



## Evaluation of Mechanical and Metallurgical Properties Al- Si-Mg /Mangiferaindica Seed Shell Ash (MSSA) Particulate Composite for Production of Motorcycle Hub

<sup>1</sup>Ochuokpa E. O. <sup>2</sup>Yawas, D. S., <sup>3</sup>Okorie, P. U., <sup>2</sup>Sumaila, M.

<sup>1</sup>Dept. of Metallurgical & Materials Engineering,  
Ahmadu Bello University Zaria

<sup>2</sup>Dept of Mechanical Engineering, Ahmadu Bello University Zaria

<sup>3</sup>Department of Electrical Engineering,  
Faculty of Engineering, Ahmadu Bello University, Zaria.

### ABSTRACT

This paper presents the hardness and impact strength as well as the metallographic analysis of Al- Si-Mg /Mango Seed Shell Ash (MSSA) Particulate Composite. The Properties of Aluminum Al- Si-Mg Alloy for the Production of the Motorcycle hub have been assessed. The Aluminum 6061 / Mango Seed Shell Ash (Al-MSSA) composite was developed through the stir casting method. The mango shell ash was characterized using X-ray fluorescent (XRF). Specimens for hardness, impact strength and microstructure as per the ASTM standards were produced. The hardness, impact, microstructure properties of the composite were evaluated. The results revealed that an increase in the percentage of MSSA progressively increases the hardness of the material from 31.9 HV at 0% wt of MSSA to a maximum hardness of 43.2 HV at 15%wt of MSSA. This represents a 26.16% improvement. However, an increase in the percentage of MSSA progressively decreases the impact value of the material from 2.25J at 0%wt of MSSA to 1.36J at 10% wt. Thereafter, it started increasing to reach an optimum value of 2.440 joules at 15%wt addition of MSSA. Microstructural analysis of the composite studied revealed a fairly uniform distribution of the mango seed shell ash particles in the Aluminium matrix indicating that there was good interfacial bonding between the matrix and the reinforcement. The presence of Si and Mg enhances wettability and formation of  $Mg_2Si$  and eutectic Si  $\alpha$ -Al matrix with MSSA particles. These results confirm that 15wt% MSSA has significantly improved the hardness of the alloy by 26.16%. It is therefore recommended for engineering material especially where hardness is a deciding factor.

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### INTRODUCTION

In the recent past, materials development has shifted from monolithic to composite materials for adjusting to the global need for reduced weight, low cost, quality, and high performance in structural materials. In composites, materials are combined in such a way as to enable one to

make better use of their parent material while minimizing to some extent the effects of their deficiencies (Aku *et al*, 2012). Most composites consist of a bulk material (Matrix) and a reinforcement of some kind added primarily to increase the strength and stiffness of the matrix (Chidebere *et al*, 2016). They typically result in lighter,



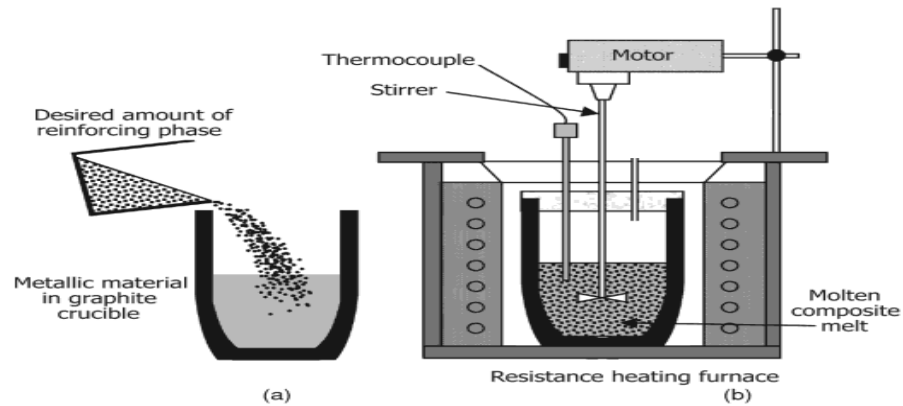
stronger, more durable solutions compared to traditional materials. Many researchers have been making attempts in the automotive industry to replace steel and cast iron materials with lighter-weight metal alloys materials such as Aluminium alloys. However, Aluminium exhibits poor resistance to wear when in relative motion with metallic surfaces. Consequently, researchers have proposed solutions to address the problem which includes the development of Aluminium matrix composites. Utilization of abundant agricultural waste products such as Mellon shell, eggshell, sugarcane, bagasse, rice husk, coconut shell, bamboo leaf, ground nutshell and other organic waste for Aluminium alloy particulate composite reinforcement have successfully carried out. (Aigbodion and Hassan 2010) This is in line with the global demand for the development of advanced engineering materials for various engineering applications in modern times. The annual production of mango worldwide is estimated at  $38.66 \times 10^9$  Kg. It is widely distributed in many parts of Nigeria. Nigeria is ranked 10th with a production estimate of  $7.90 \times 10^9$  kg among the world's producers (FAOSAT, 2010). According to Sears, (2014), Aluminium motorcycle hubs are mostly products of Al-Si-Mg alloys because of their unique casting properties, good resistance to corrosion, easy to cast into thin or thick sections, excellent machinability, and good strength to weight ratio, The use of Aluminium matrix composite hub is expected to reduce the mechanical failure of the Motorcycle hub. Aluminium alloy has many desirable properties such as high fluidity, lightweight, low melting temperature high thermal conductivity and good surface finish. These properties make the alloys widely used in casting especially in the automotive industry and remain the basis of current manufacturing equipment and manufactured goods. This paper aimed at developing an Al-Alloy/Mango seed shell Ash (MSSA) composite to improve the properties of aluminium alloy and also

addressing environmental issues created by mango seeds. The study will evaluate the mechanical properties

