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Effect of recycled spent abrasive particle addition on the tribological behavior of kenaf fiber reinforced hybrid polymer composites

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KEYWORDS

Spent abrasive particles
Reinforced hybrid polymers
Sliding abrasive wear
Worn surface analysis

ABSTRACT

The present work explores the potential of recycling and reusing spent abrasive particles obtained from abrasive water jet machining as filler materials in the production of kenaf fiber-reinforced hybrid polymer composites. The composites were fabricated using the hand lay-up technique, incorporating spent abrasive particles from abrasive water jet machining at varying weight percentages. To evaluate the tribological performance of the composites, a comprehensive analysis of their friction and wear properties was conducted using a pin-on-disk tribometer under dry sliding abrasive wear conditions. Two-body wear tests were performed with different parameters, including load, sliding velocity, and sliding distance, to assess the impact of the spent abrasive particle addition on the tribological behavior of the composites. The results exhibited that the addition of 7.5 wt. % spent abrasive particles as filler improved the wear resistance of kenaf fiber-reinforced epoxy composites, achieving a minimum wear rate of 0.01 mm^3/m and a friction coefficient of 0.06 at 5 N and 1 m/s. Excess filler addition above 7.5 wt. % reduced performance due to weaker bonding and thermal effects, confirmed by worn surface analysis.

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1.0 INTRODUCTION

The exceptional strength-to-weight ratio of polymer composites has significantly increased their applications over the past era. Jafrey Daniel and Panneerselvam (2016) investigated the mechanical properties of polypropylene polymer composites, which are extensively utilized in industrial applications, including rollers, cams, bearing materials, and clutches. Saeedi et al. (2024) sightseen the industrial applications of fiber-reinforced polymer composites, highlighting the need for a thorough examination of the tribological properties of these materials owing to their prevalent usage. Miao et al. (2023) evaluated the tribological behavior of polymer materials, while Suresha et al. (2010) analyzed the influence of graphite fillers on dry sliding and abrasive wear in carbon fabric-reinforced epoxy composites and determined that abrasive wear accounted for 64% of the total wear observed.

Further research has (Davim et al. 2001) focused on the wear behavior of polyetheretherketone (PEEK) with fiber reinforcement, elucidating the mechanisms of two-body and three-body abrasive wear. Horovistiz and Davim (2020) also contributed to the understanding of the tribological properties of polymers by detailing the conditions governing abrasive wear. In two-body abrasive wear, high strain and plastic deformation are prevalent, and material removal is initiated by harder materials acting against softer surfaces. Conversely, in three-body abrasive wear, the grit particles are free to roll and slide against the surface. Davim and Cardoso (2006) articulated the mechanisms of micro-plowing, micro-cutting, micro-fatigue, and micro-cracking in abrasive wear during a tribological study of PEEK. Different polymer types exhibit distinct tribological properties; virgin polymers are often inadequate for tribological applications because of their limited mechanical and tribological characteristics, thereby prompting extensive research on polymer composites (Aher et al. 2020). Investigations by Jafrey Daniel and Panneerselvam (2016); Mertens and Senthilvelan (2018); Zhang et al. (2007) underscored the greater tribological and mechanical properties of polymer nanocomposites.

Studies have (Ramakoti et al. 2023; Sinha Ray and Okamoto 2003; Yoon et al. 2002) corroborated that polymer nanocomposites exhibit enhanced mechanical, thermal, optical, and other properties. Research conducted by Suresha et al. (2010) explored the effects of filler incorporation into polymer matrices, revealing marked improvements in abrasive wear behavior. Suresha et al. (2010) identified critical factors influencing abrasive wear, with paramount grit size followed by load and abrading distance. Bijwe et al. (2000) investigated glass fibers reinforced with solid lubricants and documented significant enhancements in the wear performance. Roshan et al. (2024) investigated the tribological performance of carbon-fiber-reinforced polyphenylene sulfide composites and observed superior tribological properties in polymer composites. Numerous researchers, including Akhyar et al. (2024) and Ramesh et al. (2022) developed various wear models to scrutinize the effect of reinforcement quantity, tensile strength, elongation at break, material hardness, applied stress, and frictional factors on the wear rates of materials. The mechanical properties of jute/hemp/flax-reinforced hybrid polymer composites and their tribological applications were examined by Chaudhary et al. (2018). The effect of natural fiber reinforcements on the mechanical properties of polymer composites has been investigated, and positive trends have been observed (Nasir and Ghazali 2014; Radzi et al. 2020).

