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Decision-Making Framework for Manufacturing Process Selection Using the Weighted Sum Method

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Abstract: *The system generates a sorted list of other options for compatible materials and manufacturing techniques. This approach has advantages over current systems that are either deficient in decision modules or are not coupled with databases. Decisions on materials and manufacturing techniques must be determined before design for manufacture can begin. The prototype material and manufacturing process selection system known as MAMPS, which integrates a relational database and a formal multi-attribute decision model, is introduced in this paper. The decision model allows the designer's preferences in connection to the deciding elements to be represented. The needs of the product profile and the alternatives stored in the database are rated for compatibility with each choice criterion using possibility theory. The vector of compatibility ratings is used to calculate a single compatibility rating for the alternative. The possibility theory is used to produce choice criteria. It rates how well the alternatives stack up against the needs of the product profile. The vector of compatibility ratings is used to calculate a single compatibility rating for the alternative. A prioritized list of compatible material and manufacturing process alternatives is generated by the system. This approach has advantages over existing systems that either don't have a decisionmodule or aren't linked to a database. The choice of manufacturing processes has a significant impact on product quality, cost-effectiveness, and sustainability, which makes it an important research topic. Researchers can improve production processes, increase efficiency, decrease waste, and develop cutting-edge techniques by researching various process options, which helps to advance the manufacturing industries around the world. Evaluation of various factors, including cost, quality requirements, production volume, material properties, and equipment capabilities, is necessary when choosing a manufacturing process methodology. Finding the best strategy that maximises efficiency, complies with requirements, and supports business goals requires careful analysis and consideration. Taken as Alternative parameters for Process, Sand casting, Gravity die casting, Investment casting, Pressure die casting, Additive manufacturing. Taken as Evaluation parameter for Productivity, Accuracy, Complexity, Flexibility, Material utilization, Quality, Operation cost. The first ranking training is obtained with the lowest quality of compensation.*

Keywords: *Sand casting, Gravity die casting, Investment casting, Pressure die casting, Additive manufacturing.*

1. INTRODUCTION

The product life cycle accords great importance to product development, which details every step from the conception of the product to its introduction to the market. [1] A product's design and fabrication methods must be pursued concurrently in the competitive markets of today. Some of the most important choices that affect overall costs are made during the engineering design phase (Whitney, 1988). Up to 70% of a product's cost, according to some estimates, is decided during the design stage. This realisation has led to a rise in the popularity of concurrent engineering. Concurrent engineering is the practise of parallelizing project-related tasks. Early Manufacturing consideration is an essential part of concurrent engineering. in order to cut down on the amount of time, money, and quality flaws involved in product design. This is done while keeping in mind a specific manufacturing method, which is known as design for manufacturing, or DFM. After DFM, a potentially important decision-making process is the selection of the materials and manufacturing techniques. [2] Concurrent engineering must be taken into consideration when creating a product. One of the concurrent engineering concepts is early decision-making, and early manufacturing process consideration is a key element of concurrent engineering to reduce product development time, production costs, and quality flaws. Many researchers have talked about the importance of using the concurrent engineering concept to choose the best production technique for a specific circumstance. thing referred to in the writing. One of the first stages in the process of developing a product is conceptual design [3]. It has been determined that the conceptual design phase, which starts the product development process, is crucial for the successful launch of new products. Historically, selecting a manufacturing procedure [4] The manufacturing sector is presently under a lot of pressure as a result of market globalisation. Internal and external pressures on organisations have boosted competition, complicated markets, and created new client demands. It has been noted that businesses employ agile or lean manufacturing methods for resolving this problem. The methods used to design the production system must take into account a wide range of components and methodologies, but they all rely on two things in particular: the availability of equipment and people's aptitude for using this technology. [5] Given the profound changes in the industrial market brought on by globalisation and delocalization, it is challenging to be competitive in all businesses. To increase product quality and reduce production costs, the proper information must be given. [6] Choosing an AM manufacturing process remains more challenging than choosing a traditional manufacturing process. For each of the various conventional production methods, a vast amount of information has been gathered over time. techniques. In engineering, much of it is now considered "common sense". and different systems have evolved over time to support their conceived and intended applications. This cannot be said about AM processes, though. There are six sections in this article. A review of the AM literature is given in Section 2. In Section 3[9], the research methodology and the generated solution are described.

