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Investigation of Microstructure and Mechanical Properties of Hybrid Composite Aluminum 7075 Reinforced with Sugar Cane Husk Ash (SCHA) and Silicon Carbide (SiC) by Powder Metallurgy

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ABSTRACT

This paper deals with the fabrication of Al-7075 composites manufactured by powder metallurgy route reinforced with different weight percentages of Sugar Cane Husk Ash (SCHA) and Silicon Carbide (SiC) A low pressure of 400 MPa was applied for compacting the composites and sintered at a temperature of 720oC 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 Silicon Carbide (SiC) but seems to be crash by adding the weight percentage of Sugar Cane Husk Ash (SCHA). The compressive strength was found to be varying.

KEYWORDS: Al7075; Sugar Cane Husk Ash; SiC; Powder Metallurgy; Compacting; Sintering; Mechanical properties; Microstructure Analysis;.

INTRODUCTION

Today, there is a requirement for engineering materials which show better physical and mechanical properties in application fields. In order to achieve that high-performance level, we need materials having high strength and superior Mechanical properties, for that there is a need to fabricate composite materials.

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. The commonly used classification of composite is based on matrix that can be partitioned into three primary group-

1.Polymermatrix composites (PMCs)

2.Ceramic matrix composites (CMCs)

3.Metal Matrix Composites (MMCs).

The strength of the composites depends on many factors like size of the reinforcement, dispersion and also volume fraction, another important factor is interface bond strength between reinforcement and matrix material.

Now a days these materials are widely used in space shuttle, commercial airlines, electronic substrates, bicycles, automobiles, etc., Among the MMC's aluminium composites are predominant in use due to their low weight and high strength. In many industrial applications, the most important parameter in material selection is specific strength. Aluminum is a better example for this type of application because of its low density. Recently hybrid composites are more popular and cover more than one material property. The addition of the reinforcement enhances the mechanical properties of aluminium based composite, when compared to the matrix alloy. However, addition of any hard reinforcement to aluminium reduces the corrosion resistance, electrical conductivity and surface finish.

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. Al 7075 possesses very high tensile strength, higher toughness and are preferred in aerospace and automobile sectors.

2.LITERATURE SURVEY

1. Shikha Gupta, Dr. Ashutosh Gupta, BhanuPratap

Conducted experimental study on Pure Al, Al-SiC, Al-Bagasse-ash-SiC, with various compositions were successfully fabricated stir casting process. Wetting of reinforcements with the aluminium matrix was further improved by the addition of magnesium.

Based on the experimental observations the following conclusions have been drawn:

It has been seen that the different mechanical properties of metal matrix in a composite is greatly influenced with the addition of reinforcements.

In hardness test, presence of 3% wtSiC + 3% Sugarcane Bagasse ash harder particle increases the hardness of Al7075 to a greater value comparing to the metal matrx hybrid composite, keeping un equal total percentage weight of reinforcements.

In tensile testing, the value for the composite having Al7075 +3% Sic +3%SC BA comes to be the highest. This shows that the presence of Sic particles make the composite increases the brittleness in the samples causing uneven fractures.

Microstructure images show the excellent interfacial bonding and particles are well dispersed in hybrid matrix when added 3% SiC+6%SCBA.

From the above results we can conclude that instead of Al-SiC composites and the Al-SiC-SCBA ash composites could be considered as an exceptional material in sectors where lightweight and enhanced mechanical properties are essential.

2. G Manohar, K M Pandey, S R Maity

In this current research worked on, Powder Metallurgy (PM) route was selected to fabricate the AA7075/B4C Nano composite in which Nano B4C particles were made by ball milling operations.

To find the effect of addition of alloying elements to Al to reach AA7075 standard composition instead of direct AA7075 powder, two composites are prepared and named as composite-1 and composite-2 (alloyed composite).

Composite-2 shows better properties compared to composite-1 because of precipitated formed while sintering process due to reaction between alloy powders and reinforcements.

