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EXPERIMENTAL INVESTIGATION ON PHYSICO-MECHANICAL PROPERTIES OF COMPOSITE GASKET USING A COMBINATION OF PLANTAIN AND COCONUT FIBERS

Nurudeen Olatunde ADEKUNLE [1*], Olalekan Olaoluwa OLAMIDE [2], Kolawole Adesola OLADEJO [3], Oluwadamilare Samson OSINAYA [4]

[1,2,4] *Department of Mechanical Engineering, Federal University of Agriculture, Abeokuta, Nigeria*
[3] *Department of Mechanical Engineering, Obafemi Awolowo University, Ile- Ife, Nigeria.*

[*] *Corresponding Author: adekunleno@funaab.edu.ng, noadekunle@gmail.com*

Abstract
A gasket is a compressible material or a blend of materials made from metals, non-metals, polymer or hybrid gaskets consisting of a combination of metallic and non-metallic materials. They are generally used in areas where high weight/temperature, low and high pressure and sealing at low torque applications are required. It must be chemically very stable, have excellent strength to weight ratio, corrosion resistance, and have good pressure transmitting efficiency and good thermal stability coupled with a better sealing performance. Three different gasket compositions were made from coconut fibre, plantain fibre, epoxy, and mica. All paper samples were subjected to hardness, tensile strength, oil absorption, water absorption, and heat resistance tests, and the results were compared to BonTex 247 paper (control). Samples were graded based on how well they passed the tests and the mean of these samples was calculated. The results showed that sample A with 30% Coconut fibre, 30% Plantain fibre, 30% hardener and 10% binder had excellent hardness, water absorption, and oil absorption properties. The thermal properties were within the considerable limits of good gasket material. Sample B with 40% Coconut fibre, 30% Plantain fibre, 20% hardener and 10% binder possessed the best tensile properties.

Keywords
hybrid gasket, transmitting efficiency, thermal stability, sealing performance, coconut fibre, plantain fibre

1. INTRODUCTION

A gasket is a compressible material or a blend of materials that when cinched between two stationary individuals, keeps the entry of the media over those individuals and keeps up a boundary against the exchange of liquid over the mating surfaces of a mechanical coupling, impervious to the medium being fixed and ready to withstand the temperature and pressure [1].

The leak-proof sealing is ensured by different types of gaskets. In the oil and gas, chemical, petrochemical, and other heavy industries, many different types of gaskets are widely used [2]. A Gasket is a deformable material that is used to create a static seal and maintain that seal under various operating conditions in a mechanical assembly [3].

It is usually desirable that the gasket be made from a material that is to some degree yielding such that it deforms and tightly fill the space it is designed for, including any slight irregularities. Some types of gaskets require a sealant to be applied directly to the gasket surface to function properly. Gaskets for specific applications, such as high-pressure steam systems, may contain asbestos. However, due to health hazards associated with asbestos exposure, non-asbestos gasket materials are used when practical application is essential [4]. The increased use of gaskets in piping as a result of the growth of the industrial sector lead to the many experiments on natural fibres and agro-waste resources as substitutes for the synthetic resources, and over time has become more widely used in a broad range of fields. The reason for the preference for these materials in the aforementioned fields is that they have high resistance and a certain level of hardness. They become attractive in such fields owing to their high resistance, design flexibility and low weight [5]. Natural fibre-reinforced polymer composites have been widely explored by many researchers due to their improved modulus and lightness compared to other conventional construction materials such as wood, metal, and steel [6]. Natural fibres can be sourced from plant plants, leaves, bast, seed/ fruit hair, trunk/stem, or fruit bunch. Some examples of fibres that can be sourced are leaf fibres (abaca, palm, sisal, pineapple), bast fibres (hemp, jute, flax, kenaf), seed/fruit hair fibres (palm nut, cotton, coir, poplar), trunk/stem fibres (palm, banana, plantain, citrus sinensis), and fruit bunch (oil palm, plantain, banana, date palm).[7-21]. Natural

fibres are versatile materials that possess properties that vary with chemical composition and physical structure [22]. They are abundantly available and affordable and possess good mechanical properties for sustainable construction applications [23]. The fibres are cellulosic consisting of hemicellulose and micro fibrils in an amorphous matrix of lignin [24].
Coconut husk represents the entire fibrous material enveloping the fruit constituting both the inner endocarp (liquid and solid food part) and outer mesocarp (fibrous part). The mesocarp is an assemblage of fibres and elastic cellular cork-like parenchymatous cells cementing the fibrous materials dispersed throughout the mass. Retting in the water of this material causes the separation of the leathery exocarp (thin outer slippery cover) from the spongy fibrous mesocarp. The fibrous strands are composed of a highly lignified form of cellulose, hence are harsh and rigid [25]. These properties of coconut fibres have made it a considerable material for the production of composite materials in the manufacture of gaskets. One of the more desirable properties of an effective gasket in industrial applications for compressed fibre gasket material is the ability to withstand high compressive loads. Most industrial gasket applications involve bolts exerting compression well into the 14 MPa (2000 psi) range or higher. Generally speaking several truisms that allow for better gasket performance. One of the more tried and tested is: "The more compressive load exerted on the gasket, the longer it will last"(Wikipedia, 2021). The paper aims to investigate the suitability of plantain fibre and coconut husk materials for the production of gaskets.

