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A Study on Mechanical Properties of Al7068 Based Metal Matrix Composite Reinforced with Rice Husk Ash (RHA) and Silicon Carbide (SiC)

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ABSTRACT

This paper deals with the fabrication of Al-7068 composites manufactured by powder metallurgy route reinforced with different weight percentages of rice husk ash (RHA) and SiC. A low pressure of 400mpa was applied for compacting the composites and sintered at a temperature of 720°C for three hour. SEM and EDX analysis was done to study the micro-structural behavior. Hardness and compression test were carried out. The hardness has been improved by adding the weight percentage of SiC but seems to be crash by adding the weight percentage of Rice Husk Ash (RHA). The compressive strength was found to be varying.

KEYWORDS: Al7068; Rice husk ash; compacting; sintering; SiC; powder metallurgy

1.INTRODUCTION

A composites a material system that is made of two or more material in a macroscopic scale. In material science composite has a number of definitions.the main constituents of composite are matrix and reinforcement.matrix hold the reinforcement in their respective position and provide toughness to the system. Reinforcement provides stiffness to the composite. As ar result the composite has a optimum balance between strength and toughness.

The commonly used classification of composite based on matrix that can be divided into three primary group i.e polymer matrix composite(pmcs),ceramic matrix composite (cmcs), metal matrix composites (mmcs) when atleast three materials are present, it is known as hybrid composite. MMCs are widely used because of specific characteristics such as their favorable mechanical properties, low density, and electrical conductivities.

Many advancements in manufacturing in this modern world requesting new manufacturing ideas and components with more advantages than the existing one in every aspect including physical and chemical properties. In manufacturing field, extrusion process has a wide range of application. Specifically,the extrusion process is employed in manufacturing different profiles with either solid or hollow. Extruded Al products are enormously utilized in quite a lot of engineering fields like Automotive, Building partition and transport. The most commonly used material in profiles manufacturing Aluminium Alloys The hot extrusion process is mostly hired method in manufacturing aluminum profiles.

In this paper, AL7068 has been chosen because of its decent mechanical properties, ductility, and resistance to corrosion. These process is carried out through powder mettalurgy route. Powder Metallurgy is the process of mingling fine powdered materials through compacting them into an anticipated shape or form with or without application of heat and pressure in a controlled environment to bond materials. This process has many advantages like huge potential savings, flexibility, controlled porosity, and good chemical homogeneity. Through powder metallurgy,we are going to obtain billets and will conduct various test.

Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. This ensures the researcher for effective utilization of this agricultural waste.Burning the husk under controlled temperature below 800 °C can produce ash with silica mainly in amorphous form, which can produce the composites with low density and having high temperature resistance and hardness.

Silicon carbide (SiC), also known as carborundum, is a semiconductor containing silicon and carbon. It occurs in nature as the extremely rare mineral moissanite. Grains of silicon carbide can be reinforced together by sintering to frame hard earthen ware production that are broadly utilized as a part of applications requiring high endurance such as auto brakes, auto grasps and ceramic plates in bullet proof vests.

In this paper, microstructure and mechanical properties of AA7068 reinforced with RHA and SiC, which were fabricated using powder metallurgy, were reported.

2. LITERATURE SURVEY

1) **S. D. Saravanan, M. Senthil** Kumar studied the properties of the AlSi10Mg /RHA composite and found that the Tensile Strength, Compression Strength and Hardness of the metal matrix composite increases and ductility gets decrease with increase in the weight fraction of rice husk ash.
2) **Satish D, Kene, Pravin V. Domke, Sandesh D. Deshmukh, R.S.Deotale.**, did “Assessment of Concrete Strength using Fly ash and Rice husk ash” and they concluded that rice husk when burned produced amount of silica (more than 80%). For this reason it provides excellent thermal insulation. The workability of RHA concrete has been found to decrease but FA increases the workability of concrete. Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement.
3) **D. Siva Prasad, Dr .A. Rama Krishna** concluded the hardness of A356.2/RHA composites increases with increase in rice husk ash content. Incorporation of rice husk ash particles in aluminium matrix can lead to the production of low cost aluminium composites with improved hardness and strength.
4) **S Charles, et al,**. The worked on metal matrix composites: matrices and processing, in this article it is indicated that wear resistance and hardness were enhanced on increasing the vol% of SiC. The tensile strength was high at 10 vol% of SiC and it decreased as the vol% increased Microstructure showed a fairly uniform distribution of the dispersoids. Electric discharge machining was done on the composite specimens and mathematical models were developed for predicting the material removal rate and tool wear rate using design of experimentation with current, pulse duration and vol% of SiC as the process variables. Curves describing the direct and interaction effect of the process variables were drawn It was found that the material removal rate and tool wear rate increased with increase in current and decreased with increase in pulse duration and vol% of SiC. The behavior of the composites was similar both for powder metallurgy and stir casting, except the fact that stir cast specimens exhibited higher hardness, wear resistance and tensile strength.
5) **K. John Joshua, et al,** conducted the experimental study on investigation of microstructure and mechanical properties of AA7068 reinforced with MgO prepared using powder metallurgy,in this research article it states that the AA7068 gives the highest mechanical strength of all aluminum alloys. It gives yield strength of 700 MPa and good ductility with corrosion resistance similar to 7075, the mechanical properties has been improved by the addition of MgO particles. The hardness has been increased due to the addition of fine MgO particles

