International Journal of Scientific Research & Engineering Trends
Volume 5, Issue5, Sep-Oct-2019, ISSN (Online): 2395-566X

Investigation of Microstructure and Mechanical Properties of Hybrid Composite Aluminum 7068 Reinforced with Tur Husk Ash (THA) and Silicon Carbide (Sic)

Shaikh Mohammad Tayyab Raza
Dept. of Mechanical Engg
PDA College of Engineering
Kalaburagi, Karnataka, India

Associate Prof. B.S.Motgi
Dept. Of Mechanical Engg
PDA College of Engineering
Kalaburagi, Karnataka, India

Professor Dr. G.K. Purohit
Dept. Of Mechanical Engg.
PDA College of Engineering
Kalaburagi, Karnataka, India

Abstract - **This paper deals with the fabrication of Al-7068 composites manufactured by powder metallurgy route reinforced with different weight percentages of tur husk ash (THA) and SiC A low pressure of 400 MPa was applied for compacting the composites and sintered at a temperature of 720oC for three hour. TG and XRD analysis of tur husk ash (THA) was done to obtain its chemical composition. 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 tur husk ash (THA). The compressive strength was found to be varying.**

Keyword- **Al7068; Tur husk ash; compacting; sintering; SiC; powder metallurgy;.**

I. INTRODUCTION

A composite material is defined as a structural material created synthetically or artificially by combining two or more materials having dissimilar characteristics. The constituents are combined at macroscopic level and are not soluble in each other. One constituents is called Matrix phase and the other is called Reinforcing phase. Reinforcing phase is embedded in the matrix to give the desired characteristics. Reinforcing phase: Fibers, flakes, particulates and whiskers etc. Matrix phase: continuous phase. One commonly used classification of composite is based on matrix that can be partitioned into three primary group-1.Polymer matrix composites (PMCs) 2.Ceramic matrix composites (CMCs) 3.Metal Matrix Composites (MMCs). When at least 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 densities, and electrical conductivities. Some important reinforcements for MMCs are Fibers, Whiskers and Particles.

The unique combinations of properties provided by aluminium and its alloys make Aluminium one of the most versatile, economical, and attractive metallic materials for a broad range of uses—from soft, highly ductile wrapping foil to the most demanding engineering applications. Aluminium alloys are second only to steels in use as structural metals. Aluminium has a density of only 2.7 g/cm3, approximately one-third as much as steel (7.83 g/cm3). An Aluminium 7068 alloy provides the highest mechanical strength of all aluminium alloys and matching that of certain steels. This outstanding alloy combines yield strength of up to 700 MPa (up to over 30% greater than that of 7075 alloy) and good ductility with corrosion resistance similar to 7075 and other features beneficial to high performance component/ equipment designers. Developed in the mid 1990's by Kaiser Aluminium, and exclusively stocked and supplied in Europe by Advanced Metals International, 7068 alloy was designed as a higher strength alternative to 7075 for new applications. The highly attractive overall combination of mechanical properties (retained at elevated temperatures better than 7075).

India is generating huge amount of low cost by-products and waste in the form of husk. Presently the use of this husk is only for the cattle feed and possessing very less value. However as this by-product is biomass and naturally carries carbon content with it so that we can use it in industrial application and hence can be used as reinforcement in MMCs. One of the major pulse processed in India is Tur (Cajanus cajan) creating large amount of waste in the form of husk. Cajanus cajan husks in their carbon form is still no deliberated and need extensive study for the better application of these husks as composite material.

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 earthenware 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 THA and SiC, which were fabricated using powder metallurgy, were reported.

II. LITERATURE SURVEY

M K Surappa, in the work on aluminium matrix composites: challenges and opportunities, stated that AMCs have been utilized in high-tech structural and functional applications including aerospace, defense, automotive, and thermal management areas, as well as in sports and recreation. It is interesting to note that research on particle-reinforced cast AMCs took root in India during the 70's, attained industrial maturity in the developed world and is currently in the process of joining the mainstream of materials. This research survey presents an overview of AMC material systems on aspects relating to processing, microstructure, properties and applications.

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.

