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Tribological Behaviour of Furcraea Foetida Fiber-Reinforced Epoxy Composites under Varying Applied Loads

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ABSTRACT

This study investigates the tribological behaviour of Furcraea Foetida fibre-reinforced epoxy composites under varying applied loads. The aim is to understand the influence of applied load on the frictional behaviour and wear characteristics of the composites. The study employs a pin-on-disk test to examine the frictional force, coefficient of friction (COF), and specific wear rate (SWR) of identical samples subjected to four different loads (80 N, 100 N, 120 N, 140 N). Scanning electron microscopy (SEM) is used to analyse the surface morphology under different loads. The frictional force versus sliding distance graph demonstrates an increasing trend from 80 N to 120 N, followed by minimal change at 140 N. Similarly, the COF versus applied load graph shows a progressive increase from 80 N to 120 N, with the least increase observed at 140 N. The SWR versus applied load graph indicates an increasing trend from 80 N to 120 N, with marginal variation at 140 N. SEM analysis reveals that only the sample subjected to 140 N shows evidence of plastic deformation. In conclusion, the results indicate that the applied load significantly influences the frictional behaviour and wear characteristics of the Furcraea Foetida fibre-reinforced epoxy composites. At higher loads, the increase in frictional force, COF, and SWR becomes less pronounced, suggesting potential saturation in the composites' response. The presence of plastic deformation at 140 N further highlights the unique behaviour observed at this load. These findings contribute to a better understanding of the tribological performance of the composites and have implications for their practical applications.

1. Introduction

Tribology and wear are vital areas of study in modern society as they play an essential role in the performance, reliability, and efficiency of various mechanical systems. The study of tribology and wear encompasses various disciplines, including material science, physics, engineering, and chemistry [1]. Tribology and wear research has applications in a wide range of industries, including aerospace, automotive, manufacturing, and energy [2,3]. For a long time, synthetic fibres have been

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used as a reinforcement for a composite. But due to some disadvantages of synthetic fibres, natural fibre starting to take the place of synthetic fibres in areas such as the automotive industry because of the advantages it can offer over synthetic fibre.

Synthetic fibres have long been utilized as a reinforcement for their desirable properties. however, the limitations of synthetic fibres have led to a shift towards natural fibres. The superior advantages of natural fibres, including their low density, low cost, and biodegradability, abundantly available, low specific weight, high specific resistance, high rigidity, renewable resource, biodegradability, smaller energy consumption for production thus low CO_2 emission, simple and environmentally friendly processing methods, excellent electrical resistance and good thermomechanical property have made them an attractive alternative to synthetic fibres in composite material applications [4-9]. A review paper by Vinod *et al.,* [10], reported that numerous research papers, including those by Antunes *et al.,* [11], Battegazzore *et al.,* [12], and Fombuena *et al.,* [13], have highlighted the growing utilization of natural fibres in polymer composites and bio-based composites as a viable alternative to synthetic materials. This trend has prompted extensive research into the use of natural fibres, including Furcraea Foetida fibre, as a reinforcement material in composite materials for a range of applications. In a noteworthy review by Vinod *et al.,* [14], the study of Manimaran *et al.,* [15] highlighted the suitability of Furcraea Foetida as a substitute for synthetic fibres in polymer composites. This finding highlights the potential of utilizing Furcraea foetida in the development of sustainable and environmentally friendly composite materials.

In the field of natural fibre reinforced epoxy composites, several prior studies have been conducted to investigate their performance in dry sliding tests. For instance, Shuhimi *et al.,* [16] reported on the tribological behaviour of oil palm fibre and kenaf fibre reinforced epoxy composites respectively. Shuhimi *et al.,* [16] found that the incorporation of oil palm fibre and kenaf fibre into the epoxy matrix led to improvements in the tribological behaviour of the resulting composites. Specifically, the addition of oil palm fibre resulted in a decrease in wear rate and coefficient of friction compared to the neat epoxy, while the incorporation of kenaf fibre resulted in an increase in wear resistance and reduction in the coefficient of friction. The study also found that the oil palm fibre/epoxy composite had better tribological characteristics than the kenaf fibre/epoxy composite. These findings suggest that natural fibre reinforcement can enhance the tribological properties of epoxy composites. Additionally, Kumar *et al.,* [17] found that the hybridization of B. vahlii with G. optiva/epoxy composites resulted in increased mechanical properties and reduced sliding wear rate and the developed composites can be suitable for lightweight engineering applications. Moreover, Ranganathan *et al.,* [18] found that sisal fibre reinforced cashew nut shell liquid and epoxy polymer matrix composite can be used as an alternative friction material in automobiles. the researcher investigated the effect of oil palm fibres as reinforcement on the tribological performance of polyester composites. Pin-on disc (POD) tribometer is used to simulate the wear of the composite at dry contact conditions. It has been found that the wear performance of the composite was improved by three to four times when compared to neat epoxy [19]. These studies have demonstrated that the use of natural fibres as reinforcement in an epoxy matrix leads to improved wear performance.

