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A Study on Mechanical and Tribological Properties of Aluminum 7075 MMCS Reinforced with Silicon Carbide and Coconut Husk by Powder Metallurgy Process

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ABSTRACT

The metal matrix composite strengthened with ceramic material of silicon carbide has smart mechanical characteristics. Metal-based composites, however, demand progress in their friction and tribological characteristics. In this work-study an effort is made to design a completely new material through the method of metallurgy by adding Coconut husk. This study explored the effect of coconut husk on the tribological behavior of hybrid composite Al 7075/5 wt. % Sic/Xwt. %coconut husk(X=6,4 and0).The research confirms the performance of wear properties by incorporating coconut husk into the composite. The sic-coconut husk reinforced Al 7075 (aluminum alloy 7075) was studied. Metallurgy route was used to prepare the composites. Microstructures, the mixture of materials, wear and wear resistance properties were analyzed by optical micro cope and scanning electron microscope.

KEYWORDS: Al7075, Silicon carbide, Coconut husk, Powder metallurgy, Mechanical propertie

1.INTRODUCTION

Aluminum matrix composites (AMC) are used in advanced engineering applications such as automotive and aerospace industries and light weight high strength applications to fulfill the emerging industrial requirements due to their good mechanical and tribological properties. Al7075 reinforced with Sic and Coconut husk ash composites produced by Powder metallurgy route showed the improvement compressive strength and hardness properties.

Al-7075

Al-7075 is an aluminum alloy with Zinc as the primary alloying element. It is strong, with strength comparable to many steels and has good fatigue strength and average machinability, but has less resistance to corrosion than many other Al alloy. Due to its strength, high density, thermal properties and its ability to be highly polished, Al-7075 is widely used in mold tool manufacture. Al 7075 remains the baseline with a good balance of properties required for aerospace applications and it is often used in transport applications, including marine, automotive and aviation, due to their high strength-to-density ratio. Here powder metallurgy is used in this study The objective of present work is to fabricate hybrid composites of Al7075/ Sic /coconut husk ash by powder metallurgy and determine the effect of addition of coconut husk ash on mechanical properties of Al7075 MMCs.

Silicon carbide

The silicon carbide was originally produced by high temperature electrochemical reaction of sand and carbon, it is a compound of silicon and carbon with a chemical formula Sic The material has been developed into a high quality technical grade ceramic with very good mechanical properties. It is used in abrasives, refractory, ceramics and numerous high performance applications. Silicon Carbide is the only chemical compound of carbon and silicon. Silicon carbide is also known as"carborundum''. Particle size received silicon carbide was in the range of 50nm is used for the experiment.

Coconut husk

The coconut husk was easily available in the agricultural area and disposal of the waste is a major problem in the world. The use of coconut husk waste as reinforcement can reduce the cost of material and clean the environment. Coconut husk was burned in controlled environment inside electrical furnace at 500, 600 and 700 °C. These ashes were treated by using two different chemical treatments to extract the highest percentage of silica. XRF analysis of coconut husk ash (CHA) revealed that the content of SiO2 varies between 8 and 11% and increased up to 90% after chemical treatment. Based on the XRD spectrum, silica obtained was in crystalline form after acid treatment but was in amorphous form after the alkali treatment. Electrical oven at temperature of 120°C to remove most of the impurities and moisture. The coconut husk were separated from the inner coat of the coconut and stored in drying box to prevent further impurities and moisture from the surrounding environment. The clean coconut husk were placed in alumina crucible and subjected to heat at temperature of 500, 600, and 700 °C for 2 h in electrical furnace at constant heating rate. Coconut husk collected from local stores were cleaned and dried in of 10 °C/min to obtained CHA.

2.LITERATURE SURVEY

Kumar et al. evaluated the mechanical properties and wear behavior of Al6061-SiC and Al7075-Al2O3 metal matrix composites. The reinforcement of the hard ceramic particles increases the micro hardness, tensile strength and density of the composites.