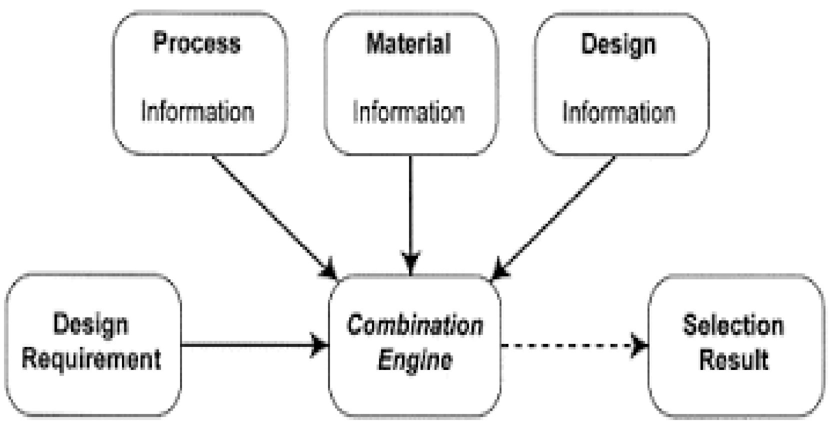

FIGURE 1.

2. MATERIALS AND METHOD

Process: Process Despite its limitations in terms of the weighted sum method for multi-objective optimisation (MOO) is still widely used because it can provide not only multiple solution points by uniformly varying the weights, but also a single solution point that reflects preferences presumably taken into account.

Sand casting: Sand casting Design optimisation seeks to identify the best design that minimises the objective function by modifying design variables while observing design constraints. When performing design optimisation, it is frequently necessary to consider multiple design criteria or objective functions at once. Engineering and the social sciences both use the Pareto optimum solutions concept from economics.

Gravity die casting: Gravity die casting Situations that fall under the umbrella of Pareto efficiency are those in which it is impossible to improve one person's situation without necessarily worsening another person's. In the absence of the explicit forms of the objective functions, a new method for approximating the Pareto front of a multi-objective simulation optimisation problem (MOP) is proposed in this work. The approach employs a weighted sum method to break down the MOP into a set of single objective optimisation problems, iteratively approximating each objective function using a scheme. Design optimisation is the process of changing design variables while adhering to design constraints in order to find the objective function. A fantastic surface reflection to improve the functionality and spectral overall performance of wireless networks has emerged. as a potential approach. Each of the many reflecting additives that make up the IRS is specifically a signal propagator.

Investment casting: Investment casting Most practical engineering design problems involve maximising a number of objectives. Since many daily decisions are based on a variety. It is crucial to identify the problem's structure and explicitly evaluate various criteria. Recently, the industry has placed a greater emphasis on improving the efficiency of complex systems, including aircraft. To develop cutting-edge design and optimisation techniques for complex systems, a new engineering discipline called multidisciplinary design optimisation (MDO) has emerged.

Pressure die casting: Pressure die casting Decomposition methodologies have significant advantages for the solution of complex MDO problems because they enable the division of a large linked problem into smaller, more manageable sub problems. The obvious benefit of solving smaller problems is one of the gains in computing that results, but another benefit is the potential creation of a distributed processing environment. The main advantage, however, is the reduction in personal hours since groups are no longer required to wait around for other groups in the process to finish their design duties.

