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Assessment of Ranking of Aluminum-Coconut Shell Ash Composites Using EDAS Method

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Abstract: *To overcome the difficulty in manufacturing through tools and materials, the present situation calls for the creation of engineering materials to address numerous specific difficulties. Due to attainable qualities that are notable for the components involved, "Metal Matrix Composites (MMCs)" are profitable.* Research significance: *AMCs are used because of their low density in comparison to aluminium alloys and their interfacial behavior. Due to their outstanding castability and significant erosion protection, AMCs have been effectively repressed in modern automotive production for the "fabrication of various segments, including cylinders, motor lids, connecting shafts, and independent casts". Research method: The complexity in the evaluation of material assemblage is well-suited to the "multi-criteria decision-making (MCDM)" methodologies. This study ranks "aluminium-coconut shell ash (CSA) composites" using the "EDAS technique", a comparatively fresh and mathematically sophisticated "MCDM (Multi-Criteria Decision Making)" tool. Result: The result obtained by using the EDAS method shows that the rank for 1100 aluminium alloy is fifth, aluminium composite with 5% is fourth, aluminium composite with 10% is second, aluminium composite with 15% is first and aluminium composite with 20% is third.Conclusion: The article's findings indicate that among all materials taken in this research, "aluminium composite with 15% CSA" emerged as the best, followed by "aluminium composite with 10% CSA", whilst the base matrix was discovered to be the material that worked the worst in this investigation.*
Keywords: *Aluminium composites, Coconut shell ash, wear rate, coefficient of friction, hardness, tensile strength and MCDM.*

1. INTRODUCTION

Through an effort to overcome the difficulty in manufacturing through tools and materials, the present situation calls for the creation of engineering materials to address numerous specific difficulties. Due to attainable qualities that are noteworthy for the components involved, Metal Matrix Composites (MMCs) are profitable. There are a lot of metallic alloys used in industry, and new compositions are being tested to fulfil the demands of various industries as they diversify [1]. In addition, despite the abundance of alloys, "aluminium alloy" is widely used in technological and industrial settings thanks to its "high strength-to-weight ratio, high specific modulus, and excellent wear resistance". In particular, "Aluminium Metal Matrix Composites (AMC)" was successfully utilized in a small number of "industrial applications", including "aerospace, automotive, defence, and electronic packaging" [2,3]. The fundamental step in the mechanical planning process is "material selection". The choice of material is not taken into consideration while designing the components, which could lead to structure failure, degradation, or inferior performance. Therefore, engineers must be precise in their material selection to produce the required output at a reasonable cost [4,5]. Since aluminium has a low density, it is employed for the composite. It can get stronger as a result of the crystallization process. It boasts higher thermal and electrical conductivity as well as good "corrosion resistance". It can dampen quite well. " Low density and high specific mechanical" qualities characterize the aluminium matrix. [6,7]. Lighter-weight parts for a variety of vehicles are manufactured using an aluminium matrix. The aluminium matrix is as strong and resistant to wear as iron metal. Compared to iron metal, "it has 67% less density and 3 times the thermal conductivity" [8]. As a reinforcing material, coconut shell ash—an agricultural waste that is readily accessible and reasonably priced for the creation of AMCs—is used in this work. The high lignin content of coconut shells contributes to the material's great qualities, which include improved corrosion resistance and weather resistance. " Coconut shell is preferred for the production of activated carbon black" due to its superior structural alignment and low percentage of ash [9,10]. "Aluminum-coconut shell ash (CSA) composites" with varied CSA volume fractions (5, 10, 15, and 20%) are alternative factors that are being researched. Throughout the process of choosing criteria, the target-based characteristics of the manufactured composites are taken into account. These characteristics include "density (physical characteristic), hardness, tensile strength, toughness (mechanical characteristics), wear rate, and coefficient of friction (tribological properties)".

