MICROSTRUCTURAL STUDIES AND CHARACTERIZATION OF ZINC ALUMINIUM ALLOY REINFORCED WITH ALUMINA AND COCONUT SHELL ASH

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Abstract

The zeal to produce materials of high quality and low weight has made metal matrix composite (MMC) very popular among other composites .Composite materials obtained by adding particles to the metals matrix have made a remarkable progress in its development and application in aerospace and automotive industries. Zinc and aluminum matrix is one of the major metal matrixes composites in the area of revolution .In this study, the microstructural and mechanical properties of zinc aluminum alumina reinforced with coconut shell ash were examined. Coconut shell ash is an agro waste generated after the removal of coconut for the production of oil. Coconut shell was burnt on a steel plate outside in an open air for three hours and ash obtained was conditioned in the furnace at temperature of 110ºC for 180mins.Six samples were prepared with different composition ,alumina, and coconut shell ash were used as reinforced phase with zinc aluminum alloy at 0,2,3,4,5and 6 wt % coconut shell ash. The agro wastes and alumina were preheated before being introduced into the zinc aluminum composite in a molten state .The mechanical properties such as tensile strength, hardness, wear and torsion were used to characterize the composite produced .The result shows a decrease in hardness, tensile, but wear loss reduces as reinforcement increases and also the shear strength increases as the volume of reinforcement increases.

Keywords: Automotive, Coconut shell ash, Composite, Reinforcement, Torsion.

1.0 INTRODUCTION

Researches all over the world today are focusing on ways of utilizing, either industrial or agricultural wastes as a source of raw materials for the industry. These wastes utilization would not only be economical, but may also result to foreign exchange earnings and environmental pollution control.[1]

However as the cost of fuel oil, natural gas and electricity supply has increased and become erratic, coconut shell has come to be regarded as source of fuel rather than refuse. Presently, the Nigeria coconut shell is used as a source of fuel for the boilers, and residual coconut shell is disposed as gravel for plantation roads maintenance. Black smiths also buy the coconut shell as fuel material in their casting and forging operations.[2]

Metal matrix composite (MMCs) is a composite material with at least two constituent parts, one being a metal and the other being a different material entirely such as ceramic or organic compound. When at least three materials are present it is referred to as an hybrid composite.

Metal matrix composites (MMCs) possess significantly improved properties including high specific strength specific modulus, damping capacity and good wear resistance compared to unreinforced alloys.[3]

Zinc-Aluminum alloys are very good materials with desirable qualities, however a lighter materials is required in engineering applications, construction, automobiles, aerospace, high load and low speed applications. This study presents an environmental friendly technology of reinforcing Zn–Al alloys with other materials. This research will add to the existing body of knowledge on Zn-Al composite alloy matrix, produce a high performance materials which is of light-weight and a relatively low cost, making use of organic materialin varying proportions. The use of the Agro waste material will also help address and mitigate the adverse effect of environmental pollution considering coconut shell ash as an organic constituent.

Zinc–Aluminum alloys has competed effectively against copper, aluminum, manganese and other iron based foundry alloys. [4] reveals that they are also used for bearing materials, low weight, excellent foundry castability, good fluidity, good machinability, improved hardness and tensile strength with good wear resistance . Hence, it seems probable that metal matrix composites will replace conventional materials in many commercial and industrial applications in the near future. [5]

2.0 LITERATURE REVIEW

Fibres and particles are used for reinforcement to increase strength, friction, wear, thermal expansion and weight.[6] The abrasive wear resistance of the particle reinforced MMCs increase with the volume fraction of the particles, under both high and low abrasive wear conditions. The addition of Graphite particles to Zn-Al alloy improves its wear behaviour.[5]

Zinc based alloys with high amount of aluminium comprises a family of die casting alloys that have proven themselves in a wide variety of demanding applications.[7]

Zinc aluminium alloys by the virtue of their excellent wear resistance have found significant industrial usage. The members of ZA alloys are ZA-8, ZA-12 and ZA-27 alloys. These alloys have completely and effectively competed with copper, aluminum and other foundry based alloy [8].Zinc base alloy is good for die casting and good demand on applications.[7]

The addition of Graphite particles to ZA alloys has however been noted to improve its wear resistance. Zinc- Aluminum alloys have excellent corrosion resistance in a variety of environments [9]. Fabrication of discontinuous Zn-Al based MMCs can be achieved by standard metal processing technologies such as powder metallurgy, direct casting, rolling, forging, and extrusion and the products can be shaped, machined and drilled using conventional facilities [5].