into ZTA and wear performance has been improved to 50%. Increased wear loss and porosity was found with increased MgO reinforcement volume fraction. Under 2N load, MgO coating showed an excellent resistance to sliding wear.

1. Gaps found from literature &objective

The work carried out by different researches can be categorized into following broad classes:

1. Very limited amount of work has been done which explains the factor effecting properties of Aluminium metal matrix composite by powder metallurgy.
2. No amount of work has been done on combined effect of Silicon carbide (SiC) and Rice Husk Ash (RHA) with Aluminium metal matrix by powder metallurgy.

3.METHODOLOGY

A. Preparation of samples by powder metallurgy

The base matrix material used in the present experimental investigation is Al7068 and Rice husk Ash (RHA) and Silicon Carbide (SiC) as the reinforcement to form a hybrid metal matrix composite. Rice husk was burnt in furnace at 600oC for about 2-3 hours in the presence of oxygen the ash content of Rice husk is 3.2% of raw husk.

The particle size of Rice husk ash (RHA) taken for this work is of 30 microns size, with the help of 30 microns sieve. The Al7068 hybrid composites with Rice husk ash (RHA) and SiC as reinforcement were produced using powder metallurgy. Table 1 shows the AL7068 powders that were weighed accurately and mechanical alloying was done for 10 hours in a pot mill (fig 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. A separate die and punch (fig 2) was made for compaction of metal powders. Cold compaction at a low pressure of 60 bar was done using a digital hydraulic press machine (fig 3) to produce green compacts of size 10 mm diameter and 12±0.5 mm height. The green compacts were sintered at 450°C for three hour in a raising hearth furnace (fig 4). The composites of Al7068 reinforced with RHA and SiC were produced according to the sample specification showed in Table II.

Table I: Chemical composition of Al-7068

Elements of Al7068	Weight %
Si	0.12
Fe	0.15
Cu	2
Mn	0.1
Mg	3
Cr	0.05
Zn	8
Ti	0.01
Zr	0.1
Al	86.47

Sample No.	Composition
1	Pure Al7068
2	Al7068 + 0% RHA + 4% SiC
3	Al7068 + 0% RHA + 6% SiC
4	Al7068 + 4% RHA + 0% SiC
5	Al7068 + 4% RHA + 4% SiC
6	Al7068 + 4% RHA + 6% SiC
7	Al7068 + 6% RHA + 0% SiC
8	Al7068 + 6% RHA + 4% SiC
9	Al7068 + 6% RHA + 6% SiC
10	Al7068 + 8% RHA + 0% SiC
11	Al7068 + 8% RHA + 4% SiC
12	Al7068 + 8% RHA + 6% SiC

Table II: The sample specification

Fig .1. Pot mill

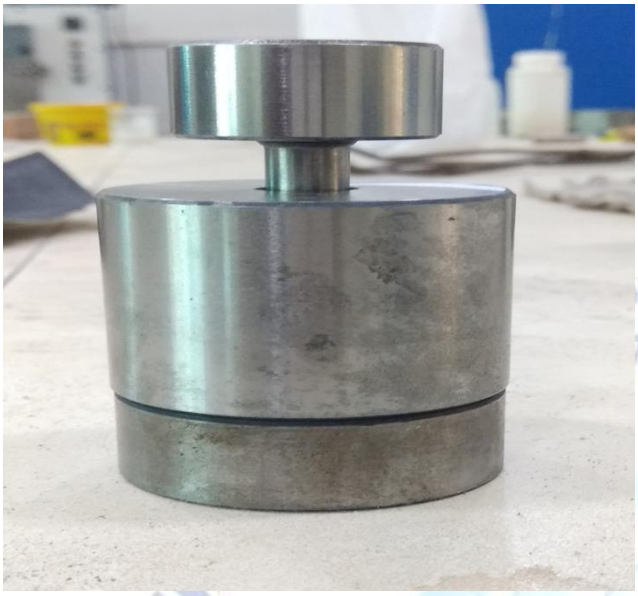

Fig .2. Punch and die

Fig.3. AL7068 40µ size powder.