2. MATERIALS AND METHODS

In the availability of a collection of evaluation criteria, the "MCDM procedures" primarily assist in the determination of the preferred solution or action to be taken. They can be used effectively to identify the ideal set of various process parameters that will result in the achievement of the most required product qualities in the manufacturing and machining industries [11,12]. They can serve as "multi-objective optimization tools" in this direction, with the relevant process attributes inherently conflicting—serving as the assessment methods and the various experimental trials made up of various mixtures of process conditions treated as suitable alternatives [13,14]. "Based on positive and negative distances from the average answer", the "EDAS approach" ranks the available solutions. " Positive and negative distances" were measured and estimated based on some useful and unhelpful criteria. It is thought desirable to choose the alternative with a "higher PDA (positive distance from average) or smaller NDA (negative distance from the average) score" [15,16]

- "The decision matrix X" is created.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ x_{31} & x_{32} & \cdots & x_{3n} \end{bmatrix} \quad (1)$$

- "Weights for the criterions" are expressed in equation 2.

$$w_j = [w_1 \quad \cdots \quad w_n], \text{ where } \sum_{j=1}^{n}(w_1 \quad \cdots \quad w_n) = 1 \quad (2)$$

- Next criteria vice average solutions are calculated

$$AV_j = \frac{\sum_{j=1}^{n} k_{ij}}{n} \quad (3)$$

- "PDA" is expressed in equation 4

$$PDA_{ij} = \begin{cases} \frac{\max(0,(x_{ij}-AV_{ij})}{AV_{ij}} & \mid j \in B \\ \frac{\max(0,(AV_{ij}-x_{ij})}{AV_{ij}} & \mid j \in C \end{cases} \quad (4)$$

- The "NDA" is expressed in equation 5

$$NDA_{ij} = \begin{cases} \frac{\max(0,(AV_{ij}-x_{ij})}{AV_{ij}} & \mid j \in B \\ \frac{\max(0,(x_{ij}-AV_{ij})}{AV_{ij}} & \mid j \in C \end{cases} \quad (5)$$

- Using equation 2 multiplied by factors 4 and 5, respectively, the "weighted sum of the positive and negative distances from the average solution" for all options is normalized.
- "Weighted sums of the positive and the negative distance" are calculated by the equation

$$SP_i = \sum_{j=1}^{m} w_j \times PDA_{ij} \quad (6)$$

$$SN_i = \sum_{j=1}^{m} w_j \times NDA_{ij} \quad (7)$$

- Equations 8 and 9 are used to normalize the "weighted sum of the positive and negative distances from the average solution for all alternatives".

$$NSP_i = \frac{SP_i}{max_i(SP_i)} \quad (8)$$

$$NSN_i = 1 - \frac{SN_i}{max_i(SN_i)} \quad (9)$$

- The "final appraisal score (ASi)" for each alternative is calculated as the "normalized weighted average of the positive and negative distances from the average solution" for all alternatives.

$$AS_i = \frac{(NSP_i + NSN_i)}{2} \quad (10)$$

where 0 ≤ ASi ≤ 1. The alternative with the highest appraisal score is selected as the best choice among the other selective alternatives [16].

"Aluminum-coconut shell ash (CSA) composites" with varied CSA volume fractions (5, 10, 15, and 20%) are alternative factors that are being researched. Throughout the process of choosing criteria, the target-based characteristics of the manufactured composites are taken into account. These characteristics include "density (physical characteristic), hardness, tensile strength, toughness (mechanical characteristics), wear rate, and coefficient of friction (tribological properties)". **Density:** The "density of a material" is one of its most important physical properties. The term "mass per unit volume" refers to a material's density. A "ratio of material mass to volume" is how it is defined. Its symbols are "P." The "KG/m3" unit is used in the SI system. Density plays a key role in many equations since most designs are limited through either "size or weight". **Hardness:** An estimate of the plastic distortion that a material may experience as a result of external stress is the idea of hardness. Particle strengthening (such as graphite or silica) boosted the material's hardness by increasing its "resistance to plastic deformation". **Tensile Strength:** The "volume and strength of the fibre reinforcement" play a major role in determining the "longitudinal tensile strength of composite materials". The fibres decide the composite's maximum strength since their "breaking strength is substantially higher than the strength of the polymer matrix". **Toughness:** The straining of fibres out of respective slots in the matrix upon crack progression is the primary energy-absorbing phenomenon increasing the toughness of composite materials. " Interfacial debonding and fibre fracture away from the crack plane" must first occur before this is permitted to happen. Wear Rate: The quantity of material lost per unit of time is known as the wear rate. To comprehend the function and lifespan of any mechanical component, this variable is one of the material's fundamental features. **Coefficient Of** Friction: "The ratio of friction force to normal force" is known as the "coefficient of friction (COF)", which has no dimensions. Those materials are said to as lubricous if their COF is less than 0.1. " Surface roughness and COF" are dependent on the composition of the polymers.

