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Selection of Magnesium Alloy to Suit Automotive Applications using WASPAS method

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Abstract: *To be able to meet confident requirements for design as well as enhance overall vehicle performance, choosing a magnesium-based alloy for automotive applications necessitates taking into factors including power, resistance to corrosion, castability, and lowering of weight prospects. When choosing a magnesium-based alloy for automotive applications, it's crucial to consider a number of significant variables. In order to ensure that the alloy can bear the necessary load and stresses, its strength and mechanical qualities must first match the exact specifications and requirements of the automobile part. Second, the alloy's capability to resist corrosion is essential since it must survive the effects of the environment and safeguard against deterioration throughout the component's lifecycle. In order to obtain the requisite lightweight attributes for enhanced fuel efficiency, production methods are optimized while taking factors like castability and lightweight potential for reduction into mental clarity. Several automotive applications, including as physique, frame, and inside parts, have utilized magnesium. Instrument clusters, steering wheels, engine cradles, chairs, transfer cases, and countless housings are some examples of Mg applications. By leveraging magnesium's potential for integrating components into single-piece, thin-wall metal castings, these kinds of applications were created mainly to provide lower-mass elements. Applying the "Weighted Aggregated Sum Product Assessment (WASPAS)" method, those making decisions are able to evaluate possibilities based on a wide range of parameters. It involves providing criteria weights, determining scores for every potential and summing the results to determine the most suitable option. Alternate Parameters: They are "AZ91, AM50, AM60, AZ31, ZE41, ZE63, EZ33, ZC63". Evaluation Parameters: They are "Impact", "Hardness", "Thermal Conductivity", "Elongation, Density", "Fatigue strength". For the Selection of Magnesium Alloy to suit Automotive Applications , the best magnesium alloy is so found out to be "AZ91", "ZC63" is in the 2nd Rank, "ZE41" is in the 3rd Rank, "ZE63" is in the 4rth Rank , "EZ33" is in the 5fth Rank, "AZ31" is in the 6th Rank, "AM60" is in the 7th Rank, "AM50" is in the 8th Rank. The "AZ91" is in the 1st Rank, "ZC63" is in the 2nd Rank, "ZE41" is in the 3rd Rank, "ZE63" is in the 4rth Rank , "EZ33" is in the 5fth Rank, "AZ31" is in the 6th Rank, "AM60" is in the 7th Rank, "AM50" is in the 8th Rank.*

Keywords: *MCDM, WASPAS, Mg Alloy, Thermal Conductivity and "AZ91".*

1. INTRODUCTION

Numerous automotive applications, including example body, chassis, and inside parts, made use of magnesium. Instrumentation groups, steering wheels, engine cradles, chairs, transfer cases, and numerous housings are a few examples of Mg implementations. These uses were mainly developed for supplying lower mass elements and to take benefit of the combining capabilities of magnesium in single-piece, thin-wall casting[1].In metals with low stacking fault energies, for instance twinning-induced plasticity (TWIP) steels and hexagonal materials, like magnesium, with a constrained number of slip systems, twinning is particularly crucial. Due to their improved strength and reduced density, respectively, TWIP steeled, and magnesium-based alloys received quite a bit of interest from automotive manufacturers recently[2].When compared to aluminium, magnesium ranks as one of the lightweight metals and yet one of the densest. Only 30% of aluminium's density may be derived from magnesium. The majority of MMC formulations, therefore, consequently take magnesium into view. Magnesium. The metal is exceptionally robust, machinable, flexible, and resistant strains. Therefore, magnesium will eventually replace aluminium in the manufacturing procedure of the majority of automotive and aeronautical parts[3]. Low rigidity, poor increased temperature effectiveness, and an elevated reactivity. Mg has limited its use in automobiles to less important parts which include seats, gearboxes, instrument panels, steering wheels, and steering column elements[4].The current research seeks to examine the potential weight loss objective: building a magnesium automobile body structure. There are two distinct areas discussed. The beneficial properties of a "magnesium car structure" when thinking of structural integrity and weight stand initial, followed by its production potential[5].Magnesium is an extremely desirable substance, and economic research has demonstrated that its demand is projected to rise.