The desire to develop a composite material using Mango Seed Shell Ash (MSSA) to reinforce the conventional motorcycle hub was prompted by the fact that motorcycles usually referred to as Okada has now become a popular mode of transportation in Nigeria especially in semi-urban and rural areas. They are imported at a very high foreign currency exchange rate, the hubs are in direct contact with the brakes and rotating sprockets leading to frequent failure as a result of bad roads. Some microstructural features limit mechanical properties of cast Al-Si- Mg alloys such as ductility, toughness and fatigue resistance such as Porosity, coarse acicular Si particles and coarse primary aluminium dendrites. Miller, et al (2000). The presence of Mg and Fe in the alloy allows the formation of eutectic  $\alpha + \text{Mg}_2\text{Si}$  and platelets of  $\text{Fe}_2\text{Si}_2\text{Al}_9$  in addition to the Si platelets. These plate-shaped phases provide easy crack nucleation sites and propagation paths, resulting in relatively low strengths and ductility. The properties of coarse acicular Si particles and coarse primary aluminium dendrites are bound to affect the hardness properties of Al-Si-Mg alloy in the production of motorcycle hub. They are therefore in high demand for replacement hence the need for composite reinforcement to reduce the mechanical failure of the Motorcycle hub. Similarly, after consumption of mango fruits, large quantities of mango seeds are discarded as waste in Nigeria constituting serious environmental hazards to the general public.

#### LITERATURE REVIEW

**Stir casting.** Manufacturing of aluminium alloy based casting composite by stir casting is one of the most economical methods of processing MMC. (Adebisi, *et al*, 2011). Stir casting is suitable for manufacturing composites with up to 30% volume fractions of reinforcement (Pradeep *et al*, 2011).



**Figure 1:** A schematic diagram showing (a) incorporation of the reinforcing phase into matrix metallic material (b) the stir casting setup (Gupta and Sharon, 2011).

**Process Parameters in the stir casting process;**

The process parameters in stir casting play a major role in the determination of the quality and characteristic properties of the cast product of the composite. Some of the major challenges include the uniform distribution of reinforcement particles, wettability between the matrix alloy and the

reinforcement particles, gas entrapment/porosity.

**Effects of processing temperature in the stir casting process.**

The Processing temperature greatly influences the change in viscosity of the aluminium composite slurry during stir casting. The change in viscosity is calculated theoretically by using the Arrhenius equation below (Miani & Matteazzi 1992);

$$\eta = \eta_0 \exp\left(\frac{E}{RT}\right) \quad (1)$$

Where  $\eta_0$  is the viscosity of aluminium at the melting temperature, E is the activation energy for the viscous flow of aluminium, R is the universal gas constant of the processing temperature T. To

calculate the viscosity of the melt aluminium matrix and the particle reinforcement, Einstein function is used as stated below (Wang, *et al*, 2003);

$$\frac{\eta}{\eta_0} = 1 + 2.5C + 10.5C^2 + \exp(ab) \quad (2)$$

Where a = 0.0023, b = 16.6, c is the volume fraction of the particles.

The Processing temperature determines the viscosity of the composite slurry which in turn influences the particle distribution in the matrix alloy depending on the volume fraction of the particles. Sozhamannan *et al* (2012) observed that Al-SiC<sub>p</sub> Composite apparent viscosity is nearly 38% higher than the Al matrix alloy. However, the viscosity of both decreases when the processing temperature is increased from 700 to 900°C. Further

studies revealed that at higher viscosity with temperature below 800°C the geometric contacts of particles are restricted by a vortex of the molten metal. Thus the particles are not distributed uniformly within this region. It is concluded from the study that viscosities of liquid decreases with increasing processing temperatures.

On the other hand, Dhanalakshmi *et al* (2005) reported that at 850°C melt



temperature particles settling is obvious when processing the aluminium matrix composites. Several models have been proposed to describe the settling phenomenon of reinforced particle

$$V_s = d^2(p_s - p) / 18\mu v \quad (3)$$

Where d is the particle diameter,  $p_s$  is the density of the particle, p is the density of the liquid, v is the velocity of the melt and g the acceleration due to gravity.

Generally for composites with higher volume fractions particles interact

$$V_p = V_s(1 - C)^{4.65} \quad (4)$$

Where C is the true concentration of particles.

*Effects of Stirring Speed; Stirring time & Reinforcement volume fraction*

Stirring Speed mostly determines the homogenous distribution of the particulate of the composite slurry. It is concluded that stirring speed has a significant effect on particle distribution. The influence of stirring time determines

movements. Stokes developed an expression for settling velocity ( $V_s$ ) of particles moving relative to a continuous fluid in the equation below Kolsgaard & Brusethaug (1993).

with each other, thereby reducing the settling velocity. Richardson and Zaki (1954) described the settling particle ( $V_p$ ) with a size greater than 100um using the hindered Stokes velocity in the following equation;

the period for uniformly and homogenous distribution of the particulate of the composite slurry.

**RELATED LITERATURE**

Several works have been carried out on the development of Aluminium matrix composites (AMCs) in Nigeria as shown in Table 1.