Fig.4.digital hydraulic press

Fig.5. Raising hearth furnace

Fig.6. Silicon carbide 40µ size powder.

Fig.7.Rice husk ash 30µ size powder

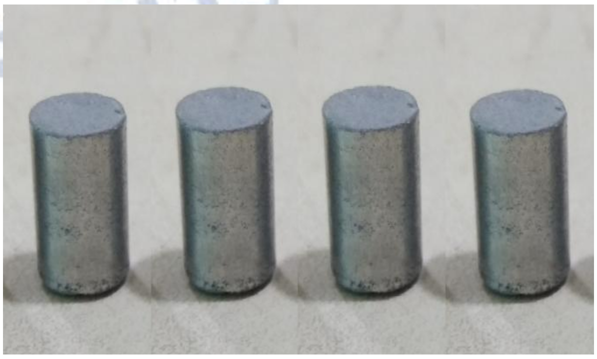

Fig.8.green samples

Fig.9.sintered samples

4.RESULTS AND DISCUSSION

1.Density

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

Table IV: Density of samples

Sample No.	Compressive Stress in kg/mm2	Compressive Stress in Mpa
1	16	156.904
2	15.2	149.06
3	14.4	141.21
4	16.5	161.80
5	13,2	129.44
6	15.3	150.04
7	16.5	198.04
8	12.7	124.44
9	13.2	129.44
10	20.2	198.04
11	18.4	180.44
12	16.5	161.80

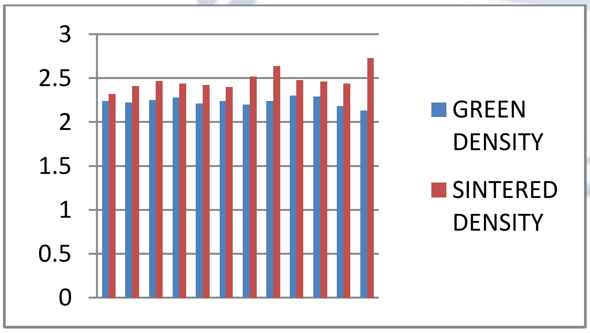

Fig .12. Graphical representation Green and Sintered density in grms/cc.

The green density and sintered density of the samples showed varying values of densities with different percentage of reinforcement of RHA 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 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.	Green Density (grms/cc)	Sintered Density (grms/cc)
1	2.24	2.32
2	2.22	2.41
3	2.25	2.47
4	2.28	2.44
5	2.21	2.42
6	2.23	2.40
7	2.2	2.52
8	2.24	2.64
9	2.3	2.48
10	2.29	2.46
11	2.18	2.44
12	2.13	2.73

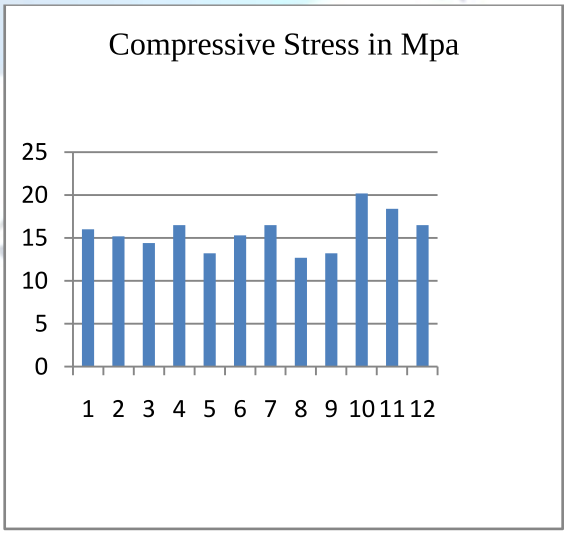

Fig.10. Representation of compression test results.