The optimization of fibre volume fraction is a critical factor in determining the tribological properties of fibre-reinforced composites. Previous research studies have consistently highlighted the significance of a 40% fibre volume fraction in achieving optimal performance. Rajeshkumar [20] reported that the optimal fibre volume fraction was found to be 40%, while Mohan and Rajmohan [21] demonstrated that composites with 40% fibre content exhibited substantial wear reduction. Furthermore, Egala *et al.,* [22] focused on the fabrication of unidirectional short castor oil fibre reinforced epoxy resin composites with a fixed 40% volume fraction. These collective findings emphasize the importance of this specific volume fraction as a benchmark for comparison. By aligning with these established results, our study aims to investigate the tribological properties of Furcraea Foetida fibre-reinforced epoxy composites using a 40% fibre volume fraction. This choice allows for direct comparisons with existing literature, facilitating a comprehensive evaluation of our composite's performance, and contributing to the ongoing optimization of natural fibre alternatives in the realm of fibre-reinforced composites.

In the pursuit of sustainable alternatives to synthetic fibre-reinforced composites, it is crucial to consider previous studies that have investigated the behaviour of such composites using pin-on-disk machines and varying applied loads. These investigations serve as a valuable reference to ensure that our natural fibre composite possesses the requisite strength and resilience to withstand similar loads. Notably, a comprehensive review conducted by Jyotikalita and Singh [23] in 2018, focusing on the tribological properties of diverse synthetic fibre-reinforced polymer matrix composites, revealed that the applied loads in synthetic counterparts typically range up to 142 N. Therefore, by employing applied loads of 80N, 100N, 120N, and 140N, our study aims to investigate the effect of load variation on the frictional force, coefficient of friction, and specific wear rate of furcraea foetida fibre-reinforced epoxy composites, enabling a comprehensive comparison with previous studies on synthetic fibre-reinforced composites.

Furthermore, Furcraea Foetida fibers remain relatively unexplored in the realm of composite reinforcements, with limited studies focused on their characterization and application potential [15]. Consequently, there exists a knowledge gap regarding the mechanical and wear properties of Furcraea Foetida fiber-reinforced epoxy composites. By investigating the tribological behavior of these composites, our research aims to contribute valuable insights into their performance characteristics. Understanding the tribological properties of natural fiber-reinforced composites assumes critical significance in various engineering applications. However, a thorough understanding of their tribological behavior is essential to determine their suitability for specific applications where friction, wear, and load-bearing properties are crucial factors.

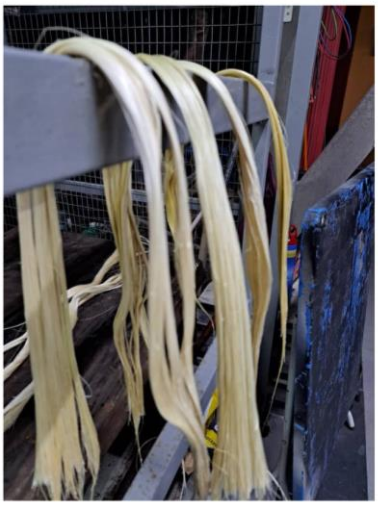
Overall, this study contributes to the development of sustainable and eco-friendly materials with excellent tribological properties. The findings of this study can be used to optimize the design and performance of various mechanical systems, thereby reducing energy consumption and environmental impact.

