REST Journal on Advances in Mechanical Engineering
Vol: 3(2), June 2024
REST Publisher; ISSN: 2583-4800 (Online)
Website: https://restpublisher.com/journals/jame/
DOI: https://doi.org/10.46632/jame/3/2/1

Evaluation of Material Selection for Automotive Piston Component using Weighted Sum (WSM) Method

*** Chandrasekar Raja, Manjula Selvam, M. Ramachandran, Vimala Saravanan,**
REST Labs, Kaveripattinam, Krishnagiri, Tamil Nadu, India.
*Corresponding Author Email: chandrasekarrajarsri@gmail.com

Abstract: *When choosing a material for automobile piston components, be sure to choose one that satisfies all necessary specifications, like durability, resistance to temperature, and wear resistance. To achieve maximum efficiency and effectiveness, factors including cost, weight, and production procedures are also taken into account. Aluminium alloys that are forged iron, and steel are common material for piston components; each has certain benefits and compromises in terms of expense and efficiency. Introduction: Material selection for auto piston components is critical to ensuring top performance and long-term durability. The piston, as a vital engine component subjected to high temperatures, hardship, and wear and tear, necessitates a material that promotes efficient combustion, lowers friction, and maintains its structural integrity. When selecting materials for automobile pistons such as aluminium alloys, wrought iron, or steel, aspects such as heat conductivity, resistance to wear, size, expense, and manufacturing capability are carefully considered to satisfy the specific needs of the application. Research Significance: Aluminum, steel, along with iron are the better frequently used goods for pistons. The effort from the expanding gas at great heat matters about the inside. Cylinder and many other important factors determine proper piston selection Material necessity are balanced more demanding, just as no single material meets all the properties required for a distinct application. Method: The weighted sum method is a decision-making approach that involves assigning weights to different criteria or objectives and combining them to make an overall assessment. It allows decision-makers to prioritize and balance various factors based on their relative importance. By utilizing this method, complex decision problems can be simplified and converted into a single weighted score, facilitating a clearer understanding of trade-offs and aiding in the decision-making process. Alternate Parameters: "LM-26 alloy + 0% Porcelain, LM-26 alloy + 2% Porcelain, LM-26 alloy +4% in weight Porcelain, LM-26 alloy +6 percent by weight porcelain, and LM-26 alloy +8 percentage of weight Porcelain". Evaluation Parameters: Hardness, Compressive strength ,Tensile strength ,Specific wear rate , and Friction coefficient Result: "LM-26 alloy +6 wt.% Porcelain" is in the 1st Rank, "LM-26 alloy +4 wt.% Porcelain" in the 2nd Rank, "LM-26 alloy +2 wt.% Porcelain" in the 3rd Rank, "LM-26 alloy +8 wt.% Porcelain" in the 4rth Rank, and "LM-26 alloy +0 wt.% Porcelain in the 5th Rank". Conclusion: For the Material Selection for Automotive Piston Component : "LM-26 alloy +6 wt.% Porcelain" is in the 1st Rank, "LM-26 alloy +4 wt.% Porcelain" in the 2nd Rank, "LM-26 alloy +2 wt.% Porcelain" in the 3rd Rank, "LM-26 alloy +8 wt.% Porcelain" in the 4rth Rank, and "LM-26 alloy +0 wt.% Porcelain in the 5th Rank".*

Keywords: *MCDM, "LM-26 alloy + 0% Porcelain, LM-26 alloy + 2% Porcelain, and LM-26 alloy +4% in weight Porcelain".*

