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Research Article

An AHP-TOPSIS Approach for Optimizing the Mechanical Performance of Natural Fiber-Based Green Composites

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Natural fibers have emerged as an effective replacement for synthetic fibers in the fabrication of green composites to be used for producing various components in automotive, aerospace, and other applications. In this proposed study, the mechanical properties of banana and coir fiber-based green composites have been optimized by using a hybrid AHP-TOPSIS approach. Corn starch along with glycerol has been used as the matrix material for fabricating the green composites. The mechanical properties such as tensile strength, flexural strength, and impact strength of the developed green composite have been optimized with a focus on the utilization of this composite in automotive and aerospace applications. Three different weight percentages (0%, 5%, and 10%) of banana and coir fibers was considered for the fabrication of green composites. The constituents of the green composite have been taken as the input variables whereas the mechanical properties of the green composite are considered as the output variables for designing the experiment. The design of the experiment consisted of nine different combinations of input and output variables. Results of the study revealed that 5 wt.% of banana fiber, 10 wt.% of coir fiber, and 85 wt.% of corn starch provide the optimum mechanical performance of the developed green composites.

1. Introduction

In recent years, the focus of the researchers working in the area of composites has shifted towards the development of green composites by utilizing natural fibers. The most common natural fibers include sisal, coconut fibers, banana fibers, jute, and others which have been used as reinforcing materials for developing green composites [1–4]. Because of their accessibility, environmental friendliness, and biodegradability, natural fibers have received a lot of attention in recent research from academia and industry [5, 6]. Natural fiber is a cellulose-rich material used as a filler alternative in rubber technology. The mechanical, temperature and biodegradable properties of natural nutrient rubber composites are investigated. Unaltered natural fibers cannot provide the requested reinforcement for rubber composites when used as filler [7, 8]. To improve the overall performance of natural fiber-filled rubber composites, a variety of surface modification techniques can be used. The majority of the plant fiber structure is composed of three basic components: cellulose, hemicellulose, and lignin [9, 10]. Natural fiber is also defined as a collection of cells with a tiny diameter compared to their length. Although there are numerous fibrous materials in nature, notably cellulose ones such as cotton, wood, grains, and straw, only a small number of them may be used to manufacture textiles or for other industrial purposes [11, 12]. Much effort has been put into improving the mechanical performance of this group of materials in order to broaden their capabilities and applications. These higher tensile strength fibers are primarily used in the paper and packaging industries. Plant leaves are used to extract fibers such as jute, melon, and many others, whereas plant seeds are used to extract fibers such as coir, cotton, and abaca. Plant fibers have higher strength and stiffness, but their properties are primarily determined by their structure and chemical makeup. These are always related to the fiber's origin, how it was extracted, when it was harvested, how much retting and modification it underwent, and how mature it was. With increased transportation and communication, highly specialized arts and crafts linked with textile manufacture spread to other countries and were customized to local demands and capabilities [13, 14]. A natural fiber's origin might be used to classify it. Jute, flax, and cotton are examples of important vegetable, or cellulose-based, fibers. Wool, mohair, and silk are examples of animal protein-based fibers [15, 16]. To fully develop and use green materials that will better serve social development, their benefits and value must be communicated during the application process. The natural fiber is a versatile and renewable resource. It is widely available, has acceptable mechanical properties, and has numerous applications in a wide range of industries. Natural fibers, however, have some flaws, such as hydrophilicity and variability. Physical and chemical processes improve the mechanical properties of natural fibers, which also improve the properties of natural fiber composites. Various recent studies have revealed that these natural fibers have the ability to replace synthetic fibers (i.e., glass and carbon fibers) in applications such as automotive and aerospace [17–20]. Researchers are highly interested in developing materials that can replace synthetic materials. As a result, demand for natural fiber-based composites for commercial use in a range of industrial sectors has increased in recent years [21, 22]. Natural fibers are easily available, ecologically acceptable materials that provide benefits such as being economical, light, renewable, biodegradable, and having high specific qualities. The sustainability of natural fiber-based composite materials has enhanced their application in a range of manufacturing industries [23, 24]. Because petroleum resources are dwindling and synthetic fiber and resin systems are not biodegradable, researchers are seeking alternatives. They easily melt and burn at very high temperatures, forming small, sticky beads. As a result, there is always the risk of getting burns while wearing synthetic clothing, particularly in the kitchen. They do not absorb sweat, as well as natural fibers, do, and the majority of these fibers only absorb a small amount. As a result of perspiring on hot summer days, they stick to the body. Methods for improving the performance of natural composites have been developed that have proven to be effective [25, 26] These natural fibers possess excellent physical and mechanical properties like lightweight, high modulus, and specific strength which enable them to be widely considered in structural applications [27–30]. Natural fibers are soft, warm, robust, and light. They have a pleasant hand feel and are easy to wear and care for. They generally have a softer feel to the touch than synthetic materials. Customers prefer natural fibers over synthetic fibers due to their superior characteristics [31, 32] Natural fibers are not only biodegradable or recyclable but also freely available in abundance. Thus, these are ecofriendly as well as cost-effective [33]. Natural fibers have various advantages in comparison to synthetic fibers which include less abrasion, not being harmful to the employees during their production process and their composites can easily be disposed of after completing their life cycle [34, 35]. Natural fiber-based composites can also be used to recover the energy after the completion of their life cycle by incinerating them in a furnace [36]. For a given application and performance, a higher proportion of natural materials will be required than glass fibers. Lowering the resin content will be required, which will significantly reduce polymer-related pollution. Burning natural fibers at the end of their lives releases carbon and energy. Also, natural fibers require far less energy to process than glass fibers. According to studies, the mechanical characteristics of natural fiber composites are comparable to or even superior better than those of glass, with the energy required to produce natural fibers from flax being approximately 17% of that required to produce the same quantity of glass fibers.

