Research Paper

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Wear Behavior of Aluminium 6061/Sic/Gr Metal Matrix Composites -An Overview

Engineering

KEYWORDS : AlMMC, Wear behavior and wear mechanisms.

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ABSTRACT

Evolution of metal matrix composite has evoked towards hybridization in the study of composites. The custom made characteristics of MMCs can be designed according to the usage. From this potential, the desired conceptions of the designer are fulfilled by the metal matrix composites. Because of their high wear resistance and intensity level to weight ratio the Al/Al alloy based Metal Matrix Composites have been widely employed as a backup material in structural, automotive and aerospace technology. The objective of this paper is to review the Wear behavior of Al matrix based MMC with different reinforcements and various parameters such as load, speed, sliding distance, etc. Sic based MMC offers great resistance to wear because of its self lubricant property.

INTRODUCTION

Now-a-days the materials, design have shifted in emphasizing a rapid growth in the use of metal matrix composites due to their achievement of tailored properties. Metal matrix composite (MMC) is engineered combination of metal (Matrix) and heavy particles (Reinforcement) to obtain desired properties. Sic, Al2O3 and Gr are widely used particulate reinforcements in MMCs. The uniqueness of the particulate reinforced composite with other is due to its formability and cost advantage. The addition of silicon carbide to the composite contributes in enhancing the hardness of the composite compared with base alloy. Similarly the graphite being self lubricant is added as second reinforcement to improve the wear resistance of the composite. The strength of this composite is majorly dependent on the percentage volume of reinforcement and the distribution. Hence the wide study of MMC is trapping many researchers and technologist.

2. Wear:

Wear can be delineated as "The process of removal of material from one or both surfaces when two surfaces are in relative motion with each other."

2.1 Types of wear:

(i) **Single-phase wear:** Single phase wear involves wear caused due to movement of a solid relative to a sliding surface. The relative motion to wear to occur may be sliding or rolling.

(ii) **Multi-phase wear:** In which war, from a solid, fluid or gas acts as a mailman for a second form that really produces the wear.

2.2 Wear mechanism:

Classification of wear is a difficult task, merely recognizing what type of wear helps in wear control. A great deal of experience, is generally considered to analyze surface topography created by wear, and to determine if wear is being produced by a chance encounter or by recurring contact.

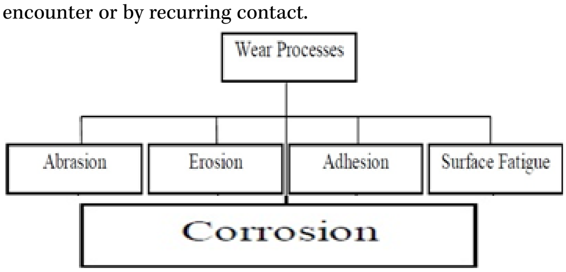

Figure 1: Wear Mechanism

(i) Abrasive wear: It is defined as the wear due to hard protuberances or hard particles forced against and moving along a solid surface. There are no atomically flat engineering surfaces. The contacting surface touches at some high points only. So high stress develops at those spots and it leads to localized plastic deformation. Abrasive wear is best visualized by plowing process.

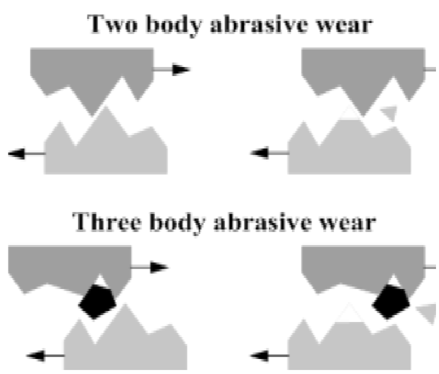

Figure 2: Abrasive wear

(ii)Solid particle erosion: It is a deprivation of material by the intrusion of solid molecules. The plastic deformation takes place in the neighborhood of the impingement while the yield strength of the material is exceeded. After several impacts, a plastically deformed surface layer may work near the eroded surface, and hence the yield strength of the material improves due to strain hardening. At this stage, the material surface becomes brittle and its fragments may be withdrawn by the subsequent impacts. *E.g.* Wear of helicopter blade leading edges in dusty environments.

(iii) Sliding and adhesive wear: When two such surfaces are in contact, the real contact actually occurs only at some high asperities which is a small fraction, e.g. 1/100 of the apparent contacting area. As a result, plastic deformation and intermetallic adhesion will occur, forming cold weld junctions between the contacting asperities. The load applied to the contacting asperities is so eminent that they deform and stick to each other, forming micro-roasts.

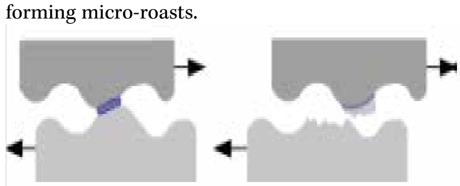

Figure 3: Adhesive wear

(iv)Fretting wear: Fatigue wear of a material is caused by the repeated cyclical rubbing between two surfaces during friction. If the applied load is more eminent than the fatigue strength of the material, the phenomenon of fatigue occurs. Fatigue cracks initially start at the material surface and distribute to the sub-surface regions.

