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Dry Sliding Wear Behavior of Al 2219/Al_2O_3-MoS_2 Metal Matrix Hybrid Composites Produced by Stir Casting Route

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Abstract:

In this paper, it is aimed to present the experimental results of the studies conducted regarding microstructure, density, hardness, dry sliding wear test of Al2219 and hybrid metal matrix composites prepared by stir casting technique. The distribution of Al_2O_3 and MoS_2 resulted in improving the hardness and density of the composite.The microphotographs of the composites studies revealed that, randomly and uniform distribution of the particles in the matrix alloy. The dry sliding wear test is carried out for different sliding speeds, sliding distances and different loads conditions using pin on disc apparatus. It is found that the addition of Al_2O_3 and MoS_2 reinforcement increases the wear resistance of the composite. The wear rate decreases with the increase in the percentage by weight of Al_2O_3 and MoS_2. As the sliding speed increases the wear rate decreases initially and then increases. The wear rate increases with increase in load and sliding distance.

Keywords- Density; Hardness, Stir Casting Technique, Microstructure, Wear resistance, Wear rate.

I. INTRODUCTION

Aluminium metal matrix composites have emerged as a noble material for advanced automobile and aerospace applications. Hybrid MMCs are the MMCs obtained by reinforcing the matrix alloy with more than one type of reinforcements having different properties i.e. hybridizing, to get the combined properties of both the reinforcements. Graphitic hybrid MMCs are obtained by reinforcing the matrix alloy with both ceramic and graphite reinforcements to obtain improved mechanical and tribological properties. Uvaraja et al. Has conducted a study based on the influence of operating parameters such as applied load, sliding speed. The reinforcement of Al 6061 alloy with SiC and B_4C particulates up to a volume fraction of 5 to 15 wt. % has marked effect on wear rate. It was observed that wear rate and coefficient of friction decrease with increasing volume fraction of reinforcements reported in [1]. Uvaraja et al. Reported in his paper based on study of Al 6061 and Al 7075 alloy-base matrix reinforced with mixtures of silicon carbide (SiC) and boron carbide (B_4C) particles, by stir casting method giving raise to hybrid composite. The wear resistance of the composites were found to be higher, further the sic contributed significantly in improving the wear resistance of Al 7075-sic-B_4C composites. From the studies we can see that Al7075-SiC-B_4C exhibits superior mechanical and tribological properties [2]. Basavarajappa et al. investigated the dry sliding wear behaviour of Al 2219 alloy and Al 2219/ SiCp/Gr hybrid composites for sliding speed, applied load and sliding distance. The dry sliding wear test is carried out for sliding speeds up to 6 m/s and for normal loads up to 60 N using a pin on disc apparatus. It is found that the addition of SiCp and graphite reinforcements increases the wear resistance of the composites[3].Swamy et al. studied on Al6061-SiC and Al7075-Al_2O_3 metal matrix. It is reported that the density and tensile strength properties of the composites are found to be improved than base matrix, the micro structural studies states that the uniform distribution of the particles in the matrix system and increase in Micro hardness of the composites was observed with increased filler content [4].Studies conducted by Sakthivel et al. Reported that the density and hardness of the composites increased with increasing weight percentage and decreasing size of particles [5].

Radhika et al. Investigated on Tribological behaviour of aluminium alloy (Al-Si 10Mg) reinforced with alumina (9%) and graphite (3%) fabricated by stir casting process. This paper shows that use of graphite as primary reinforcement forms a protective layer at the pin and counter face interface resulting in increase in the wear resistance of composites and the use of alumina as a secondary reinforcement have reported a major effect on the wear behaviour [6]. Ramesh et al. Reviewed in his paper the presence of hard reinforcement fibers or whiskers has gifted these composites with good tribological characteristics [7].Bhakthavatsala et al. gave information regarding the influence of wear parameters like applied load, sliding speed, percentage of reinforcement content and the sliding distance on dry sliding wear of the composites. It was seen that Graphite is one of the most important solid lubricants [8].Basavarajappa et.al reported in his work the dry sliding wear has distinguishing character of aluminum alloy based composites affects the wear behaviour of composites by the consequence of reinforcement, reinforcement size, sliding distance, sliding speed, applied load, volume fraction, sliding speed, hardness of the counter face and properties of the reinforcement phases [9].An attempt is made in this present work is to study the dry sliding wear behaviour of Al2219 alloy and Al2219/Al_2O_3/MoS_2 composites under room temperature.

