aluminium alloy and composites.

Metal Matrix Composites are being increasingly used in aerospace and automobile industries owing to their enhanced properties such as elastic modulus, hardness, tensile strength at room and elevated temperatures, wear resistance combined with significant weight savings over unreinforced alloys. Aluminium alloy (LM6) is used in marine, automobile, aerospace industries .MMCs possess superior wear resistance and are hence potential candidate materials for a number of tribological applications. These include pistons and cylinder liners in automotive engines, brake discs/drums in railway vehicles and in automobiles. However, cost still remains a major barrier in designing aluminium composite components for wider applications in automotive industries along with the wear problems.

Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. The need for relative motion between two surfaces and initial mechanical contact between asperities is an important distinction between mechanical wear compared to other processes with similar outcomes. Wear can also be defined as a process where interaction between two surfaces or bounding faces of solids within the working environment results in dimensional loss of one solid, with or without any actual decoupling and loss of material.

II. LITERATURE SURVEY

Aluminum alloys has more importance as structural materials. For many applications, it is essential to ameliorate wear resistance. In the automotive applications use of aluminium alloys have been avoided Due to their low rigidity, strength and wear resistance, paragon with ferrous alloys [1]. Particulate-reinforced aluminium composites, offer reduced mass, nevertheless, high strength and stiffness, and improved wear resistance [2]. Specifically, the possibility of substituting iron-base materials for Al MMC,s, in automotive components, provides the potential for considerable weight reduction. Luminous developments have been derived in the system SiC/Al MMCs. A typical composite may have a volume fraction of ceramic phase of 20 vol. % SiC and an average particle size of around 10 mm. The strength of SiC/Al composites is increased by increasing the volume % of the ceramic phase, by decreasing the size of the ceramic reinforcement; ductility, nevertheless, diminishes and by increasing the strength of the Al matrix [3]. The Al matrix can be strengthened by mechanical alloying, a technique that can also refine ceramic powder particles [4].

P.K. Rohatgi et al [1] worked on the abrasive wear properties of stir-cast A356 aluminium alloy-5 vol % fly ash composite and tested it against hard Sic abrasive paper and compared to those of the A356 base alloy. The results indicate that the abrasive wear resistance of aluminium–fly ash composite is similar to that of aluminium-alumina fibre composite and is superior to that of the matrix alloy for low loads up to 8 N(transition load) on a pin. At loads greater than 8 N, the wear resistance of aluminium–fly ash composite is reduced by deboning and fracture of fly ash particles. Microscopic examination of the worn surfaces, wear debris, and subsurface showed that the base alloy wears primarily by microcutting, but the composite wears by microcutting and delaminating caused by crack propagation below the rubbing surface through interfaces between fly ash and silicon particles and the matrix. The decreasing specific wear rates and friction during abrasion wear with increasing load have been attributed to the accumulation of wear debris in the spaces between the abrading particles, resulting in reduced effective depth of penetration and eventually changing the mechanism from two-body to three-body wear, which is further indicated by the magnitude of wear coefficient.

Zhang et al. [2] also made an attempt for finding the effect of Al_2O_3 particle content on the steady state wear rate of 6061 alloy through the use of rule of mixture. After experimental validation, they suggested that if the reinforcement is strongly bonded with the matrix, wear resistance of composite would improve linearly with increase in reinforcement volume fraction. At the same time they concluded that the counterpart will be subjected to more and more wear with increase in the reinforcement content. Hence, one must consider a balance between these phenomena for developing wear resistant composite material.

Venkataraman and Sundararajan [3] examined that the transition load and wear or seizure resistance of the pure Al could be increased distinctly with increasing SiC content. They concluded that the transition loads are 45, 120 and 240 N for Al, Al–10% SiC and Al–40% SiC respectively. It is found by these investigators that even hardness of other Aluminium alloy is greater than that of the composite; transition load is noted to be less than that of composites.

