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Mechanical Behaviour Assessment of Banana Fibres Reinforced Polymeric Composite with Aluminium-Powder Filler

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Abstract

The development of newer materials necessitates bringing composite material as an alternative to conventional materials usage in engineering applications. An especially Natural Fibre-Reinforced Plastic (FRP) finds their role in the modern era. Before applying natural FRP in the industry, the investigation of mechanical behaviour and related application tests are essential for the better replacement of existing materials. The present work studies banana natural reinforced plastics with aluminium powder as to facilitate the use in an automotive body components. The composite was fabricated from banana fibre-filled Aluminium powder (Al-Powder) through a resin-hardener mixture by simple hand lay-up technique using compression mold. The samples were fabricated on a fixed weight percentage of banana fibres by varying Al-powder filler of 5, 10 and 15wt% to analyse the mechanical and physical properties. Four samples i.e., banana FRP composite (sample ‘A’), banana FRP filled 5wt% of Al-powder filler (sample ‘B’), 10wt% Al-powder filler (sample ‘C’), and 15wt% Al-powder filler (Sample ‘D’) were used respectively. Tensile strength, compression strength, density, micro-hardness, water absorption percentage, and microstructure were conducted. The results showed that tensile strength has been increased by adding Al-powder up to 10wt%v as 33.07MPa. Beyond this 10%wt of Al-powder, tensile strength shows reduction. The density of composite samples filled Al-powder increases as the wt% of Al-powder increase. The microstructure of sample ‘C’ exhibits better than other samples. The compression strength 59.78MPa is observed in sample ‘B’ as higher than other samples.

Keywords: Banana fibres; Natural FRP; Aluminum Powder; Resin; Mechanical Properties.

1. Introduction

Increasing attention towards sustainable development and environmental awareness forces the researchers to explore more on the green biodegradable materials based on agricultural wastes composite materials [1,2]. Thus, the use of natural polymeric composite in various applications has grown rapidly. Moreover, the automotive and packaging industries are demanding to shift of their design from the oil-derived polymers and mineral reinforcement materials to the natural materials by focusing on the recyclability or biodegradability of ‘‘green’’ products at the end of life [3]. Natural fibre composites possess better electrical resistance, good mechanical properties, good thermal and acoustic insulating properties, also higher resistance to fracture [4-11]. Natural fibres are renewable, non-abrasive, and bio-degradable, possess a good calorific value, exhibit excellent mechanical properties and can be incinerated for energy recovery has low density, and inexpensive. This environmental friendly feature made the materials very popular in the automotive and construction industry [4-11]. A common application of natural fibre-reinforced composites includes interior panelling for aircraft, and automobiles, household tables, chairs, window frames, laptop cases, and other consumer items. Natural fibres composite is valued for their sustainability and lightweight compared to similar conventional composites [12]. However, some of the limitations to prevailing use, in common practice, include higher moisture absorption, poor wettability, adhesion, and de-bonding [13]. In some cases, natural fibre exhibits large variation in mechanical properties, more sensitivity to ultra-violet radiation, and low resistance to impact [14]. In general polymeric composites, fibre is embedded in or bonded to the polymeric matrix to offer high strength and modulus with a distinct interface between them. In this composite form, both fibre and matrix retain their chemical and physical identity without losing their abilities. The formation of fibre with the polymeric matrix is termed fibre-reinforced plastics (FRP). Fibres are a load-bearing member and matrix maintaining

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desired to orientating and locating the fibre to act as load transfer medium and protect from environmental damage [15].

The form of reinforcements is of three types; particulate, discontinuous fibre, and continuous fibre. In polymer matrix composites (PMC), the matrices are epoxy and polyester and vinyl-ester resins [16]. The matrix is mostly used to take compressive, in-plane shear and inter-laminar strength, however, poorer in tensile loading. The amount of bearing strength depends on the type of matrix used [17]. In polymer matrix composites the most important function of the matrix is to distribute the applied stress among the fibres. The applied stress must be transferred across the fibre/matrix interface, transverse, longitudinal, shear strength of polymer matrix composite depend heavily on the interfacial bond strength. Thus, the bonding must be maximized if the full strength of reinforcing fibre is to be realized, making accurate characterization of interfacial bonding in composite materials [18].

1.1. Physical and Mechanical Properties of Banana Fibres

Banana fibres having more advantageous in-terms of higher aspect ratio which exhibit the highest tensile properties provide high surface areas, advantageous for reinforcement purposes [19].

Table 1. Physical Properties of Banana Fibres [19-21]

S. No	Properties	Value
1	Moisture	10-11%
2	Density	1-1.5g/cm^3
3	Young's Modulus	20GPa
4	Microfibrillar angle	11°
5	Lumen size	5mm
6	Flexural Modulus	8.9GPa
7	Diameter	80-250µm
8	Length	1000-5000mm
9	Aspect Ratio (l/d)	150

Short banana fibre mechanical properties were reported [22] that the volume fraction of the fibres promotes the dynamic mechanical characteristics in FRP. It also improved the properties like flexural and impact strength which are superior to hybrid composite [23].