Sapuan et al. [37] fabricated banana fiber-based epoxy composites and tested them at different speeds and load conditions. The results showed the very stable mechanical performance of these composites. Polypropylene composites reinforced through pineapple leaf fibers provided an improvement in the tensile strength as well as in the tensile modulus of the composite with the increasing amount of fibers in the composite [38]. Sathiyamurthy et al. [39] developed coir-based polyester composite and tested their mechanical characteristics. It was found that the tensile, flexural, and impact strength of the composite was improved due to the presence of the coir-fiber in the polyester matrix. Hussain and co-workers [40] examined the mechanical characteristics of coconut fiber-reinforced HDPE composites by considering the fiber weight and fiber length as input parameters. It was observed that the fiber length had a significant influence on the mechanical performance of the composites. In another study on banana/sisal-based polyester composites, the effect of different volume fractions of banana and sisal on the mechanical properties of the composite was investigated. It was revealed that at a volume fraction of 3 : 1 for banana and sisal fibers, the composite showed maximum tensile strength [41]. Hari Ram and Edwin [42] studied and compared the mechanical characteristics of conventional glass fiber-based epoxy composite, sisal fiber-based epoxy composite, and hybrid sisal-glass-epoxy composites. Results showed that the hybrid composite had improved mechanical performance in comparison to the conventional composite. Also, sisal-epoxy composites had comparable properties with conventional glass-epoxy composites.

