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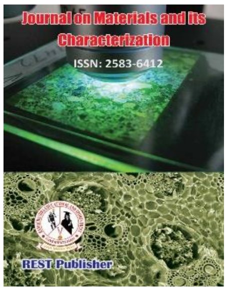

Efficiency and Innovation: Exploring the World of Material Handling Equipment for Marine Applications

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Abstract: *Material handling is a critical aspect of industrial and marine operations, ensuring the efficient movement, storage, control, and protection of goods and materials. It enhances productivity, reduces costs, and minimizes workplace hazards through specialized equipment such as conveyors, cranes, forklifts, automated guided vehicles (AGVs), robotics, and storage systems. In marine applications, material handling equipment is vital for shipbuilding, port logistics, and offshore operations, utilizing durable cranes, hoists, and conveyor systems designed for harsh environments. With advancements in automation, artificial intelligence (AI), and the Internet of Things (IoT), material handling systems now feature real-time monitoring, predictive maintenance, and improved safety measures. The Grey Relational Analysis (GRA) methodology offers a structured approach to evaluating equipment effectiveness based on key criteria, such as Positioning Equipment, Unit Load Formation Equipment, Storage Equipment, and Identification and Control Equipment. An assessment of alternative solutions—Air Film Devices, Slipsheets, Manipulators, Bar Codes, and Magnetic Stripes—ranked Air Film Devices highest in efficiency, while Manipulators ranked lowest. Selecting the right material handling equipment is essential for optimizing industrial and maritime operations, improving productivity, and ensuring a safe working environment through technological advancements and systematic evaluation methods.*

Keywords: *Internet of Things, GRA methodology, Air Film Devices*

1. INTRODUCTION

Material handling (MH) plays a crucial role in optimizing the movement, storage, and control of materials within facilities and between transportation systems, providing time and place utility that enhances efficiency. While often perceived as a cost-adding function rather than a value-adding one, MH contributes significantly by improving productivity, reducing bottlenecks, and increasing machine utilization. Effective Material Handling System (MHS) design typically focuses on cost minimization, though a comprehensive approach considers total production costs, layout constraints, and process modifications. The "Ten Principles of Material Handling," established by the College-Industry Council on Material Handling Education (CIC-MHE) and the Material Handling Institute (MHI), provide strategic guidance for optimizing MHS design. These principles emphasize planning, standardization, minimizing unnecessary MH work, ergonomics, proper unit load sizing, efficient space utilization, system integration, automation, environmental sustainability, and life cycle cost analysis. In industries such as manufacturing, logistics, and marine operations, adhering to these principles ensures seamless material flow, reduces operational inefficiencies, and enhances safety. In marine applications, specialized MH equipment such as shipyard cranes, offshore hoists, and automated cargo handling systems is essential for efficient port logistics and vessel operations. With advancements in automation, robotics, and IoT-enabled monitoring, modern MH systems offer predictive maintenance and data-driven decision-making, further improving efficiency and safety. By strategically selecting and integrating MH equipment while considering technological advancements and industry-specific needs, organizations can optimize productivity, reduce costs, and ensure a sustainable, safe working environment.

2. MATERIALS AND METHODS

The GRA (Grey Relational Analysis) method is a useful tool used in the field of material handling equipment to evaluate and optimize the performance of different equipment options. It is a multi-criteria decision-making approach that considers multiple factors and their interrelationships to determine the best solution. The GRA method is particularly suitable when dealing with complex decision problems that involve multiple criteria and uncertain or imprecise data. It helps decision-makers rank and compare alternatives based on their relative closeness to an ideal solution. In the context of material handling equipment, GRA can be applied to assess and select the most suitable equipment based on various performance indicators such as efficiency, cost, safety, and environmental impact. The following steps outline the general process of applying GRA in the evaluation of material handling equipment:
Problem Identification: Clearly define the objectives, criteria, and constraints of the material handling equipment evaluation. This involves identifying the specific performance indicators that need to be considered, such as throughput capacity, energy consumption, reliability, maintenance requirements, and ergonomic factors.
Data Collection: Gather relevant data for each criterion and alternative equipment options. This may involve conducting surveys, collecting historical data, consulting experts, or using existing literature and databases. It is important to ensure the accuracy and consistency of the data collected.
Data Pre-processing: Normalize the collected data to eliminate measurement units and scale differences. Normalization brings all criteria to a comparable range and ensures that no single criterion dominates the evaluation process. Different normalization methods can be used, such as linear scaling or normalization by reference values.