Table 2. Mechanical Properties of Banana Fibres [19-21]

S.No	Properties	Value
1.	Tensile Strength	529-914MPa
2.	Impact Strength	13.25kJ/m^2
4.	Flexural Strength	57.33MPa
5	Failure strain	1-3%

1.2. Filler /Aluminum Powder Filler Properties

In metal matrix composites (MMC) materials like Aluminium or Magnesium are frequently used as matrix material in many industries applications. It is due to their lower density, better wear, corrosion resistance, and high strength to weight ratio, etc. Aluminum-based composites reinforced with micro/nano SiC, Al_2O_3, B_4C, TiB_2, ZrO_2, and SiO_2, and graphite particles, make the microstructural characteristics superior in automotive/aerospace applications [22]. In PMC, Aluminium particulate composites, the Aluminium powder can be added with epoxy resin and hardener to modify mechanical properties as compared to a conventional type of epoxy mixture [23]. Also many other researches on the mechanical behaviour evaluation were also reported [24-26]. In recent times, experimental investigation, theoretical prediction, waste plantain utilizations, and influence of Nano-/Micro-filler addition of various natural fibres with different filler and conditions were all studied, and revealed their impact in industry applications [29-37].

Based on existing studies, the present study is defined to fabricate and analyze the mechanical and physical properties of Banana fibers reinforced polymer composite filled by Al-Powder filler for automotive application.

2. Experimental Methodology

2.1. Preparation of Banana fibres FRP with Aluminium-powder filler

The samples were fabricated based on weight fraction. The fabrication procedure of laminated composite was shown in Fig. 1 and listed below.

- The banana fibre was washed repeatedly by down running water and dried in the air. The banana fibre was treated by using 5% NaOH. Then, the treated fibre was washed many times till it became neutral using down running water and dried in air
- Unsaturated polyester resin and hardener (Catalysts) used for specimen preparation
- The mould was prepared to form an Aluminium sheet for sample fabrication
- A simple hand lay-up composite production method was used followed by compression moulding for 24 hours to remove excess resins and air bubbles
- Treated banana fibres without/with Al-powder filler and fabricated layer by layer using resin by hand lay-up and roller
- The curing of the product at room temperature for 48 hours
- The fabricated sample was made into specimens based on tests standard to evaluate their mechanical and physical properties.

Unsaturated polyester resin, Al-powder filler, and hardener were mixed based on the weight ratio. Generally, all samples were produced based on the treated fibre-filled Al-powder filler in a four different ratios to resin-hardener mixtures. The whole mixing ratio was done based on weight ratios.

2.2. Composition of PMC for experimental study

The PMC preparation was based on 10% fixed weight ratio of banana fibre to the resin-hardener mixture. The preparation procedure was indicated in Fig. 2 in various steps.

The produced mould for sample production was cleaned by releasing agent (wax) and dried before pouring resin-hardener mixture/resin-hardener-Aluminium powder mixture on it. The mixed resin-hardener mixture/resin-hardener-Aluminium mixture based on weight percentage stirred manually was poured in the clean mould. The treated banana fibres were distributed uniformly over resin poured on the mould in a non-woven orientation. Again, resin-hardener mixture/resin-hardener-Aluminium powder was poured on the banana fibre layer. The excess resin and air bubbles were removed from the composites by using a hand roller. It was also used to uniformly distribute a mixture of resin-hardener/resin-hardener-Aluminium powder through the composites. Then, banana fibre and mixtures of resin were added till the required thickness of the samples obtained. Then, it was compressed under 50kg load for 24 hours to remove excess resin mixture and air bubble. The sample composition and user's identification code were indicated shortly in Table 3.

Table 3. Fabrication of composites samples

Sample Code	Composition (wt %)
A	Resin-hardener (90 wt %) +Banana Fiber (10 wt %)
B	Resin-hardener (85wt %) +Banana Fiber (10wt %) + Aluminum Powder filler (5wt %)
C	Resin-hardener (80wt %) +Banana Fiber (10wt %) + Aluminum Powder filler (10wt %)
D	Resin-hardener (75wt %) +Banana Fiber (10wt %) + Aluminum Powder (15wt %)

Note: A represented a Banana fiber reinforced Polyester matrix composite

B=Banana fiber reinforced Polyester matrix filled by 5wt% Al-powder composite.

C=Banana fiber reinforced Polyester matrix filled by 10wt% Al-powder composite

D=Banana fiber reinforced Polyester matrix filled by 15wt % Al-powder composite

2.3. Mechanical Properties of Natural fibre

To obtain better mechanical properties of the composite, cause-effect plays a greater role. The causes/parameters that should be considered in fabrications of laminated composites are shown in Fig. 3, cause-effect [fishbone] diagram. The cause/parameters are those controls in hand lay-up process which got attention to obtaining a quality product. By considering these six root causes, laminated composites were fabricated from banana fibre-reinforced polymer composite filled Al-powder filler.

