International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 382-388 www.ijaem.net ISSN: 2395-5252

Influence of Coconut Shell Charcoal Powder Filler on the Tribological Properties of Natural Fiber Reinforced Polimer Compocite

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Submitted: 01-05-2021 Revised: 09-05-2021 Accepted: 10-05-2021

ABSTRACT:In the current work to investigate, coconut shell charcoal powder (CSCP) as a composite filler and Musa acuminata stem fiber (MASF) which is used as a reinforcement to study and analyze the potential improvement in wear-resistant property of epoxy matrix composites. For the first time, this finds applications, especially in brake pads where friction exists. Thus, it can be prepared with non-toxic and locally available cheap fibers to produce a prospective tribo material. MASF reinforced with epoxy composites was prepared with variations of CSCP 10%, 20%, 30%, and without CSCP. The composite was prepared by hand layup and open mold technique with a fiber length of 20 mm and fiber percentage of 30 wt.% for all kinds of samples. A computerized pin on disc machine was used to test tribological properties of the composites and the test was conducted with various parameters namely type of treatment, applied normal loads (15, 20, 25, and 30 N), and sliding speed (1.5, 2.0, and 2.5 m/s) for a constant sliding time of 15 min under dry condition. From the result, it was concluded that the weight loss of addition of CSCP filler to natural fiber reinforced epoxy composites got reduced by 15% and 39%, while the coefficient of friction was also decreased by 41% and 39% respectively. A scanning electron microscope (SEM) was used to observe the worn surface and wreckage in the tested composite samples. As a conclusion, experiment results and microscope observation indicate that 30 wt.% of addition of CSCP filler to natural fiber reinforced epoxy composites exhibited good wear resistance compared to other.

KEYWORDS: Epoxy matrix composites, Coconut shell charcoal powder, Musa acuminatastem fiber, Wear resistance

I. INTRODUCTION

The day, composites have become attractive materials fornumerous applications because of their many unique technicalproperties which include lightweight, high productivityand cost-effectiveness. In the context of economic andecological way of making fiber-reinforced polymeric composites,the natural fibersare found to be most attractive duringthe past few centurions. Traditionally fabricated steel materials with specific higher, strength, surface hardness, density were replaced by composite materials. As an alternate to metals, the composite materials are used in tribologicalparts such as pad brake plastics gears, artificial joints, guide rails, sliding bearings, and so on [1].This is due to the preferred characteristics of the polymer matrix composite such as self-lubrication and noisereduction.Tribologicalperformance of synthetic fibres such as glass, carbon and Kevlar reinforced polymericcomposites has been extensively studied [2-4]. Nowadays, natural fibers are becoming an alternative reinforcement for polymers due to their excellent advantages, i.e. renewable,environmental friendly, low cost, the flexibility of usage,lightweight, naturally recyclable, and biodegradable.Many applications such as housing construction materials, furniture, and automotive parts. Froma mechanical point of view, it has been proven that naturalfibers enhanced the mechanical properties of neat polymers matrix composites [5-6].

Natural fibers are generally sustainable and used in automobile industries. Automotive industries seized the initiativeto incorporate the use of plant-based fibers andcomposites in manufacturing car components that prove thefeasibility and increase in production of automotive parts.For example, natural fibers such as sisal, hemp, and flax fiberswere commonly used as the interior indoor padding, floor panels,lining for seat backs whereas cotton fibers are used in soundproofing material and coconut fibers to manufacture headrestraints and back cushion [7-8].

In polymer matrix composites, several limitations were found in substituting natural fiber with conventional fiber. Among several disadvantages, the hydrophilic nature of the reinforcementfiber which relies upon the pressure of noncrystallineparts and voids content is the most common important issues. To obtain good tribological and mechanicalproperties as well as to minimize the moisture absorptionthe capacity of natural fibers, number of techniques like surfacetreatment, additives, and coating have been used nowadays [9].

