



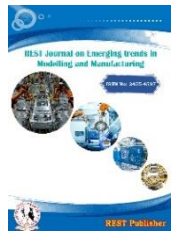
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Optimizing Material Selection for Automotive Fenders Using the WASPAS Method: A Life Cycle Engineering Approach

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Abstract: Materials selection constitutes a multidisciplinary activity that involves a wide range of knowledge subjects and professional domains. In reality, a material selection choice should include additional considerations than just the functional performance necessary for the application, but also the economic and environmental implications that arise during the product's life cycle. An approach known as life cycle engineering (LCE) strategy is provided in this study to enhance material selection by combining its suitability on behalf of the specific application according to technological, environmental, and economic aspects throughout the product's lifespan. The suggested technique examines a range concerning candidate materials and determines the "best material domains" by aggregating the three characteristics (technical, economical, and environmental). These "best material domains" are displayed beneath a ternary diagram, allowing for a worldwide inquiry into candidate materials and assisting in making an educated decision on the selection of the "best material" based on various business circumstances and corporate strategy. The technique was used to a case study aimed at the usage of freshly developed metal objects (high strength steels while participating aluminum alloys) for a vehicle fender that is constructed of mild steel, as well as the evaluation of possible benefits in terms of the material's overall performance. Transportation fenders are an important section of a vehicle's outer body that hedges the wheel arches traveler's road debris, water, in addition to other factors. They are subjected to a variety of mechanical and environmental stressors, including as impact, abrasion, corrosion, followed by temperature variations. As a result, choosing the right materials for car fenders is critical to ensuring their longevity, performance, additionally aesthetic appeal. Materials for car fenders are chosen based on a number of considerations, notably cost, performance, fabrication, and aesthetic needs. Automotive manufacturers frequently undergo thorough testing and analysis to verify that the materials used match the unique needs of their cars as well as consumer expectations. The selection of materials for vehicle fenders is an important component that live in automotive design and development. Fenders are essential regarding protecting your vehicle's body particularly components throughout highways debris, water, and various additional outside factors. As a result, the materials used for fenders have a substantial influence on the performance in general, durability, safety, together with aesthetics of cars. The substrate selection for car fenders is a significant component in automobile engineering and development. Fenders are vital for protecting your vehicle's the entire body, most especially components along roads from trash, water, and other outside influences. consequently, a result, whatever materials are chosen for flaps have a significant impact on the performance, overall durability, safety, and aesthetics of automobiles. In this research we will be using Weighted Aggregates Sum Product Assessment (WASPAS). **Alternative Parameters taken as** D600D, D1000DP, AA2036T4, AA 6010T4, PPE/PA/989, PPO/PA66, NY66/40CF, PPS/40CF, AR/PC, PC/PBT. **Evaluation Parameters taken as** Specific Heat Capacity (J/kg°C), Ultimate Tensile Strength (MPa), Yield Strength (MPa), Linear Coefficient of Thermal Expansion ($\mu\text{m}/\text{m}\cdot^\circ\text{C}$), Density (g/cc), Material Cost (\$/kg). **Result:** As per Weighted Aggregates Sum Product Assessment (WASPAS) D1000DP got more value were AA6010T4 got less value. From the above results I conclude that as per Weighted Aggregates Sum Product Assessment (WASPAS) we get to know that D1000DP got more value than others.

Keywords: Specific Heat Capacity, Ultimate Tensile Strength, Yield Strength, Linear Coefficient of Thermal Expansion, Density, Material Cost.