Other studies have focused on the effects of various fillers on the mechanical and tribological characteristics of polymer composites (Jumahat et al. 2015) (Talib et al. 2018). Kushwanth Theja et al. (2023); Praveenkumara et al. (2022) investigated the impact of fillers on the tribological properties of polymer composites, affirming that filler addition enhances tribological performance. Li et al. (2013) studied the tribological behavior and mechanical properties of glass/polyamide-6 composites with varying filler loadings, including graphite, PTFE, and UHMWPE, and confirmed that graphite fillers substantially improved both the mechanical and tribological properties.

The present study aims to compare the tribological characteristics of various epoxy polymer composites reinforced with kenaf fibers and different ratios of recycled spent abrasive fillers derived from abrasive water jet machining. Kenaf (Hibiscus cannabinus), a plant in the Malvaceae family, is also known as Java jute or Deccan hemp and is predominantly found in southern India. Kenaf fiber, with approximately 66% cellulose content, possesses a high specific strength, modulus, and reactive surface, making it a viable alternative to jute fiber. This study utilized fillers extracted from abrasive water jet machining waste, which includes valuable materials such as alumina, silica, carbide, and residual parent material particles. The effects of kenaf fibers (without fillers) and kenaf fibers with varying filler compositions (2.5%, 5%, 7.5%, and 10% by weight) on the tribological behavior of epoxy polymer matrix composites were thoroughly examined. Pin-on-disc wear tests were conducted to evaluate the abrasive wear resistance of five Kenaf fiber-reinforced epoxy polymer composite compositions with incorporated fillers. A comparative analysis of the tribological characteristics of various kenaf fiber-reinforced polymer compositions indicated that the addition of recycled spent abrasive fillers positively influenced the tribological properties. Scanning Electron Microscopy (SEM) images of the wear tracks demonstrated that the incorporation of recycled spent abrasive fillers significantly enhanced the abrasive wear resistance of kenaf fiber-reinforced polymer composites.

1.0 EXPERIMENTAL DETAILS

1.1 Materials

Bi-directional woven kenaf fiber mats, 0.9 mm thick with an areal density of approximately 180 g/m^2, feature 0°/90° fiber alignment, which is well-suited for polymer matrix composites, providing excellent compatibility with epoxy resins is used as the fiber reinforcement in this investigation. Epoxy resin (LY556), a Bisphenol-A-based resin with a viscosity of 11,510 mPa·s and a density of 1.16 g/cm^3, is combined with curing agent HY951, an aliphatic amine hardener with a viscosity of 17 mPa·s and a density of 0.98 g/cm^3, in a 100:10 weight ratio to impregnate and hold the kenaf fiber mats during composite preparation. The hand lay-up method was used to fabricate a kenaf fiber-reinforced hybrid composite filled with spent abrasive particles in five distinct combinations.

1.2 Characterization of Spent Abrasive Particles

The spent abrasive particles from abrasive water jet machining will be consisting of the abrasive particles that are standardly used such as garnet, Al_20_3, B_4C and SiC. Moreover, the spent abrasive particles will also have the debris of the workpieces that were cut in that particular machine. In order to identify them, they were systematically recycled and characterized using standard testing processes to evaluate their potential as filler material for polymer composites. Initially, the particles were dried to eliminate moisture and sieved to achieve uniform particle size, ensuring consistency in their application. Comprehensive particle size analysis was then conducted to determine the distribution and range of particle sizes, a critical step in assessing their compatibility with the polymer matrix and their influence on composite properties. A VEGA3 and TESCAN Scanning Electron Microscope equipped with a BRUKER Nano, GmbH, D-

12489 (Germany) Energy-Dispersive X-ray Spectroscopy attachment, is used to obtain the scanning electron microscopic images, which provided high-magnification insights into surface morphology, particle shape, texture, and surface irregularities that could impact the composite's mechanical performance. The energy-dispersive X-ray spectroscopic analysis elucidated the elemental composition, offering a detailed understanding of material homogeneity and the influence of specific elements on composite behavior. The integration of these analyses (Figures 1 and 2) facilitated a comprehensive evaluation of the filler material's properties, ensuring its optimal incorporation into the composite matrix to enhance performance.

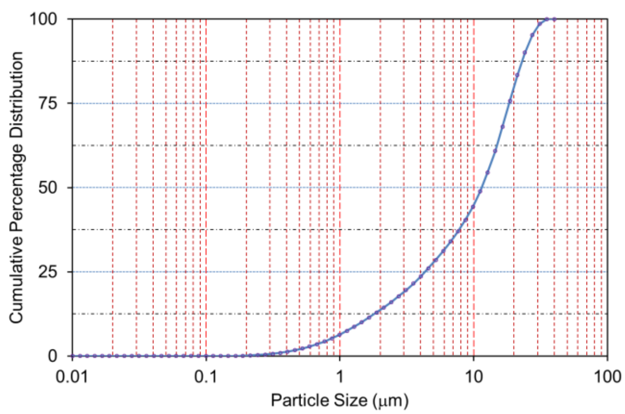


Figure 1: Particle size analysis of spent abrasive particles.