Nevertheless, less work is found on the effects of natural fibers on the tribological performance of polymeric matrix composites. In general, the tribological performance ofpolymeric matrix composites is influenced by many factors suchas test technique and operating parameters [5].The effects ofuntreated sugarcane fibres on the abrasive wear characteristicsof polyester composites was studied [10-11]. He found that the wornsurfaces of the composites were highly damaged and differenttypes of wear mechanisms took place during theabrasion tests, i.e. plastic deformation, micro cutting in thematrix, pitting, ploughing, and fragmentation of wear.

From the above, it is observed that there are very few studies on the effects of filler and natural fiberson the adhesive wear performance of polymeric matrix composites.Consequently, prediction of the adhesive wearcharacteristics of such composites is a difficult task. Thus,there is a necessity for a better understanding of the effectsof the filler and natural fibers reinforcement matrix composites on the tribological properties.

This study aims to determine the tribological properties of Musa acuminata stem fiber reinforced epoxy composites with coconut shell charcoal powder as a composite filler, for the feasibility of these composites as an alternative solution to the replacement material for brake pad categorized as Multi-Purpose Vehicle (MPV) which in its application is closely related to safety usage, especially in the automotive sector.

II. EXPERIMENTATION

The coconut shell used in this study is charcoal. The coconut shell charcoal is then blended, sieving with a size range of 200 and 500 mesh. Soaking the coconut shell charcoal powder with a solution of stearic acid in acetone (1% by weight) for 2 hours. Next, drying the coconut shell charcoal powder using an oven for one day. Musa acuminata plant available North Lombokdistrict, West Nusa Tenggarastate, Indonesia which comes under the family of Musaceae

The MASF extracted process includes Musa acuminata plant stem dipped in water for 1 weeks in order to separate fibers from stem through microbialdegradation and further by using freshwater, the soakedstem is cleaned and dried in sun light for a week. Combingprocess was performed with metal teeth brush for extracting the fiber from the stem..

Coconut shell charcoal powder.

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Musa acuminate stem fibers

It took almost 5-7 days for this entireprocess of extracting fiber from the stem.Extracted fiber is soaked in 5 wt.%NaOH solution for an hour

at room temperature and then washed in running water to remove excess NaOH. Finally, distilled water is used to wash the fiber and the fibers are dried in the direct sunlight for a period of week time. Epoxy composite reinforced with MASF was prepared with

four different condition of filler composite such CSCP 10%, 20%, 30%, and without CSCP. MASF length 30 mm andMASF percentage of 30 wt.% for all kinds of samples. In laboratory, the chopped fiber and resin were mixed. Manual stirring tookplace to scatter the fibers in the matrix for a sufficient time, whereas hand layup and open mould technique were used to prepare the samples. Mould of glass test tube with dimension of 75 mm length and 10 mm diameter was used. The sample was taken out of the mould after it was cured for 24 h and theentire process was held at a room temperature of around 29 °C. The samples were labeled as NCSCP, CSCP 10, CSCP 20, and CSCP 30according to variations in contentfiller composite.

Wear resistance testing using Pin-on-disc (POD) tribometer controlled by computerwas used to perform wear test ASTM standard of G99-95 with the dimension of 10 mm diameter and length 15 mm.

Wear specimen was placed against the stainless steel with a loads of 15, 20, 25 and 30 N at different sliding velocities of 1.5, 2.0 and 2.5 m/s corresponding with

100, 200 and 250 rpm used for the test duration of 10 min at a radial sliding distance of 80 mm. Immediate contact was made between the counter surface of the specimen and the disc by creating roughness on the specimen surface with the use of water proof silicon. The disc and samples were cleaned by the use of acetone before conducting the test. Before the experiments, the sample weight is measured as W1 and weight of the specimen after the wear test is noted as W2 with the help of electronic weighing machine of 0.001 gm as least count. The weight difference between the weight of the specimenbefore the wear test and after the wear test is called as weight loss (ΔW). The following equations are used to calculate the weight loss (ΔW), coefficient of friction (m) and wear rate respectively. By using Eq. (1), Eq. (2) and Eq. (3) with different speed and different load, the weight loss, coefficient of friction and wear rate of the specimen were determined [24].