Hardness of composite-1 was superior this can be explained by the fact that formed intermetallic's can resist the deformations produced by indentations and also mode of failure while in compression test proves ductility nature of composite-2.

Finally, adding individual alloying elements to Al instead of direct AA7075 alloy powder as matrix phase makes composite ductile in nature.

3. Madhu M G, H K Shivanand, Maibusab, SumanaB G

Conducted by experimental study on the recently developed hybrid composites have been considered as candidate materials for applications in severe environments confronting modern technologies. Among various composites, MMCs are great practical interest. MMCs feature compositional variations from ceramic at one surface to metal at the other leads to the unique advantages of a smooth transition in thermal stress across the thickness and minimized stress concentration at the interface of dissimilar materials. As a result, such composites are rapidly finding applications in aggressive environments with steep temperature gradients such as turbine components and rockets nozzles.

The summary of the effect of particulates and fibres on the Mechanical properties of Aluminum 7075 hybrid composites like Ultimate Tensile Strength, Yield strength, Young 's modulus, ductility, Compression strength etc.

4. Prof. MadhuriDeshpande, Prof.Dr. Rahul Waikar, Mr. Ramesh Gondil, Dr. S.V.S Narayan Murty& Dr. T. S. Mahata

Has investigated that Pitch based carbon fiber reinforced Al matrix composites are successfully fabricated by the Powder Metallurgy (PM) route.

The fabricated composites show good bonding between the fibers and Aluminium alloy matrix with uniform distribution of carbon fibers in the matrix even with high volume fraction of reinforcement.

The application of electro less nickel coating on the fiber surface enhances the interfacial bonding which results in increased hardness of the composite.

Fabrication of Carbon fiber reinforced Aluminium matrix composites by PM route eliminates interfacial reaction and thus the formation of Al4C3 which is detrimental to mechanical and thermal properties of composite.

Double action hot pressing gives better densification and does not show density gradient in the composite.

Therefore PM route possesses a great potential to fabricate the short/milled carbon fiber reinforced Aluminium matrix composites.

Gaps found from literature & objective

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

- Very limited amount of work has been done which explains the factor effecting properties of Aluminium metal matrix composite by powder metallurgy.
- No amount of work has been done on combined effect of Silicon carbide (SiC) and Sugar Cane Husk Ash (SCHA) with Aluminium metal matrix by powder metallurgy.
- There is no detailed chemical composition available of Sugar Cane Husk Ash (SCHA).

3.EXPERIMENTAL DETAILS

3.1. Material Selection

3.1.1 Matrix Material

Aluminum alloy 7075 is an aluminum alloy, with zinc as the primary alloying element. It is strong with strength and has good fatigue strength and average machinability. Alloy7075 is heavily utilized by the aircraft and ordnance industries because of it superior strength. The composition and various properties of Al7075 are shown in table 1.

Table 1: Chemical composition of Al7075

Chemical composition	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
Al7075	0.4	0.5	1.6	0.3	2.5	0.15	5.5	0.2	Remaining

3.2. Reinforcement

3.2.1 Sugarcane Husk Ash (SCHA)

Sugarcane is grown worldwide as an agricultural crop, whose residue after extracting juice is regarded as bagasse. It is estimated more than 200 million tons of sugarcane bagasse obtained every year in India alone. Sugarcane is a renewable and natural agricultural resource. Sugarcane Husk Approximately composed of Cellulose 40%, Hemicellulose 24.5%, lignin 20%, wax 3.5%, ash 2.4%, silica 2%.

3.2.2 Silicon Carbide (Sic)

Silicon Carbide is the only chemical compound of carbon and silicon. It was originally produced by a high temperature electro-chemical reaction of sand and carbon. It is used in abrasives, refractoriness, ceramics, and numerous high-performance applications.

3.3 Composite Preparation

The composites of Al7075 reinforced with SCHA and SiC were produced according to the sample specification showed in Table 2.

