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INFLUENCE OF PERCENT WEIGHT VARIATION OF PULVERISED PERIWINKLE SHELLS ON HARDNESS AND TENSILE STRENGTH OF PULVERISED PERIWINKLE SHELLS-ALUMINIUM ALLOY COMPOSITE.

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ABSTRACT
The Development in the applications of Aluminium Alloy in the industries is not unconnected to its lighter weight, recyclability, cost, and availability. The cost of reinforcement materials cause the increase cost of composites production thereby limiting its applications. Efforts to reduce the cost of composite materials is to source alternative reinforcement materials. The addition of pulverised periwinkle shells(PPS) would strengthened Aluminium Alloy, and increased its horizon of applications. To determine the percent weight of Pulverised Periwinkle Shells(PPS) that would give excellent strength to Aluminium alloy(AA) in increasing its hardness and tensile strength.

The Periwinkle Shells were boiled in water at 100^{0}C for thirty (30) minutes, washed using distilled water, dried in an oven at 105^{0}C for 24hours.The periwinkle shells were pulverised and discretised using a sieve shaker of mesh sizes of 70 and 53 microns. The grade of 53microns was used because it was finer. The compositional analysis of AA, PPS, and charge calculations were done and the following percent weight of PPS were used: 10%; 15%; 20%; and 25% as reinforcement, and 0% of as-cast AA was used as the control. Gas crucible furnace was used to melt the AA at 750^{0}C, and the liquid AA was taken out from the furnace and 1% of magnesium was added before the addition of the percent weight of PPS, and the mixture stirred using mechanical stirrer. The slurry was taken back to the furnace and heated, and at 750^{0}C it was fetched and poured into the reusable moulds to produce the test coupons for Hardness and Tensile strength test and the process was repeated for all the compositions. Hardness and tensile strength test was done using Indentec universal hardness tester and Universal testing machine.

The results obtained from the study shows that 20% PPS-AA Composites exhibit the highest hardness number HRB (85.35) and tensile strength value; 204.25MPa compared with unreinforced AA and other reinforced AA. From the results obtained 20% PPS-AA composite would be suitable for applications that required good hardness and tensile strength.

Keywords: Percent weight, Pulverised Periwinkle Shells, Reusable moulds, Wetting, Aluminium Alloy.

1.0 INTRODUCTION

The application of aluminium as an engineering material has been on the increase because of its lighter weight, availability, and recyclability (Francis et al, 2018; Nikhil et al, 2022). The cost of producing particles reinforced composites are expensive due to high cost of reinforcement like, Silicon Carbide(SiC), Boron Carbide(B_4C), and a host of others. The cost of composites has reduced its applications, the use of agro-waste and natural minerals would lower the cost of acquiring composite materials.

Aluminium is one of the most abundant metal on the earth core and very reactive. Preference to new material may be for reasons such as strength, light weight, cost, availability, and recyclability compared to conventional materials (Izadi *et al.*, 2013).

Composite materials are materials made from two or more basic materials with considerably different physical or chemical properties, that when combined, produce a material with properties different from the individual components (Rajesh *et al.*, 2012). Composites materials are classified based on the matrix or the reinforcement used. The following classification based on matrix: polymer; ceramics; carbon; and metals. This study is limited to metal matrix composite. Metal Matrix composite is produced by reinforcing metals like Al, Ti, Cu, Mg and others to increase their strength and widening their horizon of applications.

Aluminium metal matrix(AMCs) is a type of metal matrix that uses aluminium, as the matrix and the particulates as Al_2O_3, SiC and graphite. Rajeshkumar and Parshuram (2013) investigated the production of aluminium matrix composite produced using stir casting process and the reinforcing phases dispersed into molten matrix by a mechanical stirrer. Recent development in stir casting is two step mixing process that involves the heating of the matrix material above liquidus temperature to allow complete melting of the metal Alaneme et al (2013).

Rajesh and Gangaram (2013) Manufacturing of particulate reinforced metal matrix composites(PRMMC) using stir casting process is one of the most economical and simplest method of processing MMC. Sozhamannam et al (2012) reported that the increased desire for Aluminium matrix and SiC reinforcement by most manufacturing industries is because of its lighter weight in combination with high strength and stiffness.

