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Study On Tribological Of Polyester Composite Material Reinforced Hybrid Hibiscus Tiliaceust Bark and Palm Fibers

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Abstract:*The composite matrix polyester material was developed using hybrid Hibiscus tiliaceust bark fiber (HTBF) and palm fibers (PF) as reinforcement. Composites were made using the vacuum infusion method. The matrix used is polyester resin BTQN 157. The volume fractions between palm fibers (PF) and Hibiscus tiliaceust bark fiber (HTBF) are, 5% : 25%, 10% : 20%, 15% : 15%, and 20% : 10%. Surface hardness, wear resistance and morphological examination were carried out on composite samples using Brinellhardness tester, pin-on-disc tribometer and SEM-EDX. Results of the study revealed that all HTBF-PF hybrid fiber reinforced composite specimens had better properties than those without hybrid fiber reinforcement. The optimal combination of hardness and wear properties is obtained from hybrid fiber reinforced composite sample with a volume fraction of 20% PF and 10% HTBF Further addition of the volume fraction of PF over the volume fraction of HTBF in a ratio of 20%:10%, causing a sharp increase in the surface hardness and wear resistance of the polyester composite specimen. SEM-EDX analysis reveals the presence of various proportions of the volume fraction of PF as reinforcing fiber increase the bond between the polyester matrix and HTBF, increase the density resulting in surface hardness, and wear resistance of the specimen.*

Keywords:*Polyester compocite, hibiscus tiliaceust bark fiber (HTBF), palm fibers (PF), surface hardness, wear resistance*

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I. INTRODUCTION

Composite materials bring together many of the best qualities that traditional materials have to offer. Two-component composites include a reinforcement (synthetic fiber and natural fiber) and a matrix (such as an epoxy polymer). The matrix binds the reinforcement together to combine the benefits of the two original components. The advantages of composite materials include, Composites have a high strength-to-weight ratio, Composites are durable, Composites open up new design options, Composites are now easier to manufacture. Composites improve design processes and end products across industries, from agricultural foodization, aerospace, to renewable energy. For example in agricultural mechanization equipment every year, composites continue to replace traditional materials, such as steel and aluminum, for the manufacture of harrow combs/levellers. As composite costs fall and design flexibility increases, natural fiber-reinforced composites such as hibiscus tiliaceust bark fiber (HTBF) and palm fibers (PF) open up new design opportunities for engineers.

Harrow comb (leveler) is one of the most important agricultural mechanization equipment. Usually its use by using a hand tractor (power tiller). Its application is for crop residue management through deep conservation tillage for soil conservation and productivity management, which aims to maintain soil structure, especially for sugarcane and rice fields. The disadvantage of levelers made of medium carbon steel is that they are easily blunted due to corrosion, so their performance decreases. As a result, farmers tend to burn this residue for convenience and timeliness. Considering this need, levelers need to be developed with composite materials, which are cheaper, corrosion resistant and easy to manufacture, can be done by hand lay up.However, there are disadvantages of natural fiber reinforced composites such as inadequate adhesion, poor wettability; high water absorption rate, and de-bonding resulting in low mechanical properties such as tensile strength, surface hardness and wear resistance. Several research activities have been carried out to improve the physical and mechanical properties of natural fiber reinforced polyester composites.

The The recent years, hybrid composite material studies have been carried out(Mochane *et al.*, 2019) by combining two or more reinforcements into thematrix. The matrix can be ceramic, metal or polymer. In the study, the matrix used is a polymer (polymer composite matrix). Hybrid composites can further be defined as mixtures of two or more polymers reinforced with one or more fillers. Auto-hybrid is a more precise term usually used in cases of the same type of filler having different particle sizes/dimensions (Mochaneet al., 2019). Hybridization in composite development provides new opportunities to improvevarious applications of composite materials such as tribology(Melro et al., 2015). According to (Mochane et al., 2019) the factors that influence the properties of the resulting hybrid composite material are the type of matrix and reinforcing material used, the second factor involves the technique used in preparing the composite,which is often determined by the reinforcement and matrix material under study and a third factor involves the interaction between the filler and matrix. Increasing the adhesion properties / interfacial bonds between the components that make up the composite, will result in an increase in the overall properties of the hybrid composite (Abdel-Hamid et al., 2019; Francis et al., 2015). On the other hand, weak interfacial adhesion between matrix and filler will result in poorer composite properties(A.P.Suthar et al., 2019).