Additive manufacturing: Production using additives High schools are currently inundated with a vast amount of data pertaining to student enrollment, the number of courses they have finished, their success in each course, performance indicators, and other information. Schools should be the most preferred location for children to engage in activities like learning, playing, and developing creativity because this has led to an analytical process that is more complex due to the increasing volume of data and the inability. Holding the best candidate elections is crucial in order to create a comfortable and enjoyable learning environment. A system known as a decision support system is required to decide which school is the best in a certain location. A computer-based tool known as a decision support system collects data from various sources it, conducts analysis on it, and makes it simpler to evaluate the underlying assumptions of different models.

Evaluation parameter:

Productivity: Productivity The WSM and MADMWP methodologies can be used to identify the best schools, but only those that create the highest value will be selected as the top option. If the alternative is chosen and it meets the required requirements, the calculation will be done using this approach. This approach was chosen because it allows for the determination of the values for each attribute, followed by the selection of the best alternative, which in this case is the top-ranked school according to the established criteria. In this study, the WSM and MADMWP methodologies are used to create a decision will be addressed to the director of the department of education in which served as the study's sample districts.

Accuracy: Accuracy We must choose the best option from among the many possibilities provided by the weighted sum approach, which is a multi-criteria decision-making process. Multiply each number by its weight, then aggregate the results to obtain the weighted average. If the weights do not line up, multiply the total by each variable's weight before dividing by the total. The most hazardous hazard is waste produced by nuclear reactors and power plants. Despite their high levels of production, hazardous waste is strictly monitored and controlled in the United States and other nations. harm distribution, harm mitigation, and regulatory interactions are all part of the framework for public policy as well as the management of hazardous waste. Production of hazardous waste is influenced by industry, and both effects seem to be definite. With constant-effects variables added, the comparison of r2 with adjusted across ratings demonstrates a significant improvement. In particular, estimates of hazardous waste that use industry-standard support the theory that size is affected by independent organizational scale affects. the usage of hazardous waste that has not been handled cut down on waste. Therefore, the legal goal of include the system in our hazardous waste assessment is to ensure that it is enough to change waste production and generate economic incentives. In order to locate points like attitude, we apply heuristic methods to aggregate the weights on the barrette-optimal front. Weighing in the sum method entails multiplying each of our goals by the user-provided weight in order to quantify the group of objectives as a single target. One of the most popular strategies is this one.

Complexity: Particularly in recent years, the complexity system is frequently presented solely as a tool, and there is a wealth of literature outlining examples of applications. However, paying attention to application is costly, and there are only two objective functions that are problematic. As an early application for the approach reduced size and nodal displacement is frequently assessed by taking into account common measurements. However, because the options are ambiguous.

Flexibility: Flexibility It is uncommon for the cheapest car to also be the safest and most pleasant. When managing a portfolio, our goals include maximizing returns while minimizing risks. Once more, stocks with great return potential often also have significant risk of losing money. Customer happiness and service costs are two competing variables that should be considered in the service sector. In our daily lives, we frequently take a number of factors into consideration implicitly, and we might be satisfied with the outcomes of choices based solely on intuition. On the other hand, when the stakes are high, it's critical to clearly define the problem and explicitly examine a number of factors. There are numerous parties that will be significantly impacted by the decision's outcomes when deciding whether to build a nuclear power plant and where to do so, in addition to extremely complicated concerns like numerous variables. The Weighted Sum Method (WSM) is most likely the most well-known and frequently applied multiple-criteria decision-making technique. A fundamental discussion is provided, and the process is thoroughly defined. The decision maker gives importance weights which constitute the variables' coefficients to each of the SAW criteria. To be normalized, these weight coefficients must be.

Material utilization: Material utilization The decision maker additionally develops a numerical scale of the intra-criteria values to reflect their evaluations of marginal worth within the criteria. The decision-maker can then calculate the total score for each alternative by adding the scale ratings for each criterion's value and its importance weight, and then averaging these results across all the criteria. The alternative with the greatest score is suggested to the decision maker after the total scores for each alternative have been calculated. When the circumstance is static, the present Weighted Sum Method aids the decision-maker. However, another important component that frequently affects judgement is the consideration of the passage of time. In this paper, a Dynamic Weighted Sum Method (DWSM) mathematical model is proposed. To further clarify the DWSM, a numerical example is provided, and several potential applications of the DWSM have been described.

