

Polyester Hybrid Composite Reinforced with Banana Fibre and Kota Stone: Physical, Mechanical, and Tribological Characteristics

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Abstract:

In this study, a new polyester-based polymer composite was developed with a constant banana fibre content of 6 wt. % and varied Kota stone dust content from 5 wt. % to 20 wt. % through a hand lay-up process. Test results indicated that incorporating Kota stone dust together with banana fibre tended to improve the overall performance of the composite material. Experimental results indicated that increasing the proportion of Kota stone dust in the polyester resin led to higher density, greater void formation, and increased water absorption. As the amount of Kota dust rose, the tensile and flexural strengths of the composite declined, while impact resistance, compressive strength and surface hardness improved. When the filler content reached 20 wt. %, tensile strength decreased by about 19% and flexural strength by 20%. At this same loading, the best performance in impact strength, compressive strength and hardness was recorded, with values of 29.8 kJ/m², 125.7 MPa and 92 Shore D number. The optimization of Specific Wear Rate (SWR) was carried out using the Taguchi design of experiments with an L16 orthogonal array. The variables considered included Kota stone dust percentage, applied load, sliding speed, and sliding distance. Results from the analysis revealed that filler content had the most significant effect on the specific wear rate, followed in order by sliding velocity, sliding distance, and normal load.

Keywords: Polyester, banana fibre, Kota stone dust, mechanical properties, tribological properties, Taguchi method

1. Introduction

Material waste poses a significant challenge in manufacturing and machining processes, often resulting in environmental concerns like soil and groundwater pollution if not managed properly. However, these residues can be transformed into valuable resources. Reusing industrial and agricultural by-products not only promotes recycling but also fosters sustainable growth and innovation. Incorporating waste materials into polymer composites, for instance, reduces production costs, conserves raw materials, and minimizes carbon emissions from disposal methods, ultimately contributing to an eco-friendlier future [1-2].

Kota City faces a pressing issue with stone-processing industry waste, specifically the fine slurry powder generated during cutting, grinding, and polishing operations. This residue, accounting for 30-40% of the original material, is often dumped in open areas, occupying valuable land and posing environmental concerns. The sheer volume of waste highlights the need for effective management strategies, transforming this by-product into a valuable resource rather than a burdensome pollutant [3-4]. Hundreds of thousands of metric tons of stone slurry are generated annually, with volumes steadily rising. Unchecked disposal on vacant land poses significant environmental and health risks, as fine particles can spread through wind, water, and soil, contaminating air, groundwater, and ecosystems. Transforming industrial residue into valuable products is a pressing priority. Past initiatives have explored its potential in cement production, brick and tile manufacturing, and road construction, paving the way for innovative recycling solutions [5].

Kota stone belongs to the same general group of mineral materials as marble and granite, and therefore, its powder shares a broadly similar chemical composition. This similarity suggests that Kota stone dust could also serve effectively as a reinforcing filler in polymer matrices, just as marble powder [6-16] and granite powders [17-20] have been used successfully. Only a limited number of researchers have examined the use of Kota stone dust as reinforcing fillers in composite material development, and their work reported improvements in both mechanical and wear-related properties when Kota stone dust was added to epoxy resin. Most of these investigations were limited to epoxy-based systems.

Gupta et al [21] analysed the sliding wear performance of epoxy composites containing Kota stone dust using a grey wolf optimization approach and reported close agreement between predicted and experimental results. Their findings indicated that the addition of Kota stone dust lowers the wear rate of the epoxy matrix. They also noted that most existing studies focus only on epoxy systems, highlighting the need to examine other polymer matrices to fully assess the suitability of Kota stone dust as a reinforcing filler. Awasthi et al. [22] investigated polyester composites filled with Kota stone dust from 0–40 wt. %. The study showed that increasing filler content raises density and voids, while hardness, compressive strength, and elastic modulus improve. Peak tensile and flexural strengths were obtained at moderate filler levels rather than at the highest loading. Sliding wear behaviour was examined using a Taguchi-based experimental design, indicating the potential of stone dust waste for lightweight engineering and tribological applications.

Dholi et al. [23] developed epoxy composites reinforced with waste red stone dust and evaluated their physical, mechanical, and sliding wear performance for filler contents up to 40 wt. %. Density and void fraction increased with higher dust loading. The highest tensile and flexural strengths were observed near 20 wt% filler, while stiffness and modulus rose with further addition, leading to reduced elongation. Compressive strength and hardness peaked at about 40 wt. % red stone dust. Wear behaviour was studied using an L25 Taguchi experimental design. Singh and Jha [24] studied

polyester composites filled with Kota stone dust (about 5–40 wt. %) report notable changes in physical, mechanical, and wear properties. Increasing filler content raises density and voids, while compressive strength and hardness generally improve. In contrast, tensile and flexural strengths peak at moderate filler levels and decrease at higher loadings. Higher hardness corresponds to lower specific wear rate, with filler percentage being the dominant factor influencing wear. These results suggest that fine Kota stone dust can enhance overall performance and make such composites suitable for light structural and panel-type applications.