Grey Relational Generation: Calculate the grey relational coefficients to measure the relationship between the normalized data of each alternative and the ideal solution. The grey relational coefficient reflects the similarity or closeness of an alternative to the ideal solution for each criterion. There are different formulas available for calculating grey relational coefficients, such as the absolute difference approach or the exponential weighting approach.

Grey Relational Analysis: Aggregate the grey relational coefficients for each alternative across all criteria to obtain a comprehensive grey relational grade. The grey relational grade represents the overall performance of each alternative. The alternative with the highest grey relational grade is considered the most suitable choice.
Sensitivity Analysis: Conduct sensitivity analysis to assess the robustness of the results. This involves examining how changes in the weights assigned to criteria or variations in the data affect the ranking of alternatives. Sensitivity analysis helps identify critical criteria and their impact on the final decision.

Decision-Making and Selection: Based on the results of the GRA, make an informed decision and select the most appropriate material handling equipment option that aligns with the desired objectives and performance criteria. It is important to note that the GRA method is just one approach among many decision-making methods available for evaluating material handling equipment. The suitability and effectiveness of the GRA method depend on the specific context and the quality of data and assumptions used in the evaluation. In summary, the GRA method provides a systematic and quantitative approach for evaluating and selecting material handling equipment. By considering multiple criteria and their interrelationships, it helps decision-makers make informed choices that optimize performance and meet the requirements of their material handling operations.

3. RESULTS AND DISCUSSIONS

TABLE 1. Material handling equipment

	Positioning Equipment	Unit load Formation Equipment	Storage Equipment	Identification and Control Equipment
Air Flim Device	43.65	140.69	33.16	35.63
Slipsheets	23.63	142.97	38.65	45.63
Manipulator	36.63	130.56	42.51	53.36
Bar Codes	23.17	148.50	46.51	41.63
Magnetic stripes	45.56	186.41	36.65	50.16

Table 1 represents the Material handling equipment, in this alternative and Evaluation Values Air film device got highest value and bar codes shows the lowest value.

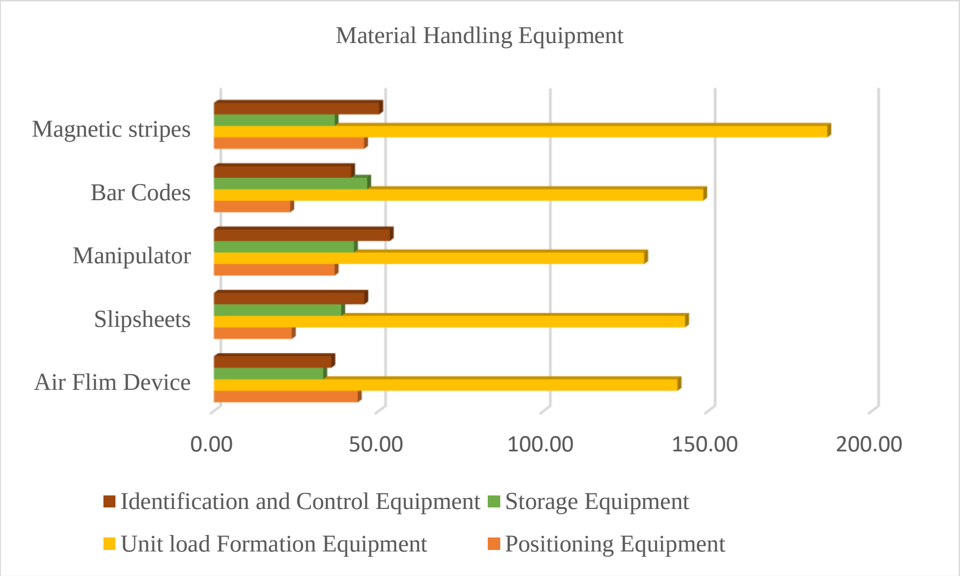

FIGURE 1. Material handling equipment

Figure 1 represents the Material handling equipment, in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

TABLE 2. Normalized Data

Positioning Equipment	Unit load Formation Equipment	Storage Equipment	Identification and Control Equipment
0.9147	0.1814	1.0000	1.0000
0.0205	0.2222	0.5888	0.4360
0.6012	0.0000	0.2996	0.0000
0.0000	0.3212	0.0000	0.6616
1.0000	1.0000	0.7386	0.1805

Table 2 represents the Material handling equipment of Normalized Data, in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