$$\text{Weight loss } (\Delta W) = W1 - W2 \quad (1)$$

$$\text{Coefficient of friction } (\mu) = \frac{f}{N} \quad (2)$$

$$\text{Wear rate (WR)} = \frac{\Delta W}{\rho L} \quad (3)$$

where, μ is coefficient of friction, f = frictional force, N = normal load, ρ = density and L= sliding distance. The test was conducted at room temperature of 29 ^{0}C and relative humidity of 65%.Morphological analysis used scanning electron microscope (Model VEGA 3 TE SCAN)for studying the surface of the wear tested specimen. Thin layer of sputtered gold was coated on the worn surface of all the tested composite specimens to improve electrical conductivity and to obtain better images.

III. OBESERVATIONS FROM THE TEST WEAR RESISTANCE

Epoxy composite material reinforced with MASF and CSCP filler has been examined based different condition of filler composite such CSCP 10%, 20%, 30%, and without CSCP with different velocity and varying loads.Wear resistance of polymer material depends on the applied load, mechanical characteristics and chemical bonding of

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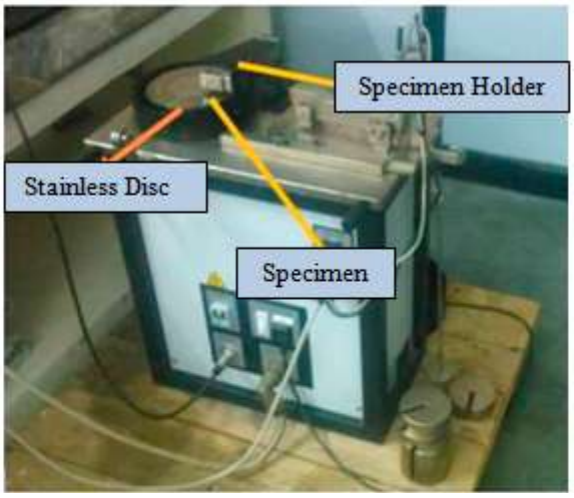
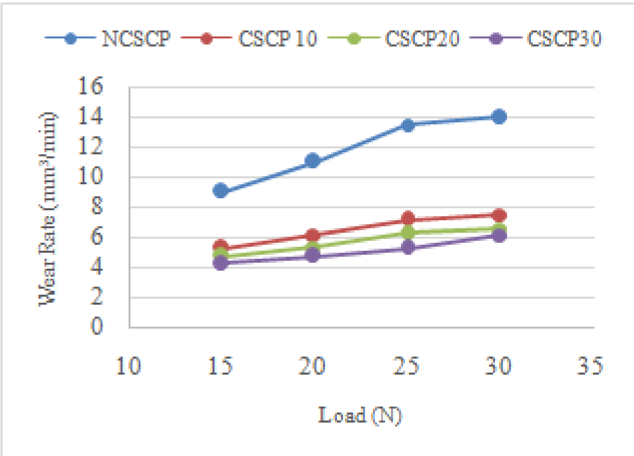
material [24]. When compared to conventional material surface, surface of polymeric material is smooth. For wear analysis, 15 N-30 N load is applied at an interval of 5 N for the velocity of 1.5, 2.0, and 2.5 m/s. Less than 15 N load and 1.5 m/s velocity was predicted as negligible.



MASF at velocity of 2.5 m/s



Wear rate of epoxy composite reinforced with Wear resistance measurement apparatus

Wear rate of epoxy composite reinforced with MASFat velocity of 1.5 m/s.

