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Tribological Performance Of Mg Alloy By Spin Coating Method

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ABSTRACT

In these work an attempt has been made to improve the tribological properties of Mg alloy. The preparation of sol-gel by using $Si(OC_2H_5)_4$- C_2H_5OH- H_2O solution and after preparation of solution it is used for coating on ZM21 Mg Alloy by using spin coating technique. After completion of coating on ZM21 Mg alloy, the tribological aspect such as wear is performed. The experiments were carried out using pin on disc type wear apparatus. From the result the samples containing SiO_2 particles have good performance of wear rate by compared with sample without SiO_2 particles.

INTRODUCTION

Magnesium alloys are using more in automobile, aerospace and electrical industry because of their lighter weight and high specific strength. These alloys are also offer a good combination of properties such as high specific buckling resistance, good damping properties, high dimensional stability, and specific stiffness. Authors are suggested that automotive applications of Mg-alloy in power transmission system, interior equipment, chasis, and car body. Mg alloys may not be the right choice for sliding seals, bearings and gears but there will be situations (e.g., cylinder-piston assembly, steering wheel-steering rod interface), where these alloys come into sliding or reciprocating contact with other materials under dry and lubricated conditions.

Considering the tribological applications of magnesium alloys, wear is serious problem under sliding conditions.To improve the wear properties of metal coating is applied. The coating is applied in metals by different techniques like surface modification, thermal spraying and powder metallurgy etc. The Preparations of coatings on the surface of metals are very important, because the coatings can not only give corrosion resistance but are also the first step to obtaining composite materials of metals.

In this project Spin coating method is using for coating the metal. Before coating on the metal a sol-gel is prepared. The prepared sol-gel technique is using for various coatings such as dip coating, PVD, Chemical vapor deposition (CVD), Electrolysis and PEO technique and Spin coating.

The Sio_2 films are prepared by using Tetra Ethyl Ortho Silicate, Ethanol and water. These Sio_2 films were deposited on the metal by using spin coating method. After completion of coating the coated metal is taking to perform the wear testing by pin on disc experiment.

2. Materials and Experimental Procedure:

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Samples used in this study were ZM21 Mg Alloy prepared in square shape with the dimension of 15 × 15 mm and the thickness is 5 mm. The composition of ZM21 Mg Alloy is presented in Table 1. To obtain more reliable results, repeatability of process, for each series of experiment at least 4 samples were used. The samples are cleaned with ethanol and washed with water, and then dried before coating.

Fig. 1: Sol-gel Solution

Table 1: Composition of ZM21 Mg alloy used in this study as substrate of coating.

Element	Mg	Zn	Fe	Mn
Wt%	Balance	2.09 %	0.002 %	0.65 %

Tetra Ethyl Ortho Silicate (TEOS) ($Si(OC_2H_5)_4$), Ethanol (C_2H_5OH) and Water (H_2O) are having different molar ratios, molecular weight and density. From these values weight is calculated. From the weight and density volume is evaluated. Based on volume of each solution the solutions are added and mix up to prepare the sol-gel.

Table 2:

SI.NO	Solution	Molar ratio	Molecular weight	Density
1	TEOS ($Si(OC_2H_5)_4$)	1 mole	208.33 gm	0.933 g/ml
2	Ethanol (C_2H_5OH)	4 moles	46.06 gm	0.789 g/ml
3	Water (H_2O)	4 moles	18 gm	1 g/ml

Calculation:

Formula for calculating the weight,

n = Weight / Molecular Weight, then Weight = Molecular Weight × n

Therefore Weight of each solution is

Table 3:

Solution	TEOS ($Si(OC_2H_5)_4$)	Ethanol (C_2H_5OH)	Water (H_2O)
Weight	208.33 gm	184.24 gm	72 gm

And Formula for calculating the volume is

Density = Mass / Volume, then

Volume = Mass / Density

Therefore Volume of each solution is shown in Table 4:

Table 4:

Solution	TEOS ($Si(OC_2H_5)_4$)	Ethanol (C_2H_5OH)	Water (H_2O)
Volume	223.29 ml	233.51 ml	72 ml

TEOS and Ethanol are poured into a 500ml beaker with the concentration showing in Table 4 and magnetic stirrer is used to mix-up the solution. During the above process, the solutions were stirred at room temperature with constant speed. At the stirring time the distilled and deionized water drop wise will be added to the solution. After stirring for 2 to 3 h, the solution will formed to gel with some viscosity. The formation of gel will be used for coating.