2. Methodology

2.1 Extraction of Fibres from Furcraea Foetida Leaves

The leaves of Furcraea Foetida were obtained from a plantation in Arau, Perlis located in the northern region of peninsular Malaysia. To extract the fibres, the water retting method was employed on a laboratory scale, as described in previous research [24]. Compared to mechanical and chemical techniques, water retting is a simpler and more cost-effective process [25,26]. Initially, the leaves were cleaned and cut into pieces of around 400 nanometers in length. They were then submerged in water for a period of 2 to 3 weeks to break down lignins, hemicelluloses, waxes, and pectins [27]. After that, the individual fibre bundles were separated from the strips, washed with tap water to remove any surface impurities, and left to dry in the sun for 2 days in an ambient temperature ranging between 30 to 31°C. After sun drying, the fibres were subjected to a thorough drying procedure in an oven set at 80°C for a duration of 24 hours [28]. This controlled drying step aimed to effectively eliminate any residual moisture content from the fibres. Subsequently, the dried fibres were meticulously stored in a sealed container, ensuring their preservation and protection. The length of the leaves was in the range of 142.7 cm. After the extraction process, the length was reduced to average length of 133.5cm with average diameter of 0.34mm [28]. Figure 1 shows the steps involved in the extraction process.

(a) (b)



(c) (d)

Fig. 1. Extraction Process of Furcraea Foetida fibers: (a) FF plant, (b) Wetting process, (c) Retting process, (d) Drying process

2.2 Composite Fabrication

The matrix used in this study is epoxy resin and the reinforcement used is the Furcraea Foetida fibres. The epoxy resin used in this study was purchased from a local supplier, Mecha Solve Engineering, and it was EpoxAmiteTM 100 series resin along with 103 slow hardeners. This low-viscosity epoxy resin and curing hardener were chosen as it is commonly employed due to their favourable characteristics, allowing for easier impregnation and penetration into the fibre matrix. The low viscosity of the epoxy resin promotes better wetting and distribution within the fibre network, resulting in improved composite formation. To manufacture the composites, a vacuum infusion process was employed while maintaining fibre volume fractions of 40Vf% and resin volume fraction of 60Vf%. An acrylic mould was prepared with length of 125mm, width of 80mm and a thickness of 7.87mm. The fibres were cut to fit the mould's length and then placed under a hydraulic press, where they were pressed for 24 hours until the desired mould thickness was achieved.

Beforehand, the top and bottom faces of the acrylic mould were coated with releasing agent, and the fibres were suitably placed inside the mould frame. To ensure the preservation of the desired fibre orientation during the flow of epoxy resin, a strategic approach was employed. Threads were utilized to secure the fibres in place prior to the compression process. This technique effectively maintained the alignment and configuration of the fibres, allowing the epoxy resin to flow through without inducing any changes in their orientation. Furthermore, to prevent air leakage, the mould was then tightly closed and sealed with screws and sealant tape, before being connected to a vacuum pump and resin trap. The composite was manufactured in normal fibre orientation at 40% volume fraction. Samples for tribological testing were then cut from the composite plate using diamond cutter in accordance with ASTM Standards.

2.3 Wear Test Set-Up Description

The friction and wear properties of the composites were evaluated using a Koehler K93500 pin-on-disc tribometer, which is a rotating type apparatus. The counterface was a ground hardened steel disc (EN-31, 60 HRC) with a surface roughness of 0.7 mm Ra and a maximum wear diameter of 140 mm and a thickness of 8 mm. The sliding occurred between a stationary pin clamped in the specimen holder and the counterface. The test requirements could be adjusted by varying the normal load, sliding speed, and wear track diameter.

2.4 Experimental Procedure

The sliding wear test procedure was carried out in accordance with the ASTM G99-95 standard. Composite specimens measuring 08 x 08 x 34 mm^3 were cut from the developed composite laminates. Prior to each test, the counterface and wear specimen were rubbed with waterproof silicon carbide (SiC) abrasive paper of 1500 grits followed by abrasive paper of 2000 grits to ensure consistent initial roughness and improve contact between the counterface and specimen surface. Both the wear specimens and counterface disc were cleaned with acetone and dried prior to the test conditions. After recording the initial weight of each test specimen, it was subjected to the sliding wear test under the specified conditions. Table 1 presents the composite details and sliding wear test conditions. The choice of a single sliding condition was made to ensure a controlled and consistent experimental setup, allowing us to assess the specific tribological characteristics of the composite material.

Table 1
Details of composite specimens and sliding conditions

Applied load (N)	Sliding speed (m/s)	Sliding distance (m)
80	1	3000
100		
120		
140		

As the rubbing starts between specimen pin and counterface, the friction and wear monitor continuously display the tangential friction force and coefficient of friction by calculating as per Eq. (1).

$$\text{Coefficient of friction: } \mu = \frac{F_f}{F_n} \tag{1}$$

where F_f is the frictional force (N), and F_n is the normal load (N).

