ISSN 2320-9186

Global Scientific JOURNALS

GSJ: Volume 6, Issue 8, August 2018, Online: ISSN 2320-9186
www.globalscientificjournal.com

COMPARATIVE ANALYSIS ON THE MECHANICAL PROPERTIES OF A METAL-MATRIX COMPOSITE (MMC) REINFORCED WITH PALM KERNEL/PERIWINKLE SHELL ASH.

IYASELE, Edgar Omondiale[1]

[1]*Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria*

**Corresponding Author: e-mail:* edgaromons2003@yahoo.com *Tel +234-8135359855*

ABSTRACT

The research presents the comparative analysis on the mechanical properties of a Metal-Matrix Composite (MMC) reinforced with palm kernel/periwinkle shell ash for automobile applications. Four specimens consisting of Sample A (300g of aluminum), Sample B (295% of aluminium, and 5% of Silicon Carbide [SiC]), Sample C (290% of aluminium, 5% of Silicon Carbide and 5% of palm kernel [PKSA]) and (285% of aluminium, 5% of Silicon Carbide, 5% of palm kernel and 5% of periwinkle shell ash [PSA]) were produced using stir casting method and their mechanical properties (hardness, tensile strength, microstructure) were evaluated. Particle reinforced Al-MMC can be synthesized stir- casting method. Commercially solid aluminium (up to 99.1% purity) served as the matrix while Silicon carbide, palm kernel shell ash and periwinkle shell ash particle were used as the reinforcements. It involved the melting of the aluminium solid followed by adding the reinforced particles for different weight percent to the melt. The microstructural examinations revealed a uniform distribution of the reinforcements. From the analysis of results obtained, we found that the ultimate tensile strength of aluminum based metal matrix composite decreased as we added the weight fraction of SiC; increased as we added the weight fraction of PKSA and decreased as we added the weight fraction of PSA particles. The elastic modulus of aluminum based metal matrix composite decreased as we added the weight fraction of SiC, increased as we added the weight fraction of PKSA and decreased as we added the weight fraction of PSA particles. The hardness of aluminum based metal matrix composite increased as

ISSN 2320-9186

we added the weight fraction of SiC, and decreased as we added the weight fraction of PKSA and increase as you add the weight fraction of PSA particles. The ductility of aluminum based metal matrix composite decreased as we added the weight fraction of SiC, and increased as we added the weight fraction of PKSA and PSA. Conclusively, with the observations made on the mechanical properties of pure Aluminium metal reinforced with SiC, PKSA and PSA, SiC and PKSA have a better mechanical properties if used as reinforcement material in Aluminium metal matrix composite. Thus, this work has provided ways of converting commercial wastes, especially palm kernel shell and periwinkle shell which are posing environmental problems, to useful substances.

Keywords: Aluminium, Meta- Matrix Composite, Reinforcement, Sample, Pure.

1.0 INTRODUCTION

Metal Matrix Composites (MMCs) are used in a broad range of high performance applications today which includes: transportation, aerospace and defense. Most of their present applications are in aviation, ground transportation, electronics, and sports industries. The usage of MMCs was over 3.5 million kg in India by the year 2004 and is increasing at an annual growth rate of over 6% (Gupta and Satyanarayana, 2006). The applications of metal matrix composites in aeronautics have been established in the aerostructural, aeropropulsion and subsystem categories. For example, ventral fins and fuel access door covers in F-16 aircrafts; rotor blade sleeves and swash plates in the Eurocopter EC120 and N4 helicopters; fan exit guide vanes for the Pratt and Whitney 4084, 4090 and 4098 engines used in Boeing 777. MMC are metals reinforced with other materials such as other metals, ceramics or organic compounds. They are made by dispersing the reinforcements in the metal matrix. Reinforcements are utilized to improve the properties of the base metal like strength, stiffness, conductivity and many more. The reinforcement of aluminum alloy 7075 with short basalt fibers resulted in the improvement of the mechanical properties such as the tensile strength, hardness, Young modulus of the aluminum alloy 7075 when compared with the unreinforced sample (Vannan and Vizhian, 2014). Aluminum and its alloys have attracted most attention as base metal in metal matrix composites (Mcdanels, 1985). Aluminum MMCs has lightweight and are widely used in aircraft, aerospace, automobiles and structural applications such as window frames and roofing sheets (Brian, 1997). A good reinforcement material is known to be stable in a given working temperature and non-reactive too. The most commonly used reinforcements for Al-MMCs are Silicon Carbide (SiC) and Alumina (Al_2O_3). Silicon carbide reinforcement increases the tensile strength, hardness, density and wear resistance of Al and its alloys (Narayana *et al.*, 2003). The particle distribution also plays a very vital role in the properties of the Al-MMC and is improved by intensive shearing. Alumina (Al_2O_3) reinforcement has good compressive strength and wears resistance. Fibers are another important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Zircon is usually used as hybrid reinforcement since it increases the wear resistance of aluminum significantly (Sanjeev *et al.*, 2007). In the last decade, the use of fly ash reinforcements has been increased due to their low cost and availability as waste by-product in thermal power plants. It increases the electromagnetic shielding effect of the Al - MMC.

The growing concern of resource depletion and global pollution has dared many researchers and engineers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials in construction. Many of these by-products are used as fillers for the production of acceptable mix design. With the global economic recession coupled with the market inflationary trends, the constituent materials used for these mix design had led to a very high cost of construction. Hence, researchers in material science and engineering are committed to having local materials to partially or fully replace these costly conventional ones (Nwaobakata and Agunwamba, 2014). Several successes have been made in these regards and this subject is drawing attention due to its functional benefit of waste reusability and sustainable development. Reduction in construction costs and the ability to produce adequate mix are added advantages (Muhamad *et al.*, 2010 and Ndoke, 2006). To assess the performance of palm kernel shells as a partial replacement for coarse aggregate in asphalt concrete, various investigation had been carried out to ascertain the suitability of palm kernel shells as aggregates in light and dense concrete for structural and non-structural purposes (Agunsoye *et al.*, 2012). Other similar efforts in the direction of waste management strategies include structural performance of concrete using oil palm shell (OPS) as lightweight aggregate. In addition, other materials explored in partial replacement for concrete aggregates include cow bone ash, palm kernel shells, fly-ash, rice husk, and rice straw as pozzolanic materials. The use of coconut husk ash, corn cob ash and peanut shell ash as cement replacement has also been investigated (Okoroigwe *et al* 2014, and Falade, 1992). The use of palm kernel shell particles has resulted to the enhancement of the mechanical properties of recycled materials such as Polyethylene (Kandahl, 1992). Palm kernel shell has been characterized and reported to possess surface elements, morphologies and crystalline qualities that is required for materials fillers in construction and absorptions industries (Nimityongskul and Daladar, 1995). Nigeria is endowed with a lot of minerals and agro-based resources that could be used in the development of environmental-friendly composite materials such as Eco-pad used in modern vehicle braking systems. As of 2009, Indonesia was the largest producer of palm oil, (Ibhadode and Dagwa, 2008) surpassing Malaysia in 2006, producing more than 20.9 million tones. Food Agriculture Organization (FAO) data showed production increased by over 400 % between 1994 and 2004, to over 8.66 million metric tons. In 2008, Malaysia produced 17.7 million tons of palm oil on 4,500,000 hectares of land, and was the second largest producer of palm oil, employing more than 570,000 people. Malaysia is the world's second largest exporter of palm oil. As of 2011, Nigeria was the third-largest producer, with more than 2.5 million hectares (6.2×106 acres) under cultivation. Until 1934, Nigeria had been the world's largest producer. From the above statement, large quantities of cracked palm kernel shell (PKS) are therefore generated by the producers. The PKS are obtained after extraction of the palm oil, the nuts