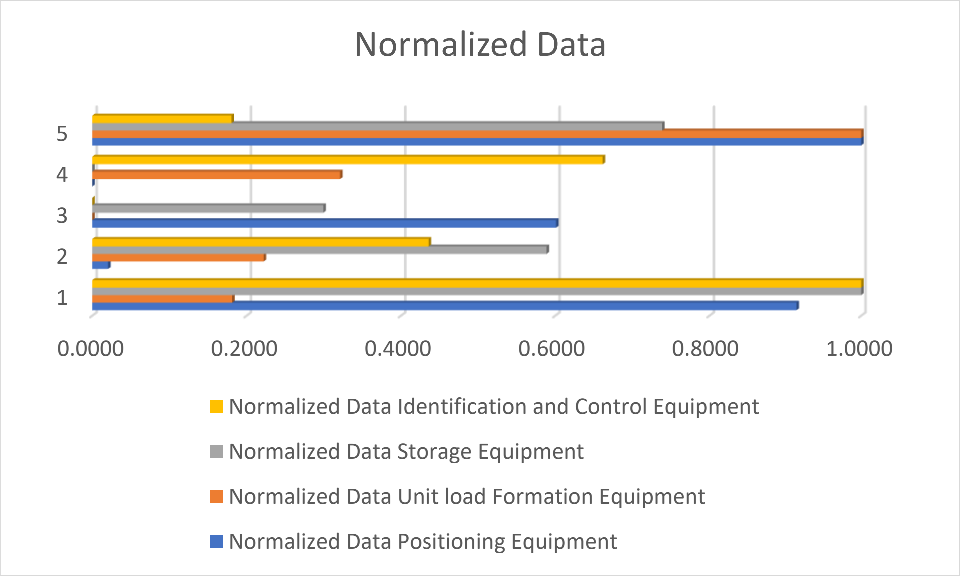

FIGURE 2. Normalized Data

Figure 2 represents the Material handling equipment of Normalized Data, in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

TABLE 3. Deviation sequence

Positioning Equipment	Unit load Formation Equipment	Storage Equipment	Identification and Control Equipment
0.0853	0.8186	0.0000	0.0000
0.9795	0.7778	0.4112	0.5640
0.3988	1.0000	0.7004	1.0000
1.0000	0.6788	1.0000	0.3384
0.0000	0.0000	0.2614	0.8195

Table 3 represents the Material handling equipment of Deviation sequence in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

TABLE 4. Grey relation coefficient

Positioning Equipment	Unit load Formation Equipment	Storage Equipment	Identification and Control Equipment
0.8543	0.3792	1.0000	1.0000
0.3380	0.3913	0.5487	0.4699
0.5563	0.3333	0.4165	0.3333
0.3333	0.4242	0.3333	0.5964
1.0000	1.0000	0.6567	0.3789

Table 4 represents the Material handling equipment of Grey relation coefficient in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

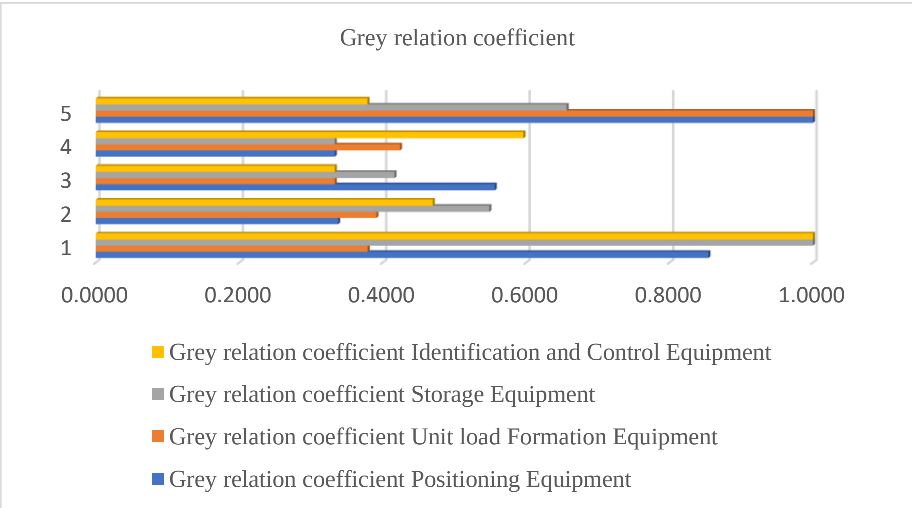

FIGURE 3. Grey relation coefficient

Figure 3 represents the Material handling equipment of Grey relation coefficient in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

TABLE 5. Rank

	GRG	Rank
Air Flim Device	0.8084	1
Slipsheets	0.4370	3
Manipulator	0.4099	5
Bar Codes	0.4218	4
Magnetic stripes	0.7589	2

Table 5 represents the Material handling equipment of rank in this alternative and Evaluation values Air film device got first rank and bar codes got last rank.