However, the production of primary magnesium today requires a lot of energy and is inefficient, which sparked research into the additive manufacture of magnesium alloys and the use of solar energy for carbothermic reduction. For the purpose of maintaining the supply circular, recycling magnesium is a further option. Research is now being done to find a recycling method that is both financially and ecologically sound[6].The present research analyses the roughening reaction of an industry-standard Al-Mg alloy confirmed by solid solution. Owing to the evaluation's conclusions, standard roughness measurements rise with uniaxial in nature plastic strain in a way that can be estimated by a straightforward linear formula[7].Recovery, grain size, and the second phase were unable to be independently explored in this study. The results of the present study, together with an additional AZ31 microstructure that incorporates high grain size with the second phase particles, will enable to distinguish the effects of grain size and the subsequent phases on the tensile behavior of AZ31 Mg sheet alloys in future studies[8].They have discovered that even though injecting tiny quantities of Li fails to enhance Mg's inherent poor ductility, it does enhance the other elastic properties. Vibrationally, we discover that plenty of the system's structures have voids within their phonon band structures. Researchers have reported the estimated the Debye temperatures and demonstrated the vibratory influence on the heat potential[9].The present review covers the research regarding magnesium matrix syntactic foams. Due to its low density, magnesium matrix composites receive a rapidly growing amount of interest in research and business development. A comprehensive examination reveals that while understanding the mechanical characteristics of magnesium alloys as well as their composites is still restricted information about their microstructural characteristics has advanced significantly. The majority of studies that are currently readily available discusses up to three different "magnesium alloy matrix syntactic foam" formulations designed[10].For some magnesium alloys, notably wrought material, implementing the right laser processing conditions can result in crack-free laser connection welding with minimal permeability along with excellent surface quality. Magnesium alloys, however, can exhibit some processing challenges and weld defects owing to their natural properties, including an unstable weld pool, significant spatter, a strong tendency to drop via sag, undercut, porosity, liquation along with solidification cracking, oxide inclusions, in addition, loss of alloying elements[11].A short description of the multiple states accelerated electrochemical and corrosion testing methods for Mg alloys which have been adopted by various schools is given in the absence of sufficient standards, together with some suggestions for additional study. In compliance with "American Society for Testing Materials (ASTM) standard 1384-96", corrosive water, hydroxide-chloride, and other substances are used to test for general corrosion, localized corrosion, and rust influenced by metallurgical factors[12].The accepted standard for creep-resistant magnesium die-casting alloy, AE42 Alloy, is greatly outperformed by the recently uncovered "Mg-Al-Ca-based ACX alloys" in terms of their overall creep resistance, secondary creep rate, and creep strength[13].The rapid increase in demand is caused by magnesium alloy's favourable strength-to-weight ratio and lightweight, allowing for numerous opportunities for reducing weight in the transportation and car sector[14].Over the span of an automobile's lifespan, energy consumption can be significantly decreased by switching out Fe-based alloys with aluminum and magnesium alloys. The use of cast magnesium yields the greatest advantages, especially in high-pressure die casting, where magnesium's outstanding castability can be leveraged to advantage. The inherent poor efficiency of the majority of high-pressured die cast (HPDC) Mg-Al alloys at temperatures higher than those typical of those needed for applications which include the automotive engine, nevertheless, poses a hurdle for the widespread acceptance of magnesium alloys. It has been demonstrated that rare earth (RE) alloying additives enhance the characteristics of magnesium alloys at high temperatures[15].

2. METHODOLOGY

2.1 WASPAS method

Six application areas were created from these papers. The papers were also grouped relative to the authors, the publication year, the names of the journals and conferences, the technique and method utilised, the research aims, the research gap, the problem and solution, the modelling, and finally the outcomes and discoveries[16]. The extended WASPAS approach is a brand-new integrated methodology that the researchers present in their work and is based on the WASPAS technique. It may be used to address MCDM problems, including interval type-2 sets of fuzzy values[17].The time and attendance software issue for the system choice issue for the private hospital is addressed in this research using a combination of the CRITIC and WASPAS approaches. Simple mathematical application steps are required for both techniques. Various parameters for the WASPAS technique result in the identical ranking of the alternatives in this investigation. With different selection issues, the influence of different values may be observed[18].The present research revisits the notion of rating correctness in the WASPAS tackle and re-derives the essential equations. It has been discovered that derivatives cannot be reliably calculated when the anticipated variation of the WPM is being used. Consequently, a modified equation is suggested, and the outcomes are supported by two examples. For the purpose of to assist practitioners in calculating estimated variances and selecting the perfect parameter, programmes for computers are also supplied [19].We have created an additional extension of the classic WASPAS system within the MCDM framework. The single-valued neutrosophic collection's conceptual framework is used in the new extension that is being suggested, called WASPAS-SVNS. It has been performed in order to contrast the outcomes of other MCDM techniques. According to the calculations, Vilnius' Gariunai District is the best location for the plant to be built in order to burn non-hazardous garbage. Based on the findings, it can be said that this area is appropriate for the execution of the project to build a waste incinerator plant[20].Numerous MCDM approaches have been enhanced for IVIFSs as as a consequence of rent areas. This research develops a novel WASPAS method-based approach under IVIFSs. The developed technique is based on the IVIFS operators, some modifications to the conventional WASPAS method, and an innovative method for calculating the weights of the decision experts and the criteria. For the purpose to arrive at accurate weights, novel techniques have been suggested to calculate the weights of the choices made by experts and criterion using interval-valued intuitionistic fuzzy data values (entropy, divergence, and similarity measures)[21].To assess the alternatives, a suggested solution technique and a weighting calculation of the criteria established within the parameters of the suggested model were produced[22].Owing to the WASPAS findings, the best means of promoting and pursuing Iran's industrial planning for the future is to take advantage of nanotechnology in both health and healthcare[23].The performance of TSPs is compared in the current study using the intuitively fuzzy weighted aggregate sum evaluation (IF-WASPAS) method. The IF-WASPAS method integrates the "weighted sum (WSM)" and product model (WPM) for processes of decision-making, as well as linguistic uncertainty in MCDM. Furthermore, the objective weights obtained using the similarity measurement method will be added to the personalized weights stated by the professionals in order to determine criterion weights[24].The station choosing problem for gas stations is examined applying the newly proposed spherical fuzzy AHP-integrated spherical WASPAS method[25].