The worn specimens were cleaned using tissue paper soaked with acetone and dried with compressed air before measuring their weight. The weight of the specimens was measured using a high-precision analytical balance (Ningbo Yinzhou Qun'an Experimental Instrument Co., Ltd., JAB 2204N) with a precision of 0.0001 g. The difference in weight before and after the test provided the weight loss of the composite specimen during the specific sliding test. The specific wear rate of the specimens was calculated using the following Eq. (2).

$$\text{Specific wear rate: } K_s = \frac{\Delta m}{\rho L F_n} \ (mm^3/\text{N} - \text{mm}) \tag{2}$$

where Δm is the mass loss during test duration (g), ρ is the density of the specimen (gm/mm^3), L is the sliding distance (m), and F_n is the normal load (N).

2.5 Scanning Electron Microscopy (SEM)

The SEM analysis was conducted to observe the morphological changes on the surface of the Furcraea Foetida fibre-reinforced epoxy composite using a TESCAN VEGA SEM (Novatiq Scientific Sdn. Bhd., Kuala Lumpur, Malaysia). In order to prevent electrical charge accumulation, the sample was coated with a thin gold layer using an ion coating machine. The analysis was conducted at a magnification of 100x. The analysis aimed to observe changes in the morphology and wear mechanisms of the FF fibres [29].

3. Results and Discussion

3.1 Frictional Force Versus Sliding Distance

The present study investigates the frictional properties of Furcraea Foetida fibre reinforced epoxy composites under varying applied loads and volume fractions. The experiments were conducted on a pin on disk machine, with identical specimens of 40Vf% subjected to sliding velocities of 1 m/s and a sliding distance of 3000 m. The loads applied were 80 N, 100 N, 120 N, and 140 N. The resultant frictional force vs sliding distance graph displayed distinct trends and patterns for each applied load.

Figure 2 displays the relationship between frictional force and sliding distance for specimens with 40Vf% under varying applying loads. At lower applied loads, such as 80 N, the frictional force exhibits a rapid increase with sliding distance, followed by a relatively stable decrease with minimal fluctuations. This behaviour indicates a progressive rise in interfacial contact resistance and demonstrates the contribution of mechanisms such as fibre-matrix interlocking and fibre plowing in governing the frictional behaviour at this load [30].

When the applied load is increased to 100 N, the frictional force shows a more significant increase compared to the 80 N load. However, the frictional force curve displays greater fluctuations throughout the sliding distance, highlighting the presence of dynamic interactions between the composite and the opposing surface. These interactions can be attributed to factors such as changes in interfacial adhesion, matrix deformation, and surface roughness effects [31].

At an applied load of 120 N, the frictional force curve exhibits a substantial increase, resulting in a noticeable gap between the frictional force curves of 100 N and 120 N. The initial rapid rise in the frictional force curve suggests enhanced interfacial adhesion and increased interactions between the composite and the opposing surface. However, the frictional force gradually decreases throughout the sliding distance, which could be attributed to factors such as wear-related effects or changes in the composite's deformation behaviour.

Similarly, at an applied load of 140 N, the frictional force curve exhibits a minimal increase compared to the 120 N load. Initially, the frictional force curve demonstrates a rapid rise, similar to the behaviour observed at 120 N. This behaviour can be attributed to the enhanced interfacial adhesion, increased contact pressure, and intensified interactions between the composite and the opposing surface resulting from the higher applied load. However, as the applied load further increases, the composite material may approach a saturation point with respect to its frictional response. This saturation occurs as the composite undergoes deformation and experiences alterations in its mechanical properties. Consequently, the frictional force response becomes reduced, resulting in a limited increase in the frictional force curve.

The observed trends in the frictional behaviour of the Furcraea Foetida fibre reinforced epoxy composites under varying applied loads provide valuable insights into their tribological response. The distinct changes in the frictional force curves demonstrate the load-dependent nature of the composite's frictional behaviour and suggest the involvement of various tribological mechanisms.