M. Singh et al. [3] Studied the effect of granite reinforcement on the dry sliding wear behaviour of an aluminium–silicon alloy (BS: LM6) using a pin-on-disc machine. The composite was prepared using liquid metallurgy technique wherein 10 wt. % granite particles were incorporated in the matrix alloy. Sliding wear tests were conducted at applied loads in the range 0.2–1.6 MPa and speeds of 1.89, 3.96 and 5.55 m/s. The matrix alloy was also prepared and tested under identical conditions in order to see the influence of the dispersoid phase on wear behaviour. It was observed that the composite exhibited lower wear rate than that of the matrix alloy. Increasing applied load increased the wear rate. In the case of the composite, the wear rate decreased with speed except at higher pressures at the maximum speed; the trend reversed in the latter case. On the contrary, the matrix alloy exhibited minimum wear rate at the intermediate test speed. Seizure pressure of the composite was significantly higher than that of the matrix alloy, while temperature rise near the contacting surfaces and the coefficient of friction followed an opposite trend. SEM examination of the worn surfaces, subsurface regions and debris enabled to understand the operating wear mechanisms.

N. Natarajan et.al [5] studied wear behavior of A356/25SiCp MMC against automobile friction material. The wear tests have been carried out on a pin on disc machine, using pin as brake shoe lining material and discs as A356/25SiCp Al MMC and grey cast iron materials. Pins of 10mm diameter have been machined from a brake shoe lining of a commercial passenger car. The grey cast iron disc has been machined from a brake drum of a commercial passenger car. The Al MMC disc has been manufactured by stir casting technique using A356 aluminium alloy and 25% silicon carbide particles and machined. Results of experiment revealed that the wear of cast iron has been found to increase with applied load and sliding velocity. The friction coefficient was almost constant because of the formation of stable friction film at the interface. The wear of lining material sliding against cast iron is comparatively lower than the wear against the MMC.

Huseyin et al. [6] produced metal–matrix composites of an aluminum–silicon based alloy (LM6) and Al_2O_3 particles with volume fractions of 0.05, 0.10 and 0.15 and in size of 44, 85 and 125 lm using pressure die-casting technique. Density, hardness, tensile strength and wear properties were examined. The density values of the composites increased by adding Al_2O_3 particle. The hardness of the composites increased with increasing particle volume fraction and with decreasing particle size. The tensile strength of the composites decreased with increasing particle volume fractions and size. The wear rate of the composites decreased with increasing particle volume fraction and with decreasing particle size but increased proportionally to the applied load. Wear mechanism for the surface of the unreinforced alloy was plastic deformation, whereas for the composites it was the layer deformation on the surface of the composites.

M. Ramachandra and K. Radhakrishna [7], prepared metal matrix composite by using stir casting method for study. Al–12% Si alloy in the form of ingots were used for the trials. Two body sliding wear tests were carried out on prepared composite specimens. Computerized pin-on-disc wear test machine was used for these tests. The tangential friction force and wear in microns were monitored with the help of electronic sensors. These two parameters were measured as a function of load, sliding velocity and % fly ash. For each type of material, tests were conducted at three different normal loads (4.9, 9.8 and 14.7 N) keeping the sliding speed fixed at 95 m/min. Fly ash was added in weight percentage of 5, 10, and 15% in Al metallic matrix using vortex method. The optical micro -graph of 10 and 5% fly ash reinforced MMCs. It was observed that the MMCs exhibited better wear resistance (20–30% improvement) due to its superior load bearing capacity. Four different wear mechanisms were found to operate under the test conditions of variation in normal load, % fly ash content and sliding velocity. They are abrasion, oxidation, delimitation, thermal softening and adhesion. Corrosion resistance of reinforced samples has decreased with increase in fly ash content. The results indicate that the wear resistance of the fly ash reinforced material increased with increase in fly ash content, but decreases with increase in normal load, and track velocity. The microscopic examination of the worn surfaces, wear debris and subsurface shows that the base alloy wears primarily because of micro cutting .Corrosion has increased with increase in fly ash content.

Manoj Singla et al [8] performed experiment by taking Al–SiC composites containing four different weight percentages of SiC have been fabricated by using liquid metallurgy method. Wear and friction characteristics of Al–SiC composites have been investigated under dry sliding conditions and compared with the pure aluminium. It was also observed that the wear rate varies linearly with variation in normal load but lower in composites as compared to that in base material. The wear mechanism appears to be oxidative for both pure aluminium and composites under the given conditions of sliding velocity and load as indicated by scanning electron microscope analysis (SEM) of the worn surfaces.