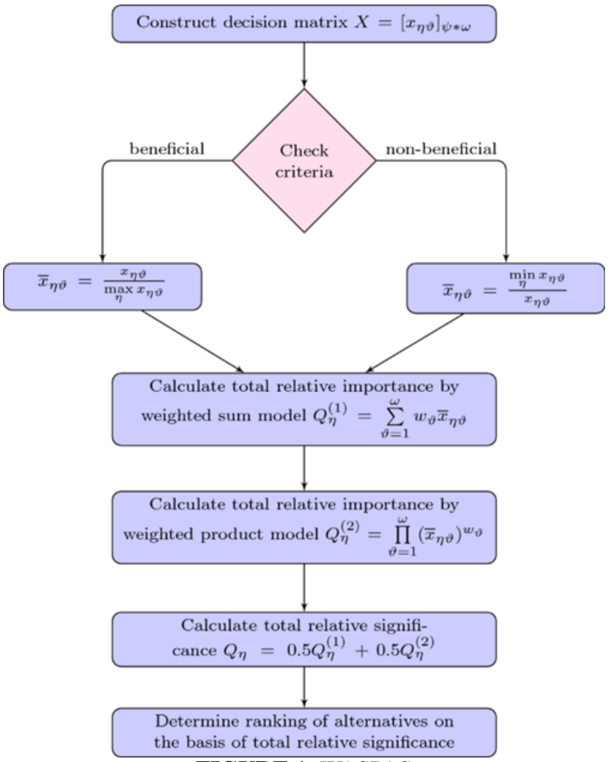

FIGURE 1. WASPAS

2.2 Parameters

Alternate Parameters:

1. AZ91 is a "magnesium alloy" consisting of 9% aluminum and 1% zinc, which exhibits high strength, low density, and good corrosion resistance.
2. AM 60 is an aluminum-magnesium alloy with approximately 6% magnesium content, commonly used in additive manufacturing applications due to its favourable combination of strength, lightweight properties, and corrosion resistance.
3. AM 50 is an aluminum-magnesium alloy with approximately 5% magnesium content, frequently utilized in additive manufacturing processes due to its advantageous balance of strength, ductility, and corrosion resistance.
4. AZ 31 is a "magnesium alloy" with approximately 3% aluminum and 1% zinc content, known for its lightweight properties, excellent machinability, and good strength-to-weight ratio, making it suitable for various applications in industries such as automotive and aerospace.
5. ZE41 is a "magnesium alloy" with approximately 4% zinc and 1% rare earth elements, recognized for its high strength, excellent creep resistance, and good corrosion resistance.
6. EZ 33 is a "magnesium alloy" with approximately 3% zinc and 3% rare earth elements, known for its high strength, good castability, and improved creep resistance.

7. ZE 63 is a “magnesium alloy” with approximately 6% zinc and 3% rare earth elements, valued for its high strength, good creep resistance, and excellent corrosion resistance.
8. ZC 63 is a zinc-copper alloy with approximately 63% zinc and 37% copper, known for its excellent corrosion resistance, high strength, and electrical conductivity.

Evaluation Parameters:

1. Thermal Conductivity: The potential of a substance to conduct heat is indicated by its thermal conductivity, which quantifies the ease with which heat circulates through the substance’s structure.
2. Fatigue Strength: The highest stress level that a substance will tolerate prior collapsing during a specific amount of loading cycles is known as fatigue strength, and it assesses a material’s resilience to repeated impact and periodic stress.
3. Impact : The impact is an expression denoting a violent impact or interaction between two things that often produces an extensive and rapid change in movement or distortion.
4. Hardness: The potential of a material to stand up to outside forces and defy persistent changes in shape can be seen in its hardness, which is an indication of its durability against indentation, scratching, or distortion.
5. Elongation: Elongation denotes the percentage rise of a material’s length before it splits under tension, showing the material’s ability for plastic deformation without breakage.
6. Density: A material’s density, a measure of the quantity of mass it possesses relative to its volume and determines the extent to which the particles are packed, dictates how heavy and compact a substance has become.