3. ANALYSIS AND DISCUSSION

TABLE 1. Properties of Al-CSA composites

Composites	MC1	MC2	MC3	MC4	MC5	MC6
Al-1100	28.30	104.00	17.10	2.72	4.07	0.41
Al-5% CSA	31.40	128.00	19.13	2.66	3.76	0.31
Al-10% CSA	40.95	157.00	23.91	2.60	3.12	0.26
Al-15% CSA	51.33	174.00	26.92	2.47	2.44	0.29
Al-20% CSA	42.80	151.00	21.12	2.40	2.69	0.39

Table 1 shows the properties of Al-CSA composites with CSA percentages of 5, 10, 15 and 20. The alternatives considered are "density (MC1), wear rate (MC2), coefficient of friction (MC3), hardness (MC4), tensile strength (MC5) and toughness (MC6)".

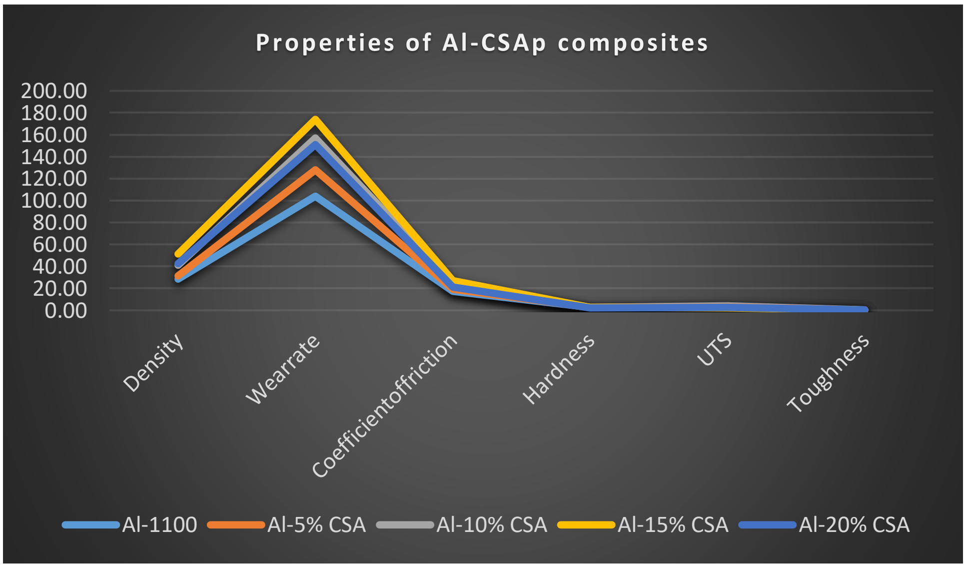

FIGURE 1. Properties of Al-CSA composites

Figure 1 shows the properties of "Al-CSA composites with CSA percentages of 5, 10, 15 and 20". The alternatives considered are density, hardness, tensile strength, toughness, wear rate, and coefficient of friction.

TABLE 2. PDA

0	0	0	0.209651	0	0
0	0	0	0.115825	0	0.068716
0.051186	0.09944	0.105103	0	0.028685	0.207354
0.31764	0.218487	0.244223	0	0.24118	0.119952
0.098675	0.057423	0	0.023849	0.1634	0

Table 2 displays the PDA. It is calculated using equation 4.

TABLE 3. NDA

0.273539	0.271709	0.209651	0.058366	0.265012	0.235684
0.193962	0.103641	0.115825	0.035019	0.168253	0
0	0	0	0.011673	0	0
0	0	0	0	0	0
0	0	0.023849	0	0	0.160338

Table 3 displays the NDA. It is calculated using equation 4.

TABLE 4. Weight

0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667
0.1667	0.1667	0.1667	0.1667	0.1667	0.1667

Table 4 shows the weights distributed to the alternatives. The alternatives considered are density, hardness, tensile strength, toughness, wear rate, and coefficient of friction. The sum of weight distributed among the evaluation parameters is one.