Rao et al. [25] used marble dust as a filler in epoxy–banana fibre composites (hybrid composite) produced by hand lay-up with fixed fibre content and varying dust percentages. Results show that higher marble dust increases density, voids, and water absorption, while tensile and flexural strengths decrease. However, impact strength and hardness improve, with the best values reported at about 20 wt% filler. Wear behaviour optimized through Taguchi L25 design indicates that filler content is the most influential factor on specific wear rate, and surface wear mechanisms were examined using microscopic analysis. Meena et al. [26] investigated hybrid polymer composites reinforced with basalt fibre and marble dust particles. During fabrication, the basalt fibre content was fixed at 50%, while the proportion of marble dust filler was changed to 0%, 8%, 16%, and 24% by weight. Their findings indicated that the composite containing 16 wt.% marble dust delivered the best overall mechanical performance. The study also examined how different testing conditions affected abrasive wear behaviour. Taguchi analysis showed that sliding distance had the greatest influence on wear rate, whereas abrasive particle size contributed the least effect.

Anwar et al. [27] produced hybrid polymer composites reinforced with coconut fibre and marble waste particles. The raw materials were prepared, blended, and moulded into specimens that were later evaluated for tensile behaviour, hardness, and impact performance. Results showed that coconut fibre contributed to higher tensile strength because of its strong fibrous structure and ability to carry load, whereas marble waste increased surface hardness owing to its stiffness. Combining a natural reinforcement with an industrial by-product demonstrated an environmentally friendly and economical route for creating composites with improved mechanical characteristics. Sharma et al. [28] developed needle-punched jute–epoxy nonwoven composites by adding marble dust content, and result shown increment in their mechanical strength and thermal performance. As the marble dust percentage increases, density, voids, and moisture uptake also rise. The composites show noticeable gains in strength and fracture toughness, along with higher storage modulus and glass transition temperature, reflecting improved stiffness and heat resistance. Singh et al. [29] developed hybrid composites reinforced with 10 wt.% banana fibre and 2 wt.% silica particulates. A series of mechanical tests, including tensile, compression, flexural, impact, and hardness evaluations, was conducted to assess their performance. The results showed that the hybrid materials achieved greater impact resistance than both the unreinforced matrix and the composites containing only natural fibre. This enhancement was mainly attributed to the silica

particles filling internal gaps within the structure. The study also noted that the addition of fillers contributed to an increase in surface hardness.

Many previous investigations have examined short-fibre composites with different fibre proportions, but the use of Kota stone dust as a waste filler in short banana-fibre composites with polyester resin has received limited attention. In addition, optimisation of abrasive wear parameters for banana fibre/Kota stone dust hybrid polymer composites using the Taguchi method has not been widely reported. Exploring such hybrid systems is necessary to properly evaluate the suitability of Kota stone dust as a reinforcing filler and to establish this industrial waste as a promising material for broader composite applications. Motivated by this gap, the present work focuses on enhancing the properties of banana-fibre-reinforced polyester by introducing Kota dust as an additional filler. The objective is to evaluate both the mechanical behaviour and abrasive wear resistance by combining the hardness of Kota dust with the natural reinforcing ability of banana fibres. The results indicate that Kota dust can serve as an effective and environmentally sustainable filler for strengthening polymer composites intended for applications involving heavy loads and significant wear.

2. Materials and Method

2.1. Materials Used

In this investigation, polyester resin was selected as the primary matrix material. The resin, available in liquid form, has an approximate density of 1.142 g/cm^3 . Curing was initiated using Methyl ethyl ketone peroxide (MEKP) as the coupling agent and cobalt naphthalene (CN) as the catalyst, which enabled the resin to solidify under room-temperature conditions. Banana fibres served as the reinforcing component in the composite system. These fibres were extracted from the pseudo-stem of banana plants and sourced from local vendors for use in the study. They are used in short form by cutting the fibres of length of around 5 mm. The banana fibres are treated with 2 moles NaOH solution before being used as a reinforcement. Kota stone dust, a by-product generated during the cutting of Kota stone, was also utilised as a filler material. This waste powder, having a density of 2.65 g/cm^3 , was gathered from nearby sources for fabricating hybrid composites.

2.2. Composite Preparation

The samples are prepared using a simple hand lay-up method. First, the banana fibre of 6 wt. % is added to the polyester resin, which is mixed well to ensure uniform distribution of fibre. Later, the Kota stone dust of the required weight fraction is added to the combination, which is mixed properly for the uniform distribution of filler. This is followed by the addition of 1 wt. % cobalt accelerator. The cobalt accelerator is used to enhance the reaction rate. After that, 1 wt. % of the

methyl ethyl ketone peroxide is added and stirred for proper mixing. It is used to initiate the reaction process. The combination is thus poured into the mould. A coating of silicon spray is applied over the mould before pouring the combination into the mould. After 4 hours, samples are removed from the mould, which will then be tested at least after 48 hours. In total, five sets of samples are prepared where the weight fraction of banana fibre is kept constant at 6 wt. % and Kota stone dust content varied from 5 wt. % to 20 wt. %. The composite specimens prepared in the present investigation are presented in Table 1.