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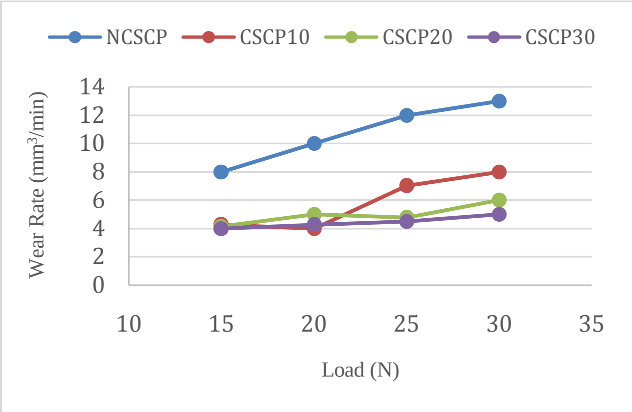
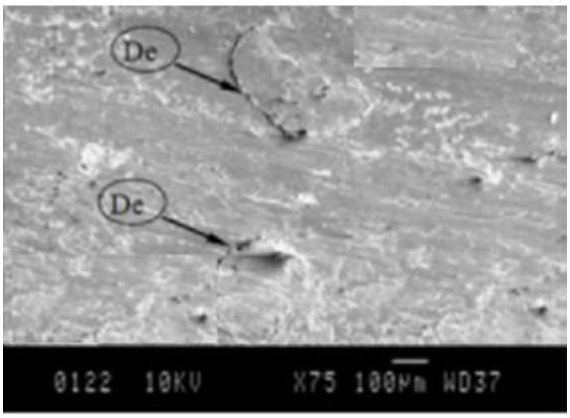


Wear rate of epoxy composite reinforced with MASF at velocity of 2.0 m/s.

The wear rate of MASF reinforced epoxy composite, without CSCP filler, CSCP 10%, 20% and 30% is different at 100 rpm, 200 rpm and 250 rpm with a load variation of 15 N, 20 N,25 N and 30 N with constant sliding for 10 minutes.

When compared with epoxy composite with filler, CSCP 10%, 20% and 30% reinforced with MASF,composites with different loads and different speeds, that's all found epoxy composites without CSCP fillers has a high wear rate. Under different loads and speed. It was found that the addition of the CSCP filler experienced less wear rate when compared to composites without filler CSCP. Less wear means better wear resistance. Additional 30% CSCP filler has the best wear resistance quality. The reason is a good interface bond. Composite without CSCP filler occurs cracking, plastic deformation, wear, poor adhesion, pulling of fibers and dirt, wear rates increase incomposite. The higher wear rates for the epoxy composites cause the fibers to be pulled easily from the matrix, but still less tensile and peel of fibers in silane treated composites. This may be due to the influence that CSCP filler fed fibers are preferred due to polymer cross-linking. The presence of good MASF CSCP filler fibers in epoxy composites decreased wear rate and friction appearance and similar results reported by [4]. When comparing wear rates for all shear speeds, loads applied and maintenancefibers, composites without CSCP fillers showed a greater reduction in wear rates compared to other samples. The addition of the CSCP filler leads to formation of better interlocking bonds between matrices and fibers and hence composites show lower wear rateor increased wear resistance [12].



SEM micrographs of epoxy composite-MASF-NSCSP at 30 N applied load and 2.5 m/s sliding velocity

The micrograph of epoxy composite-MASF-NSCSP at 30 N applied load and 2.5 m/s sliding velocity, under this condition, it can be seen that the MASF are slightly debonded (marked ‘‘De’’). Furthermore, the wear mechanism in the resinous region is predominated by deformation. Because there is no addition of filler, the matrix and fiber bonds are not homogeneous.