The use of Periwinkle Shells as reinforcement is borne out of the elemental composition obtained from characterisation, and solving environmental problems the Shells causes to where they are dumped after the meat has been consumed. Mfon(2015) investigated the development of an abrasive materials using Periwinkle Shells and reported that the use of Periwinkle Shells as reinforcement increases the hardness, compressive strength, and wear resistant of the product using the inedible outer casing of tiny sea snails which are discarded.

Hashim(2001) reported that placing all substances in a graphite crucible and heating in an inert atmosphere until the matrix alloy melted, has advantages in terms of promoting wettability between silicon carbide particles and the matrix alloy. The problem of poor wettability of a ceramics and a metallic melt is enhanced by the use of Mg as a wetting agent and the combination of the two methods were used to give a very good wettability between silicon carbide particles, and the matrix alloy. Jenix et al (2012) defined wettability as the ability of a liquid to spread on a solid surface, and further describes the degree of intimate contact between a liquid and a solid. The addition of solid ceramic particles into the metal melt requires wetting of the solid ceramic surface. Metal coating of ceramic particles increases the total surface energy of the solid, and improves wetting by increasing the contact interface of metal to metal in place of metal to ceramic. Pradeep S., et al(2008) reported graphite/magnesium, graphite/aluminium, and several other fibre-reinforced composites as valuable structural materials because they possess high specific strength and stiffness with a near-zero coefficient of thermal expansion, and high electrical, and thermal conductivities. Wetting, and bonding of the fibres with the metal is achieved by coating the fibres with a thin layer of titanium, and boron or $SiO_{2.}$ Also posited that the following factors: heat of formation; temperature; contact times; electron valence; and stoichiometry are considered for wetting of particles by liquid metals. Hashim, (2001)reported the production of PPS/AA6063 composite using modified stir casting method. The uniform dispersion of PPS in AA6063 alloy refines grains from coarse to fine in smaller particles size, improves strength, elastic modulus, ductility, and hardness of the composite. The properties obtained depend on the PPS particle size and volume fraction in AA6063 alloy. The composites are cheaper than aluminium matrix reinforced with carbides, oxides, and boride fillers. The composites can be used in applications where strength and weight are required in electronics, aerospace, and automotive such as liners in engines.

2.0 MATERIALS AND METHODS

2.1.1 **Matrix**

The matrix used for the investigation was pure aluminium (97.81%Al) gotten from Tower Aluminium, Sango- Ota, Industrial Estate, Ogun State. The chemical composition was done to ascertain the chemical composition of the sample and it was carried out at the company's laboratory using Spark Test. The following table shows the result of the test.

Table1: Elemental Composition of Aluminium

Element	Fe	Si	Mn	Cu	Zn	Ti	Mg	Pb	Sn	Al
% Composition	0.823	0.546	0.088	0.145	0.204	0.013	0.366	- .013	- .016	97.81

2.1.2 **Reinforcement**

Pulverised Periwinkle Shells (PPS), biological waste bought from the local market Nkwo, Nnewi, Anambra state was washed and dried in the sun for a period of two weeks; the dried periwinkle Shells was pulverised using a ball mill. The PPS was discretised using sieve shaker with the following mesh sizes 70, and 53. The sieves were arranged in a descending order, the 200 followed by 270. The machine was switched on and allowed to work for 15mins for each batch of screening of 100g of PPS. The grade of 53μm was used because the finer the particle the better the dispersion and strength (Ramnath, 2014; and Amir, 2019). Sample of the grade was analysed using Sky ray Instrument EDX 3600H Alloy Analyser. Table 2 below shows the compositional analysis.