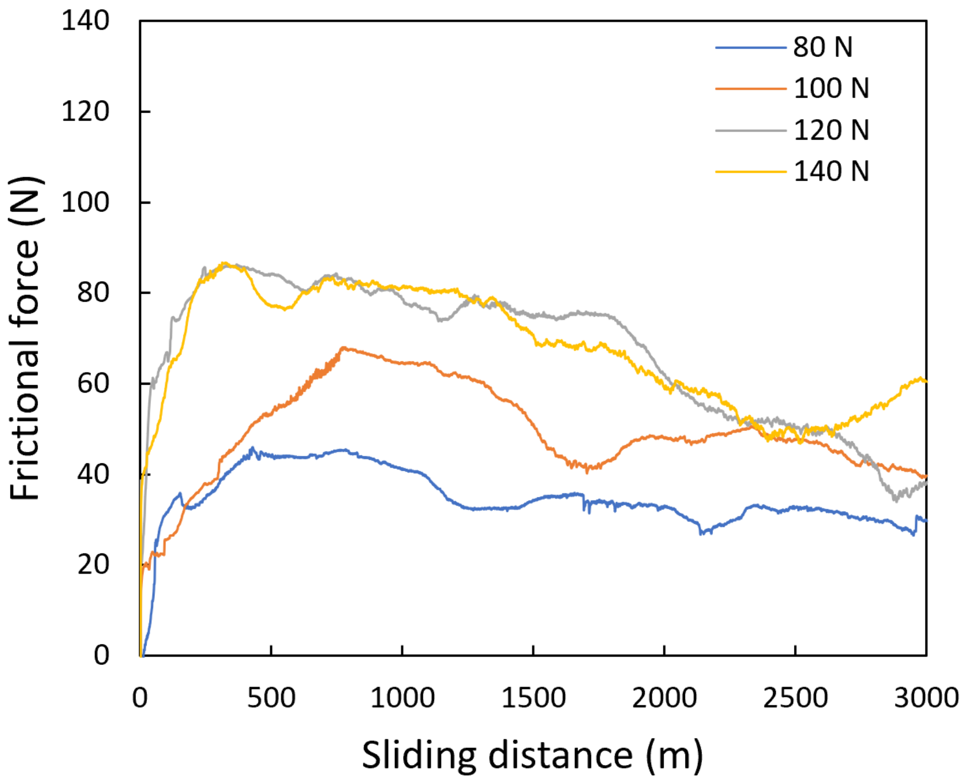


Fig. 2. Frictional force vs sliding distance for normal orientation with 40Vf%

3.2 Coefficient of Friction Versus Applied Load

The present study investigates the tribological behaviour of Furcraea Foetida fibre-reinforced epoxy composites in pin-on-disk configuration. The influence of applied load on the coefficient of friction (COF) of 40Vf% of Furcraea Foetida fibre-reinforced epoxy composites is examined by testing identical samples of composites with four different applied loads (80 N, 100 N, 120 N, 140 N).

The results depicted in Figure 3 demonstrate a clear relationship between the applied load and the COF for the Furcraea Foetida fibre-reinforced epoxy composites. Overall, it is observed that the COF increases as the applied load increases, indicating a stronger resistance to relative motion between the composite and the opposing surface with higher applied loads [32].

At an applied load of 80 N, the COF is measured to be 0.44. This relatively low COF suggests that the composite exhibits favourable tribological properties under this load condition. As the applied load is increased to 100 N, the COF rises to 0.5, indicating a moderate increase in frictional resistance. This trend suggests that the composite's ability to withstand sliding motion and resist material transfer is enhanced with higher applied loads [33].

Further increasing the applied load to 120 N results in a noticeable rise in the COF, reaching a value of 0.57. This substantial increase suggests a stronger interfacial interaction between the composite and the opposing surface, leading to an increased frictional response. The observed rise in the COF can be attributed to factors such as higher contact pressure, enhanced interlocking between the fibres and the matrix, and increased energy dissipation within the composite material [34].

At the highest applied load examined in this study (140 N), the COF reaches a value of 0.6. This further increase in the COF indicates an elevated frictional resistance compared to the lower applied loads. The higher applied load likely induces greater deformation within the composite material, leading to increased interfacial adhesion and interlocking between the fibres and the matrix. These effects contribute to a higher COF and signify the composite's enhanced ability to withstand sliding motion under the highest applied load investigated [35].

The observed trends in the COF versus applied load curves demonstrate the load-dependent nature of the Furcraea Foetida fibre-reinforced epoxy composites' tribological behaviour. The increasing COF with higher applied loads suggests the importance of considering the applied load as a key parameter when designing and utilizing these composites in friction-related applications.