Table 1: List of samples prepared

Sample Code	Polyester Content (wt. %)	Banana Fibre content (wt. %)	Kota stone dust content (wt. %)
S-1	94 %	6 %	0 %
S-2	89 %	6 %	5 %
S-3	84 %	6 %	10 %
S-4	79 %	6 %	15 %
S-5	74 %	6 %	20 %

2.3 Characterization

The density of the fabricated composite specimens was measured using a water-displacement method in accordance with ASTM D792-91 guidelines. Theoretical density values were estimated through the rule-of-mixtures approach, and the difference between experimental and calculated densities was used to determine the percentage of voids present in the material. Water uptake characteristics were evaluated following the ASTM D570 procedure. Mechanical performance was assessed through tensile testing (ASTM D638), flexural testing (ASTM D2344-84), impact testing (ASTM D7136), compressive testing (ASTM D695) and hardness measurement (ASTM D2240). Surface hardness was specifically determined using the Barcol hardness method as specified in ASTM D2583-95. Tensile, flexural and compressive tests were carried out on an Instron 3382 universal testing system, while impact strength was measured using a Tinius Olsen impact testing machine. All experiments were performed under standard laboratory environmental conditions. Hardness is measured using a PosiTector Shore D durometer. A pin-on-disc tribometer, configured in line with ASTM G99 guidelines, was employed to evaluate the

sliding wear behaviour of the polymer composite specimens. The experiments are designed as per the Taguchi design of experiment method. Surface morphology and the bonding characteristics between the matrix and the reinforcing fibres, as well as the worn regions after testing, were examined using a Field emission scanning electron microscopy (FE-SEM, Quanta 250 FEG).

3. Results and Discussions

3.1 Physical Properties

Figure 1 presents the experimental density obtained through the water-immersion method, the theoretical density values, and the void fraction of polyester/banana fibre/Kota stone dust hybrid composites with different Kota stone dust percentages. The density of pure polyester resin is about 1.142 g/cm³. When only banana fibre is added, the overall density drops because banana fibre has a lower density compared to the polyester matrix. For composites containing 6 wt.% banana fibre, the measured density is approximately 1.085 g/cm³. The trend changes when Kota dust is introduced into the polyester banana fibre mixture.

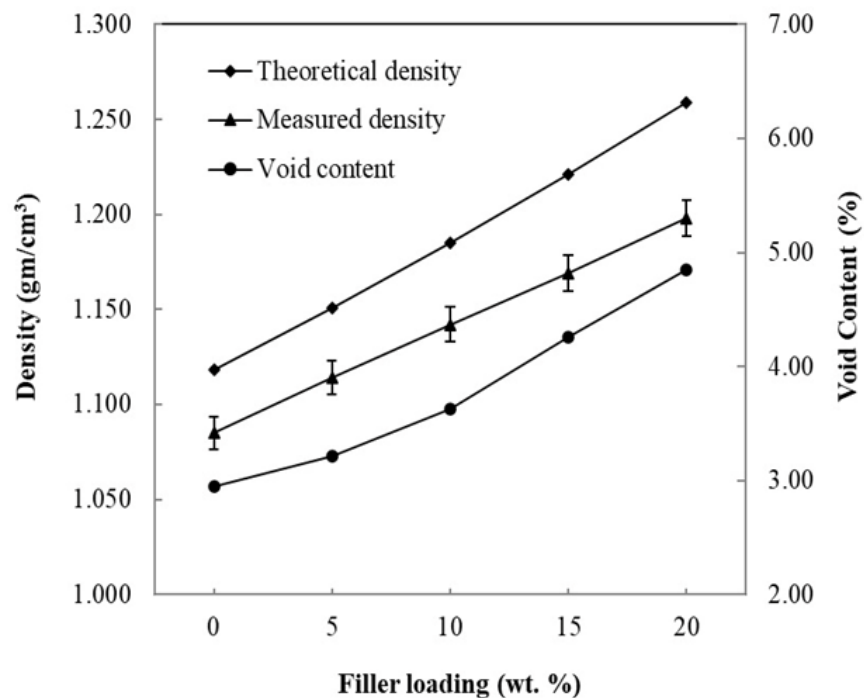


Figure 1: Density and void content of Polyester/Banana fibre/Kota stone dust composites

The graph indicates a steady rise in density with increasing Kota stone dust content. Adding 5.0 wt.% Kota stone dust results in a density of about 1.114 g/cm³, and while increasing the filler to 20 wt.%, the density increases to 1.198 g/cm³. This increase occurs mainly because Kota stone

dust possesses a much higher density than the polyester resin. This shows that the maximum increment of 10.41 % against polyester/6 wt. % banana fibre content. It is also noted that, for each composition, the theoretical density values are slightly higher than the experimentally measured densities. The reduction in density is primarily due to the formation of internal voids in the manufactured specimens. These voids are mostly trapped air pockets that develop during composite production, especially when the hand lay-up technique is used, where controlling air entrapment is difficult. Since the density of air is significantly lower than that of both the reinforcing fibres and the matrix material, the existence of these pockets lowers the overall density of the composite structure.

