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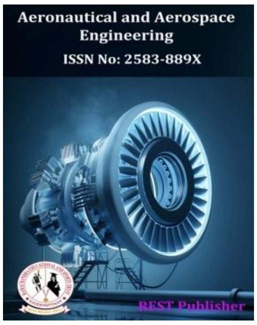

Analysis of Materials Used in Spar of Human Powered Aircraft by TOPSIS Method

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Abstract. *The process of design is a sequential decision-making endeavor that strives to create a successful product while considering technological, societal, and economic constraints. Regarding product design, meeting two fundamental requirements is vital for a successful product. First, it should fulfill all functional or design specifications. Second, it must be economically competitive. In achieving these goals, the careful selection of the materials used in the product plays a critical role. It is important to consider a variety of criteria while choosing materials. These variables encompass a wide range of factors, spanning from physical, mechanical, and electrical characteristics to corrosion resistance and financial aspects. However, when it comes to mechanical design, the primary emphasis lies in the mechanical qualities. Strength, stiffness, toughness, hardness, density, and creep resistance stand out as the most critical material characteristics that frequently arise during the materials selection processes. Making decisions takes information and always involves some level of risk and uncertainty. A common element of the design activity is choosing between possibilities. The result of the TOPSIS analysis is followed by Al 7075-T6 is rank nine, Al 2024-T4 is tenth rank, Ti–6Al–4V is fifth ranked, Ti–2Fe–3Al is ranked second, S-glass 70% Epoxy cont. fibers is rank fourth, S-glass 70% Epoxy fabric is eight ranked, Carbon 63% Epoxy is first, Aramid 62% Epoxy is third, E-glass73%-Epoxy is sixth, E-glass 56% Epoxy is seventh, and for E-glass 65% Polyester is eleventh. The result of the analysis shows that the best materials used Carbon 63%-Epoxy alloy followed by Ti–2Fe–3Al, Aramid 62%-Epoxy, S-glass70%-Epoxy cont. fibers.*

Keywords: *Human-Powered Aircraft, Tensile strength, Young's modulus, MCDM.*

1. INTRODUCTION

According to estimates, plastics, ceramics and glasses, composites and more than 40,000 including semiconductors practical metal alloys and so on There are non-metallic engineering materials. Wide range available to engineer's materials and manufacturing processes and between various selection criteria Given the complex interactions Selecting materials for the component Often challenging [1]. The process of material selection is multiple Criteria as a decision-making challenge considered. This process is usually Physical, electrical, magnetic, mechanical and Chemical properties are also important Trade-offs between variables including, as well as manufacturing considerations, Chemical properties such as cost of an important material, its environmental impact moreover, during the materials selection processes, factors such as availability, market trends, cultural considerations, aesthetics, recycling capabilities, and the needs of other target groups are taken into account [2]. Nevertheless, when it comes to mechanical design, the primary focus is on mechanical qualities, including strength, stiffness, hardness, density, and creep resistance. These material characteristics are of paramount importance and are commonly taken into consideration during the material selection stages [3]. Human power has been shown to be adequate to drive an aero plane through careful design. These unique aircraft, known as Human-Powered Aircraft (HPAs), are made for a single pilot and are incredibly light and fly at very low speeds [4]. The development of quick, transcontinental flights, as well as aircraft that can break the sound barrier, are just a few of the inventions that have contributed to aviation's astounding rise over the past century. Another is the first flight of a heavier-than-air vehicle. HPAs are a unique and challenging class of aircraft because of the power restrictions placed on them [5]. The main wing component of any aircraft, the spar, is a The beam works. to the wing of an aircraft This piece that stretches over the top, is all direct and indirect aerodynamics and static Bears loads. The permissible weight for constructing an aircraft is significantly limited. Therefore, the selection of materials and the design process become crucially important [6]. In the construction of the spar for a human-powered aircraft, several primary properties are taken into consideration to ensure desirable performance. These properties include Young's Modulus, Tensile Strength, Compressive Yield Strength, Specific Gravity, Creep resistance, and price. Various materials are evaluated as alternatives for the spar, including Al 7075-T6, Al 2024-T4, Ti–6Al–4V, Ti–2Fe–3Al, S-glass 70% Epoxy continuous fibers, S-glass 70% Epoxy fabric, Carbon 63% Epoxy, Aramid 62% Epoxy, E-glass 73%-Epoxy, E-glass 56% Epoxy, and E-glass 65% Polyester [7]. The selection of the most suitable material from this list is crucial to achieve optimal performance in the construction of the aircraft's spar. Zinc is the main alloy in the composition Acts as raw material Made of aluminum 7075 aluminum. of aluminum Copper in alloy 2024 aluminum alloy Acts as the main mixing ingredient. Alpha-beta titanium alloy Ti-6Al-4V, often as TC4, Ti64 or ASTM grade 5 is called, high specific strength and has excellent corrosion resistance [8]. Iron commonly known as Ti 10-2-3 Non-beta titanium alloy Ti-10V-2Fe-3Al, it has an excellent balance of Strength, Ductility, Fracture hardness and high cyclic fatigue strength. Common applications in the aerospace sector include crucial aircraft components like landing gear [9]. One of the more crucial glasses from a technological standpoint is definitely s-glass. Its strength, stiffness, and softening point are the highest of any commercially available reinforcement glass fiber. When compared to alternative reinforcements, the elastic moduli of e-glass fibers are comparably low. Additionally, E-glass fibers can creep and burst under stress [10].