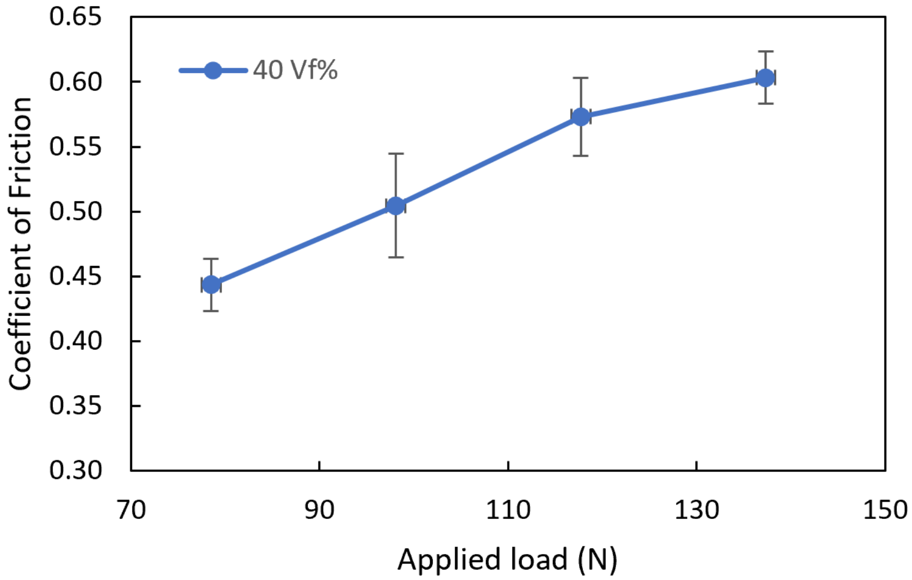


Fig. 3. Coefficient of friction vs applied load

3.3 Specific Wear Rate Versus Applied Load

The present study aimed to investigate the specific wear rate (SWR) of Furcraea Foetida fibre-reinforced epoxy composites in the normal orientation under varying applied loads. Figure 4 illustrates the relationship between the SWR and applied load (80 N, 100 N, 120 N, 140 N) for composites with a fixed fibre volume fraction of 40Vf%.

The results presented in Figure 4 provide valuable insights into the wear behaviour of the Furcraea Foetida fibre-reinforced epoxy composites as influenced by the applied load. Overall, it is observed that the SWR increases with higher applied loads, indicating a more pronounced wear behaviour under increased loading conditions.

At an applied load of 80 N, the SWR is measured to be 5.53(10^{-5}) mm^3Nm^{-1}. This value indicates a moderate wear rate for the composite under this load condition. As the applied load is increased to 100 N, the SWR rises to 7.04(10^{-5}) mm^3Nm^{-1}, signifying an increase in the wear rate. This trend suggests that the composite experiences greater material loss and wear damage with higher applied loads [36,37].

Further increasing the applied load to 120 N results in a noticeable escalation of the SWR, reaching a value of 9(10^{-5}) mm^3Nm^{-1}. This substantial increase indicates a significantly higher wear rate compared to the lower applied loads. The elevated wear rate can be attributed to factors such as increased contact pressure, enhanced material deformation, and greater frictional forces within the composite material [34]. These effects contribute to increased wear and material loss, leading to a higher SWR.

At the highest applied load investigated in this study (140 N), the SWR reaches a value of 10.06 (10^{-5}) mm^3Nm^{-1}. This further increase in the SWR signifies an intensified wear behaviour under the highest applied load condition. The higher applied load induces higher stress levels and deformation within the composite, resulting in more significant material damage and wear [34].

The observed trends in the SWR versus applied load graph demonstrate the load-dependent nature of the Furcraea Foetida fibre-reinforced epoxy composites' wear behaviour. The rising SWR with increasing applied loads highlights the significance of considering the applied load as a crucial factor in assessing the wear resistance and durability of these composites.

In conclusion, the findings presented in Figure 4 highlight the influence of applied load on the specific wear rate of Furcraea Foetida fibre-reinforced epoxy composites in the normal orientation. The increasing SWR with higher applied loads emphasizes the importance of load as a critical parameter affecting the wear behaviour of these composites. These insights contribute to the advancement of wear-related applications and provide a basis for further research in the field of Furcraea Foetida fibre-reinforced epoxy composites' wear characteristics.