2. EXPERIMENTAL STUDIES

2.1. Materials

In this paper, aluminium 2219 alloy was used as a matrix material and composition of Al2219 is shown in Table I. Aluminium oxide (Al_2O_3) with average particle size 30 μm was used as a primary reinforcement material and molybdenum disulfide (MoS_2) with average particle size 1.3 μm was used as a secondary reinforcement material.

TABLE I
CONSTITUENT OF AL2219 IN WEIGHT %

Elements	Weight in %
Mg	0.02Max
Si	0.20 Ma
Cu	5.8-6.8
Zr	0.1-0.25
Fe	0.30 Max
Mn	0.14Max
Ti	0.02-0.1
V	0.05-0.15
Zn	0.1 Max
Al	Remaining

2.2 Fabrication of Composites

Metal matrix hybrid composites are fabricated by using liquid metallurgy technique (stir casting). The resistance furnace used for casting purpose is shown in "Fig. 1," and composition used for fabrication of composites is shown in Table II.

"Figure 1," Composite Furnaces

Monolithic Al2219 is taken for charge into crucible made from graphite and Al 2219 is heated above liquids temperature up to 750^0 -800^0 C for melting. The mixed Al_2O_3 and MoS_2 were added in to molten metal; stirring is carried out at 150-200 rpm for time duration of 5 min. The particles started distribute around monolithic Al 2119 and then slurry is poured in to cast iron mould.

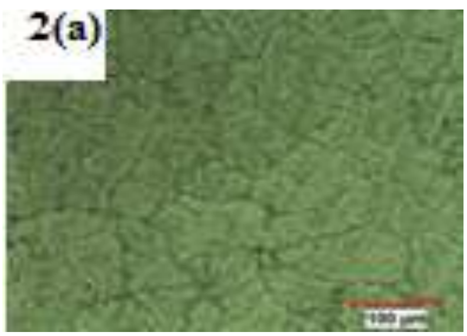
TABLE II

COMPOSITION AND CODE OF PREPARED MATERIALS

Sl. No.	Composition	Code
1	Al alloy 2219	**A0**
2	Al alloy + 5% by wt Al_2O_3 +3% by wt MoS_2	**A1**
3	Al alloy + 5% by wt Al_2O_3 + 4% by wt MoS_2	**A2**
4	Al alloy + 5% by wt Al_2O_3 + 5% by wt MoS_2	**A3**

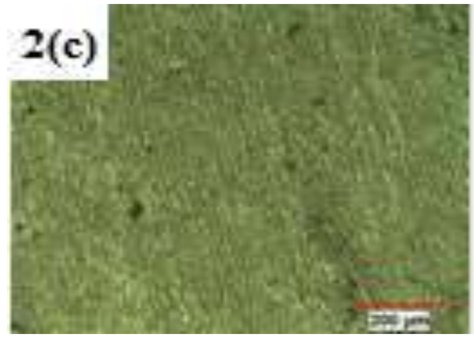
3. RESULTS AND DISCUSSIONS

3.1Micro Structure Study

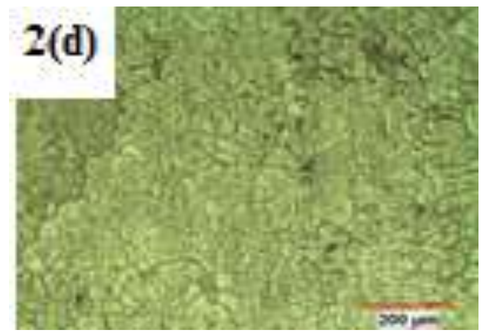


"Fig. 2(a)," Optical microscope images of Al 2219 alloy

"Fig. 2(b)," Optical microscope images of Al 2219+5% Al_2O_3+3% MoS_2.



"Fig. 2(c)," Optical microscope images of Al 2219+5% Al_2O_3+4% MoS_2.