2. MATERIALS AND METHODS

The TOPSIS approach is a mechanism for ranking preference based on how closely it resembles the ideal answer. Many times, it is difficult to convey alternatives' exact ratings in relation to local criteria, hence these ratings are instead thought of as intervals [11]. The selected option represents the positive ideal, while the smallest distance from the solution is negative and further away from the ideal solution. This describes the basic theory of the TOPSIS technique. TOPSIS theory and Countless books about applications and Articles are written [12]. TOPSIS is recognized as one of the most widely used multi-criteria decision analytical techniques. The concept was initially introduced by Hwang and Yoon, and later Yoon made further contributions to its development. This According to the approach, the negative ideal and which are far from the solution for positive ideal solution (BIS) (NIS) Closer is the best option. PIS is an imaginary alternative, which is the only one Increases benefit criteria (B) in time and reduces cost criteria (C). [13]. NIS, on the other hand, is a simultaneous benefit Reduces scale and cost at the same time Increases criteria. Far from NIS Farthest and smallest from PIS It is optimal to have Euclidean distance is optional. The options are ordered in descending order using the closeness coefficient (CCi) determined in the final stage after each alternative has had its closeness coefficient calculated [14].

Step 1: A decision matrix, denoted as X, is formulated to present the performance of different options concerning specific criteria.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & x\cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

Step 2: The criteria's weights are given as

$$w_j = [w_1 \cdots w_n], \tag{2}$$

where ,$\sum_{j=1}^{n}(w_1 \ \cdots \ w_n) = 1$

Step 3: The matrix x_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sqrt[2]{\sum_{i=1}^{m} x_{ij}^2}} \tag{3}$$

Weighted normalized matrix N_{ij} is calculated by the following formula

$$N_{ij} = w_j \times n_{ij} \tag{4}$$

Step 4: We'll start by determining the ideal best and ideal worst values: Here, we must determine whether the influence is "+" or "-." If a column has a "+" impact, the ideal best value for that column is its highest value; if it has a "-" impact, the ideal worst value is its lowest value.

Step 5: Now we need to calculate the difference between each response from the ideal best,

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^+)^2} \qquad \text{For } i \in [1, m] \text{ and } j \in [1, n] \tag{5}$$

Step 6: Now we need to calculate the difference between each response from the ideal worst,

$$S_i^- = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^-)^2} \qquad \text{For } i \in [1, m] \text{ and } j \in [1, n] \tag{6}$$

Step 7: Now we need to calculate theCC_i of i$_{\text{th}}$ alternative

$$CC_i = \frac{S_i^-}{S_i^+ + S_i^-} \qquad \text{Where } 0 \le CC_i \le 1, i \in [1, m] \tag{7}$$