Void percentage also rises as the proportion of Kota dust increases. In samples without Kota stone dust, the measured void fraction is about 2.95%, while adding 20 wt.% Kota stone dust raises it to approximately 4.85%. When a small amount of banana fibre is introduced, the void fraction grows rapidly; however, at higher Kota stone dust concentrations, the rate of increase becomes more gradual. This trend is largely attributed to particle clustering at higher filler loadings, which promotes void formation.

Figure 2 illustrates the water uptake behaviour of all the composite specimens developed in this study. The results indicate that, regardless of the amount of dispersed filler added, the composites absorb noticeably more moisture than pure polyester resin. Adding banana fibre to the polyester matrix leads to a noticeable rise in moisture uptake, with the highest absorption reaching about 6.62 %. Even a relatively small fibre proportion of 6 wt.% produces a marked increase in water absorption. This behaviour is mainly linked to the naturally hydrophilic nature of banana fibre, particularly due to constituents such as cellulose and hemicellulose that readily attract and retain water. When Kota stone dust is further introduced into the polyester–banana fibre system, the water absorption level increases further. A small addition of 5 wt.% Kota stone dust causes only a slight change, bringing the absorption to around 6.68 %, whereas a higher loading of 20 wt.% raises it to approximately 7.95 %. Although Kota stone dust contributes to higher moisture uptake, the rate of increase is gradual compared to natural fibre because stone dust itself is far less hydrophilic and has limited inherent affinity for water. Another factor influencing moisture absorption is the presence of internal voids within the composite, which create spaces where water molecules can accumulate. As filler content rises, void formation typically increases as well, thereby enhancing the likelihood of greater water penetration.

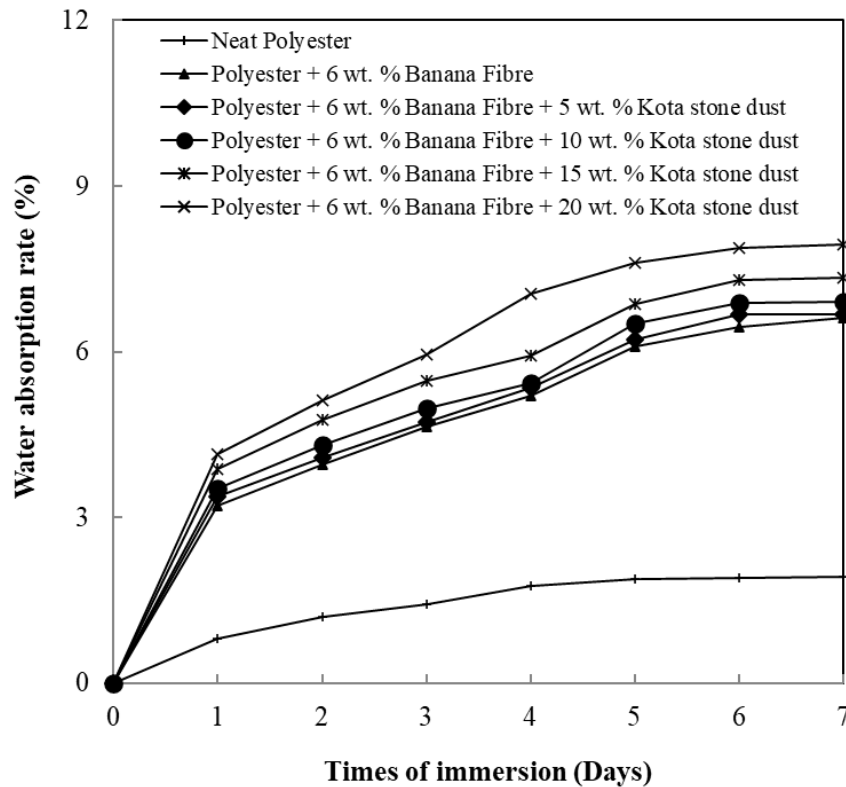


Figure 2: Water absorption rate of Polyester/Banana fibre/Kota stone dust composites

The duration for which the composite specimens remain submerged in water also plays an important role in determining their moisture uptake. The trend shown in the figure indicates that water absorption increases with longer immersion periods for all types of samples. This occurs because extended exposure provides more opportunity for water to diffuse through the surface and move into the internal structure of the material. However, after a certain period, the rate of absorption begins to slow and eventually stops once the material reaches its saturation limit. The time required to reach this saturation point varies with the amount of fibre or filler present. Pure polyester typically attains saturation after about 4 days, while the composite samples generally reach this stage at roughly 7 days of immersion.

3.2 Mechanical Properties

Figure 3 displays the tensile behaviour of the developed composite samples, focusing on tensile strength and tensile modulus. Unreinforced polyester exhibits a tensile strength of about 20.5 MPa and a tensile modulus close to 2739 MPa. When 6 wt.% banana fibre is introduced, both properties improve significantly, with strength rising to roughly 35.2 MPa and modulus increasing to around 3857 MPa. However, the addition of fine Kota stone dust to the polyester 6 wt.% banana fibre system results in a gradual reduction in tensile strength across the entire range of dust content. At

a loading of 5 wt.% Kota stone dust, the strength drops slightly to about 34.3 MPa, and with 20 wt. % dust it declines further to nearly 28.4 MPa. This reduction is mainly attributed to excessive filler within the matrix.

