March, 2014. Vol. 4, No. 10 ISSN2305-8269
International Journal of Engineering and Applied Sciences

www.eaas-journal.org

ASSESSMENT OF HARDNESS AND TENSILE PROPERTIES OF STIR-CAST ALUMINIUM MATRIX REINFORCED WITH TETRACARPIDIUM CONOPHORUM KERNEL

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ABSTRACT

African walnut kernel (Tetracarpidium Conophorum kernel) was dried in an oven at a temperature of 80^{o}C then milled in a ball mill to obtained -150 micron size powder. Aluminium 6063 alloy was melted and cast as the control sample. Walnut powder was added to other castings in the following percentages by composition: 3 %, 5 %, and 7 %. It was stirred thoroughly in the furnace before casting into a sand mould prepared with a circular rod of 15 mm diameter. Brinel hardness machine was used to take the hardness measurement of the as-cast aluminium composite. Electronic tensile testing machine was used to take the tensile properties. It was observed that the hardness of the reinforced matrix increased relative to the control sample, also the tensile properties was improved having progressively higher ultimate tensile strength

Keywords: Walnut, hardness, casting, tensile, composites, slurry.

INTRODUCTION

Composite materials are materials consisting of two or more different materials that are mutually insoluble in bonding or mixing to obtain performance characteristic beyond those that could be achieved by the constituents individually (Robert et al., 2007). Composites materials can be classified based on the matrix component. There are three broad types of composites which are Metal matrix composites (MMC), Polymer matrix composites (PMC) and Ceramic matrix composites (CMC) (Callister, 2000).Metal matrix composites offer great improvements over polymer matrix composites with respect to several properties, which include tolerance of high temperature, strength, hardness and wear resistance, while significantly outperforming ceramic matrix composites in terms of toughness and ductility (Froyen and Verlinden, 1994).

Metal matrix composites (MMC's) combine into a single material- a metallic base with a reinforcing constituent which is usually non metallic. They are produced by means of processes other than convectional metal alloying such as powder metallurgy, diffusion bonding, liquid phase sintering, squeeze infiltration and liquid metallurgy (Hizombor et al., 2010; Dobrzanski et al., 2007). Metal matrix composites development helps to alter or change the physical properties of the metallic materials and also produced materials with tailored combination of properties such as: high thermal conductivity, high tensile strength, wear resistances, specific stiffness and light weight and so on (Kumar et al., 2010)

Metal Matrix Composites could be reinforced with continuous fibers, discontinuous particles or whiskers. However, particle reinforced MMC's posses some distinct advantages over fiber reinforced composites in terms of low cost and isotropic mechanical property (Ahmad et al., 2003) Particle reinforced MMC's are compatible with most metal working processes such as machining, deformation and welding especially when the volume fraction is less than 30 % (Adiamak, 2006).

African walnut is botanically called Tetracarpidium Conophorum or Plukenetia Conophora. It belongs to the family of Euphorbiaceae. In Nigeria it is called Asala or Awusa in Yoruba, Ukpa in Ibo and Okhue or Okwe in Edo. African walnut composition is Linolenic acid 64 %, palmitic acid and stearic acid 15

%, Oleic acid 11 % and linoleic acid 10 %. (Guardian, 2008) It is edible and could be used in food preparations. The kernel pod used for this reinforcement is free from fatty acids. The kernel is hard and very strong. The aim of this work is to produce aluminium composites having an improved strength in terms of hardness and tensile which will be able to meet challenges in the area of application of aluminium alloys and composites in structural works. We look forward to a time where aluminium and non ferrous at large will be able to compete favourably with steel for structural application.

METHODOLOGY

Preparation of Tetracarpidium Conophorum Kernel

The kernel was collected into an oven and dried at a temperature of 80^o C for 2 hours. The dried kernel was put in a ball mill with balls as a grinding media and milled. After grinding it was poured into a set of sieves and vibrated for sieving exercise. -150 microns size of the grinded kernel was collected for the reinforcement.

Casting of the Reinforced composite

A rod of diameter 15 mm was used as a pattern for mould preparation using green sand. The mould was prepared and allowed the surface of the mould to be air dried naturally for 24 hours. Aluminium 6063 ingot was melted in a lift out crucible furnace using cooking gas as fuel. Aluminium (6063) ingot was charged into the furnace and heated to a temperature of 670^{o}C and the walnut kernel was added, the slurry was mixed manually for about 5 minutes. The composites slurry was then heated to a temperature of 700^o C and stirred using mechanical stirrer at a speed of 250 rpm for 10 minutes. This is to help in having higher recovery of the kernel in the melt. Slag was removed from the surface of the composites slurry. It was cast into the already prepared mould at a temperature of 700^{o}C and allowed to solidify to room temperature in the mould. These castings were made with the composition of the prepared walnut kernel of -150 microns to be varied as 3 %, 5 % and 7% by weight composition of the casting. Previously before the addition of walnut kernel for reinforcement, the aluminium (6063) ingot was melted and cast into mould at a temperature of 690^o C for control experimentation. The castings were knocked out of mould after it has cooled to room temperature and fettled.