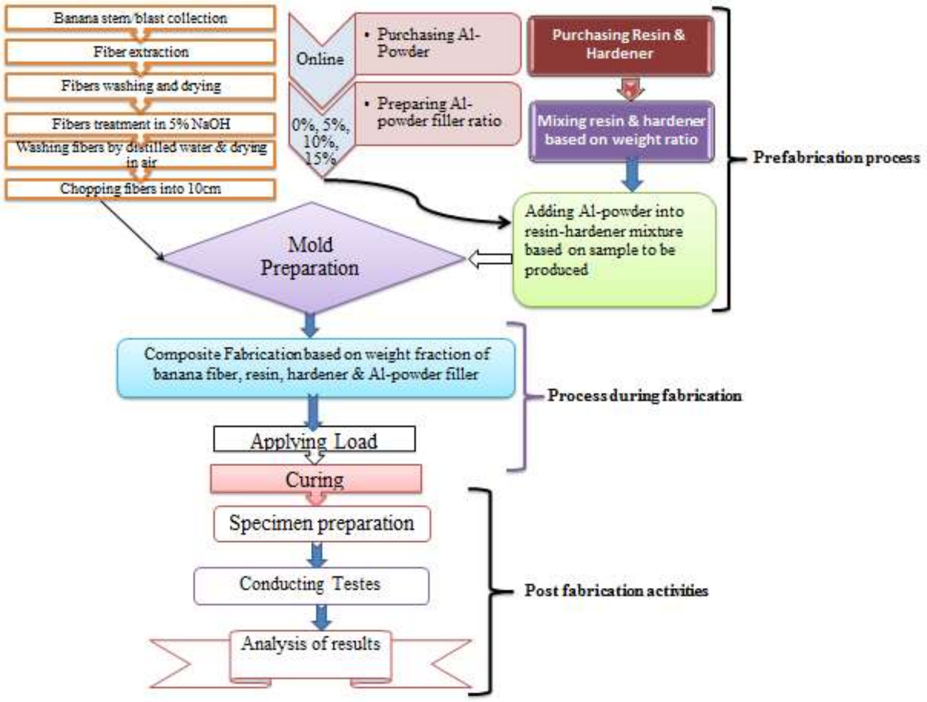

Figure 1. Flow diagram of sample prefabrication, during fabrication and post-fabrication process

Figure 2. Banana fibre reinforced polymer composite fabrication procedures

2.4. Fibre orientation and reinforcement

The fibre orientation selected for this study was chopped short and randomly distributed (non-woven mat fashion). The fibre was chopped into 80-100mm length and randomly distributed over 1200x750mm^2 areas and filled with Al-powder filler and resin mixture. After equally distributed over the area, the load was applied over fibre to hold fibres on distributed location under compression moulding method. Mixing and curing process occurs before applying the whole mixture to produce the composite. The test batch verifies that resin: hardener to Al-powder filler ratio is accurate each time.

2.5. Experimental setups and Procedures

Specimen for Mechanical and physical tests are prepared according to dimension requirement and ISO 6892-1 standard. The average results of the test were taken for analysis. For density measurement, three specimens were taken from each sample and an average result was taken for analysis. Physical tests such as Microhardness and water absorption tests were conducted on single specimens of each sample. The dimension requirement for tensile strength test on 2000kN UTM of Ethiopian Conformity Assessment Enterprise based on ISO 6892-1 were shown in Fig. 4. Three specimens per sample were prepared by using a circular cutter and grinder and finally polished by polishing paper. Microstructure and micro-hardness specimens were also shaped using an abrasive cutter. The specification identification code for this study is indicated in Fig. 5. Similar manner, compression test was also conducted on UTM-50kN as shown in Fig. 6 along with the test specimens.

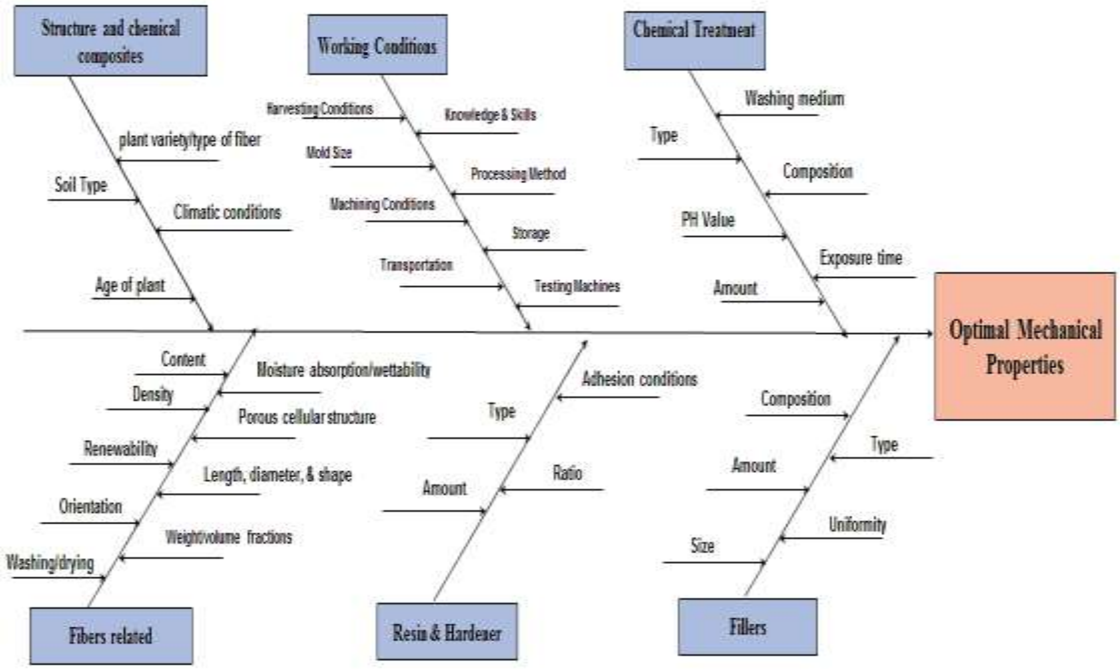

Figure 3. Fishbone diagram showing probable factors affecting the properties of FRP