**Table 1:** Review of related past works.

Authors/year	Title	Findings	Area of application
Aku, et al. (2012)	An XRF analysis on Periwinkle shell ash	The student confirmed that SiO <sub>2</sub> , CaO, MgO, Cr <sub>2</sub> O <sub>3</sub> . and Fe <sub>2</sub> O <sub>3</sub> were found to be major constituents of Periwinkle ash. The presence of hard elements like SiO <sub>2</sub> , CaO, MgO, Cr <sub>2</sub> O <sub>3</sub> . and Fe <sub>2</sub> O <sub>3</sub> suggested that Periwinkle shell ash particles can be used as reinforcement material.	Composite
Chidiebere, et al (2016)	Motorcycle Hub Materials and Analysis Under Critical Load Environments.	The findings showed that the aluminium alloy hub has a good weight to strength ratio when compared to cast iron which helps to reduce the inertia (the work done to move or stop the motorcycle hub). The study concluded that, regardless of the material cost and manufacturing cost of both hubs, the aluminium alloy hubs are better alternatives to the cast iron hubs.	Automotive industry
Madakson et al (2012),	characterized coconut ash as a constituent of	Characterized coconut ash as a constituent of metal matrix composite for potential application	

Corresponding author: Ochuokpa, E. O. [ochuokpaotor@gmail.com](mailto:ochuokpaotor@gmail.com) Department of Metallurgical & Materials Engineering, Ahmadu Bello University, Zaria. © 2021, Faculty of Tech. Edu, ATBU Bauchi. All rights reserved



Authors/year	Title	Findings	Area of application
	metal matrix composite	in the automobile sector. Microscopic (particle size, SEM, and XRF) and spectroscopic analysis (XRD, and FTIR) were carried out for the characterization of the coconut shell ash.	
Oladele and Omotoyinbo (2010)	Aluminium-alloy with magnesium and silicon as an alloying element	Magnesium and silicon as alloying element improve the mechanical properties of Aluminium-alloy due to the formation of Mg <sub>2</sub> Si intermetallic compound which improves the casting, corrosion resistance properties as well as strength of the alloy. However, The presence of <b>Mg and Fe</b> in the alloy allows the formation of eutectic $\alpha + \text{Mg}_2\text{Si}$ and <b>platelets of Fe<sub>2</sub>Si<sub>2</sub>Al<sub>9</sub></b> in addition to the <b>Si</b> platelets. These plate-shaped phases provide easy crack nucleation sites and propagation paths, resulting in relatively low strengths and ductility.	Aluminium-alloy
Aigbodion et al (2010)	The possibility of using kankara clay as reinforcement for Al-Si-alloy.	the result shows that kankara clay can serve as a potential reinforcement for aluminium alloy up to a maximum of 20wt% of this clay body in the alloy	
Kittiphoom, S (2012)	The Utilization of Mango seed	The author concluded that Mango seed kernels have a low content of protein but they contain most of the essential amino acids, with the highest values of leucine, valine and lysine.	Medical
Ofedile. et al (2005)	Assessment and development of indigenous Technology in Nigeria,	According to Ofodile et al, the absence of efficient foundry industries in Nigeria is large because of inadequate planning.	foundry industries

### Research Gap

To the best of our knowledge, no previous work has been done on the use of abundant mango seed shell as in the reinforcement of Al- Matrix composites (AMCs) for engineering applications. The addition of MSSA particles is expected to

improve the mechanical properties, address the problem of MgAl<sub>2</sub>O<sub>4</sub>. (**spinel**), **Fe<sub>2</sub>Si<sub>2</sub>Al<sub>9</sub>** platelets, and **Si plate-shaped phases** in Al-alloys provide easy crack nucleation sites and propagation paths. The harnessing of the lightweight and low cost of processing of Mango seed shell ashes (MSSA) for the



production of AMCs is yet to attract much attention from researchers. Therefore, there is a gap in the study area that needs to be filled. The study will also bridge the gap between existing literature concerning Nigeria, and Africa, and the rest of the world.

## METHODOLOGY

### *Determine the Chemical Composition*

Min pal compact energy dispersive X-ray spectrometer was used for elemental analysis of mango seed shell ash and the powder from the conventional motorcycle hub. The system is controlled by a pc running the dedicated Min pal analytical software

### *Sample Preparation*

The Mango seeds shells collected in Zaria and were sun-dried for three days, decorticated and ground. The ground MSSA was packed in a steel box and carbonized in an air tightened condition using a furnace at 600°C for four hours. Sieved to the particle size between 250µm and 106µm.

### *XRF Analysis*

The oxford instruments X-Ray fluorescent machine in the multi-user laboratory, Department of chemistry A.B.U Zaria was used for chemical analysis of the mango seed shell as hand the conventional motorcycle hub. Min pal compact energy dispersive X-ray spectrometer (XRF) was used for elemental analysis of mango seed shell ash. The system is controlled by a PC

running the dedicated Min pal analytical software.

### *Determine the hardness Properties*

The hardness test of the cast samples was determined using a Vickers Hardness Testing Machine according to ASTM; E18-15 standards. The Sample was cut from the cast test pieces. They were ground to obtain smooth surfaces suitable for use. The test was conducted on each specimen using a load of 0.1kgf with max/min. limits 150/20HV. The corresponding values of hardness (HV) were calculated from the standard formula. The readings of three different positions were taken and an average was taken in each case.

### *Determine the impact properties of the composite.*

The Impact strength was determined using the Charpy impact machine by name Hounsfield Balance impact machine in the Department of Mechanical Engineering, Ahmadu Bello University Zaria. The sample was prepared according to the standard of ISO 8256 (2004) for dent specified. The dimensions used to determine the impact strength was a diameter of 8mm, v- notched to 0,5mm depth from the middle with a total length of 46mm. The sample was fixed parallel between the stationary clamp and at a crosshead of the pendulum hammer set to hit the crosshead at the lowest point of the circular motion. The hammer speed was set at 1.5m/s which corresponded to the falling angle of 60°.

## *Development of the Composite through Stir Casting*

**Table 2:** Charging of matrix and reinforcement into crucible furnace.

Casting Runs	% Al-Si-Mg Alloy	% MSSA	Samples No
1	100	-	Control C
2	95	5	A
3	90	10	B
4	85	15	D
5	80	20	E



The matrix and reinforcement were charged into the furnace and the temperature raised to 720 to superheat the solid aluminium. The crucible was removed from the furnace and molten metal continuously stirred as the MSSA was poured in. The furnace heat was increased while stirring continued until the pouring temperature was attained. After casting, the bars were machined to standard samples for mechanical and physical tests.