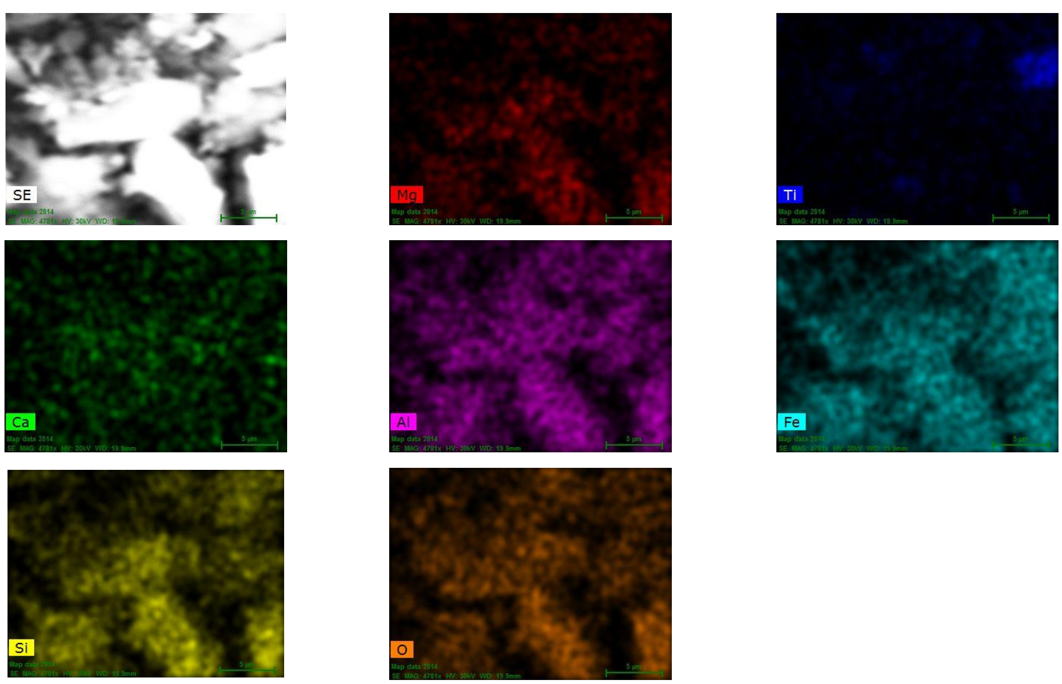


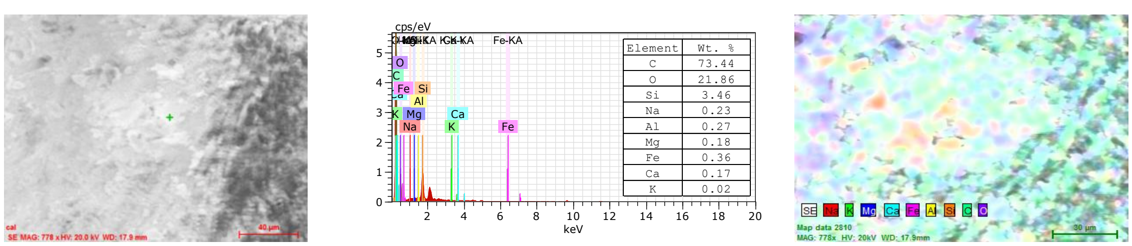
Figure 2: Scanning electron microscopic image and elemental analysis of spent abrasive particles.

1.3 Fabrication Details

The most widely used hand lay-up process (Rajak et al. 2019) has been adopted for the fabrication of kenaf fiber-reinforced epoxy hybrid polymer composites with spent abrasive particles from abrasive water jet machining as fillers. Bi-directional kenaf fiber was chosen as the primary reinforcement because of its sustainability and growing use in composite applications, and it consisted of epoxy resin (LY556) and hardener (HY951) in a stoichiometric ratio for optimal cross-linking. Recycled abrasive particles from water jet machining were used as the filler material, and a particle size analysis was performed. The composites were fabricated using the hand lay-up method combined with a hydraulic compression molding machine, where kenaf fiber mats (300 mm × 300 mm) were weighed, and the composite was designed with 20% fiber and 80% matrix by weight, with a matrix containing 90 wt. % epoxy resin and 10 wt. % hardener. A 500 kN FIE hydraulic compression molding machine with a 300 mm square cavity (20 mm depth) was employed. The process involved pouring a homogeneous mix of epoxy resin, filler, and hardener into the die cavity and distributing it evenly, followed by placing a layer of kenaf fiber mat over the resin matrix; this was repeated to create a composite with four resin layers and three kenaf fiber layers. Five different filler concentrations (0%, 2.5%, 5%, 7.5%, and 10% by weight) were tested to assess their effects on mechanical properties. After fabrication, the composites were cured at ambient temperature for 24 h, followed by post-curing at 70°C for three hours to enhance their mechanical performance. The plates were sectioned into standard geometries according to ASTM D4762-23 using a BSM Pvt. Ltd BS6040 laser cutting machine and calibrated for high precision.