The Closeness Coefficient's value illustrates how superior the alternatives are in comparison. A larger CC_i denotes a substantially better alternative, whereas a smaller CC_idenotes a significantly worse alternative. In the design of the spar for a manned aircraft, the primary goal is straightforward: to make the spar as lightweight as possible while ensuring it maintains the aerodynamic efficiency of the wings and provides sufficient stiffness and strength. Additionally, considerations for safety, cost, and other objectives are also taken into account [15]. Tensile strength (Mpa): Tensile strength is measured in pounds per square inch (psi) or megapascals (MPa) and represents the force required to pull a specimen until the material fails. Ultimate tensile strength, also referred to as tensile strength or tensile, denotes the force at which the material undergoes rupture [16]. Young's modulus (GPa): A measure of the stiffness of an elastic material It is called tensile modulus Mostly Young's modulus or elasticity called modulus. wires, Elastic like rods and columns How materials are tensioned or compressed This is to describe what works under is used The ratio of stress along an axis (force per unit area) to strain (start ratio of deformation over length) tensile called modulus [17].Compressive strength (MPa): A certain amount (1% or 10% transformation etc) before or to decompose A plastic model in front is the biggest one can bear Compressive strength is called as compressive strength. When a breakdown occurs A certain value of compressive strength contains, but by broken fractures This is for non-failing polymers Arbitrary and by degree of distortion is determined [18].Creep resistance: For structural materials with possible high temperature uses, such as in aircraft gas turbines and spacecraft airframes, creep resistance is a crucial quality to consider. According to a review of the literature, adding ceramic reinforcements to the matrix alters both the creep resistance and the creep mechanism, which in turn affects the creep behaviour in a complex way [19]. Density (Mg/m3): Along with the elastic modulus, material density is crucial for the structural effectiveness of aero planes and spacecraft. The aerospace industries are using titanium alloys increasingly frequently as a result of their low density and strong strengths, particularly at high temperatures. Low density, moderate cost, great corrosion resistance, and high ductility are just a few of the characteristics that make polymers suitable for use as aviation materials (except thermosets) [20].

3. RESULTS AND DISCUSSION

TABLE 1. Performance rating matrix

	Tensile strength (Mpa)	Young's modulus (GPa)	Compressive strength (Mpa)	Creep resistance	Density (Mg/m3)	Price (₹/kg)
Al 7075-T6	572	71.7	572	4	3	600
Al 2024-T4	423.84	72.486	423.84	4	2.6	291.92
Ti–6Al–4V	950	113.8	950	5	4.43	2000
Ti–2Fe–3Al	1310	120	1310	5	4.5	3000
S-glass70%-Epoxy cont. fibers	2098.57	62.967	2098.57	3	2.11	990
S-glass70%-Epoxy fabric	678.68	21.896	678.68	3	2.11	880
Carbon 63%-Epoxy	1722.85	157.685	1722.85	3	1.61	4424
Aramid 62%-Epoxy	1308.67	82.689	1308.67	3	1.38	2400
E-glass73%-Epoxy	1641.58	55.967	1641.58	3	2.17	412
E-glass56%-Epoxy	1026.98	42.786	1026.98	2	1.97	430
E-glass65%-Polyester	338.97	19.567	338.97	2	1.8	420

Table 1 presents the dataset of performance ratings for materials used in the spar of a Human Powered Aircraft. The alternatives considered in this analysis are Al 7075-T6, Al 2024-T4, Ti–6Al–4V, Ti–2Fe–3Al, S-glass 70% Epoxy continuous fibers, S-glass 70% Epoxy fabric, Carbon 63% Epoxy, Aramid 62% Epoxy, E-glass 73%-Epoxy, E-glass 56% Epoxy, and E-glass 65% Polyester. The evaluation parameters used in this analysis include Tensile strength (Mpa), Young's modulus (GPa), Compressive strength (Mpa), Creep resistance, Density (Mg/m3), and Price (₹/kg).

FIGURE 1. Performance ratings

Figure 1 illustrates the graphical representation of the performance ratings of the materials used. The available substitutes in the analysis are Al 7075-T6, Al 2024-T4, Ti-6Al-4V, and Ti-2Fe-3Al. The other materials evaluated include Carbon 63% Epoxy, Aramid 62% Epoxy, S-glass 70% Epoxy continuous fibers, S-glass 70% Epoxy fabric, E-glass 65% Polyester, E-glass 73% Epoxy, and E-glass 56% Epoxy.