ISSN 2320-9186
are broken and the kernels are removed with the shells mostly left as waste. The PKS are hard stony endocarps that surround the kernel and the shells come in different shapes and sizes (Alangaram *et al.*, 2008).These shells are mainly of two types the "Dura" and "Tenera". The Tenera is a hybrid which has specially been developed to yield high oil content and it has a thin shell thickness compared to Dura type. There are several efforts being made towards the utilization of the PKS. Some of the areas where palm kernel shell are used or are being considered for use include: automobile disk brake pad, carbon activation for water purification, concrete ingredient in building industry, fuel for heat generation (Okly, 1987), thermal insulator and many more. The shell is made up of 33 % charcoal, 45 % pyro ligneous liquor and 21 % combustible gas (Dagwa *et al.*, 2012). The choice of the local product as reinforcement for aluminum is based on the large quantity of oil palm grown in Nigeria. These agricultural wastes (waste biomass) impact negatively on the environment because of indiscriminate disposal of such wastes. Hence producing reinforcement materials from these wastes is an alternative method of waste reduction and reuse. The reinforcement of aluminum alloy with fibers has resulted in the improvement of the mechanical properties such as tensile, strength, stiffness, hardness, young modulus of the aluminum alloy when compared with the unreinforced sample (Vannan and Vizhian, 2014). Various investigation had been carried out to ascertain the suitability of palm kernel shells as aggregates (Agunsoye *et al*, 2012). Other materials explored in partial replacement as aggregates' include, cow bone ash, palm kernel shells, fly-ash, rice husk and rice and straw as pozzolanic material. The use of coconut husk ash, corn cob ash and peanut shell ash as replacement has also been investigated (Okoroigwe *et al*, 2014). However, not much work has been done combining palm kernel and periwinkle shell ash. Hence, this study to investigate the effect of palm kernel shell ash and Periwinkle Shell Ash as reinforcements on the mechanical properties of as-cast aluminum matrix composites. The aim and objectives of this project are: to carry out melting of the aluminum metal; reinforce the molten aluminum metal with SiC, palm kernel and periwinkle shell ash; produce the cast metal–matrix composite (MMC) and carry out mechanical analysis on the samples produced.

A composite material is a non-uniform solid consisting of two or more different materials that are mechanically or metallurgically bonded together in which one of the materials called the reinforcing phase is in the form of fiber, sheets or particles and is imbedded in the other material called the matrix phase. Each of the various composites retains its identity in the composite and maintains its characteristic properties such as stiffness, strength, weight, high temperature, corrosion resistance, hardness, and conductivity, which are not possible with the individual components by themselves. Example of the traditional composite is brick which consists of clay that mix up with grass and

ISSN 2320-9186
concrete that have mixture of cement and sand. In this example, clay and cement are matrix component while grass and sand are the reinforcement (Hashim, 2003).

Generally, one component acts as a matrix in which the reinforcing phase is distributed. The matrix component is, thus the continuous phase. When the matrix component is metal, we call such composite a metal matrix composite (MMC). The reinforcement can be in the form of particles, whiskers, short fibers, or continuous fiber. There are three entities that determine the characteristics of a composite which are reinforcement, matrix and interface. The role of matrix was considered to be that of a medium or binder to hold the strong and stiff fibers or other types of reinforcement. Over the years, however, it has been realized that the matrix microstructure and consequently its mechanical properties have a considerable influence on the overall performance of a composite. This is particularly true of the MMCs because the very act of incorporating a reinforcement can result in change(s) in the microstructure of the metallic matrix and, consequently in their structure-sensitive properties such as a strength and toughness (Cahn, 2005).

Composites are classified as follows organic matrix composite (OMC), Metal matrix composite (MMC) and Ceramic matrix composite (CMC**)**. By reinforcements, they are classified as: Particle reinforced composite, Fiber reinforced composite and Structural reinforced composite. Factors to consider when choosing constituents are: Component, their proportions, their distributions, their crystallographic textures, structure and composition of the interface between components. The two categories of constituent materials are; the matrix and the reinforcement. Matrix materials provide support for the fibers and assist the fibers in carrying the loads. It also provides stability to the composite material resin, matrix system acts as a binding agent in a structural component in which the fibers are embedded. The reinforcement material is embedded into a matrix. The reinforcement does not always serve a purely structural task [reinforcing the compound], but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous or discontinuous. Discontinuous MMCs can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging and rolling. In addition, they may be machined using conventional techniques, but commonly would need the use of polycrystalline diamond tooling.

Particle-Reinforced Composite can be classified under two sub-regions: large particle and dispersion-strengthened composites. The distinction between these is based upon reinforcement or strengthening mechanism. The term 'large' indicate that particle-matrix interaction cannot be treated on the atomic or molecular level, rather continuum mechanics is used. The particulate phase for most of these composites is harder and stiffer than the matrix. In the vicinity of each particle, these reinforcing particles tend to restrain movement of the matrix phase. Obviously, the matrix transfers some of the

ISSN 2320-9186
applied stress to the particles, which bear a fraction of the load. The degree of reinforcement or improvement of mechanical behavior depends on strong bonding at the matrix particle phase.

Particles for dispersed-strengthened composites are normally much smaller (diameter between 0.001 and 0.1μm). Particle-matrix interactions occur on the atomic or molecular level and lead to strengthening. We may note that the mechanism of strengthening is similar to that of precipitation. The matrix bears the major portion of an applied load, whereas the small dispersed particle hinder or impede the motion of dislocations. Obviously, plastic deformation is restricted such that yield and tensile strengths, as well as hardness improve.

We may note that particles can have quite a variety of geometries, but they should be approximately the same dimension in all directions (equiaxed). Particles should be small and evenly distributed throughout the matrix for effective reinforcement. Moreover, the volume fraction of the two phases influences the behaviour, mechanical properties are enhanced with increasing particulate content. The rule of mixture equations reveal that the elastic modulus should fall between an upper bound given by equation 1.1 below:

$$E_c(u) = E_m V_m + E_p V_p ----------- 1.1$$

And a lower bound or limit given by equation 2.2. below:

$$E_c(t) = \frac{E_m E_p}{V_m E_p + V_p E_m} ----------- 1.2$$

Where E and V denote the elastic modulus and volume fraction respectively and the subscript c, m, and p represent composite, matrix and particulate phases respectively.

Elasis guineesis is a species of palm commonly called African oil palm or macaw-fat (USDA GRIN Taxonomy). It is the principal source of palm oil. It is a native of west and southwest Africa, especially the area between Angola and the Gambia; the species name guineensis refers to one of the countries where it flourishes, Guinea (Kenneth *et al*., 2000).

Palm kernel shell is an agro waste in palm oil mills. It is a hard endocarp covering the palm kernel, and produced when the nut is cracked with a machine or manually using a stone. The palm kernel is only exposed after palm oil has been extracted from the palm fruits.

In 2010/2011, total production of palm kernel was 12.6 million tons ("Food Outlook".fao.org. Food and Agriculture Organization of the United Nations, May 2012). Demand for palm oil has increased in recent years due to its use as a biofuel ("Eco-conscious palm oil" The Star Malaysia 2008), but unfortunately, the production of palm oil has detrimental effects on the environment and is not

ISSN 2320-9186
considered to be a sustainable biofuel "condition for sustainability of biomass based fuel use." Energy policy 34(7):863) and most often the disposal of its waste (Palm kernel shell) is a problem. However, this study is poised to proffer solution to the environmental hazards caused by palm kernel shells and/or its ash, which is a by-product electricity generation (Palm kernel are used as fuel to produce steam). Table 2.1 below shows the physical and chemical composition of ash from PKSA.

Considerable efforts are being taken worldwide to improve on the strength and durability performance of concrete through the use of pozzolanic materials. The commonly used pozzolans have been fly ash, silica fume, metakaolin, and blast furnace slag. In continuing quest for more cost - efficient and environmentally acceptable materials, recently, there has been a growing interest in the use of agricultural wastes as pozzolans. Some of the pozzolans of agricultural origin include sawdust ash (Sumaila and Job, 1999; Udoeyo and Dashibil, 2002), rice husk ash (Zhang and Malhotra, 1996), corn cob ash (Adesanya, 2001; Adesanya and Raheem, 2009; Adesanya and Raheem, 2009), palm oil fuel ash (Tangchirapat *et al*., 2009) and periwinkle shell ash (Badmus *et al*., 2007; Dahunsi and Bamisaye, 2002; Job *et al*., 2009; Koffi, 2008).

Periwinkle Shell Ash (PSA) is obtained by burning periwinkle shell which is the by-product of periwinkle which, in zoology is any small greenish marine snail from the class of gastropod, the largest of the seven classes in the phylum mollusc (Okon, 1987; Olorunoje and Olalusi, 2003). They are herbivorous and found on rocks, stones or pilings between high and low tide marks; on mud-flats as well as on prop roots of mangrove trees and in fresh and salt water. Dance (1980) observed that ten (10) out of the eighty (80) species of periwinkle in the world are found in West Africa. The common periwinkle (Littorina littorea) is one of the most abundant marine gastropods in the North Atlantic, but Tympanotonus fuscatus is commonly found in the estuaries and mangrove swamp forest of the South - South region of Nigeria (Badmus *et al.*, 2007). Massive periwinkle harvesting has been reported from some communities in this region of Nigeria (Powell *et al.*, 1985; Job, 2008; Jamabo and Chinda, 2010; Mmom and Arokoya, 2010).