### Metallography Procedure

The surface of the samples was prepared using ASTM standard E8-11 (Anon, 2011) as a guide. The grinding procedure involves the use of successive grit papers used are 320, 400, 600, 800 and 1200. Typically, the finest grit paper used in the experiment is 1200, and once the only scratches left on the specimen was from 1200 grit paper. The specimen was thoroughly washed with distilled water and then allowed to dry. The polishing process was conducted using a Presi Mecapol P260 machine with a  $\varnothing$  200 mm adhesive polishing cloth on the wheel disc. The polishing cloth has an abrasive size of less than  $1\mu\text{m}$  and an alumina micro polisher of  $0.5\mu\text{m}$  was used with a rotation rate of 150-200 rpm. This process took about 5 minutes. After polishing operation a mirror-like surface was prepared to ensure that all phases are identified when viewed under a

microscope. The etching of the polished specimen was done using Keller's reagent to reveal the microstructure of AMC samples. The samples were immersed for 10 minutes in Keller's reagent containing 190ml of distilled water, 5ml Nitric acid, 3ml Hydrochloric acid (HCl) and 2ml Hydrofluoric acid (HF) contained in a small beaker with the polishing face up, using tongs. Surfaces were properly cleaned before etching, or etching results will be impaired. The etching was halted when the proper degree of surface dulling was produced. The specimen was removed from the beaker and then rinsed with clean running water and blown dry with warm air.

### Production of Motorcycle Hub from Optimized Output Using Sand Casting

The sketched drawing of the conventional motorcycle hub was carried out according to standard casting process planning procedures as shown in Figure 2. This incorporated the shrinkage and machining allowances. The standard shrinkage allowance for aluminium alloy which is 13 mm per meter or 1.3% was used in the pattern design. Draft allowance was provided on all the vertical surfaces of the pattern and mould to enable casting to be removed easily.  $1^\circ$  taper for external details and  $3^\circ$  for internal detail was provided as recommended by Bansa (2007).

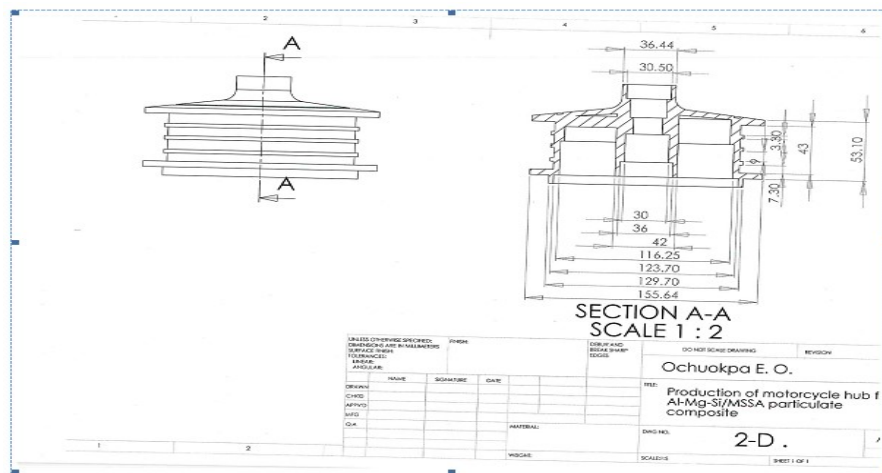


Figure 2: The sketched drawing of conventional motorcycle hub.

#### *Pattern making / Core making*

Pattern making is a crucial part of planning for production. This includes core making for products like the motorcycle hub which has some internal cavities. A core box

was designed with provision for core prints as shown in plate 1. The cassava starch which is an organic binder was used for the preparation of the core to enhance collapsibility of the core after casting.



**Plate 1:** Pattern and the assembled core box.

#### *Melting/ casting process.*

Crucibles are placed in furnaces. The Al-Mg-Si /MSSA particulate composite to be melted is charged into the crucible, which is covered with a lid. The metal melts as the crucible is heated. When the metal has reached the correct pouring temperature of 750° c, the crucible was removed from the furnace with special tongs, the slags floating on top of the liquid

metal is removed then the molten metal/alloy is poured into the mould cavity and left to solidify to form the casting. The casting is removed from the mould box and taken to the cleaning and finishing section to remove the defects if any finally testing and inspection of the casting is carried out. Plate's 2-3 present melting and mould cavity respectively.



**Plate 2:** Melting process





**Plate 3:** Pouring into the mould cavity

*Machining cleaning*

After casting the surfaces and edges of the product were rough, the cleaning and fettling operations carried out

includes cutting the gating system, filing and machining as seen in plate 4 A and motorcycle hub testing methodology in plate 4 B below.