Quality: quality and choosing options in line with the decision-maker's values and preferences is quality science. Multi-criteria decision making is a branch of operations research that addresses problems involving many criteria in decision-making. Multiple-Criteria Decision Making's most well-known and frequently used approach, the Weighted Sum approach (WSM), has been proposed as a means of resolving decision-making issues. The Weighted Sum Method, often known as a static weighted sum method, is time independent. This paper introduces the Dynamic Weighted Sum Model and presents the mathematical model for it. This model can be utilized in situations when more complicated Dynamic Weighted Sum Multi-Criteria Decision operations are not necessary. the disciplines of social sciences, medicine, politics, education, and economics.

Weighted sum method (WSM): Individual or a decision-maker, rather than capturing the true preferences of a group or society. The weighted sum method is a popular approach for multi-objective optimization problems, where multiple conflicting objectives need to be considered simultaneously. It involves assigning weights to each objective function to reflect their relative importance. By systematically varying the weights, different solutions can be obtained that trade-off between the objectives. Made an early application of the weighted sum method to generate multiple Pareto optimal solutions by changing the weights systematically. Their focus was on reducing size and nodal displacement, and they used the weighted sum approach to explore different trade-offs between these objectives. While the weighted sum method can be a useful tool, it has limitations. One of the main drawbacks is that it relies on the decision-maker to specify the weights, which can be subjective and may not capture the true preferences of a group or society. This approach may reflect the will of an individual decision-maker rather than considering a broader perspective. To address this limitation, other approaches have been developed, such as interactive methods or evolutionary algorithms, that allow decision-makers to explore the trade-offs between objectives and refine their preferences through a process of interaction and iteration. These methods aim to capture a more comprehensive understanding of the problem's objectives and preferences, incorporating diverse viewpoints and avoiding undue influence from a single decision-maker .In summary, the weighted sum method is a valuable tool for multi-objective optimization, but it should be used with caution, especially when it comes to capturing the preferences of a group or society. Considering alternative approaches that facilitate interaction and iteration can lead to more robust and inclusive decision-making processes. Yes, determining the weights in the weighted sum method can be challenging, especially when the options or criteria are vague or when there are conflicting opinions on their importance. In multi-criteria decision-making, the goal is to find the best alternative based on multiple criteria, and assigning appropriate weights is crucial in this process. To calculate the weighted average using the weighted sum method, you multiply each value by its corresponding weight and then sum up the results. This approach assumes that the weights are proportional to the relative importance of the criteria. If the weights do not add up to one, you can normalize them by multiplying each variable by its weight and then dividing the sum of all the weighted variables by the sum of the weights. In the context of waste generated by nuclear power plants and nuclear facilities, it is often considered a significant and potentially dangerous hazard. Proper waste management is crucial to minimize the risks associated with nuclear waste. Weighting the criteria related to waste generation and its impact can help decision-makers prioritize solutions or evaluate different alternatives. When dealing with complex and sensitive issues like nuclear waste, it is important to involve experts, stakeholders, and consider multiple perspectives to determine the appropriate weights for the criteria. This can help ensure that decisions are well-informed, transparent, and consider a broader range of factors, including safety, environmental impact, and public health concerns. The significant influence of industry on hazardous waste production. The regulation and control of hazardous waste in the United States and other industrialized countries are important to mitigate the potential negative impacts on public health and the environment. .By including industry-related variables and controlling for other factors, such as constant-effects variables, in the analysis, researchers can better understand the relationship between industry and hazardous waste generation. Different estimation techniques, including those incorporating fixed effects, can provide additional insights into the impact of industry on hazardous waste production. In summary, the regulation and control of hazardous waste in industrialized countries, including the United States, are important for protecting public health and the environment. Industry has a significant influence on hazardous waste production, and evaluating its impact involves considering various components of the regulatory framework and conducting statistical analyses that account for relevant variables. It seems like you're discussing various aspects related to hazardous waste and the assessment of waste management systems. However, the provided information is fragmented and lacks context. If you could please provide a clear question or specific topic you would like to discuss, I'll be happy to provide relevant information and assistance. Continued research and advancements in this field are crucial for developing sustainable and efficient waste management practices. Transport planning for hazardous waste is a critical aspect of ensuring its safe and efficient disposal. The condensed quadratic optimization model proposed by Hsu et al. provides a practical approach to address this issue. This model aims to optimize the transportation logistics while considering various factors and constraints. The use of the Analytical Hierarchy Process (AHP) and the modified Delphi technique by Hsu et al. in the medical field can help in selecting the appropriate hazardous waste disposal company. AHP allows decision-makers to systematically evaluate and prioritize criteria and alternatives, while the modified Delphi technique involves gathering expert opinions and achieving consensus in decision-making. When assessing the health effects arising from hazardous waste exposure, it is important to consider various factors, including socioeconomic factors. These factors can play a significant role in understanding the impact on vulnerable populations, evaluating potential risks, and implementing appropriate mitigation measures. Regular assessment of hazardous waste generation and its impact on health is crucial to identifying trends, addressing emerging concerns, and implementing effective strategies for waste management. Monitoring and evaluating the health effects arising from exposure can help inform decision-making processes and guide the development of policies and regulations.