2. MATERIALS AND METHOD

2.1. Materials

The materials employed in this research procedure were plantain fibre, coconut husk, hardner (mica), binder (epoxy resin) and sodium hydroxyl NaOH. The instruments and materials used were: bore mill, kitchen scale, furnace, hammer mill, extracted fibres, mould, caustic soda, sieve, measuring cylinder and digester

2.2. Plantain Fibre Preparation

The pseudo-stem is a part of the plantain tree that looks like a trunk, which consists of a soft central core is tightly wrapped up to 25 leaf sheaths. These leaf sheaths unwrap from the stem and transform into recognizable plantain leaves when they have matured. Fibres from the plantain pseudo-stem leaves were extracted manually, first a procedure called tuxing which refers to the separation of fibre bundles from the remaining parts was carried out. Afterwards, a knife is put at the butt end between the outer and middle layers of the leaf shaft, and then the outer part is held firmly and pulled out. The second step is to remove the gum or non-fibrous and any residual components contained in the fibres after the tuxing process, this was done by washing repeatedly with water and squeezing. Furthermore, the fibres were then thoroughly washed and dried.

2.3. Coconut Fibre Preparation

Coconut husk represents the entire fibrous material enveloping the fruit constituting both the inner endocarp (liquid and solid food part) and outer mesocarp (fibrous part) (Fig. 1).

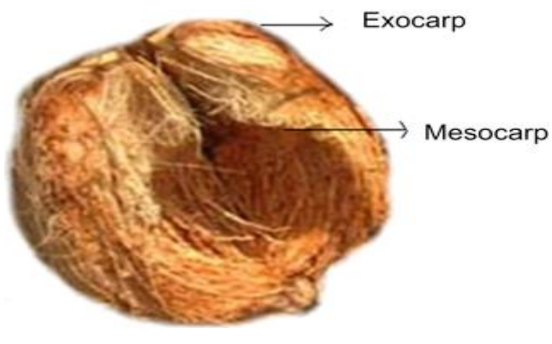

Figure 1: Coconut husk.

2.3.1. Fibre extraction

The separation of tightly bound fibres i.e. extraction of fibres was done manually by peeling out the fibres by hand one husk at a time.

2.4. Extracted Fibre Preparation

The fibres were prepared by the process employed in the manufacture of paper which is termed pulping process by a machine known as digester.

2.4.1. Pulping process

The kitchen weight was used to weigh 3kg of waste material and loaded into the digester, 500g of Caustic Soda (NaOH) diluted with 7ml of water was added for the removal of lignin that was present in the waste material and the digester was tightened. The mixture was then heated in the digester and processed at a temperature below 170°C until fine homogeneous grain fibre was produced.

The homogeneity of the composite was obtained by the rotational motion of the digester during the heating process. The material was then discharged and ready to be formed like paper. Afterwards, the material was washed with water to remove any persistent impurities and placed on a cloth sieve to get rid of water present in the extracted fibre.

2.5. Sample Preparation

Mica, the hardener was crushed in the ball mill and mixed with epoxy which was the binder. This mixture was then added to the extracted fibre to prepare the sample.

Three different samples were prepared with the following composition:

Table 1: Samples Prepared with their percentage material composition

	Percentage Composition by Sample		
	Sample A	Sample B	Sample C
Plantain Fibre	30	40	40
Coconut Coir	30	30	40
Hardener	30	20	10
Binder	10	10	10

The samples are poured into the mould and placed in the oven to dry and made ready for testing.

2.6 Tests Carried Out on Composites

The following are the tests carried out on the samples:

2.6.1. Tensile strength

The tensile strength test of the specimens was performed using a Tensometric Machine, model TUF-100KN Servo. The samples diameter of 10 mm by 5 mm were subjected to tensile force and loaded continuously until failure occurred. The load at which failure occurred was then recorded.

2.6.2. Water absorption

The 24-hour water soak test was used in determining the water absorption behaviour of the samples. The samples were oven-dried at 100°C for 24 hours and their weight was measured after it has cooled to room temperature. Subsequently, the dimensions (thickness) of the samples were measured using a vernier calliper. The samples were late submerged in water for 24 hours, after which the excess water had drained off, and the samples were weighed.