It can be observed from the literature that researchers have significantly focused on the development and mechanical testing of the green composites but a focus on identifying the optimum composition of the various constituents is missing or less explored [43, 44]. Generally, the weight percentage of reinforcing materials is a crucial deciding factor for the mechanical performance of composites [45, 46]. Therefore, the main focus of this study is on the optimization of the mechanical performance of green composites developed through the reinforcement of banana fiber and coir fiber. A combined AHP-TOPSIS approach is adopted in the proposed study for exploring the optimal combination of natural fibers to achieve the optimum mechanical performance of developed green composites. For the information, the AHP- TOPSIS is most useful when making decisions about difficult issues with high stakes. It is distinct from other decision-making techniques as it quantifies criteria and options that are typically difficult to quantify with precise numbers. The use of the analytic hierarchy process in multi-criteria programming is a technique for making decisions in complex environments in which many variables or criteria are considered in the prioritization and classification of alternatives or projects. Rather than dictating a "correct" decision, AHP assists decision makers in making the decision that best fits their values and understanding of the problem.

2. Materials and Methods

In this study, a polymer-based composite has been developed by using natural fibers. There are three main constituents of the developed composite which are described below:

2.1. Banana Fibers (BF). It is a natural fiber that is generally obtained from the stem of banana trees. Banana fibers are taken as the reinforcing material to develop the green composite. An alkali treatment was carried out for banana fibers by using sodium hydroxide. Such a treatment results in the improved crystalline structure of banana fibers. Different weight percentages (0, 5, and 10) wt. % of banana fibers were used for the fabrication of green composite samples.

2.2. Coir Fibers (CF). This natural fiber is obtained from the outer husk of the coconut fruit. Coir fibers have also been used as reinforcement in the matrix material. Coir fibers have the excellent ability to offer resistance to any kind of damage. Also, they possess a significant water resistance ability which is a key aspect in the applications of composites. Different weight percentages (0, 5, and 10) wt. % of coir fibers was also considered for the development of the composite samples.

2.3. Corn Starch (CS). Corn starch along with glycerol is used as the matrix material for developing the green composite. Corn starch and glycerol were mixed in a weight percent ratio of 70 : 30. A high-speed mixing was carried out by using a robust mixing machine for preparing the polymer-based green composite. The compounding of corn starch and glycerol was achieved with the help of a twin screw extruder.

The block diagram of the methodology used for this study is provided in Figure 1.

Treated banana fibers along with coir fibers and corn starch-based polymer matrix pallets were mixed together in different weight percentages, as provided in Table 1. The mixed pallets were fed to a 40 Ton injection molding machine for manufacturing of the samples required as per Table 1.

2.4. Mechanical Properties of Developed Green Composites. Three mechanical performance parameters in terms of tensile, flexural, and impact strength were calculated for each sample of the developed green composites, as shown in Table 1. A brief detail for the computation of each mechanical property is provided:

2.4.1. Tensile Strength. The specimens for the tensile test were prepared through an injection molding process. The samples were tested on universal testing machine according to ASTM D638 standard.

2.4.2. Flexural Strength. ASTM D790 standard was used for measuring the flexural strength of the developed green composites. In this measurement process, a three-point loading condition was applied to the composite sample to bend it.

2.4.3. Impact Strength. Impact testing of the samples was carried out as per ASTM D256 standard on an Izod impact testing machine. The impact strength of the sample is a measure of energy absorbed by the sample before it fails.

2.5. AHP Method. AHP is a popular and reliable multi-criteria approach that was developed by Saaty [47]. Different steps of the AHP technique are as follows.

Identify the main goal of the study followed by the different performance criteria and alternatives. In this study, the main goal is the optimization of the mechanical properties of the green composite. Three different mechanical properties have been considered as the three performance criteria and all 9 samples are taken as 9 alternatives to the study. A hierarchy of these factors is shown in Figure 2.