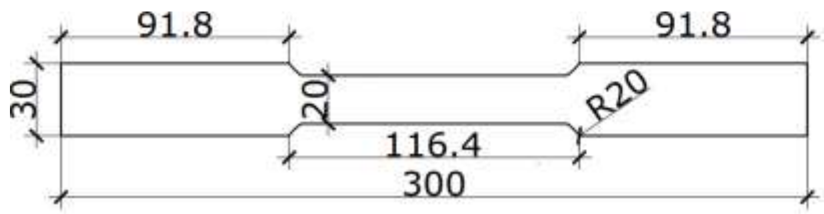

Figure 4. Specimen dimension for tensile test

2.6. Test and procedure

The details of the tests and machines to characterize the banana fibre-Aluminium filler composites are listed in Table 4.

Tensile and compression test was done at Ethiopian Conformity Assessment Enterprise on UTM 2000kN and UTM-50kN respectively. It determines the tensile and compression strength of banana fibre polymer composite filled Al-Powder filler in the prepared samples. The specimens were designed as **A1, A2, A3, B1, B2, B3, C1, C2, C3** and **D1, D2, D3** based on the Aluminium powder filler content and trial number for each sample.

2.6.1. Density measurement

The density (ρ_{ce}) of the composite was determined by immersing the specimen in the water. Weight of the sample by digital weighing machine and the volume of each sample was obtained from displaced water level during immersion of composite into the water. Figure 7 shows the weight and density measuring method for fabricated banana fibre reinforced polymer composite samples.

Table 4. Tests and machine on which tests were conducted

S. No	Name of the test	Name of the Machine
1	Tensile Strength	UTM-2000kN
2	Compression test	UTM-50kN
3	Density	Water immersion method
4	Micro Hardness	Vickers Hardness Tester (HVS-50)
5	Moisture Absorption	Water immersion Method
6	Microstructure	Metallurgical Microscope

Figure 5. Specimen identification codes (User's code) for tensile test

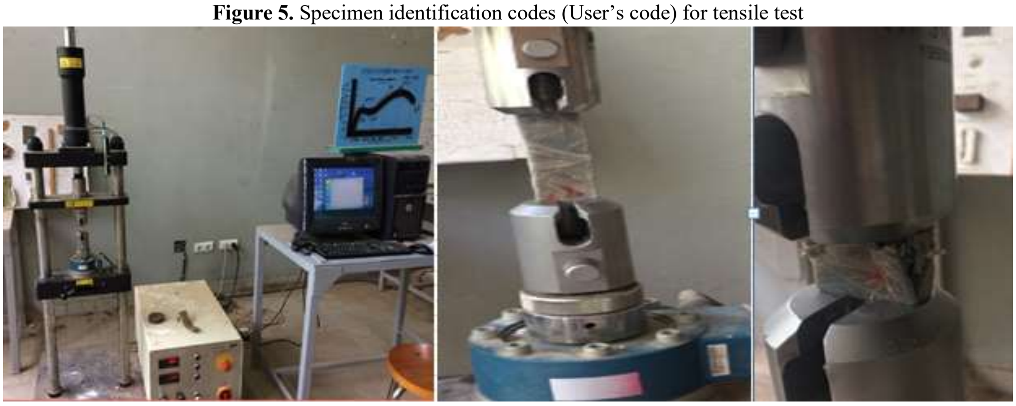
Figure 6. Compression Stress testing UTM-50kN

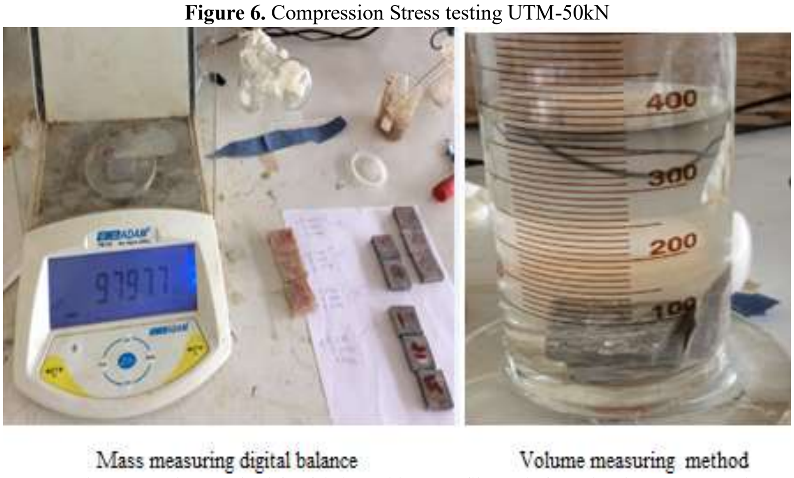

Figure 7. Density measuring method for fabricated banana fibre reinforced polymer composite samples

2.6.2. Micro-hardness test

The Vicker's hardness HVS-50 machine used for this study has a measuring range: 5-2900 HV; Test Force: 9.807, 49.03, 98.07, 196.1, 294.2, 490.3N, the maximum height of test piece: 180mm, depth of throat: 125mm; magnifications of the measuring system: 125×, 250×; and minimum measuring unit of the optical micro-meter: 0.5µm. The load applied during the hardness test was 49.03N on samples shown in Fig. 8. The average result was taken for comparison of HV value of all samples.