2.6.3. Flame resistance

The flame resistance test of the samples was determined by placing the samples on wire gauze, positioned directly on the Bunsen burner blue flame. The samples' weight before and after burning were taken after 10 minutes on the flame. A 1.20g+ 0.1g of the samples was weighed and placed in a cooled crucible previously oven-dried by heating in a furnace at 550°C for 1 hour. The samples were charred by heating in a hot plate and the charred samples were later taken into the furnace and heated at 550°C for 1 hour. Subsequently, the samples were placed in desiccators and weighed. These cycles of heating, cooling, and weighing were repeated until a constant weight was obtained [26] (Elakhame *et al*., 2014). The percentage of ash content was calculated.

2.3.4 Hardness test

Material Hardness Testing determines a material's strength by measuring its resistance to penetration. Equip Tip Hardness Tester was used to conduct tests at ambient and elevated temperatures. The materials were mounted horizontally on the platform at room temperature, and the indenter was pressed five times on each sample for indentation. The materials were put in the furnace and held at an elevated temperature to test the hardness. After extracting the samples from the furnace, the hardness measurements were performed using the same technique. The screen will display hardness values corresponding to the Brinell hardness number (Laboratory Testing, 2021).

3. RESULTS AND DISCUSSION

Figures 2, 3, 4, 5 and 6 show the graphs of the various tensile properties against the samples. It can be seen from Figures 2 and 3 that sample B (with a yield strain of 0.012 N/mm^2 and yield stress of 1.336 N/mm^2) displayed the best properties at yield. Furthermore, sample B displayed outstanding fracture energy of 194 N.mm and Young modulus of 35.158 N/mm^2. Sample A (with 5.444 mm elongation at break) showed a slightly better property than sample C (with 4.527 mm elongation at break). Sample B (with 4.233 mm elongation at break) had the least elongation properties. Nevertheless, sample B is considered to possess the best tensile properties.