Table 2: The sample specification

Sample No.	Composition
1.	Pure Al7068
2.	Al7075 + 0% SCHA + 4% SiC
3.	Al7075 + 0% SCHA + 6% SiC
4.	Al7075 + 4% SCHA + 0% SiC
5.	Al7075 + 4% SCHA + 4% SiC

6.	Al7075 + 4% SCHA + 6% SiC
7.	Al7075 + 6% SCHA + 0% SiC
8.	Al7075 + 6% SCHA + 4% SiC
9.	Al7075 + 6% SCHA + 6% SiC
10.	Al7075 + 8% SCHA + 0% SiC
11.	Al7075 + 8% SCHA + 4% SiC
12.	Al7075 + 8% SCHA + 6% SiC

3.4 Experimental Work

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

The particle size of Sugar Cane Husk Ash (SCHA) taken for this work is of 30 microns size, with the help of 30 microns sieve. The Al7075 hybrid composites with Sugar Cane Husk Ash (SCHA) and SiC as reinforcement were produced using powder metallurgy. Table 2 shows the AL7075 powders that were weighed accurately and mechanical alloying was done for 10 hours in a pot mill. 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 was made for compaction of metal powders. Cold compaction at a low pressure of 400 MPa was done using a digital hydraulic press machine 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 1: Pot mill

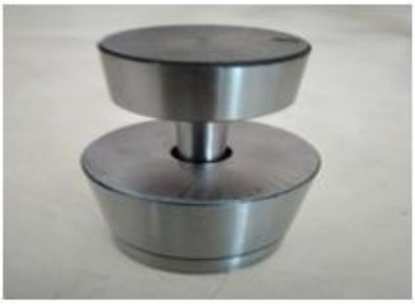
Fig 2: Punch and die


Figure 3: Aluminium 7075 40µ size powder


Figure 4: Silicon carbide 40µ size powder


Fig 5: Sugar Cane Husk Ash 30µ size powder

Fig 6: Digital hydraulic press

Fig 7: Green samples

Fig 8: Raising Hearth Furnace

Fig 9: Sintered samples

4.RESULT AND DISCUSSION

4.1 Density

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

Table 3: Density of samples

Sample No.	Green Density (grms/cc)	Sintered Density (grms/cc)
1.	2.31	2.52
2.	2.36	2.57
3.	2.38	2.58
4.	2.34	2.48
5.	2.31	2.51
6.	2.39	2.59
7.	2.37	2.56
8.	2.33	2.53
9.	2.38	2.58
10.	2.32	2.52
11.	2.29	2.49
12.	2.33	2.54

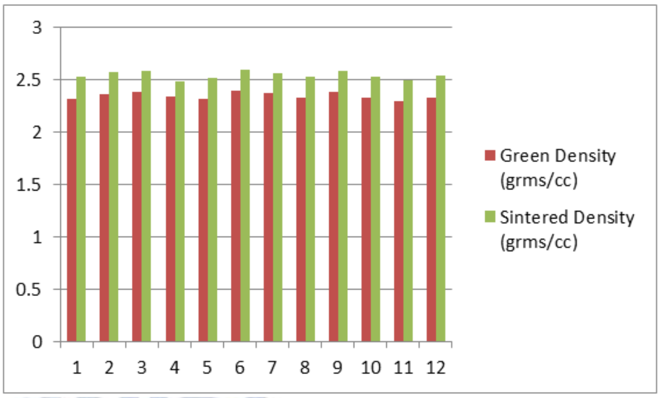

Fig 10: Graphical representation of Green and Sintered density in grms/cc.

The green density and sintered density of the samples showed varying values of densities with different percentage of reinforcement of SCHA 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 (figure 10) in grams per centimeter square.

