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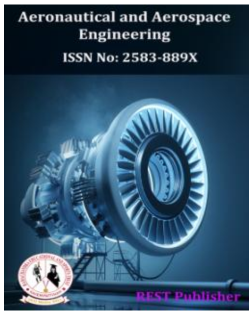

Robust Design of Aero Engine Structures: Using the Weighted Product Method

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Abstract: *Total loss of quality in products or processes Reduction is the objective of robust design. Strong Design is an effective approach that aims to simultaneously decrease product costs and enhance quality while also significantly reducing development time. Strength is defined as a skill Raw material, operating conditions, process equipment, environmental conditions, and human Expected variation in factors Tolerant manufacturing process. Robust design is the design of products, devices, and manufacturing equipment so that their performance and functionality are insensitive to multiple variations, such as manufacturing and assembly tolerances, ambient use conditions, or degradation over time. Therefore, there is not strong design sensitivity – meaning that variation in the product will have minimal influence. In essence, robust design means minimizing the impact of variation on a product. One or more due to unforeseen circumstances Input variables or assumptions are rigorous although modified, their output and predictions are accurate A model is considered robust if. The alternatives being considered are related to specific aircraft features: the aerodynamic characteristic (C1), maximum takeoff weight (C2), armament (C3), and avionics (C4). The evaluation options are Ao, F-16, Su-35, and Mig-35. Based on the evaluation results, Ao obtained the top rank, while Mig-35 received the lowest rank.The value of the dataset for Robust Design of Aero Engine in Weighted product method shows that it results in Ao and top ranking*
Keywords: *robust design, Aero Engine, The aerodynamic characteristic, Armament, Ao.*

1. INTRODUCTION

ACE some of the solid design of conventional design Uncertainty of mechanical performance of component performance Reference to a robust design that exists can be used. A probabilistic approach was employed [1] to assess the impact of cycle effects on component performance. During each flight cycle, the TRS (Turbine Rear Structure) generates significant heat due to the loads it experiences, as the hot exhaust from the combustor passes through the rear of the engine, affecting the aero surfaces with temperatures reaching 600°C. Consequently, this heating causes material expansion, resulting in considerable thermal stress on the structure. [2] Robust designs are often design compromises, with built-in design flexibility provide a practical "package" of functional features; The specific efficiency per gallon or speed of certain vehicles is seldom optimized according to miles per gallon. Instead, they may be geared towards achieving highly sophisticated or "high-tech" features. However, it's important to note that such designs may not always be the most suitable or appropriate for every application. Hovercraft, for instance, exemplifies this notion and illustrate the variability in design choices. [3] It Cognition in performance design of ACE system Uncertainties and imprecise uncertainties Considers both. This time the other global robust design with design principles Integrates theory. Indeed, many new technologies share a similar characteristic when it comes to the design of electrical systems and other related components. These technologies often offer various features and functionalities that can be harnessed to meet specific needs and requirements. This adaptability and versatility make them valuable for a wide range of applications and industries. As technology continues to advance, we can expect even more innovative solutions that enhance the efficiency, performance, and usability of electrical systems and related devices. The following two categories are performance Implicit uncertainty also includes cognitive uncertainties in the design They also analyze the characteristics of the ACE system, respectively. [4] Also, Robust based on the format of PDFs of programs The article offers a new definition of character. The effects of uncertainty in the system are closely related to both its strength and quality. These two concepts are interconnected and can be thought of as being held together by a simple rule of thumb. This rule of thumb suggests that the proposed method for robust design changes becomes a valuable approach due to its ability to account for and navigate the uncertainties present in the system. By considering both strength and quality in tandem, this approach helps ensure the system's resilience and performance even in the face of unpredictable factors or variations. [5] By employing robust optimization and particularly robust design techniques, substantial decreases in development time and cost can be achieved, while simultaneously enhancing product quality and reliability. Despite these potential benefits, deterministic optimization methods are predominantly used, and the integration of unobtrusive and robust design practices in product reliability remains underexplored. [6] To reflect production variability that increases with scale, To broaden the scope of our results, at face value We also create uncertainty in multiples. Since the design problem is tightly constrained, of modified robust design constraints Consider only small variations to make the bottom problem possible can take [7] The case study findings reveal insights into innovation promotion and the limitations faced. There are some high-level guidelines for enhancing reproducibility in design features during development. Additionally, efforts are made to identify design issues at the component level and to formulate more robust Design for Reproducibility (DFR) guidelines [8]. This problem is approached from a statistical perspective, focusing on statistical methods to address the challenges of reproducibility in design and development processes. High cost of aerodynamic simulations Undoubtedly strong design methods Make it difficult to use. In recent years Only more powerful computers are available made this approach possible. [9] The application of the evolution-based NSGA-II algorithm is expected to bring several improvements. This algorithm is particularly useful for solving robust design problems. In this context, an 18-dimensional normal distribution was assumed to model the problem, and statistical sampling was performed 500 times to address various factors and ensure reliability in the results. By employing this approach, the study aims to enhance the robustness of the design and achieve more optimal solutions. Surrogate With the help of a model, mass, outer integral Life cycle, and high-pressure turbine blade multi-purpose robust design of performance A large number of evaluations for optimization Possible. [10]. The typical uncertainty parameters encompass a range of factors, such as operating conditions, manufacturing variations in geometry, and degradation over time during service. These uncertainties are often incorporated into transformations or numerical models, which may include various constants. To assess the effects of these uncertainties on performance, Uncertainty Quantification (UQ) approaches can be employed. These methods are capable of handling expensive high-fidelity simulations, which are often crucial for accurately capturing complex system behavior. However, it is essential to consider the cost associated with conducting Uncertainty Quantification, as it can be of fundamental importance in decision-making and resource allocation [11]. Only at the end of the process, the received configuration Check if really strong, design evaluates the advantage under point conditions A statistical approach was used. An advantage of the proposed method is that it Account for all important unknown effects and allows taking. [12]