ISSN 2320-9186

2.0 METHODOLOGY

2.1 Materials

The following materials/equipment listed below were used in the processing of the various samples of the composite materials: Aluminum, Silicon carbide (SiC), Palm kernel shell, Periwinkle shell, Locally constructed laboratory-size electric furnace, Electronic weighing machine, Crucible pot (stainless steel), Sand mould, Tongs, Stirrer, Hacksaw, Lathe machine, Extensometer, Rockwell hardness testing machine, Green sand, Heater, Grinding deck, Abrasive papers (220, 400, 600, 800 and 1000 grits), Polishing table, Electric dryer, and Phenolic powder.

2.2 Work Plan for the Experiment

Figure 2.1 below shows the flow chart of the work plan for the experiment.

2.2.1 Material Preparation

The aluminium used for this study was purchase from First Aluminum Company in Port Harcourt River State of Nigeria. Based on the chemical analysis obtained from the manufacturer, it was 99.1% pure Al. The data of the composition of the ingot is shown below in Table 2.1:

Table 2.1: Chemical Analysis of Pure Aluminium

Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Ni	V	Pb
0.14012	0.52354	0.03862	0.00937	0.00564	0.04119	0.00683	0.00174	0.01355	0.01863	0.00739

The aluminum ingot was cut into small sizes using an electric grinder and a hack saw. The pieces of Al were weighed using an electronic weighing machine. The sizes obtained were 300 grams, 295 grams, 290 grams, 285grams.

ISSN 2320-9186

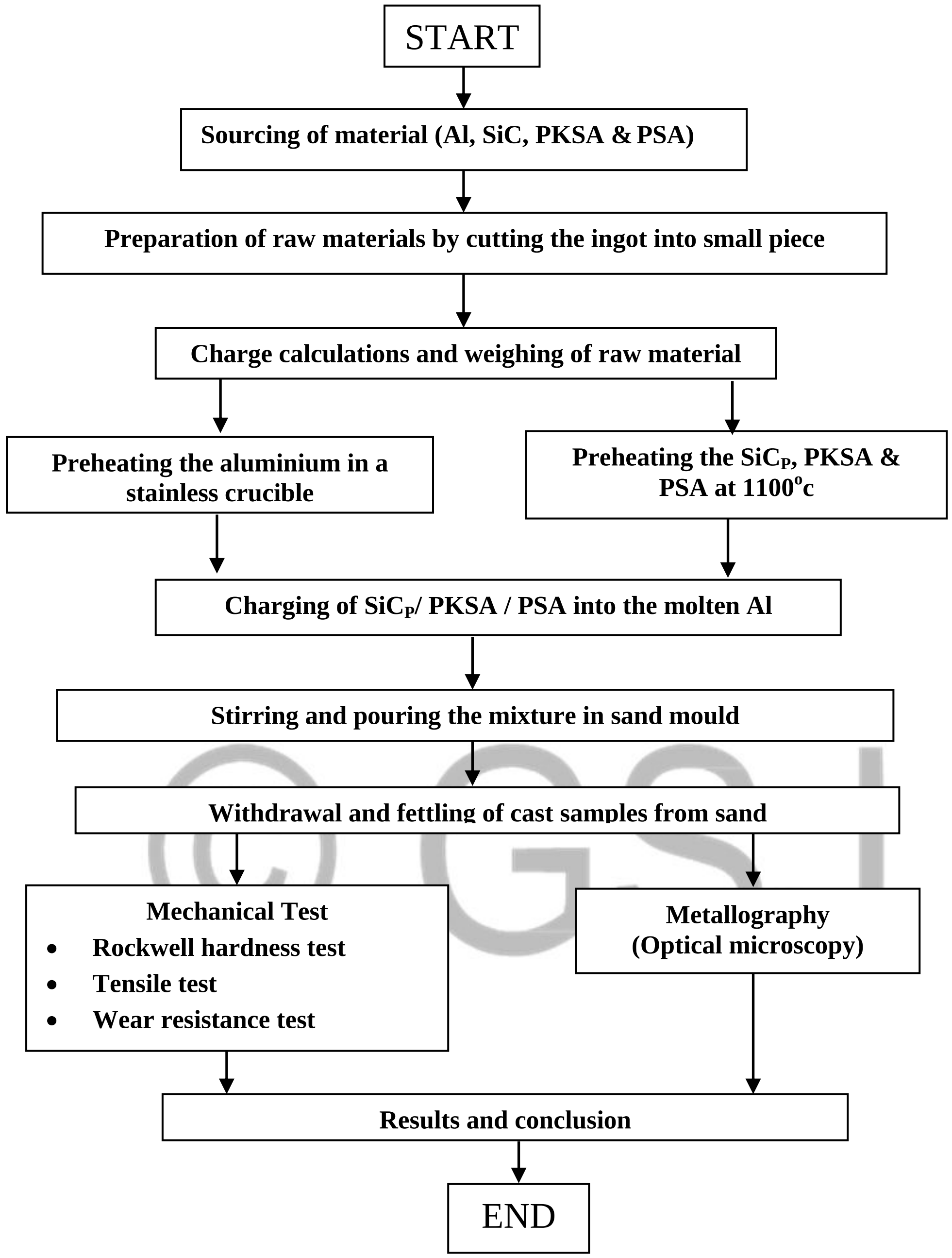

Fig 2.1: Flow chart of the work plan for the experiment

The percentage compositions of the raw materials used for this study are 300% aluminium as the control experiment; 295% aluminium with 5% of Silicon Carbide; 290% aluminium with 5% of Silicon Carbide and 5% of palm kernel; 285% aluminium with 5% of Silicon Carbide, 5% of palm kernel and 5% of periwinkle. Table 2.2 below shows the various weight % SiC, PKSA and PSA ash (or mass) as weighed using an electronic weighing machine.

The palm kernel shells were purchased from Azaraegbelu in Aboh Mbaise Local Government Area of Imo State. They were exposed to direct sun rays and left to dry for (2) weeks until no sign of

ISSN 2320-9186
moisture was observed. The palm kernel shells were then burned at a temperature of about 550ºC and ground into fine powder when cold, 100mesh pass was used to reinforce.

The periwinkle shells for the production of PSA were collected from one of the dumpsites in Otto market in Ikot Ekpene, Akwa Ibom State in the South-south region of Nigeria. The shells were calcined in a furnace and stopped as soon as the temperature reaches 800∘C. At this temperature, the energy input is far less than what is involved in cement production. Then, the ash was ground and sieved with 150μm size.

Table 2.2: Various weight % SiC, PKSA and PSA ash (or mass) as weighed using an electronic weighing machine.

S/NO	Al (g)	SiC (g)	PKSA (g)	PSA (g)
1.	300	0	0	0
2.	295	5	0	0
3.	290	5	5	0
4.	285	5	5	5

The palm kernel shells were purchased from Azaraegbelu in Aboh Mbaise Local Government Area of Imo State. They exposed to direct sun rays and left to dry for (2) weeks until no sign of moisture was observed. They were then burned at a temperature of about 550ºC and ground into fine powder when cold.
The periwinkle shells for the production of PSA were collected from one of the dumpsites in Otto market in Ikot Ekpene, Akwa Ibom State in the South-South region of Nigeria. The shells were calcined in a furnace and stopped as soon as the temperature reached 800ºC. Then, the ash was ground and sieved with 150μm size mesh.

2.3 Methods

The aluminium (99.1% pure) used for this study was purchase from First Aluminium Company in Port Harcourt River State of Nigeria; and the powdered form Silicon Carbide was purchased from industrial area, Onitsha, Anambra State.

2.3.1. Aluminium Casting

Pure aluminum samples used weighed 300gramms on an electric weighing balance; SiC, PKSA and PSA were also weighed using the electric weighing balance. Three samples of aluminium metal were

ISSN 2320-9186
reinforced with SiC, PKSA and PSA; there was an additional control sample of aluminium, making a total of four sample.

Control sample: The aluminum was melted and cast into the mould without any reinforcement and was called the pure sample of the aluminum. (Control sample)

First sample: The aluminium was melted and reinforced with {5 wt % of Silicon Carbide}.

Second sample: The aluminium was melted and reinforced with {5 wt % of Silicon Carbide and 5 wt % of palm kernel shell ash}.