1. INTRODUCTION

The piston plays a crucial role in an engine cylinder, and intense competition among manufacturers drives them to investigate the optimal material for pistons. Various factors, including the pressure exerted by hot gases and other critical considerations, make the choice of piston material particularly challenging. This is because no single material can fully satisfy all the necessary requirements for a specific application. This study assesses the performance of eight potential piston materials using eight selection criteria[1]. Knowledge base objects that are related by an object hierarchy. Constraint variables that each component is expressed as slots. The knowledge-based system has the capacity to rank materials according to component properties and select the best material. Users can choose the most effective materials via taking into account a number of constraint values [2].A thorough analysis of the development of composites that are hybrid in automotive applications is conducted, focusing on areas like the use of automotive pistons, the development of medium-duty automotive brake contact materials, the design of eco-friendly automotive products anti-roll bars, and the evaluation of the response of mixed carbon/glass fiber-reinforced composites made of polymers to low-velocity impacts. An extensive study of these changes is given in the review [3].The pistons are subjected to high thermal stress because of the substantial temperature disparity among the head of the piston and their cooling galleries. During piston reciprocation, cyclical pressure of gas and inertial forces generate a mechanical burden on the piston. The combination of heat and fatigue from mechanical loads can cause pistons side use, head splits, and other serious problems. Manufacturers are devoting significant effort and resources to addressing these issues. This research analyses several piston materials while taking into account different thermodynamic and structural conditions in order to optimize piston designs and mitigate these issues [4]. Titanium's favorable features, such as its high toughness-to-density ratio, resistance to fatigue, and ability to sustain power at high temperatures, are able to successfully reduce the overall weight of piston engine components such are linking rods of steel, pistons that rotate, and piston pins. Titanium has been proven to work well in various engine components including engines controls, valve retainer agreements, and valve spring. The reduction in bulk of those engine components has the added benefit of lowering friction, which leads to increased engine efficiency [5]. The technique of squeeze casting originated at the Illinois Institute of Technology Research Institute (IITRI) in the early 1970s in the United States. Initially, its application in the automotive industry focused on enhancing the performance of pistons, wheels, hubs, and other components, rather than primarily aiming for significant weight reduction. These applications aimed to improve performance compared to conventionally cast components or to substitute forged parts[6].There is currently a considerable focus on the development of piston designs utilizing composite materials such as graphite/carbon fiber or carbon/carbon fiber composites. These materials feature a matrix of graphite or carbon reinforced by carbon fibers. Typically, the reinforcement occurs in four directions, resulting in the material possessing isotropic mechanical properties at the macro scale. The primary benefit of these materials lies in their ability to combine low density with high strength[7].It is essential to reassess the strategy aimed at promoting the use of Metal Matrix Composites (MMCs) in domestic automotive applications. While the initial research and groundwork originated in the United States, it was Japanese companies that achieved notable progress in incorporating aluminum-based composites. Notable examples of such advancements are Toyota's introduction of pistons in 1983 and Honda Prelude's implementation of cylinder liners in 1990[8].Notably, the creation of an engine piston using Al7075 has been successful, showcasing strength comparable to various steel materials. Additionally, it possesses favorable fatigue strength and satisfactory machinability. Through fatigue analysis, the piston has demonstrated a significantly extended lifespan, enduring a load of 10,000 cycles. Furthermore, a linear static analysis has confirmed that the piston meets all stress and strain requirements, establishing its suitability as a design choice for two-wheeler segment engines [9].Because these hard silicon particles form during the solidification process, aluminium alloys containing distributed basic silicon particles are categorized as in-situ composites. These alloys are suitable for combustion engine pistons, engines barriers, compressors and pumping cylinder bodies, and braking parts [10].The use of metal-matrix alloys in lighter connection rods as well as pistons has received a lot of interest. There are various advantages to reducing the total weight of these parts. Four-cylinder engines are popular due to their high fuel efficiency. Whenever the engine's displacement exceeds about 2.0 liters, however, the revolving loads of the connection rod and piston assembly produces imbalanced and undesired secondary shaking forces. The reduction of secondary forces is a primary benefit of using compact connecting rods and pistons[11].The engine encounters a reduction in fluids dynamics forces caused by friction as the the weights movement through the oil in the engine in the oil pan through lowering the size of their counterbalance. Furthermore, using lighter mass connecting rods reduces the forces of friction in the crankshaft's and rod bearings, allowing for more fluid and responsive motion of the rod-piston system. Collectively, these elements contribute to increased power from the engine and the potential to achieve greater engine RPM, hence expanding the engine's capabilities[12]. The phrase "warm" or protected high temperature components" refers to a number of different engine components, including the piston, the cylinders head, controls, cylinders liner, the exhaust valves, and the ports for exhaust. These parts are essential for an adiabatic engine to produce more power and operate more efficiently. By utilizing the thermal energy that is typically wasted with the water used for cooling and exhaust gas, this is made possible. This thermal energy is turned into practical power by using turbomachinery and high-temperature materials, which enhances performance and efficiency [13].A brief synopsis of the laboratory setting used to look at ceramic materials suitable for internal combustion engine components that experience thermal and mechanical stresses is given. The combustion chamber also contained two pistons having ceramic top plates, and thermocouples were installed in various locations between the liner and exhaust Despite ceramics having superior qualities, the experiment found that the method of fixing a plate of ceramic over a piston was inappropriate and needed to be modified [14].Finite element analyses indicate that considerable temperature differences observed during cyclic fluctuations in temperature over 400 K have the potential to deteriorate the ceramic coating at the point where the piston's surface contacts the bowl area in bowl-in pistons [15].