2. MATERIALS AND METHOD

A New that turns every bid into a score a weighted product method to provide a scoring function. Scoring rules and bidding objective functions there are basically two types of multi-attribute bidding models that have been introduced. Equilibrium Bidding Strategies, Buyer revenue comparisons, and optimal bid design are classified into these two models. Finally, regarding our assumptions Some improvements in the robustness of the models Balanced power consumption across nodes a method of maintaining is proposed considering Minimum hop using multiple criteria together count. Edges and N are flow graph nodes count. Method of using this test Based on the algorithm flow graph in the script located. The weights used in this study Script of production method? Indeed, criteria, weight and acceptability In determining the limited time Difficulties Complications to Employee Recruitment Process may be included. Hence, the purpose of this study the company Product sampling method weighted according to criteria Used to assist in employee recruitment activities.

Step 1. “Design of weight matrix and decision matrix

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

The weight vector may be expressed as,

Step 2. Normalisation of DM

$$n_{ij} = \begin{cases} \dfrac{x_{ij}}{max.x_{ij}} & | \ j \in B \\ \dfrac{min.x_{ij}}{x_{ij}} & | \ j \in C \end{cases}$$

The normalized value of each alternative for a criterion is determined by dividing the actual value of that alternative by the maximum value in the column for benefit criteria (B) or the minimum value in the column for cost criteria (C).

Step 3. Weighted normalized Decision Matrix

$$W_{n_{ij}} = w_j n_{ij}$$

Step 4. Ranking of alternatives

$$S_i^{WPM} = \prod_{j=1}^{n} (n_{ij})^{w_j}$$

The alternatives are ranked using the Weighted Product Model (WPM) approach, where SjWPM represents the ranking score of the j-th alternative, and wj denotes the weight of the j-th criterion. To determine the ranking score for each alternative, the WPM multiplies the normalized values of each alternative for all criteria, each raised to the power of its respective weight. The alternatives are then arranged in descending order, with the highest SjWPM value being ranked at the top.