TABLE 2. Normalized Data

Al 7075-T6	80.4613	1.2643	80.4613	0.0039	0.0022	88.5314
Al 2024-T4	44.1773	1.2921	44.1773	0.0039	0.0017	20.9567
Ti–6Al–4V	221.9433	3.1848	221.9433	0.0061	0.0048	983.6823
Ti–2Fe–3Al	422.0243	3.5413	422.0243	0.0061	0.0050	2213.2853
S-glass70%-Epoxy cont. fibers	1083.0333	0.9750	1083.0333	0.0022	0.0011	241.0268
S-glass70%-Epoxy fabric	113.2726	0.1179	113.2726	0.0022	0.0011	190.4409
Carbon 63%-Epoxy	729.9445	6.1147	729.9445	0.0022	0.0006	4813.1026
Aramid 62%-Epoxy	421.1678	1.6815	421.1678	0.0022	0.0005	1416.5026
E-glass73%-Epoxy	662.7031	0.7703	662.7031	0.0022	0.0012	41.7435
E-glass56%-Epoxy	259.3695	0.4502	259.3695	0.0010	0.0010	45.4707
E-glass65%-Polyester	28.2564	0.0942	28.2564	0.0010	0.0008	43.3804

Table 2 showcases the normalized matrix of Performance Ratings of Materials Used in the Spar of a Human Powered Aircraft. The normalization process was carried out using Equation three.

TABLE 3. Weight

Al 7075-T6	0.17	0.17	0.17	0.17	0.16	0.16
Al 2024-T4	0.17	0.17	0.17	0.17	0.16	0.16
Ti–6Al–4V	0.17	0.17	0.17	0.17	0.16	0.16
Ti–2Fe–3Al	0.17	0.17	0.17	0.17	0.16	0.16
S-glass70%-Epoxy cont. fibers	0.17	0.17	0.17	0.17	0.16	0.16
S-glass70%-Epoxy fabric	0.17	0.17	0.17	0.17	0.16	0.16
Carbon 63%-Epoxy	0.17	0.17	0.17	0.17	0.16	0.16
Aramid 62%-Epoxy	0.17	0.17	0.17	0.17	0.16	0.16
E-glass73%-Epoxy	0.17	0.17	0.17	0.17	0.16	0.16
E-glass56%-Epoxy	0.17	0.17	0.17	0.17	0.16	0.16
E-glass65%-Polyester	0.17	0.17	0.17	0.17	0.16	0.16

The preferred weight for the evaluation parameters is shown in Table 3. In this case, 0.17 kg and 0.16 is used.

TABLE 4. Weighted normalized decision matrix

Al 7075-T6	13.67841773	0.214922615	13.67841773	0.000668904	0.000354126	14.16502571
Al 2024-T4	7.510134019	0.219660554	7.510134019	0.000668904	0.000265988	3.353069592
Ti–6Al–4V	37.7303658	0.541412563	37.7303658	0.001045162	0.000772187	157.3891746
Ti–2Fe–3Al	71.7441338	0.602013593	71.7441338	0.001045162	0.000796783	354.1256429
S-glass70%-Epoxy cont. fibers	184.1156585	0.165756211	184.1156585	0.000376258	0.000175178	38.56428251
S-glass70%-Epoxy fabric	19.25634719	0.020043491	19.25634719	0.000376258	0.000175178	30.4705442
Carbon 63%-Epoxy	124.0905586	1.039500183	124.0905586	0.000376258	0.000101992	770.0964175
Aramid 62%-Epoxy	71.59852882	0.285850716	71.59852882	0.000376258	7.4933E-05	226.6404114
E-glass73%-Epoxy	112.6595234	0.130950711	112.6595234	0.000376258	0.000185282	6.678967013
E-glass56%-Epoxy	44.09281002	0.076532725	44.09281002	0.000167226	0.000152703	7.275314596
E-glass65%-Polyester	4.803594423	0.016006349	4.803594423	0.000167226	0.000127485	6.9408626

Table 4 shows the N_{ij} and it is calculated by table 2 and table 3 using equation 4.