Table 2: Elemental Composition of Pulverised Periwinkle Shells

Element	%
Mg	30.689
Al	0.007
Si	0.062
P	4.143
K	8.73
Ca	13.662
Ti	38.291
V	9.172
Cr	7.014
Mn	6.315
Fe	4.853
Co	7.363
Ni	4.336
Zn	2.909
As	1.206
Zr	0.019
Nb	0.007
Mo	0.259
Ag	0.465
W	3.073

Au	0.298
Hf	1.076
Hg	0.254
Bi	0.003

2.2 **Methods**

There are two types of processing methods namely: solid state; and liquid state. The liquid state processing and double-stir casting method was adopted (Alaneme et al 2016; Rajesh, and Gangaram, 2013). Stir casting process is mainly used for manufacturing of particulate reinforced metal matrix composite (PRMMC). Manufacturing of aluminium alloy based casting composites by stir casting is one of the most economical method of processing MMC. Rana et al(2012) describes stir casting as the process where the reinforcement are distributed in the molten Aluminum Alloy by mechanical stirring.

The furnace used for the composite fabrication was a gas fired crucible furnace, preheated for Ten(10) minutes to remove dampness. The calculated amount of AA ingot was charged into the furnace and covered with the lid after charging till there was a yellow flame to signal that the AA has melted. It was further heated to 750^0C for the AA to melt completely.

The crucible pot was removed from the furnace and 1% of mg was added to the melt to create the surface for bonding and upon addition of Mg to the melt a glowing light emanated from the surface and after the dazzling flame, the PPS preheated to 250^0C was introduced via the side of the pot into the mixture and stirred using a mechanical stirrer for five minutes and upon turning to paste the mixture was further heated before the composite slurry was fetched and poured into preheated reusable moulds to produce the various test coupons: hardness; and Tensile Strength. The left- over returned to the furnace before the removal of the castings from the mould after it has cooled.

The melting and casting process was repeated for the following: 74%AA, 25% PPS; 79%AA, 20%PPS; 84%AA, 15% PPS; and 89%AA, 10% PPS and 1% Mg in all the castings. Four samples were produced of all the required test pieces and the castings were labelled 0%, 10%, 15%, 20%, and 25%. 0% was AA castings without PPS and Mg that was used as the control.

2.2.1 **Hardness Test (Rockwell Test)**

Hardness is the degree of resistance to scratch or a measure of the surface strength of a material. Indentec Universal Hardness Tester can be used to perform the following: Vickers; Brinel; and Rockwell using the specified indenter. Rockwell is used in all metals except where the test metal structure or surface conditions would introduce too much variation, and where the indentations would be large for the application, or where the sample size prohibits its use.

Rockwell B was used to test for the hardness of PPS/AA composite sample because the material is not as hard as steel. The PPS/AA sample was held by a work-holder and an indenter of 1/16inch steel ball was used to put the mark on the surface of the samples before the preload of 10KgF and was increased to 100KgF and held for a predetermine dwell time(10seconds for standard test). The load was decreased to the preload and the difference in the depth of the indentation between the initial and final preload positions was determined. The conversion of the depth to Rockwell Hardness(HR) value was done using the following equations:

$$HRB = 100 - 500 \times d \qquad 1$$

$$130 - \left(\frac{h}{0.002mm}\right) \qquad 2$$

h=indentation depth in mm,

$$HR = N - hd \qquad 3$$

HR=hardness number, N value is 130 and 100 for scale B, d=depth of penetration(mm), h value is 500 for scale B and C

It was easier to performed, more precise; measures the permanent depth of indentation produced by a force/load and the depth of indentation showed hardness of the material. Figure 2.1 below shows the hardness testing machine.

Figure 2.1: Hardness testing machine

2.2.2 **Tensile Test**

Tensile Test is one of the most important mechanical tests for all mechanical designs and fabrications; it provides essential data for material selection, evaluation, and quality assurance. The test helps to give critical input for material integrity assurance that it will meet the minimum required tensile/ yield strength, and elongation for the product life.

The coupon of standard dimensions and gauge length was placed between two fixtures called grips, and the load applied to the material gripped at the upper end, and fixed at the base of the machine. The gradual increase of the weight and the corresponding elongation of the sample measured and recorded against the applied load. The load was reduced after the elastic limit; the sample continue to elongate, and become thinner and thinner(necking) till it fractured. The test was conducted for other samples. The results and graph were printed from the dedicated computer.