Develop a matrix that compares all the criteria with each other. This matrix is known as a pairwise comparison matrix. This matrix is developed by using a rating scale which is provided in Table 2. If there are total N criteria, then the comparison matrix K is presented as follows:

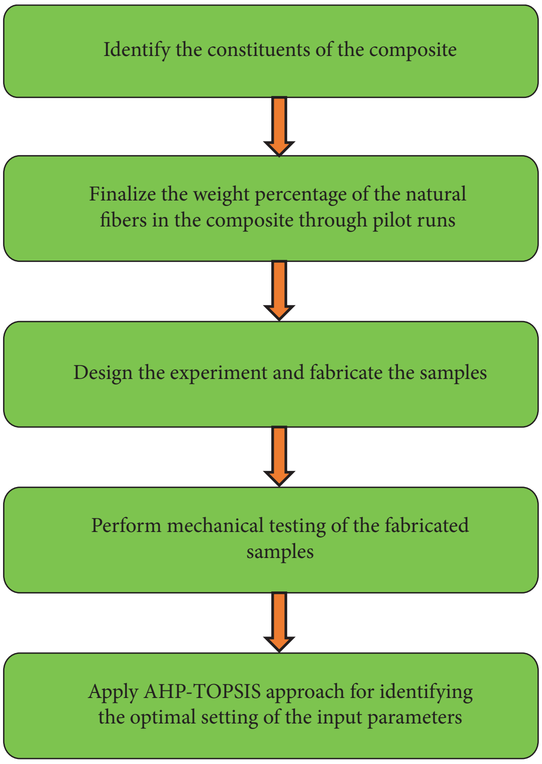

FIGURE 1: Workflow and methodology used for the mechanical performance of natural fiber-based green composites.

$$K = \begin{bmatrix} K_{11} & K_{12} & \dots & K_{1N} \\ K_{21} & K_{22} & \dots & K_{2N} \\ \vdots & \vdots & \dots & \vdots \\ K_{N1} & K_{N2} & \dots & K_{NN} \end{bmatrix}, K_{ji} = \frac{1}{K_{ij}}, K_{ij} \neq 0. \quad (1)$$

Determine the weightage for each criterion by following the equation:

$$\varpi_i = \frac{\{\prod_{j=1}^{N} K_{ij}\}^{1/N}}{\sum_{i=1}^{N}\{\prod_{j=1}^{N} K_{ij}\}^{1/N}}, i = 1,2,\dots\dots N, j = 1,2,\dots\dots N. \quad (2)$$

2.6. TOPSIS Method. TOPSIS method was introduced by Hwang and Yoon [48]. Different steps of this technique are as follows.

First, a decision matrix is developed on the basis of different criteria and alternatives. If there are X alternatives and Y criteria, then the decision matrix will be presented as follows:

$$D = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1Y} \\ a_{21} & a_{22} & \dots & a_{2Y} \\ \vdots & \vdots & \dots & \vdots \\ a_{X1} & a_{X2} & \dots & a_{XY} \end{bmatrix}. \quad (3)$$

TABLE 1: Experimental design for sample manufacturing.

Sample number	Composition of the inputs (% wt.)		
	Banana fibers (BF)	Coir fibers (CF)	Corn starch (CS)
1	0	0	100
2	0	5	95
3	0	10	90
4	5	0	95
5	10	0	90
6	5	5	90
7	5	10	85
8	10	5	85
9	10	10	80

Here, a_{ij} indicates the decision value for the i^{th} alternative against the j^{th} criteria.

Normalize the developed decision matrix to ensure that each value is comparable. The normalization is carried out with the help of the following equation.

$$d_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{X} a_{ij}^2}}. \quad (4)$$

Develop the weighted normalized matrix which is obtained through the multiplication of the column values of the normalized matrix (d_{ij}) with relevant criteria weight (ϖ_i).

$$\overline{d_{ij}} = d_{ij} \times \varpi_i. \quad (5)$$

Compute the positive and negative ideal reference points represented as (β) and (γ), respectively, as follows.