1. INTRODUCTION

To address market demands, innovation in products cannot be limited to traditional methodologies such as both technological and economic performance. Environmental issues have arisen as a major societal concern in the previous decade. As a result, initiatives and invention methods to promote goods that are as environmentally friendly as is practicable have been introduced into product design. [1] Prior to recent decades, novel components have been employed to replace old materials in engineering applications, particularly in the automobile sector, in order to accomplish weight reduction as well as efficiency enhancement. Sophisticated steels, magnesium alloys, aluminum alloys and titanium alloys, polymers and composites are now utilized in the automobile sector to build lightweight cars. New lightweight car trends can not only increase fuel efficiency but also cut pollutants for better driving performance. [2] Because 96% of the world's transportation systems now rely on petroleum-based fuels and goods, putting together commuter trains products using sustainable technologies has been an increasing focus of study. These worldwide transportation systems account for over 40% of the world's oil consumption, which is somewhat 75 million barrels each day. [3] To satisfy the demands of today's markets, the development of products cannot be limited to design appearance, product performance, alongside industrial costs. Decisions made at the product design stage have a significant impact on the product's prices and environmental impacts over the span of its lifespan. [4] The picking of materials and production procedures is a crucial activity within the innovation processes. Materials have an effect on and are impacted by the product fabrication procedure because they have to be entrusted with function (supporting loads, resisting pressure, keeping heat inside, transferring heat, and so on), structure (materials are a product's physical manifestation), particularly access with the the user or client or other components of the product. [5] However, in fact, the potentially infinite number of individuals processes in both the upstream and downstream stages throughout the method or item of the interest, coupled with the inaccessibility of private data, need analytical and conceptual concessions throughout the inventory stage. Institutions have attempted to create criteria that indicate where an analysis may "cut corners" and yet generate an appropriate life cycle inventory in order to assist the compilation of inventories in constrained time with finite resources. The SETAC guidebook of practice serves as a single such device, however many more exist or are in the works. [6] Any revolutionary process, of particular importance product creation, is now a collaborative endeavor comprising engineers, business strategists, marketing personnel, and environmental specialists working together as combined teams [Cooper, 2001]. Leading corporations are releasing new items with high perceived quality, requiring other companies to adapt in order to remain competitive. Adopting innovative product development methodologies results in a dynamic influx of new goods [Rouibah, Caskey, 2003]. [9] New developments in vehicle light-weighting aspire not just to improve automobile gasoline efficiency, but rather also to improve driving performance while cutting emissions [1]. To achieve minimal weight reductions, present abundant generates like stainless steel in chassis while participating suspension, as well as other power-train and drive line motor vehicles subsystems, might be replaced with lightweight materials. [10]

2. MATERIALS AND METHOD

WASPAS (Weighted Aggregates Sum Product Assessment) corresponds to a multicriteria decision-making (MCDM) system for assessing alternatives based on many criteria. It is frequently utilized in a variety of sectors, including financial services, engineering, in addition project management. The WASPAS technique enables decision-makers to assess alternatives by taking into account various criteria and their corresponding weights. It considers the relevance of each criterion as well as how well it performs of each alternative in relation to these criteria. [13] WASPAS demonstrates a systematic method to decision-making by taking into account both the relevance of the criteria and alternative performance at the same time. Decision-makers can stress some elements more than others by giving weights to criteria, reflecting what they prefer and priorities. It should be noted that precisely the execution of WASPAS may differ based on the decision issue and the environment in which it is used. The normalization procedures, the weighting of methods, and aggregation algorithms employed may differ. [15]

Specific Heat Capacity (J/kg.°C): The specific heat capacity of a substance, typically abbreviated as "c," is a physical parameter that reflects the precise quantity of heat energy necessary in order to boost temperature of one kilogramme (kg) regarding the element in question by one degree Celsius (°C). It is calculated in joules per kilogramme according degree Celsius (J/kg.°C). [16] Because various materials absorb and retain heat differently, the particular capacity for heat will differ depending on the composition. Water, for example, has an extremely elevated specific warmth value of roughly 4,186 J/kg.°C, implying that raising its temperature demands a large amount of energy. Metals, on the other hand, possessed lower specific heat capacity, such as copper, which has a value of around 385 J/kg.°C. [17]

Ultimate Tensile Strength (MPa): The ultimate tensile strength (UTS) of a material is a measure of how much tensile stress it can bear before breaking or failing. It is usually represented in millions of Pascals (MPa). [18] The maximum breaking strength of a material varies based on the substance being tested. Because various materials have varied intrinsic strength qualities, their owners UTS values can differ greatly. Common materials, such as steel, aluminium, and concrete, have varying UTS values. [19]

Yield Strength (MPa): Yield strength has become a material mechanical parameter that quantifies the highest stress that a material can sustain before deforming plastically or irreversibly. A tensile test is commonly used to determine it, in which an individual piece in question is exposed to increasing quantities concerning stretching stress until it hits its yield point. [20] Yield strength is measured in pressure measures such as megapascals (MPa) along with pounds per square inch (psi). The previously megapascal has become a metric pressure unit proportionate to a single million pascals that is extensively used in science and engineering. [21]