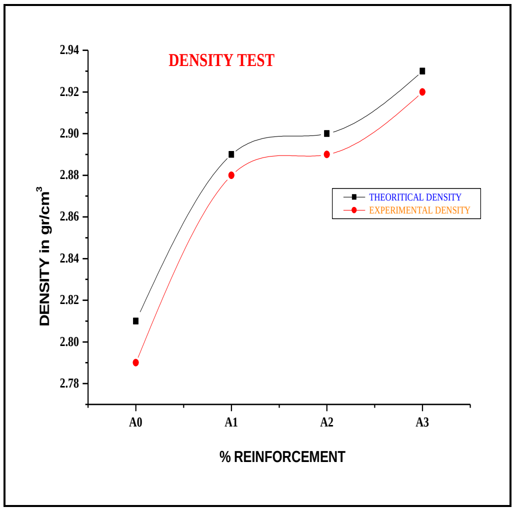


"Fig. 2(d)," Optical microscope images of Al 2219+5% Al_2O_3+5% MoS_2.

Optical microscope is used for microscopic examination of matrix alloy & prepared composites. "Fig. 2(a)," shows Al 2219 microstructure where no reinforcement is seen. "Fig. 2(b)," to "Fig. 2(d),"shows Al alloy+5% by wt Al_2O_3+3% by wt MoS_2, Al alloy+5% by wtAl_2O_3+4% by wt MoS_2 and Al alloy+5% by wt Al_2O_3+5% by wt MoS_2, the distribution of Al_2O_3/MoS_2 particles are randomly and uniform distribution in fine dendrites of Al 2219 matrix. It can also see that, very good bonding between matrix and reinforcement in the prepared hybrid composites.

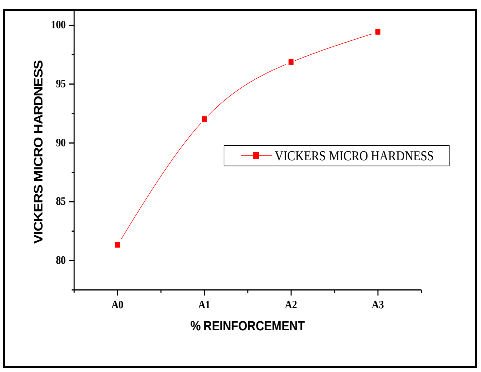
3.2 . Density and Hardness Test

"Fig.3,"shows the experimental density values and theoretical density values of the both the matrix Al2219 alloy and prepared hybrid composites containing various filler percentages. From Fig:3 it can be observed that the densities of composites are higher than that of their base matrix(Al2219), further the density increases with increased percentage of filler content in the composites i.e. MoS_2. From the Fig: 3 it can be concluded that Al2219/Al_2O_3/ MoS_2 composites exhibits higher density than that of the Al2219 because MoS_2 is having higher density as compared to Al2219 and Al_2O_3 particles.



"Fig. 3," Comparison, Changes in Experimental Density and Theoretical Density of the Material with Percentage Reinforcement.

The Vickers micro-hardness of Al2219 base matrix and prepared composites are evaluated using diamond indenter at an applied load of 50g for dwell time of 10 sec. From the "Fig.4," it can be observed that the hardness of the hybrid composite is greater than that of its matrix alloy (Al 2219). The composites containing higher filler content exhibits higher hardness. Further, it can be observed that the hardness of the Al2219/Al_2O_3/MoS_2 composite is increased with the increase of MoS_2 percentage this is due to the increase of MoS_2 which hardness of the composites increases.

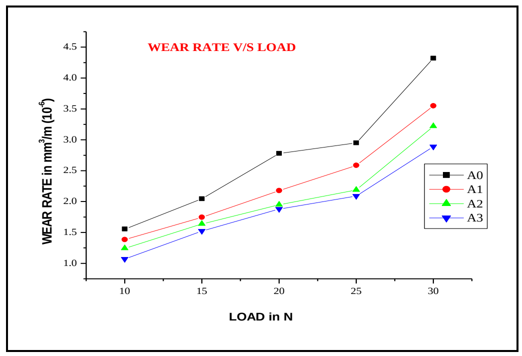


"Fig. 4," Change in Hardness of the Material with percentage reinforcement

3. DRY SLIDING WEAR TEST

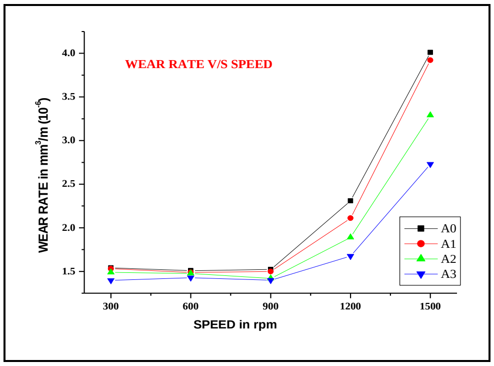
3.1. Effect of Load, Sliding speed & Sliding distances on wear rate