.The low cost of obtaining this agro waste product, advantages it possess as to waste management, its excellent properties and it readily available nature has made it a promising approach as alternatives in MMCs reinforcement. Literature has also reported that reinforce MMCs with agro waste materials has help to improve the thermal resistance of such materials. Agro-waste ashes are characterized with densities far lower than that of SiC (3.18 g/cm3) and Al_2O_3 (3.9 g/cm^3) (Prasad and Krishna 2011)[10].The strength levels achieved using these ashes as reinforcement in aluminium matrices is marginal even for high volume percent's of the reinforcement. This is due largely to the presence of SiO_2 which is the predominant constituent of agro-waste ashes (Prasad *et al*., 2012).[11]

The use of particulate reinforcements such as silicon carbide (SiC) which is not produced in most developing countries has a disadvantage of extra cost and high weight of product.

The mechanical and physical behaviour of metal matrix composites (MMCs) indicates variation of dislocations in composites in a distinctive state, either a liquid- solid and solid-liquid-states. (Ibrahim *et al*, 1991)[12]. A lot of work has been done to study the microstructural behaviours of the proposed composite material based on interface energy estimation process. It was discovered that porosity in the cast composites damages the mechanical properties and appropriate mould design was found efficient in controlling the damages (Kumar *et al*., 2006).[13]

A major breakthrough in waste recycling is that which involves the conversion of waste into green material for use. A lot of researches have been conducted pertaining to the use of this green material for reinforcement in composites. Cost effective alternative materials produced from solid waste by an environmental friendly and energy efficient technology will exhibit good market potentials to fulfil people's needs in rural urban areas .[14]

However at elevated temperatures (100^0C) properties of zinc aluminium alloys are unsatisfactory and restrict their use in some applications. They also highlighted that to improve the elevated temperature properties ZA alloys will be reinforced with silicon carbide fibres or particles, Alumina particles and glass fibres.

Zinc based alloys are best in terms of impact and tensile strength, they are good for production of miniature parts.

Reinforcement with Al_20_3 increase the hardness and wear resistance of composite increase weight percent of Al_20_3, increase hardness wears resistance in the properties of the Composite. Zinc–Aluminium alloys have competed effectively against copper, aluminium, manganese and other iron based foundry alloys. Zinc –Aluminium composite has been used as bearing materials due to low weight, excellent foundry castability, good fluidity, good machinability, improved hardness and tensile strength with good wear resistance.[15] Hence, it seems probable that metal matrix composites will replace conventional materials in many commercial and industrial applications in the near future.[6]

3.0 METHODOLOGY

Pure zinc ingot and aluminum 6011 alloy were used in the production of zinc-aluminum (ZA-27) alloy matrix. Chemically pure aluminate particles (Al_2O_3) having average particle size (5micron) and agro waste material which is the coconut shell ash (CSA) derived from controlled burning and sieving to a grain of size 250µm.

Cylindrical patterns were selected for torsion, microstructural and hardness specimen. After selection of pattern, the mould was then prepared. Two steps stir casting process was used in production of the composite material, this was adopted to allow homogeneity and even distribution of particle .[16]

The Al_2O_3 particles were pre- heated to a temperature of about 250^0C for 30min, this was done in order to improve wettability and harmonize the temperature in conformity with [17] .The aluminum was fired into the furnace and heated to a temperature around 670^0C till it melts completely. Zinc was then charged into the furnace and allowed to melt completely. After melting the melt was taken out of the furnace and stirred. The melt was returned to the furnace and heated for 7 minutes, the pre-heated Al_2O_3 particles were charge into the furnace followed by the coconut shell ash (CSA) particle and was heated for 5minutes. A gas fired crucible furnace was used for the operation. The whole process lasted for 3hours. The slurry was then casted into the moulds. This sequence was repeated for the rest of the samples.

Table 1: Composition.