Linear Coefficient of Thermal Expansion ($\mu\text{m}/\text{m}\cdot^{\circ}\text{C}$): The proposed linear coefficient regarding thermal expansion, often referred to just like the coefficient of thermal extension or deliberately simply coefficient concerning expansion, is a measurement regarding how much a material increases or decreases in response to temperature changes. It denotes a small alteration throughout length (or volume) corresponding to a temperature change. [22] The proposed linear coefficient residing in thermal expansion is commonly represented by the symbol (α) and is measured in micrometres per metre per degree Celsius ($\text{m}/\text{m}\cdot^{\circ}\text{C}$) or simply parts per million according to degree Celsius ($\text{ppm}/^{\circ}\text{C}$). [23]

Density (g/cc): Density is a gauge for what proportion of mass is contained inside a particular volume of an opaque substance. It is frequently referred to as unique gravity or elsewhere mass density. It is commonly represented in terms of grammes per cubic centimetre (g/cc) or grammes per millilitre (g/mL). A material's density is a fundamental attribute that is frequently used to characterise and compare various substances. [24] Because of differences with regards to their atomic or intentionally molecular structures, different substances have varied densities. Metals, for example, have greater density than gas or liquid substances. Water is frequently used as a standard for density calculations, followed by its density starting 4 degrees Celsius is roughly 1 g/cc. [25]

Material Cost (\$/kg): The material cost per kilogramme varies greatly based on the commodity in consideration. Furthermore, material prices might change over time as a result of variables that encompass demand and supply dynamics, market circumstances, and inflation.

3. RESULT AND DISCUSSION

TABLE1. Data Set

Material Properties	Specific Heat Capacity (J/kg. $^{\circ}\text{C}$)	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Linear Coefficient of Thermal Expansion ($\mu\text{m}/\text{m}\cdot^{\circ}\text{C}$)	Density (g/cc)	Material Cost (\$/kg)
D600 DP	460	650	400	10.8	7.9	0.8
D1000 DP	486	1100	850	11.7	7.9	0.8
AA 2036 T4	882	338	193	23.4	2.7	11.8
AA 6010 T4	890	290	170	24.8	2.7	12.7
PPE/ PA/ 989	1700	55	60	85	0.9	5.2
PPO/ PA66	1630	53	54	64.8	1.3	4.7
NY66/ 40CF	1520	267	120	14.8	1.5	6.05
PPS/ 40CF	1330	175	143	17.3	1.5	20.4
AR/ PC	1580	49.8	56.3	93.6	1.2	3.8
PC/ PBT	1420	54	58	46	1.3	2.7

This table shows Weighted Aggregates Sum Product Assessment (WASPAS). Here in this table Specific Heat Capacity, Ultimate Tensile Strength, Yield Strength, Linear Coefficient of Thermal Expansion, Density, Material Cost.