Figure 8. Samples for Hardness test

2.6.3. Water Absorption percentage

The moisture absorption test was observed as per ASTM D570-98 standard. Each type of test specimen sample was weighed before and after water immersion. The duration was eight days. The specimen size was 30×30mm². The following equation obtained was adopted [23]

$$\%\text{Water Absorption} = \frac{Wt-Wo}{Wo} \times 100 = \frac{mw-ma}{ma} \times 100$$

Where: w_t = weight of the wet sample
w_o = weight of the dry sample
m_w = mass of the wet sample
m_a = mass of dry samples

2.6.4. Microstructure observation

The Microstructure of Banana fibre reinforced filled by Al-powder filler was observed by using Metallurgical Microscope of model: Huvitz HR-300 series, magnification: 50×, 100×, 200×, 500×, 1000×, scanning area: 104×102mm, illumination system: 12V, 1000W halogen lamp shown in Fig. 9. All, samples were seen at 50× magnification.

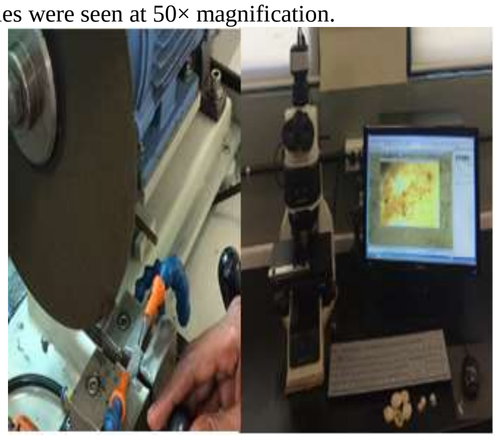

Figure 9. Abrasive cutting in action (RB-203), Microscopic study under Metallurgical Microscope

3. Results and Discussion

Based on the objectives and methodology, the results of physical properties are listed in Table 5. The graphical interpretation of data and analysis is discussed in a subsequent section based on the results obtained from the experiment.

Table 5 shows individual results of each sample specimen for tensile strength, compression strength, and actual density. For results analysis, the average value of each test has been taken. The analysis for tensile strength, compression strength, and density has been carried out in the below sections.

Table 5. Tensile strength, compression strength, and density results of banana FRP composites

Sample code	Tensile strength (MPa)	Compression Strength (MPa)	Density (g/cm³)
Treated banana fibre composite with unsaturated polyester resin (90wt %) +banana fibre (10wt %)			
A_1	28.1	21.48	1.031
A_2	19.8	33.91	1.098
A_3	23.7	**27.69**	1.079
Average	**23.87**		**1.069**
Treated banana fibre composite with unsaturated polyester resin (85wt %) +banana fibre (10wt %) + Aluminum Powder (5wt %)			
B_1	32.8	74.06	1.096
B_2	32.3	45.5	1.095
B_3	23.7	**59.78**	1.096
Average	**29.6**		**1.096**
Treated banana fibre composite with unsaturated polyester resin (80wt %) +banana fibre (10wt %) + Aluminum Powder (10wt %)			
C_1	42.1	21.46	1.075
C_2	24.7	26.67	1.138
C_3	32.4	**24.06**	1.239
Average	**33.07**		**1.151**
Treated banana fibre composite with unsaturated polyester resin (75wt %) +banana fibre (10wt %) + Aluminum Powder (15wt %)			
D_1	25.3	43.74	1.154
D_2	35.6	35.52	1.178
D_3	30.9	**39.63**	1.244
Average	**30.6**		**1.192**

3.1. Tensile strength

Based on test results, the tensile value of sample ‘C’ (banana fibre reinforced polymer composite filled 10wt% Al-powder filler) has been noted more than other composites. It has been observed that by increasing Al-powder filler upto 10wt% tensile strength increases.

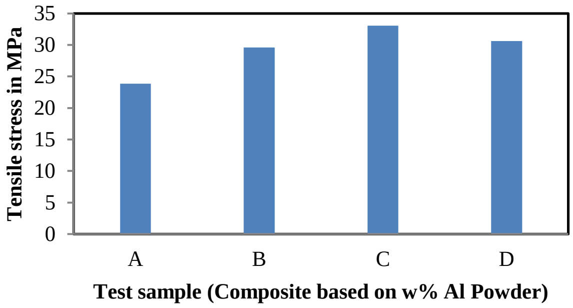

Figure 10. Tensile stress Vs composite samples based on wt% of Al-powder filler

However, beyond 10wt% Al-powder filler there is decrement in the tensile strength of the composite. From this study aspect, Sample ‘A’ (banana fibre-reinforced composite that doesn’t have Al-powder filler) exhibits lower tensile stress as shown in Fig. 10.

3.2. Compressive strength

From the compression test, sample ‘B’ (banana fibre reinforced polymer composite filled 5wt% Al-powder filler) has been recorded with higher compression strength and followed by Sample ‘A’ and ‘C’ as shown in Fig. 11. The lowest compressive strength has been observed in sample ‘C’.