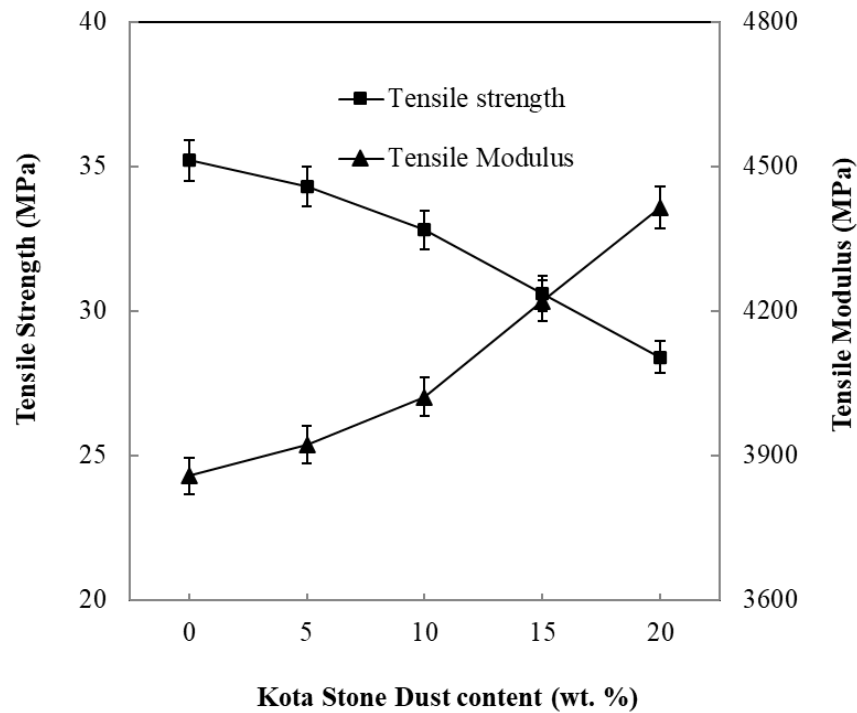


Figure 3: Tensile properties of Polyester/Banana fibre/Kota stone dust composites

Once the polyester resin is effectively saturated with 6 wt.% fibre, introducing more filler can lead to particle clustering and inadequate wetting of the reinforcements. Increased void formation at higher filler concentrations also contributes to the deterioration of tensile performance. The tensile modulus shows a steady rise as the proportion of Kota stone dust particles increases. With the introduction of 5 wt. % Kota stone dust, the modulus reaches approximately 3923 MPa, and it further climbs to about 4415 MPa when the dust content is raised to 20 wt.%. This enhancement in stiffness, observed with both banana fibre and stone dust additions, is mainly due to the presence of rigid fillers within the polyester matrix, which restricts deformation and makes the composite structure stronger and more resistant to stretching. Comparable behaviour has been noted in previous studies on high-density polyethylene composites reinforced with palm oil empty fruit bunch fillers, where researchers reported reduced tensile strength but improved tensile modulus [30].

A comparable pattern is observed in the bending performance of the specimens, as illustrated in Figure 4. For the unreinforced resin, the recorded flexural strength is about 44.6 MPa, while the

flexural modulus is 1062 MPa. Introducing 6 wt. % banana fibre into the polyester matrix produces a substantial improvement in both parameters, with flexural strength increasing to nearly 53.2 MPa and the modulus rising to around 1401 MPa. When fine Kota stone dust is further blended with the polyester–banana fibre mixture, the flexural strength begins to decline, whereas the flexural modulus continues to increase. This behaviour mirrors the trend noted in tensile testing, where additional rigid filler enhances stiffness but can weaken strength due to issues such as particle clustering, insufficient bonding, and higher void formation. At a Kota stone dust content of 20 wt. %, the measured flexural strength drops to about 43.1 MPa, while the flexural modulus reaches approximately 1834 MPa.