Third sample: The aluminium was melted and reinforced with {5 wt % of Silicon Carbide, 5 wt % of palm kernel shell ash and 5 wt % of periwinkle shell ash}.

The casting temperature used in the aluminum casting was 750 ± 10 degree Celsius. The reinforcement materials (SiC, PKSA and PSA) were preheated at elevated temperature of about 1100°C before pouring into the molten metal at a superheat temperature of 800°C and stirred properly to ease wettability and strengthen the dispersing of the reinforcement materials throughout the matrix of the aluminum metal.

The melting of aluminium metal was carried out in a locally made electric furnace lined with a refractory material that produces heat of about 950°C using a stainless steel crucible pot. The furnace has a mechanical manual stirrer constructed at the top of the furnace cover. Figures 2.2 and 2.3 below show an experimental Electric Furnace and an Experimental Improvised blacksmith Open Hearth Furnace that were used.

Fig 2.2: The Experimental Electric Furnace

Fig 2.3: The Experimental Improvised Blacksmith Open Hearth Furnace

2.4 Specimen Preparation

Each of the samples was prepared into a round test specimen of gauge length {lo} 28 mm and diameter 5 mm as shown in Figure 2.4 below. This was done by machining the samples on a lathe machine.

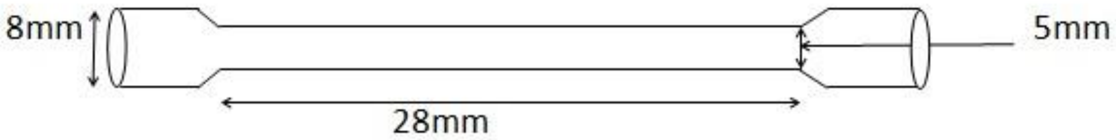

Fig: 2.4: A sketch of the prepared test specimen

2.4.1 Tensile Test

The tensile tests were carried out at the Department of Materials and Metallurgical Engineering, Federal University of Technology, Owerri using a Monsanto Tensometer Machine {type W, serial 11148}. Figure 2.5 below shows the Monsanto Tensometer that was used for the test.

Fig 2.5: Monsanto Tensometer

2.4.2 Hardness Test

The hardness tests were carried out in the Department of Materials and Metallurgical Engineering, Federal University of Technology, Owerri. Rockwell hardness test was performed on the specimens using the Rockwell hardness machine shown in figure 2.6 below.

ISSN 2320-9186

Fig 2.6: Rockwell hardness machine

2.4.3 Metallographic Test

The metallographic tests were carried out at the metallurgical laboratory of the Federal University of Technology, Owerri.

Test specimens were cut from the test materials [5 mm × 5 mm × 5 mm]. The specimens were mounted on a Bakelite thermosetting powder. Each specimen was ground with several emery papers of different coarseness. After grinding, the specimens were polished and then etched before the micro examination test.

3.0 RESULTS AND DISCUSSIONS

Results from the Tensile Test of Aluminium, SiC, PKSA and PSA are presented as thus:

Figures 3.1 to 3.4 below show the Stress-Strain values and curves for Pure Aluminium (Sample 1), Aluminium with 5 wt% SiC (Sample 2), Aluminium with 5 wt% SiC and 5 wt% PKSA (Sample 3) and Aluminium with 5 wt% SiC, 5 wt% PKSA and 5 wt% PSA (Sample 4).

ISSN 2320-9186

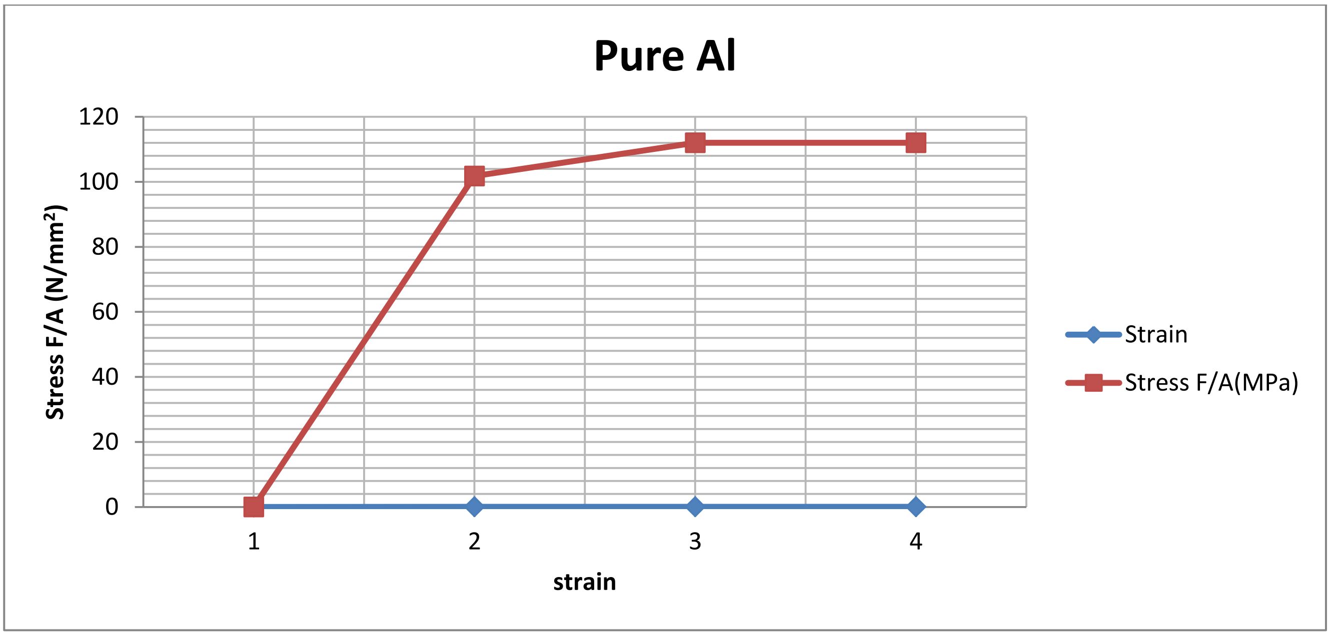

Fig 3.1: Engineering Stress-Strain Curve for Pure Aluminium Sample 1

The ultimate tensile strength and total elongation for the sample of pure aluminium were found to be 112.02N/mm^2 and 7.5% respectively. The yield strength was calculated to be 91.65N/mm^2.

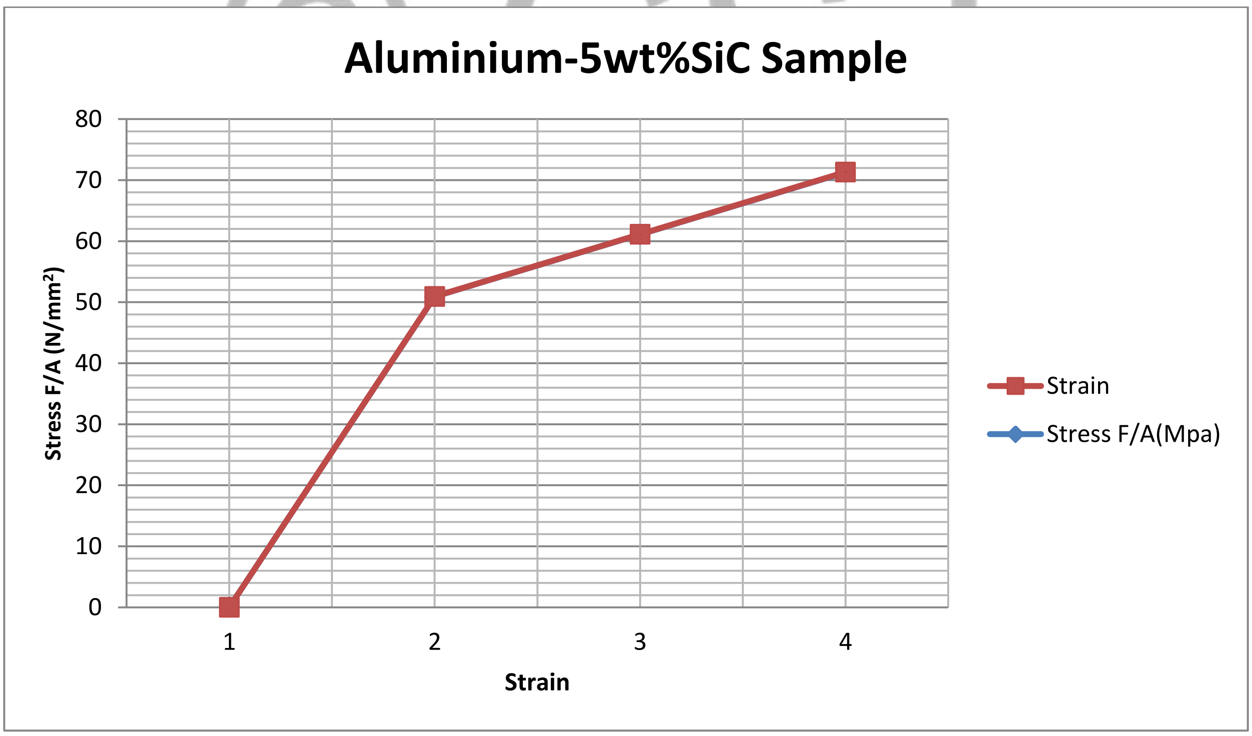

Fig 3.2: Engineering Stress-Strain Curve for Al-5wt% SiC

The ultimate tensile strength and total elongation for the sample of Al-5wt% SiC were found to be 71.28N/mm^2 and 3.57% respectively. The yield strength was calculated to be 61.10N/mm^2