Based on the results of the research, the way to improve the mechanical properties and tribolgy is done by hybrid matrix and hybrid synthetic fiber composite reinforcement. So it is necessary to do research on hybrid natural fiber. In a study that has been carried out using hybrid natural fiber, HTBF-PF as a composite polyester matrix reinforcement. The goal is to increase surface hardness and wear resistance, so that it is feasible as a leveler material in the agricultural mechanization industry.

II. EXPERIMENTAL PROCEDURE

2.1 The material

The the material compositeused in this study consisted of matrix and fiber,shown in Figure 1.Matrix in the form of polysterresin BTQN 157, methyl-ethyl-ketone-peroxide (MEKP) catalyst which is reinforced withhybrid natural fiber, HTBF-PF. The volume fractions between palm fibers (PF) and Hibiscus tiliaceust bark fiber (HTBF) are, 5% : 25%, 10% : 20%, 15% : 15%, and 20% : 10%. The process of taking fiber is done by soaking for 2 days then dredging, drying at room temperature or aerating. The fibers were immersed in 4% NaOH solution for 2 hours.The length of the fiber is 20 mm with random oriented.

Figure 1. The material used in this study

HTBF Palm Fiber (PF) Specimen Composite

2.2 The research method

The hardness test was carried out according to the ASTM E10 standard using a phase II model 900355 Brinell hardness tester. Specimen dimensions 10 mm × 10 mm × 10 mm. Pressing load 614 N, with 5mm diameter ball indenter, pressing for about 15 seconds. Brinell hardness values are given in HBW units on the machine screen for reading. Ifconverted into units of Brinell hardness number (BHN) divided by 0.102.

The dry shear wear study was carried out at room temperature on a Pin-on-Disc tribometer, with a constant load of 10 N, a rotational speed of 200 rpm, with varying shear distances. Specimen dimensions 40mm x 10mm x 6mm, Wear evaluation carried out follows the ASTM G99-04 standard guidelines, which express the effect of friction in terms of material loss in volume (mm) as a function of shear distance. The specific wear rate (W_S) is defined as the specimen volume loss per unit shear distance per unit applied normal load.