From the above graph it is seen that the highest value of compressive strength was observed for the composition Al7068 + 8% RHA + 0% SiC i.e 198.04MPa.

3.Scanniing Electron Microscopy (SEM)

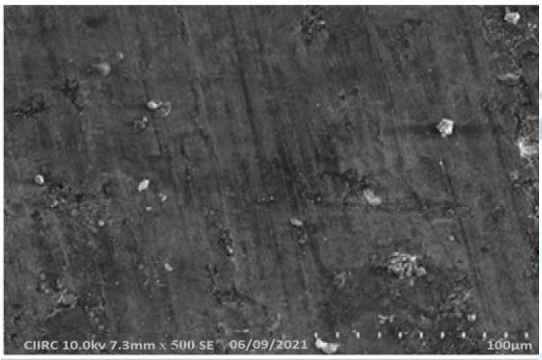

Fig .11 SEM image of Al7068.

The above image shows the sintered sample of AL-7068 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.

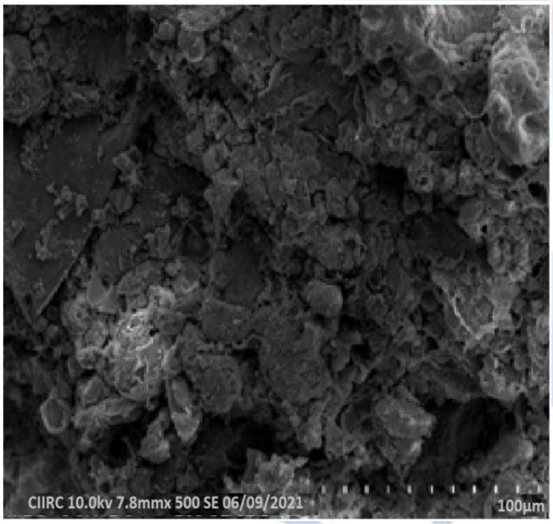

Fig .12 SEM of Al7068 +0% RHA +6% SiC sample.

The above fig shows the hybrid composite with SiC as reinforcement to AL-7068, 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.

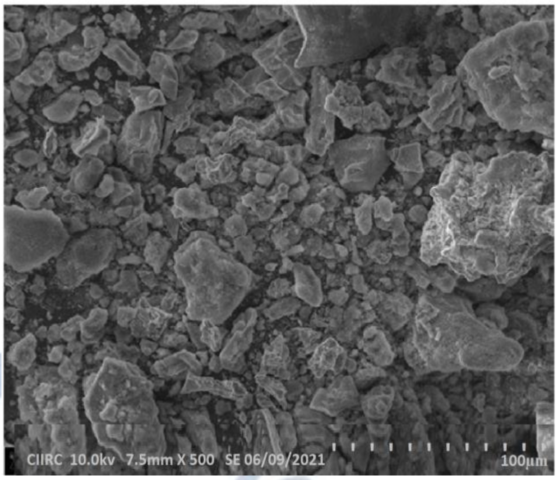

Fig.13 SEM of Al7068 +4% RHA +6% SiC sample.

Above fig represents SEM image of sintered sample with RHA reinforcement. The image taken at 500x magnification represents decrease in porosity as compared with image but further it is still observed that the sample is not been sintered properly because the particles are loosely bond and have not formed grain boundaries.

4.Energy Dispersive X-Ray Study (Edx)