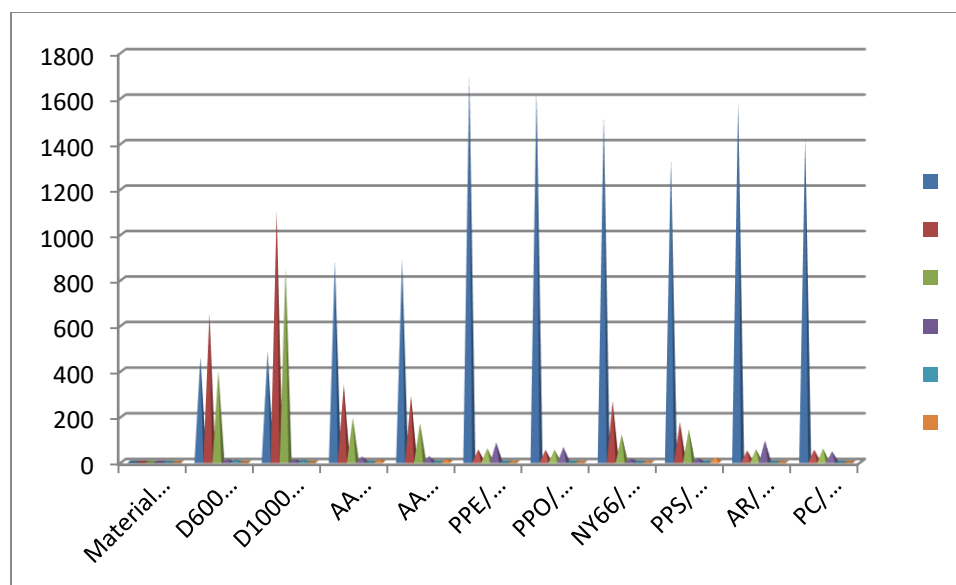


Figure 1 This shows Weighted Aggregates Sum Product Assessment (WASPAS). Here in this table Specific Heat Capacity, Ultimate Tensile Strength, Yield Strength, Linear Coefficient of Thermal Expansion, Density, Material Cost.

TABLE 2.

Material Properties	Specific Heat capacity (J/kg.°C)	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	Linear Coefficient of Thermal Expansion ($\mu\text{m}/\text{m}\cdot^{\circ}\text{C}$)	Density (g/cc)	Material cost (\$/kg)
D600 DP	0.27059	0.38235	0.23529	0.00635	0.00465	0.00047
D1000 DP	0.28588	0.64706	0.50000	0.00688	0.00465	0.00047
AA 2036 T4	0.51882	0.19882	0.11353	0.01376	0.00159	0.00694
AA 6010 T4	0.52353	0.17059	0.10000	0.01459	0.00159	0.00747
PPE/ PA/ 989	1.00000	0.03235	0.03529	0.05000	0.00053	0.00306
PPO/ PA66	0.95882	0.03118	0.03176	0.03812	0.00076	0.00276
NY66/ 40CF	0.89412	0.15706	0.07059	0.00871	0.00088	0.00356
PPS/ 40CF	0.78235	0.10294	0.08412	0.01018	0.00088	0.01200
AR/ PC	0.92941	0.02929	0.03312	0.05506	0.00071	0.00224
PC/ PBT	0.83529	0.03176	0.03412	0.02706	0.00076	0.00159

This table shows Weighted Aggregates Sum Product Assessment (WASPAS). Here in this table Specific Heat Capacity, Ultimate Tensile Strength, Yield Strength, Linear Coefficient of Thermal Expansion, Density, Material Cost.

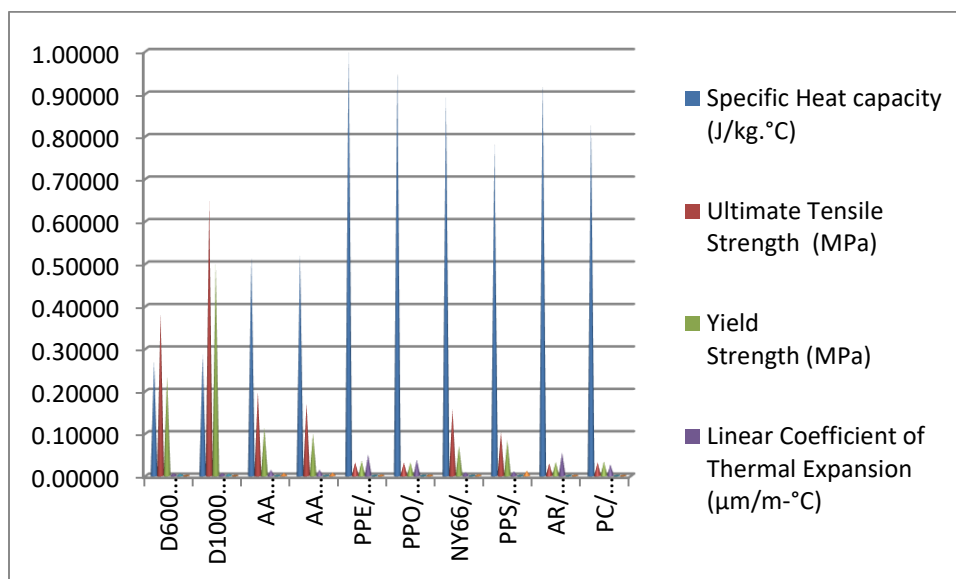


FIGURE 2.

Figure 2 This table shows Weighted Aggregates Sum Product Assessment (WASPAS). Here in this table Specific Heat Capacity, Ultimate Tensile Strength, Yield Strength, Linear Coefficient of Thermal Expansion, Density, Material Cost.