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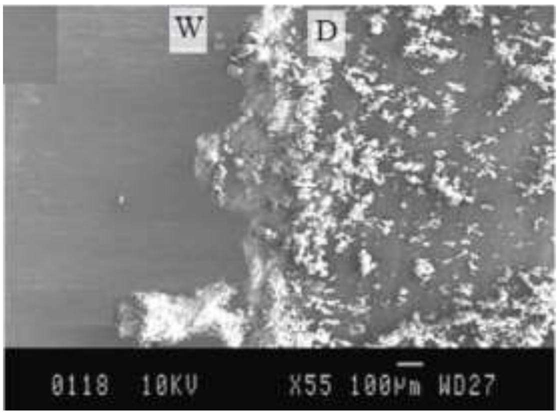
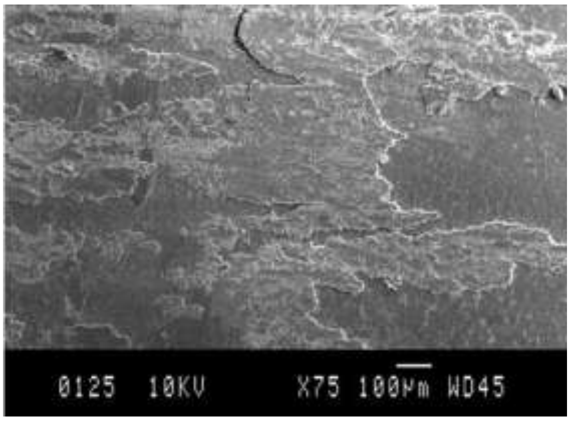
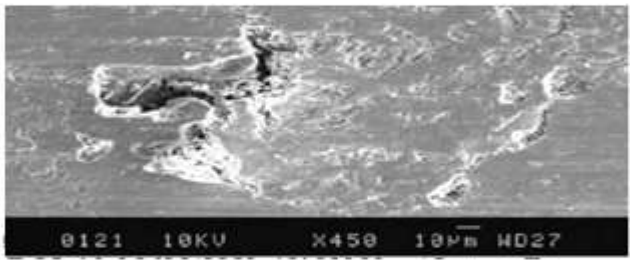
The micrograph of epoxy compositeMASF-SCSP10% at 30 N applied load and 2.5 m/s in can be seen of the worn surface of the neat MASF. Due to this reason, epoxy compositeMASF-SCSP 20% can be seen of the debris was worn away from the interface, especially at the longer sliding distances. shows two regions of the neat composite surface as the end of the worn area (marked as W'') and the generated epoxy debris from the interface (marked as 'D'').The better wear performance of epoxy composite-MASF-SCSPfiller could be due to theenhanceement of the adhesion characteristic between theoil palm fibres and the polyester matrix. It was reported that the interfacial adhesion of the oil palm fibres with the matrix enhanced the mechanical properties [5], where during the tensile loading condition, the break occurred in the composite and no sign of pull-out was observed. From tribological point of view, during the sliding, the possibility of pull-out or debonding could be lesser for the treated fibrthan the untreated ones. In addition to that, there could be another reason, which is the porosity of the composite



SEM micrographs of epoxy composite-MASF-SCSP 20% at 30 N applied load and 2.5 m/s sliding velocity



SEM micrographs of epoxy composite-MASF-SCSP 30% at 30 N applied load and 2.5 m/s sliding velocity



SEM micrographs of epoxy composite-MASF-SCSP 10% at 30 N applied load and 2.5 m/s sliding velocity

SEM micrographs of epoxy composite – MASF-SCSP30%shows no sign of debonding and/or emptybundles of fibres. This could contribute to the lower wear rate (higher wear resistance) values of ofepoxy composite-MASF-SCSP30%compared to NSCSP, SCSP 10%, and SCSP 20%

IV. CONCLUSION

The effects of applied load and sliding velocity were highly pronounced on the wear rate. Higher wear rate was exhibited at higher load and sliding velocity. On the other hand, sliding velocity showed less effect on the frictional behaviour.Adding filler coconut shell charcoal powder (CSCP)to epoxy composite material reinforced Musa acuminata stem fiber (MASF)reduces wear rate or increases wear resistance about 40–60%. Wear resistance performance of epoxy composite material reinforced MASF was heavily influenced by interface fiber and its adhesion characteristics porosity, which allows it to be filled by the CSCP filler.The wear mechanism of the composite is dominated by debonding and fiber bending,whereas fragmentation and deformation in resinousproven area. In addition, the fiber without CSCP filler causes higher material displacement in comparisoncomposite with CSCP filler.