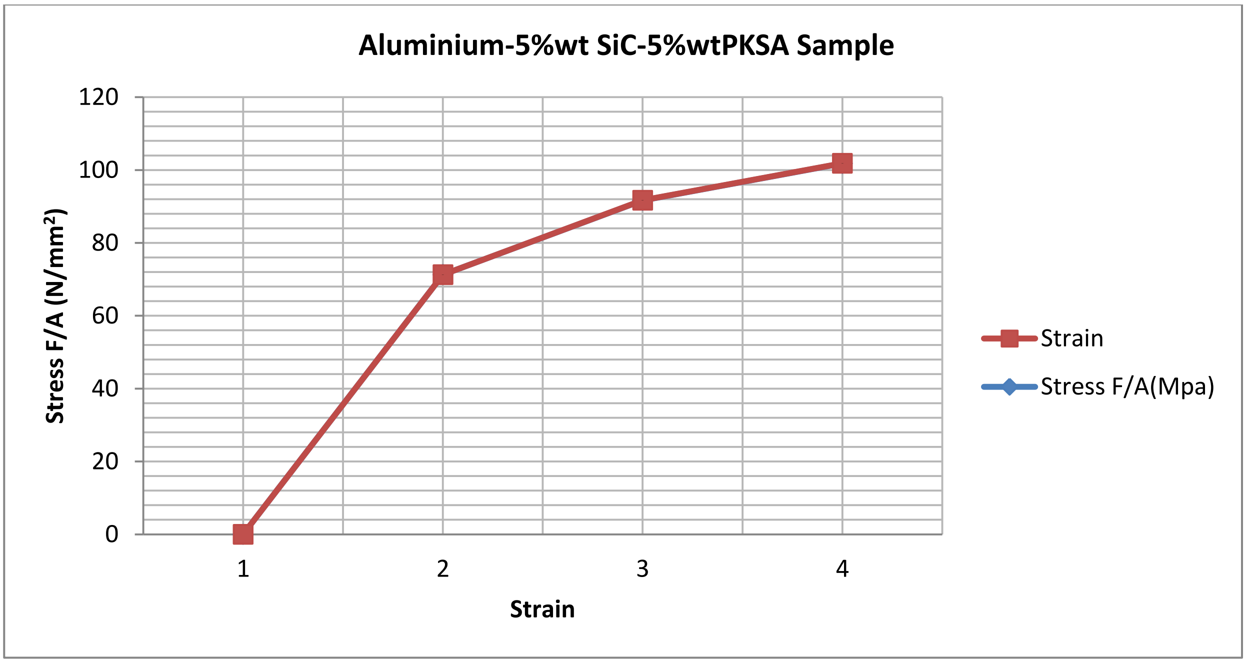

Fig 3.3: Engineering Stress-Strain Curve for Al-5wt% SiC-5wt%PKSA

The ultimate tensile strength and total elongation for the sample of Al-5wt% SiC-5wt% were found to be 101N/mm^2 and 4.64% respectively. The yield strength was calculated to be 91.65N/mm^2

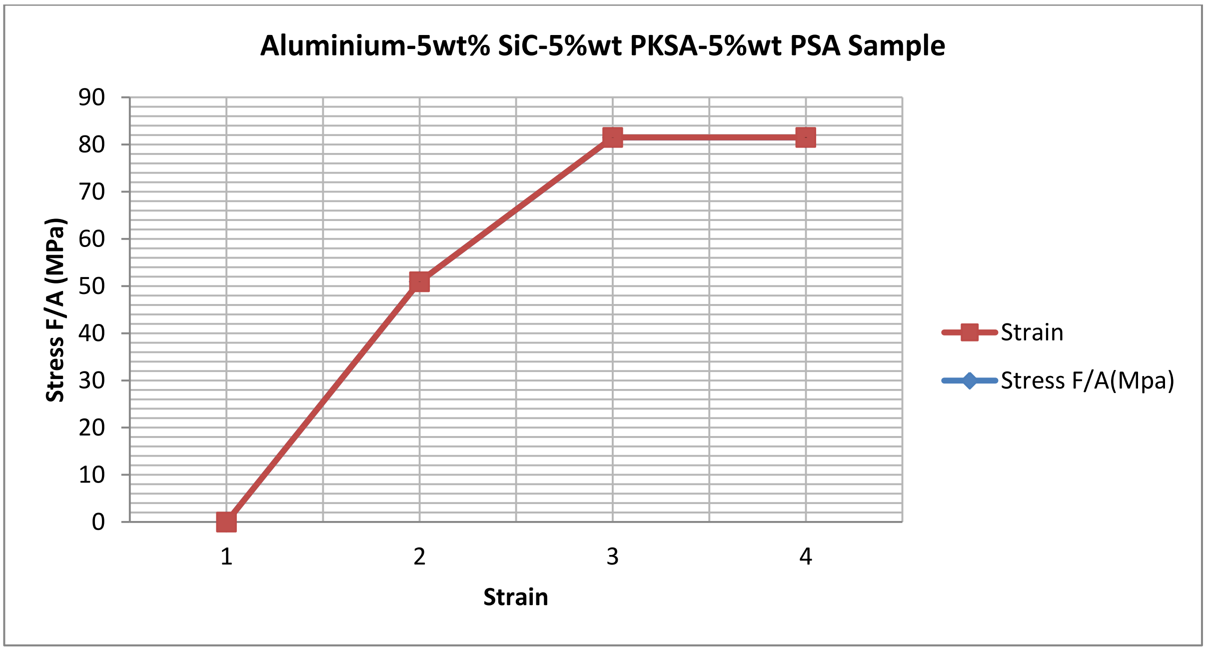

Fig 3.4: Engineering Stress-Strain Curve for Al-5wt% SiC-5wt% PKSA-5wt% PSA

ISSN 2320-9186

The ultimate tensile strength and total elongation for the sample of Al-5wt% SiC-5wt% PKSA-5wt% PSA were found to be 81.47N/mm^2 and 4.64% respectively. The yield strength was calculated to be 71.28N/mm^2.

Results from the Ultimate Tensile Strength of Aluminium, SiC, PKSA and PSA are presented as thus:
Figure 3.5 below show the values and Histogram of the Ultimate Tensile Strength (UTS) of Pure Aluminium (Sample 1), Aluminium with 5 wt% SiC (Sample 2), Aluminium with 5 wt% SiC and 5 wt% PKSA (Sample 3) and Aluminium with 5 wt% SiC, 5 wt% PKSA and 5 wt% PSA (Sample 4).