TABLE 5. Positive Matrix

	Positive Matrix					
Al 7075-T6	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
Al 2024-T4	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
Ti–6Al–4V	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
Ti–2Fe–3Al	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
S-glass70%-Epoxy cont. fibers	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
S-glass70%-Epoxy fabric	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
Carbon 63%-Epoxy	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
Aramid 62%-Epoxy	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
E-glass73%-Epoxy	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
E-glass56%-Epoxy	184.1	1.0395	184.11566	0.001045	0.0008	770.0964
E-glass65%-Polyester	184.1	1.0395	184.11566	0.001045	0.0008	770.0964

Table 5 shows the positive matrix calculated by using table 4. The ideal best for a column is the maximum value of that column in table 4.

TABLE 6. Negative matrix

	Negative matrix					
Al 7075-T6	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
Al 2024-T4	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
Ti–6Al–4V	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
Ti–2Fe–3Al	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
S-glass70%-Epoxy cont. fibers	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
S-glass70%-Epoxy fabric	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
Carbon 63%-Epoxy	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
Aramid 62%-Epoxy	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
E-glass73%-Epoxy	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
E-glass56%-Epoxy	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307
E-glass65%-Polyester	4.803594	0.016006	4.803594	0.000167	7.4933E-05	3.35307

Table 6 shows the negative matrix calculated by using table 4. The Ideal best for a column is the minimum value in that column in table 4.

TABLE 7. SI Plus and Si negative

Materials	**Si plus**	**Si minus**
Al 7075-T6	793.4297	16.56692
Al 2024-T4	806.3963	3.833039
Ti–6Al–4V	646.7362	160.9215
Ti–2Fe–3Al	445.2938	363.3233
S-glass70%-Epoxy cont. fibers	731.5327	256.0185
S-glass70%-Epoxy fabric	775.5028	33.95764
Carbon 63%-Epoxy	84.88831	785.0829
Aramid 62%-Epoxy	566.2731	242.4468
E-glass73%-Epoxy	770.0773	152.5676
E-glass56%-Epoxy	788.1052	55.70164
E-glass65%-Polyester	804.1847	3.587793

Table 7 shows the Si plus and Si negative values. difference of each response from the ideal best (S_i^+) is calculated using equation 5 and the difference of each response from the ideal worst (S_i^-) is calculated using equation 6.

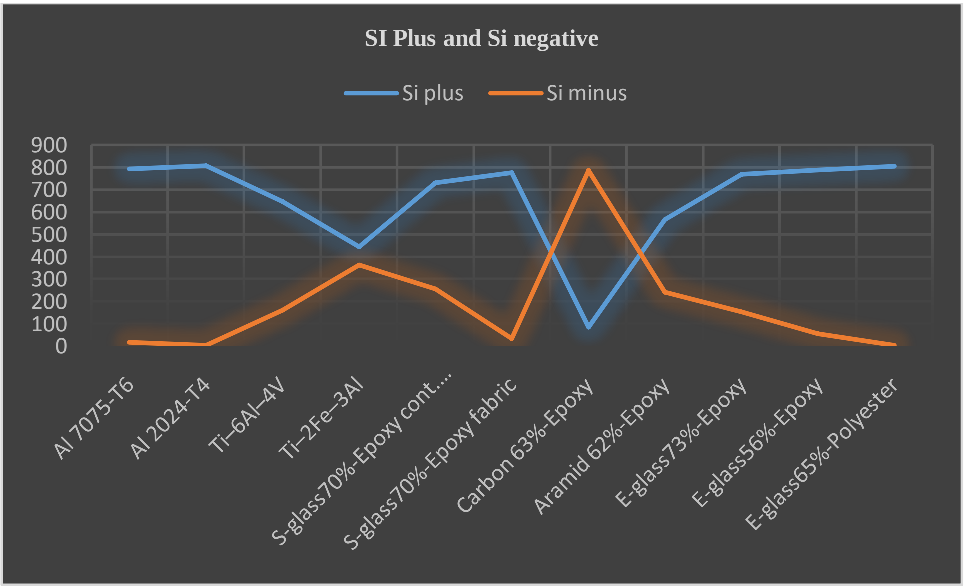

FIGURE 2. SI Plus and Si negative

Figure 2 depicts the graphical representation of the Si plus (S_i^+) and Si negative (S_i^-) values. The difference of each response from the ideal best is calculated using Equation 5, and the difference of each response from the ideal worst is calculated using Equation 6.