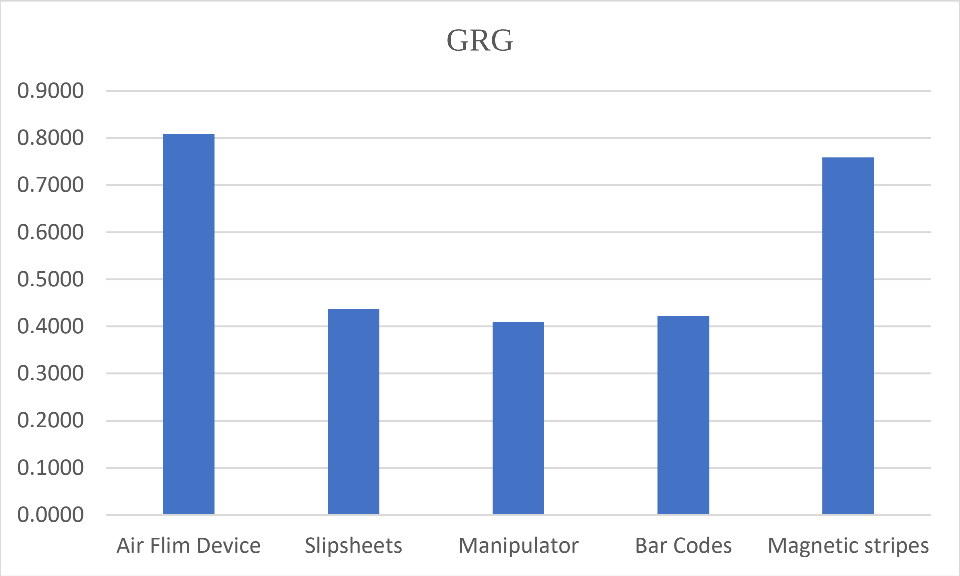

FIGURE 4. GRG

Figure 4 represents the Material handling equipment of GRG in this alternative and Evaluation values Air film device got highest value and bar codes shows the lowest value.

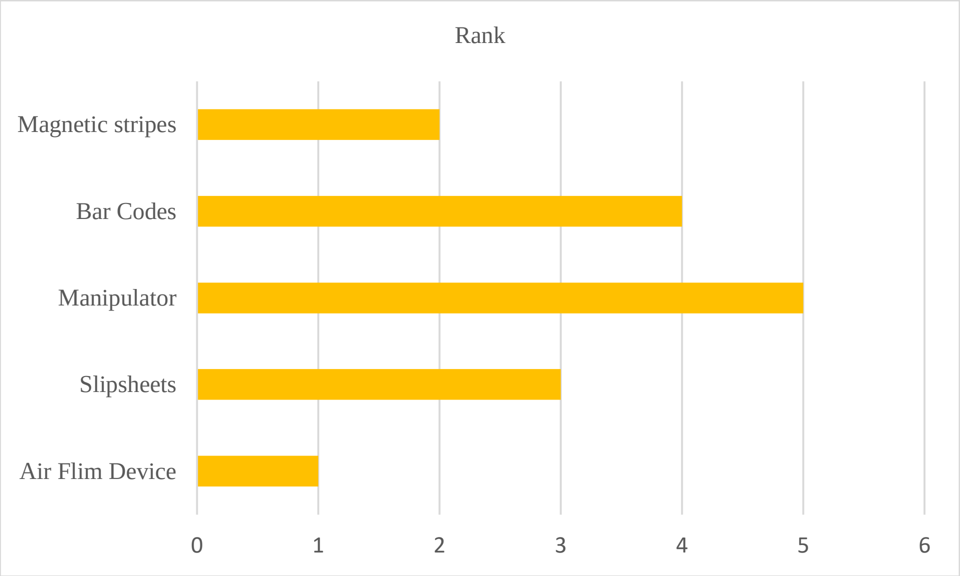

FIGURE 5. Rank

Table 5 represents the Material handling equipment of rank in this alternative and Evaluation values Air film device got first rank and bar codes got last rank.