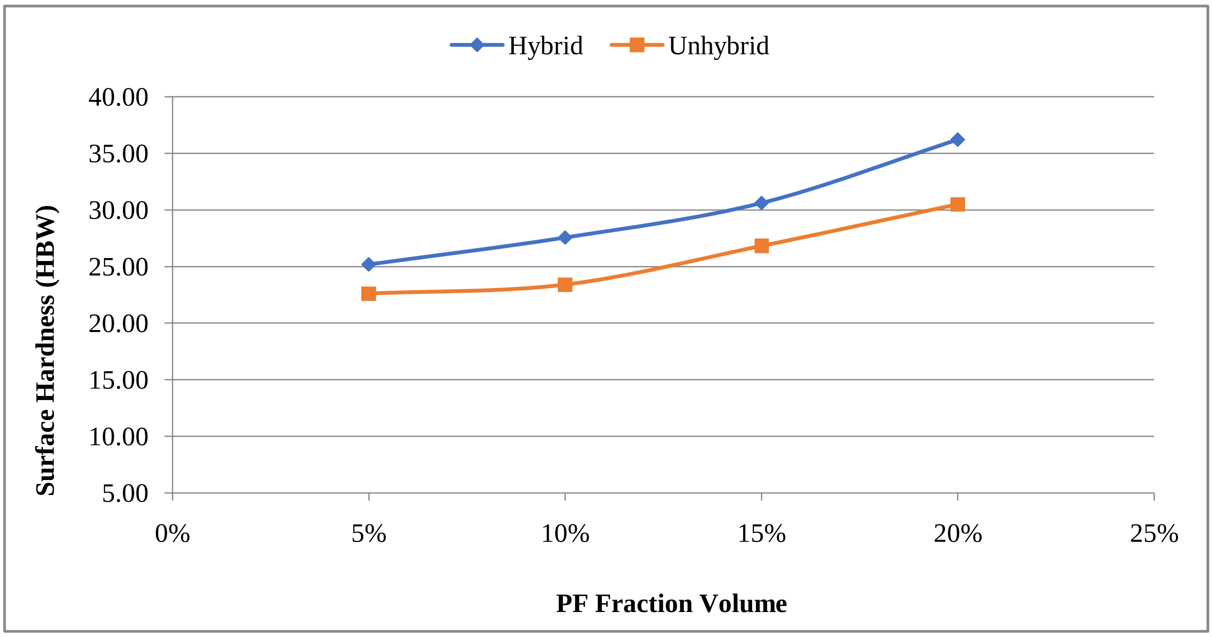
For deeper observation of worn surfacestribological samples and characterization of their micro-composition using the Phenom Pro X Model SEM (Phenomworld, Eindhoven, Netherlands) equipped with EnergiDispersive X-ray spectroscopy (EDX), 15 kV acceleration, 500, 1000 & 1500x magnification. The resulting morphology is transferred electronically to EDX coupled withElemental identification software that automatically characterizes the major, minor and trace constituents of a sample element in atomic percentage and weight.

III. RESULTS AND DISCUSSIONS

3.1. The suface hardnessof material compocite reinforced hybrid fiber

Figure 2is shown that the addition of the volume fraction of palm fiber can increase the surface hardness of the specimen (polyester matrix composite reinforced hybrid fiberHTBF-PF). In general, polyester matrix composites with hybrid fiber reinforcement have higher surface hardness than single fiber reinforced specimens (unhybrid).

Figure 2. The suface hardnessof specimens



The surface hardnessnumber of the specimen is 22.62 ; 23.41; 26.81; 30,51 HBW on polyester matrix composite specimens using a single fiber (unhybrid). The hardness number of composite matrix polyester specimens using HTBF-PF hybrid fiber is 25.18; 27.57; 30.62; 36.21 HBW, respectively at the volume fraction conditions of 5%, 10%, 15%, and 20% PF.The increase in the surface hardness of the specimen was caused by the increase in the density of the specimen due to the addition of PF which was hybridized with HTBF. The physical properties of PF (high hardness, density, and rigidity) also lead to an increase in the surface hardness of the specimen.The chemical composition of palm fiber, a lignocellulosic waste ejected from the palm oil industry, was analyzed(Yojiro Koba, 2019). The fiber consisted of holocellulose (59.6%), lignin (28.5%), lipid (1.9%), protein (3.6%), ash (5.6%), and others (0.8%).The high content of holocellulose and lignin in PF caused the surface hardness of thepolyester matrix composite reinforcedhybrid fiber HTBF-PF increased significantly. An increase in surface hardness tends to increase the tensile strength of the composite.

3.2. The wear resistanceof material compocite reinforced hybrid fiber

Figure 3. shows the wear resistance of the thepolyester matrix composite reinforcedhybrid fiber HTBF-PF. The wear resistance(WR) is inversely proportional to the weight loss (WL). The addition of PF volume fraction to the specimen (polyester matrix composite reinforcedhybrid fiber HTBF-PF)tends to decrease the weight loss and increase the wear resistance(Eli Buchman et al., 2010). The decreasing in the weight lossthat occurred were 0,096; 0,075; 0,059; 0,038; and 0,024 grwhile the increasing in wear resistance were0,021; 0,085; 0,182; 0,438; and 0,845 mm^3/N.mm, respectively in the volume fraction; 0%, 5%, 10%, 15% and 20% PF .