4.2 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 sampleswas 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 4: Compression test results

Sample No.	Compressive Stress in kg/mm2	Compressive Stress in Mpa
1.	16.1	157.75
2.	15.3	145.26
3.	16.6	163.63
4.	16.2	160.84
5.	15.8	152.95
6.	15.4	151.12
7.	16.5	168.37
8.	14.7	133.74
9.	19.2	189.15
10.	17.4	169.28
11.	16.3	157.85
12.	17.1	161.17

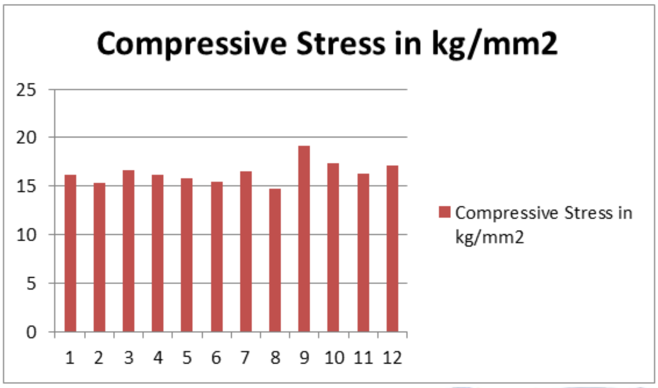

Fig 11: Representation of compression test results

From the above graph (figure 11) it is seen that the highest value of compressive strength was observed for the composition Al7075 + 6% SCHA + 6% SiCi.e 189.15 MPa.

4.3 Scanning Electron Microscopy (SEM)

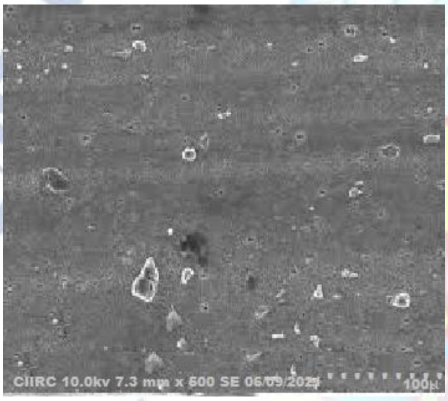

Fig 12: SEM image of Al7075

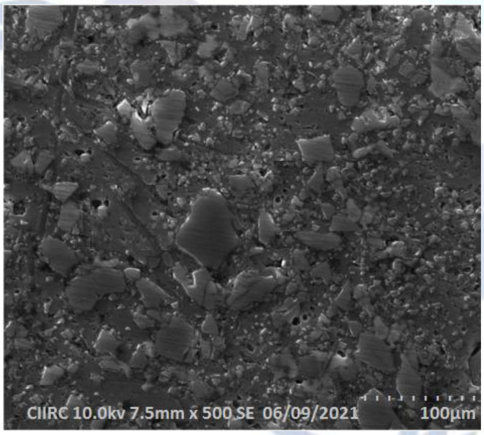

Fig 13: SEM of 90% Al7075 +0% SCHA +6% SiC sample

The above fig 13 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.

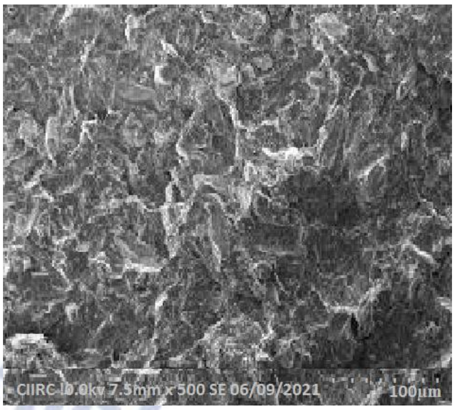

Fig 14: SEM of 90% Al7075 +4% SCHA + 6% SiC sample

Above fig 14 represents SEM image of sintered sample with SCHA 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.