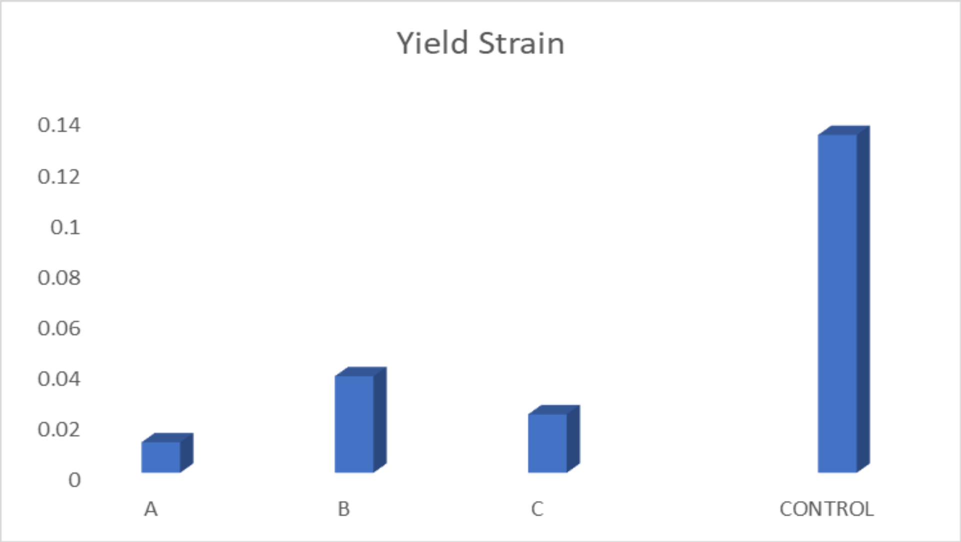

Figure 2: Yield strain of composite gasket samples

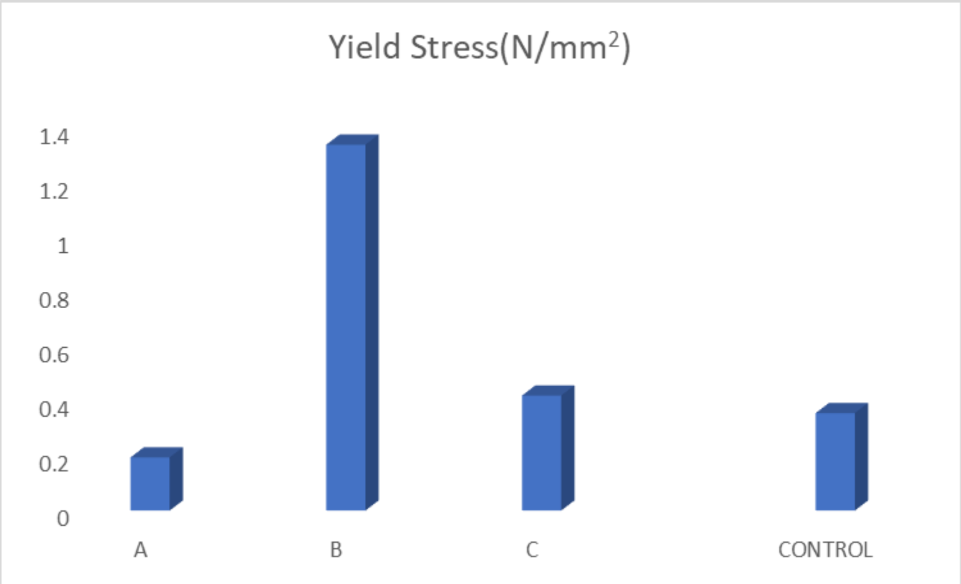

Figure 3: Yield stress of composite gasket samples

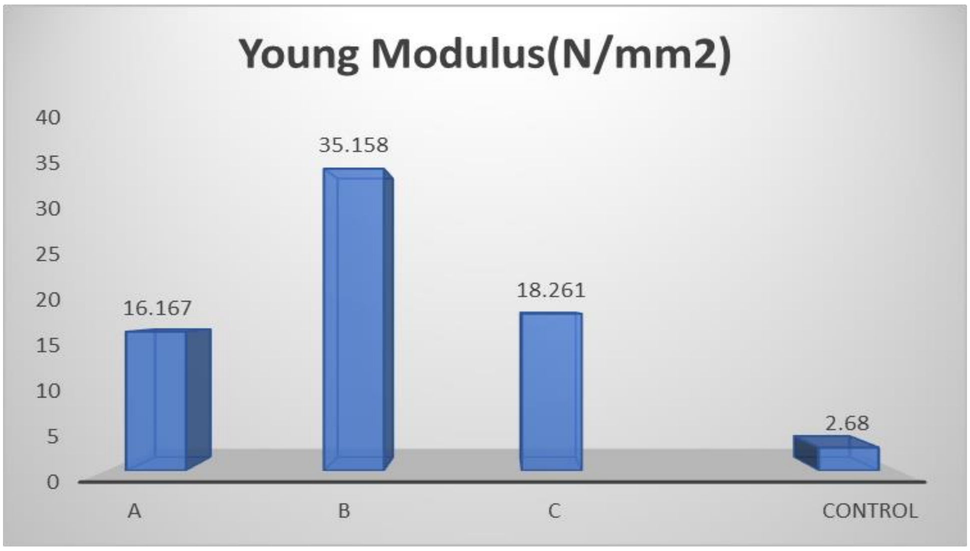

Figure 4: Young modulus of composite gasket samples

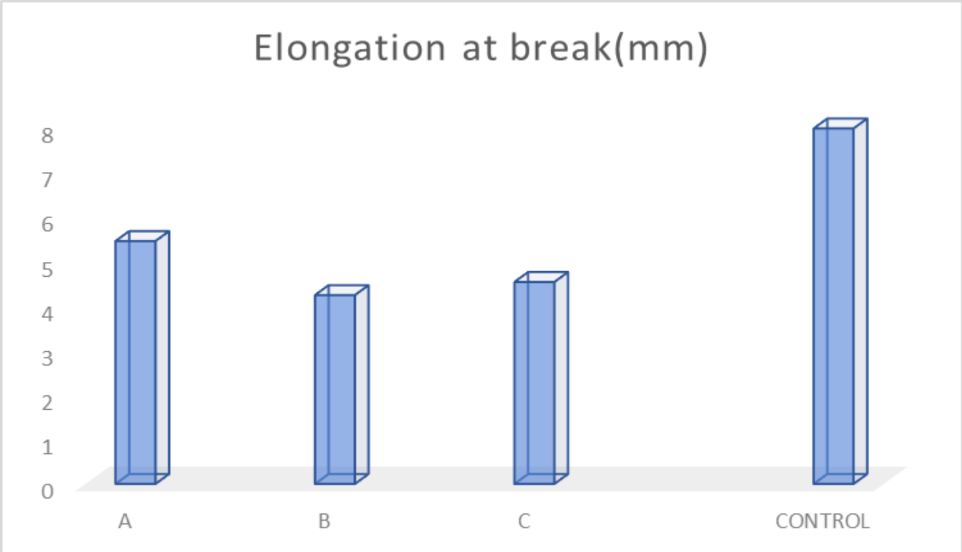

Figure 5: Elongation at break of composite gasket sample

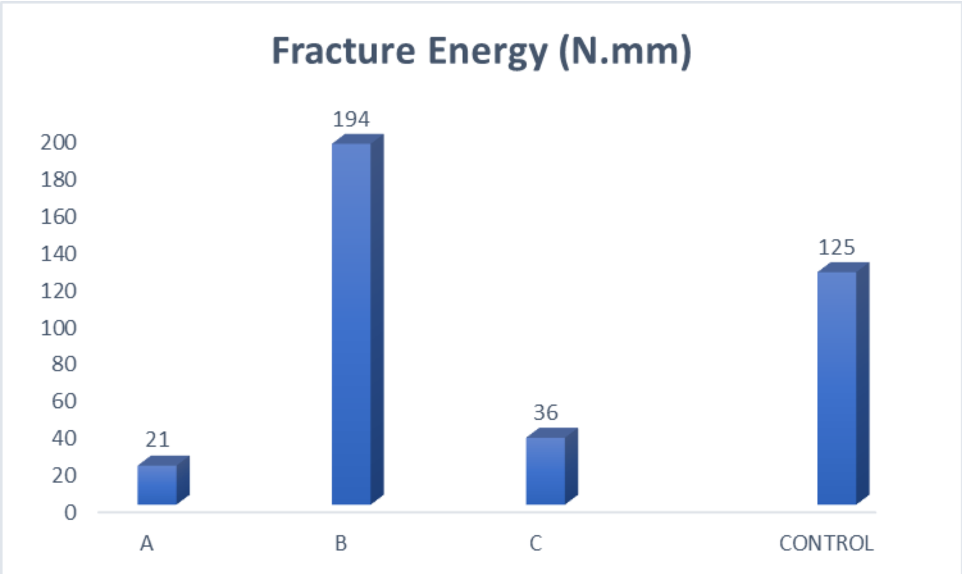

Figure 6: Fracture energy of composite gasket sample

The percentage oil and water absorption of the samples is presented in Figure 7 as a percentage increase in weight. In general, Sample A showed the least absorption, with a percentage weight increase of 0.56 percent and 0.20 percent in water and oil, respectively while sample B (with 2.33 wt. % increase in water and 1.5 wt. % increase in oil) showed the poorest absorption properties. In water, the control gasket had 1.29 percent absorptivity, and in oil, it had 0.13 percent absorptivity. Although the control's absorptivity was slightly lower than the samples', Sample A and Sample C can still be used as local gasket replacements because they have very low absorptivity.