TABLE 3. Weight

Weight					
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25	0.25	0.25

TABLE 4. Weighted Normalized Decision Matrix

Material Properties	Weighted Normalized Decision Matrix					
D600 DP	0.06765	0.09559	0.05882	0.00159	0.00116	0.00012
D1000 DP	0.07147	0.16176	0.12500	0.00172	0.00116	0.00012
AA 2036 T4	0.12971	0.04971	0.02838	0.00344	0.00040	0.00174
AA 6010 T4	0.13088	0.04265	0.02500	0.00365	0.00040	0.00187
PPE/ PA/ 989	0.25000	0.00809	0.00882	0.01250	0.00013	0.00076
PPO/ PA66	0.23971	0.00779	0.00794	0.00953	0.00019	0.00069
NY66/ 40CF	0.22353	0.03926	0.01765	0.00218	0.00022	0.00089
PPS/ 40CF	0.19559	0.02574	0.02103	0.00254	0.00022	0.00300
AR/ PC	0.23235	0.00732	0.00828	0.01376	0.00018	0.00056
PC/ PBT	0.20882	0.00794	0.00853	0.00676	0.00019	0.00040

This table shows Weighted Aggregates Sum Product Assessment (WASPAS) of Weighted Normalized Decision Matrix.

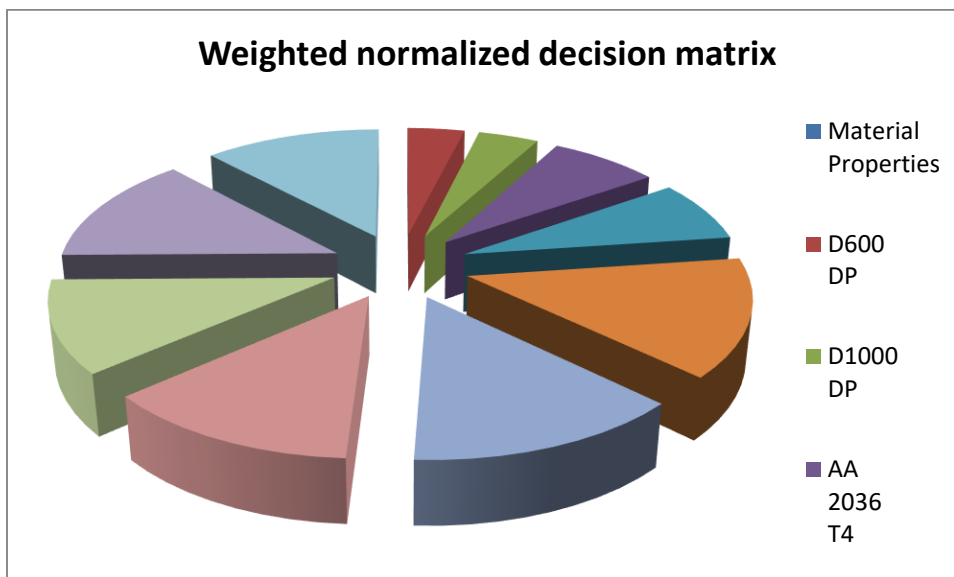


FIGURE 4. Weighted normalized decision matrix

This table shows Weighted Aggregates Sum Product Assessment (WASPAS) of Weighted Normalized Decision Matrix.

TABLE 5. Weighted normalized decision matrix

Material Properties	Weighted normalized decision matrix					
D600 DP	0.72124	0.78635	0.69647	0.28232	0.26109	0.14729
D1000 DP	0.73122	0.89688	0.84090	0.28803	0.26109	0.14729
AA 2036 T4	0.84870	0.66775	0.58047	0.34252	0.19963	0.28864
AA 6010 T4	0.85062	0.64267	0.56234	0.34754	0.19963	0.29399
PPE/ PA/ 989	1.00000	0.42411	0.43344	0.47287	0.15169	0.23517
PPO/ PA66	0.98954	0.42020	0.42217	0.44186	0.16629	0.22930
NY66/ 40CF	0.97241	0.62953	0.51545	0.30546	0.17235	0.24425
PPS/ 40CF	0.94048	0.56643	0.53854	0.31761	0.17235	0.33098
AR/ PC	0.98187	0.41371	0.42659	0.48440	0.16300	0.21744
PC/ PBT	0.95600	0.42217	0.42978	0.40558	0.16629	0.19963

This table shows Weighted Aggregates Sum Product Assessment (WASPAS) of Weighted Normalized Decision Matrix.