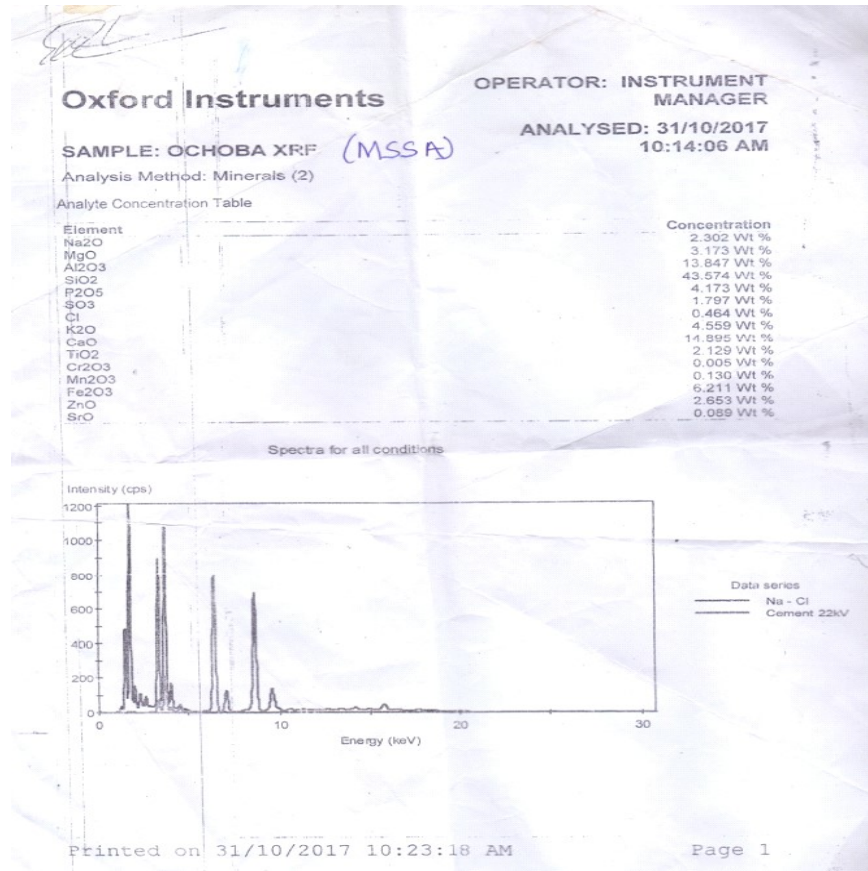
**Plate: 4 A & B** Grooving and boring the intricate parts of the motorcycle hub.

## RESULTS AND DISCUSSIONS.

This section presents the results and discussion of the study.

### Characterize MSSA using X-ray Fluorescence (XRF).

The characterize outcome results using X-ray fluorescence (Oxford Instrument) is as shown in Figure 2.



**Figure 2:** X-ray fluorescent (XRF) pattern of mango shell ash (MSSA)

1. The result of the X-ray fluorescent (XRF) pattern of mango shell ash (MSSA) reveals SiO<sub>2</sub>, has the highest percentage composition followed by CaO, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub> and Mg<sub>2</sub>O as major phases while Cr<sub>2</sub>O<sub>3</sub> is the least.
2. The chief function of silicon is to improve casting soundness and freedom from cracking, Application base on an aluminium-silicon alloy system (Davis, 1993). Aluminium casting alloys must contain enough amount of silicon which is a eutectic-forming element, this is to enhance
- adequate fluidity to fill the shrinkage that usually occurs during casting. The MSSA that contain a high amount of silicon is, therefore, an attractive material for reinforcement of AMC for wear applications.
3. The presence of Si and Mg enhances wettability and formation of Mg<sub>2</sub>Si and eutectic Si α-Al matrix with MSSA particles.
4. The role of Magnesium is to the improvement of wettability between the Al-Mg-Si alloy and the reinforcements. Magnesium and

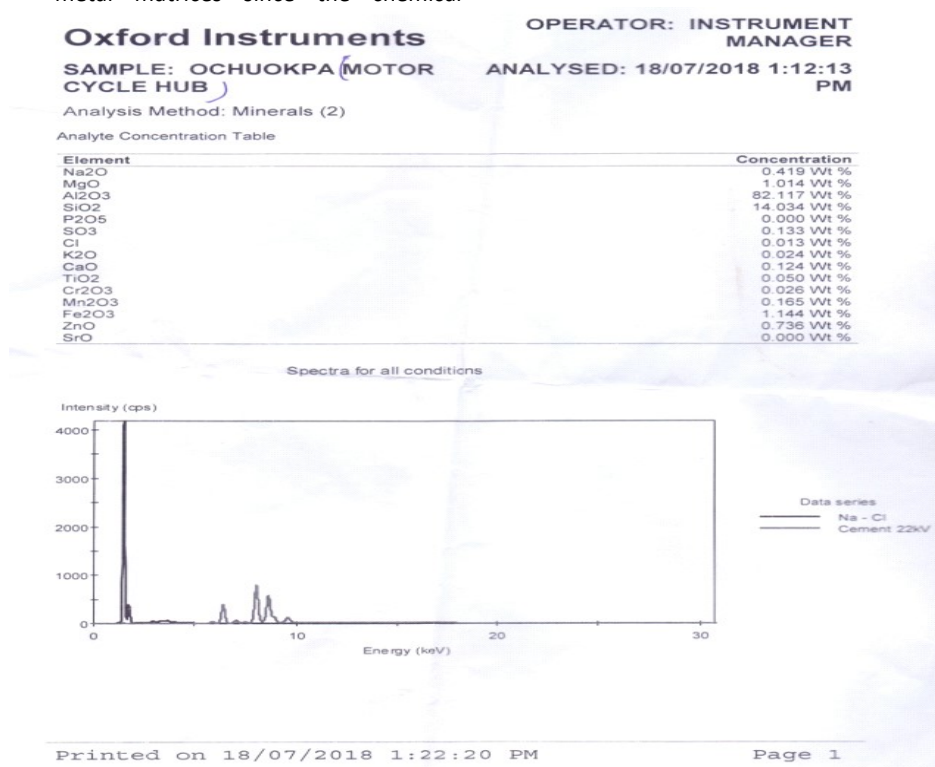
magnesium alloys are amongst the lightest materials for practical use as the matrix phase in metal matrix composites. When compared to other available structural materials, Magnesium is very attractive because of its unique combination of low density and excellent machinability.

