Analysis of Micro-Hardness And Wear Properties Of Lm13 Aluminium Hybrid Composites Fabricated Using Stir Casting

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Abstract- *This paper focuses on the fabrication of the Aluminium hybrid composite because of its high flexibility properties. The aim of this project is to enhance the wear properties by enhancing the Wear resistance of Aluminium alloy by adding the different reinforcement. The reinforcement used here is that Alumina and CSC (Coconut Shell Charcoal) of varying proportions is fabricated using the stir casting techniques. The wear behaviour of the sample is then tested using Pin-On-Disc apparatus by considering the corresponding process parameters such as Load, Speed, and Time. The microstructure analysis is also carried out using the inverted microscope and thereby revealing that there is the proper distribution of the reinforcements.*

Keywords- Aluminium composite, Al_2O_3, CSC ,Wear analysis, Wear Morphology, Micro-hardness analysis.

I. INTRODUCTION

The aluminium metal matrix composite is selected in this project because it has good strength to weight ratio used in many of the aerospace as well as the automobile industry; It has high performance and light weight properties. Most of the literature survey reveals that the introduction of the reinforcement into the Aluminium alloy shows the increase in the properties embedded in the Aluminium alloy. V.V.Manikandan, et al., [1] analysed the wear behaviour of Aluminium alloy of series Al6061 the introduction of reinforcement is B_4C and MoS_2, the results shows that the presence of MoS_2 reduces the wear rate as well as the coefficient of friction thereby results in the decrease in the hardness. Mohammed Zakaulla, et al.,[2] found that the most common method for the calculation of coefficient of friction and specific wear rate is Taguchi Method and in this literature survey determines the sliding wear properties of Al6061/Cu-10 SiC/Cu-1% Gr composite. Ravindra Singh Ranaa, et al.,[3] conducted the wear analysis of Al5083 with 10wt% SiC and concluded that the applied load has the more influence on the wear rate having its sliding distance and speed. A.Baradeswaran,et al.,[4] optimized the wear behaviour of Aluminium alloy Al7075 with the introduction of Al_2O_3 reinforcement the wear resistance of the composite gets increased. Siddhartha Prabhakar,et al.,[5] investigated the tribological behaviour of Aluminium/B_4C composite and it showed that optimum conditions for good tribological behaviour under the low load and high velocity and distance, the corresponding wear is analysed using the SEM techniques. Faisal.M,et al.,[6] fabricated the Aluminium using the Stir casting by introducing B_4C particles and this alloy revealed that the proper distribution of the particles and has the good lubricating properties. Dr.R.V.Kurahatti,et al.,[7] fabrication of the aluminium alloy reinforced with the Zirconium Silicate, it increases the wear resistance and also shows the uniform distribution of reinforcement of particles. Sumod Daniel,et al.,[8] tested the abrasive wear of the aluminium alloy which has dual reinforcement (6% TiB_2 + 6%SiC) shows the good resistance to wear at both high and low load corresponding to all the temperatures. S.Rajesh,et al.,[9] analysis the wear behaviour of Aluminium incorporated with the graphite particles found out the wear volume loss and coefficient of friction.

The present work in this project mainly depends upon the experimental determination of analysing the wear behaviour of the aluminium alloy LM13 alloy reinforced with the alumina/CSC.

II. MATERIALS PREPARATION

A. Preparation of hybrid composites

The aluminum alloy which is selected in this project is LM13 which is the light metal series has a good fluildity properties and can be eaily converted into thin sections. The reinforcement such as the aluminium oxide and CSC is added in the different weight ratios so as to enhance the wear resistance and as well as the other properties. The chemical composition of the LM13 aluminum alloy is tabulated in the table I.

TABLE I: CHEMICAL COMPOSITION OF LM13

Chemical Composition Of Lm13		
S.No	Chemicals	Contribution %
1	Copper	0.7-1.5max
2	Magnesium	0.8-1.5 max
3	Silicon	10.0-13.0 max
4	Iron	1.0 max
5	Manganese	0.5 max
6	Nickel	0.5 max
7	Zinc	0.1 max
8	Lead	0.1 max

LM13 aluminum alloy is mainly used in many automobile industry applications such as the Rim of the Wheel, Connecting Rod and encoders. The major alloy present in this is the elements like Silicon and copper which provides the better castability and machinability. The major Mechanical properties of the aluminium alloy LM13 is tabulated in table II.