2. MATERIALS & METHODS

Despite its simplicity, aggregation techniques like the AHP (Analytic Hierarchy Process) typically outperform the Weighted Sum Method. An alternative's score is calculated using the weighted sum technique, and it reflects the relative weights given to each attribute in the alternative evaluation ratings [16]. The weighted sum technique has two key limitations that have been consistently demonstrated in the body of literature: (i) it cannot discover answers in irregular Pareto Front regions, & (ii) it has a higher search efficiency than the Chebyshev method. This paper proposes the localised utilisation of the weighted sum technique or method, limiting its use within a hypercone, in order to take advantage of its benefits and get over its drawbacks[17]. In order to address issues comprising a maximum of two objective functions, this research offers an augmentation to the bi-objective adaptable weighted sum method. The strategy consists of two separate phases. The initial phase involves quickly approximating the Pareto surfaces using the conventional weighted sum method. The mesh is then identified as an accumulation of Pareto front patches. The proposed approach effectively generates a well-distributed mesh of the Pareto front, allowing for efficient visualization and the identification of solutions in non-convex regions. The effectiveness of this method is demonstrated through the resolution of two numerical examples and a case study involving a simple structural optimization problem[18]. The weighted sum method is commonly utilized for assessing the overall sustainability performance of decision alternatives. However, it is crucial to acknowledge that this approach is merely one of several available in Multi-Criteria Decision Analysis (MCDA). Each of these methods operates on different underlying assumptions, which can influence their suitability for different problem contexts[19]. This article examines a new way to choosing the best option that combines features of the weighted total Through ratio analysis with the full multiplication form method, the strategy is inspired by the concepts of multi-objective optimisation. Additionally, it integrates elements of the combination compromise solution approach and weighted aggregated total product assessment methods [20]. The recommended method facilitates ranking alternatives, anticipates the employment of a substantially simpler normalization process, and employs four usefulness metrics to quantify the total usefulness of alternatives. As a result, this simple weighted sum methodology or procedure is simple to implement and helps to improve the reliability of judgements [21]. This research paper specifically addresses the design of transmitting beamforming to optimize the Weighted Sum-Rate (WSR) while adhering to a transmit power limitation. This problem is known to be complex and non-convex. The WSR metric is valuable for prioritizing various users and finds applications in different scenarios. For example, the weights can be selected based on the packet queue status for achieving max-stability service. Alternatively, equal weights can be used to maximize the sum-rate for best effort service[22]. This article presents an improved weighted sum model which includes expert opinions for the proportions and values of personal requirements in the choice of robots. Unlike traditional methods, our strategy does not presuppose that the experts agree on these values. We exclude the greatest and lowest values given by professionals for both the objective weights and the subjective criteria when selecting the robots in order to reduce the impact of potential bias. Eliminating these values aims to reduce the likelihood of skewed preferences having an impact on the decision. A numerical instance is provided to clarify the model and show its impact. It reveals a reversal in ranks in weighed against a model that fails to eliminate these extreme values[23]. Despite having some drawbacks, the weighted sum technique is an increasingly common option because of how easy it is to use. The weights given have significance since they indicate how important certain objective functions are in comparison. We put forth an adaptive approach to multiobjective optimisation to get around these restrictions. Our method generates a rough solution and identifies areas for refinement by dynamically adjusting weights depending on the Pareto front. The weighted sum technique is used to optimise these regions, and the algorithm is repeated until the resolution you want is attained. We present the bi-objective optimisation methodology and talk about how it might be expanded to deal with more objectives [24].The weighted sum method uses the accelerations at specific locations on the masses to determine the forces at work. When the response weight as well as base plate both display rigid body behavior, this method provides a trustworthy estimation of the ground's force. However, the estimated value corresponding to the ground's force turns into less precise as the frequency rises, perhaps leading to wavelet distortions [25]. Alternate Parameters: “LM-26 alloy +0 wt.% Porcelain, LM-26 alloy +2 wt.% Porcelain, LM-26 alloy +4 wt.% Porcelain, LM-26 alloy +6 wt.% Porcelain and LM-26 alloy +8 wt.% Porcelain” Evaluation parameters: Hardness (Hv): Hardness denotes a material's capacity to withstand localized plastic deformation, encompassing a broad spectrum of values. Compressive Strength (MPa):Compressive strength refers to the capacity of a material to withstand direct pressure exerted through applied compression force. The presence of voids and microchannels within the hydraulic cement facilitates sufficient hydration, leading to an enhancement in the material's compressive strength. Tensile Strength (MPa): Tensile strength is an essential mechanical characteristic that significantly influences the structural integrity and overall performance of materials. It serves as a metric for evaluating a material's ability to withstand and endure the forces of tension or stretching, exerted in opposite directions along its length, without undergoing fracture or deformation. Through the process of tensile testing, engineers and scientists can precisely determine the maximum stress or load that a material can bear before it reaches the point of failure under tension. This information is crucial in various fields and industries, as it enables informed material selection and ensures the reliability and durability of structures and components subject to pulling or stretching forces. Specific wear rate (in mm3 /N-m) : The specific wear rate is a numerical metric that quantifies the speed at which a material experiences wear and surface damage when exposed to mechanical contact or friction. It offers valuable insights into the material's ability to withstand and endure wear and abrasion under specific operating conditions. Typically, the specific wear rate is calculated by measuring the amount of material lost relative to the sliding distance, applied load, or duration of exposure. By analyzing the specific wear rate, engineers and researchers gain a better understanding of a material's wear resistance and its suitability for various applications. Friction coefficient (μ) : The friction coefficient is an essential characteristic that defines the behavior of two contacting surfaces. It offers valuable information about the level of resistance encountered when these surfaces slide or move in response to an external force. This coefficient, which is dimensionless, quantifies the relationship between the frictional force acting between the surfaces and the normal force exerted to keep them in contact. By examining the friction coefficient, we gain insights into the nature of friction and its impact on the overall interaction between the surfaces.