1.4 Characterization of Kenaf Fiber Reinforced Hybrid Polymer Composite

Energy-dispersive X-ray spectroscopy (EDS) and elemental analysis were conducted on a kenaf-fiber-reinforced hybrid polymer composite contains 7.5 wt. % filler, as shown in Figure 3. The results from these analyses revealed significant contributions from several key elements as shown in Figure 3 (b), including iron (Fe), silicon (Si), and aluminum (Al). These elements are typically associated with spent abrasive materials that are intentionally incorporated into a composite matrix. The presence of these elements supports the hypothesis that abrasive materials have been successfully integrated into the polymer matrix, demonstrating that they play a substantial role in the composition of the hybrid composite. This outcome not only highlights the effective utilization of waste materials but also underscores the potential of such composites for applications where enhanced mechanical properties are desired owing to the synergistic effects of the fiber reinforcement and filler materials.



(a) (b) (c)

Figure 3: Energy dispersive X-ray spectroscopy analysis of the kenaf fiber reinforced polymer composite with filler addition (a) SEM image (b) Spectrum analysis and (c) Elemental mapping.

1.5 Abrasive Wear Testing

Using a DUCOM TR-20LE pin-on-disc tribo tester, a single pass two-body abrasive wear test was performed in accordance with the ASTM G-99 standard. An AISI D3 steel disc was covered with an 800-grit abrasive paper. In the Kenaf-fiber-reinforced epoxy hybrid polymer composite, friction and wear tests were conducted under dry conditions with varying filler additions by weight (0%, 2.5%, 5%, 7.5%, and 10%), a constant sliding distance of 800 m, velocities of 1 m/s, 2 m/s, and 3 m/s, and loads of 5 N, 10 N, and 15 N. 320 grade SiC emery was used to pre-wear pin specimens. Small polymer sample discs were adhered to the ends of the pin specimens using adhesives, as shown in Figure 4. The samples were prepared in a manner that guaranteed full pin-to-abrasive disc surface contact. An electronic digital analytical balance with 0.0001 g readability was used to weigh the pin specimen both before and after the experiment to determine the amount of abrasive wear loss. Using Equation (1), the wear rate K (mm3/m) was determined.

$$\text{Wear rate, K} = \frac{m_1 - m_2}{\rho \times S} \quad (1)$$

where the masses (g) of the pin specimen before and after the experiment are denoted as m_1 and m_2 respectively. ρdenotes the density (g/mm^3) of the kenaf fiber-reinforced composite specimen. The load (N) and sliding distance (m) are represented by N and S, respectively. The friction force (N) was directly measured from the friction monitor, and the coefficient of friction (COF) was calculated using Equation (2).

$$\text{Coefficient of friction} = \frac{\text{Frictional Force}}{\text{Load}} \quad (2)$$

Figure 4: Wear test sample prepared as per ASTM G99 standard.

2.0 RESULTS AND DISCUSSION

2.1 Abrasive Wear Analysis

Table 1 shows the results of abrasive wear tests conducted on different compositions of kenaf fiber-reinforced hybrid epoxy polymers containing spent abrasive particles as fillers. It was observed that the wear resistance of the kenaf fiber-reinforced hybrid polymer composites was enhanced by the addition of spent abrasive particles from abrasive water jet machining as a filler material. There was a gradual enhancement in the wear resistance property of the polymer when the abrasive wear test was conducted with a 5 N load. The wear rate of the polymers abruptly increased when the wear test was conducted with a load higher than 5 N. The wear resistance performance of polymers varies widely with higher loads and sliding velocities. The tribological properties of the polymers increased with the addition of filler material. The wear rate of the polymers decreased with the addition of spent abrasive particles as a filler up to 7.5% by weight, and it increased when more than 7.5% of the filler material was added.

Table 1: Experimental results of abrasive wear tests conducted on kenaf fiber-reinforced hybrid epoxy polymers containing different amount of spent abrasive particles as fillers.