Ramesh et al. [9] analysed Al6061–Ni–P–Si3N4 composite revealed lower coefficient of friction and low wear rate compared to matrix alloy. The coefficient of friction for both matrix alloy and developed composite decreased with increasing load up to 80 N. Beyond this limit, with further increase in the load, the coefficient of friction increased slightly. However, with the increase in sliding velocity, coefficient of friction of both matrix alloy and developed composite increases continuously. Wear rates of both matrix alloy and developed composites increased with increase in both load and sliding velocity.

K.V. Mahendra et.al. [10] Al-4.5% Cu alloy was used as the matrix and silicon carbide and fly ash as reinforcements produced by using conventional foundry techniques. The fly ash and SiC were added in 05%, 10%, and 15% by weight to the molten metal. The hybrid composite was tested for hardness, fluidity, mechanical properties, density, impact strength, slurry erosive wear, dry sliding wear, and Corrosion. The microstructure examination did using SEM to assess the distribution of the particulates in the Aluminium matrix. The results show that there is an increase in hardness with the increase in the particulates content. The density decreases with increase in fly ash and SiC content. The compression strength, tensile strength, and impact strength increases with the increase in SiC and fly ash.

Ravi Mishra et al. [11] Reported the tribological properties of fly ash particle reinforced aluminium alloy –Al061 composite samples processed by stir casting. Two sets of composites with fly ash particle sizes of 45-50mm and 75-100mm were used. Each set had three types of composite samples with reinforcement weight fractions of 10%, 15%, and 20%. Sliding wear tests were conducted using Pin-on-disc apparatus with hardened steel disc as counter face material. The sliding speed used was 1.11 m/s and 2.086 m/s (track diameter is constant at 80mm). The pin was loaded with various loads viz. 9.81 N and 29.43 N. It was found that wear rate increased with increase in sliding velocity and decreased with increase in fly ash particle size and test load when slide against hardened steel counter face materials. The composite samples with 15% weight fraction fly ash particle showed minimum WR. The surfaces of slid samples, when examined under Scanning Electron Microscope (SEM) showed that ductility of the matrix decreased with the increase in weight fraction of the reinforcement. It is also found that 15% weight fraction of Fly ash is optimal for minimum wear of composite.

Prashant Kumar Suragimath et. al. [12] studied the tribological and mechanical properties of aluminium-silicon (LM6) alloy with silicon carbide and fly ash metal matrix composite. The work deals with developing a conventional low cost method of producing MMC‟s and to obtain homogeneous dispersion of material. Experiment has been conducted by varying weight fraction of Fly Ash (5% and 15%) while keeping SiC constant (5%). The microstructure of the samples was observed to study the particle distribution. The casting procedure was examined under the Light optical microscope was used having 100X resolution to determine the reinforcement pattern and cast structure. It is observed that particles were present throughout the casting. Wear test was performed on the pin on disc machine with various applied load, sliding speed and time interval for all samples. Wear resistance increases due to increase in wt. % of fly ash. It is concluded that we can use Fly Ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage of Fly ash.

Bharat Admile et al. [13] observed the influence of wear parameters 1) load, 2) sliding speed, 3) sliding distance and 4) weight percentage of reinforcement on dry sliding wear of aluminium LM 25 fly ash composite. The composite was prepared with 4, 8 and 12 % of fly ash using stir casting method due to its simplicity, flexibility and minimum cost. Samples were prepared with 5mm diameter and 30mm length for dry sliding experiment on pin on disc machine with G99 standard. The counter face material used was EN32 steel with hardness 65HRC. Taguchi L9 orthogonal array with four parameters at three levels were used to design the experiment. Results revealed that load and sliding speed are more influencing parameters with their percentage 50.60% and 15.60% respectively [12].