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

Prasanna Gubbi, et al,. on a study on mechanical and tribological properties of Aluminium 7068 MMC'S reinforced with silicon carbide (SiC) and tur husk, the results showed that two phases namely a matrix and a reinforcement phase constitute composite materials. Most of studies shows that the material used for components should posses better mechanical and tribological properties. In this paper five samples were prepared by using stir casting. First sample is Al7068, second sample consist of Al7068 with 2% SiC and 8%Tur Husk, third sample consist of Al7068 with 4% SiC and 6% Tur Husk the fourth sample consist of Al7068 with 6% SiC and 4% Tur Husk and the fifth sample is of Al7068 with 8%SiC and 2%Tur Husk. It was found that tensile strength and impact is increased when SiC and Tur Husk is added to Al7068. Wear is decreased when SiC and Tur Husk is added to Al7068.

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 Tur Husk Ash (THA) with Aluminium metal matrix by powder metallurgy.
3. There is no detailed chemical composition available of tur husk ash (THA).

II. METHODOLOGY

1. Preparation of samples by powder metallurgy

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

The particle size of tur husk ash (THA) taken for this work is of 30 microns size, with the help of 30 microns sieve. The Al7068 hybrid composites with tur husk ash (THA) 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 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. 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 Al7068 reinforced with THA 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

Table II: The sample specification

Sample No.	Composition
1	Pure Al7068
2	Al7068 + 0% THA + 4% SiC
3	Al7068 + 0% THA + 8% SiC
4	Al7068 + 0% THA + 12% SiC
5	Al7068 + 4% THA + 0% SiC
6	Al7068 + 4% THA + 4% SiC
7	Al7068 + 4% THA + 8% SiC
8	Al7068 + 4% THA + 12% SiC
9	Al7068 + 8% THA + 0% SiC
10	Al7068 + 8% THA + 4% SiC
11	Al7068 + 8% THA + 8% SiC
12	Al7068 + 8% THA + 12% SiC
13	Al7068 + 12% THA + 0% SiC
14	Al7068 + 12% THA + 4% SiC
15	Al7068 + 12% THA + 8% SiC
16	Al7068 + 12% THA + 12% SiC

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. Tur husk ash 30μ size powder.

2. Tur Husk Ash (THA) analysis

2.1Thermogravometry analysis of tur husk ash:

Fig.8. TG Analysis.

TG = thermal gravimetric
DTG = Derivative thermal gravimetric
It represents the TG analysis of tur husk ash (THA) which provides knowledge of the presence of ash content in the sample. The analysis showed that the presence of total ash content observed in the graph is 3.2%. Thermalgravimetric (TG) analysis is the process in which moisture and volatile matter changed according to the heat supplied which is plotted on a graph.

Derivative thermal gravimetric (DTG) analysis gives us the data of the sample weight changed with respect to increase in temperature. This graph shows the reduction of moisture in the tur husk at 200C and upon further increase in the temperature the binder material i.e. cellulose matter has been reduced at 600C.and upon further increase in the temperature there is no matter to be reduced so the content left is only ash.

2.2 XRD Analysis:

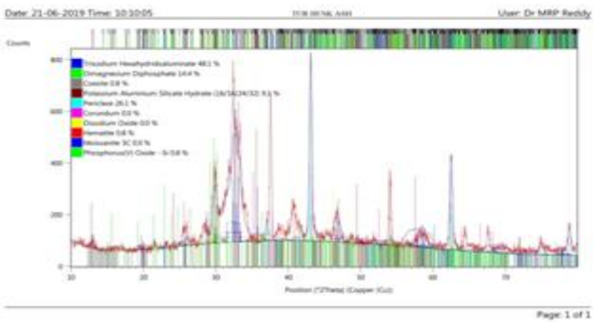

Fig.9. XRD Analysis.

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue5, Sep-Oct-2019, ISSN (Online): 2395-566X

Above fig represents the XRD analysis of tur husk ash (THA) which provides knowledge of the presence of MgO in the sample. The analysis showed that the presences of crystalline structure as sharp peaks are observed in the graph. Table III shows the chemical composition of tur husk ash (THA).

Table III: Composition of Tur Husk Ash (THA).