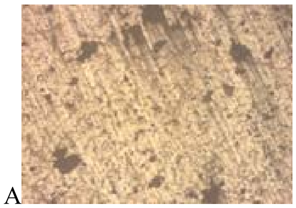
SAMPLE	ZINC %	ALUMINIUM %	Al_2O_3 %	CSA %
A	68	27	5	0
B	66	27	5	2
C	65	27	5	3
D	64	27	5	4
E	63	27	5	5
F	62	27	5	6

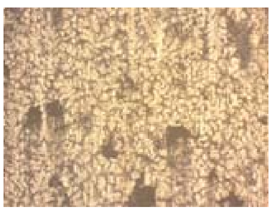
Table 2: Charge Calculation

SAMPLE	ZINC(g)	ALUMINIUM(g)	Al_2O_3(g)	CSA(g)
A	1,227.33	487.32	90.25	0
B	1170.31	478.76	88.66	35.46
C	1142.25	474.47	87.866	37.72
D	1114.528	1114	87.0725	69.65
E	1087.118	465.90	86.279	86.28
F	1060	461.2	85.48	102.58

4.0 RESULT AND DISCUSSION

Figure 1shows the hardness test results. The BHN value decreases from sample A –F. Sample A has the highest valueand reduction on sample B by 2.40%.The decrease in the hardness value occur as aresult of increase in wt% of CSA.

SAMPLE A


SAMPLE B


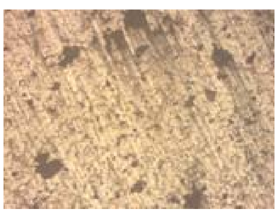
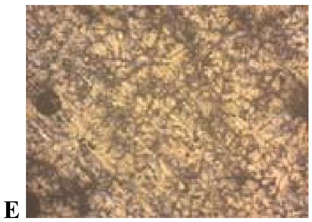
SAMPLE C


Figure.1

Sample A has the high tensile value but shows a decline of 12.45% decrease in sample B as a result of addition of 2wt% of SCA.The reduction in hardness was less in Sample C,D and E as percentage of reduction is less **5%.**Sample E gives a lower hardness as a result of high value of CSA 6%wt of CSA.

SampleD


Sample E


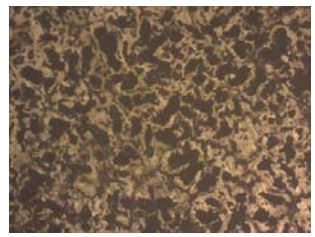
Sample F


Figure 2

In figure.2 Sample D with 4wt % CSA shows rapid decline in hardness because of 4wt% CSA presence in the matrix composite which is not uniformly dispersed give rise to sharp reduction in shear stress value but fairly increase in wear resistance. Sample E shows reduction in hardness due to heavy presence of CSA (5%wt) but high wear resistance value showing heavy presence of CSA well dispersed in the matrix of the composite.Sample F micrograph shows high presence of CSA (6wt%) well dispersed in the matrix of the composite which give rise to high wear resistance but increase in shear strength .

4.1 Hardness

The harness reduces drastically from A-EF because of the volume fraction of CSA of 6% .In contrary to Ajibola etal 2015 in which icrease involume fraction of CSA increase the harnesss value of the composite.

Table 3.: Hardness value of A-F composite samples.

SAMPLES	A	B	C	D	E	F
VALUE	54.8	48.0	45.9	44.2	43.0	29.8

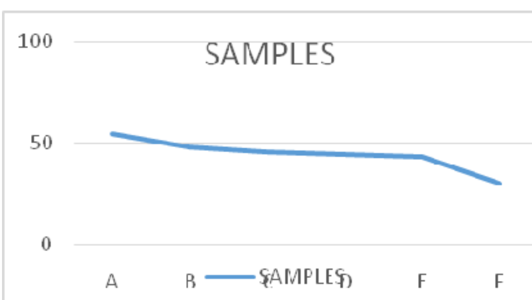


Fig 3. GRAPH OF HARDNESS VALUES

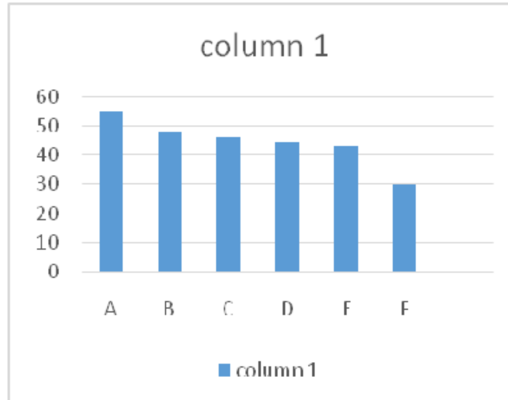


Fig. 4 BAR CHAT HARDNESS VALUES

4.2 TENSILE STRENGHT

Table 4: Tensile values of A-F composite samples.