Md. Habibur Rahman et al. [14] Fabricated composites of Aluminium alloy with 0, 5, 10, 20 wt. % of SiC by stir casting process. Microstructures, Vickers hardness, tensile strength and wear performance of the prepared composites were analyzed. The microstructure observation revealed clustering and nonhomogeneous distribution of SiC particles in Al matrix. Wear test was conducted using pin-on-disc machine at room temperature and dry sliding condition. All test were conducted at 300rpm and applying fixed load of 10N on test samples. It is observed that as wt. % of SiC increases, the resistance to wear at contacting surface is increases. The hardness and tensile strength was highest for 20 wt. % of SiC [14].

Vijay Kumar S Maga et. al. [15] Fabricated aluminium-silicon alloys with fly ash, redmud and silicon carbide metal matrix composite. Microstructure and mechanical properties such as tensile strength, impact strength and wear behaviour of produced test specimen are studied. The metal matrix composite was processed using stir casting technique aluminium alloy (LM6) and SiC, Fly ash, redmud has been chosen as matrix and reinforcing material respectively. Experiment has been conducted by varying weight fraction of Sic, Fly Ash, Redmud. Wear test were carried out at room temperature for 30 min ,by keeping load 1.5kg,Disc speed 300 rpm, track diameter 65mm on pin on disc machine. Wear resistance was found to be increased with SiC, Flyash and Redmud content.

Ajit Kumar Senapati [16] utilized waste fly ash from two different industries (named as type A and type B) as reinforcement in fabricating aluminium alloy (LM6) based matrix composites (AMC). The AMCs were fabricated by continuous stir-casting method in a bottom pouring furnace at 7000C. Effect of adding different fly ash contents were realized thorough various mechanical behaviour tests. For measuring mechanical properties such as Brinell hardness, impact strength, compression strength, tensile strength, and micro hardness of both the AMCs, samples were prepared as per the standards in the mechanical workshop. The fly ash distributions in the AMCs were confirmed through microstructure examination conducted on image analyzer and scanning electron micrographs. Results revealed that there is a great effect of reinforcing different fly ash in aluminium alloy matrix composites. Type B fly ash gave more enhanced mechanical properties compared to type A fly ash. Thus, selection of fly ash for reinforcement was found one of the most important criteria for fabricating aluminium matrix composites.

Yogesh kumar singla et al. [17] studied wear behavior of aluminium 6061 alloy reinforced with Sic, Red mud and Al_2O_3 separately. Results of dry sliding wear test revealed that wear rate of composite decreases as compared to the matrix material. Lowest value of wear rate is observed for 10 weight % of Sic particles and highest value of hardness is observed for 7.5 weight % of Red mud. Therefore it is concluded that the wear rate is independent of the hardness.

U. Prakash et.al [18] made an attempt to study the influence of operating parameters like applied load, sliding speed and sliding distance on dry sliding wear of A356 aluminium alloy reinforced with different percentages of 23 μm Sic particulates. Taguchi technique is used based on ANOVA sliding distance and loads were found to be highest influence on sliding wear of the specimens. Particulate-reinforced aluminum composites offer reduced mass, high stiffness and strength, and improved wear resistance. Specifically, the possibility of substituting iron-base materials for Al metal-matrix composites (MMCs), in automotive components, provides the potential for considerable weight reduction [4]. Effect of SiC content on aluminum matrix in sliding wear behavior was established for varying process parameters, and the results revealed that as the SiC content increases the wear rate and temperature decreases, but reverse trend has been observed for the coefficient of friction [4].

V. Bharathi et al. [19] reported the comparison of dry and wet sliding wear behavior of squeeze cast Aluminium alloy. This investigation makes an attempt to analyze the dry and wet sliding wear behavior of squeeze cast LM25 aluminum alloy for the varying load, speed, and sliding distances. Further, to determine the effect of each input parameter on the wear rate, ANOVA analysis using MINITAB-17 is carried out. Microstructural studies were carried out to analyze patterns of wear mechanisms on the worn surfaces using an optical microscope and scanning electron microscope Effect of SiC content on aluminum matrix in sliding wear behavior was established for varying process parameters, and the results revealed that as the SiC content increases the wear rate and temperature decreases, but reverse trend has been observed for the coefficient of friction