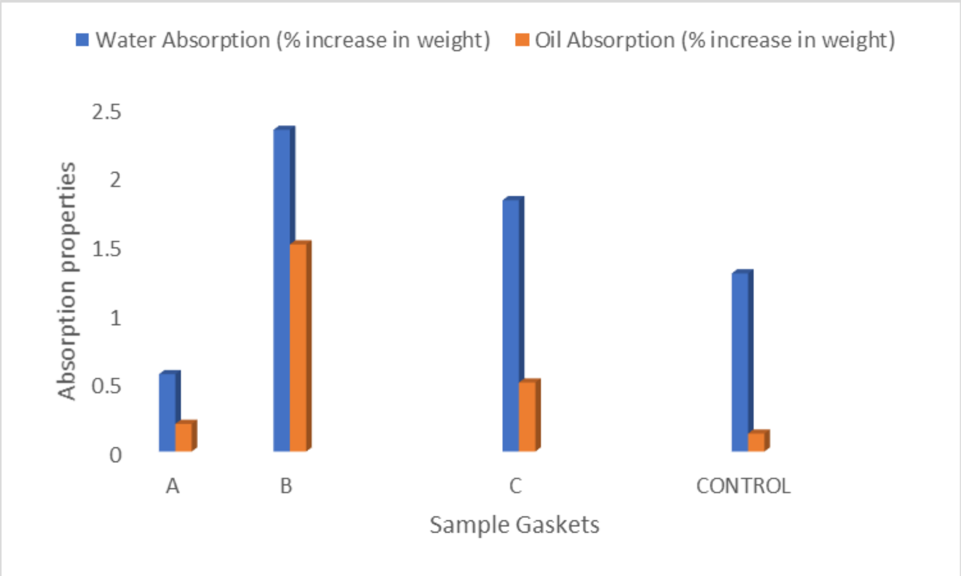

Figure 7: Absorption rate of the composite gaskets sample

3.1 Hardness Testing Analysis

Hardness tests are widely used to characterize a material and determine whether it is suitable for its intended purpose. The hardness values of the gasket samples are shown in Figure 8. Sample A has the highest hardness rating of 40.41 BHN out of the three samples. Sample B had a hardness of 31.47 BHN and Sample C had a hardness of 36.50 BHN, respectively. When compared to the control gasket, which had a hardness value of 37.22 BHN, the results show that Sample A is most qualified as an alternative to the conventional gaskets. Sample C, based on the hardness requirement, also has the potential to be an alternative to conventional gaskets. As seen, fibre played a major role in the hardness of the sample. The hardness of the materials is significant since the gasket must be more resistant to deformation to avoid leakage during compression and in working conditions.