3. RESULT AND DISCUSSION

Table 1. Selection of manufacturing process data set

	Productivity	Accuracy	Complexity	Flexibility	Material utilization	Quality	Operation cost
Sand casting,	6	2	8	8	4	3	5
Gravity die casting	8	7	2	5	6	9	7
Investment casting	5	8	8	7	8	9	9
Pressure die casting	8	8	3	7	7	9	9
Additive manufacturing	3	7	8	9	9	9	9

Table no.1 shows the Selection of manufacturing process date set using the Analysis method in WSM

"Alternative: Productivity" "Evaluation preference Process, Sand casting, Gravity die casting Investment casting, Pressure die casting Additive manufacturing,"

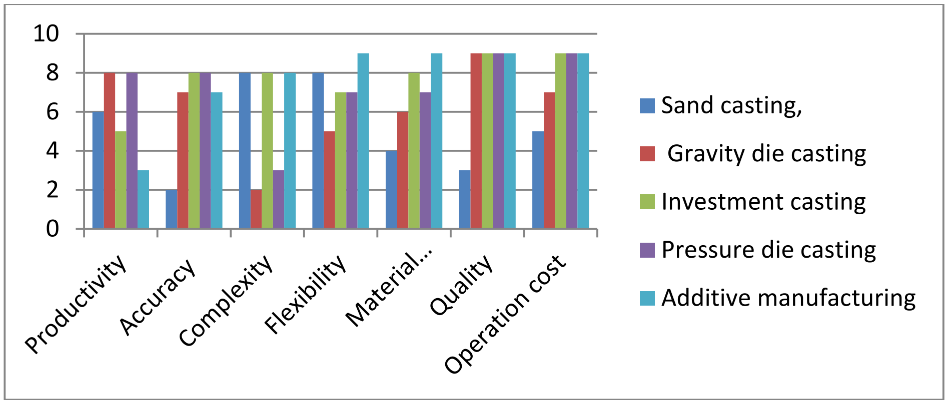

FIGURE 1. Selection of manufacturing process data set

Figure 1 Shows the in use productivity it is seen that is showing the highest value for sand casting for Selection of manufacturing process ''Alternative. Productivity''. "Evaluation preference: Process, Sand casting, Gravity die casting Investment casting, Pressure die casting Additive manufacturing." Also data set.