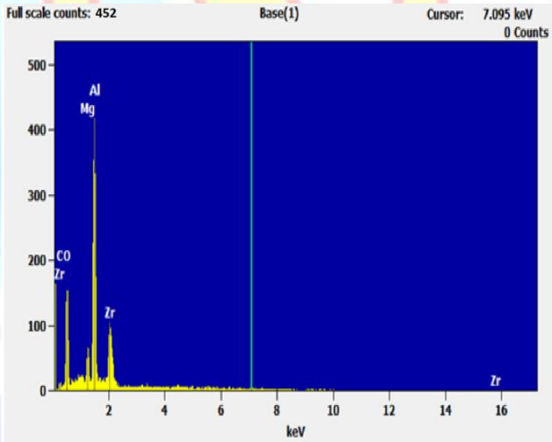

Fig .14. EDX of Al 7068 sample

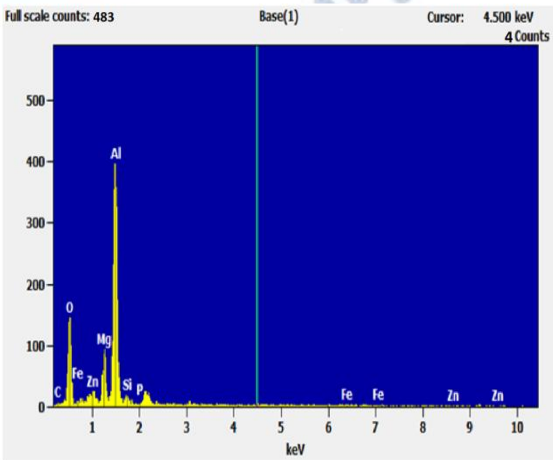

Fig .15: EDX of Al7068 +0%RHA +6% SiC sample

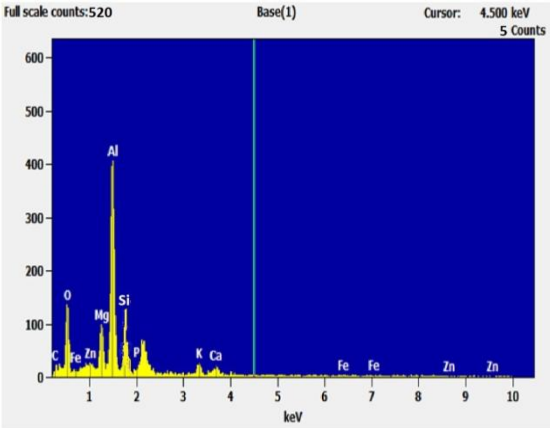

Fig .16: EDX of Al7068 +4% RHA +6% SiC sample

From the fig 14 we can say that the sample of AL-7068 with no reinforcement, its edx shows the compositional elements present by comparing it with the standard composition of the Al7068. Edx in fig 15 shows the presence of SiC and the aluminium matrix as we can say that through the peaks. The fig 16 represents the presence of RHA as well as SiC with the aluminium matrix by obtaining the peaks of MgO and SiC through the peaks obtained in the graph.

5. Hardness test

Hardness of the samples were tested on Brinell Hardness Tester.

Sample No.	Brinell Hardness (HB)
1	92
2	95
3	97
4	93
5	85
6	82
7	86
8	76
9	71
10	78
11	69
12	88

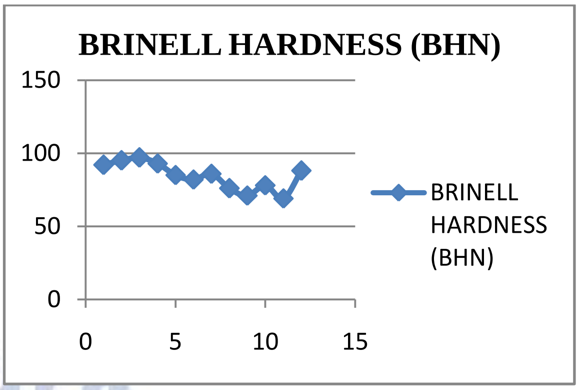

Fig .17. Representation of Hardness test results.

From the results, it is observed that the hardness of the samples decreases as percentage of rice husk ash increases. As well, the hardness increases as the weight percentage of silicon carbide increases. The maximum hardness value obtain is 97 BHN for the composition of Al7068 reinforced with 0% RHA and 6% Sic.

5.CONCLUSION

From the present work on the aluminium based hybrid MMC the following conclusions have been derived:

- The density was measured before and after sintering was found to be increasing.
- The microstructure analysis (SEM) of sintered MMC showed that the samples were blended very well but were found to be partially sintered.
- Due to partial sintering of MMC it was observed that the compressive strength was significantly low, but reinforced RHA enhanced the compressive strength.
- The hardness test shows that the hardness increases as percentage of SiC increases.

6.SCOPE FOR FUTURE WORK

The above work has been completed in view based on the literature already available. By applying Design of experiments (Taguchi Technique) the optimization of number of samples can be carried out, yielding better results. In this work only random composition (based on the literature available) was taken and the results were analyzed, discussed and documented. In the future work.

Design of experiments can be effectively used to study the mechanical properties of the hybrid composites.

The mechanical properties can be further improved by increasing compacting load. Different reinforcement such as ZrO2, TiO2, B4C, TiC etc can be used to fabricate the different hybrid composites and analyze their effects on mechanical properties of the MMC's.

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