The dried samples are using for coating, the coating is applied by Spin Coating Equipment. The prepared solution is injected into needle and from the needle drop wise will be deposited into the center of the each substrate. Before start of the experiment the time and Speed will be set on the equipment. At the time of spinning time the centripetal force will cause the solution is spread to the edge of the substrate. After completion of the spinning process to further dry the coated substrates by heating the substrate at the temperature of 70º C. Repeat the process for other substrates.

Fig. 2: Spin Coating Equipment

Fig. 3: Muffler Furnace

To investigate the wear performance for the coated samples Pin on disc equipment is used. Before going to experiment the samples were again cutting into square type with the dimension 11 × 11 mm and with same 5 mm thickness. The samples were grinding perfectly to fit into the pin specimen. The experiment is done by different parameters by varying the speed, load and time. Depending on the results calculating the wear rate and wear resistance.

Fig.4: Pin on Disk Wear type

RESULTS AND DISCUSSION

In this experiment Four Samples were used to calculate the wear test and Wear Resistant by varying the load, time, speed, Track radius and Sliding Distance as shown in table 5.

Table 5:

S.No	ZM21 Metal	Speed N rpm	Load kg	Time min	Track radius R mm	Sliding Distance m	Wear Rate mm^3/m	Wear Resistance m/mm^3
1	Without Coating (Sample 1)	500	2	5	47.74	149.979	0.0646	15.493
2	With Coating(Sample 2)	500	2	5	47.74	149.979	0.0242	41.322
3	With Coating (Sample 3)	600	3	5	39.78	149.967	0.01613	61.969
4	With Coating (Sample 4)	600	4	5	39.78	149.967	0.00806	123.939

Here Track radius is calculated by using the formula $V = \pi DN / 60$ or $\pi(2R)N / 60$ m/s

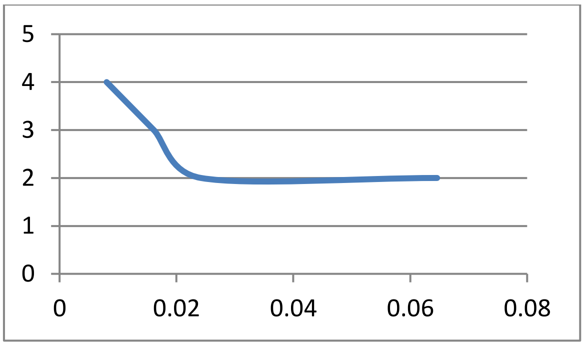

Fig. 5: Graph of Load vs Wear rate

The Fig. 4. Shows the Graph ploted between Load vs Wear Rate.

In table 5 shows the experiment is conducted between samples containing SiO_2 particles and sample without SiO_2 particles. For sample1 the experiment is conducted at 500 rpm speed, 2 kg load and 5 min time the value of wear rate is 0.0646mm^3/m and with the same parameters the experiment is conducted for sample2 the value of wear rate is 0.0242mm^3/mso the wear performance has been decreased for sample2 containing SiO_2 particles by compared with sample1 without SiO_2 particles.

For sample3 the experiment is conducted at 600 rpm, 3 kg, and 5 min time the value of wear rate is 0.01613mm^3/m. For sample4 the experiment is conducted with same parameters but change in load the performance of wear rate is decreased by compared with sample2 and sample3.

The final result is by comparing the results from sample1and sample2, the sample2 containing SiO_2 particles have good performance of wear rate then sample1 without SiO_2 particles. Also comparing the results for containing SiO_2 particles i.e., sample2, sample3 and sample4 having good performance of wear rate, while increasing in load the wear rate of these samplesis decreases.