3. RESULTS AND DISCUSSIONS

TABLE 1. Selection of various Magnesium Alloys to suit automotive application.

Alloy	Thermal Conductivity (W/mK)	Fatigue Strength (MPa)	Impact (J)	Hardness (BHN)	%Elongation (in 50 mm)	Density (g/cm^3)
AZ91	72.7	97	2.7	63	3	1.81
AM60	62	80	2.8	65	13	1.79
AM50	65	75	2.5	60	15	1.77
AZ31	96	90	4.3	49	15	1.771
ZE41	113	63	1.4	62	3.5	1.84
EZ33	99.5	40	0.68	50	3.1	1.80
ZE63	109	79	2.3	75	7	1.87
ZC63	122	93	1.25	60	4.5	1.87

Table 1 shows the selection of various Magnesium Alloys to suit automotive application.

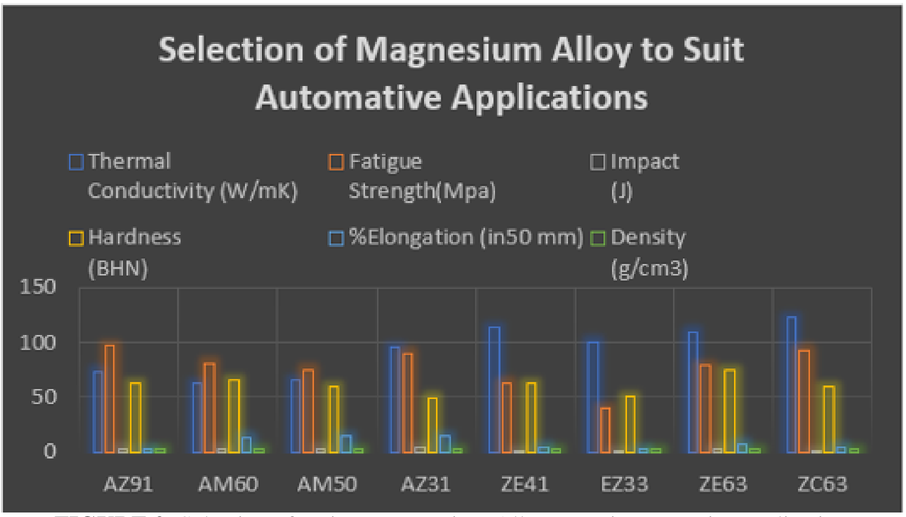

FIGURE 2. Selection of various Magnesium Alloys to suit automotive application

Figure 2 illustrates the selection of various Magnesium Alloys to suit automotive application.

TABLE 2. Normalized Matrix

Alloys	Normalized Matrix					
AZ91	0.595902	0.795082	0.022131	0.516393	1	1.657459
AM60	0.508197	0.655738	0.022951	0.532787	0.230769	1.675978
AM50	0.532787	0.614754	0.020492	0.491803	0.2	1.694915
AZ31	0.786885	0.737705	0.035246	0.401639	0.2	1.693958
ZE41	0.92623	0.516393	0.011475	0.508197	0.857143	1.630435
EZ33	0.815574	0.327869	0.005574	0.409836	0.967742	1.666667
ZE63	0.893443	0.647541	0.018852	0.614754	0.428571	1.604278
ZC63	1	0.762295	0.010246	0.491803	0.666667	1.604278

Table 2 shows the Normalized Matrix for the eight types of magnesium alloys and the evaluation parameters such as hardness, fatigue strength and density as listed above in methodology.

TABLE 3. Weight Matrix

Alloy	Weight Matrix					
AZ91	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
AM60	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
AM50	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
AZ31	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
ZE41	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
EZ33	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
ZE63	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667
ZC63	0.166667	0.166667	0.166667	0.166667	0.166667	0.166667

Table 3 shows the weight matrix which is taken as same for all the alloys.