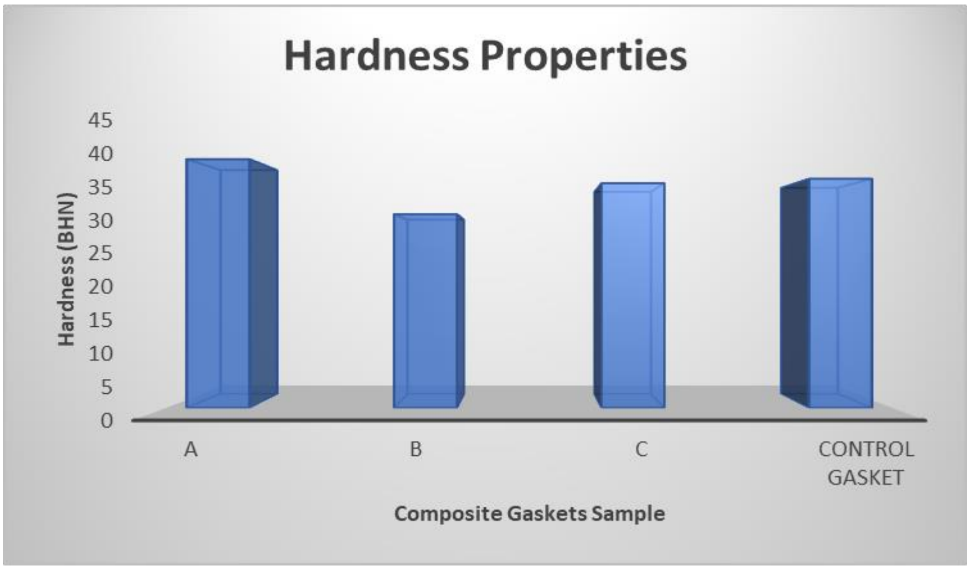

Figure 8: Hardness properties of composite gasket samples.

3.2 Heat Resistance Test

This test was carried out by measuring the mass of the samples when subjected to extreme temperatures. The results of the heat resistance test on the gasket material are represented as shown in Figure 9 below which is the thermal resistance vs. type of samples. The heat resistance of the gasket samples as represented in figure 9 is expressed as a percentage of the total weight of the samples that converted to ash when heated. Sample A, Sample B, and Sample C all showed good heat resistance, with percentage ash residue of 0.88%, 0.75%, and 1.00% respectively. All of the samples passed the heat resistance test when compared to the control, which had a 0.96% ash content. Sample B had the best heat resistance, with only 0.75 percent ash residue, while Sample C (with 1.00 % ash residue) had the lowest heat resistance.

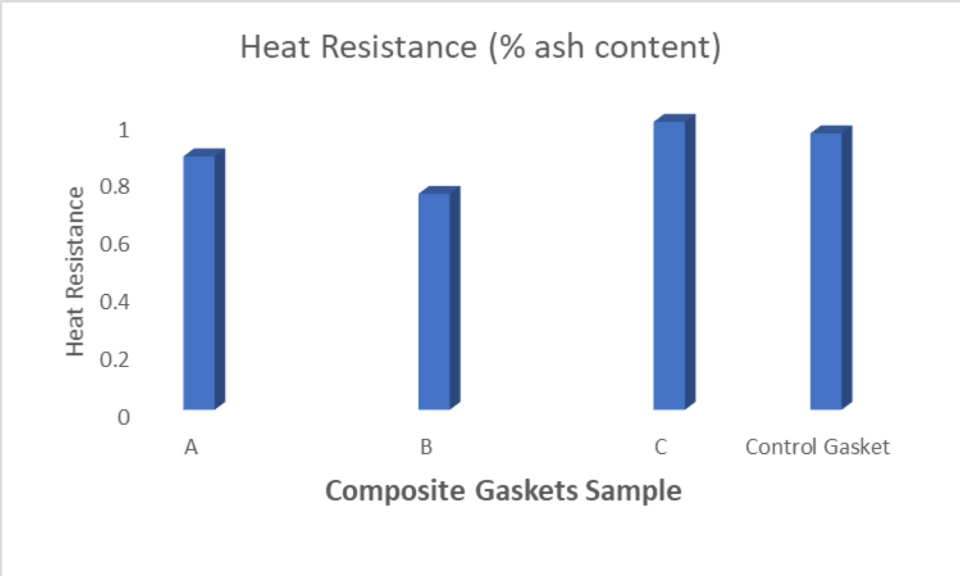

Figure 9: Heat resistance of composite gasket samples.