Senthilvelan et al. investigated mechanical properties of Al7075 metal matrix composites reinforced with 10% volume fraction of B4C, SiC and Al2O3 fabricated by stir casting process. The author reported that Al7075 with B4C reinforced composite off ered good mechanical properties compared to other particle reinforced composites.

Baradeswaran and perumal studied the mechanical and wear properties of Al 7075/Al2O3/graphite hybrid composites. It was found that the mechanical properties increased with increasing the weight percentage of reinforced particles.

Deeparaj.E and Vivek.B studied the Mechanical Properties of MMCs of AL7075 and Silicon Carbide. It is observed that the hardness of the composite is increased with increase of reinforced particle weight fraction. The tensile strength and impact strength both are increased with rising of reinforced weight fraction compared to pure metal. Different mechanical tests were conducted and presented by varying the weight fractions of SiC.

G.B. Veeresh Kumar and C.S.P. Rao conducted experimental results of the studies conducted regarding hardness, tensile strength and wear resistance properties of Al6061-SiC and Al7075- Al2O3 composites. In the result it shows that, The SiC and Al2O3 resulted in improving the hardness and density of their respective composite

3.PROBLEM STATEMENT & OBJECTIVE

The extensive review of literature carried out for present study reveals that lot of work has been reported to enhance properties of Aluminium metal matrix composites through stir casting.

After the review of literature the following gaps were found:

- Very limited amount of work has been done which explains the factor effecting properties of Aluminium metal matrix composite by powder metallurgy.
- There is no detailed chemical composition available of coconut husk ash (CHA).
- No amount of work has been done on combined effect of silicon carbide(SIC) and coconut husk Ash (CHA) with Aluminium metal matrix by powder metallurgy.

Due to the following gaps this work is done to develop the new material using Aluminium alloy composites,

so that it should be lighter in its weight and with improved properties which can be used for industrial purpose such as automobile and aircraft industries.

4.METHODOLOGY

Preparation of samples by powder metallurgy

Preparation of samples by powder metallurgy The base matrix material used in the present experimental investigation is Al7075 and coconut Husk Ash (CHA) and Silicon Carbide (SiC) as the reinforcement to form a hybrid metal matrix composite. Coconut husk was burnt in furnace at 600oC for about 2-3 hours in the presence of oxygen the ash content of coconut husk is 3.2% of raw husk.

Table1. Chemical Composition Of Al-7075In (Wt%)

Elements of Al7068	Weight %
Iron (Fe)	0.3
Copper (Cu)	1.6
Magnesium (Mg)	2.5
Silicon (Si)	0.2
Zinc (Zn)	5.5
Chromium (Cr)	0.22
Titanium (Ti)	0.1
Aluminium (Al)	89.48

The particle size of coconut husk ash (CHA) taken for this work is of 30 microns size, with the help of 30 microns sieve. The Al7075 hybrid composites with coconut husk ash (CHA) and SiC as reinforcement were produced using powder metallurgy. Table 1 shows the AL7075 powders that were weighed accurately and mechanical alloying was done for 10 hours in a pot mill (fig 2.1). The hybrid composite was milled in 500ml polypropylene bottle with the alumina balls of sizes 10mm and 3mm as a grinding media. The powder to grinding media ratio used is 1:4 where 50% of total grinding media includes 10 mm alumina balls and other 50% of grinding media includes 3mm of alumina balls. The particles were added with 2% stearic acid to have proper bonding

Table II: The sample specification

Sample No.	Composition
1	Pure Al7075
2	Al7075 + 0% CHA+ 4% SiC
3	Al7075 + 0% CHA + 6% SiC
4	Al7075 + 4% CHA + 0% SiC
5	Al7075 + 4% CHA + 4% SiC
6	Al7075 + 4% CHA + 6% SiC
7	Al7075 + 6% CHA + 0% SiC
8	Al7075 + 6% CHA + 4% SiC
9	Al7075 + 6% CHA + 6% SiC
10	Al7075 + 8% CHA + 0% SiC
11	Al7075 + 8% CHA + 4% SiC
12	Al7075 + 8% CHA + 6% SiC

A separate die and punch (fig 2.2) was made for compaction of metal powders. Cold compaction at a low pressure of 400 MPa was done using a digital hydraulic press machine (fig 2.3) to produce green compacts of size 10 mm diameter and 12±0.5 mm height. The green compacts were sintered at 720oC for three hour in a raising hearth furnace (fig 2.4). The composites of Al7075 reinforced with CHA and SiC were produced according to the sample specification showed in Table II.