- The presents of hard constituent compounds like SiO<sub>2</sub>, CaO, Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, Mg<sub>2</sub>O, K<sub>2</sub>O, and TiO<sub>2</sub> suggests that the mango seed shell ash can be used as particulate reinforcement in various metal matrices since the chemical

composition has similarity with the XRF analysis of Periwinkle shell ash, rice husk, fly ash, and bagasse ash currently used in metal matrix composite. Aku, et al. (2012), Aigbodion, and Hassan, (2010).

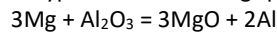
**Characterize the Convectional Motorcycle Hub Using X-Ray Fluorescence (XRF).**

Figure 3 present the outcome result by conventional motorcycle hub using X-ray fluorescence.



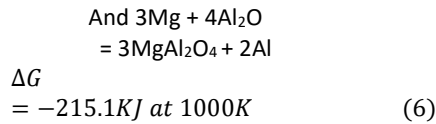
**Figure 3:** (XRF) pattern of typical motorcycle hub

In figure 3 the (XRF) pattern of the convectional motorcycle hub reveals Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub> and MgO as major phases. The presence of Mg and Fe in the alloy allows the formation of eutectic α + Mg<sub>2</sub>Si and platelets of Fe<sub>2</sub>Si<sub>2</sub>Al<sub>9</sub> in addition to the Si platelets. These plate-shaped phases produced in typical sand casting provide



easy crack nucleation sites and propagation paths, resulting in relatively low strengths and ductility. Al<sub>2</sub>O<sub>3</sub> is known to be stable in aluminium, but it reacts with magnesium in aluminium alloys containing Mg to form MgO and MgAl<sub>2</sub>O<sub>4</sub>. (Spinel) as shown in the following equations;

$$\Delta G = -117KJ \text{ at } 1000K \quad (5)$$



MgO may form at a high magnesium level and lower temperature

whereas the spinel will form even at very low magnesium levels (Ikechukwuka, 1997). This explains why  $\text{Al}_2\text{O}_3$  is not thermodynamically stable in most aluminium alloys and the need for composite reinforcement.

**Determination of the Physical and Mechanical Properties.**

Hardness Test.

**Table 3:** Variation of hardness property of the composite

0% MSSA	Hardness Value
Control C 0% MSSA	31.9 HV
A 5% MSSA	33.63 HV
10% MSSA	42.9 HV
D 15% MSSA	43.2 HV
E 20% MSSA	36.5 HV

Table 4.4 shows the increasing trend of hardness strength with an increase in the weight percentage of MSSA up to 15% weight fraction. Beyond this weight fraction, the hardness and impact trend started decreasing as MSSA particles interact with each other leading to clustering of particles and consequently settling down. The increase in hardness is due to the presence of silicon particles formed as a result of the reaction between the reinforcement MSSA particles and the molten Al- alloy matrix as well as other processing parameters. Factors such as the non-uniform distribution of particles, the cooling rate of the casting have affected the hardness value negatively hence there is no

uniform hardness. The increase in hardness values of the developed composite could be attributed to the proper distribution of hard and brittle phases of the reinforcement (MSSA) in the relatively ductile Aluminium matrix. In this Aluminium Based MSSA Particulate composite, the wettability of the particles in the melt started decreasing thereby lowering the hardness. The optimum value of hardness and toughness comes out to be of a sample containing 15% MSSA i.e. 43.2 HV (Hardness). This represents a 26.16% improvement over the conventional alloy. The optimized 15% wt of MSSA reinforcement which has the best mechanical properties was selected for the production of the hub.

**Table 4:** Impact Test

Samples	Diameter (mm)	Notch (mm)	Energy (lb. pounds)	Average En (pounds)	Average (Joules)
Control C. 0% MSSA	10.3	9.8	2.2	1.66	2.251
	10.4	9.4	1.3		
	10.0	9.3	1.5		
A. 5% MSSA	10.0	9.0	0.5	1.0	1.356
	10.3	9.4	1.5		
	10.5	9.7	1.0		
B 10% MSSA	10.5	9.9	1.6	1.7	2.305
	10.5	10.0	2.0		
	10.2	9.6	1.5		
D 15% MSSA	10.4	9.8	2.0	1.80	2.440

Corresponding author: Ochuokpa, E. O. [echuokpaator@gmail.com](mailto:echuokpaator@gmail.com) Department of Metallurgical & Materials Engineering, Ahmadu Bello University, Zaria. © 2021, Faculty of Tech. Edu, ATBU Bauchi. All rights reserved



Samples	Diameter (mm)	Notch (mm)	Energy (lb. pounds)	Average En (pounds)	Average (Joules)
	9.8	9.7	1.5		
	10.4	9.6	1.9		
E 20% MSSA	10.0	9.3	1.3	1.1	1.491
	10.0	9.0	1.0		
	10.0	9.4	1.0		