Table 2 selection of manufacturing process Normalized data

Process	Productivity	Accuracy	Complexity	Flexibility	Material utilization	Quality	Operation cost
Sand casting	0.75000	0.25000	1.00000	0.88889	0.44444	0.33333	1.00000
Gravity die casting	1.00000	0.87500	0.25000	0.55556	0.66667	1.00000	0.71429
Investment casting	0.62500	1.00000	1.00000	0.77778	0.88889	1.00000	0.55556
Pressure die casting	1.00000	1.00000	0.37500	0.77778	0.77778	1.00000	0.55556
Additive manufacturing	0.37500	0.87500	1.00000	1.00000	1.00000	1.00000	0.55556

Table no.2 the shows Normalized data for Selection of manufacturing process "Alternative: Productivity." "Evaluation preference: Process, Sand casting, Gravity die casting Investment casting, Pressure die casting Additive manufacturing" also normalized data.

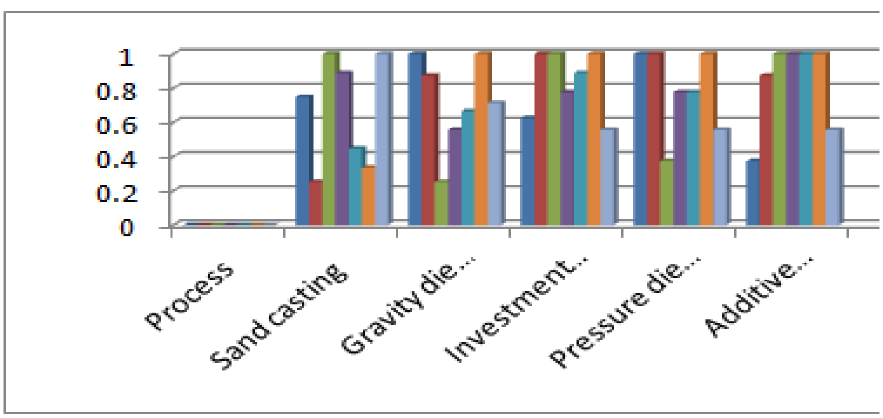

FIGURE 2. Normalized data

Figure 2 shows the Normalized data for "Alternative: Productivity, Accuracy, Complexity, Flexibility, Material utilization, Quality, Operation cost". "Evaluation preference: Process, Sand casting, Gravity die casting

Investment casting, Pressure die casting Additive manufacturing**"**. is also the Maximum in Normalized?

TABLE 3. Selection of Manufacturing Process Weighted Normalized Decision Matrix

Process	Productivity	Accuracy	Complexity	Flexibility	Material utilization	Quality	Operation cost
Sand casting	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Gravity die casting	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Investment casting	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Pressure die casting	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Additive manufacturing	0.14	0.14	0.14	0.14	0.14	0.14	0.14

Table 3 shows Weighted used for the analysis we take same weights for all the parameters for the analysis.

TABLE 4. Selection of Manufacturing Process Weighted Normalized

Productivity	Accuracy	Complexity	Flexibility	Material utilization	Quality	Operation cost
0.10500	0.03500	0.14000	0.12444	0.06222	0.04667	0.14000
0.14000	0.12250	0.03500	0.07778	0.09333	0.14000	0.10000
0.08750	0.14000	0.14000	0.10889	0.12444	0.14000	0.07778
0.14000	0.14000	0.05250	0.10889	0.10889	0.14000	0.07778
0.05250	0.12250	0.14000	0.14000	0.14000	0.14000	0.07778

Table 4 weighted normalized for Selection of manufacturing process "Alternative: Productivity**". "**Evaluation preference: Process, Sand casting, Gravity die casting Investment casting, Pressure die casting Additive manufacturing**"**.