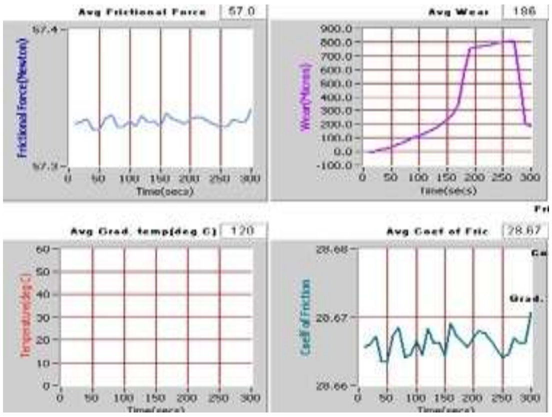

Fig. 6: Shows wear test result for sample 1

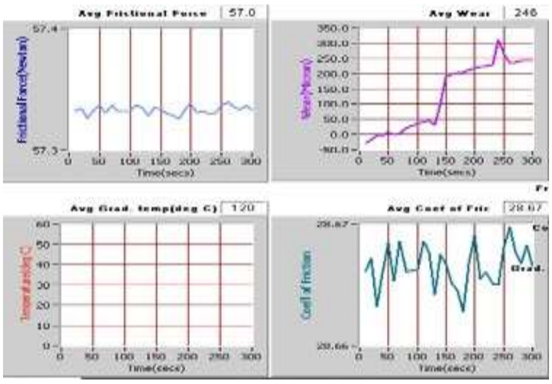

Fig. 7: Shows Wear test result for sample 2

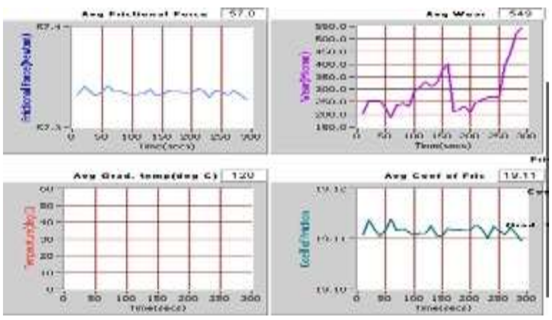

Fig. 8: Shows wear test result for sample 3

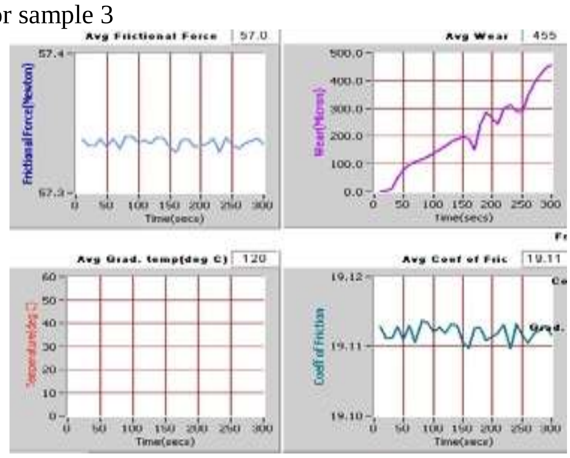

Fig. 9: Shows wear test result for sample 4

The Fig. 6, Fig. 7, Fig. 8, Fig. 9 shows wear test results performed on pin on disk apparatus.

Here Caluculated the wear rate, sliding distance and wear resistant for sample1 only by using these calculation other calculations done.

Wear rate and Wear resistant calculation for Sample1:

Fig 1. Shows the wear performance of sample 1 (without coating) load 2 kg, time 5 min. and speed 500 rpm. Based on load, time and speed calculating the wear rate and wear resistance.

Wear rate = Volume / Sliding Distance

Where Volume = Initial Volume – Final Volume mm^3

Initial Volume=Square×Square×Height mm^3

$= 11 \times 11 \times 5.44\ mm^3$

$= 658.24\ mm^3$

Final Volume=Square×Square×Height mm^3

$= 11 \times 11 \times 5.36\ mm^3$

$= 648.56\ mm^3$

Volume=Initial Volume–Final Volume mm^3

$= 658.24 - 648.56\ mm^3$

$= 9.68\ mm^3$

Sliding Distance = πDN m

$= \pi \times 2 \times R \times N$ m

$= \pi \times 2 \times 0.04774 \times 500$ m

$= 149.979$ m

Therefore Wear rate = Volume / Sliding Distance mm^3 / m

$= 9.68 / 149.979\ mm^3 /m$

$= 0.0646\ mm^3 / m$

And Wear Resistance = 1/Wear rate m/mm^3

$= 1/0.0646\ m/mm^3$

$= 15.493\ m/mm^3$

Conclusion:

In this experiment the samples containing SiO_2 particles have good performance of wear rate comparing with samples without SiO_2 particles. Also for samples containing SiO_2 particles having good performance of wear rate while increasing in load.

This method should be a fundamental technique for making metal-ceramic composites by coating on the surface of magnesium metal with SiO_2 thin films.

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