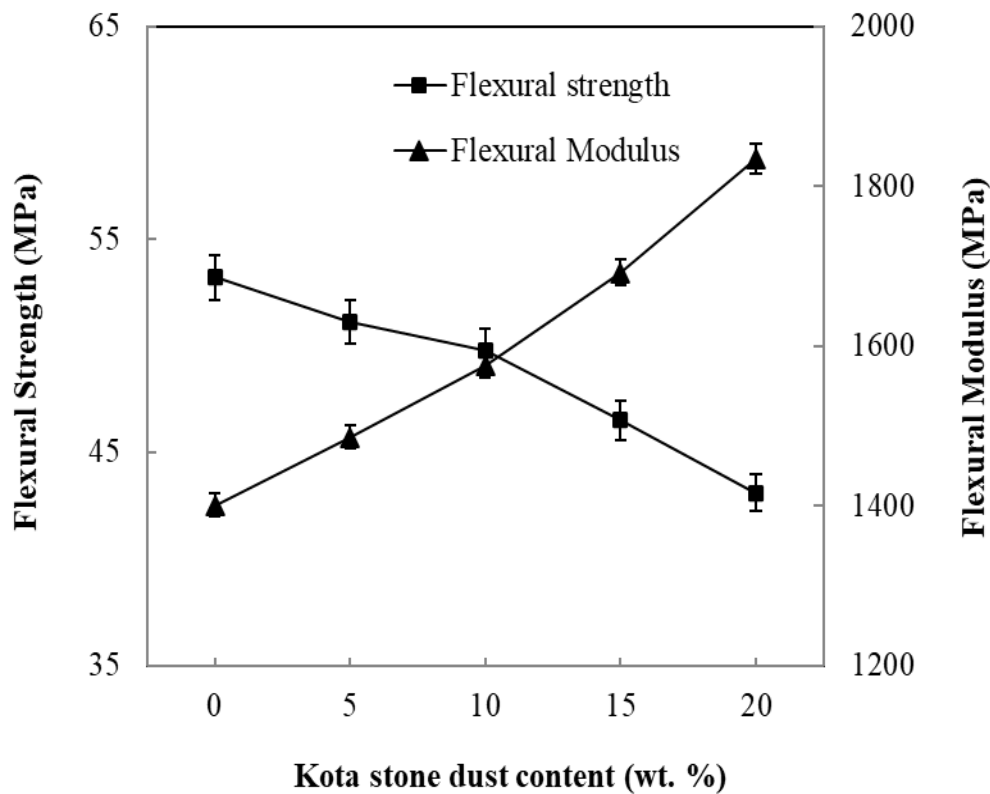


Figure 4: Flexural properties of Polyester/Banana fibre/Kota stone dust composites

Figure 5 shows the impact performance of the produced composite specimens. In contrast to the trends observed in tensile and flexural testing, the resistance to sudden loading improves when Kota stone dust is added to the polyester–banana fibre system. Pure polyester records an impact strength of roughly 12.3 kJ/m², while polyester reinforced with 6 wt.% banana fibre achieves about 21.7 kJ/m², indicating an increase of nearly 76 %. When Kota stone dust is further incorporated, the impact resistance continues to increase. With 5 wt. % dust, the impact value rises to approximately 23.3 kJ/m², and at 20 wt.% it reaches nearly 29.8 kJ/m². Overall, the combined presence of banana fibre and Kota stone dust produces an improvement of about 142.2 % compared

with neat polyester, while the addition of Kota stone dust alone contributes an extra gain of roughly 37.2 % over the polyester–banana fibre composite without Kota stone dust. A similar behaviour is observed in the past [25]

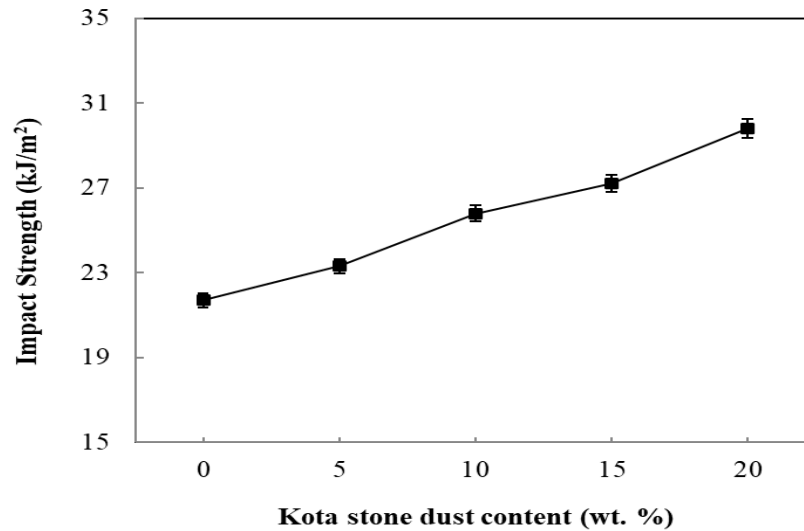


Figure 5: Impact strength of Polyester/Banana fibre/Kota stone dust composites

Figure 6 shows the compressive strength and the hardness values obtained for the various composites produced in this study. From the figure, it is observed that the compressive strength of the composites increases with the content of Kota stone dust. The increment in the value of compressive strength is for the entire range of filler content. For polyester/6 wt. % banana fibre, the measured value of the compressive strength is 106.6 MPa. With the addition of 5 wt. % Kota stone dust, the compressive strength increases to 110.5 MPa, showing an increment of 3.6 %. For a maximum Kota stone dust content of 20 wt. %, the maximum value of compressive strength is registered. This value is 125.7 MPa, and the same is 17.9 % higher than polyester/6 wt. % banana fibre composite. While measuring the hardness, the neat polyester sample records a Shore D hardness of about 84. When 6 wt.% banana fibre is added, the hardness increases to nearly 86 Shore D, corresponding to an improvement of roughly 2.3 %. Compared with other mechanical characteristics, the rise in hardness due to fibre addition is relatively modest. This limited change occurs because the presence of banana fibre slightly increases the brittleness of the polyester matrix, leading to only a moderate gain in surface hardness. With the further introduction of Kota stone dust, hardness continues to increase. Adding 5 wt.% of the dust raises the hardness value to around 87 Shore D. When the marble dust content reaches 20 wt. %, the Shore D number of the composite reaches 92, reflecting an impressive improvement of 7 % against the polyester/ 6 wt. % banana fibre composites.