3. ANALYSIS AND DISCUSSION

In the context of aircraft evaluation, four crucial criteria are being considered: Aerodynamic characteristic (C1), Maximum takeoff weight (C2), Armament (C3), and Avionics (C4). The aerodynamic characteristic (C1) is crucial for assessing the aircraft's overall efficiency and performance in flight. The maximum takeoff weight (C2) holds significance as it directly impacts the aircraft's payload capacity and operational capabilities. Armament (C3) plays a pivotal role in determining the aircraft's combat capabilities and its potential in offensive and defensive operations. Lastly, avionics (C4) represent the advanced electronic systems and instruments utilized for navigation, communication, and overall mission success. Evaluating these four criteria holistically enables a comprehensive understanding of an aircraft's capabilities and effectiveness in various operational scenarios.

TABLE 1. Robust Design of Aero Engine in Weighted product method Data Set

	C1	C2	C3	C4
Ao	61.08	259.5	33.15	25.05
F-16	79.12	273	26.69	45.3
Su-35	24.08	192.6	44.18	38.1
Mig-35	43.17	138.3	37.6	66.59

Table 1 presents the dataset for the Robust Design of an Aero Engine using the Weighted Product Method. The evaluation options include four alternatives: Aerodynamic characteristic (C1), Maximum takeoff weight (C2), Armament (C3), and Avionics (C4). These alternatives are evaluated against the following aircraft models: Ao, F-16, Su-35, and Mig-35. The table likely contains the relevant values and scores for each alternative against the specified criteria, enabling a comprehensive comparison and assessment of the aero engine's performance and robustness for each aircraft model.

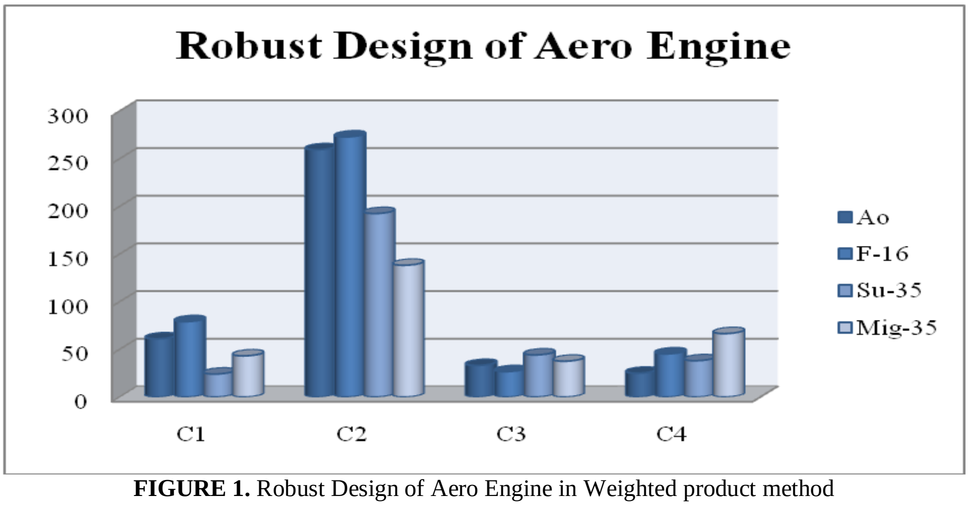

FIGURE 1. Robust Design of Aero Engine in Weighted product method

Figure 1 illustrates the dataset for the Robust Design of an Aero Engine using the Weighted Product Method. The evaluation options consist of four alternatives: Aerodynamic characteristic (C1), Maximum takeoff weight (C2), Armament (C3), and Avionics (C4). These alternatives are assessed for various aircraft models, including Ao, F-16, Su-35, and Mig-35. The figure likely showcases the relevant data and scores for each alternative with respect to the specified criteria, providing a visual representation of how the aero engine's performance and robustness compare across the different aircraft models.

TABLE 2. Robust Design of Aero Engine in Weighted product method Performance value

	Performance value			
Ao	0.772	0.9508	0.8051	1
F-16	1	1	1	0.553
Su-35	0.3043	0.7055	0.6041	0.6575
Mig-35	0.5456	0.5066	0.7098	0.3762

This table 2 shows that the values of Robust Design of Aero Engine in Weighted product method for Performance value using Weighted product method Find the pair wise comparison value for Ao, F-16, Su-35, Mig-35.