SAMPLES	A	B	C	D	E	F
VALUE	186.1 9	163	156	150	146.2	101.2

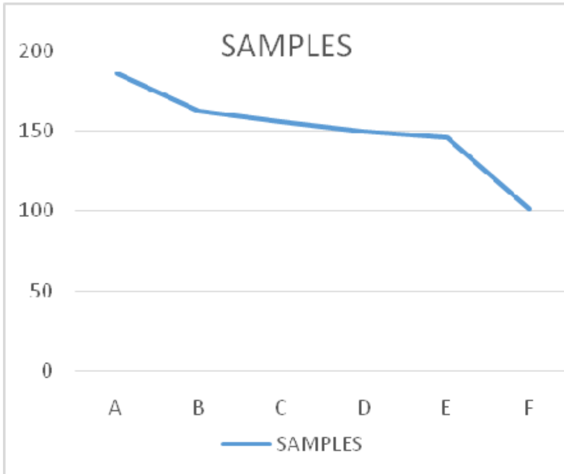


Fig 5. GRA**PH OF TENSILE VALUES**

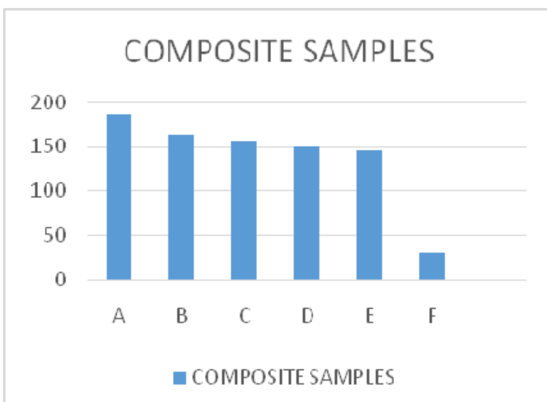


Fig. 6.BAR CHAT TENSILE VALUES

W
E
A
R
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4.3 WEAR TEST

Figure 7 below describes the wear test values of the composite material. The result followed an undulating form This may be due to the minimum quantity (wt%) of reinforcing particle needed to improve property. In line with Madakson *et al.*, (2012)[18]and Pruthvuraj 2011 it was observed that wear rate increased with an increase in weight percentage of coconut shell ash.

WEAR LOSS(g)

Table 5: Wear values of A-F composite samples.

SAMPLES	A	B	C	D	E	F
VALUES	0.83	0.82	0.81	0.80	0.68	0.66

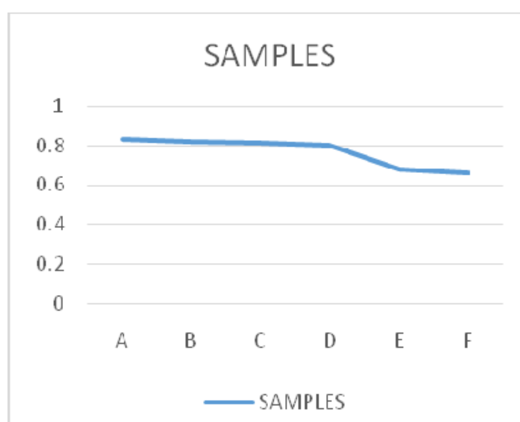
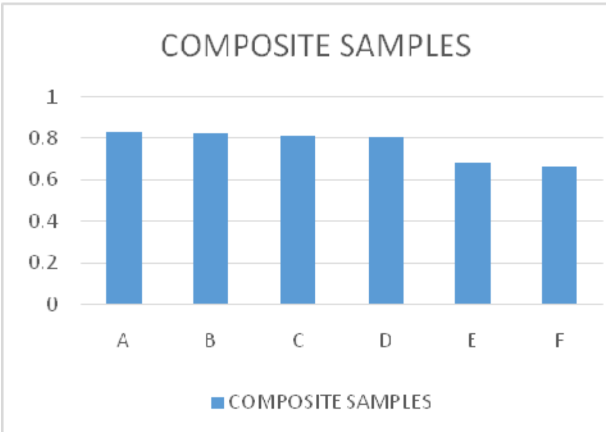