$$\beta = \left(\overline{d}_1^+, \overline{d}_2^+, \dots \overline{d}_N^+\right), \quad (6)$$

$$\gamma = \left(\overline{d}_1^-, \overline{d}_2^-, \dots \overline{d}_N^-\right), \quad (7)$$

where

$$\overline{d}_j^+ = \left\{ \operatorname*{Max}_i^X \overline{d}_{ij} \text{ (in case of a benefit criterion)} \right.$$

$$\overline{d}_j^+ = \left\{ \operatorname*{Min}_i^X \overline{d}_{ij} \text{ (in case of a cost criterion)} \right.$$

and

$$\overline{d}_j^- = \left\{ \operatorname*{Min}_i^X \overline{d}_{ij} \text{ (in case of a benefit criterion)} \right.$$

$$\overline{d}_j^- = \left\{ \operatorname*{Max}_i^X \overline{d}_{ij} \text{ (in case of a cost criterion)} \right.$$

Determine the distances of each alternative from positive and negative ideal reference points as follows:

$$\alpha_i^+ = \sqrt{\sum_{j=1}^{Y} \left(\overline{d}_j^+ - \overline{d}_{ij}\right)^2}, \quad (8)$$

$$\alpha_i^- = \sqrt{\sum_{j=1}^{Y} \left(\overline{d}_{ij} - \overline{d}_j^-\right)^2}, \quad (9)$$

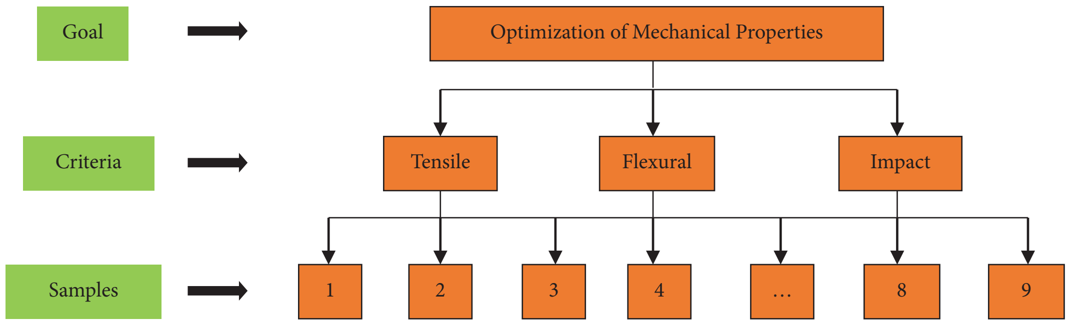

Figure 2: The hierarchical structure for AHP.

Table 2: rating scale for developing the pair-wise comparison matrix of criteria.

Rating	Importance	Description
1	Equal importance	If two criteria are similar in importance
3	Somewhat higher importance	If one criterion slightly dominates the other
5	Much higher importance	If one criterion strongly dominates the other
7	Very much higher importance	If one criterion very strongly dominates the other.
9	Absolutely higher importance	If there are verified sources that a criterion dominates the other
2, 4, 6, 8	Intermediate values	If there exists a trade-off between two odd ratings

here α_i^+ and α_i^- represent the gap for each alternative from (β) and (γ), respectively.

Determine the closeness coefficient (CC) for different alternatives by using the following equation:

$$CC_i = \frac{\alpha_i^-}{\alpha_i^+ + \alpha_i^-} \text{where } i = 1, 2, \ldots, M. \quad (10)$$

In this study, the integration of the AHP-TOPSIS technique is adopted because such a combination has the potential to provide realistic and reliable results [49, 50]. Such a hybrid approach based on AHP-TOPSIS is utilized in various optimization-based researches such as for the optimization of performance parameters of polymer gears [51] and for optimizing the cobalt bonded tungsten carbide composite [52].

3. Results and Discussion

The results achieved through the mechanical testing of green composite samples are provided in Table 3 in terms of tensile, flexural, and impact strength of the samples.

The natural fibers were blended in different quantities to get the desired composite which befits the mechanical properties. The illustration of the results has been done in Table 3. Three major parameters were considered to judge the capability of the green composite. Samples were taken in and output was acquired. From the findings, it is thus observed that the impact strength is the most suitable property. The variation in the mechanical performance of the green composite with respect to the varying wt. % of the natural fibers is presented in Figures 3–5 for tensile, flexural, and impact strength, respectively.