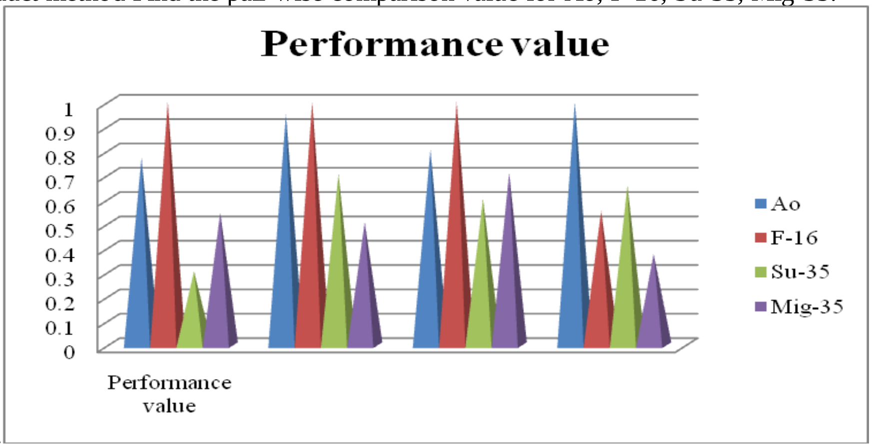

FIGURE 2. Robust Design of Aero Engine in Weighted product method Performance value

This Figure 2 shows that the values of Robust Design of Aero Engine in Weighted product method for Performance value using weighted product method find the pair wise comparison value for Ao, F-16, Su-35, Mig-35.

TABLE 3. Robust Design of Aero Engine in Weighted product Weight age

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

This table 3 shows that the values of Robust Design of Aero Engine in Weighted product method for Weight age using Weighted product method Find the pair wise comparison value for Ao, F-16, Su-35, Mig-35.

TABLE 4. Robust Design of Aero Engine in Weighted product Weighted normalized decision matrix

Weighted normalized decision matrix			
0.9374	0.9875	0.9473	1
1	1	1	0.8623
0.7427	0.9165	0.8816	0.9005
0.8595	0.8436	0.9179	0.7832

This table 4 shows that the values of Robust Design of Aero Engine in Weighted product method for Weighted normalized decision matrix using Weighted product method Find the pair wise comparison value for Ao, F-16, Su-35, Mig-35.

TABLE 5. Robust Design of Aero Engine in Weighted product Preference Score

	Preference Score
Ao	0.876773893
F-16	0.862337718
Su-35	0.540403335
Mig-35	0.521224614

According to the data presented in Figure 3, the rankings of the evaluation options are as follows: "Ao" achieves the highest rank with a score of 0.876773893, securing the 1st position. "F-16" attains the 2nd rank with a score of 0.862337718, while "Su-35" takes the 3rd position with a score of 0.540403335. Finally, "Mig-35" acquires the 4th rank with a score of 0.521224614. This figure provides a clear depiction of the relative performance levels of each evaluation option in the context of the Robust Design of the Aero Engine.