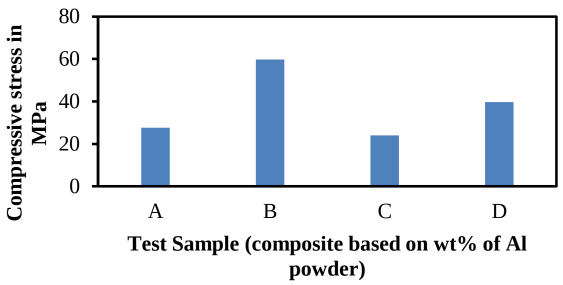

Figure 11. Compression stress vs composite samples based on wt% of Al-powder filler

3.3. Density

The density of banana fibre reinforced composite increases as wt% of Al-powder filler increases. The result of Sample ‘D’ (banana fibre reinforced polymer composite filled 15wt% Al-powder filler) indicates a higher density than other sample results. Sample ‘A’ has a lower value than other composite samples that filled Al-powder based on wt% Al-powder filler. Sample ‘B’ and Sample ‘C’ have medium density as shown in Fig. 12. As the main objective of the work is the weight and density reduction of automotive body components, increasing Al-powder filler beyond some wt% is not recommended.

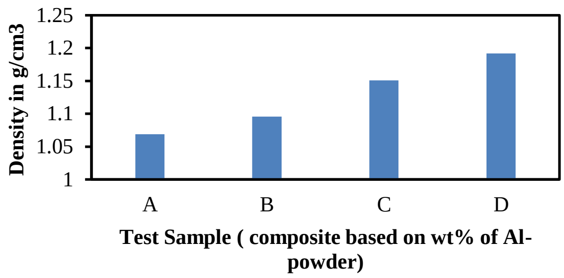

Figure 12. Density vs wt.% Al-powder filler Banana fibre composite

3.4. Micro-hardness

The results of micro-hardness of each sample are tabulated in Table 6 and also plotted for all the trials in Fig. 13.

Table 6. Micro-hardness of banana FRP composite filled Al-powder filler

Composite	Trial 1	Trial 2	Trial 3	Average
A	293.8	212.4	198.3	234.83
B	136.6	191.0	207.5	178.37
C	132.0	206.1	148.4	162.17
D	133.2	123.2	207.3	154.57

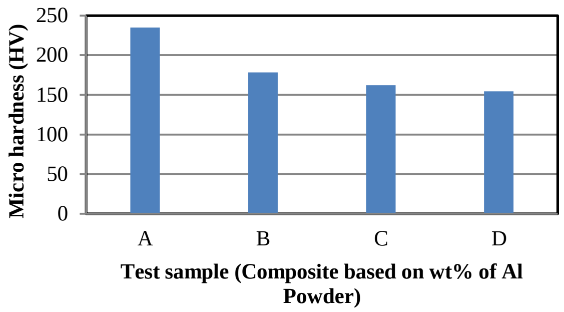

Figure 13. Micro-hardness vs wt% Al-powder filler Banana fibre composite

The trend of micro-hardness indicates that as wt% Al-powder filler increases the hardness of samples decreases. Sample ‘A’ has a higher micro hardiness value while sample ‘D’ has the lowest among this group. The resistance to load is decreased by increasing the Al-powder wt% amount.

3.5. Water Absorption percentage

Weight measurement for each 24 hours interval and water absorption percentage is indicated in Table 7 and Figure 14.

The water absorption percentage of all samples have been tabulated and analyzed individually by 24 hours time interval for 8 days. The comparison is done on the average value of each sample.

Sample ‘A’, sample ‘C’, and Sample ‘D’ have more water absorption percentage than sample ‘B’. From Fig. 14, it shows that after passing 192 hours, sample ‘D’ has the highest water absorption percentage compare to other samples.

Table 7. Water absorption percentage for 8 days (196 hours) results

Samples	Mass (grm)	Measuring duration of samples water absorption test								WA%
		24hrs	48hrs	72hrs	96hrs	120hrs	144hrs	168hrs	192hrs	
A	9.7119	9.9237	10.0121	10.0491	10.0498	10.0550	10.0473	10.0398	10.0465	3.25%
WA (%)		2.18%	3.09%	3.47%	3.48%	3.53%	3.45%	3.38%	3.45%	
B	8.1079	8.3267	8.3953	8.4904	8.5273	8.5489	8.5410	8.5316	8.5306	4.66%
WA%		2.69%	3.54%	4.72%	5.17%	5.44%	5.34%	5.22%	5.21%	
C	7.9688	8.0721	8.1764	8.1953	8.2480	8.2694	8.2650	8.2619	8.2590	3.13%
WA%		1.29%	2.6%	2.84%	3.50%	3.77%	3.72%	3.67%	3.64%	
D	8.2457	8.3572	8.4005	8.4702	8.5011	8.5258	8.5097	8.5212	8.5190	2.79%
WA%		1.35%	1.88%	2.72%	3.09%	3.39%	3.20%	3.34%	3.31%	