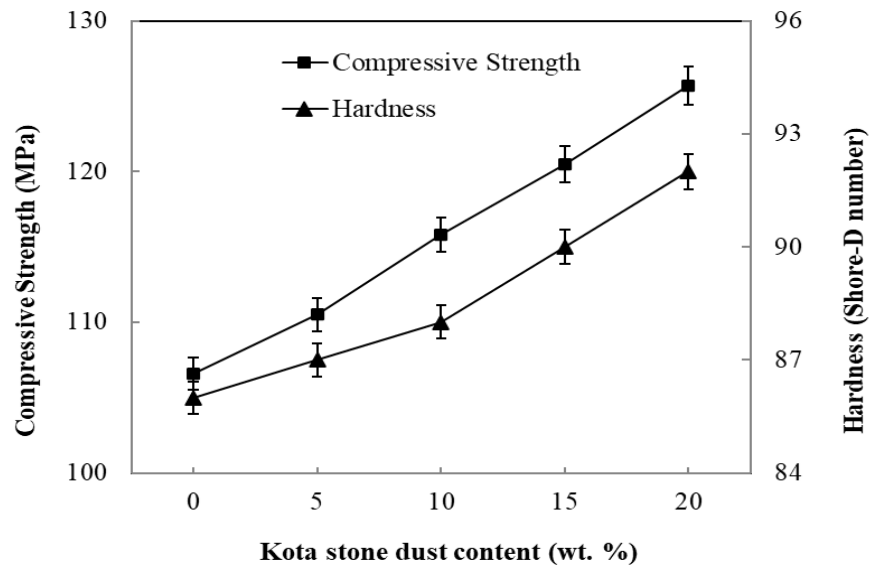


Figure 6: Compressive strength and hardness of polyester/banana fibre/Kota stone dust composites

3.3. Sliding wear behaviour

The sliding wear rates of the polyester/banana fibre/Kota stone dust composites under different experimental conditions, as designed by the Taguchi method, are presented in Table 2. After each test, the mass of the pin will reduce due to sliding wear. This measured mass loss is converted into a volume loss per unit load per unit sliding distance, referred to as the specific wear rate. The calculated specific wear rate is then expressed as a signal-to-noise (S/N) ratio. Both the specific wear rate and the corresponding S/N ratio are summarized in Table 2.

Table 2: Specific wear rate and corresponding S/N ratios

Run	Filler (Wt.%)	Normal Load (N)	Sliding Velocity (m/s)	Sliding Distance (m)	Specific Wear Rate (mm ³ /Nm)	S/N Ratio (dB)
1	5	10	1	600	0.0005122	65.8112
2	5	20	2	1200	0.0005205	65.6715
3	5	30	3	1800	0.0005344	65.4427
4	5	40	4	2400	0.0005192	65.6933
5	10	10	2	1800	0.0005096	65.8554
6	10	20	1	2400	0.0005275	65.5556
7	10	30	4	600	0.0004906	66.1854

8	10	40	3	1200	0.0005181	65.7117
9	15	10	3	2400	0.0004874	66.2423
10	15	20	4	1800	0.0004536	66.8665
11	15	30	1	1200	0.0005101	65.8469
12	15	40	2	600	0.0004934	66.1360
13	20	10	4	1200	0.0004408	67.1151
14	20	20	3	600	0.0004342	67.2462
15	20	30	2	2400	0.000476	66.4479
16	20	40	1	1800	0.000452	66.8972

Figure 7 displays the main effects plot, and Table 3 displays the signal-to-noise ratio response table. Table 3 shows that the marble dust loading has a greater impact on the specific wear rate than the velocity of sliding. The other two parameters affect the specific wear rate, but their effects are less significant than those of the previous two parameters. The factor combinations A₄ (Kota stone dust loading 20 wt. %), B₂ (Normal Load 20 N), C₄ (sliding velocity 4 m/s), and D₁ (sliding distance 600 m) have the lowest specific wear rate, as the figure illustrates.