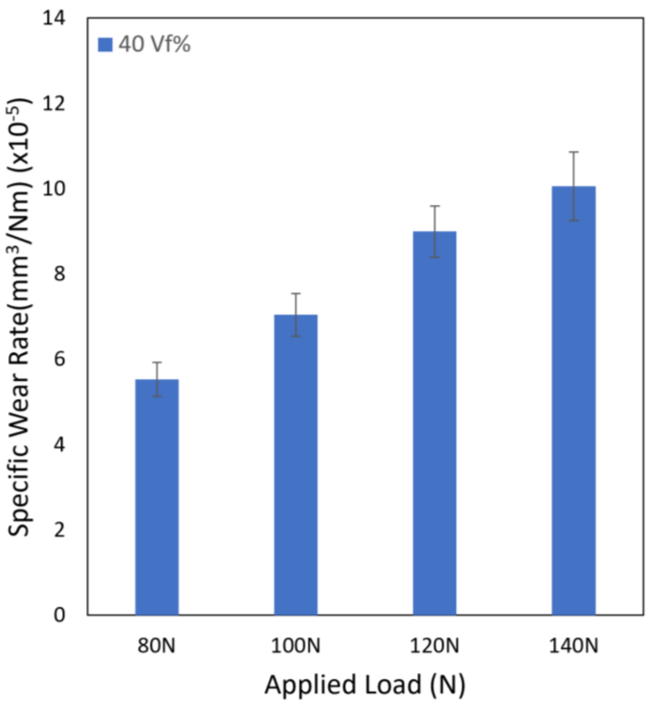


Fig. 4. Specific wear rate vs applied load

3.4 Scanning Electron Microscope

The present study employed scanning electron microscopy (SEM) to comprehensively investigate the surface morphology and microstructural changes of worn-out samples of normal orientation Furcraea Foetida fiber-reinforced epoxy composites subjected to various applied loads (80N, 100N, 120N, and 140N). The SEM images presented in Figure 5(a) to Figure 5(d) provide detailed insights into specific features and wear patterns that are crucial for understanding the composite's response under different load conditions.

Upon closer examination of the SEM images in Figure 5, several notable findings emerge. Firstly, the presence of distinct scratches on the composite surface indicates the occurrence of abrasive wear. These scratches vary in size and orientation, indicating different contact mechanisms and material removal during sliding. Notably, the scratches at 100N applied load in Figure 5(b) are more prominent compared to those at 80N applied load in Figure 5(a), which can be attributed to the higher contact pressure and increased severity of the sliding conditions. The elevated applied load results in a greater force acting on the composite surface, leading to intensified contact stress and more significant material removal [38]. Consequently, deeper and more distinct scratches are observed on the composite surface. This is further supported by the increase in specific wear rate when the applied load is increased from 80N to 100N.

Secondly, the SEM images reveal the occurrence of debonding between the fibers and the epoxy matrix, particularly pronounced in the composites with applied loads of 120N and 140N. This observation highlights the potential weakening of interfacial bonding under higher applied loads, which can significantly affect load transfer and overall mechanical properties of the composite [39]. The greater frictional force observed in the composites with applied loads of 120N and 140N compared to 80N and 100N can be attributed to this phenomenon.

Moreover, the presence of fiber pull-out, indicated by partially exposed fibers, signifies interfacial failure and fiber-matrix debonding due to the high applied loads. The interfacial shear stresses exceed the bonding strength between the fiber and the matrix, leading to debonding and subsequent fiber pull-out [40].

Furthermore, the identification of debris particles dispersed on the worn-out surface, particularly noticeable at higher applied loads such as 120N and 140N, indicates the generation of wear particles or debris during sliding. These particles play a significant role in influencing the frictional behaviour and wear characteristics of the composites. Notably, they contribute to a decrease in the rate of increase of frictional force and wear rate, thus influencing the overall tribological performance of the composite [41].

Lastly, evidence of plastic deformation, such as localized deformation and flattening of the composite surface, is observed in the composites with an applied load of 140N. This can be attributed to the exceeding of the material's elastic limit under the high applied load. When subjected to a load beyond its elastic limit, the composite material undergoes plastic deformation, resulting in permanent changes in shape and structure [41].

The presence of these features and the insights gained from the SEM analysis provide a comprehensive understanding of the mechanical response and deformation behavior of the Furcraea Foetida fiber-reinforced epoxy composites under varying applied loads.