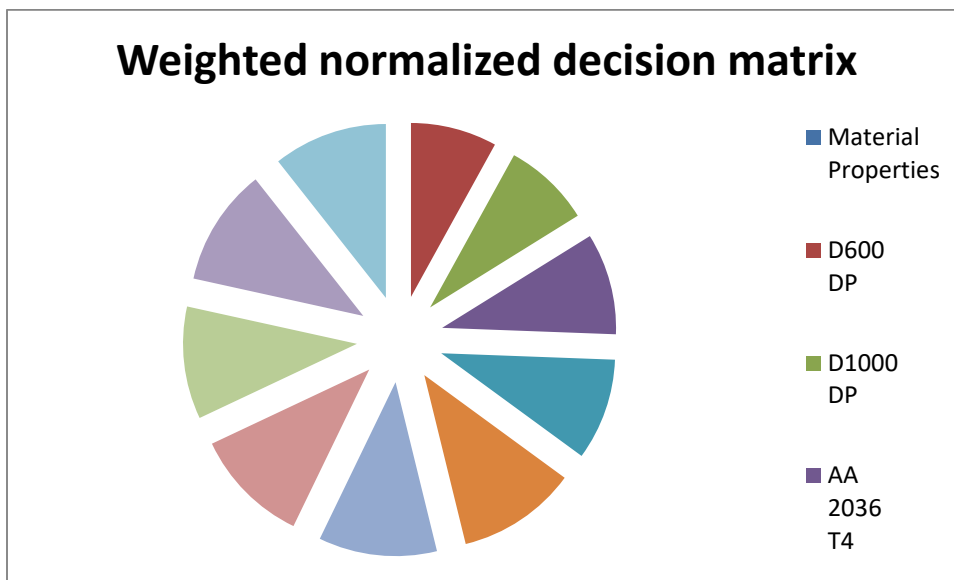


FIGURE 5. Weighted normalized decision matrix

This table shows Weighted Aggregates Sum Product Assessment (WASPAS) of Weighted Normalized Decision Matrix.

TABLE 6. Preference Score

Preference Score	WPM Weighted Product Model	lambda	WASPAS Coefficient	
		0.5		
0.22493	WSM Weighted Sum Model		0.11461	
0.36124			0.18367	
0.21337			0.10993	
0.20444			0.10536	
0.28031			0.14170	
0.26585			0.13441	
0.28373			0.14389	
0.24812			0.12666	
0.26246			0.13272	
0.23265			0.11749	
Preference Score				
0.00429		WPM Weighted Product Model		
0.00611				
0.00649				
0.00627				
0.00310				
0.00296				
0.00406				
0.00520				
0.00297				
0.00234				

This table 6 shows the models WPM and WSM. It includes Preference Score and WASPAS Coefficient.

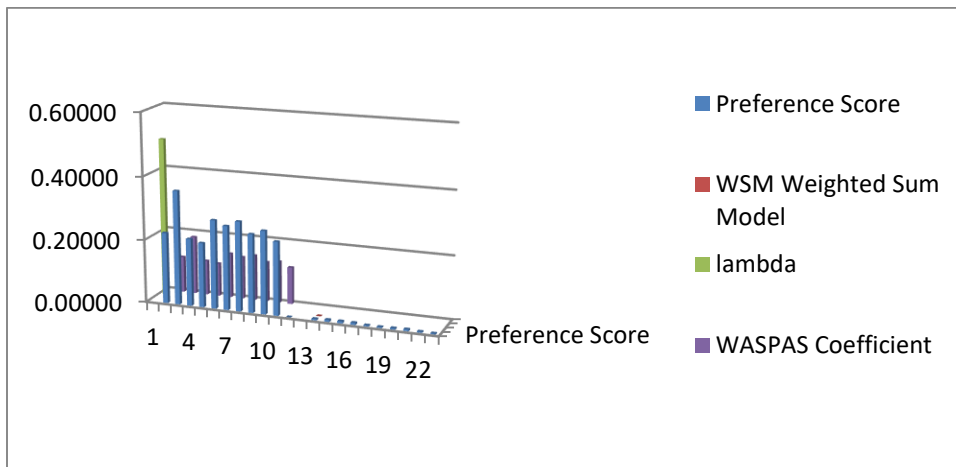


FIGURE 6. Preference Score

This table shows the models WPM and WSM. It includes Preference Score and WASPAS Coefficient.