S. No.	Filler Addition (wt. %)	Load (N)	Sliding Velocity (m/sec)	Wear Rate (mm3/m)	Coefficient of Friction
1	0	5	1	0.0253	0.11
2	0	5	2	0.0336	0.19
3	0	5	3	0.0372	0.24
4	0	10	1	0.0542	0.47
5	0	10	2	0.0569	0.54
6	0	10	3	0.0664	0.60
7	0	15	1	0.0860	0.55
8	0	15	2	0.1104	0.61
9	0	15	3	0.1193	1.16
10	2.5	5	1	0.0218	0.10
11	2.5	5	2	0.0307	0.17
12	2.5	5	3	0.0369	0.21
13	2.5	10	1	0.0516	0.40
14	2.5	10	2	0.0567	0.45
15	2.5	10	3	0.0578	0.49
16	2.5	15	1	0.0803	0.43
17	2.5	15	2	0.0971	0.46
18	2.5	15	3	0.1166	0.66
19	5.0	5	1	0.0139	0.08
20	5.0	5	2	0.0273	0.14
21	5.0	5	3	0.0353	0.18
22	5.0	10	1	0.0510	0.32
23	5.0	10	2	0.0543	0.36
24	5.0	10	3	0.0575	0.41
25	5.0	15	1	0.0737	0.37
26	5.0	15	2	0.0941	0.43
27	5.0	15	3	0.1094	0.61
28	7.5	5	1	0.0067	0.06
29	7.5	5	2	0.0262	0.11
30	7.5	5	3	0.0339	0.15
31	7.5	10	1	0.0396	0.23
32	7.5	10	2	0.0416	0.24
33	7.5	10	3	0.0455	0.30

34	7.5	15	1	0.0696	0.27
35	7.5	15	2	0.0896	0.27
36	7.5	15	3	0.1064	0.41
37	10	5	1	0.0104	0.06
38	10	5	2	0.0273	0.12
39	10	5	3	0.0341	0.17
40	10	10	1	0.0400	0.25
41	10	10	2	0.0435	0.34
42	10	10	3	0.0488	0.37
43	10	15	1	0.0705	0.35
44	10	15	2	0.0937	0.39
45	10	15	3	0.1077	0.55

2.2 Worn Surface Analysis

Scanning electron microscopy (SEM) images of abrasive wear surfaces of kenaf fiber-reinforced hybrid polymer composites are shown in Figure 5 (a)-(e).

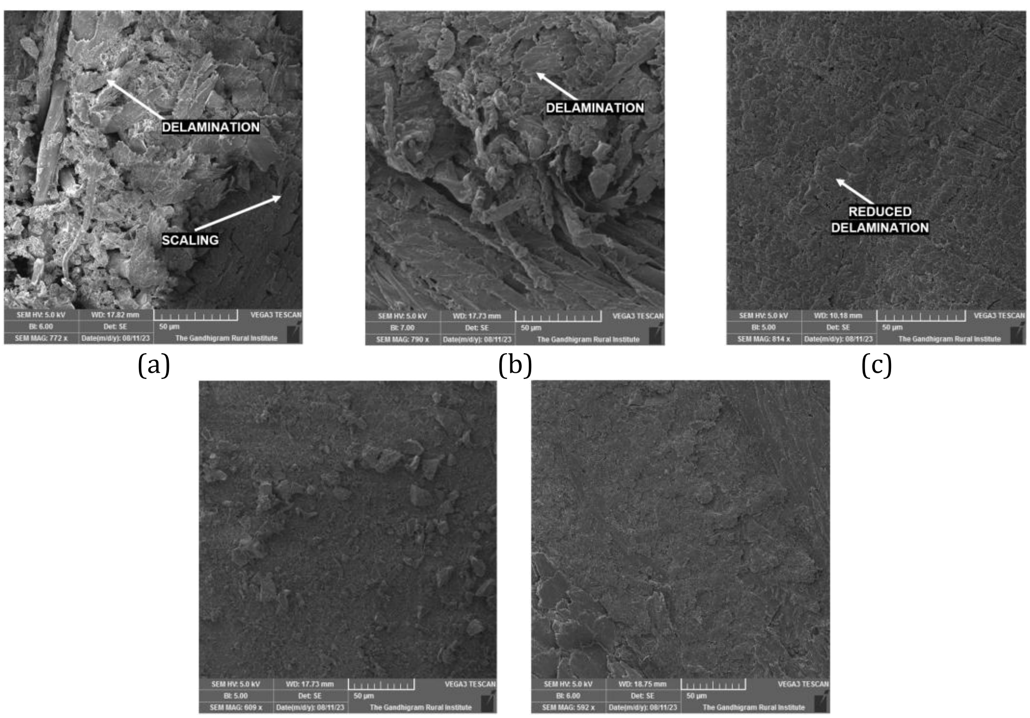


Figure 5: Worn surface of kenaf fiber reinforced polymer composite with (a) 0 wt. % (b) 2.5 wt. % (c) 5 wt. % (d) 7.5 wt. % and (e) 10 wt. % filler additions.