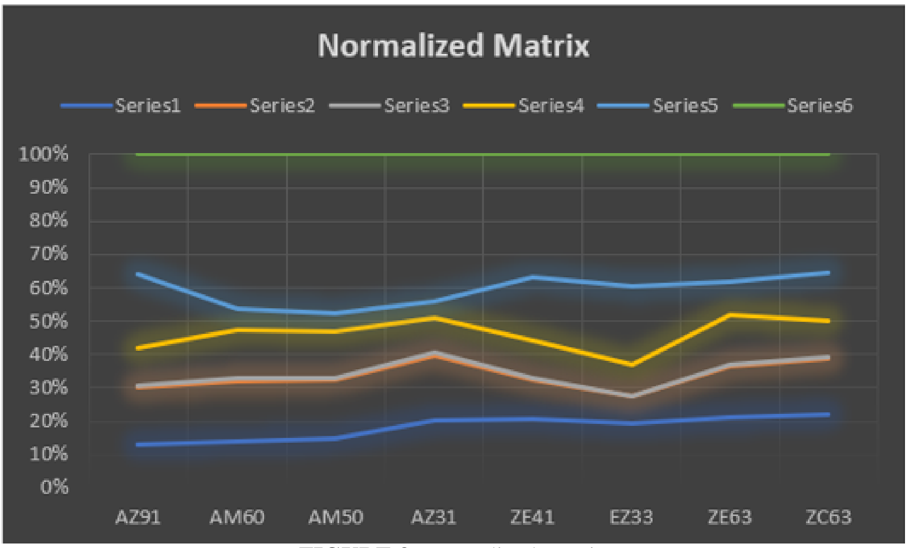

FIGURE 3. Normalized Matrix

Figure 3 illustrates the normalized matrix of various Magnesium Alloys to suit automotive application.

TABLE 4. Weight normalised decision matrix (WSM)

0.099317	0.132514	0.003689	0.086066	0.166667	0.276243
0.084699	0.109290	0.003825	0.088798	0.038462	0.279933
0.088798	0.102459	0.003415	0.081967	0.033333	0.282486
0.131148	0.122951	0.005874	0.066940	0.033333	0.282326
0.154372	0.086066	0.001913	0.084699	0.142857	0.271739
0.135929	0.054645	0.000929	0.068306	0.161290	0.277778
0.148907	0.107923	0.003142	0.102459	0.071429	0.267378
0.166667	0.127049	0.001708	0.081967	0.111111	0.267378

Table 4 shows the Weight normalised decision matrix by wsm for eight types of magnesium alloys using the weight sum method.

TABLE 5. Weight Normalized Decision Matrix by WPM

0.917337	0.962503	0.529868	0.895702	1	1.087862
0.893316	0.932084	0.533089	0.900379	0.783183	1.089878
0.900379	0.922112	0.523114	0.888448	0.764724	1.091921
0.960842	0.950562	0.5726	0.85896	0.764724	1.091819
0.987309	0.895702	0.474928	0.893316	0.974635	1.084886
0.966594	0.830392	0.421074	0.861857	0.99455	1.088867
0.981396	0.930132	0.515895	0.922112	0.868301	1.081965
1	0.955771	0.466042	0.888448	0.934655	1.081965

Table 5 shows the weight normalized decision matrix for the eight types of the alternate parameters and five of the evaluation parameters. It is done using the weight product method.

TABLE 6. Preference Score (WSM and WPM)

Alloy	Preference Score (WSM)	Preference Score (WPM)
AZ91	0.764494	0.4558644
AM60	0.604403	0.3411353
AM50	0.592459	0.3222063
AZ31	0.642572	0.3750697
ZE41	0.741645	0.3967126
EZ33	0.698877	0.3154437
ZE63	0.70124	0.4079601
ZC63	0.755882	0.4001986

Table 6 shows the Preference Score for Eight types of Mg alloys. The score is evaluated using two method i) Weight Sum method ii) Weight Product method.

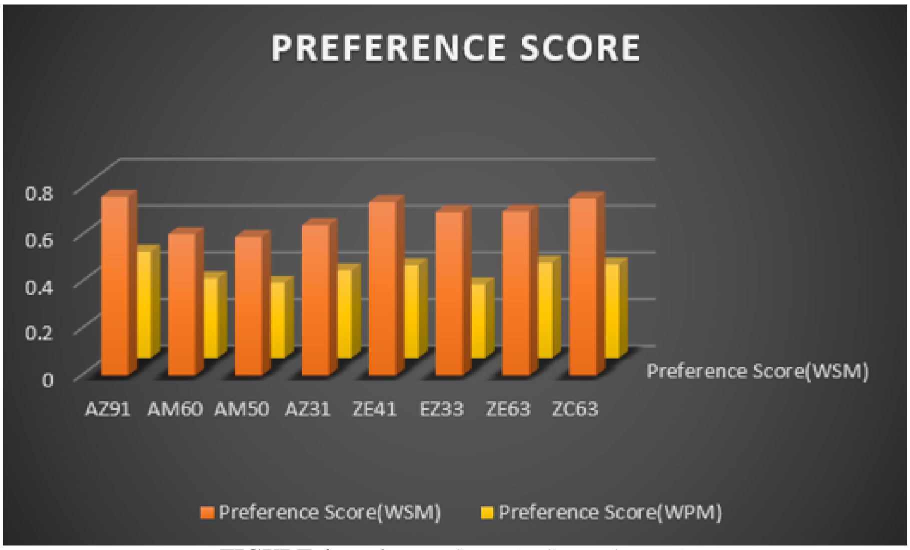

FIGURE 4. Preference Score (WSM and WPM)

Figure 4 shows the Preference Score for Eight types of Mg alloys. The score is evaluated using two method i) Weight Sum method ii) Weight Product method.

