IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 4, No. 1
February 2015

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 4, No. 1, February 2015

Research Paper

MATERIAL CHARACTERIZATION OF ALUMINIUM HYBRID COMPOSITE FOR CLUTCH PLATE

M P Navin[1]* and R Deivasigamani[1]

Corresponding Author: **M P Navin ✉ navinvin05@gmail.com*

Hybrid Metal Matrix Composites (MMCs) possess significantly improved properties including high specific strength, higher specific modulus, larger damping capacity, better wear resistance and tribological behaviour when compared to unreinforced alloys. Aluminium matrix composites with SiC and ash reinforcement exhibit excellent wear resistance and thermal resistance property. Coconut Shell Ash (CSA) is one of the most inexpensive and low density reinforcement available in large quantities as solid waste obtained from the combustion of coconut shell. Hence, composites with SiC and coconut shell ash as reinforcement are likely to result in cost reduction and improvement of tribological properties for wide spread applications in automotive and small engine applications. The present investigation has focused on the improvement of wear resistance of clutch plate by CSA and SiC mixed in the weight ratios 1:3, 1:1 and 3:1 were utilized to prepare 10 wt% of reinforcing phase with Al360.0 where the investigation of wear analysis using pin on disc machine, hardness test on Vickers hardness machine and material characterization on SEM for the different percentage of compositions were done.

Keywords: Aluminium alloy based composite, Coconut Shell Ash, Silicon Carbide, Stir Casting, Hardness and Wear

INTRODUCTION

A clutch is a mechanical device for quickly and easily connecting or disconnecting a pair of rotating coaxial shafts. It is usually placed between the driving motor and the input shaft to a machine where permitting the engine to be started in an unloaded state. Single plate, dry clutch is one among the popular type of clutches in use. A clutch is a mechanism designed to disconnect and reconnect driving and driven members and enables one rotary drive shaft to be coupled to the another shaft, either when the shaft are stationary or when there is relative motion between them. The need for the clutch mainly seems from the characteristics of the turning effort developed by the engine by its lower speed range. When in idling condition, the engine develops an insufficient torque for the transmission to be positively engaged. In order to obtain a smooth engagement, the clutch must be progressively engaged to take up the drive until

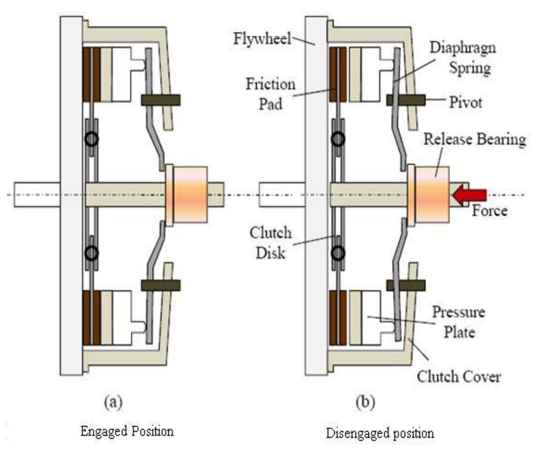
[1] Dept. of Mechanical Engg., Kongu Engineering College, Erode.

the torque transmitted from the engine equals that required to propel the vehicle and also the clutch disconnects the engine from the transmission to change the gear. The clutch, takes up the drive smoothly and also disengages the drive whenever necessary.

Automotive Clutch System

Automotive clutches are located between the engine and the transmission which provides mechanical coupling between the engine and transmission input shaft. Manual transmission cars need a clutch to enable engaging and disengaging the transmission. The clutch engages the transmission gradually by allowing a certain amount of slippage between the flywheel and the transmission input shaft. Clutch basically consists of six major parts: flywheel, clutch disc, pressure plate, diaphragm spring, clutch cover and the linkage necessary to operate the clutch as shown in Figure 1.