Figure 3. The wear resistance and weight loss of specimens

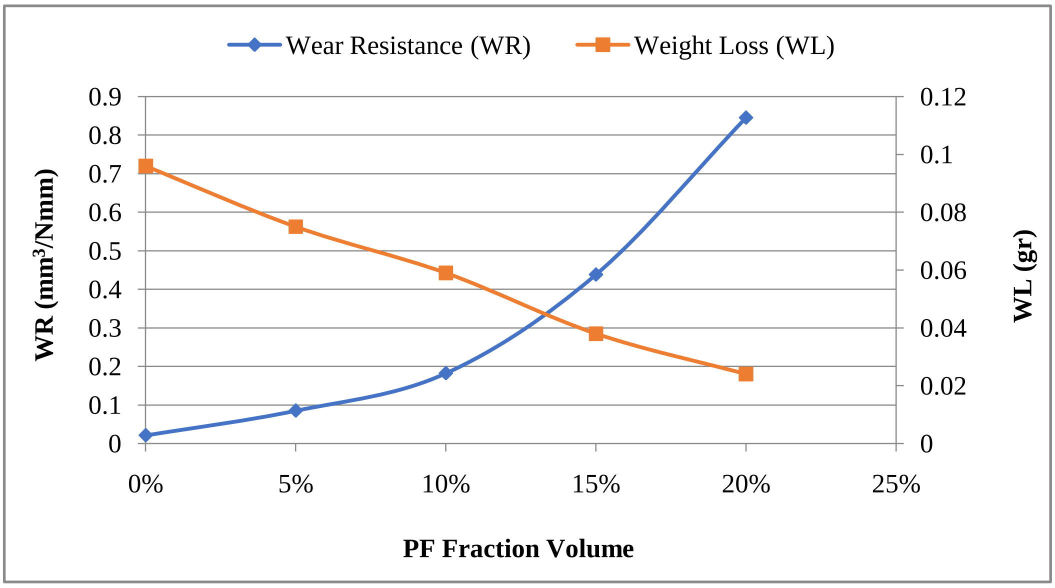
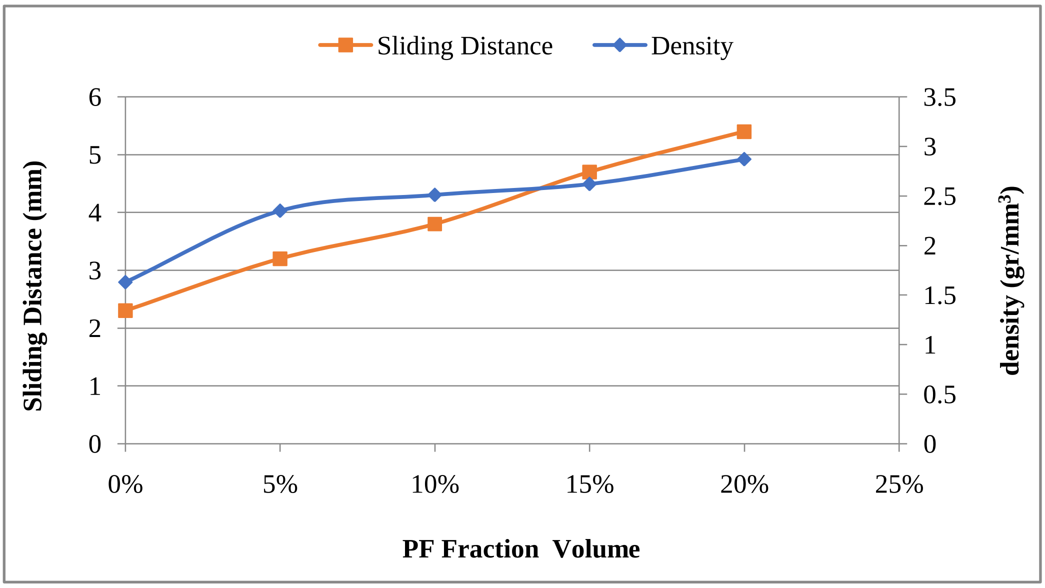


Figure 4. shows the sliding distance and density of the thepolyester matrix composite reinforcedhybrid fiber HTBF-PF. Itis shown that the addition of the volume fraction of palm fiber can increase the sliding distance and density of the specimen.