3. RESULT AND DISCUSSION

TABLE 1. Piston Material

Piston material	C1	C2	C3	C4	C5
LM-26 alloy +0 wt.% Porcelain	102.02	37.42	150.59	0.000279	0.067
LM-26 alloy +2 wt.% Porcelain	104.48	41.37	161.82	0.000263	0.063
LM-26 alloy +4 wt.% Porcelain	106.94	43.37	168.84	0.000246	0.059
LM-26 alloy +6 wt.% Porcelain	109.9	46.4	181.03	0.000167	0.05
LM-26 alloy +8 wt.% Porcelain	112.26	39.19	156.97	0.000249	0.073

Table 1. shows the piston material properties of alternatives used in material selection for automotive piston component. Here alternatives are “LM-26 alloy +0 wt.% Porcelain, LM-26 alloy +2 wt.% Porcelain, LM-26 alloy +4 wt.% Porcelain, LM-26 alloy +6 wt.% Porcelain, LM-26 alloy +8 wt.% Porcelain”. Here the Evaluation parameters are “Hardness (Hv), Compressive strength (MPa), Tensile strength (MPa), Specific wear rate (in mm3 /N-m) at Load = 45 N; Velocity = 3.768 m/s, and Friction coefficient (μ) at Load = 45 N, Velocity = 3.768 m/s”.

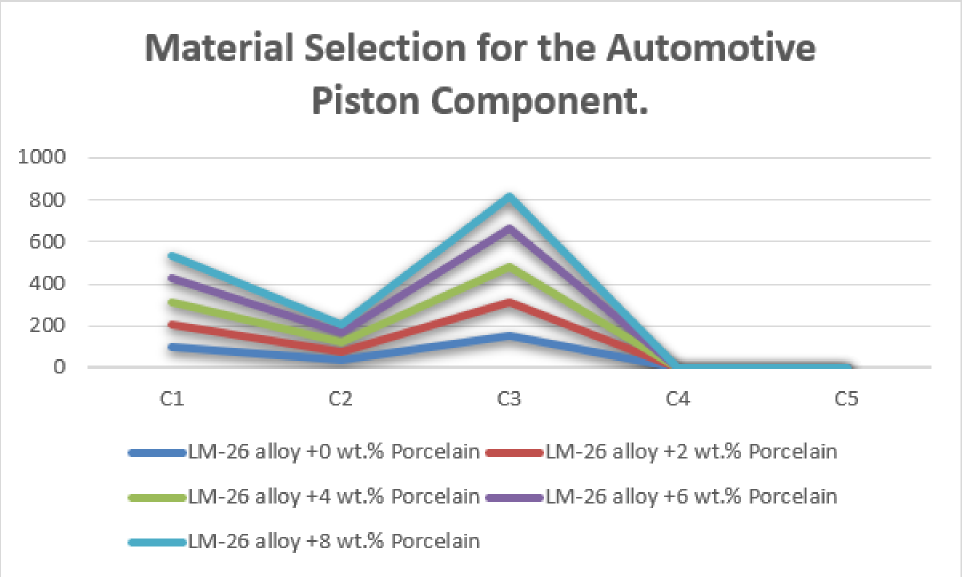

FIGURE 1. Material Selection for the Automotive Piston Component.

Figure 1. Illustrates the material selection for Automotive Piston Component.

TABLE 2. Normalized Data

0.9087832	0.8064655	0.8318511	0.5985663	0.7462687
0.9306966	0.8915948	0.893885	0.634981	0.7936508
0.95261	0.9346983	0.9326631	0.6788618	0.8474576

0.9789774	1	1	1	1
1	0.8446121	0.8670939	0.6706827	0.6849315

Table 2 shows the Normalized Data.

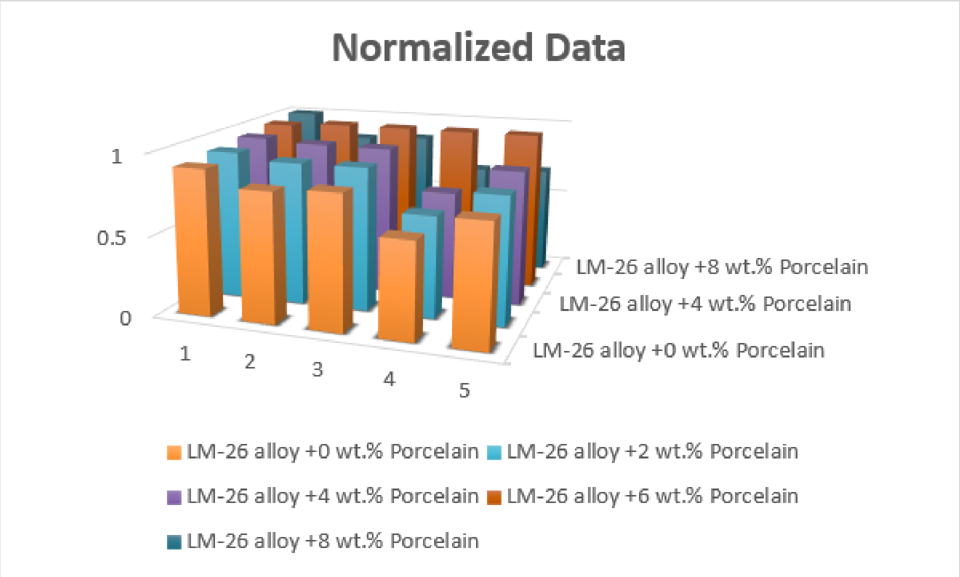

FIGURE 2. Normalized Data

Figure 2 shows the Normalized Data for “LM-26 alloy +0 wt.% Porcelain, LM-26 alloy +2 wt.% Porcelain, LM-26 alloy +4 wt.% Porcelain, LM-26 alloy +6 wt.% Porcelain, and LM-26 alloy +8 wt.% Porcelain”.