TABLE 7. WASPAS Coefficient

Alloy	WASPAS coefficient
AZ91	0.382247
AM60	0.302202
AM50	0.296229
AZ31	0.321286
ZE41	0.370823
EZ33	0.349438
ZE63	0.35062
ZC63	0.377941

Table 7 shows the WASPAS Coefficient for the Alternatives used here.

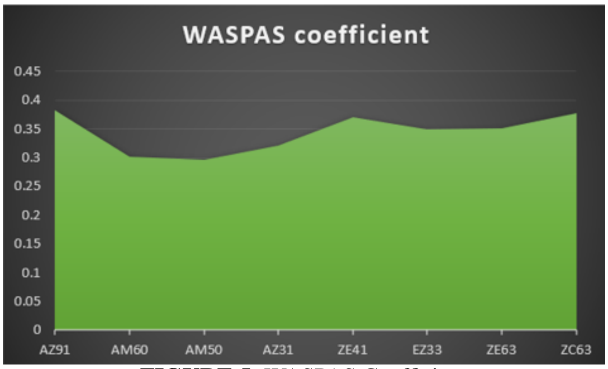

FIGURE 5. WASPAS Coefficient

Figure 5 shows the WASPAS Coefficient for the Alternatives used here.

TABLE 8. Rank

Alloy	Rank
AZ91	1
AM60	7
AM50	8
AZ31	6
ZE41	3
EZ33	5
ZE63	4
ZC63	2

Table 8 shows the Rank for the eight types of alternatives used in this research.

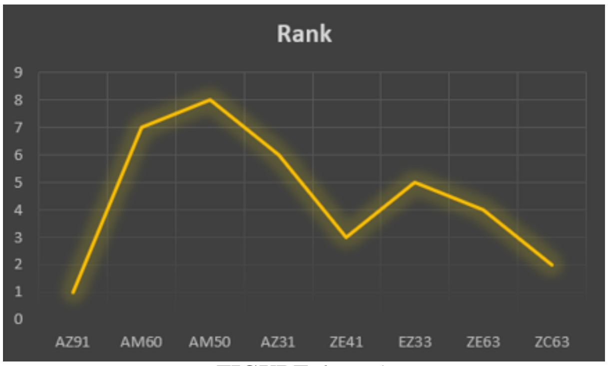

FIGURE 6. Rank

Based on the analysis presented in Figure 6, the ranking for the selection of magnesium alloys suitable for automotive applications is as follows: AZ91 is ranked 1st, followed by ZC63 in 2nd place. ZE41 holds the 3rd rank, while ZE63 and EZ33 are ranked 4th and 5th, respectively. The 6th position is occupied by AZ31, with AM60 and AM50 placed in the 7th and 8th ranks, respectively. This ranking reflects the evaluation of the alloys based on multiple performance parameters such as impact strength, hardness, fatigue strength, and other relevant criteria using the weight sum method.

4. CONCLUSION

To be able to meet confident requirements for design as well as enhance overall vehicle performance, choosing a magnesium-based alloy for automotive applications necessitates taking into factors including power, resistance to corrosion, castability, and lowering of weight prospects. In order to obtain the requisite lightweight attributes for enhanced fuel efficiency, production methods are optimized while taking factors like castability and lightweight potential for reduction into mental clarity. Numerous automotive applications, including example body, chassis, and inside parts, made use of magnesium. Instrumentation groups, steering wheels, engine cradles, chairs, transfer cases, and numerous housings are a few examples of Mg implementations. These uses were mainly developed for supplying lower mass elements and to take benefit of the combining capabilities of magnesium in single-piece, thin-wall casting. Furthermore, the objective weights obtained using the similarity measurement method will be added to the personalized weights stated by the professionals in order to determine criterion weights.

REFERENCES

[1]. Joost, William J., and Paul E. Krajewski. "Towards magnesium alloys for high-volume automotive applications." Scripta Materialia 128 (2017): 107-112.

[2]. Godet, Stéphane, Lin Jiang, A. A. Luo, and J. J. Jonas. "Use of Schmid factors to select extension twin variants in extruded magnesium alloy tubes." Scripta Materialia 55, no. 11 (2006): 1055-1058.

[3]. Kumar, R. Praveen, P. Periyasamy, S. Rangarajan, and T. Sathish. "League championship optimization for the parameter selection for Mg/WC metal matrix composition." Materials Today: Proceedings 21 (2020): 504-510.

[4]. Ambhore, Dhairysheel, Akash Tiwari, Ujval Patel, Jishnu Patil, and M. Ramachandran. "Effect of aluminium oxide nano filler in tetrafluoroethane (R-134a) refrigerant." In IOP Conference Series: Materials Science and Engineering, vol. 810, no. 1, p. 012018. IOP Publishing, 2020.