TABLE 7. Rank

	Rank
D600 DP	8
D1000 DP	1
AA 2036 T4	9
AA 6010 T4	10
PPE/ PA/ 989	3
PPO/ PA66	4
NY66/ 40CF	2
PPS/ 40CF	6
AR/ PC	5
PC/ PBT	7

This Table 7 shows the ranking. D1000 DP1, NY66/ 40CF 2, PPE/ PA/ 989 3, PPO/ PA66 4, AR/ PC 5, PPS/ 40CF 6, PC/ PBT 7, D600 DP 8, AA 2036 T4 9, AA 6010 T4 10.

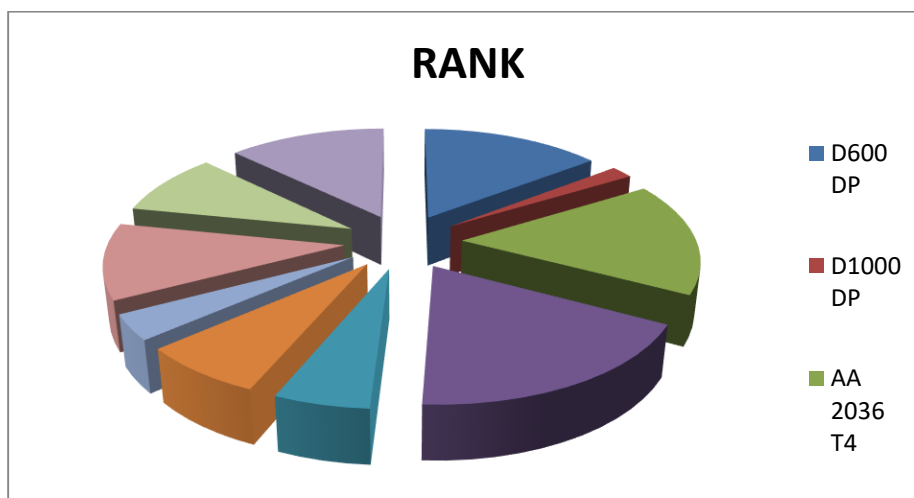


Figure 7 shows the ranking. D1000 DP1, NY66/ 40CF 2, PPE/ PA/ 989 3, PPO/ PA66 4, AR/PC 5, PPS/ 40CF 6, PC/ PBT 7, D600 DP 8, AA 2036 T4 9, AA 6010 T4 10

4. CONCLUSION

Finally, choosing the appropriate materials for vehicle fenders is critical for assuring maximum performance, longevity and safety. When making this option, several elements must be addressed, ranging from pounds, endurance, durability against impacts, cost, and manufacturing viability. Steel is a popular material for car fenders because to its excellent durability and impact resistance. Steel fenders offer great protection against mild crashes and are reasonably priced. They are, however, heavier than various other materials, resulting in can reduce fuel economy. Another typical material for fenders is aluminum. It strikes an excellent mix concerning strength and weight loss. Because of their reduced weight, aluminum fenders provide appropriate protection while also contributing to increased fuel economy. They are, however, often costlier than steel fenders. Carbon fibre reinforced polymers (CFRP) and other sophisticated composite materials have gained popularity in the automobile sector in recent years. CFRP fenders have an excellent strength-to-weight ratio, which may drastically reduce automobile pounds. This weight decrease increases fuel economy and performance. CFRP fenders, on the other hand, are pricey and need specialized production procedures. Fenders are also made out of polymer composites, featuring fiberglass-reinforced polymers (FRP). They have benefits like a minimal pound, anti-corrosion properties, and design flexibility. Polypropylene composite fenders are inexpensive and simple to produce utilizing various molding processes. They may not, however, provide the same amount of impact protection just like steel nor CFRP fenders. Finally, the materials used for automobile fenders are determined by a number of criteria, including the vehicle's unique specifications, performance goals, economic concerns, and production capabilities. Automobile manufacturers must carefully consider these criteria in order to select the best material that satisfies the necessary balance associated with cost, effectiveness, alongside weight reduction to supply their vehicle fenders.

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