TABLE 3. Weight Matrix

0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2

Table 3 shows the weightages used for the analysis. We take the same weight for all the parameters for the analysis.

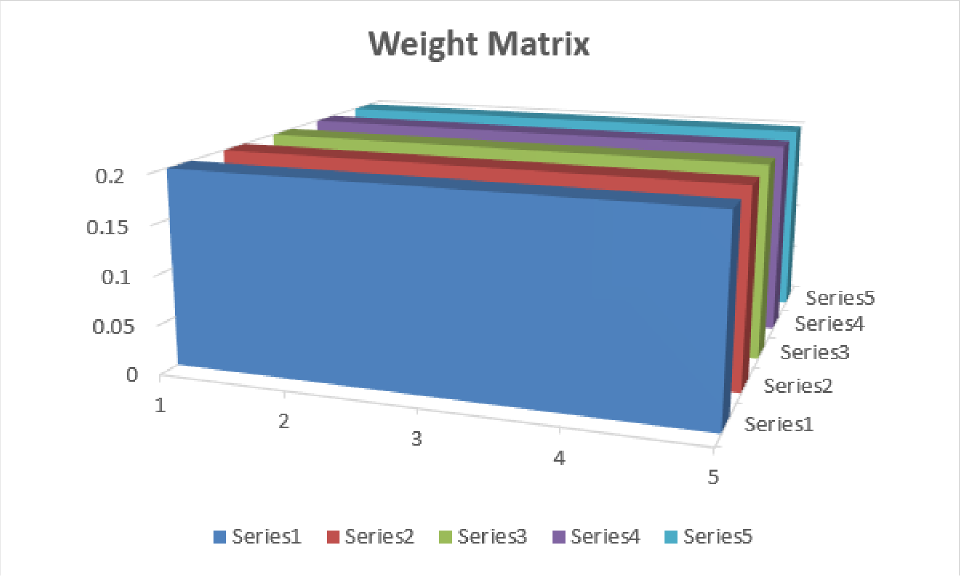

FIGURE 3. Weight Matrix

FIGURE 3. This figure shows the weight distributed among the following evaluation parameters. The Evaluation parameters are “Hardness (Hv), Compressive strength (MPa), Tensile strength (MPa), Specific wear rate (in mm3 /N-m) at Load = 45 N; Velocity = 3.768 m/s, Friction coefficient (μ) at Load = 45 N; and Velocity = 3.768 m/s”.

TABLE 4. Weighted Normalized Decision Matrix

0.1817566	0.1612931	0.1663702	0.1197133	0.1492537
0.1861393	0.178319	0.178777	0.1269962	0.1587302
0.190522	0.1869397	0.1865326	0.1357724	0.1694915
0.1957955	0.2	0.2	0.2	0.2
0.2	0.1689224	0.1734188	0.1341365	0.1369863

Table 4 shows the weighted normalized Decision matrix for alternatives .

TABLE 5. Preference Score

	Preference Score
LM-26 alloy +0 wt.% Porcelain	0.7783869
LM-26 alloy +2 wt.% Porcelain	0.8289616
LM-26 alloy +4 wt.% Porcelain	0.8692582
LM-26 alloy +6 wt.% Porcelain	0.9957955
LM-26 alloy +8 wt.% Porcelain	0.813464

Table 5 shows preference score for the alternatives : “LM-26 alloy +0 wt.% Porcelain, LM-26 alloy +2 wt.% Porcelain, LM-26 alloy +4 wt.% Porcelain, LM-26 alloy +6 wt.% Porcelain, LM-26 alloy +8 wt.% Porcelain”.