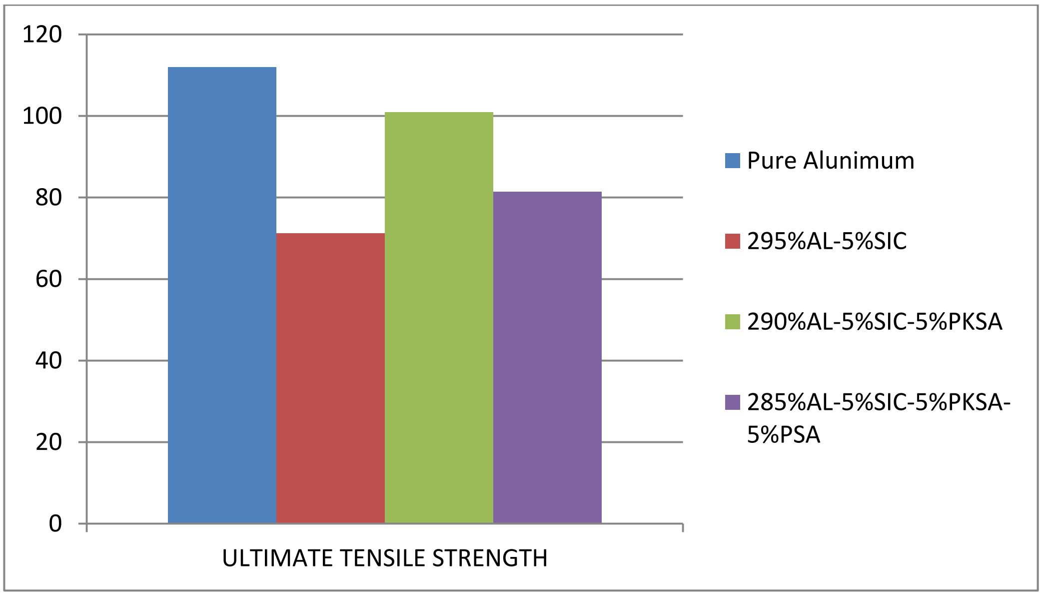

Fig 3.5: Histogram showing values of UTS for Al-SiC-PKSA-PSA samples

Results from the Yield Strength (YS) of Aluminium, SiC, PKSA and PSA are presented as thus:
Figure 3.6 below show the values and Histogram of Yield Strength (YS) of pure Aluminium, Al-5wt% SiC-5wt%PKSA-5wt% PSA.

ISSN 2320-9186

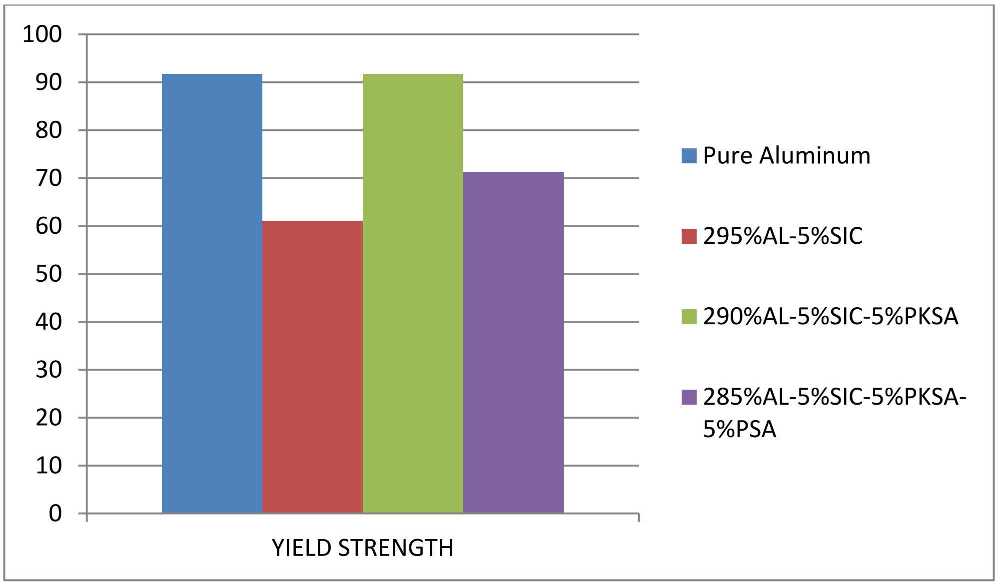

Fig 3.6: Histogram showing values of YS for different Al-SiC-PKSA-PSA samples

Results from the Percentage Elongation of Aluminium, SiC, PKSA and PSA are presented as thus: Figure 3.7 below show the values and Histogram of percent elongation of the samples; pure Aluminium, Al-SiC-PKSA-PSA.

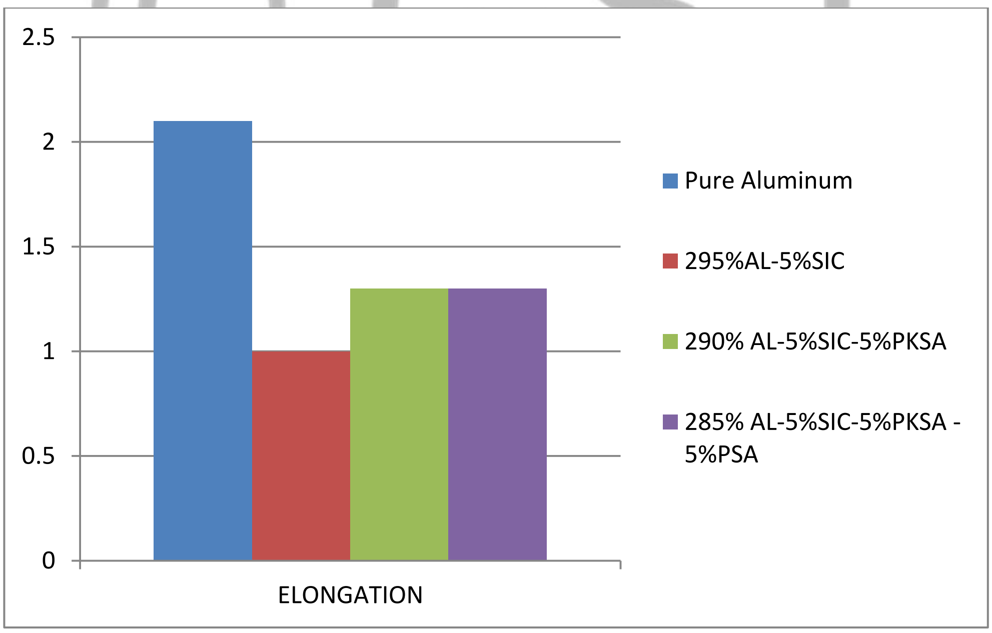

Fig 3.7: Histogram showing values of % elongation for different Al-SiC-PKSA-PSA samples

Results from the Hardness test of Aluminium, SiC, PKSA and PSA are presented as thus:

ISSN 2320-9186

Figure 3.8 below show the values and Histogram of Hardness test of the samples; pure Aluminium, Al-SiC-PKSA-PSA. The hardness tests of all the samples were carried out using a Rockwell hardness testing machine. Minor load of 10kg and a major load of 100kg were used. The reading was taken on the B scale for each composition.

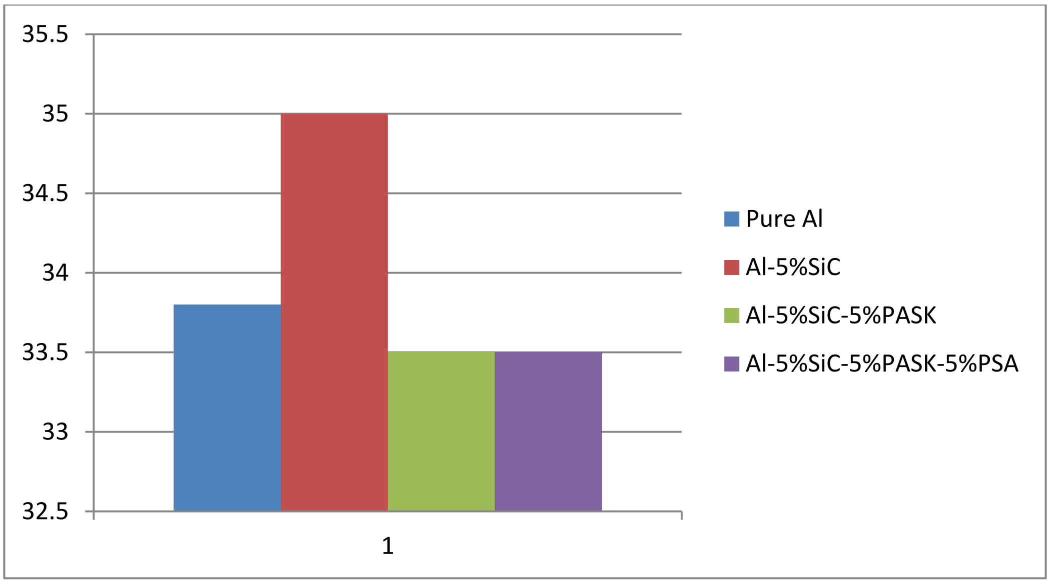

Fig 3.8: Histogram showing values of Hardness Test of Al-SiC-PKSA-PSA Samples

Results from the microstructural examinations of Aluminium, SiC, PKSA and PSA are presented as thus:

Micrographs obtained from computerized optical microscope are shown in figures 3.9, 3.10, 3.11 and 3.12 below for the samples; pure Aluminium, Al-SiC-PKSA-PSA.