4. CONCLUSION

Material handling equipment plays a critical role in various industries by facilitating the movement, storage, control, and protection of goods and materials. The efficient and safe handling of materials is essential for optimizing productivity, reducing costs, and minimizing the risk of injuries and accidents. Throughout this paper, we have explored the significance of material handling equipment in streamlining operations and ensuring workplace safety. We have examined different types of equipment commonly used in industries, highlighted their benefits, emphasized the importance of safety, and discussed the factors to consider when selecting the right equipment based on specific industry requirements. Material handling equipment encompasses a wide range of tools and machinery designed to handle different types of materials, including conveyors, cranes, forklifts, pallet jacks, and automated systems. These equipment options are crucial for achieving efficient material flow, reducing manual labor, and optimizing storage and transportation processes. By investing in the appropriate material handling equipment, organizations can enhance operational efficiency, improve throughput, and minimize product damage and losses. One of the key benefits of utilizing proper material handling equipment is the improvement in productivity. By automating manual tasks and reducing physical strain on workers, equipment enables faster and more efficient material movement. This leads to increased production rates, shorter cycle times, and improved overall operational performance. Additionally, material handling equipment helps optimize space utilization, allowing organizations to maximize their storage capacity and streamline inventory management. Furthermore, material handling equipment significantly contributes to workplace safety. The use of appropriate equipment reduces the risk of manual handling injuries, such as strains and sprains, by minimizing the need for manual lifting and carrying of heavy objects. Safety features such as load sensors, interlocks, and ergonomic designs further enhance worker safety. Moreover, equipment like automated guided vehicles (AGVs) and robotic systems can operate in hazardous environments, reducing the exposure of workers to potential dangers. When selecting material handling equipment, several factors must be considered. Load characteristics, such as weight, shape, and fragility, should be matched with the equipment's capacity and capabilities. Space constraints, layout design, and facility infrastructure are also important considerations. Operational complexity, including the required level of automation and integration with other systems, should align with the organization's goals and capabilities. Additionally, future scalability and adaptability of the equipment to evolving business needs should be evaluated to ensure long-term viability. In conclusion, material handling equipment is an integral part of modern industrial operations. It provides the means to efficiently and safely handle materials, contributing to increased productivity, reduced costs, and improved workplace safety. By understanding the various equipment options available and considering the specific requirements of their industry, organizations can make informed decisions to optimize their material handling operations. Investing in the right equipment and embracing technological advancements in this field will undoubtedly yield significant benefits and competitive advantages in today's dynamic business landscape.

REFERENCES

[1]. Kay, Michael G. "Material handling equipment." *Fitts Dept. of Industrial and Systems Engineering North Carolina State University* 65 (2012).

[2]. Chakraborty, Shankar, and Debabrata Banik. "Design of a material handling equipment selection model using analytic hierarchy process." *The International Journal of Advanced Manufacturing Technology* 28 (2006): 1237-1245.

[3]. Onut, Semih, Selin Soner Kara, and Sinan Mert. "Selecting the suitable material handling equipment in the presence of vagueness." *The International Journal of Advanced Manufacturing Technology* 44, no. 7-8 (2009): 818-828.

[4]. Chan, F. T. S., R. W. L. Ip, and H. Lau. "Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system." *Journal of Materials Processing Technology* 116, no. 2-3 (2001): 137-145.

[5]. Mathew, Manoj, and Sagar Sahu. "Comparison of new multi-criteria decision making methods for material handling equipment selection." *Management Science Letters* 8, no. 3 (2018): 139-150.

[6]. Tuzkaya, Gülfem, Bahadır Gülsün, Cengiz Kahraman, and Doğan Özgen. "An integrated fuzzy multi-criteria decision making methodology for material handling equipment selection problem and an application." *Expert systems with applications* 37, no. 4 (2010): 2853-2863.

[7]. Fisher, Edward L., Jeremy B. Farber, and Michael G. Kay. "MATHES: an expert system for material handling equipment selection." *Engineering Costs and Production Economics* 14, no. 4 (1988): 297-310.

[8]. Mohsen, and Hassan. "A framework for selection of material handling equipment in manufacturing and logistics facilities." *Journal of Manufacturing Technology Management* 21, no. 2 (2010): 246-268.

[9]. Horňáková, Natália, Lukáš Jurík, Henrieta Hrablik Chovanová, Dagmar Cagáňová, and Dagmar Babčanová. "AHP method application in selection of appropriate material handling equipment in selected industrial enterprise." *Wireless Networks* 27, no. 3 (2021): 1683-1691.