[4]. The overall study of available literature is found to have sufficient scope for further studies. The scope is presented in the following lines as literature gap analysis. Aluminum alloy composites have been extensively investigated for use in tribo-contact applications. However, little-detailed literature exists on the sub-surface microstructural evolution as a result of lubricated sliding wear. Two un-reinforced alloys 2124 and 5056 and identical alloy composites, reinforced with 15 vol.% $MoSi_2$ intermetallic particles were produced by a powder metallurgy route and subject to lubricated sliding at initial hertzian contact pressures of 0.9-1.2 GPa. Results indicated that the depth of deformation was minimal in the alloys, evidence of surface erosion by solid particle impact was also observed, with wear debris generated as a result of material exceeding the ductility limit. Reinforcement fracture was observed both at the worn surface and in areas further away in the bulk, for particles which were in direct contact with each other. Thus, intermetallic reinforcements may have potential to replace reinforcements that are more abrasive to counter faces, such as SiC or Al_2O_3, while still providing adequate wear resistance for the aluminum alloy.

The relationship between the tribological properties of the lubricants and their chemical reactivity with aluminum was also found. Experimental program using ball-on-cylinder tester has been conducted to investigate the effects of temperature, normal load, sliding speed, and type of lubricating oil on sliding wear mechanism. The worn surfaces and debris have been examined. Surface examination of the samples using scanning electron microscope (SEM) was used to study the wear surfaces. The results show that the temperature of the oils affects the probability of adhesion, oxidation, wear rates, and friction coefficient. At room temperature and under lubrication conditions, friction, and wear decrease with increase of the running time. The phosphorated oil SAE 90 was superior in minimizing friction and wear as compared with other oils. The results have shown that the lubricant temperature has a significant role in wear mechanism [19].

Therefore, interest in Al-based MMCs continues to grow, especially from the transport industries, wherever component weight reduction is the main objective. While to an extent this has been successful, where a critical load exists during dry sliding, above which a ceramic based composite offers little improvement in wear resistance compared to an unreinforced sample. Esteem, it was found that hard ceramics can actually increase the wear rate of the mating counter face, due to their abrasive action, and thus reduce the overall wear resistance of the tribosystem [6]. Particulate reinforced Al-MMCs exhibits better mechanical properties and improved wear resistance over other conventional alloys.

III. CONCLUSION

The all-round literature survey presented above reveals that:

1. The extensive work has been reported to improve wear properties of Aluminium based Metal Matrix Composites. It reveals that when aluminium alloy treated with different reinforcements like ceramics, silicon, magnesium, fibres, alumina oxide and fly ash are tested with different wear tests, renders improved wear properties. Apart from this it also helps to improve other mechanical properties like hardness, tensile strength and corrosion resistance. Finally there is much more scope, potential and opportunities for the researchers, in the field of investigation of wear and other mechanical properties of the aluminium alloys by reinforcement.
2. The composite's wear behaviour is influenced by operating parameters such as speed, load, temperature and sliding distance as well as the material parameters like percentage composition and particulate size of the reinforcement.

From above literature we can also conclude that, cost is the key factor for the wider application of MMCs in modern industry. Cost reductions can be achieved by using cheaper reinforcements, simpler fabrication methods, and higher production volume. Particulate reinforcements are relatively cheaper and easily available. Also, stir casting is the most economical processing route.

IV. REFERENCES

[1]. P. K. Rohatgi and R. Guo, Mechanism of abrasive wear of Al-SiC Hypoeutectic alloy containg 5 vol% ash, Tribology letters 3 1997.

[2]. Zhang Zhenfang, Zhang Liangchi, Mai Yiu-Wing. Modeling steady wear of steel/Al2O3 Al particle reinforced composite system. Wear 1997;211:147-50.

[3]. Venkataraman B, Sundararajan G. Correlation between the characteristics of the mechanically mixed layer and wear behaviour of aluminium, Al-7075 alloy and Al-MMCs. Wear 2000;245:22-38.

[4]. M. Singh et al. "Dry Sliding Wear Behaviour of an aluminium Alloy-Granite Particle Composite", Tribology International, Vol.34, 2001, pp.557-567.

[5]. N. Natarajan , S. Vijayarangan and I. Rajendran, "Wear behaviour of A356/25SiCp aluminium matrix composites sliding against automobile friction material", Wear 261, 2006, pp.812-822.