Figure 1: Single Plate Diaphragm Clutch System



Aluminium Hybrid Composite

The development of Aluminium based composites using agro based wastes as sole or complementary reinforcement to the more conventional reinforcing materials such as alumina and silicon carbide is attracting much attention from researchers (Prasad, 2011; Zuhailawati, 2007). Aluminium based Metal Matrix Composites (MMCs) are highly acclaimed for the attractive property combinations which they possess, making them more popular and top choice candidate material for a wide range of engineering applications (Senthilevan, 2012). The properties of Aluminium Matrix Composites (AMCs) which have been explored for varied technical uses are: high specific strength and stiffness, good wear resistance, low thermal coefficient of expansion, high temperature mechanical properties among others (Hao, 2013; Kaveendran, 2013). Aluminium based matrices are also noted to be the cheapest among other common metallic matrix materials (copper, titanium, magnesium) for Metal Matrix Composites (MMCs) production (Rohatgi, 2007). They can also be processed easily using similar techniques adopted for the production of metals and alloys (Tahamtan, 2013). Currently, AMCs are being reinforced using waste products derived from industrial processes (red mud, fly ash) and agro based materials (rice husk ash, bamboo leaf ash, coconut shell ash, ground nut shell ash, bagasse, among others) [(Naresh, 2006; Alaneme, 2013). All the enumerated advantages have made AMCs become very popular and among top choice materials for a wide range of engineering applications by virtue of its excellent combination of material properties, easy processing, reduced cost and accommodation of waste materials as a reinforcement resource materials.

The development of reliable material property database for AMCs newly developed with the use of agro wastes as hybrid reinforcing materials (to either alumina or silicon carbide) is highly crucial. This is of vital importance in the area of materials selection to determine the most suitable areas and limits of application of these AMCs reinforced with agro based wastes. To this end, there has been effort to generate material properties data for a number of AMCs developed with the use of agro waste based reinforcements (Madakson, 2012; Suresha, 2012; Prasad, 2012; Apasi, 2012). From the results generated, a fairly consistent trend in mechanical behaviour has been observed for the different agro wastes used as hybrid reinforcements in AMCs (Madakson, 2012; Suresha, 2012; Prasad, 2012; Apasi, 2012; Dora, 2014). But in the case of wear and hardness properties, the results have not been as consistent as the observations recorded for mechanical properties (Apasi, 2012).

Wear behavior of AMCs in particular has been acknowledged to be difficult to comprehensively predict as shown by the wide variation and not too infrequent contradicting results reported by researchers for different AMC systems (Madakson, 2012; Dolata, 2012; Alaneme, 2011). A measured forecast of the wear behaviour of AMCs in different environments is very helpful as part of assessments required in establishing its performance and suitability in a number of service environments. This is of major importance in AMCs developed with the use of agro wastes as hybrid reinforcements, since little wear data are currently available to understand its mechanisms of wear. Wear assessments are also very crucial where AMCs developed with the use of hybrid reinforcements are to be considered as replacement for the conventional AMCs (reinforced with Silicon carbide or alumina solely) for tribological applications (Rohatgi, 2010).

There is currently no work available which has studied the wear behavior and hardness of Al 360 alloy matrix composites reinforced with coconut shell ash and silicon carbide. The output from this paper will be helpful in understanding the wear behavior and hardness of these peculiar AMCs. It would also serves as resource information in building a database of material.

MATERIALS AND METHODS

Materials

Al 360 was selected as aluminium alloy matrix for the investigation. The alloy were obtained inthe form of billets and its chemical composition were determined using spark spectrometric analysis (Table 1). Silicon carbide (SiC) and coconut shell ash (RHA) were selected for use as hybrid reinforcement for the composite to be developed. For this purpose, a high purity silicon carbide with an average particle size of 28 μm was procured. The coconut shell ash (with a mesh size under 50 μm and chemical composition as presented in Table 2 and was prepared from complete burning of the coconut shell, thermal processing, and sieving following procedures in accordance

Table 1: Elemental Composition of Al 360 Alloy

Element	Si	Fe	Cu		Mn	Mg	Cr	Zn	Ti
wt%	9.0-10.0	1.2201	0.600		0.3109	0.5001	0.0302	0.0202	0.0125
Element	**Ni**	**Sn**	**Pb**	**Ca**	**Cd**	**Li**	**Na**	**V**	**Al**
wt%	0.5101	0.0021	0.0011	0.0015	0.0003	0.0000	0.0009	0.0027	98.88

with Alaneme (Madakson, 2012). Magnesium was selected as a wetting agent to improve wettability between the Al 360 alloy and the reinforcements.