It is evident from Figure 3 that the tensile properties of the developed composite increase with the increasing weight percentage of natural fibers. However, the increment in tensile properties with respect to banana fibers is more significant in comparison to that of coir fibers.

It is evident from Figure 4 that flexural strength is enhanced with an increasing percentage of natural fibers. It is clear that the coir fiber causes a more significant effect on flexural strength as compared to banana fibers. Maximum flexural strength of 16 kg/cm^2 is obtained for 10 wt.% of each, banana fiber and coir fiber.

Figure 5 reveals that the impact strength of composites is enhanced with incremental wt.% of the natural fibers. In this case, coir fiber has again a superior influence on the impact strength as compared to banana fibers. Figure 5 clearly indicates that with the increment in the number of natural fibers in the composite sample, the impact strength has gradually increased. The durability of the material will also be enhanced. The blend of sample 7 has shown the maximum results for the impact strength. Moreover, it is clear from the above Figures 3 and 4, the flexible properties, as well as tensile strength have also shown significant change. The presented method has enhanced the performance of natural composites thus the method developed has proven to be effective. The maximum impact strength of 98.8 J/m is achieved at a fiber loading of 5 wt.% of banana fiber and 10 wt.% of coir fiber. It can be observed from the above Figures 3–5 is found that the sample with no reinforcement (i.e., sample 1) provides the worst performance for all three mechanical properties.

3.1. Result of AHP. AHP approach was adopted to determine that which mechanical properties are crucial for green composite to be utilized effectively in automotive and aerospace applications. The importance of each mechanical property was determined by computing their weights as provided in Table 4.

Table 3: Results of experimental design.

Sample number	*Composition of the inputs (% wt.)*			*Mechanical properties (outputs)*		
	Banana fibers (BF)	Coir fibers (CF)	Corn starch (CS)	Tensile strength (kg/cm^2)	Flexural strength (kg/cm^2)	Impact strength (J/m)
1	0	0	100	6	4	40.2
2	0	5	95	10	8	52.8
3	0	10	90	12	14	60.1
4	5	0	95	14	6	41.5
5	10	0	90	18	8	47.2
6	5	5	90	16	10	70.1
7	5	10	85	17	15	98.8
8	10	5	85	20	14	90.6
9	10	10	80	21	16	94

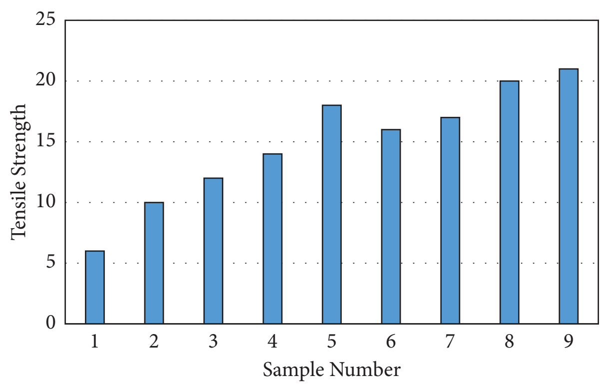

Figure 3: Variation in tensile strength against the varying wt. % of natural fibers.

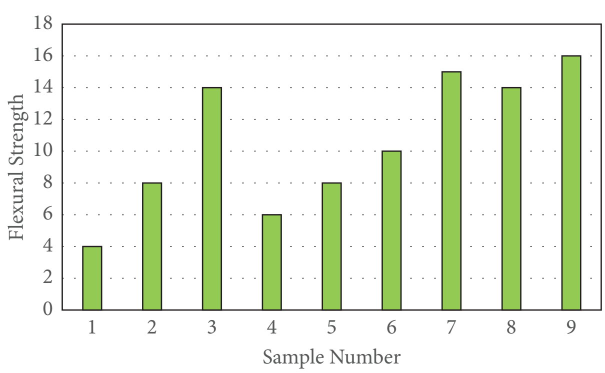

Figure 4: Variation in flexural strength against the varying wt. % of natural fibers.