Sl. No.	Compound Name	Chemical Formula	Weightage Percentage
1	Phase Trisodium Hexahydridoaluminate	Na_3H_6Al	48.10%
2	Phase Periclase:	MgO	26.10%
3	Phase Dimagnesium Diphosphate	$Mg_2O_7P_2$	14.40%
4	Phase Potassium Aluminium Silicate Hydrate	$K_{16}Al_{16}Si_{24}O_{12}H_{64}$	9.00%
5	Phase Coesite	SiO_2	0.80%
6	Phase Hematite	Fe_2O_3	0.80%
7	Phase Phosphorus(V) Oxide	P_2O_5	0.80%

Fig .10. Green samples.

Fig .11. Sintered samples.

III. 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	2.21	2.37
2	2.28	2.44
3	2.25	2.51
4	2.26	2.49
5	2.27	2.42
6	2.23	2.47
7	2.2	2.48
8	2.33	2.64
9	2.38	2.48
10	2.24	2.43
11	2.19	2.44
12	2.42	2.75
13	2.27	2.42
14	2.21	2.4
15	2.17	2.42
16	2.21	2.46

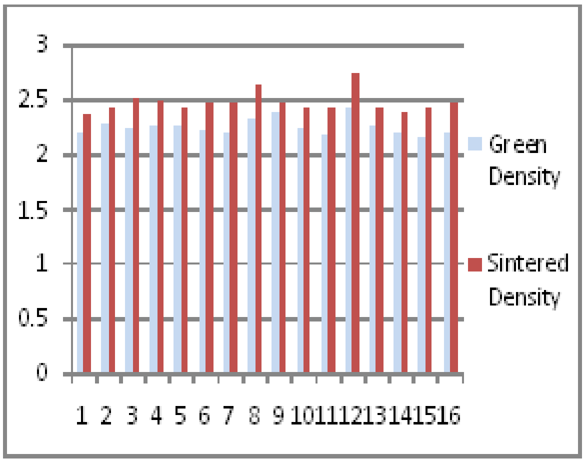

Fig .12. Graphical representation of Green and Sintered density in grms/cc.

The green density and sintered density of the samples showed varying values of densities with different percentage of reinforcement of THA 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	16.3	159.85
2	15.1	148.08
3	16.9	165.73
4	16.5	161.81
5	15.7	153.96
6	15.4	151.02
7	14.7	144.16
8	11.2	109.83
9	13.2	129.45
10	16.9	165.73
11	18.1	177.50
12	17.6	172.60
13	19.2	188.29
14	14.3	140.24
15	12.8	125.53
16	13.3	130.43

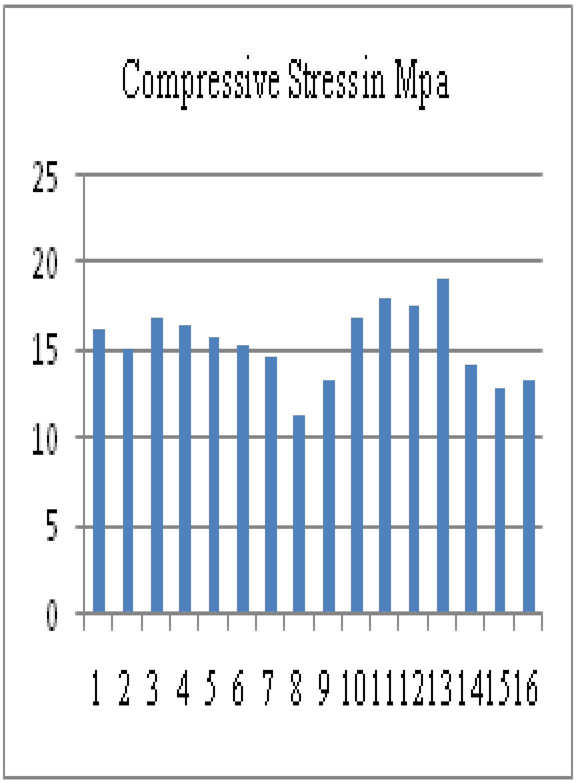

Fig.13. Representation of compression test results.

From the above graph it is seen that the highest value of compressive strength was observed for the composition Al7068 + 12% THA + 0% SiC i.e188.29 MPa.

3.Scanniing Electron Microscopy (SEM)

Fig .13. 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.

