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Corrosion and Wear Characteristics of A356.0-SIC-RHA Hybrid Composite

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Abstract: *This paper deals with the wear and corrosion characteristics of Aluminium A356.0 based hybrid composite. Aluminium A356.0 as matrix, Silicon Carbide (SIC) and Rice Husk Ash (RHA) as reinforcement with weight percentage varying were fabricated using stir casting technique for wear characteristics Pin on Disc testing was done at different speed(rpm) conditions, for corrosion behavior the testing was done in Salt spray chamber whereas the testing related to damping was done on dynamic mechanical analyzer to find the damping capacity of samples at different frequencies. The proportion of SIC and RHA in the metal matrix were in increasing order and the results were compared with only Aluminium A356.0.*

Keywords: *Corrosion, wear, Pin on Disc, Dynamic, metal matrix, Rice Husk Ash.*

1. INTRODUCTION

In case of any mechanical equipment the most essential thing is to add a limit to the mechanical vibration. In order to restrict the mechanical vibration it is necessary to select the materials which are having proper as well as appropriate damping and expected stiffness and strength. The damping capacity is the ability of the material, when it vibrates dissipates the heat or mechanical energy. Hybrid composites are now a days raising a toast to be better substitutes for the conventional alloys because of characteristics like high stiffness high strength and low density. It is important to note that the ashes of controlled burning of agricultural wastes such as coconut shell, rice husk, Banana leaf bagassee or bamboo leaf has been used in Aluminium Matrix composites which has given up to the mark results. Due to ash there is environmental threat to the lands (Due to burning of RHA). But this is the most efficient way of utilization of rice husk ash for which there is no any kind of environmental hazard. However, under controlled burning conditions, amorphous silica with high reactivity, ultra- fine size and large surface is produced. In service applications where high strength and wear resistance are of prime importance, these grades of AMCs have been found to have fairly limited use. In order to harness the low cost and physical property benefits offered by these waste derived reinforcing materials, there are current efforts to complement them with conventional synthetic reinforcing materials such as silicon carbide and ashes of agricultural wastes.

2. LITERATURE REVIEW

Alaneme and Sanusi [1] proposed the micro structural characteristics, mechanical and wear behavior of Aluminium matrix hybrid composites reinforced with alumina, rice husk ash (RHA) and graphite. Hardness, tensile properties, scanning electron microscopy, and wear tests were used to characterize the composites produced. The results show that Hardness decreases with increase in the weight ratio of RHA and graphite in the composites; and with RHA content greater than 50%, the effect of graphite on the hardness becomes less significant. The tensile strength for the composites containing 0.5wt% graphite and up to 50% RHA was observed to be higher than that of the composites without graphite. The tensile fracture surface morphology in all the composites produced was identical characterized with the presence of reinforcing particles housed in ductile dimples. The composites without graphite exhibited greater wear susceptibility in comparison to the composite grades containing graphite. Alaneme et. al.[3] proposed the corrosion and wear behavior of Al–Mg–Si alloy matrix hybrid composites developed with the use of rice husk ash (RHA) and silicon carbide (SiC) particulates. The results show that the effect of RHA/SiC weight ratio on the corrosion behavior of the composites in 3.5% NaCl solution was not consistent for the different weight percent of reinforcement. It was evident that for most cases the use of hybrid reinforcement of RHA and SiC resulted in improved corrosion resistance of the composites in 3.5% NaCl solution. Kenneth Alaneme et.al [4] proposed the work in which the corrosion behavior of aluminum hybrid composites reinforced with rice husk ash and silicon carbide subjected to thermal cycling has been investigated. The results showed that the composites composite grades with a higher RHA content generally exhibited a lower tendency to corrode compared to the other composite grades. Generally, the composites seemed to be structurally stable as they maintained their corrosion resistance levels even after exposure to thermal cycling.

George and Ilay[6] investigated the damping characteristics of Al based hybrid nano composites and concluded that P/M specimen had less voids or pores as compared to Cast specimen, P/M Specimen had significant behaviour characteristics of damping. V. Janiwarad, et. al [7] In their study, A356.0 alloys were reinforced with varied percentage of Alumina and Graphite by liquid metallurgy route and tested for Microstructure, Mechanical properties and Damping behavior.Microstructure revealed uniform distribution of reinforcement in the matrix resulting in improved Mechanical properties and Damping behavior compared to un-reinforced material. The ceramic reinforced alloys were found to have improvement in Mechanical properties and Damping behavior which may be attributed to the uniform distribution and bonding of reinforcement in the matrix. Dora Siva Prasad, et.al.[9] concerned with the measurement of damping behavior in elemental rice husk ash (RHA), fly ash (FA), silicon carbide (SiC) and graphite (Gr) powders. The storage modulus and damping capacity were analyzed. They observed that the damping behavior increases with the increase in the rice husk ash content. Experimental results showed that the addition of fly ash in A356 alloy exhibited improved ambient temperature damping capacity.