[5]. Mohiuddin, Mohammed Quadir. "Retention strategies for talent." International Journal of Management, IT and Engineering 4, no. 10 (2014): 26-42.

[6]. Sundram, Suja, Manju Shree Raman, and S. Balamuralitharan. "Influence of process parameters on machining studies on stir casted MMCs with AA6351 and TiO2 by grey and desirability approaches." Materials Today: Proceedings 77 (2023): 551-556.

[7]. Somesh Nagalla, Deepak Das, Nihari Paladugu, A Study on Key Drivers and Deterrents in Digital Payment in the State of Odisha, Journal on Electronic and Automation Engineering, 3(2), June 2024, 25-41.

[8]. Pekguleryuz, M., and M. Celikin. "Creep resistance in magnesium alloys." International Materials Reviews 55, no. 4 (2010): 197-217.

[9]. Lee, Woo Geun, Jung-Seok Kim, Seung-Ju Sun, and Jae-Yong Lim. "The next generation material for lightweight railway car body structures: Magnesium alloys." Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit 232, no. 1 (2018): 25-42.

[10]. Tan, Jovan, and Seeram Ramakrishna. "Applications of magnesium and its alloys: A review." Applied Sciences 11, no. 15 (2021): 6861.

[11]. Stoudt, Mark R., and Richard E. Ricker. "The relationship between grain size and the surface roughening behavior of Al-Mg alloys." Metallurgical and Materials Transactions A 33 (2002): 2883-2889.

[12]. Joshi, Ritvik, Jishnu Patil, Sidakdeep Singh Luthra, and Sankalp Gaud Prof Giridhar Chavan. "Three Wheeled Omnidirectional Soccer Robot Modelling and Wireless controlling using Bluetooth enabled PlayStation Controller." REST J. Emerg. trends Model. Manuf 5, no. 2 (2019).

[13]. Mohiuddin, Mohammed Quadir. "Evaluation of Organizational Psychology using GRA Method.", Trends in Finance and Economics, 1(1), June 2023, 8-14.

[14]. Sundram, Suja, Sunil E. Tambvekar, S. Sekar, Shiv Kant Tiwari, and R. Gopinathan. "THE EFFECT OF SERVICE QUALITY ON PATIENT LOYALTY MEDIATED BY PATIENT SATISFACTION." Journal of Pharmaceutical Negative Results 13 (2022).

[15]. Somesh Nagalla, Nihari Paladugu, Deepak Das, The Development of Pedagogical Tasks and Evaluation of Computer Mediated Communication for Using GRA Method, Journal on Innovations in Teaching and Learning, 3(4), December 2024, 13-20.

[16]. Marya, Manuel, Louis G. Hector, Ravi Verma, and Wei Tong. "Microstructural effects of AZ31 magnesium alloy on its tensile deformation and failure behaviors." Materials science and engineering: A 418, no. 1-2 (2006): 341-356.

[17]. Pavlic, Olivia, Wilfredo Ibarra-Hernandez, Irais Valencia-Jaime, Sobhit Singh, Guillermo Avendaño-Franco, Dierk Raabe, and Aldo H. Romero. "Design of Mg alloys: The effects of Li concentration on the structure and elastic properties in the Mg-Li binary system by first principles calculations." Journal of Alloys and Compounds 691 (2017): 15-25.

[18]. Gupta, Nikhil, Dung D. Luong, and Kyu Cho. "Magnesium matrix composite foams—density, mechanical properties, and applications." Metals 2, no. 3 (2012): 238-252.

[19]. Cao, Xin-jin, M. Jahazi, J. P. Immarigeon, and W. Wallace. "A review of laser welding techniques for magnesium alloys." Journal of Materials Processing Technology 171, no. 2 (2006): 188-204.

[20]. Ghali, Edward, Wolfgang Dietzel, and Karl-Ulrich Kainer. "General and localized corrosion of magnesium alloys: a critical review." Journal of materials engineering and performance 13 (2004): 7-23.

[21]. Mohiuddin, Mohammed Quadir. "Role of a women entrepreneur in agcc (ARAB GULF cooperation council) women empowerment." Journal of Interdisciplinary Research (ISSN: 2408-1906) 1, no. 2 (2016).

[22]. Sundram, Suja, Himanshu Chauhan, Iskandar Muda, Femmy Effendy, Somya Choubey, and Ity Patni. "The effects of electronic word-of-mouth (E-WOM) on integrated results and destination picture of traditional image of tourists." Webology 19, no. 1 (2022): 4847-4866.

[23]. Nihari Paladugu, Somesh Nagalla, Deepak Das, Comprehensive Evaluation and Ranking of Technology-Enhanced Learning Methods A Comparative Analysis, Journal on Innovations in Teaching and Learning, 3(3), September 2024, 8-18.