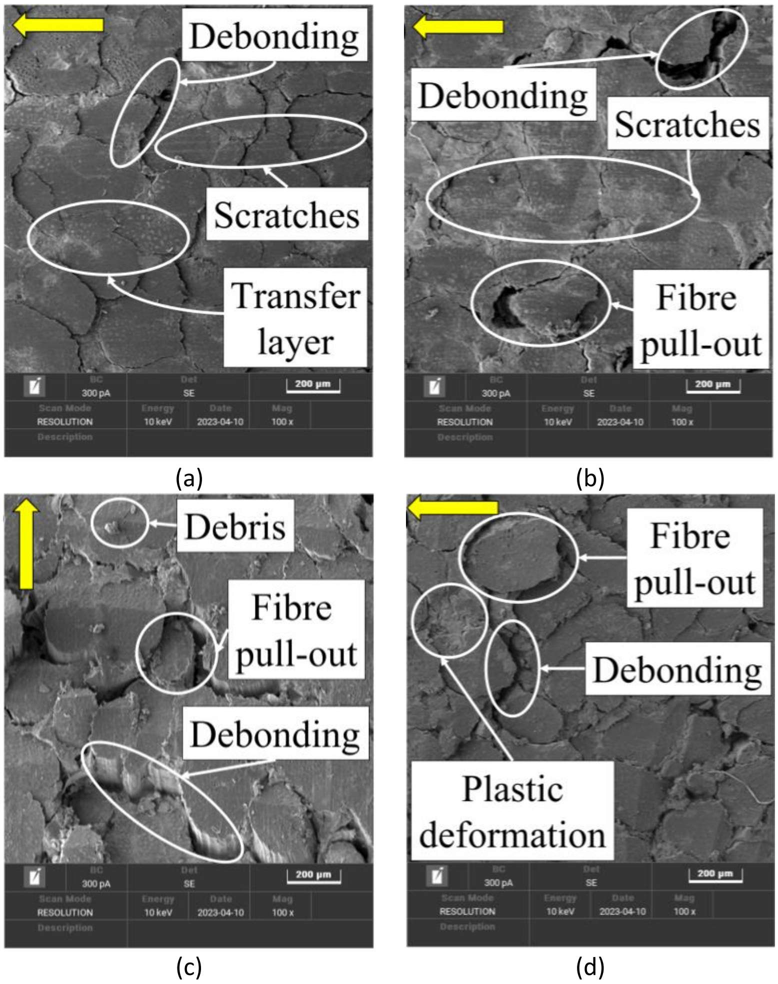


Fig. 5. Scanning electron microscopy (SEM) images of normal orientation Furcraea Foetida fibre reinforced epoxy composite under applied loads of (a) 80N, (b) 100N, (c) 120N and (d) 140N. The yellow arrow represents sliding direction

4. Conclusions

In conclusion, this research study provides valuable insights into the tribological behaviour of Furcraea Foetida fibre-reinforced epoxy composites under varying applied loads. The investigation aimed to understand the influence of applied load on the frictional behaviour and wear characteristics of the composites, and the findings directly address the research objective. The results demonstrate a clear relationship between the applied load and the frictional response of the composites. The frictional force, coefficient of friction (COF), and specific wear rate (SWR) exhibit increasing trends as the applied load increases. At lower loads, such as 80 N, the frictional force and COF increase gradually with sliding distance, while the SWR remains relatively low. As the applied load reaches 120 N, a significant rise in the frictional force and COF is observed, indicating enhanced interfacial contact resistance and potential interlocking mechanisms between fibres and the matrix. Simultaneously, the SWR experiences a notable increase, suggesting increased material removal and wear under higher loads. Interestingly, at the maximum applied load of 140 N, the frictional force, COF, and SWR show minimal changes compared to the 120 N load. This behaviour suggests a potential saturation point in the tribological response of the composites. The presence of plastic deformation in the SEM analysis further supports the unique behaviour observed at this load. The findings highlight the importance of considering the applied load when evaluating the performance of Furcraea Foetida fibre-reinforced epoxy composites in friction-related applications.The tribological properties of Furcraea Foetida fibre-reinforced epoxy composites have significant implications in automotive applications, where they can reduce friction, minimize wear, and improve fuel efficiency. These composites hold potential for fuel economy and emissions reduction. Moreover, their excellent specific wear rate makes them suitable for sliding wear applications like low-load bearings and bushings, enhancing mechanical component durability. It is important to acknowledge the limitations of this study. Further investigations should focus on enhancing interfacial bonding strength, evaluating long-term durability, thermal stability, and moisture resistance, and exploring the composite's behaviour in outdoor and harsh environments. While the investigation focused on a specific sliding condition, future research could explore multiple sliding conditions to gain a more comprehensive understanding of the composite's performance in various operating conditions. This would enhance our knowledge of the composite's tribological properties and broaden its potential real-world applications. In summary, this study contributes to the knowledge of tribological behaviour in Furcraea Foetida fibre-reinforced epoxy composites. The observed findings shed light on the mechanisms underlying wear and deformation under different applied loads. The practical implications and potential applications of these composites in various industries highlight their promising prospects. Addressing the identified limitations and conducting future research in the recommended areas will further optimize the performance and expand the utilization of Furcraea Foetida fibre-reinforced epoxy composites.

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