TABLE 8. Closeness coefficient

Materials	CCi
Al 7075-T6	0.020453
Al 2024-T4	0.004731
Ti–6Al–4V	0.199245
Ti–2Fe–3Al	0.449314
S-glass70%-Epoxy cont. fibers	0.259246
S-glass70%-Epoxy fabric	0.041951
Carbon 63%-Epoxy	0.902424
Aramid 62%-Epoxy	0.299791
E-glass73%-Epoxy	0.165359
E-glass56%-Epoxy	0.066012
E-glass65%-Polyester	0.004442

The proximity coefficient values of the alternatives are displayed in Table 8. Equation 7 is employed in the calculation. Here Closeness coefficient value for Al 7075-T6 is 0.020453, Al 2024-T4 is 0.004731, Ti–6Al–4V is 0.199245, Ti–2Fe–3Al is 0.449314, S-glass 70% Epoxy cont. fibers is 0.259246, S-glass 70% Epoxy fabric is 0.041951, Carbon 63% Epoxy is 0.902424, Aramid 62% Epoxy is 0.299791, E-glass73%-Epoxy is 0.165359, E-glass 56% Epoxy is 0.066012, and for E-glass 65% Polyester is 0.004442.

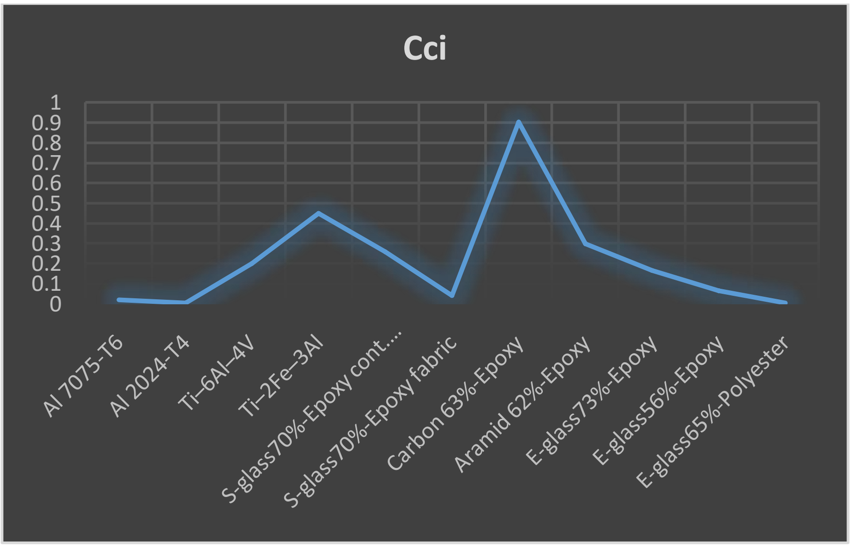

FIGURE 3. Closeness Coefficient (CCi)

Figure 3 illustrates the graphical representation of CCi. It is calculated by using equation 7. Here Closeness coefficient value for Al 7075-T6 is 0.020453, Al 2024-T4 is 0.004731, Ti–6Al–4V is 0.199245, Ti–2Fe–3Al is 0.449314, S-glass 70% Epoxy cont. fibers is 0.259246, S-glass 70% Epoxy fabric is 0.041951, Carbon 63% Epoxy is 0.902424, Aramid 62% Epoxy is 0.299791, E-glass73%-Epoxy is 0.165359, E-glass 56% Epoxy is 0.066012, and for E-glass 65% Polyester is 0.004442.

TABLE 9. Rank

Materials	Rank
Al 7075-T6	9
Al 2024-T4	10
Ti–6Al–4V	5
Ti–2Fe–3Al	2
S-glass70%-Epoxy cont. fibers	4
S-glass70%-Epoxy fabric	8
Carbon 63%-Epoxy	1
Aramid 62%-Epoxy	3
E-glass73%-Epoxy	6
E-glass56%-Epoxy	7
E-glass65%-Polyester	11