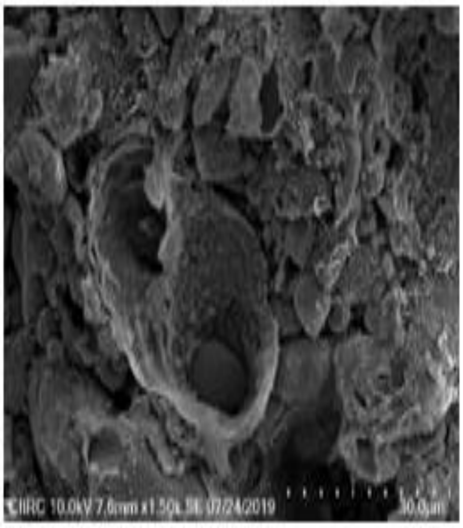

Fig .14. SEM of Al7068 +0% THA +12% SiC sample.

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.

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue5, Sep-Oct-2019, ISSN (Online): 2395-566X

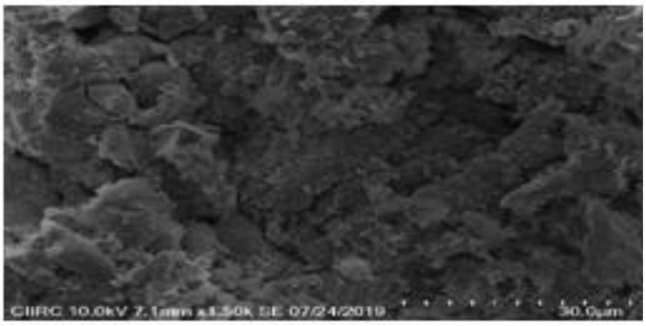

Fig.15. SEM of Al7068 +12% THA +0% SiC sample.

Above fig 3.5 represents SEM image of sintered sample with THA 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.

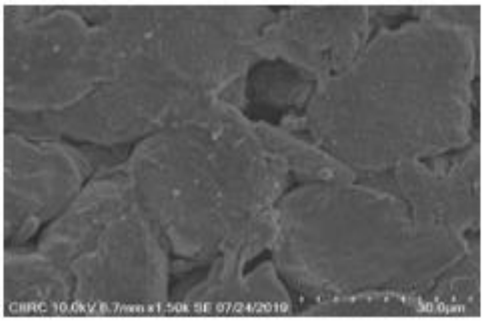

Fig .16. SEM of Al7068 +12% THA +12% SiC sample.

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.

4. Energy Dispersive X-Ray Study (Edx)

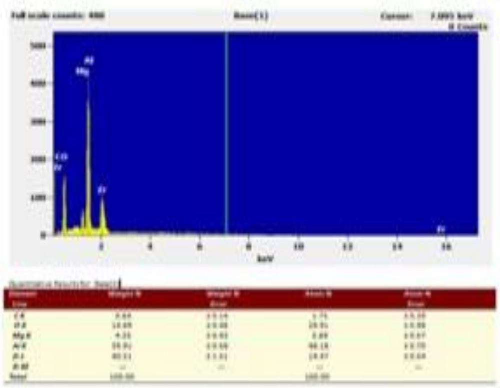

Fig .17. EDX of Al 7068 sample.

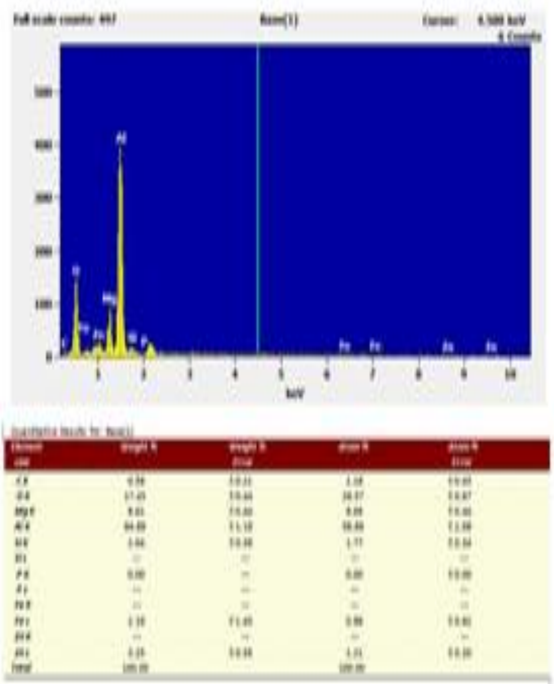

Fig .18: EDX of Al7068 +0% THA +12% SiC sample.