[6]. Huseyin Sevik et.al, "Properties of Alumina Particulate Reinforced Aluminium Alloy Produced by Pressure Die Casting", Materials and Design, Science Direct, vol. 27, 2006, pp.673-686.

[7]. M. Ramchandra et. al., Effect of reinforcement of fly ash on sliding wear, slurry erosive wear and corrosive behavior of aluminium matrix composites, wear 262, 2007, 1450-1462.

[8]. Manoj Singla, Lakhvir Singh, Vikas Chawla, "Study of Wear Properties of Al-SiC Composites", Journal of Minerals & Materials Characterization & Engineering, 2009, Vol.8, pp. 813-819.

[9]. Ramesh CS, Keshavamurthy R, Channabasappa BH, Pramod S. 'Friction and wear behavior of Ni-P coated Si3N4 reinforced Al6061 composites', Tribol Int 2010;43:623-34.

[10]. K.V. Mahendra and K. Radhakrishna, "Characterization of stir Cast Al-Cu- (fly Ash +SiC) Hybrid Metal Matrix composites", Procedia CIRP 1, SciVerse ScienceDirect, 2010, pp. 989-1005.

[11]. Ravi Mishra, Anilkumar H.C, H. Suresh Hebbar, "Tribological Characterization of Fly Ash Reinforced Aluminium Alloy Composites", International Journal of Engineering Sciences, 2011, Vol.5, pp8-11.

[12]. Prashant Kumar Suranginath, G.K. Purohit, "Study on Mechanical properties of Al LM6 Alloy Reinforced with SiC and Fly Ash", IOSR Journal of Mechanical Engineering, Vol. 8, 2013, pp.13-18.

[13]. Bharat admile, S.G. Kulkarni, S. A. Sonawane," Review on Mechanical & Wear Behavior of Aluminum-FlyAsh Metal Matrix Composite", International Journal Of Emerging Technology and Advanced Engineering, Vol.4, 2014, pp. 863-866.

[14]. Habibur Rahman et al. "Characterization of Silicon Carbide Reinforced aluminium Matrix Composites", Science Direct, Procedia Engineering, Vol.90, 2014, pp.103-109.

[15]. Vijay Kumar S Maga, B.S. Motagi, "Study on Mechanical Properties of Al LM6 Alloy with Fly ash, Redmud and Silicon Carbide", IOSR Journal of mechanical engineering, Vol. II, 2014, pp.07-16.

[16]. Ajit kumar Senapati et.al, "Use of Waste Fly Ash in Fabrication of Aluminium Alloy Matrix Composite", International Journal of Engineering and Technology, Vol. 6, 2014, pp.905-912.

[17]. Yogesh Kumar Singla, Rahul Chhibber, Hitesh Bansal and Anil Kalra, "Wear Behavior of Aluminum Alloy 6061-Based Composites Reinforced with SiC, Al2O3, and Red Mud: A Comparative Study", The Minerals, Metals & Materials Society 2015.

[18]. U.Prakash et.al, "Study of parametric influence on dry sliding wear of Al-SiCp MMC using taguchi technique", ScienceDirect, volume 2, 2014, pp. 1825-1832.

[19]. V. Bharathi*, M. Ramachandra, S. Srinivas "Comparison of Dry and Wet Sliding Wear Behavior of Squeeze Cast Aluminum Alloy" Indian Journal of Advances in Chemical Science S1 (2016) 101-106.

[20]. R. N. Rao, S. Das, (2011) "Effect of SiC content and sliding speed on the wear behaviour of aluminium matrix composites", Materials and Design, 32: 1066-1071.

[21]. G. B. Veeresh Kumar, C. S. P. Rao, N. Selvaraj, (2012) "Studies on mechanical and dry sliding wear of Al6061-SiC composites", Composites: Part B: Engineering, 43(3): 1185-1191.

[22]. C. Walker, I. M. Ross, W. M. Rainforth, M. Lieblich, (2007) "TEM characterization of near surface deformation resulting from lubricated sliding wear of aluminium alloy and composites", Wear, 263: 707-718.