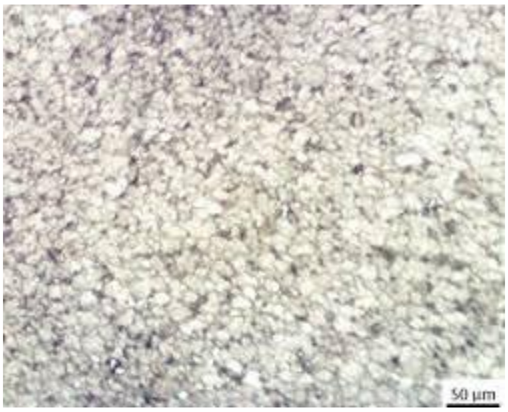

Fig. 3.9: Control sample (Pure Aluminium)

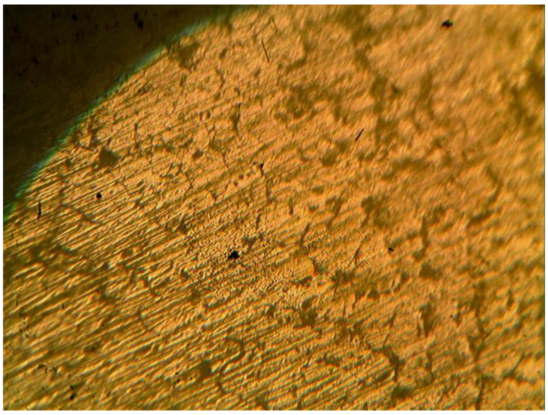

Fig. 3.10: Al-5wt%SiC

ISSN 2320-9186

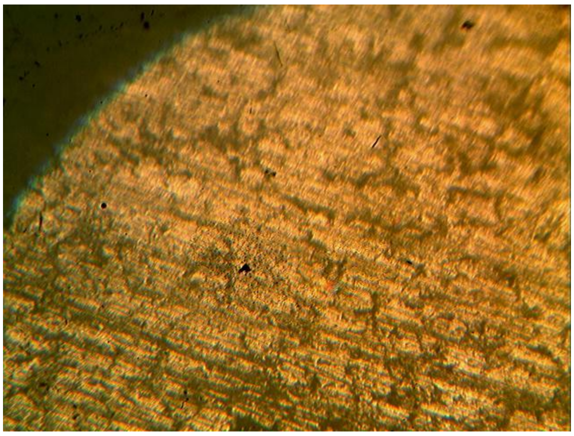

Fig. 3.11: Al-5wt%SiC-5wt%PKSA

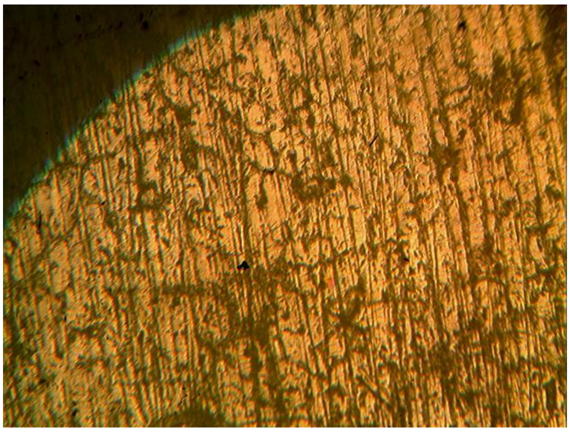

Fig. 3.12: Al-5wt%SiC-5wt%PKSA-5wt%PSA

From the micrograph in Fig 3.9, the pure Aluminium has few impurities in its grain boundary, hence it is 99.1%purity. The main phase is the matrix while the tiny black spots are the impurities or introduced materials in the matrix. From Fig 3.10, the introduced material SiC was randomly dispersed throughout the matrix of Aluminium metal, as the percentage reinforcement of the material increase the dispersed phase increases. From Figures 3.11 and 3.12, the reinforced material is randomly dispersed in the Aluminium matrix which strengthens the material, as the percentage reinforcement increase the dispersed phase in the Aluminium matrix increases as well.

4.0 CONCLUSION

In a developing country like Nigeria where the need for technological growth and advancement is imperative, agro waste materials are not properly disposed or converted into useful substances. There is therefore the need to find ways of converting them into something useful. This research work has provided ways of converting commercial wastes, especially palm kernel shell and periwinkle shell which are posing environmental problems, to useful substances.

From the analysis of results obtained during this study, the following conclusions were made: The ultimate tensile strength of aluminum based metal matrix composite decreases as you add the weight fraction of SiC, increase as you add the weight fraction of PKSA and decrease as you add the weight fraction of PSA particles. The elastic modulus of aluminum based metal matrix composite decreases as you add the weight fraction of SiC, increase as you add the weight fraction of PKSA and decrease as you add the weight fraction of PSA particles. The hardness of aluminum based metal matrix composite increases as you add the weight fraction of SiC and decrease as you add the weight fraction of PKSA and also increase as you add the weight fraction of PSA particles. The ductility of aluminum based metal matrix composite decreases as you add the weight fraction of SiC and increase as you add the weight fraction of PKSA and PSA. Therefore with the observations made on the mechanical properties of pure Aluminium metal reinforced with SiC, PKSA and PSA. SiC and PKSA have a better mechanical properties if used as reinforcement material in Aluminium metal matrix composite.

ISSN 2320-9186

REFERENCES

Adesanya, D. A. . (2001). “The effects of thermal conductivity and chemical attack on corn cob ash blended cement.” *Professional Builder*, 66(5), 3–10.

Adesanya, D. A. and Raheem, A. A. (2009a). “Development of corn cob ash blended cement.” *Construction and Building Materials*, 23(1), 348–352.

Adesanya, D. A. and Raheem, A. A. (2009b). “A study of the workability and compressive strength characteristics of corn cob ash blended cement concrete.” *Construction and Building Materials*, 23(1), 311–317.

Agunsoye, J. O., Talabi, S. I., Obe, A. A.and Adamson, I. O. (2012). Effects of Palm Kernel Shell on the Microstructure and Mechanical Properties of Recycled Polyethylene/Palm Kernel Shell Particulate Composites. *Journal of Minerals and Materials Characterization and Engineering*, 11, 825-831.

Alangaram, U. J., Jumaat, M. Z. and Mahmud, H. (2008). Ductility Behaviour of Reinforced Palm Kernel Shell Concrete Beams, *European Journal of Scientific Research*, 23(3), 406- 420.

Badmus, M. A. O., Audu, T. O. K., and Anyata, B. U. (2007). “Removal of lead ion from industrial wastewaters by activated carbon prepared from periwinkle shell (typanotonus fuscatus).” *Turkish Journal of Engineering and Environmental Science*, 31, 251–263.

Bhanja, S. and Senguptab, B. (2002). “Investigation on the compressive strength of silica fume concrete using statistical methods.” *Cement and Concrete Research*, 32(9), 1391–1394.

Bhatty, J. I. and Taylor, P. (2006). “Sulpahte resistance of concrete using blended cement or supplementary cementitious materials.” *Portland Cement Association*, 1–12.

Brian, R., Yuen, H. C. and Lee, W. B. (1997). The processing of metal matrix composites -an overview, *Journal of Materials Processing Technology*, 63, 339-353.

British Standard Institution (1985). *Structural Use of Concrete Part 2: Code of Practice for Special Circumstances.Ť*. British Standard Institution, London, United Kingdom.

Dagwa, I. M., Builders, P. F.and Achebo, J. (2012). Characterization of Palm Kernel Shell Powder For Use In Polymer Matrix Composites, *International Journal of Mechanical & Mechatronics Engineering*, 12(4), 88.

Dahunsi, B. I. O. and Bamisaye, J. A. (2002). “Use of periwinkle shell ash (PSA) as partial replacement for cement in concrete.” *Proceedings Nigerian Materials Congress and Meeting of Nigerian Materials Research Society*, Akure, Nigeria, 184–186.

Dance, S. P. (1980). *The Encyclopaedia of Shells*. Littlehampton Book Services Ltd., Faraday Close Worthing, West Sussex, United Kingdom.

Doel., T.J.A, Lorretto., M.H. and Bowen, P. (1993), “Mechanical Properties of aluminium based particulate metal matrix composites”, *Journal of composites*, 24, 270-275.