4. CONCLUSION

From both physical and mechanical tests conducted, it could be concluded that sample A with (30% Coconut fibre, 30% Plantain fibre, 30% hardner and 10% binder) showed a good physical and fair mechanical strength properties. The hardness, water absorption, and oil absorption properties of sample A were excellent. The thermal properties were within the considerable limits of good gasket material. Due to its poor tensile properties, sample A would be most applicable in conditions where fluid absorptivity is of more importance. In conditions where the load that is to be applied to the composition of sample B with 40% Coconut fibre, 30% Plantain fibre, 20% hardener and 10% binder is recommended.

REFERENCES

[1] Aibada, Noshirwaan & Manickam, Ramachandran & Gupta, Krishna & Raichurkar, Pramod. (2017). Review on Various Gaskets Based on the Materials, their Characteristics and Applications. International Journal on Textile Engineering & Processes. 3. 12-18.

[2] Weiting Hu, Hong Li, and Jinfeng Zhuang, (2024). Non-Asbestos Fiber Gasket Materials & Their Applications in Automobile Powertrain Sealing. International Journal of Automotive Manufacturing and Materials IJAMM 2024, 3(2), 5 https://doi.org/10.53941/ijamm.2024.100011

[3] Zhu, L.; Liu, Y.; Li, M.; Lu, X.; Zhu, X.(2022). Calculation Model of Mechanical and Sealing Properties of NiTi Alloy Corrugated Gaskets under Shape Memory Effect and Hyperelastic Coupling: I Mechanical Properties. Materials 2022, 15, 4836. https://doi.org/10.3390/ma15144836

[4] Charles L. Blake, Kevin M. Guth , Raymond D. Harbison (2024).Asbestos Exposure during Gasket Removal from Aircraft Engine. Occupational Diseases and Environmental Medicine, 12, 59-67. https://www.scirp.org/journal/odem

[5] Bello, A., & Umar, S. Y. (2025). Exploring The Potential Of Agro- Waste In The Development of Sustainable, Lightweight, And Thermally Insulating Building Materials. International Journal of Innovation and Industrial Revolution, 7 (20), 210-223. DOI: 10.35631/IJIREV.720012

[6] Adeniyi A.G, Ighalo J.O, Onifade D.V (2019) Banana and plantain fber reinforced polymer composites.J Polym Eng 39(7):597–611

[7] Sachin S. Harak, K. Krishnaveni, K. Karthick, K. Chinnarasu, P. Venkata Hari Prasad, Anu Tonk and S. Mayakannan (2024). Experimental Study on the Mechanical Properties of Hybrid Areca and Abaca Fiber Reinforced Polymer Composites. Journal of Environmental Research. Nanotechnol.,Vol. 13(4), 92-101 (2024) https://doi.org/10.13074/jent.2024.12.244977

[8] Magdi El Messiry, Shaimaa Youssef, El-Tarfawy and Rania El Deeb (2024) A study on hybrid jute and palm fibers blend/polyester composites: Properties and potential end uses. Journal of Industrial Textiles. Volume 54, https://doi.org/10.1177/15280837241251493

[9] Seid Ahmed, Million Ayele, and Ketema Alemu Babo (2024). Fabrication of Reinforcement from Sisal Fiber and Its Application in Leather Goods. Wiley Journal of Engineering. Volume 2024, Article ID 1982233, 15 pages. https://doi.org/10.1155/2024/1982233

[10] Mohamad Reda A. Refaai, U. Tamilarasan, K. Dilip Kumar, M. Karthe, C. Anbu, and Simon Yishak (2022). Mechanical Behaviour and Thermal Properties of Pine Apple Leaf Fiber Reinforced Vinyl Ester Composites. Advances in Polymer Technology.Volume 2022, Article ID 4386650, 8 pages. https://doi.org/10.1155/2022/4386650

[11] Caio Fernando de C Lambert, Evandro Alves Barbosa Filho, Karen Viviana Castaño Coronado and Ravindra B. Malabadi (2024). Exploring the potentialities of industrial hemp for sustainable rural development. World Journal of Biology Pharmacy and Health Sciences,18(01), 305–320.