The images obtained from the abrasive surfaces resulted from the abrasive wear test conducted under a 15 N load, 3 m/s sliding, and a sliding distance of 800m for all five combinations of the polymer composites. The worn surface of the kenaf fiber-reinforced hybrid polymer composite without filler addition is shown in Figure 5(a). Abrasive wear by delamination was observed in the polymer sample. Inter-laminar failure of the polymer sample resulted in a delaminated surface. The epoxy resin surface is worn out more easily than the fiber phase of the polymers. Kenaf fiber-reinforced composites without filler additions show less resistance to abrasive wear when exposed to high loads and high sliding velocities. The bonding between the polymer matrix and reinforced fibers was separated by the frictional force caused by the interaction between the abrasive wheel and polymer samples. Evidently, the kenaf fiber-reinforced hybrid polymer composite can withstand a load range of 5 N to 10 N.

Figure 5(b) depicts the worn surface of the kenaf fiber-reinforced hybrid polymer composite with 2.5% filler addition by weight. The samples exhibited a decrease in surface delamination and scaling resulting from abrasive wear compared to those without filler addition. The resistance of kenaf fiber-reinforced hybrid polymer composites against abrasive wear was improved by the addition of filler material. the polymer sample's inter laminar failure was partially repressed. When low abrasive loads were used during the wear tests, the kenaf fiber-reinforced polymer composite with filler addition exhibited a slightly lower wear rate than the samples without filler addition. In contrast to the polymer samples without filler material under the same testing conditions, a noticeable drop-in wear rate was observed when the wear test was carried out with higher loads. The stratified layers of fiber, fillers, and epoxy resin of the kenaf fiber-reinforced hybrid polymer composite samples reduced the wear rate. The tribological properties of the kenaf fiber-reinforced hybrid polymer composite samples improved marginally under low abrasive loads and considerably under higher abrasive loads when compared with those of samples with and without filler addition.

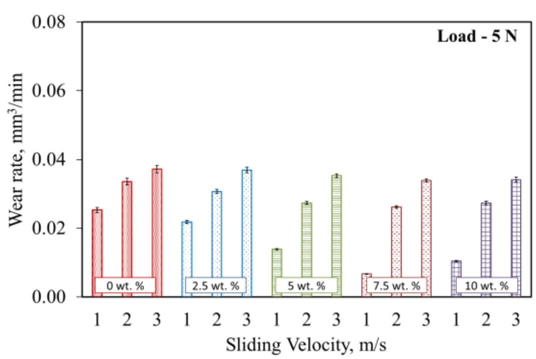
The worn surface of the kenaf-fiber-reinforced hybrid polymer composite with 5 wt. % filler additions by weight is shown in Figure 5(c). When compared to samples without filler and samples with 5% filler addition by weight, the samples exhibited less surface delamination and scaling from abrasive wear. By adding a filler material, the resistance of the kenaf fiber-reinforced hybrid polymer composites to abrasive wear was further strengthened. The inter-laminar failure of the polymer sample was nearly suppressed. The kenaf fiber-reinforced hybrid polymer composite with 5% filler addition had a marginally lower wear rate than the samples without filler addition and with 2.5% filler addition by weight when low abrasive loads were used during wear tests. When high abrasive loads were applied during the wear tests, the kenaf fiber-reinforced hybrid polymer composite with 5% filler addition had a noticeably lower wear rate than the samples without filler addition and with 2.5% filler addition by weight. As more filler material is added, the wear rate decreases.

Figure 5(d) shows the worn surface of the kenaf fiber-reinforced hybrid polymer composite with 7.5% filler by weight. Delamination was not observed in any of the samples. The resistance of kenaf fiber-reinforced hybrid polymer composites to abrasive wear was increased by the addition of filler material. the polymer sample's inter laminar failure was inhibited. When low abrasive loads were used during the wear tests, the kenaf fiber-reinforced hybrid polymer composite with 7.5% filler addition had a slightly lower wear rate than the samples without filler addition and with 2.5% and 5% filler addition by weight. The kenaf fiber-reinforced hybrid polymer composite with 7.5% filler addition had a significantly lower wear rate than the samples without filler addition and with 2.5%, 5% filler addition by weight when high abrasive loads were applied during wear tests. The wear rate decreased with the addition of more filler material. The addition of 7.5% filler material resulted in an improved tribological performance.