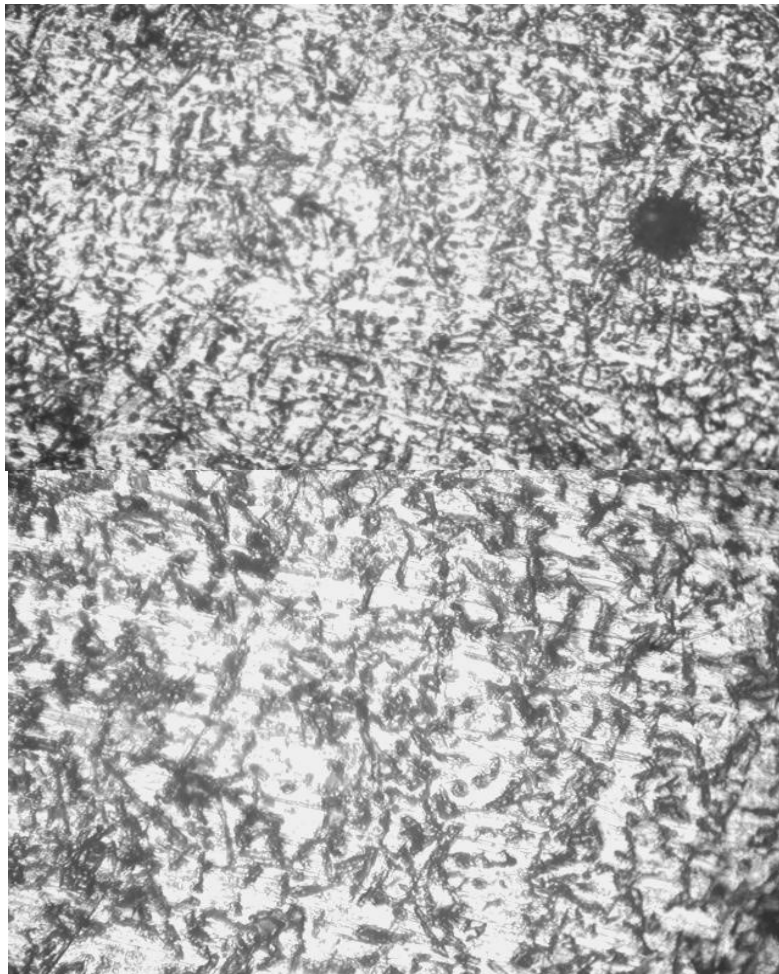
$$1^{lb} = 1.35581795J$$

*Impact Test*

Table 4.4; The impact test shows a decreased at 5% wt, 20%wt and 25% wt while the increase in value at 10%wt to an optimum value of 43.2 HV obtained at

15%wt addition of MSSA. Thereafter an increase in the percentage of MSSA progressively decreased the impact strength.

*Microstructure Analysis using Optical microscopy.*

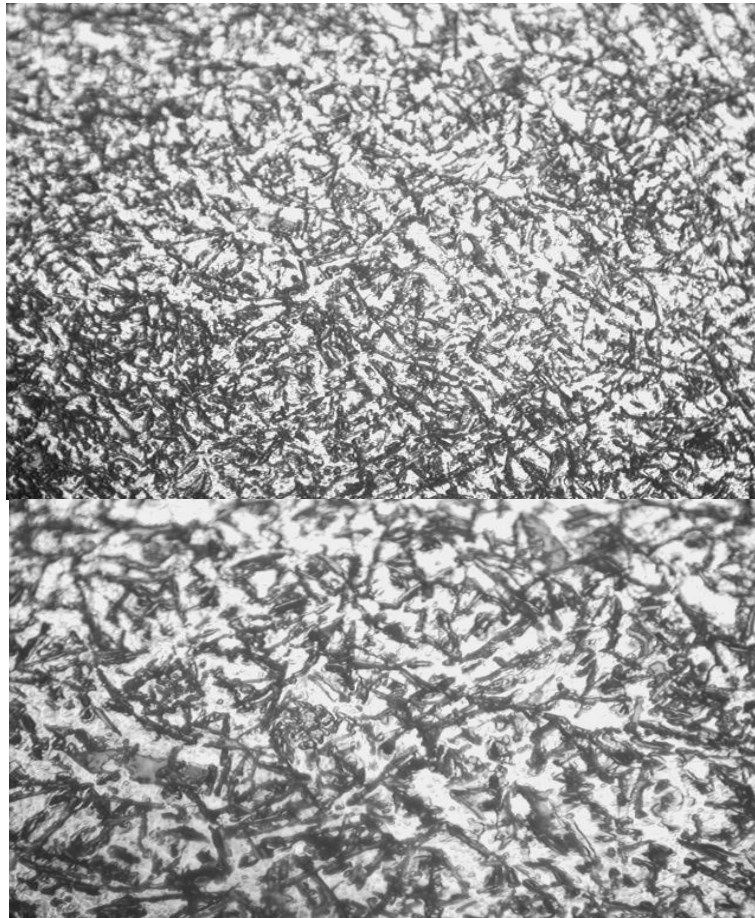


**Plate 6A:** Sample C 0% MSSA \*100

**Plate 6B:** Sample C 0% MSSA \*200

Plate 6A & B shows a control sample (C) of the convectional motorcycle hub with 0% MSSA \*100 and \*200 magnification. The presence of Mg and Fe in the alloy allows the formation of eutectic  $\alpha$  +  $Mg_2Si$  and platelets of  $Fe_2Si_2Al_9$  in addition to the Si platelets. These plate-

shaped phases produced in typical sand casting provide easy crack nucleation sites and propagation paths, resulting in relatively low strengths and ductility. This is the reason for the frequent mechanical failure of the hub.