[12] R.Pavendhan, D. Sriram, Ambrose Edward Irudayaraj, S. Vijayan and C.Chanakyan (2024). An experimental investigation into the Mechanical properties of jute Fiber / nano-sized ZrC Polymer Composites. Journal of Physics: Conference Series 2925 (2024) 012013. doi:10.1088/1742-6596/2925/1/012013

[13] Yuan Wang, Tianqiang Du, wenkai Ma, Pengyu Song, Yiyu Chen (2024). Research on mechanics and acoustic properties of Jute fiber composite material. Heliyon 10 (2024) e33869

[14] Subrata Chandra Das, Angela D. La Rosa, Stergios Goutianos, Sotirios Grammatikos (2024). Glass fibre hybridization to improve the durability of circular flax fibre reinforced composites with off-the-shelf recyclable polymer matrix systems for large scale structural applications. Composites Part C: Open Access 14 (2024) 100491. https://doi.org/10.1016/j.jcomc.2024.100491

[14] Mahesh, C.K., Gowtham, K., Narendhiran, B. (2019). Experimental Investigation of Suitable Car Bumper using GFRP, Kenaf, SisalI and Kapok FibreI. *Vol-5 Issue-2 2019 IJARIIE-ISSN(O)-2395-4396*

[15] H. A. Aisyah, E. Hishamuddin, A. W. Noorshamsiana, Z. Ibrahim and R. A. Ilyas (2025). Oil Palm Fiber Hybrid Composites: A Recent Review. Journal of Renewable Materials. DOI: 10.32604/jrm.2024.055217

[16] Feng Liang, Qinxian Chen, Zhen Shi, Rui Dan, Huan Liang, Xu Feng, Chuanyun Tang, Xijing Yu, Xianqin Shang, Denglu Zhang, Yuanyuan Hu (2025). Multifunctional composites made from waste polyester cotton fabric and waste rigid polyurethane foam for potential building wall material applications. Energy and Buildings. Volume 329, 115274. https://doi.org/10.1016/j.enbuild.2025.115274

[17] Nissar, M.; N., C.K.; Birjerane, Y.A.; Patil, S.; Shetty, S.; Das, A. (2025). Coconut Coir Fiber Composites for Sustainable Architecture: A Comprehensive Review of Properties, Processing, and Applications. J.Compos. Sci. 2025, 9, 516. https://doi.org/10.3390/jcs9100516

[18] Can, A., Gencel, O., Sarı, A., Hekimo˘ glu, G., Ustao˘ glu, A., Temiz, A., Erdo˘gmu, E., Erdeyer, O.N. (2025). Development of Poplar Wood/Bio-Based Composite Phase-Change Material as Novel Ecofriendly Thermo-Regulative Material. Forests, 16, 763. https://doi.org/10.3390/f16050763

[19] Ernest Jaho, Peter Ufuoma Anaidhuno and Chinedum Ogonna Mgbemena (2024). Development and Analysis of Sisal and Plantain Fibre Hybrid Composites for Pipeline Flange Applications. Asian Review of Mechanical Engineering. Vol.13 No.2, 2024, pp.12-24. DOI: https://doi.org/10.70112/arme-2024.13.2.4272

[20] Teng, B., Wu, J., Zhong, Y., Wang, Y., Qiao, D., Quan, R., Zhou, Z., Cai, L., Qi, P., Luo, Z. (2025). Innovative Utilization of Citrus Sinensis Peel Hydrogels: Enhancing Soil Water Retention and

Efficient Removal of Methylene Blue from Wastewater. Polymers **2025**, 17, 428. https:// doi.org/10.3390/polym17030428

[21] Emmanuel Owoichoechi MOMOH, Adelaja Israel OSOFERO (2020). Recent developments in the application of oil palm fibers in cement composites. Front. Struct. Civ. Eng. 2020, 14(1): 94–108.

[22] Adeniyi, Adewale O. Ighalo, Joshua & Onifade, Damilola. (2019). Banana and plantain fiberreinforced polymer composites. Journal of Polymer Engineering. 39. 10.1515/polyeng-2019 0085.

[23] Danso H (2020a) Infuence of plantain pseudostem fbres and lime on the properties of cement mortar. Adv Mater Sci Eng 2020. https:// doi.org/10.1155/2020/4698603

[24] Kulkarni, H.B., Tambe, P.B., Joshi, G.M., (2020) Infuence of surfactant assisted exfoliation of hexagonal Boron nitride nanosheets on mechanical, thermal and dielectric properties of epoxy nanocomposites. Compos Int 27(6):529–550

[25] Leena Mishra, Gautam Basu (2020). Coconut fibre: its structure, properties and applications. Handbook of Natural Fibres-Volume 1: Types, Properties and Factors Affecting Breeding and Cultivation. https://doi.org/10.1016/B978-0-12-818398-4.00010-4

[26] Z.U. Elakhame, O.A. Alhassan, A.E. Samuel (2014). Development and Production of Brake Pads from Palm Kernel Shell Composites. International Journal of Scientific & Engineering Research, Volume 5, Issue 10, 735-744. ISSN 2229-5518