[24]. Luo, Alan A., Bob R. Powell, and Michael P. Balogh. "Creep and microstructure of magnesium-aluminum-calcium based alloys." Metallurgical and Materials Transactions A 33 (2002): 567-574.

[25]. Winzer, Nicholas, Andrej Atrens, Guangling Song, Edward Ghali, Wolfgang Dietzel, Karl Ulrich Kainer, Norbert Hort, and Carsten Blawert. "A critical review of the stress corrosion cracking (SCC) of magnesium alloys." Advanced Engineering Materials 7, no. 8 (2005): 659-693.

[26]. Chia, Teck Li, Mark Alan Easton, Su-Ming Zhu, Mark A. Gibson, Nick Birbilis, and Jian Feng Nie. "The effect of alloy

composition on the microstructure and tensile properties of binary Mg-rare earth alloys." Intermetallics 17, no. 7 (2009): 481-490.

[27]. Mardani, Abbas, Mehrbakhsh Nilashi, Norhayati Zakuan, Nanthakumar Loganathan, Somayeh Soheilirad, Muhamad Zameri Mat Saman, and Othman Ibrahim. "A systematic review and meta-Analysis of SWARA and WASPAS methods: Theory and applications with recent fuzzy developments." Applied Soft Computing 57 (2017): 265-292.

[28]. Ghorabaee, Mehdi Keshavarz, Edmundas Kazimieras Zavadskas, Maghsoud Amiri, and Ahmad Esmaeili. "Multi-criteria evaluation of green suppliers using an extended WASPAS method with interval type-2 fuzzy sets." Journal of Cleaner Production 137 (2016): 213-229.

[29]. Tuş, Ayşegül, and Esra Aytaç Adalı. "The new combination with CRITIC and WASPAS methods for the time and attendance software selection problem." Opsearch 56 (2019): 528-538.

[30]. Baykasoğlu, Adil, and İlker Gölcük. "Revisiting ranking accuracy within WASPAS method." Kybernetes 49, no. 3 (2020): 885-895.

[31]. Sundram, Dr Suja, and Dr P. Kavitha. "A Review On Customer Service Quality in Big Bazaar Tirupur." Int. J. of Aquatic Science 12, no. 3 (2021): 1867-1876.

[32]. Somesh Nagalla, Deepak Das, Nihari Paladugu, Exploring Optimization Techniques Applications in Metal Cutting, Food Chemistry, and Embedded Systems, REST Journal on Advances in Mechanical Engineering, 3(2), June 2024, 15-21.

[33]. Kazimieras Zavadskas, Edmundas, Romualdas Baušys, and Marius Lazauskas. "Sustainable assessment of alternative sites for the construction of a waste incineration plant by applying WASPAS method with single-valued neutrosophic set." Sustainability 7, no. 12 (2015): 15923-15936.

[34]. Mishra, Arunodaya Raj, and Pratibha Rani. "Interval-valued intuitionistic fuzzy WASPAS method: application in reservoir flood control management policy." Group Decision and Negotiation 27 (2018): 1047-1078.

[35]. Yücenur, G. Nilay, and Ahmet Ipekçi. "SWARA/WASPAS methods for a marine current energy plant location selection problem." Renewable Energy 163 (2021): 1287-1298.

[36]. Somesh Nagalla, Nihari Paladugu, Deepak Das, Optimization of Bio-based Polymer Composites Using Grey Relational Analysis (GRA) Method, REST Journal on Advances in Mechanical Engineering, 3(3), September 2024, 19-31.

[37]. Taderera, Faustino, Said Al-Nabhani, Vibha Bhandari, Paul Sundar Kirubakaran, Hanan Hamood Abdullah Al Rahbi, Godwell Karedza, Mike Sikwila, and Suja Sundaram. "Marketing excellence: myth or reality in oman." International Journal of Arts & Sciences 7, no. 04 (2014): 195-206.

[38]. Ghorshi Nezhad, Mohammad Reza, Sarfaraz Hashemkhani Zolfani, Fathollah Moztarzadeh, Edmundas Kazimieras Zavadskas, and Mohsen Bahrami. "Planning the priority of high tech industries based on SWARA-WASPAS methodology: The case of the nanotechnology industry in Iran." Economic research-Ekonomska istraživanja 28, no. 1 (2015): 1111-1137.

[39]. Mishra, Arunodaya Raj, Rahul Kumar Singh, and Deepak Motwani. "Multi-criteria assessment of cellular mobile telephone service providers using intuitionistic fuzzy WASPAS method with similarity measures." Granular Computing 4 (2019): 511-529.

[40]. Ayyildiz, Ertugrul, and Alev Taskin Gumus. "A novel spherical fuzzy AHP-integrated spherical WASPAS methodology for petrol station location selection problem: a real case study for İstanbul." Environmental Science and Pollution Research 27, no. 29 (2020): 36109-36120.