Fig 7 GRAPH OF WEAR VALUES

S H E A R S T R E S S



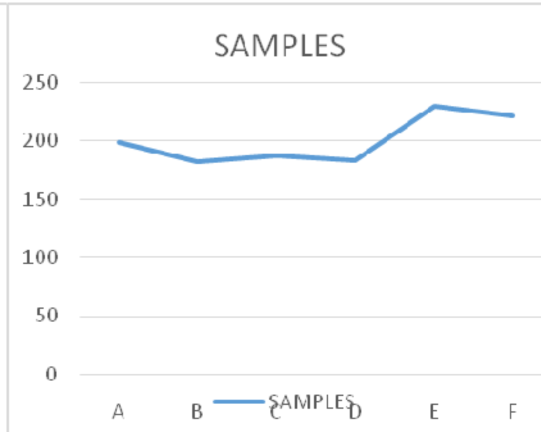


Fig 8 BAR CHART WEAR VALUES

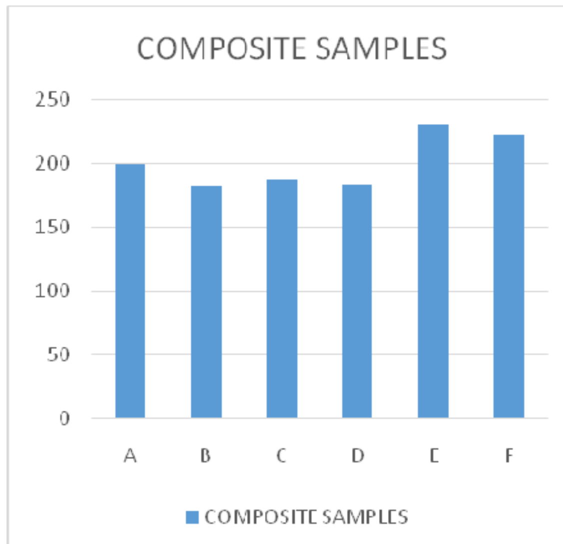


Fig 10. BAR CHART OF SHEAR STRESS

4.4 TORSION TEST

Table 6. Shear Stress Values

SAMPLES	A	B	C	D	E	F
VALUES (MNm^{-2})	199.0	182.3	187.2	183.1	230.1	222.0

Fig. 9. GRAPH OF SHEAR STRESS VALUES

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The mechanical properties of Zinc Aluminium alloy metal matrix composite reinforced with alumina and coconut shell ash containing :0,:2,3, 4,5,6 wt % CSA as reinforcement were investigated. The hardness,tensile, torsion and wear resistance tested. CSA particle has little effect on the hardness of the composite material and also have a significant effect on the maximum shear stress.

5.2 Recommendations

Extra charge should be added during the charge calculation to compensate for excesses in the sprue, ingate and runners.

Other agro- waste such as palm kernel ash (PKSA) groundnut ash and maize husk,sugar cane bagasse ash should be used as reinforcement to improve the properties of the alloy.

Due to excellent surface finish, this composite is recommended for use in automobiles; alloy wheel, vehicle door handles and some other parts of the vehicle part that in not in contact with extreme heat. It can also be used in food industry for food packaging, electronics, aerospace industries, construction, wood work and metal work to complement the final product.

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Author's Biography.

Ajibola Wahab .A. attended Egbado South Local Government Primary School for his Primary Education and later to Egbado College Ilaro . He furthers his Education by obtaining National Diploma in Mechanical Engineering and Higher National Diploma in Mechanical Engineering at Federal Polytechnic Ilaro. He later went to Prestigious University of Lagos where he obtained his First Degree in Metallurgical and Materials Engineering. He also obtain his Master Degree in Metallurgical and Materials Engineering in the same University. Ajibola Wahab is presently a Lecturer at the Federal Polytechnic Ilaro .He is married with two children. He is currently at university of Lagos for his Doctorate degree in Metallurgical and Materials Engineering.

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