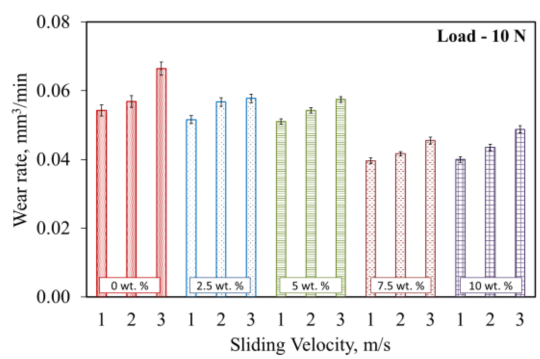
Figure 5(e) shows the worn surface of the kenaf fiber-reinforced hybrid polymer composite with 10 wt. % filler additions by weight. Wear is caused by the disintegration of the polymer layers as microgranules. This type of disintegration of the wear surface is caused by weaker adhesive bonding between the matrix and reinforcements as well as thermal effects. Excess addition of filler material weakened the adhesive bonding in the polymer samples. Repeated loading of the abrading surface induced a high thermal zone in the samples and catalyzed the wear rate. No delamination was observed in the samples, but grooving was observed on the surface. The resistance of kenaf fiber-reinforced polymer composites to abrasive wear started to decline with the addition of more than 10% filler material by weight. When low abrasive loads were used during the wear tests, the NFRP composite with 10% filler addition had a slightly higher wear rate than the samples with 7.5% filler addition by weight. The kenaf fiber-reinforced hybrid polymer composite with 10% filler addition had a significantly higher wear rate than the samples with 7.5% filler addition by weight when high abrasive loads were applied during the wear tests. The wear rate increased by more than 7.5% by weight with the addition of filler material.

2.3 Effect of Wear Parameters on Wear Behaviour

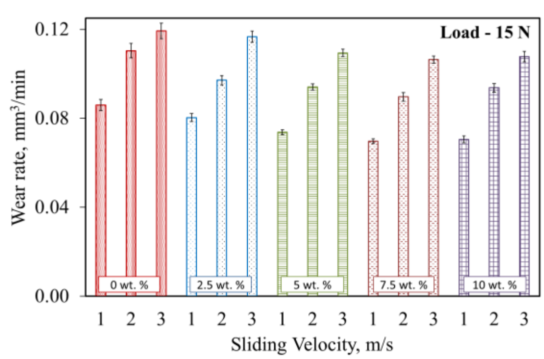
The impact of various experimental parameters on the wear rate of kenaf fiber-reinforced hybrid polymer composites, incorporating different levels of filler addition, is illustrated in Figure 6(a)-(c).



(a)



(b)



(c)

Figure 6: Effect of sliding velocity on the wear rate for (a) 5 N (b) 10 N and (c) 15 N load.

The effect of the experimental parameters on the wear rate of kenaf fiber-reinforced hybrid polymer composites with different levels of filler addition under a load of 5 N, sliding velocity of 1 m/s, 2 m/s, 3 m/s, and sliding distance of 800m are shown in Figure 6(a). At this condition, the wear rates of the polymer composite samples with filler additions of 2.5%, 5%, 7.5%, and 10% showed reductions of 13.83%, 45.22%, 73.66%, and 58.88%, respectively, compared to samples without filler addition under the same experimental conditions. The effect of the experimental parameters on the wear rate of kenaf fiber-reinforced hybrid polymer composites with different levels of filler addition under a load of 10 N, sliding velocity of 1 m/s, 2 m/s, 3 m/s, and sliding distance of 800m are shown in Figure 6(b). At this condition, the wear rates of the polymer composites with filler additions of 2.5%, 5%, 7.5%, and 10% by weight decreased by 8.57%, 18.54%, 21.97%, and 18.6%, respectively, compared to the samples without filler addition under a load of 10 N. Figure 6(c) presents the effects of various experimental parameters on the wear rate of kenaf fiber-reinforced hybrid polymer composites with different levels of filler addition under a 15 N load, employing sliding velocities of 1, 2, and 3 m/s with a sliding distance of 800 m. At this condition, the wear rates of the polymer composite samples containing 2.5%, 5%, 7.5%, and 10% filler by weight exhibited reductions of 0.74%, 5.06%, 8.97%, and 8.36%, respectively, when compared to the wear rates of the unfilled control samples under the same loading conditions.