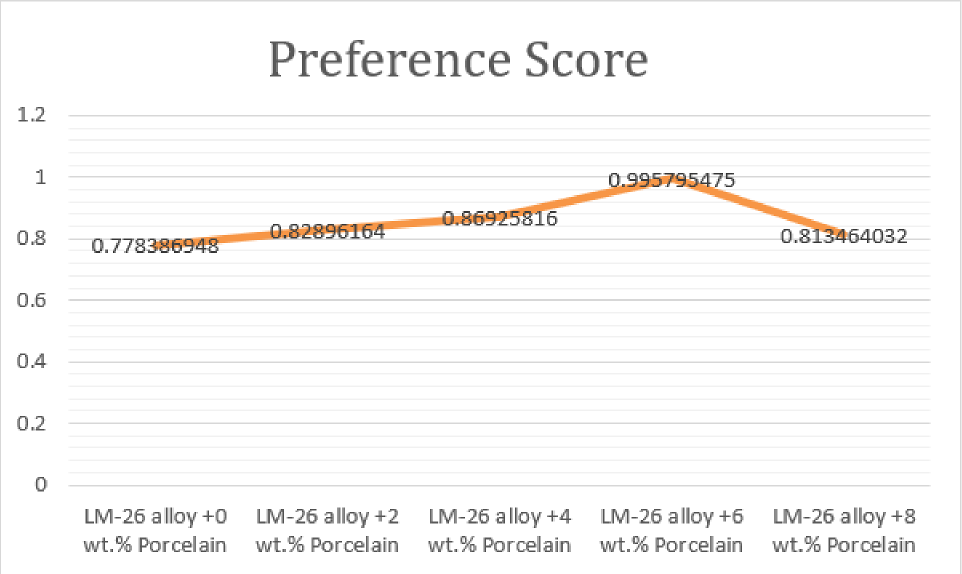

FIGURE 5. Preference Score

Figure 5 shows the preference score for “LM-26 alloy +0 wt.% Porcelain 0.778386948, LM-26 alloy +2 wt.% Porcelain 0.82896164, LM-26 alloy +4 wt.% Porcelain 0.86925816, LM-26 alloy +6 wt.% Porcelain 0.995795475, LM-26 alloy +8 wt.% Porcelain 0.813464032”.

TABLE 6. Rank

Piston Materials	Rank
LM-26 alloy +0 wt.% Porcelain	5
LM-26 alloy +2 wt.% Porcelain	3
LM-26 alloy +4 wt.% Porcelain	2
LM-26 alloy +6 wt.% Porcelain	1
LM-26 alloy +8 wt.% Porcelain	4

Table 6 shows the rank for the alternatives : "LM-26 alloy +0 wt.% Porcelain, LM-26 alloy +2 wt.% Porcelain, LM-26 alloy +4 wt.% Porcelain, LM-26 alloy +6 wt.% Porcelain, LM-26 alloy +8 wt.% Porcelain".

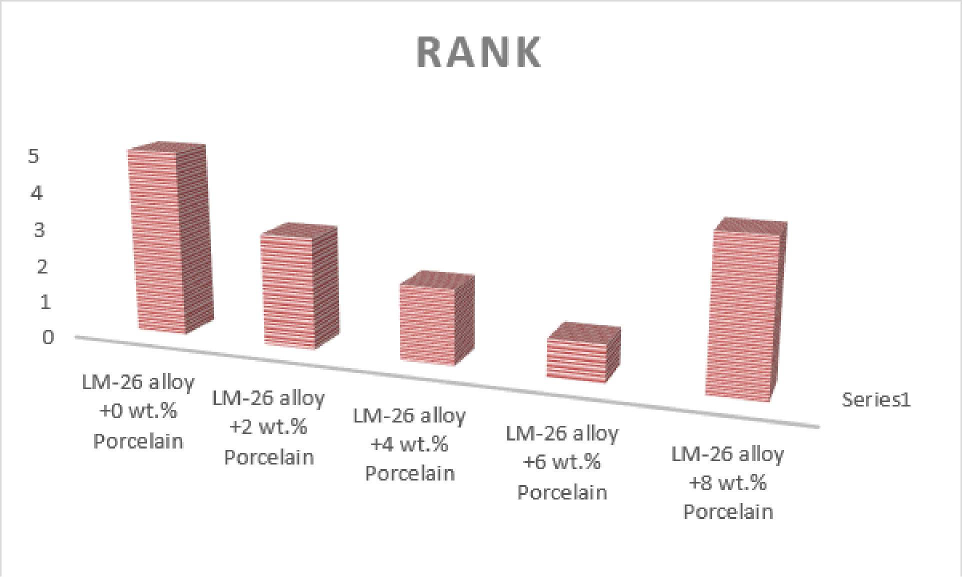

FIGURE 6. Rank

Figure 6 shows the rank of the alternatives. Here : "LM-26 alloy +6 wt.% Porcelain" is in the 1st Rank, "LM-26 alloy +4 wt.% Porcelain" in the 2nd Rank, "LM-26 alloy +2 wt.% Porcelain" in the 3rd Rank, "LM-26 alloy +8 wt.% Porcelain" in the 4rth Rank, and "LM-26 alloy +0 wt.% Porcelain in the 5th Rank".

4. CONCLUSION

To achieve maximum efficiency and effectiveness, factors including cost, weight, and production procedures are also taken into account. Aluminium alloys that are forged iron, and steel are common material for piston components; each has certain benefits and compromises in terms of cost and performance. When selecting materials for automobile pistons such as aluminium alloys, wrought iron, or steel, aspects such as heat conductivity, resistance to wear, size, expense, and manufacturing capability are carefully considered to satisfy the specific needs of the application. The piston plays a crucial role in an engine cylinder, and intense competition among manufacturers drives them to investigate the optimal material for pistons. Various factors, including the pressure exerted by hot gases and other critical considerations, make the choice of piston material particularly challenging. This is because no single material can fully satisfy all the necessary requirements for a specific application. This study assesses the performance of eight potential piston materials using eight selection criteria. The weighted sum method is commonly utilized for assessing the overall sustainability performance of decision alternatives. However, it is crucial to acknowledge that this approach is merely one of several available in Multi-Criteria Decision Analysis (MCDA). Each of these methods operates on different underlying assumptions, which can influence their suitability for different problem contexts.

REFERENCES

[1]. Chatterjee, Saikat, and Shankar Chakraborty. "A multi-attributive ideal-real comparative analysis-based approach for piston material selection." OPSEARCH 59, no. 1 (2022): 207-228.