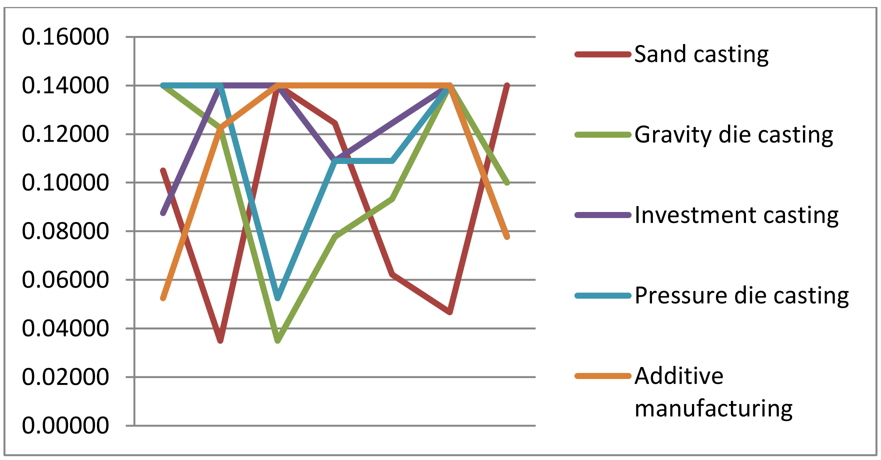

FIGURE 3. Weighted normalized

Figure.4 shows the weighted normalized **"**Alternative: Productivity, Accuracy, Complexity, Flexibility, Material utilization, Quality, Operation cost" "Evaluation preference: Process , Sand casting , Gravity die casting Investment casting , Pressure die casting Additive manufacturing" also weighted normalized**.**

Table 5. Selection of Manufacturing Process Preference Score

Sand casting	0.65333
Gravity die casting	0.70861
Investment casting	0.81861
Pressure die casting	0.76806
Additive manufacturing	0.81278

Table 5 shows the preference Score for sand casting preference Score is 0.65333, gravity die casting is 0.70861, investment casting is 0.81861, pressure die casting is 0.76806, additive manufacturing is 0.81278.

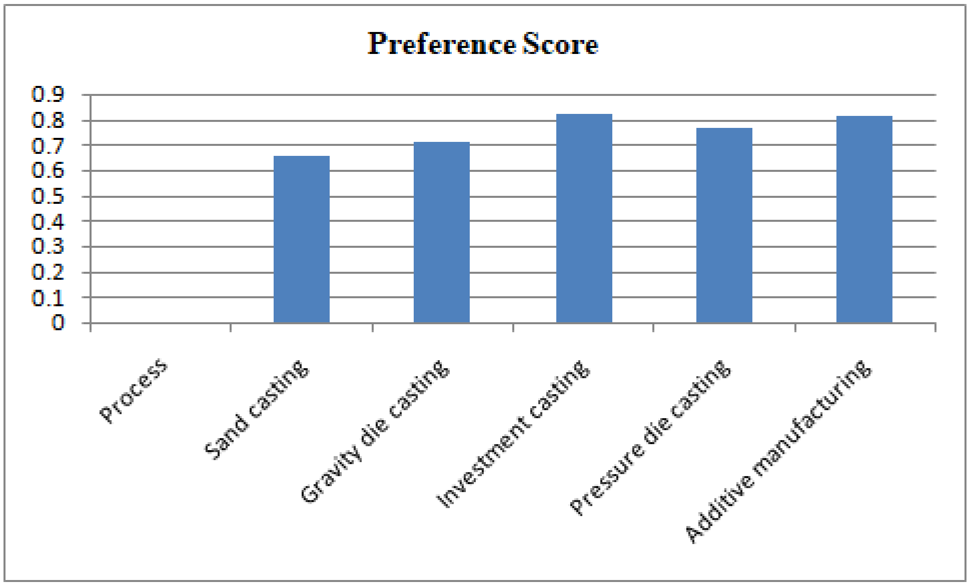

FIGURE 4. Preference Score

Figure.5 shows the preference Score" process, sand casting 0.65333, gravity die casting 0.70861, investment casting 0.81861, pressure die casting 0.76806, additive manufacturing 0.81278." also preference Sc