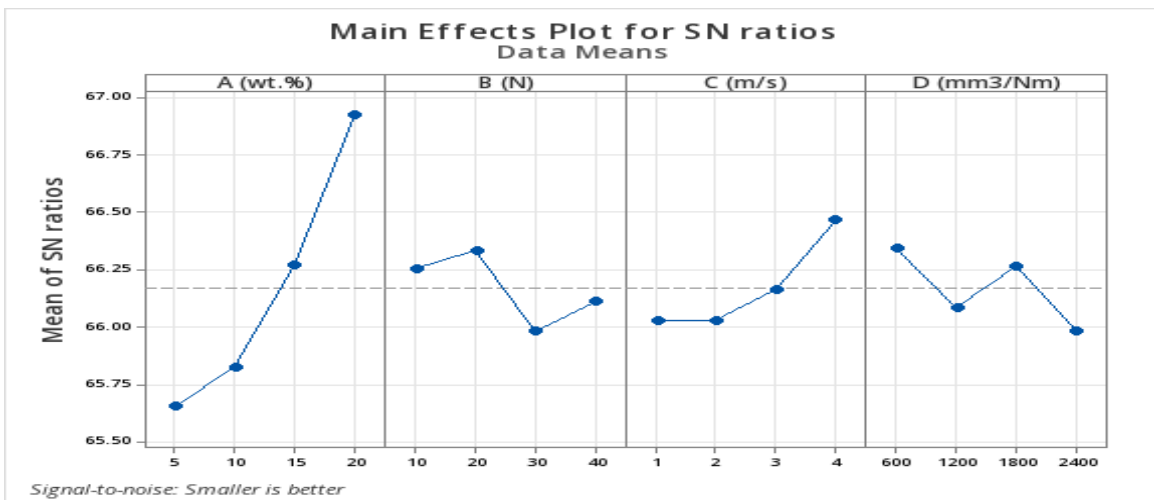


Figure 7 Variation of S/N ratios showing the relative implication of input factors on specific wear rate

It has been observed that the Kota stone dust content and the sliding velocity have a major influence on the specific wear rate of the prepared hybrid composite material. Hence, here, it is required to study the variation in the specific wear rate as a function of Kota stone dust content and the sliding velocity. The test is performed on all four samples where the content of Kota stone

dust varied from 5 wt. % to 20 wt. %. This gives the effect of Kota stone dust content and the sliding velocity on the specific wear rate of the composites. For conducting the test, the normal load is kept constant at 20 N, and the sliding distance is kept constant at 1200 m.

Table 4.2: Response table: smaller is better

Level	A (wt.%)	B (N)	C (m/s)	D (m)
1	65.65	66.26	66.03	66.34
2	65.83	66.33	66.03	66.09
3	66.27	65.98	66.16	66.27
4	66.93	66.11	66.47	65.98
Delta	1.27	0.35	0.44	0.36
Rank	1	4	2	3

The sliding velocity is varied from 1 m/s to 4 m/s, and the Kota stone dust content varies from 0 wt. % to 20 wt. %. At this condition, the wear test is performed, and the wear rate is calculated. The specific wear rate of the composites under such operating conditions is presented in Figure 8.

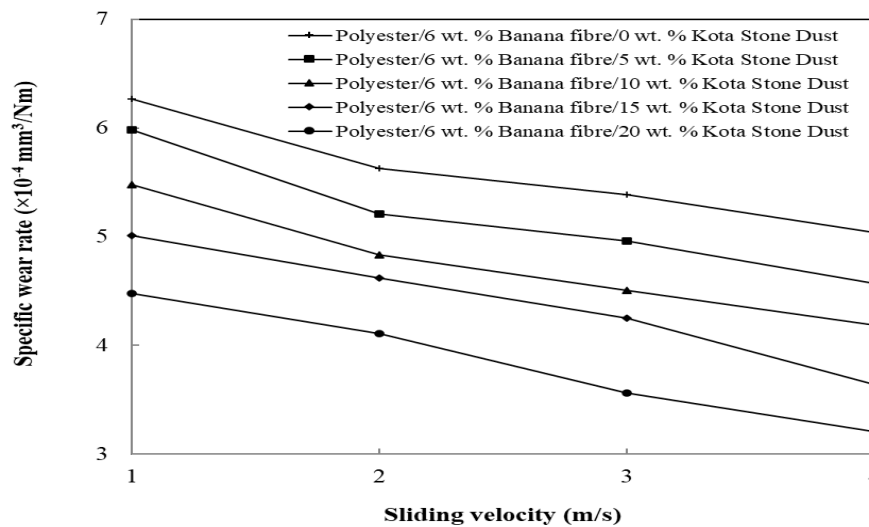


Figure 8 Variation of specific wear rate with sliding velocity

The figure shows that as the sliding velocity on a polyester/banana fibre/Kota stone dust composite increases, the specific wear rate of the composite decreases. The inclusion of Kota stone dust in the polymer composites showed improvement in the abrasive wear resistance because of the high hardness value of the filler material. Hence, it can be concluded that with either an increase in Kota stone dust content or an increase in the sliding velocity, the specific wear rate of the composite decreases.

4. Conclusions

In this study, a novel category of hybrid composites was produced using polyester as the primary matrix, while banana fibre and Kota stone dust were employed as reinforcing phases. The banana fibre proportion was fixed at 6 wt.%, whereas the Kota stone dust content was varied between 5 and 20 wt.%. Experimental observations indicate that introducing Kota stone dust into the polyester–banana fibre system leads to a rise in composite density. Increasing the Kota stone dust proportion also contributes to higher void formation, with the maximum void fraction of around 4.85 % observed at 20 wt.% loading. Moisture uptake similarly increases with both filler content and immersion duration. Mechanical testing reveals that tensile and flexural strengths decline as the amount of Kota dust increases. In contrast, properties such as tensile modulus, flexural modulus, impact strength, compressive strength and hardness show consistent improvement with higher filler addition. It has been observed that the Kota stone dust content and the sliding velocity have a major influence on the specific wear rate of the prepared hybrid composite material. Wear behaviour under steady-state conditions demonstrates that the specific wear rate decreases with increasing sliding speed and filler loading. Considering the overall set of properties, these hybrid composites appear suitable for lightweight automotive parts subjected to relatively low loads, such as interior panels, roof sections, and similar components.

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