[2]. Sapuan, S. M., M. S. D. Jacob, F. Mustapha, and N. Ismail. "A prototype knowledge-based system for material selection of ceramic matrix composites of automotive engine components." Materials & design 23, no. 8 (2002): 701-708.

[3]. Ayyalasomayajula, Madan Mohan Tito, Santhosh Bussa, and Sailaja Ayyalasomayajula. "Forecasting Home Prices Employing Machine Learning Algorithms: XGBoost, Random Forest, and Linear Regression." *ESP Journal of Engineering & Technology Advancements (ESP-JETA)* 1, no. 1 (2021): 125-133.

[4]. Ms B Sakthimala, Ms N Hemamalini, "FACETS OF GLOBALIZATION AND MULTICULTURALISM IN KIRAN DESAI'S THE INHERITANCE OF LOSS" Journal of Critical Reviews, 7(13), 2020, 3982-3983.

[5]. KUMAR, NEERAJ, MANORANJAN KUMAR MANOJ, and M. KALYAN PHANI. "Material Science Research India." (2018).

[6]. Ravishankar, B., Sanjay K. Nayak, and M. Abdul Kader. "Hybrid composites for automotive applications–A review." Journal of Reinforced Plastics and Composites 38, no. 18 (2019): 835-845.

[7]. Singh, Ujjwal, Jatin Lingwal, Abhishek Rathore, Sumit Sharma, and Vipin Kaushik. "Comparative analysis of different materials for piston and justification by simulation." Materials Today: Proceedings 25 (2020): 925-930.

[8]. Mallick, P. K. "Advanced materials for automotive applications: An overview." Advanced materials in automotive engineering (2012): 5-27.

[9]. Ayyalasomayajula, Madan Mohan Tito, Sathishkumar Chintala, and Sandeep Reddy Narani. "INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING."

[10]. Benedyk, J. C. "Aluminum alloys for lightweight automotive structures." In Materials, design and manufacturing for lightweight vehicles, pp. 79-113. Woodhead Publishing, 2010.

[11]. Dixit, Varun, and Davinderjit Kaur. "A Systematic Review for Sustainable Software Development Practice and Paradigm." Journal of Computational Analysis and Applications (JoCAAA) 33, no. 06 (2024): 170-185.

[12]. Myagkov, L. L., Khamid Mahkamov, N. D. Chainov, and Irina Makhkamova. "Advanced and conventional internal combustion engine materials." In Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance, pp. 370-408e. Woodhead Publishing, 2014.

[13]. Rohatgi, Pradeep. "Cast aluminum-matrix composites for automotive applications." Jom 43 (1991): 10-15.

[14]. Koli, Dinesh Kumar, Geeta Agnihotri, and Rajesh Purohit. "Advanced aluminium matrix composites: the critical need of automotive and aerospace engineering fields." Materials Today: Proceedings 2, no. 4-5 (2015): 3032-3041.

[15]. Phani, Makkuva Kalyan. "Quantitative mapping of elastic properties in nickel and titanium base alloys at nanoscale using atomic force acoustic microscopy."

[16]. Ayyalasomayajula, Madan Mohan Tito, and Sailaja Ayyalasomayajula. "Support Vector Machines in Virtual Screening for Therapeutic Exploration Using Radial Basis Function (RBF) Kernel for Kinase Inhibitor Discovery."

[17]. Hemamalini, N., and M. Kavi Bharathi. "Prominence of Indianess in English Literature with Reference to Indian English Writers and Their Notable Works." *Elementary Education Online* 20, no. 5 (2021): 5568-5568.

[18]. Arsha, A. G., E. Jayakumar, T. P. D. Rajan, V. Antony, and B. C. Pai. "Design and fabrication of functionally graded in-situ aluminium composites for automotive pistons." Materials & Design 88 (2015): 1201-1209.

[19]. Allison, John E., and Gerald S. Cole. "Metal-matrix composites in the automotive industry: opportunities and challenges." JoM 45 (1993): 19-24.

[20]. Faller, Kurt. "Management justification to select titanium automotive components." SAE Transactions (2002): 173-180.

[21]. Verma, Pradeep. "Transforming Supply Chains Through AI: Demand Forecasting, Inventory Management, and Dynamic Optimization." *Integrated Journal of Science and Technology* 1, no. 9 (2024).

[22]. Bryzik, Walter, and Roy Kamo. "TACOM/Cummins adiabatic engine program." SAE transactions (1983): 1063-1087.

[23]. Phani, M. Kalyan, Victor Pfahl, Chengfu Ma, Anish Kumar, W. Arnold, and K. Samwer. "Nonlinear Behavior of Contact Resonance Atomic Force Microscopy Due to Stick-Slip Phenomena." In *2018 IEEE International Ultrasonics Symposium (IUS)*, pp. 1-4. IEEE, 2018.

[24]. Singh, Prabhjot, Varun Dixit, and Jaspreet Kaur. "Green healthcare for smart cities." In Green and Smart Technologies for Smart Cities, pp. 91-130. CRC Press, 2019.