Table 9 shows the rank of alternatives Al 7075-T6, Al 2024-T4, Ti–6Al–4V, Ti–2Fe–3Al, S-glass 70% Epoxy cont. fibers, S-glass 70% Epoxy fabric, Carbon 63% Epoxy, Aramid 62% Epoxy, E-glass73%-Epoxy, E-glass 56% Epoxy, E-glass 65% Polyester using utility degree values in table 6. Here rank of alternatives using TOPSIS method for Al 7075-T6 is rank nine, Al 2024-T4 is tenth rank, Ti–6Al–4V is fifth ranked, Ti–2Fe–3Al is ranked second, S-glass 70% Epoxy cont. fibers is rank fourth, S-glass 70% Epoxy fabric is eight ranked, Carbon 63% Epoxy is first, Aramid 62% Epoxy is third, E-glass73%-Epoxy is sixth, E-glass 56% Epoxy is seventh, and for E-glass 65% Polyester is eleventh.

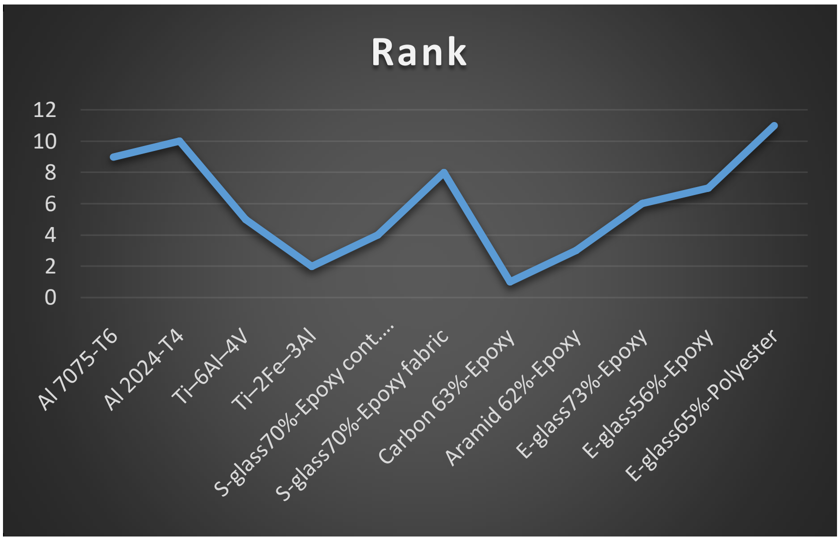

FIGURE 4. Rank

The ranking indicates that Carbon 63% Epoxy is the most suitable material for the Spar due to its superior performance in the evaluated criteria, while E-glass 65% Polyester ranks last among the considered alternatives. This information aids in making an informed decision for the Spar material selection, considering the specific requirements and objectives of the Human Powered Aircraft project.

4. CONCLUSION

Due to the growing adoption of this adaptable material by manufacturers across numerous industries, the use of composite materials has increased in recent years. In sectors including aircraft, automotive, construction, and sporting goods, among others, composites are beginning to be widely employed. This substantial rise is caused by the superior qualities that these materials demonstrate in comparison to the conventional ones. The ability to produce products with greater tensile strength, less weight, excellent corrosion resistance, improved surface polish, and ease of processing have been key drivers. Particularly in the aerospace industry, composite materials have a lot of potential because of their superior strength-to-weight ratio, which results in reduced weight and fuel consumption as well as corrosion resistance. A specialized field within aerospace engineering focuses on studying aircraft with exceptional energy efficiency, capable of being propelled into the air and sustained for extended periods solely by human power, without relying on external or stored energy sources. These aircraft are commonly known as human-powered airplanes (HPA). While aviation has seen remarkable progress in the last century, with achievements such as the first flight of a heavier-than-air vehicle, the development of fast transcontinental flights, and supersonic planes, human-powered airplanes present a unique and challenging category of aircraft due to their inherent power limitations. In order to preserve the aerodynamic effectiveness of the wings, HPA's spar must be as light as it can be while still being sufficiently rigid. Every step of the design process requires the use of judgement by the designer. Researchers have suggested and applied a variety of materials selection techniques, most of which were based on the quantitative and qualitative characteristics of the materials. The TOPSIS approach was utilized in this analysis. The analysis's findings indicate that Carbon 63%-Epoxy, Ti–2Fe–3Al, Aramid 62%-Epoxy, S-glass70%-Epoxy cont. fibers are the optimum materials for human-powered aircraft spars.

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