Fig .1. Pot mill

Fig .2. Punch and die.

Fig.3. AL7068 40µ size powder.

Fig .4. Digital hydraulic press

Fig .5. Raising Hearth Furnace.

Figure.6. Silicon carbide 40µ size powder.

Fig.7. coconut husk ash 30µ size powder.

Fig .8. Green samples.

Fig .9. Sintered samples.

4.RESULTS AND DISCUSSION

1) Density

The density of samples is determined by measuring the weight and volume of the specimens

Table IV: Density of samples

Sample No.	Green Density (grms/cc)	Sintered Density (grms/cc)
1	2.18	2.26
2	2.22	2.34
3	2.23	2.41
4	2.17	2.39
5	2.20	2.32
6	2.15	2.37
7	2.11	2.38
8	2.21	2.54
9	2.25	2.38
10	2.14	2.33
11	2.16	2.34
12	2.21	2.55

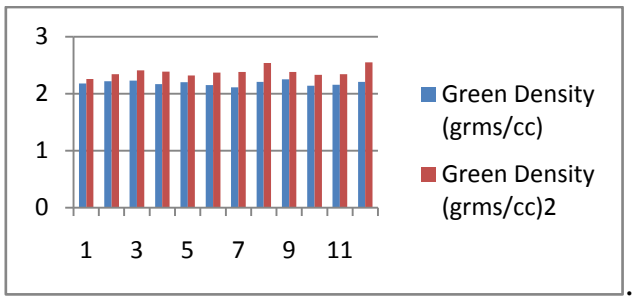

Fig .12. Graphical representation of Green and Sintered density in grms/cc.

The green density and sintered density of the samples showed varying values of densities with different percentage of reinforcement of CHA and Sic. The calculation of density of sintered samples showed increased in density values as compared with the green density. The data is graphically represented in above graph in grams per centimeter square.

2) Compression test

The compression Test was performed on the digital hydraulic press which was suitable for the compression test as the size of the samples were small in dimension e.i 10 mm dia and 12 mm height.The samples was placed between lower punch and upper punch and the load was applied in the sample from the upper punch. The load was applied until fracture was observed on the sample compacts and the respective readings were noted down.

Table V: Compression test results

Sample No.	Compressive Stress in kg/mm2	Compressive Stress in Mpa
1	15.3	150.04
2	13.6	133.37
3	15.6	152.9
4	13.3	130.42
5	14.7	144.15
6	14.5	142.19
7	10	98.06
8	8.5	83.35
9	12.2	119.64
10	17.2	168.67
11	16.3	159.84
12	14.1	138.27

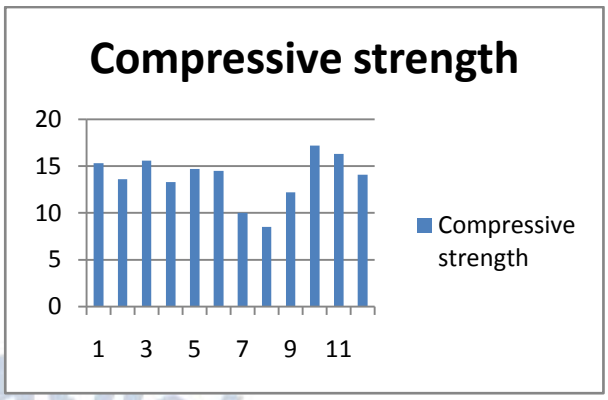

Fig.13. Representation of compression test results.

From the above graph it is seen that the highest value of compressive strength was observed for the composition Al7075 + 8% CHA + 0% SiC i.e168.67 MPa.