[25]. Tzabari, Yhuda, Marcel Gutman, Arthur Stotter, and David Brandon. "Ceramic piston-cup: design and testing." SAE transactions (1990): 379-387.

[26]. Assanis, Dennis N., and Edward Badillo. "Transient heat conduction in low-heat-rejection engine combustion chambers." SAE transactions (1987): 82-92.

[27]. Narani, Sandeep Reddy, Madan Mohan Tito Ayyalasomayajula, and Sathishkumar Chintala. "Strategies For Migrating Large, Mission-Critical Database Workloads To The Cloud." *Webology (ISSN: 1735-188X)* 15, no. 1 (2018).

[28]. Prasad, Devu Jagadish Chandra, Kalepalli Venkata Ravi Kiran, Neeli Syamala, Bandi Kiran Kumar, Kamili Jagadeesh Babu, and D. Shyam Prasad. "ISM band CPW-fed antenna for detection of skin cancer." *Journal of Instrumentation* 19, no. 09 (2024): P09024.

[29]. San Cristóbal Mateo, José Ramón, and José Ramón San Cristóbal Mateo. "Weighted sum method and weighted product method." Multi criteria analysis in the renewable energy industry (2012): 19-22.

[30]. Wang, Rui, Zhongbao Zhou, Hisao Ishibuchi, Tianjun Liao, and Tao Zhang. "Localized weighted sum method for many-objective optimization." IEEE Transactions on Evolutionary Computation 22, no. 1 (2016): 3-18.

[31]. Verma, Pradeep. "Sales of Medical Devices–SAP Supply Chain." *International Journal of Computer Trends and Technology* 70, no. 9 (2022): 6-12.

[32]. Kim, Il Yong, and Olivier de Weck. "Adaptive weighted sum method for multiobjective optimization." In 10th AIAA/ISSMO multidisciplinary analysis and optimization conference, p. 4322. 2004.

[33]. Rowley, Hazel V., Gregory M. Peters, Sven Lundie, and Stephen J. Moore. "Aggregating sustainability indicators: beyond the weighted sum." Journal of environmental management 111 (2012): 24-33.

[34]. Lin, Cheng, Fengling Gao, and Yingchun Bai. "An intelligent sampling approach for metamodel-based multi-objective optimization with guidance of the adaptive weighted-sum method." Structural and Multidisciplinary Optimization 57 (2018): 1047-1060.

[35]. Jindal, Mayank, Madan Mohan Tito Ayyalasomayajula, Dedeepya Sai Gondi, and Harish Mashetty. "Enhancing Federated Learning Evaluation: Exploring Instance-Level Insights with SQUARES in Image Classification Models." *Journal of Electrical Systems* 20, no. 7s (2024): 2516-2523.

[36]. Vidhya Prasanth, Sathiyaraj Chinnasamy, M. Ramachandran, Chinnasami Sivaji, "Assessment of Pyrolysis Material Selection Using WPM as an Auxiliary Tool" Building Materials and Engineering Structures,1(4), December 2023, 35-40

[37]. Prasad, Devulapalli Shyam, Srinivasa Rao Chanamallu, and Kodati Satya Prasad. "EEG signal enhancement and spectrum estimation using fourier transform magnitude response derivative functions." *Journal of Mobile Multimedia* (2022): 231-250.

[38]. Stanujkic, Dragisa, Gabrijela Popovic, Darjan Karabasevic, Ieva Meidute-Kavaliauskiene, and Alptekin Ulutaş. "An integrated simple weighted sum product method—WISP." IEEE Transactions on Engineering Management (2021).

[39]. Christensen, Søren Skovgaard, Rajiv Agarwal, Elisabeth De Carvalho, and John M. Cioffi. "Weighted sum-rate maximization using weighted MMSE for MIMO-BC beamforming design." IEEE Transactions on Wireless Communications 7, no. 12 (2008): 4792-4799.

[40]. Goh, Chon-Huat, Yung-Chin Alex Tung, and Chun-Hung Cheng. "A revised weighted sum decision model for robot selection." Computers & Industrial Engineering 30, no. 2 (1996): 193-199.

[41]. de Weck, Olivier, and Il Yong Kim. "Adaptive weighted sum method for bi-objective optimization." In 45th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics & Materials Conference, p. 1680. 2004.

[42]. Verma, Pradeep. "Effective Execution of Mergers and Acquisitions for IT Supply Chain." *International Journal of Computer Trends and Technology* 70, no. 7 (2022): 8-10.

[43]. Van Der Veen, Michiel, Jan Brouwer, and Klaus Helbig. "Weighted sum method for calculating ground force: An evaluation by using a portable vibrator system." Geophysical Prospecting 47, no. 3 (1999): 251-267.

[44]. Ayyalasomayajula, Madan Mohan Tito. "Metadata Enhanced Micro-Partitioned Bitmap Indexes for Managing Large-Scale Datasets." PhD diss., Aspen University, 2024.

[45]. Manjulaselvam, Prabakaran Nanjundan, M. Ramachandran, Chinnasami Sivaji, "Waste-to-energy technologies that are investable in India both technically and commercially A WSM approach built on the MCDM method strategy" Building Materials and Engineering Structures,1(4), December 2023, 28-34