2.4 Effect of Wear Parameters on Coefficient of Friction

Figure 7(a) illustrates the impact of various experimental parameters on the coefficient of friction of kenaf fiber-reinforced hybrid polymer composites with different levels of filler addition under a load of 5 N, sliding velocities of 1, 2, and 3 m/s, and a sliding distance of 800 m. A significant downward trend in the coefficient of friction was observed up to a filler addition of 7.5% by weight, after which an increase occurred at 10% filler addition by weight. Similarly, Figure 7(b) shows the effect of these experimental parameters on the coefficient of friction for the same polymer composites under a load of 10 N. A moderate downward trend in the coefficient of friction was observed up to 7.5% filler addition by weight, followed by an increase at 10% filler addition by weight. Figure 7(c) further examines the coefficient of friction of the kenaf fiber-reinforced hybrid polymer composites under a load of 15 N. Here, a slight downward trend persists up to 7.5% filler addition by weight, after which the coefficient of friction increases with the addition of 10% filler by weight.

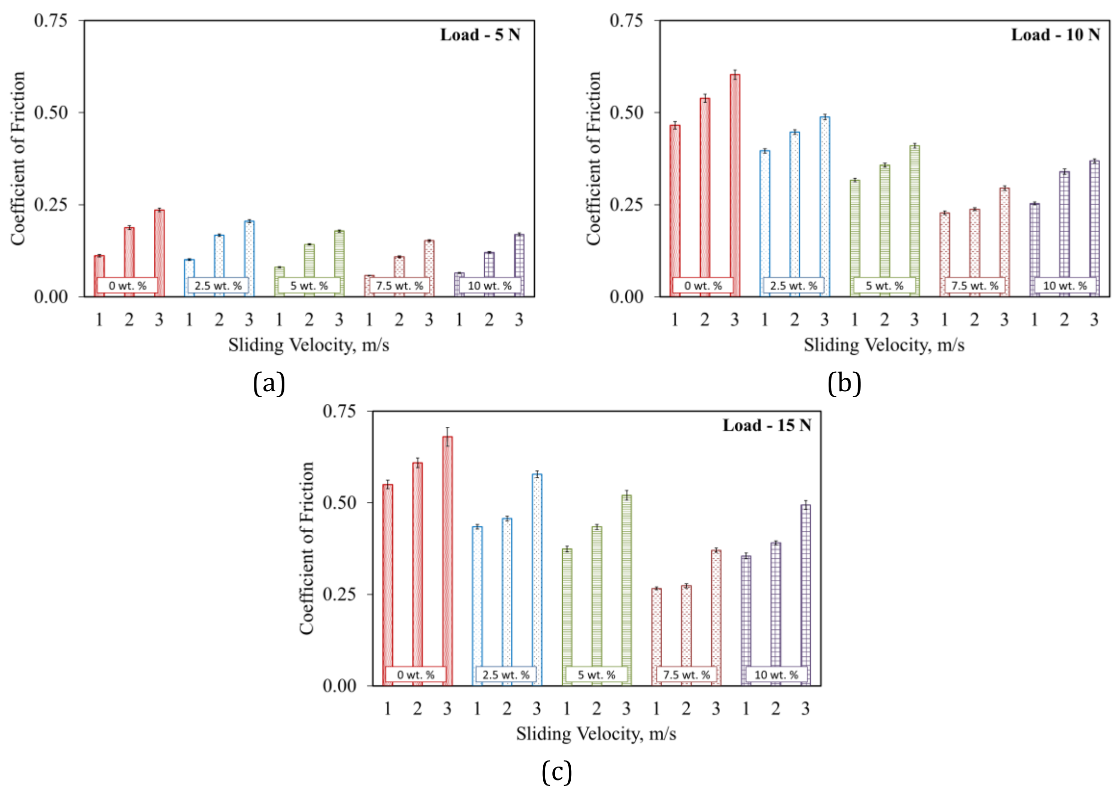


Figure 7: Effect of sliding velocity on coefficient of friction for (a) 5 N (b) 10 N and (c) 15 N load.

CONCLUSIONS

The following conclusions were drawn from the wear tests conducted on kenaf fiber-reinforced hybrid polymer composites with varying filler compositions:

The incorporation of spent abrasive particles from abrasive water jet machining as a filler significantly influences the tribological performance of the kenaf fiber reinforce epoxy hybrid polymer composites. The minimum wear rate of is 0.01 mm^3/m and a minimum coefficient of friction of 0.06 were obtained for the composite made with 7.5 wt. % of spent abrasive particle as filler at the wear parameter combination of 5 N load and 1 m/s sliding velocity. Whereas the maximum wear rate of 0.12 mm^3/m and maximum coefficient of friction of 1.16 were obtained for the kenaf fiber reinforced epoxy polymer composites without filler addition at the wear parameter combination of 15 N load and 3 m/s sliding velocity. Although, the addition of fillers increased the wear resistance up to the addition of 7.5 wt. %, further increase in the addition resulted in the deterioration of wear resistance due weaker adhesive bonding between the matrix and reinforcements as well as thermal effects, which has been confirmed by worn surface analysis.

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