Method

Preparation of Coconut Shell Ash

A simple metallic drum with perforations to allow for air circulation to aid combustion was used as burner for the preparation of the CSA. The coconut shell was grinded to form coconut shell powder shown in Figure 2. Dry coconut shell powder was placed inside the drum while charcoal which served as the fire source was used to ignite the shell powder. The shell powder was left to burn completely and the ashes removed 24 h later. The ash was conditioned by heat-treating the ash at a temperature of 650°C for 180 min to reduce the carbonaceous and volatile constituents of the ash. The chemical composition of the CSA is presented in Table 2.

Figure 2: Photograph of (a) Coconut shell powder and (b) coconut shell ash

Composites Production

The Al 360 alloy matrix composites reinforced with CSA and SiC were produced using double stir casting process (Alaneme, 2012). The quantitative amounts of Coconut Shell Ash (CSA) and silicon carbide (SiC) required to produce 10 wt% reinforcement consisting of CSA and SiC in weight ratios 1:3(A1), 1:1(B1) and 3:1(C1) respectively, were determined initially. In order to eliminate the dampness in the reinforcements and improve wettability with the molten Al 360 alloy, the coconut shell ash and silicon carbide particles were preheated in an oven at a temperature of 250°C. A gas fired crucible (fitted with a temperature probe) was used to melt the Al 360 alloy billets completely by firing to a temperature of 750 ± 30°C (above the liquidus temperature of the alloy). The molten liquid alloy was allowed to cool to a semi solid state at a temperature of about 600°C before charging in the preheated coconut shell ash and SiC particles (along with 0.1 wt% magnesium). Manual stirring of the slurry was performed at a temperature (600°C) for 5–10 min. The composite slurry was superheated at 800 ± 50°C and a second stirring performed using a

Table 2: Chemical Composition of the Coconut Shell Ash

Compound/element (constituent)	Weight Percent
Silica (SiO_2)	45.05
Alumina (Al, Oƒ)	15.6
Calcium oxide CaO	0.57
Magnesium oxide, MgO	16.20
Potassium oxide, K_2O	0.39
Haematite, Fe_2O_3	12.40
Others	0.93

mechanical stirrer. The stirring speed of 400 rpm was performed for 10 min before casting into prepared sand moulds inserted with metallic chills.

Wear Test

The wear behavior of composites produced was tested using a pin-on-disc machine, according to ASTM: G 99 where test samples of size 30 mm of length, 10 mm of breadth and width. Sliding wear test was carried out at a constant velocity (5 ms^{-1}) and at a constant sliding distance (1.2 km) at various normal applied loads of 30, 60 and 90 N.

Hardness Test

The Vickers hardness test method (ASTM: E-384) consists of indenting the test material with a diamond indenter, in the form of right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 kgf. The full load is applied for 10 to 15 s. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated. The area of sloping surface of the indentation is calculated. Hence the Vickers hardness is the quotient obtained by dividing the kgf load by the square mm area of indentation.