TABLE 5. Weighted PDA

Weighted PDA						SPi
0	0	0	0.034942	0	0	0.0349
0	0	0	0.019304	0	0.011453	0.0308
0.008531	0.016573	0.017517	0	0.004781	0.034559	0.0820
0.05294	0.036415	0.040704	0	0.040197	0.019992	0.1902
0.016446	0.00957	0	0.003975	0.027233	0	0.0572

Table 5 shows the data values of the Weighted Positive Distance from the Average and the sum of the Weighted Positive Distance from the Average. It is calculated using equation 6.

TABLE 6. Weighted NDA

Weighted NDA						SNi
0.04559	0.045285	0.034942	0.009728	0.044169	0.039281	0.2190
0.032327	0.017274	0.019304	0.005837	0.028042	0	0.1028
0	0	0	0.001946	0	0	0.0019
0	0	0	0	0	0	0.0000
0	0	0.003975	0	0	0.026723	0.0307

Table 6 shows the data values of "Weighted Negative Distance from Average and the sum of Weighted Negative Distance from Average". Equation 7 is used to calculate SNi.

TABLE 7. NSPi and NSNi value

Composites	NSPi	NSPi
Al-1100	0.1837	0
Al-5% CSA	0.1617	0.5307
Al-10% CSA	0.4308	0.9911
Al-15% CSA	1	1
Al-20% CSA	0.3008	0.8598

Table 7 shows values of NSPi and NSNi values calculated from Tables 5 and 6 respectively. It is calculated using equations 8 and 9.

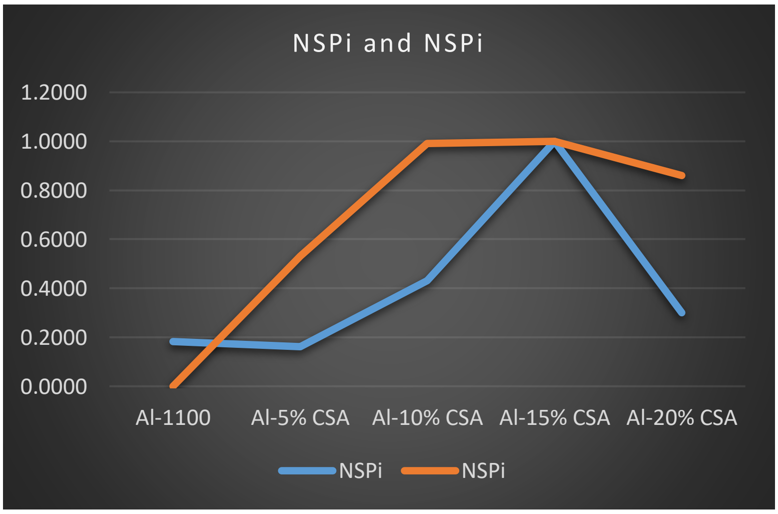

FIGURE 2. NSPi and NSNi value

Figure 2 Show the above picture shows a graphical representation of values of NSPi and NSNi values calculated from Tables 5 and 6 respectively. It is calculated using equations 8 and 9.

TABLE 8. ASi

Composites	ASi
Al-1100	0.0918
Al-5% CSA	0.3462
Al-10% CSA	0.7110
Al-15% CSA	1
Al-20% CSA	0.5803

Table 8 shows the final appraisal score of Aluminum-coconut shell ash (CSA) composites calculated by using equations 8,9 and 10. Here final appraisal score of 1100 aluminium alloy is 0.0918, aluminium composite with 5% CSA is 0.3462, aluminium composite with 10% CSA is 0.7110, aluminium composite with 15% CSA is 1 and aluminium composite with 20% CSA is 0.5803.