SOME OF THE ADVANAGES FROM THE ABOVE RESULTS

The Material surfaces of epoxy composite reinforced MASF with CSCP filler showed less wear damage compared to without CSCP (NCSCP). There was no sign of fiberdebonding and fiber empty (without filler), where the transfer of material appears to be on the resinous more fibrous areas of MASF without CSCP filler

REFERENCES

[1]. Nozawa JI, Komoto T, Kawai T, Kumehara H., 2009, “TribologicalProperties of Polymer-Sheet-Adhered Metal Hybrid Gear”.Wear,266(9e10):893e.https://doi.org/10.1016/j.wear.2008.12.008.

[2]. Srinath, G., Gnanamoorthy, R., 2005, “Effect of short fibre reinforcementon the friction and wear behaviour of nylon 66”. Appl.Compos. Mater. 12(6), 369–383, doi:10.1007/s10443-005-5824-6.

[3]. Senthilvelan, S., Gnanamoorthy, R.: Selective carbon fiber reinforcednylon 66 spur gears: development and performance. Appl. Compos. Mater. 13(1), 43–56 (2006). doi:10.1007/s10443-005-9003-6.

[4]. Yousif, B.F., El-Tayeb, N.S.M., 2007, “Tribological evaluations ofpolyester composites considering three orientations of CSM glassfibres using BOR machine. Appl. Compos. Mater. 14(2), 105–116, doi:10.1007/s10443-007-9034-2.

[5]. Yousif, B.F., El-Tayeb, N.S.M., 2006, “Mechanical and tribologicalproperties of OPRP and CGRP composites”. In: InternationalConference of ICOMAST, pp. 384–388. Malacca, Malaysia,28–30 August.

[6]. Navin, H., Dwivedi, U.., 2006, “Effect of coupling agent on abrasivewear behaviour of chopped jute fibre-reinforced polypropyleneComposites”. Wear 261(10), 1057–1063 (2006).doi:10.1016/j.wear.01.039.

[7]. Holbery J, Houston D., 2006, “Natural-fiber-reinforced polymercomposites in automotive applications. JOM (J Occup Med),58(11):80e6. https://doi.org/10.1007/s11837-006-0234-2.

[8]. Puglia D, Biagiotti J, Kenny JM., 2005, “ A review on natural fibrebasedcomposites - Part II: application of naturalreinforcements in composite materials for automotiveindustry”. J Nat Fibers, 1(3):23e65. https://doi.org/10.1300/J395v01n03_03.

[9]. Omrani E, Menezes PL, Rohatgi PK., 2016, “ State of the art ontribological behavior of polymer matrix compositesreinforced with natural fibers in the green materials world”, Engineering Science Technology, International J, 19(2):717e36. https://doi.org/10.1016/j.jestch.10.007.

[10]. El-Tayeb, N.S.M., 2008, “Abrasive wear performance of untreated SCF reinforced polymer composite”, J. Mater. Process Technol.206 (1–3), 305–314, doi:10.1016/j.jmatprotec.2007.12.028.

[11]. El-Tayeb, N.S.M., Yousif, B.F., Yap, T.C., 2006, “Tribological studiesof polyester reinforced with CSM 450-R-glass fiber slidinggainst smooth stainless steel counterface”, Wear 261(3–4), 443–452, doi:10.1016/j.wear.2005.12.014.

[12]. Gang D., 2018, “The influence of surface treatment on the tensile and tribological properties of wood fiber-reinforced polyimide composite”. Surf Interface Anal, 50(3):304e10.https://doi.org/10.1002/sia.6369.