4.4 Energy Dispersive X-Ray Study (Edx)

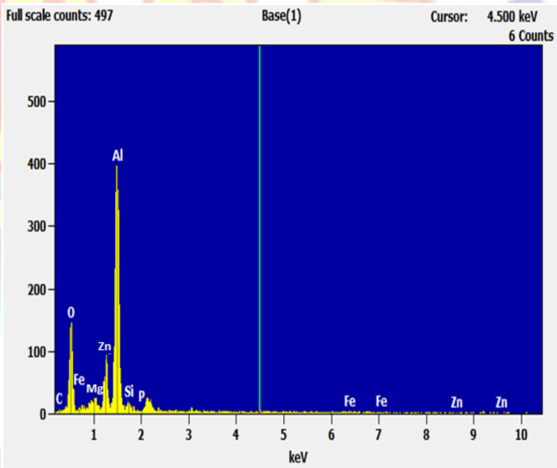

Fig 15: EDX of Al 7075 sample

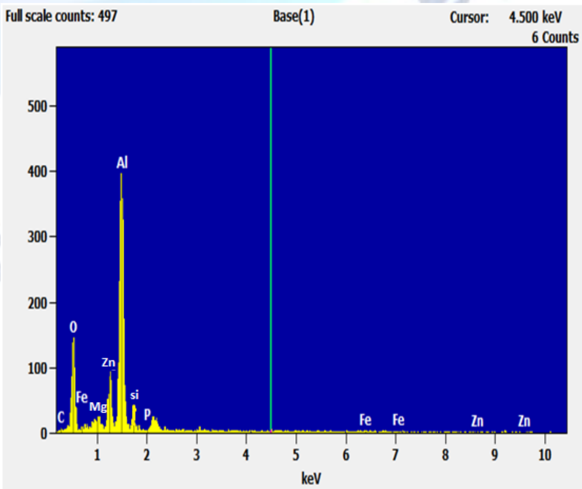

Fig 16: EDX of Al7075 +0% SCHA+6% SiC sample

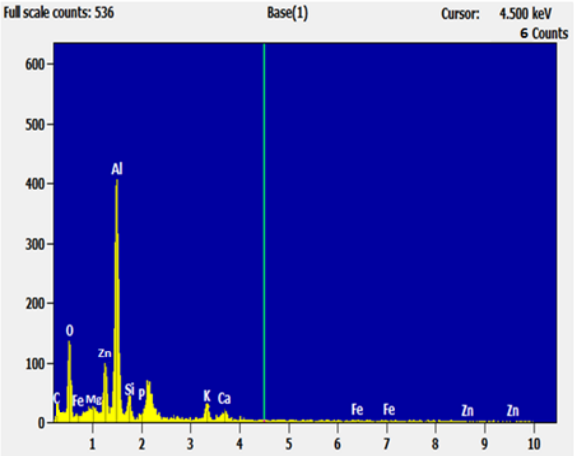

Fig 17: EDX of Al7075 +4% SCHA +6% SiC sample

From the fig 15 we can say that the sample of al-7075 with no reinforcement, its edx shows the compositional elements present by comparing it with the standard composition of the Al7075. Edxin fig 16 shows the presence of SiC and the aluminium matrix as we can say that through the peaks.

The fig 17 represents the presence of SCHA as well as SiC with the aluminium matrix by obtaining the peaks of Carbon, Oxygen and SiC through the peaks obtained in the graph.

4.5 Hardness Test

Hardness of the samples were tested on Brinell Hardness Tester.

Table 5: Hardness test results

Sample No.	Brinell Hardness (HB)
1.	93
2.	95
3.	98
4.	96
5.	97
6.	99
7.	88
8.	87
9.	90
10.	83
11.	82
12.	78

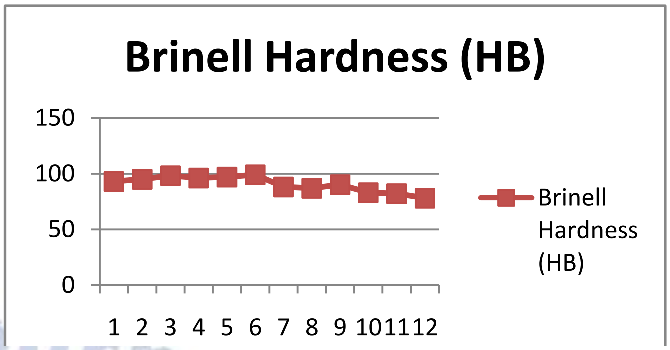

Fig 18: Representation of Hardness test results

From the results, it is observed that the hardness of the samples decreases as percentage of Sugar Cane 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 Al7075 reinforced with 4% SCHA 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 SCHA enhanced the compressive strength.
- The hardness test shows that the hardness increases as percentage of SiC increases but it decreases with increasing percentage of Sugar Cane Husk Ash (SCHA).