$$HV = \frac{2F \sin \frac{136^\circ}{2}}{d^2}$$

$$HV = 1.854 \frac{F}{d^2} \text{ approximately}$$

where,

F = Load in kgf

D = Arithmetic mean of the two diagonals, d1 and d2 in mm

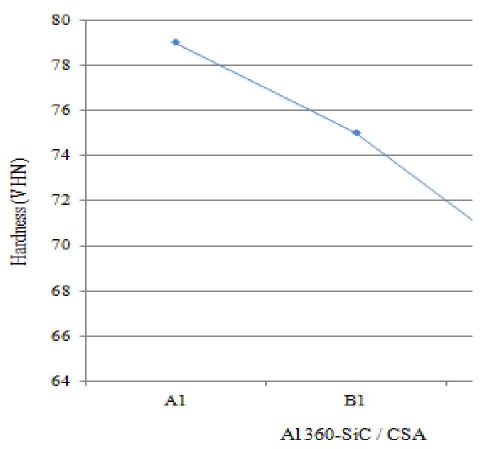
HV= Vickers hardness

RESULTS AND DISCUSSION

Mechanical Behavior

The hardness values of the composites are presented in Figure 3. It is observed that the hardness of composite decreases slightly with increase in the weight percent of CSA in the hybrid composites. 4.58%, 8.14% and 10.94% reduction in hardness was observed for the hybrid composites having respectively 3:1, 1:3 and 1:1 wt% of SiC and CSA reinforced with Al 360 matrix. The composition of CSA which consists mainly of SiO which is noted to have a lower hardness level in comparison with SiC. Hence the slight decrease in the hardness of the hybrid composites is to be expected.

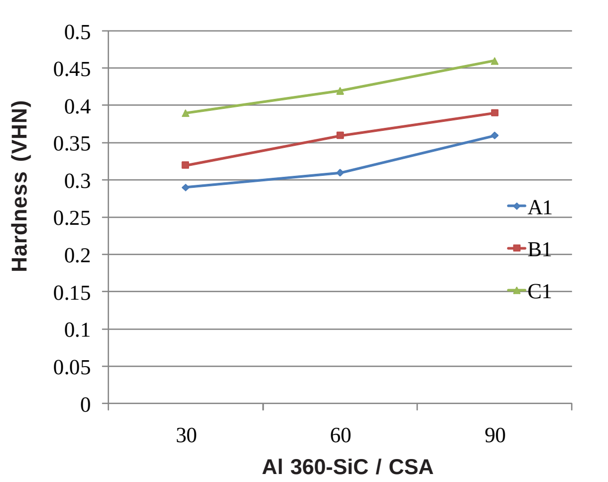
Figure 3: Variation of hardness for the hybrid reinforced Al360-SiC/CSA



Wear Behavior

The variations of coefficient of friction with time for the composites produced are presented in Figure 4. For the composite grades containing 10 wt% CSA–SiC reinforcement, it is observed that the hybrid composite A1 (which has CSA and SiC weight ratio of 1:3) had the least coefficient of friction in comparison with the other composites in this series. The other hybrid composite compositions B1 and C1 (which have CSA and SiC weight ratios of 1:1 and 3:1, respectively) had more coefficient of friction comparable to that of the hybrid composite A1. Coefficient of friction for each hybrid composite series slightly increases by increasing the load of 30, 60 and 90 N respectively. Hence the coefficient of friction increases when the load gets increases. This is a clear indication that the addition of low cost agro waste product, CSA, as complementary reinforcement to SiC in Al 360 alloy based hybrid composites does degrade the wear resistance characteristics of the composites.

Figure 4: Variation of coefficient of friction for the hybrid reinforced Al360-SiC/CSA



CONCLUSION

The fabrication characteristics and mechanical behavior of Al 360 alloy matrix composites containing 3:1, 1:1 and 1:3 wt% CSA and SiC as reinforcement was investigated. The results show that:

- Hybrid metal matrix composites with upto 10 % coconut shell ash and SiC particles could be easily fabricated using stir casting process.
- The hardness of hybrid composites decreases slightly with increase in CSA content.
- The coefficient of friction and the wear resistance of hybrid composites were increases with increase in SiC content.
- The coefficient of friction decreases when the applied load increases.

REFERENCES

1. Alaneme K K (2011), "Corrosion behaviour of heat-treated Al-6063/SiCp composites immersed in 5 wt% NaCl solution", *Leonardo J Sci.,* Vol. 18, pp. 55–64.

2.Alaneme K K, Akintunde I B, Olubambi P A and Adewale T M (2013), "Fabrication characteristics and mechanical behaviour of rice husk ash–alumina reinforced Al–Mg–Si alloy matrix hybrid composites", *J Mater Res Technol., Vol.* 2, pp. 60–7.