Falade, F. (1992). The use of palm kernel shells as coarse aggregate in concrete. *Journal of Housing Science*, 16(3), 213-219.

ISSN 2320-9186
Gnjidi, X., Boi, D. and Mitkov, M. (2001), “The influence of SiC particles on compressive properties of metal matrix composites”, *Materials Characterization*, l47 (2), 129-138.

Gupta, N., Satyanarayana, K. G. and Materials, C. (2006). “Symposium Review: Solidification Processing of MMCs,” *Journal of Materials Science,* 58(11), 91-93

Hasan, A., (2012). Fabrication of Aluminium Matrix Composites (AMCs) by Squeeze Casting Technique Using Carbon Fiber as Reinforcement, a master thesis in Mechanical Engineering, Ottawa-Carleton Institute for Mechanical and Aerospace Engineering University of Ottawa Ottawa, Canada.

Hashim, J., Looney, L. and Hashmi, M.S.J. (2001), “The enhancement of wettability of SiC particles in cast aluminium matrix composites”, *Journal of Materials Processing Technology*, 119 (1-3), 329-335.

Hashim, J., Looney, L. and Hashmi, M.S.J. (2001), “The wettability of SiC particles by molten aluminum alloy”, *Journal of Materials Processing Technology*, 119 (1-3), 324-328.

Ibhadode, A. O. A. and Dagwa, I. M. (2008). Development of Asbestos-Free Friction Lining Material From Palm Kernel Shell, *Journal of the Brazilian Society of Mechanical Science and Engineering*, 30(2), 166-173.

Jamabo, N. and Chinda, A. (2010). “Aspects of the ecology of tympanotonous fuscatus var fuscatus (linnaeus,1758) in the mangrove swamps of the Upper Bonny River, Niger Delta, Nigeria.” *Current Research Journal of Biological Sciences*, 2(1), 42–47.

Job, O. F. (2008). *The Durability Characteristics of Periwinkle Shell Concrete*. Ph.D thesis, University of Jos, Nigeria University of Jos, Nigeria.

Job, O. F., Umoh, A. A., and Nsikak, S. C. (2009). “Engineering properties of sandcrete blocks containing periwinkle shell ash and ordinary portland cement.” *International Journal of civil engineering*, 1(1), 18–24.

Kandahl, P. (1992). Waste materials in hot mix asphalt, *National Center for Asphalt Technology*, 92-106.

Koffi, N. E. (2008). *Compressive Strength of Concrete Incorporating Periwinkle Shell Ash*. Unpublised B.Sc project, University of Uyo, Nigeria.

lllston, J. M. (1994). *Construction Materials: Their Nature and Behaviour*. Chapman and Hall, London, United Kingdom.

Llyod, D.J., Lagace, H., Mcleod, A. and Morris, P.L. (1989), “Microstructural aspects of aluminium silicon carbide particulate composites produced by a casting method”, *Materials Science and Engineering,* 107, 73-80.

Lucas, J.P., Stephens, J.J. and Greulich, F.A. (1991), “The effect of reinforcement stability on composition redistribution in cast aluminium metal matrix composites”, *Materials Science and Engineering,* 131(2), 221-230.

ISSN 2320-9186
Mares, M. (2001), "Some issues on tailoring possibilities for mechanical properties of particulate reinforced metal matrix composites" *Journal of Optoelectronics and Advanced Materials*, 3 (1), 119 – 124.

McDanels, D. L. (1985). Analysis of stress-strain, fracture and ductility behaviour of aluminium matrix composites containing discontinuous SiC reinforcement, *Metallurgical and Materials Transaction A*, 16, 1105-1115.

Mehta, P. K.and Monteiro, P. J. M. (2006). *Concrete: Microstructure, Properties, and Materials*. McGraw-Hill publishing company Ltd., New Delhi, India.

Mindess, S., Young, J., and Darwin, D. (2003). *Concrete*. Pearson Education Inc., Upper Saddle River, New Jersey, United States.

Mmom, P. C. and Arokoya, S. B. (2010). "Mangrove forest depletion, biodiversity loss and traditional resources management practices in the Niger Delta, Nigeria." *Research Journal of Applied Sciences, Engineering and Technology*, 2(1), 28–34.

Muhamad, N. B., Amiruddin I. and Riza, A. R. (2010). Evaluation of Palm Oil Fuel Ash (POFA) on Asphalt Mixtures, *Australian Journal of Basic and Applied Sciences*, 4(10), 5456- 5463.

Narayana, M. S. V., Nageswara R. B., and Kashyap, B.P. (2003). On the hot working characteristics of 6061Al-SiC and 6061–Al2O3 particulate reinforced metal matrix composites, *Journal of Composites Science and Technology*, 63(1), 119-135.

Ndoke P. N. (2006). Performance of Palm Kernel Shells as a Partial replacement for Coarse Aggregate in Asphalt Concrete, *Leonardo Electronic Journal of Practices and Technologies*, 145-152.

Neville, A. M. (2000). *Properties of Concrete*. Pitman, New York, United States.

Nimityongskul, P. and Daladar, T. U. (1995). Use of Coconut Husk Ash, Corn Cob Ash and Peanut Shell Ash as Cement Replacement. *Journal of Ferrocement*, 25(1), 35-44.

Nwaobakata, C. and Agunwamba J. C. (2014). Effect of palm kernel shells ash as filler on the mechanical properties of hot mix asphalt, *Archives of Applied Science Research*, 6 (5), 42-49.

Okly, D.A. (1987). Chemical and Biological Characterization of the by-products of NIFOR Palm oil. Proceedings of the 1987 international oil palm/palm oil conferences (progress and prospectus) organized by palm oil research institute of Malaysia, Kaula Lumpur.

Okon, B. I. (1987). *Utilization of Periwinkle Flesh by Broilers feed Palm Kernel Based Ratios*. Ph.D thesis, University of Ibadan, Nigeria University of Ibadan, Nigeria.

Okoroigwe, C. E., Saffron, C. M. and Kamdem, P. D. (2014). Characterization of Palm Kernel shell for Materials Reinforcement and Water Treatment, *Journal of Chemical Engineering and Materials Science*, 5(1), 1-6.

ISSN 2320-9186
Olorunoje, G. S. and Olalusi, O. C. (2003). “Periwinkle shell as alternative to coarse aggregate in lightweight concrete.” *International Journal of Environmental Issues*, 1(1), 231–236.

Ourdjini, A., Chew, K.C. and Khoo, B.T. (2001), “Settling of silicon carbide particles in case metal matrix composites”, *Journal of Materials Processing Technology*, 116 (1), 72-76

Powell, C. B., Hart, A. I., and Deekae, S. (1985). “Market survey of the periwinkle tympanotonus fascatus in rivers state: Sizes, prices, trade routes and exploitation levels.” *Proceedings of the 4th Annual Conference of the Fisheries Society of Nigeria (FISON)*, Port-Harcourt, Nigeria.

Sanjeev, D., Siddhartha D. and Karabi D. (2007). Abrasive Wear of Zircon Sand and Alumina Reinforced Al–4.5wt% Cu Alloy Matrix Composites - A Comparative Study, *Journal of Composites Science And Technology*, 67(3), 746-751.

Skibo, D.M, Schuster, D.M, and Jolla, L. Process for preparation of composite materials containing non-metallic particles in a metallic matrix, and composite materials made by US Patent No. 4 786 467, 1988

Sumaila, S. A. and Job, O. F. (1999). “Properties of SDA-OPC concrete: A preliminary assessment.” *Journal of Environmental Sciences*, 3(1-2), 155–159.

Tangchirapat, W., Jaturapitakkul, C., and Chindaprasirt, P. (2009). “Use of palm oil fuel ash as a supplementary cementitious material for producing high-strength concrete.” *Construction and Building Materials*, 23(7), 2641–2646.

Udoeyo, F. F. and Dashibil, P. U. (2002). “Sawdust ash as concrete material.” *Journal of Materials in Civil Engineering*, 14(2), 173–176.

Vannan, E. S. and Vizhian, P. S. (2014). Microstructure and Mechanical Properties of as Cast Aluminium Alloy 7075/Basalt Dispersed Metal Matrix Composites, *Journal of Minerals and Materials Characterization and Engineering*, 2, 182-193.

William, F. and Smith, J. H., (2006) Foundations of Materials Science and Engineering. *Mcgraw* – Hill International Edition.

Zhang, M. H. and Malhotra, M. H. (1996). “High performance concrete incorporating rice husk ash as a supplementary cementing material.” *ACI Materials Journal*, 93(6), 629–636.