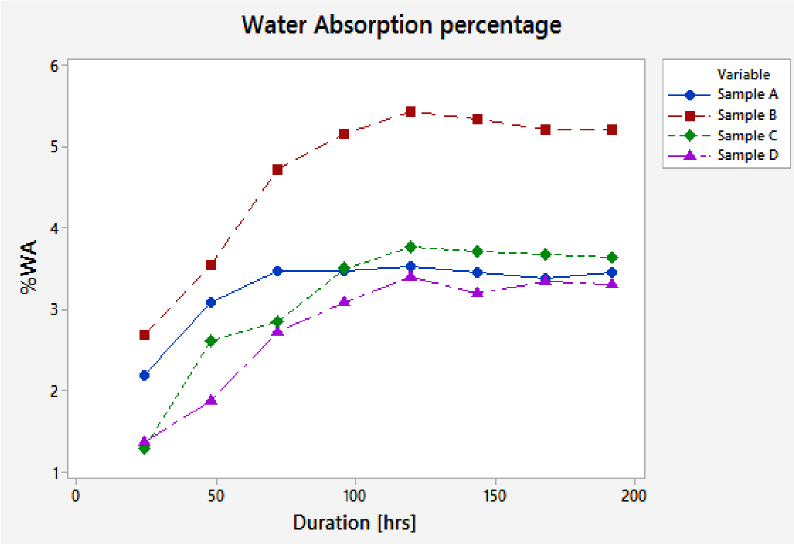

Figure 14. Water absorption percentage *vs* duration for 8 days

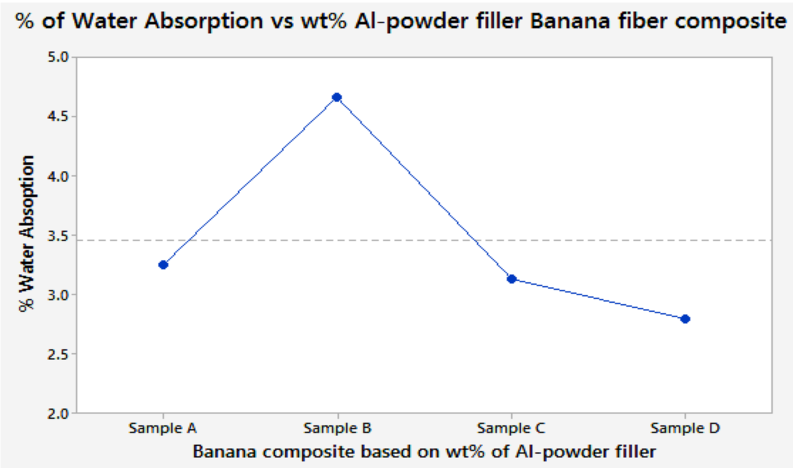

Figure 15. WA% *vs* wt% of Al-powder filler Banana fibre composite

From the results shown in Fig 15, as wt% Al-powder filler increases the water absorption percentage of the samples decrease. Sample ‘C’ and sample ‘D’ have more water absorption properties. Higher water absorption percentage is not recommended for automotive bodies and other industrial applications.

3.6. Microstructure

The microstructure of sample ‘A’ shows (Fig. 16 a) that banana fibre polymer matrix distribution was even and uniform. To obtain more uniformity, fibre chopped length will play a critical role in Polymeric composite in terms of surface finish and size of an automotive component application.

Al-powder filler is seen (Fig. 16 b) as it has been distributed randomly throughout the laminated composite. In Microstructure, Al-powder filler is seen by white point boundary from banana fibre mixed by the resin-hardener mixture.

Al-powder distribution is seen (Fig. 16 c) at the randomly mixed boundary to banana fibre polymeric matric composite. As Al-powder wt% increases the boundary of mixtures is clearly shown. It has a better micro-structure mixture.

From the microscopic result seen (Fig. 16 d) in sample ‘D’ the distribution of Al-powder was not evenly distributed. This is due to the metallic property of Al-powder that creates oxidation with the resin-hardener mixture. Therefore, as Al-powder wt% exceeds some limit, it becomes weaker and prone to oxide former in Polymeric composite itself under corrosive environment.