Hardness and Tensile Measurement

A sample not less than 20 mm height was cut out of the as-cast reinforced aliuminium composite for hardness test. The surfaces were prepared by grinding on emery paper of 400 grits. The samples were placed one after the other on the brinnel hardness testing machine, the results were obtained as measured by the machine.

The tensile test was carried out on each sample using PC2000 model electronic tensiometer. Tensile specimen was earlier machined on lathe machine to conform to the size which the tensiometer machine can accommodate. The samples have gauge length of 40 mm and diameter of 5 mm. Analyses of the tensile results were generated and obtained from the machine in the process of pulling the samples.

Table 1: Composition of aluminium 6063 alloy used

Si	Fe	Cu	Mn	Mg	Zn	Cr	Ti	Al
0.46	0.22	0.02	0.03	0.52	0.02	0.03	0.02	Bal.

RESULTS

Table 2: Hardness Result of the as-cast Reinforced Aluminium

Sample	Reading 1	Reading 2	Reading 3	Average Hardness
A(Control)	84.3	86.5	85.10	85.3
B (with 3 % kernel)	102.2	104.4	103.2	103.27
C (with 5 % kernel)	78.4	92.7	103.5	91.53
D (with 7 % kernel)	109	117.6	114.3	113.6

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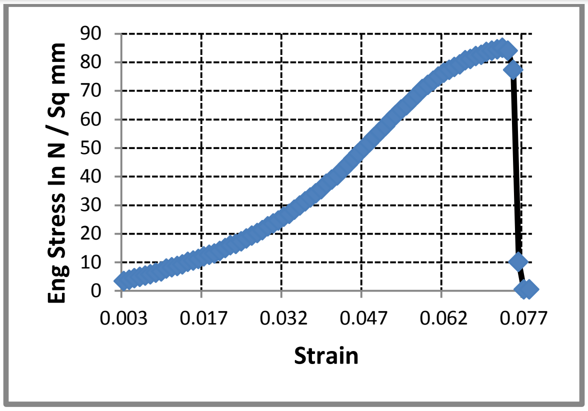

Fig.1: Stress- Strain Curve for Sample A. (Control Sample)

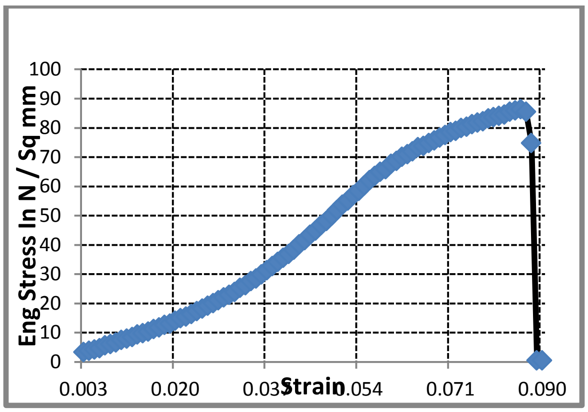

Fig 2: Stress- Strain Curve for Sample B (with 3 % walnut kernel)

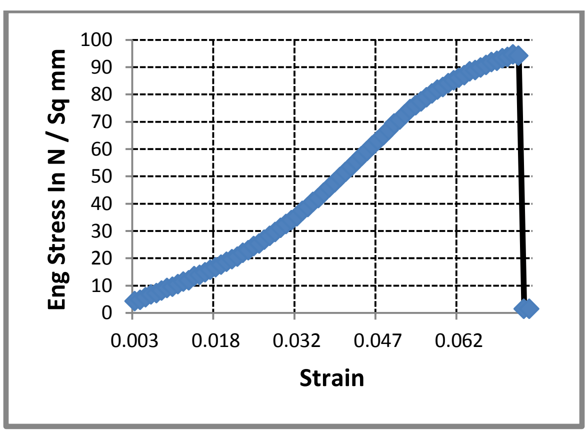

Fig.3: Stress-Strain Curve for sample C (with 5 % walnut kernel)