SCOPE OF 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, TiCetc can be used to fabricate the different hybrid composites and analyze their effects on mechanical properties of the MMC's.

REFERENCES

[1] Shikha Gupta, Dr. Ashutosh Gupta, BhanuPratap "Experimental Investigation of Mechanical properties of Bagasse Ash and SiC reinforced Al 7075 alloy matrix hybrid composites manufactured by stir casting method" International Journal of Scientific & Engineering Research Volume 8, Issue 12, December-2017, ISSN 2229-5518.

[2] G Manohar, K M Pandey, S R Maity "Aluminium (AA7075) Metal Matrix Composite Reinforced with B4C Nano Particles and Effect of Individual Alloying Elements in Al Fabricated by Powder Metallurgy Techniques". 1451 (2020) 012024, doi:10.1088/1742-6596/1451/1/012024.

[3] Madhu M G, H K Shivanand, Maibusab, Sumana B G "Evaluation of Mechanical Properties of Graphite Powder and Bagasse Ash Reinforced Al 7075 Hybrid Metal Matrix Composites" International Journal of Research and Scientific Innovation (IJRSI), Volume VI, Issue V, May 2019 | ISSN 2321–2705,

[4] Prof. MadhuriDeshpande, Prof.Dr. Rahul Waikar, Mr. Ramesh Gondil, Dr. S.V.S Narayan Murty& Dr. T. S. Mahata "Processing of Carbon fiber reinforced Aluminium (7075) metal matrix composite".

[5] R. Karthigeyan, G. Ranganath, S. Sankaranarayanan ―Mechanical Properties and Microstructure Studies of Aluminium (7075) Alloy Matrix Composite Reinforced with Short Basalt Fibre‖ European Journal of Scientific Research, ISSN 1450-216X Vol.68 No.4 (2012), pp. 606- 615.

[6] P. Pradeep, P. S. Samuel Ratna Kumar, Daniel Lawrence I, Jayabal S ―Characterization of par particulate reinforced Aluminium 7075 / TiB2 Composites‖ International Journal of Civil Engineering and Technology (IJCIET), Volume 8, Issue 9, September 2017, pp. 178–190.

[7] Arunkumar D T , RaghavendraRao P S, Mohammed ShadabHussain , Naga SaiBalaji P R ―Wear Behaviour and Microstructure Analysis of Al-7075 alloy reinforced with Mica and Kaolinite‖ IOP Conf. Series: Materials Science and Engineering 376 (2018) 012067

[8] Rajesh Kumar Bhushan, Sudhir Kumar and S. Das, ―Fabrication and characterization of 7075 Al alloy reinforced with SiC particles‖, International Journal of Advanced Manufacturing Technology, No. 65, pp. 611- 624, 2013

[9] Jamaluddin Hindi, AchutaKini U, S.S Sharma ―Mechanical Characterisation of Stir Cast Aluminium 7075 Matrix Reinforced ith Grey Cast Iron & Fly Ash‖ International Journal of Mechanical And Production Engineering, ISSN: 2320-2092. Volume- 4, Issue-6, Jun.- 2016.

[10] Mohan Kumar S, Pramod R, Shashi Kumar M E, Govindaraju H K ―Evaluation of Fracture Toughness and Mechanical Properties of Aluminum Alloy 7075, T6 with Nickel Coating‖ Science Direct, Procedia Engineering 97 (2014) 178 – 185.