[10]. Chu, H-K., P. J. Egbelu, and Chung-Te Wu. "ADVISOR: A computer-aided material handling equipment selection system." *International Journal of Production Research* 33, no. 12 (1995): 3311-3329.

[11]. Kulak, Osman. "A decision support system for fuzzy multi-attribute selection of material handling equipments." *Expert systems with applications* 29, no. 2 (2005): 310-319.

[12]. Chatterjee, Saikat, and Shankar Chakraborty. "Application of the R method in solving material handling equipment selection problems." *Decision Making: Applications in Management and Engineering* (2022).

[13]. Karande, Prasad, and Shankar Chakraborty. "Material handling equipment selection using weighted utility additive theory." *Journal of Industrial Engineering* 2013 (2013).

[14]. Mirhosseyni, S. Hamid L., and Phil Webb. "A hybrid fuzzy knowledge-based expert system and genetic algorithm for efficient selection and assignment of material handling equipment." *Expert Systems with Applications* 36, no. 9 (2009): 11875-11887.

[15]. Raman, Dhamodharan, Sev V. Nagalingam, Bruce W. Gurd, and Grier CI Lin. "Quantity of material handling equipment—A queuing theory based approach." *Robotics and Computer-Integrated Manufacturing* 25, no. 2 (2009): 348-357.
[16]. Soufi, Zakarya, Pierre David, and Zakaria Yahouni. "A methodology for the selection of Material Handling Equipment in manufacturing systems." *IFAC-PapersOnLine* 54, no. 1 (2021): 122-127.
[17]. Mousavi, S. Meysam, Behnam Vahdani, Reza Tavakkoli-Moghaddam, and N. Tajik. "Soft computing based on a fuzzy grey group compromise solution approach with an application to the selection problem of material handling equipment." *International Journal of Computer Integrated Manufacturing* 27, no. 6 (2014): 547-569.
[18]. Hadi-Vencheh, A., and Amir Mohamadghasemi. "A new hybrid fuzzy multi-criteria decision making model for solving the material handling equipment selection problem." *International Journal of Computer Integrated Manufacturing* 28, no. 5 (2015): 534-550.
[19]. Yun, Lingxiang, Lin Li, and Shuaiyin Ma. "Demand response for manufacturing systems considering the implications of fast-charging battery powered material handling equipment." *Applied Energy* 310 (2022): 118550.
[20]. MD Hassan, Mohsen. "An evaluation of input and output of expert systems for selection of material handling equipment." *Journal of Manufacturing Technology Management* 25, no. 7 (2014): 1049-1067.
[21]. Carli, Raffaele, Salvatore Digiesi, Mariagrazia Dotoli, and Francesco Facchini. "A control strategy for smart energy charging of warehouse material handling equipment." *Procedia Manufacturing* 42 (2020): 503-510.
[22]. Goswami, Shankha Shubhra, and Dhiren Kumar Behera. "Solving material handling equipment selection problems in an industry with the help of entropy integrated COPRAS and ARAS MCDM techniques." *Process Integration and Optimization for Sustainability* 5, no. 4 (2021): 947-973.
[23]. Sayarshad, Hamid Reza. "Using bees algorithm for material handling equipment planning in manufacturing systems." *The International Journal of Advanced Manufacturing Technology* 48 (2010): 1009-1018.
[24]. Asef-Vaziri, Ardavan, and Gilbert Laporte. "Loop based facility planning and material handling." *European Journal of Operational Research* 164, no. 1 (2005): 1-11.
[25]. Khandekar, Anant V., and Shankar Chakraborty. "Selection of material handling equipment using fuzzy axiomatic design principles." *Informatica* 26, no. 2 (2015): 259-282.
[26]. Momani, Amer M., and Abdulaziz A. Ahmed. "Material handling equipment selection using hybrid Monte Carlo simulation and analytic hierarchy process." *International Journal of Industrial and Manufacturing Engineering* 5, no. 11 (2011): 2170-2175.
[27]. Wei, Gui-Wu. "GRA method for multiple attribute decision making with incomplete weight information in intuitionistic fuzzy setting." *Knowledge-Based Systems* 23, no. 3 (2010): 243-247.
[28]. Liu, Sifeng, Yingjie Yang, Ying Cao, and Naiming Xie. "A summary on the research of GRA models." *Grey Systems: Theory and Application* 3, no. 1 (2013): 7-15.