Table 6 selection of manufacturing process final Rank

Process	
Sand casting	5
Gravity die casting	4
Investment casting	1
Pressure die casting	3
Additive manufacturing	2

Table 6 Shows the rank final rank of this paper the sand casting 5th rank, gravity die casting 4th rank, investment casting 1th rank, pressure die casting 3th rank, and additive manufacturing 2th rank**.**

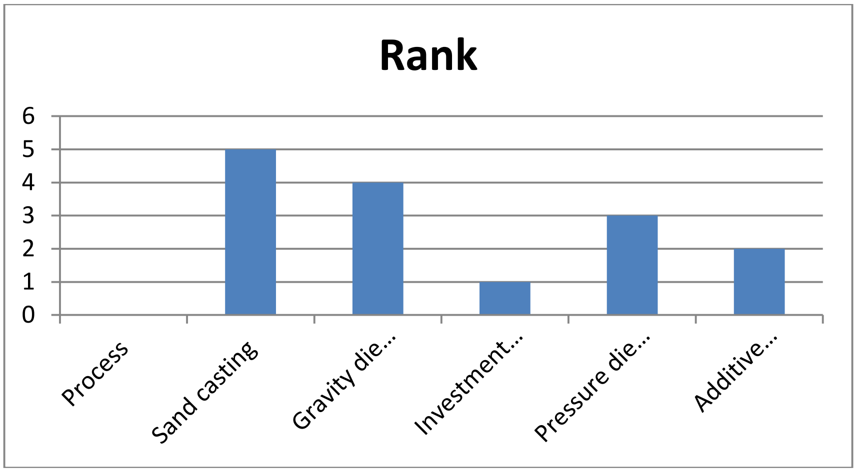

FIGURE 5. Ranking

Figure 6 shows the final rank of "this paper the sand casting 5thrank, gravity die casting 4th rank, investment casting 1th rank, pressure die casting 3th rank, and additive manufacturing 2th rank**.**".

4. CONCLUSION

For the selection of materials and manufacturing processes, a decision support system that combines a relational database and a multi-attribute decision making model was described. The requirements for the manufacturing process and the material requirements were identified as the decision criteria. The assessment of compatibility ratings between the product profile requirements and each alternative using necessity and possibility measures forms the theoretical basis problem's representation of imprecision by The vague questions more accurately reflect the qualitative needs and preferences of the designer. As a result, the flexible querying strategy enhances models and supports the task of choosing. Furthermore, the representation of uncertainty in terms of the capabilities of the manufacturing process and material properties better simulates the ambiguity of this information during the preliminary engineering design phase. This representational strategy might prompt the designer to alter the design to make better use of a particular material or to lower the price of the chosen manufacturing process, ultimately leading to an improved design. Both process economics and feasibility must be addressed in the DFM problem. The focus of the compatibility rating strategy is on assessing how well a specific material and manufacturing procedure work together. Here, a filler is not subjected to high shear stress. The suggested methodology supports the choice of the manufacturing processes, materials, and designs. It helps lead to the incorporation of topology optimization as a tool for choosing a material design process. The decision methodology can include mass and buy-to-fly ratio as selection criteria by completing a design step. The case study demonstrates that although the designs produced by constrained topology optimization are heavier than those obtained without constraints, interpretation is made simpler by the addition of constraints that lower design complexity. By adding machining constraints to the constrained results, a lighter component was produced as the unconstrained result was found to be too difficult to fabricate by machining. This demonstrates how crucially important experts are to the design process. SLM is always preferred and all of the components were SLM. Results highlight the significance of redesign prior to comparative manufacturing process analysis and the interest in using topology optimization as a selection aid. Experimental confirmation is required for the obtained mass and yield strength. In a subsequent study, secondary manufacturing processes will be included, and the impact of environmental criteria on the choice of material, design, and manufacturing process will be examined.

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