The three major factors or parameters were considered for the mechanical properties of natural fiber-based green composites. It is clear from Table 4 that the impact strength is the most significant property. It is to be noted that even a small introduction of any of the two natural fibers enhanced the mechanical performance of the developed green composite. The rating values filled in Table 4 were decided by a group of five researchers having a significant research experience in the field of composite materials. These rating values were extracted by using the rating scale provided in Table 2. The results of the AHP analysis presented in Table 4 clearly indicate that the impact strength of the composite is

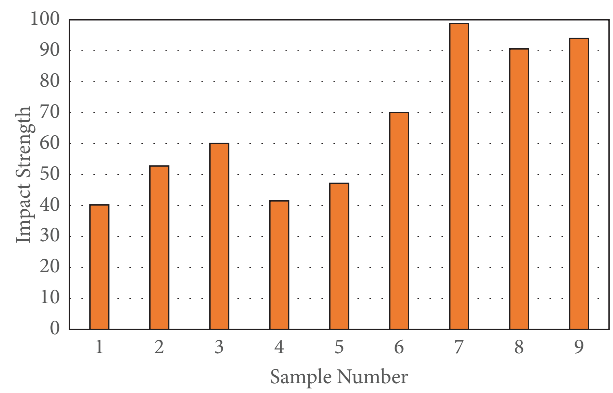

Figure 5: Variation in impact strength against the varying wt. % of natural fibers.

the most significant mechanical property for automotive and aerospace applications. It is followed by flexural strength and tensile strength.

Once the weights of mechanical properties are achieved through the AHP approach, these weight values will be utilized in the TOPSIS approach for identifying the best alternative (sample) for achieving the optimal mechanical performance of the developed green composite.

3.2. Result of TOPSIS. The first step in the TOPSIS approach is to develop a decision matrix that includes decision criteria (i.e., mechanical properties in the current study) and alternatives (i.e., samples in the current study). This matrix is already presented in the form of Table 3. Then, a normalized matrix is developed by using Eq. (4). Further, the weighted normalized matrix is constructed with the help of Eq. (5). Normalized and weighted normalized matrices are provided in Table 5.

In the next step, positive and negative ideal reference points i.e., (β) and (γ), respectively, are computed with the help of Eq. (6). Then, the values of α_i^+ and α_i^- are measured by using Eq. (7). Further, the values of closeness coefficient (CC) are calculated for each sample by utilizing Eq. (8). Finally, a rank is assigned to each sample based on its closeness coefficient, as presented in Table 6. The sample with the highest value of closeness coefficient is assigned with rank 1; then, successive ranks are provided in the

Table 4: Weights of mechanical properties through AHP.

	Tensile strength	Flexural strength	Impact strength	Geometric mean	Weight
Tensile strength	1	0.33	0.25	0.435	**0.117**
Flexural strength	3	1	0.33	0.997	**0.268**
Impact strength	4	3	1	2.289	**0.615**

Table 5: Normalized and weighted normalized matrices.

Sample number	*Normalized matrix*				*Weighted normalized matrix*		
	Tensile strength (kg/cm^2)	*Flexural strength* (kg/cm^2)	*Impact strength* (J/m)		*Tensile strength* (kg/cm^2)	*Flexural strength* (kg/cm^2)	*Impact strength* (J/m)
1	0.1283	0.1178	0.1923		0.0150	0.0316	0.1183
2	0.2139	0.2356	0.2526		0.0250	0.0631	0.1554
3	0.2567	0.4123	0.2875		0.0300	0.1105	0.1768
4	0.2994	0.1767	0.1986		0.0350	0.0474	0.1221
5	0.3850	0.2356	0.2258		0.0450	0.0631	0.1389
6	0.3422	0.2945	0.3354		0.0400	0.0789	0.2063
7	0.3636	0.44175	0.4727		0.0425	0.1184	0.2907
8	0.4278	0.4123	0.4335		0.0500	0.1105	0.2666
9	0.4492	0.4712	0.4497		0.0526	0.1263	0.2766
				β	0.0526	0.1263	0.2907
				γ	0.0150	0.0316	0.1183

Table 6: Ranking of the samples.