3. EXPERIMENTATION

Table 1: *Chemical composition of Rice HuskAsh*

Calcium	Magnesium oxide	Potassium Oxide	Ferric Oxide
0.419%	0.404%	0.344%	0.418%

Table 2: *Chemical composition of A356.0*

Si (%)	Mg (%)	Fe (%)	Cu (%)	Mn (%)	Ni (%)	Zinc (%)
7.24	0.42	0.084	0.010	0.018	0.025	0.005

Table 3: *Chemical composition of various Samples*

Composition	wt.% A 356.0	wt.% SiC	wt.% RHA
1	Pure	0	0
2	85	5	10
3	70	10	20
4	55	15	30
5	40	20	40

3.1 Wear test Experimentation

Dry sliding wear tests were conducted on Pin-on-Disc apparatus (TR-20LE) (DUCOM). The counter Disc was made up of EN-31, wear test samples were made up of site of 10 mm × 35 mm. The test surface was properly polished on varying grade of sand paper so that there is proper contact between the pin surface and disc surface. The Disc was cleaned with acetone after each run on the machine. The track diameter of 80mm was kept constant with constant load of 30N with varying speed of 200 rpm, 400 rpm and 600 rpm. The sliding wear loss was measured. The specific wear rate was calculated as per following equation.

Specific Wear Rate = (ΔV) / (L× D)

ΔV = Volume loss

L = Load applied in N.

D = Sliding Distance (m).

The figure 1 below shows the Pin-on-Disc apparatus and the pins for wear tests.

Fig 1: *Pin on Disc Apparatus*

3.2 Salt spray Testing

The testing was conducted at Nasik Engineering Cluster (NEC) in accordance with ASTM-B117-11 the sample was tested with air cleaning prior to the exposure. The samples were tested for 24 hours with following conditions as shown in Table 4.

Table 4: *Conditions for Salt spray testing.*

Test Media	5 % Salt solution
Cabinet Temperature	35 degree Celsius
Fog Collection (ml/hr)	1.4 to 1.5
Specific gravity	1.031
Initial pH	7.1
pH of collected solution	6.8
Humidifier Temperature	46 degree Celsius
Tower Pressure	84 kpa

Fig 2: *Salt spray chamber*

4. RESULTS AND DISCUSSION

4.1Results related to Pin on Disc testing

To study the anti-frictional behavior of the various compositions several trials were carried out at different speeds (200rpm, 400rpm, 600rpm) with the constant load of 30N. The table 5 below shows the wear of compositions in microns with respect to speeds with constant wear track diameter of 80 mm and sliding distance of 500m.

Table 5: *Wear of specimen with respect to speed.*

Speed (rpm)	Composition Wear (µm)				
	1	2	3	4	5
200	48	45	35	24	19
400	50	48	38	34	29
600	75	72	64	55	49

Table 6: *Specific Wear Rate with respect to speed.*

Composition	**Sample / speed (rpm)**	**Sp. Wear rate**	**Volume loss (m3)**
1	A (200)	2.513E-13	3.7699E-09
	B (400)	2.617E-13	3.9269E-09
	C (600)	3.926E-13	5.8904E-09
2	A (200)	2.4081E-13	3.6122E-09
	B (400)	2.5656E-13	3.848E-09
	C (600)	3.7695E-13	5.6548E-09
3	A (200)	1.8325E-13	2.7488E-09
	B (400)	2.042E-13	3.0630E-09
	C (600)	3.2426E-13	4.8694E-09
4	A (200)	1.1780E-13	1.7671E-09
	B (400)	1.7016E-13	2.55254E-09
	C (600)	2.7750E-13	4.16260E-09
5	A (200)	0.9686E-13	1.45298E-09
	B (400)	1.5184E-13	2.27765E-09
	C (600)	2.5656E-13	3.84845E-09

With respect to above Table 5. It is seen that for the speed of 200rpm the wear in microns (µm) decreases as the weight percent of the reinforcement was increased, consider the case of speed 200rpm the wear of first sample was 48 microns whereas the wear of the fifth sample was only 19 microns, similarly for speed 400rpm, the wear in microns of first sample was 50 microns whereas the wear of fifth sample was 29microns. Which shows that as the speed increases the wear in microns decreases in addition to reinforcement to the samples.

Table 6 shows the relationship of percent weight of sample with respect to the specific wear rate and sample speed, it is seen that the specific wear rate increases as the speed increases.