The variation of wear rate with sliding distance of 2000 m for a sliding speed 900 rpm is shown in the "Fig. 5,".From the "Fig" it can be seen that as the applied load increases the the wear rate tends to increases.Al 2219 under goes more wear when compared to prepared hybrid composites.The wear rate increases with increasing applied load due to increasing contacting pressure leads to increases in wear rate in both Al2219 and prepared hybrid composites.

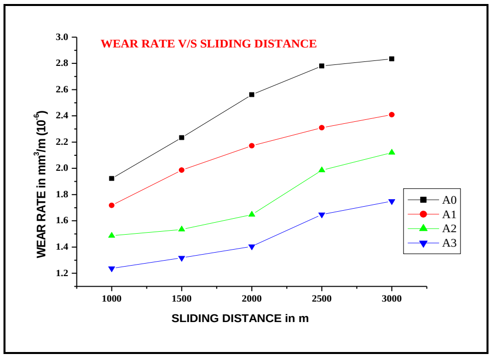


"Fig. 5," Variation of Wear Rate with Applied Load at a Sliding Speed of 900 rpm for A Sliding Distance of 2000m

The variation of wear rate with applied load of 20 N for a sliding distance of 2000 m is shown in the "Fig. 6," The wear rate of Al2219 alloy initially decreases up to a sliding speed of 900 rpm and then rapidly increases. The wear rate increases with the increase in sliding speed, at these high sliding speeds, the hard particles of Al_2O_3 and MoS_2 fragments of iron oxide from the MML layer. The wear rate is more for Al2219 alloy and less for prepared hybrid composites because in case of prepared hybrid composites the asperities of Al_2O_3 and MoS_2 particles are project out from the surfaces of pin reduces the wear rate and increases the wear resistance of prepared hybrid composites.



"Fig. 6," Variation of Wear Rate with Applied Load 20 N for a Sliding Distance of 2000 M.



"Fig. 7," Variation of Wear Rate with Applied Load 20 N for a Sliding Speed 900 rpm.

"Fig. 7," shows the variation of dry sliding wear rate with sliding distance at an applied load of 20N and for a sliding speed of 900rpm.The wear rate of the monolithic alloy and composites increase with the increase in sliding distance. The wear rate is more for Al 2219 and less for prepared hybrid composites because due to increase in hardness in hybrid MMCs.In a prepared composites the crushed Al_2O_3 and MoS_2 acts as a protecting layer, thus wear rate reduces and wear resistance is increases in prepared hybrid composites. The wear resistance of the composite increases with increase of volume fraction of Al_2O_3 and MoS_2 reinforcement.

4. CONCLUSIONS

This paper reports the studies conducted regarding microstructure, density, hardness and dry sliding wear test of Al2219/Al_2O_3/MoS_2 hybrid metal matrix composites. Microscopic examination of prepared composites shows the distribution of Al_2O_3 and MoS_2 particles are randomly and uniform distribution in fine dendrites of Al 2219 matrix. Density and hardness increases with increasing percentage of reinforcement. Density and Hardness of Al2219 is relatively low as compared to prepared composites and Al2219+ 5%Al_2O_3+5%MoS_2 are having higher Density and hardness. Wear rate is higher for Al2219 and lower for Al2219+5% Al_2O_3+5%MoS_2 composites. The wear rate decreases with increase in the percentage of Al_2O_3 and MoS_2.As the sliding speed increases the wear rate decreases initially and then increases. The wear rate increases with increase in load and sliding distance. The reinforcements reduce the wear rate and increase the transition load from mild to severe wear. The addition of Molybdenum disulfide to the composite increases the wear resistance of the composites by smearing a layer at the interface between the pin and the counter face

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