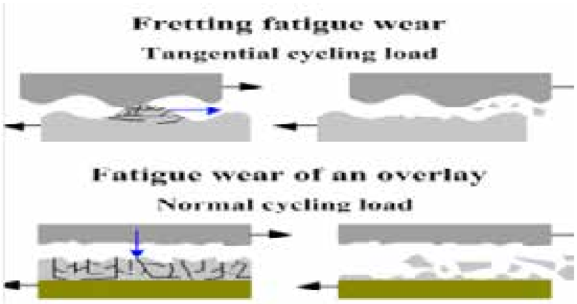

Figure 4: Fatigue wear

(v) Corrosive wear: The central cause of these forms of wear is a chemical reaction between the tired material and a corrosive medium which can be either a chemical reagent, reactive lubricant or even air**.** By the increasing load the amount of corrosive wear may be increased. It is a general term referring to whatever sort of wear dependent on a chemical or corrosive process. The wear caused by atmospheric oxygen is concerned to be the oxidative.

3.1 Wear behavior:
The seizure, wear and tear of components are major problems in various automotive and engineering industries, Hence the study of wear behavior plays a lively function. The abrasive and sliding wear behaviour of Al-alloy has been examined by many investigators. According to these reports, the base alloy produces less seizure and wear resistance than the Al-alloy. This mainly replicates to the fact that the hard dispersoids (reinforcing phase) protect the surface from the destructive act of the abrasives by depleting the depth of insight of the abrasives and the contact between the matrix and the abrasive. The geometrical parameters like shape, size, dispersion and volume fraction of the dispersoids and experimental parameters like applied load and abrasive size are the major influencing parameters of the abrasive wear behavior of an alloy.In this paper, presenting the previous researchers work on tribological studies of AMMCs.

"Siham Hussain Ibrahem Al et.al, [1] studied the effect of SiC reinforcement with 6061-T6 alloy and prepared the composite by melting the alloy in vortex with 4% and 10% weight fractions of SiC reinforcement. In this paper, it was found that wear resistance ameliorate during the carbide addition, compared with the base alloy. The effect of SiC addition contributed to the increased hardness of the alloy and ameliorates the wear resistance.

M. Asif, et.al [2] examined the effect of reinforced with silicon carbide particles and solid lubricants such as graphite/antimony Tri sulphide (Sb2S3) with 20% and the results shows that the wear rate of hybrid composite is less than that of binary composite. The wear rate depleted with the increasing load and increased by enhancing speed. He has compared the same with the iron based alloy fabricated by P/M route with the same testing parameters and establish that the hybrid composite with Sic and solid lubricants reinforcement presents less wear than the iron based alloy.

Jaspreet Singh, et.al [3] presented the Mechanical and Tribological behavior of Al matrix composites reinforced with SiC and Gr particulate up to 10%. Parametric studies indicate that the hardness, tensile strength of Al-SiC composite is more than that of Al-Gr composite because of high hardness of SiC particulates. As graphite being self solid lubricant property, the excess percentage reinforcement of Gr leads to decrease in wear characteristics. In this report the results depict that the either increasing of load or sliding distance or both enumerates to increase in wear. The wear is also influenced by the hardness and the tensile strength of the composite.

Ashok Kr. Mishra, et.al [4] considered the tribological behavior of Al-6061being Silicon carbide particles with a weight percentage of 10 and 15 as reinforcement. The composite is manufactured using stir casting process. The pin on disc is used for the dry sliding wear test of the composite. The objective of this paper is to study the influence of applied load, sliding speed and sliding distance on the wear rate. Finally the answers evidenced that the wear rate is extremely found out by the sliding distance followed by a load and sliding velocity. The applied load has a higher impact on the coefficient of friction.

Manoj Singla et.al [6], In this paper he examined the effective addition 4 different wt% of SiC which is fabricated by liquid metallurgy method. The variable parameters in this study are reckoned to be the load and a constant sliding velocity of 1.0m/s. With the linear variation of normal load the wear rate also varied linearly and found to be lower in composite compared to the pure aluminum alloy. Moreover the wear rate depletes linearly with higher wt% of Sic similarly the C.O.F decreases with the normal load.

N. Radhika et.al [7] presented the investigation on the Tribological behavior of aluminium alloy (Al-Si10Mg) with graphite (3%) and alumina (9%) as reinforcements which is produced by stir casting process. The wear resistance is increased by the incorporation of graphite as primary reinforcement and the inclusion of alumina as another reinforcement also has a critical effect on the wear behavior. Sliding distance has the highest influence on the wear rate followed by an applied load and sliding velocity.

S. Mahdavi. et.al [8], analyzed the characteristics of Al6061/SiC/Gr hybrid composites with 20 Vol% of SiC particles along with 0–13 vol.% uncoated graphite particles processed by in situ powder metallurgy method. And the results indicate that the ameliorate wear resistance of these hybrid composites was obtained with the 5vol% graphite along with the enlarging size of SiC particles."

Applications:
1. Presently, discontinuously reinforced MMCs such as silicon-carbide particulate reinforced aluminum (SiC_p/Al) and Gr/Al composites were developed cost effective both for aerospace applications (e.g., electronic packaging) and commercial applications.
2. Used in Global Positioning System satellites.
3. Widely applied in automotive parts.

Conclusion:
- The wear resistance is improved by the addition of reinforcement compared to the base alloys.
- An increment in the addition of weight percentage of reinforcement increases the wear resistance compared with the base alloy.
- Sic has high tendency to resist the wear because of its abrasive in nature.
- In summation, of graphite, wear resistance improves by its self-lubricating property.
- Wear rate is primarily determined by sliding distance, load and speed respectively.
- Coefficient of friction is influenced by speed , load and sliding distance respectively.

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- Increase in addition of reinforcement up to 20% wt yields good results and then changes beyond addition.

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