**Plat 7A:** Sample A 5% MSSA\*100

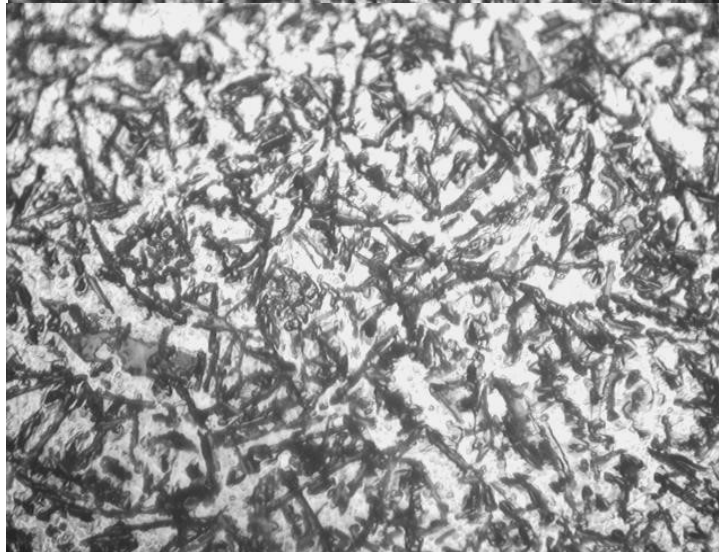
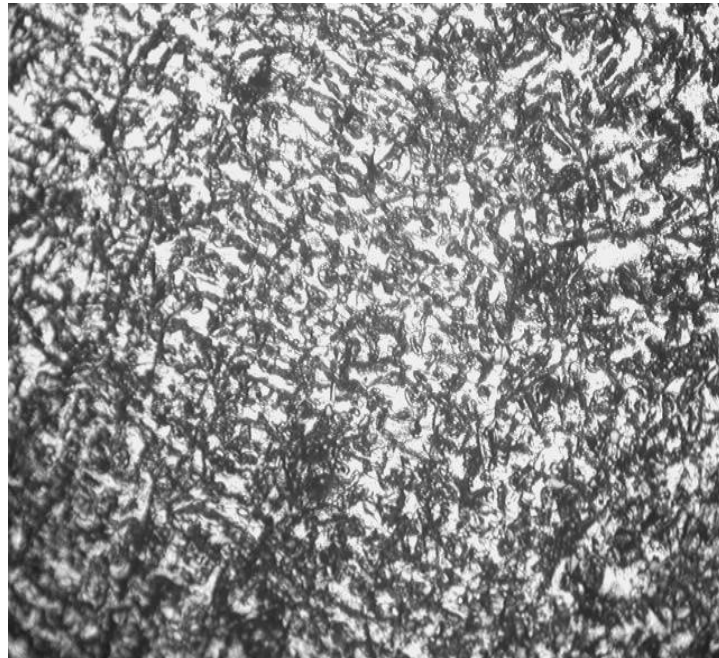
**Plate 7B:** Sample A 5% MSSA \*200

Plate 7A & B shows a 5% MSSA \*100 and \*200 magnification. The presence of a considerable amount of silicon in MSSA reinforcement in the Aluminium matrix which ensures the formation of the required bonds between the matrix and the reinforcement and the presence of

magnesium which improved the wettability of MSSA particle is common to all the samples in Plates 7 to 9.

The addition of 5% MSSA has slightly improved the structure of the control sample (C) the unreinforced alloy.





**Plate 8A:** Sample B 10% M SSA \*100

**Plate 8B:** Sample B 10% M SSA \*200

Plate 8A & B shows a 10% M SSA. The addition of 10% M SSA has further improved the structure of the control sample (C) of the unreinforced alloy and has

improved structure over sample 7 above. This is due to the improved distribution of mango seed shell ash in the Aluminium matrix and other casting parameters.



**Plate 9A:** Sample D 15% MSSA \*100

**Plate 9B:** Sample D \*200

The Microstructures analysis of the composite samples D 15% MSSA as reinforcement clearly shows the maximum uniform distribution of mango seed shell ash in the Aluminium matrix. This revealed that  $Mg_2Si$  and eutectic  $Si$   $\alpha$ -Al matrix with MSSA particles has significantly modified the platelet phases and has further improved the structure of control sample (C) of the unreinforced alloy and has an improved the structure over sample 7 above.

Generally samples A, B, D & E shows a good interfacial bonding between the reinforcement MSSA and the Al- matrix was made possible by heating MSSA particles before dispersion in the liquid

matrix. There are no unfavourable phenomena such as gas blisters, sedimentation etc. The presence of a considerable amount of silicon on the matrix alloy and in the reinforcement ensures the formation of the required bonds between the matrix and the reinforcement. The presence of magnesium improved the wettability of MSSA particle

#### *Motorcycle hub produced and tested*

The diameter of the sprocket holes and the internal cavities of the new hub were measured and compared with the conventional hub. It was then fixed into the motorcycle wheel and the wheel rotation was tested. It was a very smooth rotation as

seen in the video. This implies that the new hub has met the required standard measurements. The motorcycle wheel was

fixed to the motorcycle and successfully test run for about 10 km in 30 minutes.



**Plate 10A:** Replacing old Motorcycle hub

**Plate 10B:** Old and New motorcycle hubs.

## CONCLUSION

The conclusions drawn from the result of the XRF pattern of mango shell ash reveals the presence of hard constituent compounds like  $\text{SiO}_2$ ,  $\text{CaO}$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Mg}_2\text{O}$ . This suggests the possibility of mango seed shell ash particulate in metal matrix composite since the chemical composition has similarity with the XRF analysis of rice husk, fly ash, and bagasse ash currently used in metal matrix composite. The addition of Mango Shall Ash particles to a typical Al-Si-Mg alloy used for the production of the motorcycle has resulted in microstructural changes which result in an increase of 26.16% hardness value over the as-cast Al-Si-Mg alloy. By these results, it can be concluded that MSSA can be successfully added at 15wt% to reinforce Al-Si-Mg alloy for Production of Motorcycle hub hence providing the desired lightweight, good mechanical and wear-resistant properties as well as reducing the environmental problems created by them. The stir casting technique applied shows a reasonably homogenous dispersion of MSSA particles in the Al matrix and this is revealed in an increasing trend of the optical micrographs analysis. This is in good agreement with the expected result. This confirms that MSSA can be used as a

reinforcement material for the Aluminium matrix. Microstructure Analysis of the composite studied revealed  $\text{Mg}_2\text{Si}$  and eutectic Si  $\alpha$ -Al matrix with MSSA particles. This indicates that there was good interfacial bonding between the matrix and the reinforcement. The motorcycle hub was successfully produced through the sand casting process using the optimum sample containing 15% MSSA.

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