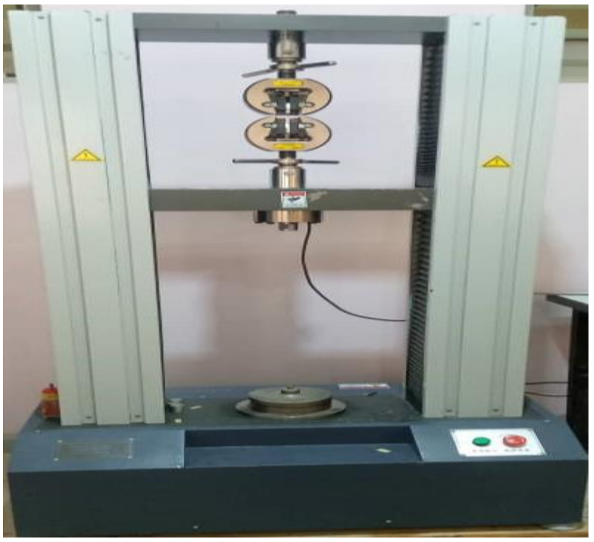

Figure 2.2: Universal Testing Machine

3.0 RESULTS AND DISCUSSIONS

3.1 Hardness

Hardness of AA was done using indenter universal hardness tester and four samples were subjected to the test and the mean of the result was obtained to be 64.49HRB) and similar thing was done to the reinforced coupons and the mean obtained for the various compositions. The hardness of AA and PPS/AA composite were used to plot the figure 3.1. It was observed that 20% PPS reinforcement has the best hardness with a value of 87.5 (HRB) followed by 25% reinforcement. The unreinforced AA was harder than 10%, and 15% reinforced PPS/AA Composite. Figure 3.1 below shows the plot of hardness against percent weight variations.

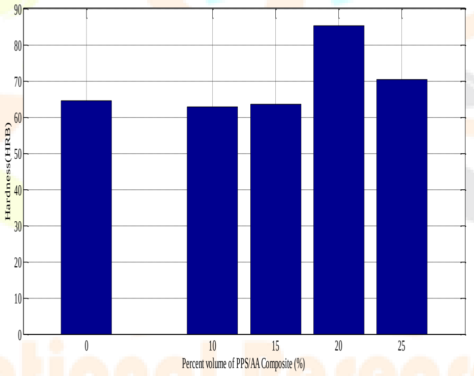

Figure 3.1: The Plot of Hardness against Percent weight of PPS in PS/AA Composite

3.2Tensile test.

The plot in figure3.2 shows that the PPS reinforced AA have better strength to unreinforced AA. From the plot it showed that 20% PPS weight has the highest tensile strength followed by 25% PPS weight, 15% PPS weight in PPS/AA composite, 10% PPS weight in PPS/AA composite with tensile strength 110.67MPa, and AA with tensile strength 110.46MPa.

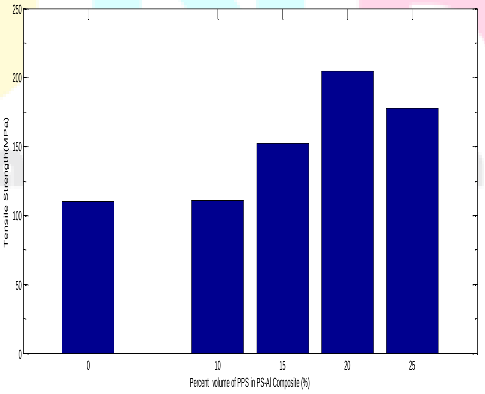

Figure3. 2: The plot of tensile strength against percent weight of PPS in PS/AA Composite.

Conclusion

The highest value of hardness and tensile strength obtained was 20% weight of PPS/AA composite, implying that 20% PPS/AA was the best mix. The PPS/AA composite with 20% weight of PPS has the highest tensile strength with a value of 204.25MPa and hardness number HRB(87.5). The reinforced AA has higher tensile strength than the unreinforced AA, while 20% and 25% reinforced AA has higher hardness number to unreinforced AA. The unreinforced AA exhibit higher hardness number HRB(64.4) than 10%, HRB(62.7) and 15% HRB(63.5) reinforced AA. This could mean that 10% and 15% reinforcement act like inclusions thereby reducing the hardness of AA.

Recommendation

20% PPS reinforcement of AA is recommended as the best mix. Further work is required.

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