TABLE II**.** LM13 properties

Density	2.68 g/cm^3
Elastic Modulus	69.3 Gpa
Melting Point	670-780 °C
Specific Heat Capacity	880 J/Kg-K
Tensile Strength: Ultimate (UTS)	195 - 290 Mpa
Vickers Hardness	98 HV
Thermal Conductivity	138W/mK
Elongation	7-27%

Alumina is added as the reinforcement because of its good wettabilty and temperature stability , it also has the various levels of purity than any other ceramics which are commonly used. CSC is used as a other reinforcement which enhances the wear properties. The compositions of the hybrid composite is presented in table III

TABLE III. Compositions of Hybrid composites

Sl. No.	Al(Vol%)	Al_2O_3(Vol%)	CSC(Vol%)
1	83	2	15
2	81	4	15
3	79	6	15

B. Fabrication of LM13–Al_2O_3-CSC

The method employed for fabricating the specimens are Stir Casting. The aluminium alloy LM13 ingot were machined as the small pieces and are then it is introduced in the crucible, it is headed at the temperature of 700^0C-750^0C for changing its phase from solid to semi-liquid state, the reinforcement is then preheated at a temperature of about 900^0 C then the known quantity of CSC is added to the mixture and stirring is carried out by means of the mechanical stirrer at a 600rpm for about 5minutes. The mixture which is molten is then poured on the preheated die of about 250mm height and 300mm diameter. The bottom pouring type of the stir casting apparatus is shown in Fig. 1.

Fig 1. Stir Casting Equipment

Fig. 2. Preheater electric Furnace

The casted specimen is then machine into the smaller diameter of about 10mm diameter and 30mm height, where it is subjected to the wear test.

III. EXPERIMENTAL PROCEDURE

A Dry Sliding Wear

The apparatus used for testing the wear behaviour is Pin-On-Disc, the pins which are machined into the suitable diameter are holder on the suitable fixture against the rotating steel disc. The track diameter of about 80mm is kept constant at all the experiments. The wear rate thereby produced for each experiment is monitored by means of LVDT (Linear Variable Differential Transducer; the weight of the sample which is to be measured before and after the experiment is verified and noted by means of the weighing machine of least count of 0.1mg. the corresponding wear rate as well as the coefficient of friction is recorded by the software named WINDUCOM software. The wear rate thereby obtained is tabulated in the table IV as below and the images of the specimen as well as the apparatus are shown in the Fig 3 and Fig 4.

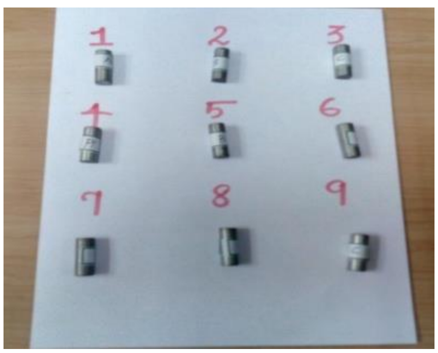

Fig 3. Samples for Pin-On-Disc

Fig 4. Pin-On-Disc Apparatus

TABLE IV. Results of wear analysis

Samp No.	Load (N)	Speed (rpm)	Time (mins)	Velocity (m/mins)	Wear rate (micrometer)
A	10	500	6.6	1	113
B	10	500	25	1	109
C	10	500	33	1	90
A	20	500	8.3	2	163
B	20	500	16.6	2	145
C	20	500	12.5	2	94
A	30	500	5.5	3	166
B	30	500	8.3	3	152
C	30	500	11.1	3	106

Fig 5. Wear graph-Sample C at load 20Kg

From the above figure 5 and table IV, the graph shows that the sample 3 exhibits the higher wear resistance when compared to the samples 1 and 2. Therefore, it is clear that the aluminium alloy LM13 series exhibits the higher wear rate when the percentage of reinforcement introduction in the alloy gets increased.