The increasing in the sliding distance that occurred were 2,3; 3,2; 3,8; 4,7; and 5,4mmwhile the increasingin density were1,63; 2,35; 2,51; 2,62; and 2,87 gr/mm^3, respectively in the volume fraction; 0%, 5%, 10%, 15% and 20% PF.The high content of holocellulose and lignin in PF caused the density and sliding distance of thepolyester matrix composite reinforcedhybrid fiber HTBF-PF increased significantly.

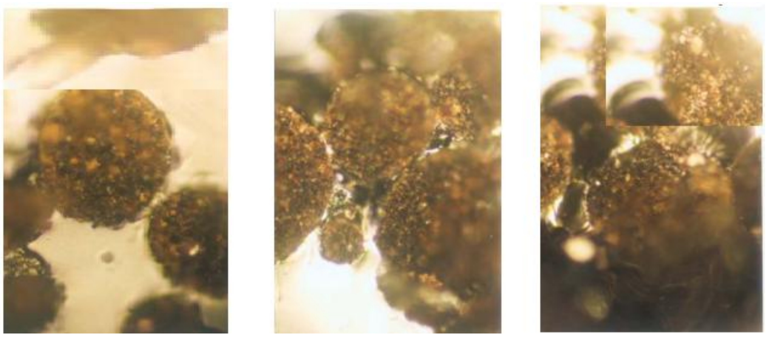
Figure 4. The sliding distance and density



3.3. Microstructure polyester matrix compositereinforced hybrid fiber

The results of the observation SEM of thepolyester matrix compositereinforcedhybrid fiber HTBF-PF microstructure are shown in Figure 5. It shows a polyester matrix filled with HTBF-PF hybrid fibers. Hybrid fibers in the polyester matrix are still able to withstand shear loads and because the bond between the matrices with HTBF-PF hybrid fibers is better than with HTBF single fibers. The load can be passed on to the HTBF-PF hybrid fiber. The larger the PF volume fraction, the stronger the bond between the polyester matrix and the hybrid fiber, as shown in Figure 5a, 5b and 5c. The bond was strongest at the volume fraction of 20% PF, and the weakest at the volume fraction of 5% PF. At volume fraction 5% PF fiberwill break at the same time as the matrix fracture . This material will experience brittle fracture. At the volume fraction of 10% and 20%PF, the more PF in the polyester matrix, the wider the interfacial area between PF and polyester is getting bigger, so that the load transfer from the matrix to the fiber will be more effective which makes the composite material morestrong enough to accept the load. This is seen by increasing the value of surface hardness with the addition of PF to polyester matrix(Pradeep P, et al., 2015). But here the field bond interface between fiber and matrix is not visibleclearly.

Figure 5. Microstructure polyester matrix compositereinforced hybrid fiber HTBF-PF



a. 5% PF b. 15% PF c. 20% PF

IV. CONCLUSION

From data analysis and discussion that has been done, the conclusion are the addition of the volume fraction of banana stem fiber by 5%, 10%, 20% and 30% affected the surface hardenesss, impact toughnesh and wear resistance of the polyester matrix composite reinforced hybrid fiber HTBF-PF. The greater the fractionvolume of PF added, the higher the hardnesssurface, dan wear resistance . The highest hardnesssurface were36,21 HBW, wear resistance 0,845 mm^3/Nm, on fractionvolume20% PF and the lowest hardnesssurface were25,18 HBW, wear resistance 0,085 mm^3/Nm, on fractionvolume 5% PF.Based observation SEM shows a polyester matrix filled with HTBF-PF hybrid fibers. Hybrid fibers in the polyester matrix are still able to withstand shear loads and because the bond between the matrices with HTBF-PF hybrid fibers is better than with HTBF single fibers. The load can be passed on to the HTBF-PF hybrid fiber.

Conflict of interest

There is no conflict to disclose.

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