3) Hardness test

Hardness of the samples were tested on Brinell Hardness Tester.

Table 5. Hardness of results

Sample No.	Brinell Hardness(HB)
1	74
2	77
3	73
4	68
5	69
6	65
7	70
8	73
9	52
10	53
11	59
12	63

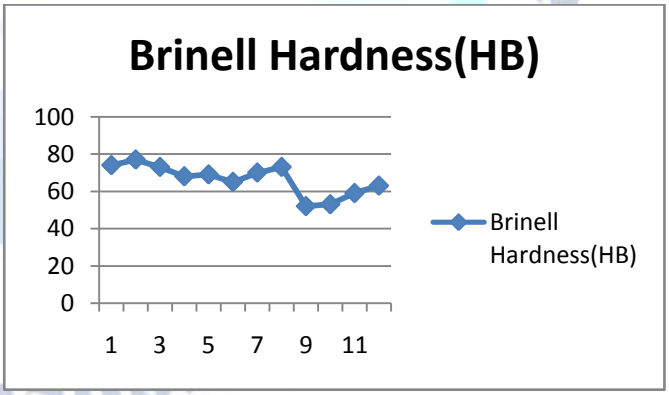

Fig .21. Representation of Hardness test results.

From the results, it is observed that the hardness of the samples decreases as percentage of coconut husk ash increases. As well, the hardness increases as the weight percentage of Al2O3 increases. The maximum hardness value obtain is 87 BHN for the composition of Al7075 reinforced with 0% CHA and 12% Al2O3.

4) Scanning Electron Microscopy (SEM)

Fig 13. SEM image of Al7075.

The above image shows the sintered sample of AL-7075 with no reinforcement, by seeing this fig it was observed that the sample was sintered properly without any pores left and with no pores. So we cannot go further magnification inside the sample.the particles are binded excellently with each other.

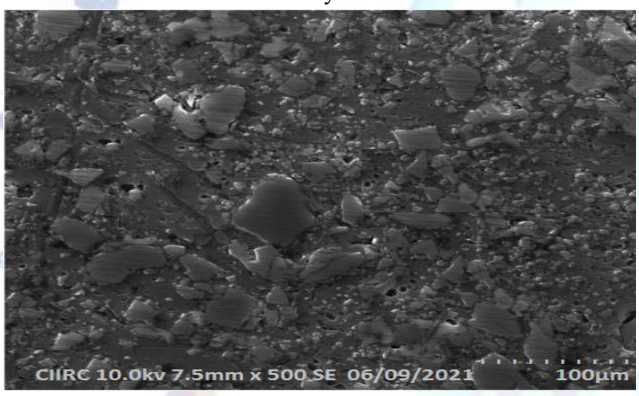

Fig 14. SEM image of Al7075 +0% CHA +4% SIC sample.

The above fig shows the hybrid composite with SiC as reinforcement to AL-7075, by which we can say that the particles are properly milled together in the milling process, but due to the large pore sizes seen after sintering we can say that it needs higher force for the compaction.

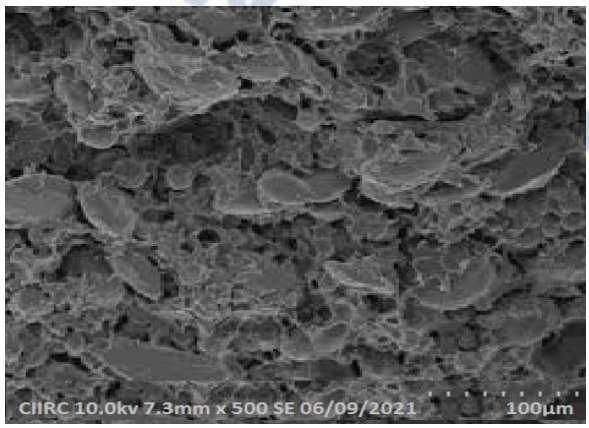

Fig 15. SEM image of Al7075+ 4%CHA+4%SIC sample.