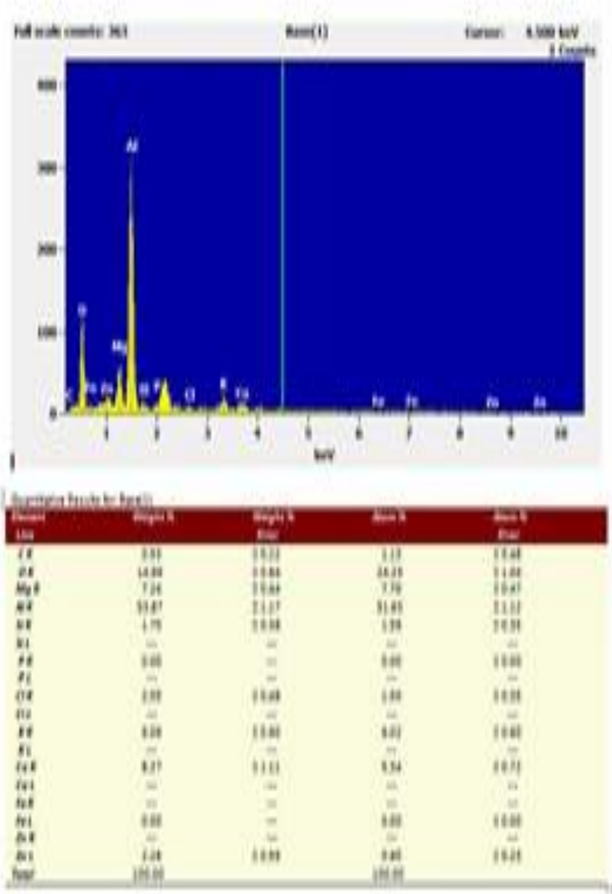

Fig .19. EDX of Al7068 +12% THA +0% SiC sample.

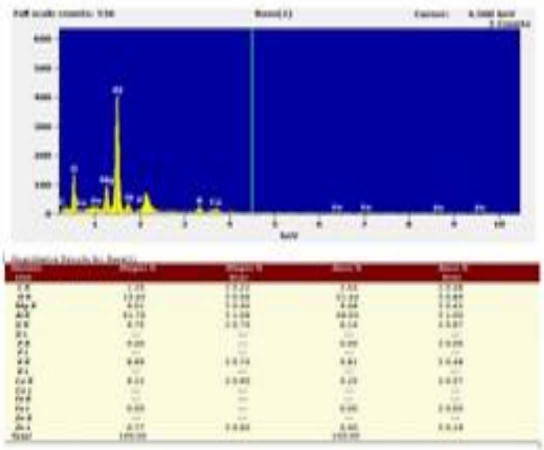

Fig .20: EDX of Al7068 +12% THA +2% SiC sample

From the fig 3.7 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 3.8 shows the presence of SiC and the aluminium matrix as we can say that through the peaks.

Edx samples of fig 3.9 shows the composites with tur husk as reinforcement which is rich in MgO, from the peaks and the table we can say that the presence of the al-7068 composition and tur husk composition can be verified. The fig 3.10 represents the presence of THA 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.

Table VI: Hardness test results

Sample No.	Brinell Hardness (HB)
1	94
2	95
3	97
4	98
5	88
6	85
7	89
8	93
9	72
10	73
11	79
12	83
13	58
14	59
15	65
16	71

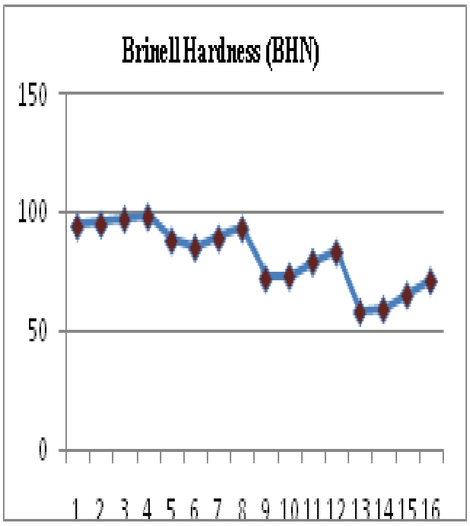

Fig .21. Representation of Hardness test results.