Sample number	α_i^+	α_i^-	CC	Rank
1	0.2003	0.0000	0.0000	**9**
2	0.1519	0.0497	0.2466	**6**
3	0.1171	0.0994	0.4591	**5**
4	0.1870	0.0258	0.1212	**8**
5	0.1646	0.0482	0.2265	**7**
6	0.0976	0.1030	0.5134	**4**
7	0.0127	0.1950	0.9386	**1**
8	0.0289	0.1716	0.8557	**3**
9	0.0141	0.1883	0.9302	**2**

decreasing order of CC, as shown in Table 6. It can be understood from Table 6 that sample 7 achieved the maximum closeness coefficient value of 0.9386 and therefore assigned with Rank 1. Sample 1 had the least closeness coefficient value of 0 and received the last Rank 9.

Thus, it can be attributed from the results presented in Table 6 that the banana fiber with 5 wt.% and coir fiber with 10 wt.% is the optimal setting for ensuring the optimum mechanical performance of the developed green composite. Although, 10 wt.% of each natural fiber, i.e., banana fibers and coir fibers (i.e., sample 9) provide the best flexural and tensile strength but the impact strength is slightly deteriorated in this case. This might have occurred due to the agglomeration of the fibers with the matrix material.

4. Discussion

Natural fibers have emerged as an effective replacement for synthetic fibers in the production of green composites for use in automotive, aerospace, and other applications. To fully develop and use green materials that will benefit social development, their benefits and value must be clearly communicated throughout the application process. The natural fiber is both versatile and renewable. It is widely available, has good mechanical properties, and has many applications in a variety of industries. For each sample of the developed green composites, three mechanical performance parameters were calculated: tensile, flexural, and impact strength. According to research, the most important mechanical property for automotive and aerospace applications is the impact strength of composite materials. Flexural strength and tensile strength come next. When banana fiber is loaded at 5% and coir fiber at 10%, the maximum impact strength of 98.8 J/m is reached. The samples with no reinforcement performed the worst for all three mechanical properties, as can be seen from the result. It became clear that even a small addition of either of the two natural fibers improved the developed green composite's mechanical performance.

5. Conclusion

This study presents the optimization of mechanical performance of banana and coir fibers-based green composites to be used in automobile and aerospace applications. Corn starch along with glycerol was used as the matrix material for developing the green composite. An AHP-TOPSIS-based hybrid approach was used for the optimization. The optimal setting of the natural fibers in the green composite was identified to be 5 wt.% of banana fibers and 10 wt.% of coir fibers to achieve the optimum mechanical performance of the green composite. It was evident that even a small introduction of any of the two natural fibers enhanced the mechanical performance of the developed green composite. Coir fibers are crucial for achieving an improved flexural and impact strength of the developed composite whereas the enhancement in tensile strength of the green composite was much dependent on the banana fibers.

The limitation associated with this research is that the natural fibers were used only up to 10 wt.% for developing the composites. A higher weight percentage can be added to verify if there will be any additional improvement in the mechanical properties of green composite or not. Also, the developed composite samples were tested in a laboratory setup only but not in any real-life scenario.

As a part of the future study, the same natural fibers, i.e., banana and coir fibers can be reinforced with some other matrix materials such as epoxy or polyester for fabrication and mechanical testing of the composite.

Data Availability

The data utilized for the presented study can be obtained by submitting a request to the corresponding author.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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