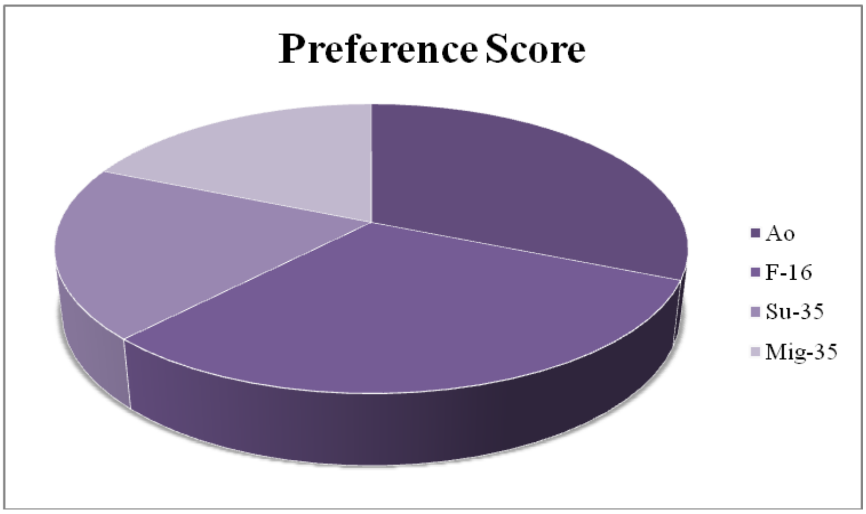

FIGURE 3. Preference Score

As per the data displayed in Figure 3, it can be observed that the ranking of the evaluation options is as follows: "Ao" achieves the highest score of 0.876773893, securing the 1st rank. "F-16" obtains the 2nd rank with a score of 0.862337718, while "Su-35" attains the 3rd rank with a score of 0.540403335. Finally, "Mig-35" is ranked 4th, having a score of 0.521224614. The figure clearly illustrates the relative positions of each evaluation option based on their respective scores in the context of the Aero Engine's Robust Design.

TABLE 6. Robust Design of Aero Engine in Weighted product Rank

	Rank
Ao	1
F-16	2
Su-35	3
Mig-35	4

According to the data presented in Table 6, it is evident that "Ao" has obtained the highest rank, securing the first position. On the other hand, "Mig-35" is ranked the lowest among the alternatives. This table provides a clear depiction of the relative rankings of the evaluation options, with "Ao" being the top performer and "Mig-35" ending up with the lowest rank in the context of the study's results.

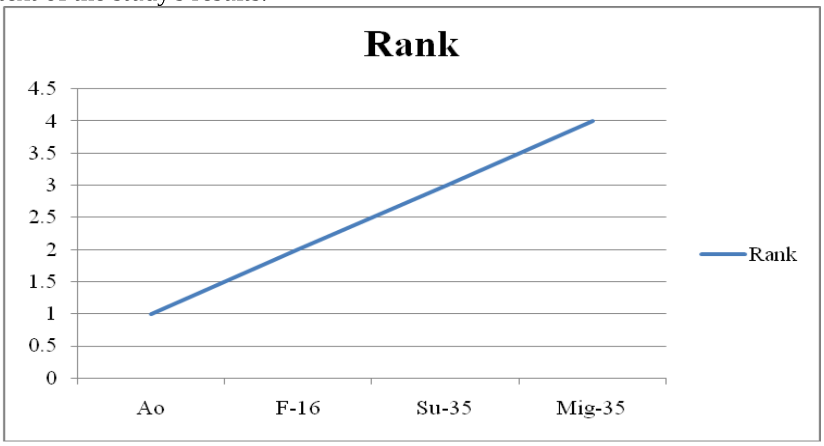

FIGURE 4. Rank

This figure 4 shows that from the result it is seen that Ao and is got the first rank whereas is the Mig-35 got is having the lowest rank.

4. CONCLUSION

A control system design that is good when determining the use of only nominal sample values, obviously taking known uncertainties into account, may have poles that are poorly mapped over a large area in the complex plane. Therefore, RRL being an analytical tool has provided an opportunity to verify whether this phenomenon is occurring or not. For strongly designed products variation Insensitivity and variations in use, degradation Desired operational performance despite, etc provide RD in Industrial Product Development Implementation and application of policies reportedly challenging. The design method is based on 1D design codes and Commercial Turbo Engine Design/Analysis Various compressors using software create a configuration database for geometry based on with neural network Gap detection and cost function reducing structure. This practice is mixed-flow Used to design compressor excitation. The expert panel in the study selected a total of thirteen criteria to evaluate the aircraft. To determine the importance of each criterion, the FUCOM (Fuzzy Compromise Method) was utilized as the decision-making process, resulting in the final weight values assigned to each criterion. The ARAS (Additive Ratio Assessment) method was then applied to rank the fighters based on these weighted criteria. To ensure the robustness of the findings, a sensitivity analysis was conducted, examining how changes in the criteria's weight values affect the final rankings. The results of this sensitivity analysis were then compared with those obtained using the WP (Weighted Product) method, confirming the reliability and stability of the ranking outcomes. This comprehensive approach allows for a rigorous evaluation of the fighters and ensures that the final rankings are well-supported and dependable.

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