B Wear Morphology

The wear morphology of the samples before and after the wear test experiment was carried out using the inverted microscope equipmemt, it reveal that the proper distribution of the reinforcements added to the main alloy material. The wear morphology of the specimen is shown in the figure 6,7 and 8.

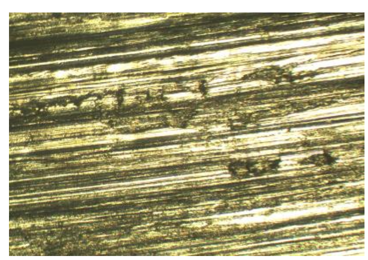

Fig 5. Wear morphology-Sample C at load 10Kg.

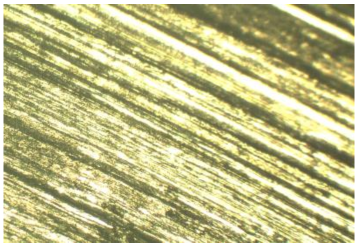

Fig 6. Wear morphology-Sample C at load 20Kg.

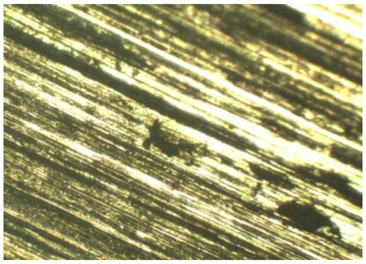

Fig 7. Wear morphology-Sample C at load 30Kg.

C. Microhardness Analysis

The fabricated specimens with the different proportions are subjected to the Microhardness test, here the Microhardness apparatus used is Vickers Microhardness of ASTM G99 05 standards having a 1/16 inch diameter diamond indenter pressed towards the samples at a specific period of time and this indentation towards the specimen is repeated at the various locations on the samples. The value which is obtained is tabulated as follows in table V.

The Vickers microhardness testing machine is shown in figure 8.

Fig 8. Vickers microhardness testing machine

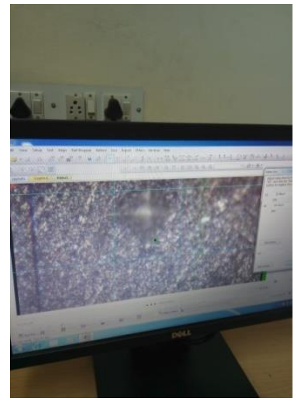

Fig 9. Vickers microhardness testing machine-indentation

TABLE V. Results of microharness test analysis

Sample number	Load (g)	Trial 1 (HV)	Trail 2 (HV)	Trail 3 (HV)	Average (HV)	Indentation depth (mm)
01	50	126.4	125.4	127.8	126.53	4.2
02	50	154.5	145.5	162.6	154.2	3.5
03	50	175.9	172.1	170.5	172.83	3.2

The hardness results from the table shows that the 3rd sample has greater hardness value when compared to other 2 samples, this is because of increase in the reinforcement percentage of Aluminium and CSC. It is to be well known that the indentation depth is inversely proportional to the hardness value, In other words when the indentation depth decreases the hardness value obtained will be higher.

IV. CONCLUSIONS

The following are the some of the conclusions from this present project work.

- It is concluded that the composite having the composition of LM13-Al_2O_3 (6%) – CSC(3%) shows the extreme wear resistance properties, in other words which lowers has the lower wear rate as observed in the Pin-On-disc apparatus.
- The morphology of the wear also showed the proper distribution of the reinforcements added to the samples.

V. FUTURE SCOPE

This project work mainly focuses on the wear resistance of the aluminium hybrid composites. Some of the corresponding can be considered to exhibit the future possibilities to enhance the other properties embedded into LM13 aluminum alloy.

- The composites can be fabricated by varying the compositions of the reinforcement used.
- With this same percentage of the reinforcement with reference to this paper, the project can be done with the help of Squeeze casting technique.

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