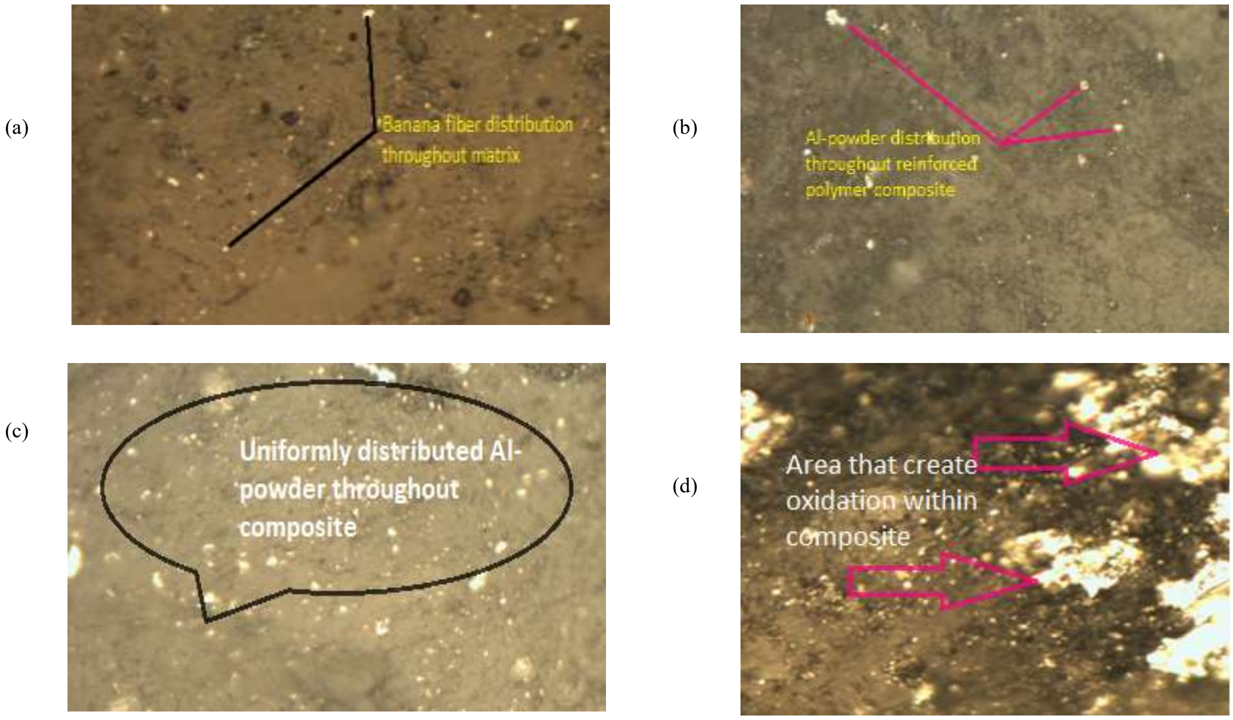

Figure 16. Microstructure of samples A, B, C, and D

4. Conclusions

Banana fibre reinforced polymer composite filled with Al-powder exhibits excellent tensile strength as Al-powder filler amount increases (by wt%). However, beyond 10wt% of Al-powder, the tensile strength of the composite decreased. The maximum is observed in sample ‘C’ which is 33.07MPa.

The compression strength result indicating that sample ‘B’ (banana fibre reinforced polymer composite filled 5wt% Al-powder filler) has the highest value than other samples. The compression strength of Sample ‘B’ is 59.78MPa which followed by sample ‘D’ (banana fibre reinforced polymer composite filled 15wt% Al-powder filler) with a compression strength of 39.63MPa. Sample ‘C’ has the lowest compression result when compared to other samples. More compressive strength is expected in the bumper body in automotive. Sample ‘B’ best suitable amoung this group.

Densities of the samples are increasing with Al-powder filler wt% increment. Based on the result obtained from this study sample, ‘D’ has the highest density value, while sample ‘A’ has the lowest density. The density of samples ‘D’, ‘C’, ‘B’ and ‘A’ is 1.192, 1.151, 1.096, and 1.069g/cm^3 respectively. Generally, all samples of banana fibre reinforced polymer composite fabricated have a lower density than pure Aluminium that has 2.7g/cm^3. So, all samples are lightweight and low in density as compared to the steel sheet.

The experimental result on microhardness shows decreamnet as Al-powder filler wt% increases. Sample ‘A’ has the highest micro hardiness value of 234.83VHN while sample ‘D’ has the lowest micro hardiness value of 154.57VNH.

Results on water absorption shows that as Al-powder filler wt% increases up to 15%, water absorption percentage decreases. Sample ‘D’ has the lowest water absorption percentage of 2.79% followed by sample ‘C’ of 3.13%. Sample ‘B’ has the highest absorption value of 4.66%. So, sample ‘D’ is the optimal sample followed by sample ‘C’ for best water absorption percentage as the least number is more preferable.

The microstructure of each sample is observed by a metallurgical (optical) microscope. Banana fibre reinforced polymer composite distribution of sample ‘A’ shows a random distribution of fibre through the matrix. Sample ‘B’ Al-powder distribution microstructure is seen in a non-uniform fashion. Sample ‘C’ has best Al-powder filler distribution throughout banana FRP composite. Then, in sample ‘D’ Al-powder filler creates oxidation and forms an Aluminium oxidized major zone. Due to the metallic property of the Aluminium reaction will happen with the resin-hardener mixture before uniformly distributed throughout banana FRP composite samples fabricated. Addition of Al –powder more than 10wt% forms oxidation before uniformly distributed throughout the produced composite.

From the automotive body application point of view, sample ‘C’ has the best property compared to other composite in terms of tensile strength, microstructure, moderate water absorption percentage, and medium density. Based on mechanical and physical properties, all samples are suitable for the automotive body. When compared to other Polymeric composites such as sisal epoxy composite, sisal-epoxy-Aluminium powder composite [25] has 13.323MPa and 15.807MPa tensile strength respectively has better strength. Boopalan, (2013) [13] studied on jute/banana hybrid composite and obtained tensile strength of 17.82MPa, 18.96MPa, 18.25MPa, and 17.92 MPa for 75/25, 50/50, 25/75, and 0/100 jute/banana fibre ratio respectively.

Tensile strength of banana FRP composite filled Al-powder filler fabricated under this study for sample ‘A’, Sample ‘B’, sample ‘C’, and Sample ‘D’ has an average tensile strength value of 23.87MPa, 29.6MPa, 33.07MPa, and 30.6MPa respectively. When compared to other researcher's tensile values; the samples produced for this study are feasible and applicable for the automotive body.

Among all the experiemntal results and their behavious, the present work showed the importace Al-filler powder addition in a limited percentage to banana natural FRP for their improvements on their properties. Theses improved properties will lead to the best application part in the automotive applicartions.

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