3.Alaneme K K and Adewale T M (2013), "Influence of rice husk ash/silicon carbide weight ratios on the mechanical behaviour of aluminium matrix hybrid composites", *Tribol Ind.,* Vol. 35, pp. 163–72.

4. Alaneme K K and Aluko A O (2012), "Production and age hardening behaviour of borax pre-mixed SiC reinforced Al–Mg–Si alloy composites developed by double stir casting technique", *West Indian J Eng.,* Vol. 34, pp. 80–5.

5. Apasi P B, Madakson D S, Yawas V S Aigbodion (2012), "Wear Behaviour of Al-Si-Fe \ Alloy/Coconut Shell Ash Particulate Composites", *Tribology in Industry,* Vol. 34, pp. 36-43.

6. Dolata A J, Dyzia M and Walke W (2012), "Influence of particles types and shape on the corrosion resistance of aluminium hybrid

composites", *Solid State Phenom.,* Vol. 191, pp. 81–7.

7. Dora Siva Prasad, Chintada Shoba and Nallu Ramanaiah (2014), "Investigations on mechanical properties of aluminium hybrid composites"; *J. Mater. Res. Technol.,* Vol. 3, No. 1, pp. 79–85.

8. Hao S and Xie J (2013), "Tensile properties and strengthening mechanisms of SiCp-reinforced aluminum matrix composites as a function of relative particle size ratio", J *Mater Res.,* Vol. 28, pp. 2047–55.

9. Kaveendran B, Wang G S, Huang L J, Geng L and Peng H X (2013), "In situ (Al_3Zr + Al_2O_3np)/2024Al metal matrix composite with novel reinforcement distributions fabricated by reaction hot pressing", *J Alloys Compd.,* Vol. 581, pp. 16–22.

10. Madakson P B, Yawas D S and Apasi A (2012), "Characterization of Coconut Shell Ash for Potential Utilization in Metal Matrix Composites for Automotive Applications", *Int J Eng Sci Technol (IJEST),* Vol. 4, pp. 1190–8.

11. Naresh P (2006), "Development and characterization of metal matrix composite using red Mud an industrial waste for wear resistant applications", India: Department of Mechanical Engineering, National Institute of Technology Rourkela, pp. 23–34 (Ph.D. Thesis).

12. Prasad S D and Krishna R A (2011), "Production and mechanical properties of A356.2/RHA composites", *Int J Adv Sci Technol.,* Vol. 33, pp. 51–8.

13. Prasad S D and Krishna R A (2012), "Tribological properties of A356.2/RHA composites", *J Mater Sci Technol.,* Vol. 28, pp. 367–72.

14. Zuhailawati H, Samayamutthirian P, Mohd Haizu C H (2007), "Fabrication of low cost aluminium matrix composite reinforced with silica sand", *J Phys Sci*., Vol. 18, pp. 47–55.

15. Senthilvelan T, Gopalakannan S, Vishnuvarthan S and Keerthivaran K (2012), "Fabrication and characterization of SiC, Al_2O_3 and B_4C reinforced Al–Zn–Mg–Cu alloy (AA 7075) metal matrix composites: A study", *Adv Mater Res*., pp. 622–623:1295–9.

16. Suresha S and Sridhara B K (2012), "Friction characteristics of aluminium silicon carbide graphite hybrid composites", *Materials and Design,* Vol. 34, pp. 576–583.

17. Rohatgi P and Schultz B (2007), "Light weight metal matrix composites – stretching the boundaries of metals", *Mater Matters,* Vol. 2, pp. 16–9.

18. Rohatgi P K, Schultz B F, Daoud A and Zhang W W (2010), "Tribological performance of A206 aluminum alloy containing silica sand particles", *Tribol Ind* ., Vol. 43, pp. 455–66.

19. Tahamtan S, Halvaee A, Emamy M and Zabihi M S (2013), "Fabrication of Al/A_2O_6-Al_2O_3 nano/micro composite by combining ball milling and stir casting technology", *Mater Des.,* Vol. 49, pp. 347–59.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991