From the results, it is observed that the hardness of the samples decreases as percentage of tur husk ash increases. As well, the hardness increases as the weight percentage of silicon carbide increases. The maximum hardness value obtain is 98 BHN for the composition of Al7068 reinforced with 0% THA and 12% Sic

IV. CONCLUSION

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

- The chemical composition of the Tur husk ash was obtained by the process of TGA and XRD.
- XRD report shows that the tur husk ash (THA) has 26.1% of MgO in it.
- 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 THA enhanced the compressive strength.
- The hardness test shows that the hardness increases as percentage of SiC increases but it decreases with increasing percentage of tur husk ash.

V. 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. The other test like tensile test and wear test can be analyzed. 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.

VI. ACKNOWLEDGMENT

The authors would like to thank Prof. S. B. Patil for providing valuable guidance. Also thank to Mr. Mohammed Imran, Mr. Taqui Minhaj and Mr. Wajahatullah for their help and support.

REFERENCES

[1]. M K Surappa, Aluminium matrix composites: Challenges and opportunities, Department of Metallurgy, Indian Institute of Science, S¯adhan¯a Vol. 28, Parts 1 & 2, February/April 2003.
[2]. S Charles &V P Arunachalam, Property analysis and mathematical modeling of machining properties of aluminium alloy hybrid (Al-alloy/SiC/fly ash) composites produced by liquid metallurgy and powder metallurgy techniques.IJEMS, VOL 11,dec2004.
[3]. K. John Joshua, S.J. Vijay, P. Ramkumar, KIM, Hong Gun, Investigation of Microstructure and Mechanical Properties of AA7068 Reinforced with MgO prepared using Powder Metallurgy, International Conference on Recent Advances in Aerospace Engineering (ICRAAE). 2017.
[4]. Prasanna Gubbi, Prof B.S. Motagi, A Study On Mechanical And Tribological Properties Of Aluminium 7068 Mmc's Reinforced With Silicon Carbide (Sic) And Tur Husk, (Ijtimes) Volume 4, Issue 7, July-2018.
[5]. Clyne T W 2001 Metal matrix composites: Matrices and processing. In Encyclopedia of materials science and technology (ed.) A Mortensen (Elsevier).
[6]. J. Lakshmipathy, S. Rajesh Kannan,b, K. Manisekar, S. Vinoth Kumar, Effect of Reinforcement and Tribological Behaviour of AA 7068 Hybrid Composites Manufactured through Powder Metallurgy Techniques, Applied Mechanics and Materials Submitted: 2016.
[7]. A.Praveen Kumar, M. Meignanamoorthy, M. Ravichandran, Influence Of Sintering Temperature And The Amount Of Reinforcement On The Microstructure And Properties Of Al–Tio2 Composites, Ijmet,Volume 9, Issue 9, Sep 2018.
[8]. Anil Kumar Bodukuria, K. Eswaraiahb, Katla Rajendara,V. Sampath, Fabrication of Al—SiC—B4C metal matrixcomposite by powder metallurgy techniqueand evaluating mechanical properties, Perspectives in Science, 2016.
[9]. M.A. Baghchesara, H. AbdizadeH and H.R. Baharvandi, Microstructure and Mechanical Properties of Aluminum Alloy Matrix Composite Reinforced with Nano MgO Particles, Asian Journal of Chemistry Vol. 22, No. 9, 2010.
[10]. E. Mohammad Sharifi, F. Karimzadeh, M.H. Enayati, Fabrication and evaluation of mechanical and tribological properties of boron carbide reinforced aluminum matrix nanocomposites, Materials and Design 32 2011.
[11]. Mohammad Umair Ansari, B S Motgi, Evaluation Of Mechanical Properties Of Al7075 Mmcs Reinforced With Nano Silicon Carbide (Sic), And Nano Aluminium Oxide (Al2o3), Ijsrd| Vol. 4, Issue 04, 2016.