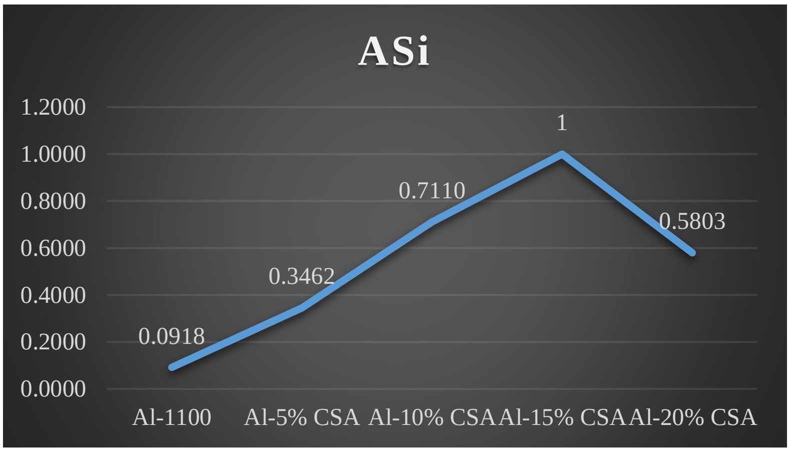

FIGURE 3. final appraisal score of

Figure 3 illustrates the final appraisal score of "Aluminum-coconut shell ash (CSA) composites" calculated by using equations 8,9 and 10. Here final appraisal score of 1100 aluminium alloy is 0.0918, aluminium composite with 5% CSA is 0.3462, aluminium composite with 10% CSA is 0.7110, aluminium composite with 15% CSA is 1 and aluminium composite with 20% CSA is 0.5803.

TABLE 8. Rank

Composites	Rank
Al-1100	5
Al-5% CSA	4
Al-10% CSA	2
Al-15% CSA	1
Al-20% CSA	3

Table 9 shows the final rank of alternative robots calculated by using equations 8,9 and 10. Here rank obtained by using the EDAS method for 1100 aluminium alloy is fifth, aluminium composite with 5% CSA is fourth, aluminium composite with 10% CSA is second, aluminium composite with 15% CSA is first and aluminium composite with 20% CSA is third.

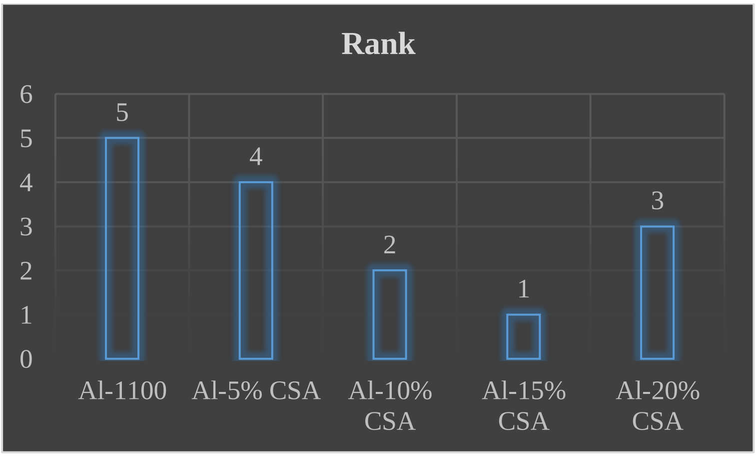

TABLE 4. Rank

Graph 4 shows the final rank of alternative robots calculated by using equations 8,9 and 10. Here rank obtained by using the EDAS method for 1100 aluminium alloy is fifth, aluminium composite with 5% CSA is fourth, aluminium composite with 10% CSA is second, aluminium composite with 15% CSA is first and aluminium composite with 20% CSA is third. The article's findings indicate that among all materials taken in this research, "aluminium composite with 15% CSA" emerged as the best, followed by "aluminium composite with 10% CSA", whilst the base matrix was discovered to be the material that worked the worst in this investigation.

4. CONCLUSION

Given the extensive property of both intrinsic and extrinsic impact of ceramic conditioning with "physical, tribological, and thermo-mechanical properties, aluminium metal matrix composites" (AMC) have been widely used in transportation, structures, and "applications of defence, aerospace, and sports". Typically, two significant components, such as "reinforcement and matrix", are combined to create composites. As a result, AMC can be created by combining soft particles like graphite, mica, talc, and boric acid with a variety of hard ceramics including "SiC, Al2O3, and TiO2", which have greater qualities than their alloys. The complexity in the evaluation of material assemblage is well-suited to the "multi-criteria decision-making (MCDM)" methodologies. In this study, the EDAS method, an MCDM tool, was used. The results of this analysis show that "aluminium composite with 15% CSA"—which has a "hardness value of 51.33, a density of 2.47 g/cc, a tensile strength of 174 N/mm^2, a toughness of 26.92 J, a wear rate of 2.44 mm^3/m, and a coefficient of friction of 0.29"—is the best alternative. The article's findings indicate that among all materials taken in this research, "aluminium composite with 15% CSA" emerged as the best, followed by "aluminium composite with 10% CSA", whilst the base matrix was discovered to be the material that worked the worst in this investigation.

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