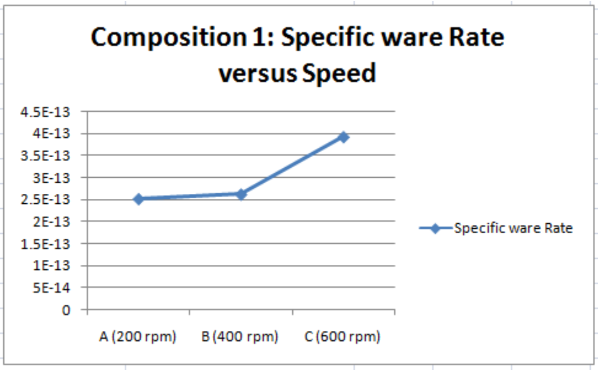

Fig 3: *Specific wear rate of composition 1 V/s Speed.*

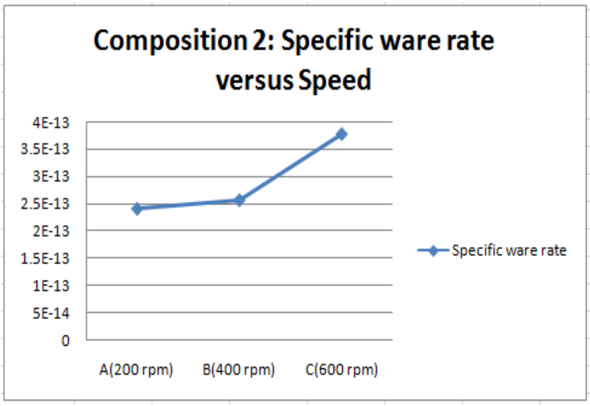

Fig 4: *Specific wear rate of composition 2 V/s Speed.*

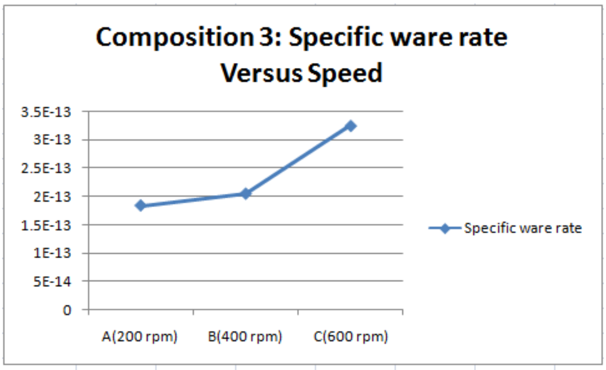

Fig 5: *Specific wear rate of composition 3 V/s Speed.*

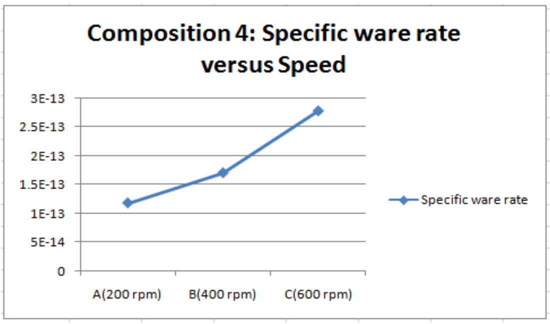

Fig 1: *Specific wear rate of composition 4 V/s Speed.*

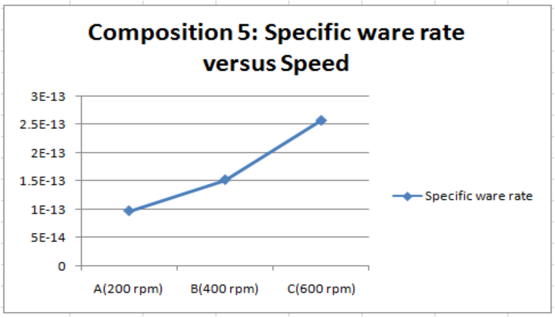

Fig 7: *Specific wear rate of composition 5 V/s Speed.*

Fig. 6, 7, 8, 9, 10 shows that as the speed of the rotating Disc is increased the specific wear rate also increases.

4.2ANALYTICAL CORRELATION

The correlation was carried out with the help of MINITAB software where the regression equations were obtained for samples which are as follows,

Wear of composition 1 = 30.7 + 0.0675× (Speed)

Wear of composition 2 = 28.0 + 0.0675× (Speed)

Wear of Composition 3 =16.7 + 0.0725× (Speed)

Wear of Composition 4 =6.67 + 0.0775× (Speed)

Wear of Composition 5 =2.33 + 0.0750× (Speed)

After getting these equations again the samples were tested at speed of 300 rpm in order to check the conformity Table 7 shows the actual readings and the theoretical readings and percentage error which lies below 15%.

Table 7: *Analytical correlation for wear test*

Sample No.	Experimental Value	Analytical Value	Error (%)
1	49	50.95	4
2	50	48.25	3.5
3	42	38.45	9.5
4	30	29.17	3
5	22	24.83	13

4.3Results related to Salt Spray testing

The test was conducted for 24 hrs which denotes white rust on the samples up to 24 hrs and no red rust was observed after 24hrs, the picture below shows before test samples and after test samples.

Fig.8 Salt spray test Samples

5. CONCLUSION

- The wear of reinforced composite was comparatively less with respect to the unreinforced matrix.
- On the other hand as the speed was increased the wear rate of the samples went on increasing, which means that as the speed is directly proportional to the specific wear rate.
- The reinforced samples showed less trend to corrosion as no red rust was observed on the samples.

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