From the image of the hybrid composite above it was observed that the tur husk ash is completely submerged the matrix and is eventually appeared but the SiC reinforcement can be seen as the brighter particles as it has the higher atomic weight. But it can be seen that the pores size did not reduce this might be due to improper sintering.

5.Energy Dispersive X-Ray Study(Edx)

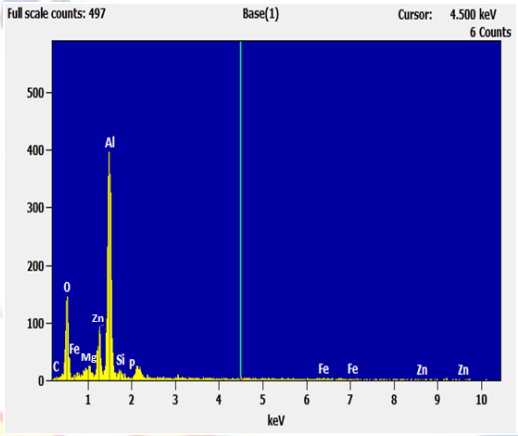

Fig 16.EDX of Al7075 sample.

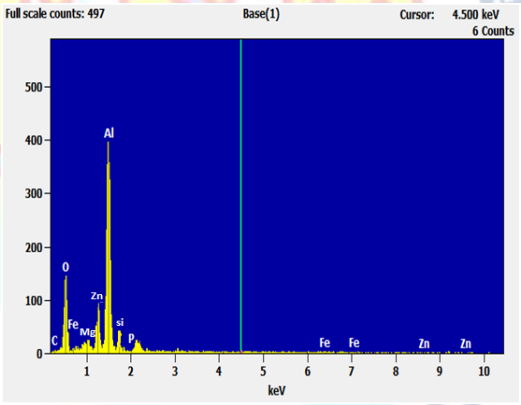

Fig 17. EDX of Al7075 +0% CHA+4% SIC

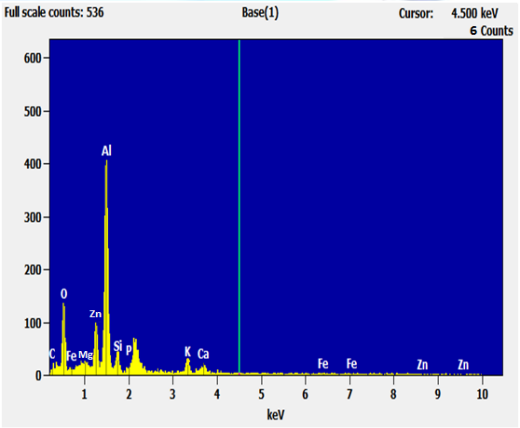

Fig 18. EDX of Al7075 +4%CH+4%SIC

From the fig 16 we can say that the EDX of sample containing only Al-7075 with no reinforcement ,shows all the compositional elements present in it and it matches with standard Al-7075 composition.

From the fig 17 EDX of sample containing Al7075 +0% CHA+4% SIC confirms the presence of alumina and the aluminium matrix as we can see through the peaks and data provided by table. It contains high percentage of aluminium.

From the fig 18 EDX of sample containing Al7075 +4%CH+4%SIC confirms the presence of CHA, alumina and the aluminium matrix as we can see all the elements present in the composition are observed in the table

6.CONCLUSION

From the experiments conducted to study the effects of adding various volumes fractions of SiC, coconut Husk and Al-7075.

Following conclusions can be drawn.

- The chemical composition of the Coconut husk ash was obtained by EDX.
- Composites material AL-7075 alloy reinforced with SiC and coconut husk were successfully mixed by powder metallurgy process.
- The density was measured before and after sintering,and was found to be increasing.
- The microstructure analysis (SEM) of sintered sample showed that it was partially sintered as pores were identified.
- As sample reported to be partially sintered, it was observed that the compressive strength was found to be varying and were significantly low.
- The hardness test shows that the hardness increases as percentage of Alumina increases but it decreases with increasing percentage of coconut husk ash.

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