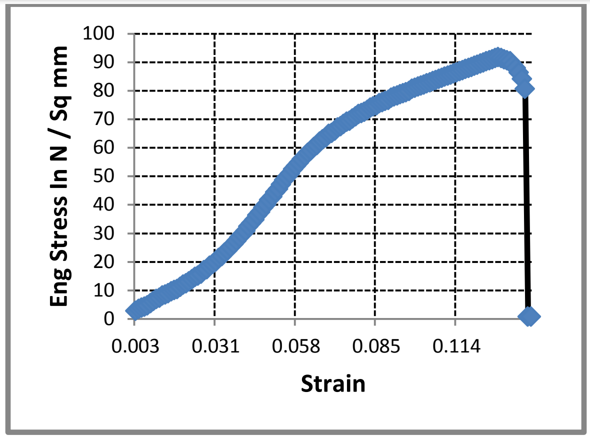

Fig.4: Stress- Strain Curve for Sample D (with 7 % walnut kernel)

Table 3: Some Analysis of the Tensile Result

Sample	Eng.UTS (Nmm^{-2})	Peak load (N)	Break load (N)	Work done (Nmm)
A (control)	84.9	1735.8	1578.9	655.3
B (with 3% kernel)	86.4	1814.3	1569.1	763.4
C (with 5% kernel)	94.6	1941.8	1932.0	852.8
D (with 7% kernel)	91.8	2334.1	2049.7	1413.5

DISCUSSION

Tensile Analysis

Considering the control sample (sample A), it has an ultimate tensile strength (U.T.S.) of 84.9 N mm^{-2}, peak load of 1735.8 N and work done of 655.3 Nmm. This was used as a reference sample to others (Samples B, C, and D).

From the test sample B (with 3% walnut kernel) has UTS of 86.4 Nmm^{-2} and peak load of 1814.3 N. This shows that tensile property has been increased in comparison to sample A. Sample C (with 5% walnut kernel) and sample D (with 7 % walnut kernel) have UTS of 94.6 Nmm^{-2} and 91.8 Nmm^{-2} respectively. These have also show significant increase in tensile properties as compared to control sample. From these results it can therefore be said that the inclusion of walnut kernel has improved the tensile properties of the reinforced aluminium matrix. The reinforced aluminium It will therefore be useful in structrural work.

Hardness

The hardness result values obtained from the tests indicated that the hardness of the reinforced aluminium increased compared to the control sample (sample A). This increased hardness values has further enhanced the increased in tensile properties (increased UTS, peak and break load).

Conclusion and Recommendation

From the tests and analysis carried out it was confirmed that the inclusion of walnut kernel as a reinforcement to the aluminium matrix has improved both the hardness and tensile properties of the aluminium matrix. Therefore it will be suitable for structural use. It will be able to withstand the conditions that is obtainable in structural use, such as stress and impact that is applicable in structural environment. It is therefore recommended for use in critical areas of domestic building such as in railing, stair cases and so on.

REFERENCES

1. 1.Adiamak M. (2006): "Selected Properties of Aluminium Based Composites Reinforced with Intermetallic Particles" Journal of Achievement in Materials and Manufacturing Technology. Volume 14, Issue 1-2Pp 44 – 46.
2. 2.Ahmad, K.R., J.B. Shansul, L.B. Hussain and Z.A Ahmad (2003) " The Effect of Reinforcement Particle size on the Microstructure and Hardness of Al/Al_2O_3 Composite via Powder Metallurgy Route" 12th Conference and 13th Annual General Meeting of Electron Microscopy Society of Malaysia Langkawi.
3. 3.Callister W.D (2000); Fundamental of Material Sciences and Engineering, 5th edition, John Wiley and sons inc. U.S.A. Pp 62-170.
4. 4.Debrzanski L.A Kremzer M. Nagel A.(2007) : Aluminium EN Al-SiC Alloy Maztrix Composite Reinforced by Al_2O_3 Perform" Archives of Materials Science and Engineering. Volume 28 Issue 10 Pp 594-596.
5. 5.Froyen L. and Verlinden B. (1994); Aluminium Matrix Composites, European Aluminium Association, TALAT Pp 1-15.
6. 6.Guardian Newspaper 2008; Walnut as panacea for stress, infections, infertility-Health-Nairaland http://guardianmewsngr.com/natural-health/article 01
7. 7.Hizombor M, Mirbagher S.M.H. and Abdideh (2010): "Casting of A356/ TiB_2P Composite Based on the TiB_2P/ CMC/ PPS MORTAR" Volume 18, Roznov pod Radhostem, Czech Republic, EU.
8. 8.Kumar G.B.V., Rao C.S.P., Selvary N.,Bhagyashekar M.S (2010) "Studies on Al7075-Al_2O_3 Metal Matrix Composites" Journal of Minerals and Materials Characterization and Engineering, Volume 9, No. 1, Pp 44-46.
9. 9.Robert B. Mason, Michael A. Miller, Lawrence A.G. and Mark Singleton (2007); Corrosion Testing and Assessment of Metal Matrix Composites Components for Military Assets, TRI service corrosion conference. Pp 1-5