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Numerical Analysis of the Aluminium Alloy Structure of the Brackets based on Conceptualization Processes

Raad M. Abed[1], Thaer Abdulwahhab Shihab[2], Abdulwahab M. Al-Mushehdany[3], Hussain Jasim M. Alalkawi[3,*]

[1] Department of studies engineering, Ministry of higher education and scientific research, Baghdad, Iraq
[2] Technical college of engineering, Al-Bayan University, Baghdad 10070, Iraq
[3] Bilad Alrafidain University College, Diyala 32001, Iraq

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ABSTRACT

In this study, three conceptual designs of bracket constructions made of aluminum alloy underwent numerical investigation. To analyze the von Mises stresses, present throughout the entire structure, the Ansys program was employed in conjunction with the static structure tool. The selection criteria are determined by two primary elements. The first element is the performance of the design, represented by normal stresses and deformation resulting from the applied load. The second criterion is volume, dependent on the volume itself, represented by a certain density of metals. To select an appropriate design for the aluminum brackets, the procedure was carried out utilizing the Analytic Network Process (ANP) technique. Through the conceptualizing approach, it has been demonstrated that the second design is superior to the alternative.

1. Introduction

In the middle of the fourth industrial revolution, the specific requirements of customers are changing at a dizzying rate, which requires real-time modifications to be made to product development and the formulation of market strategy [1]. In order to maintain a competitive advantage over their rivals or to win over consumers, businesses are always developing new technology and looking for better products to offer [2]. One method that is utilized by a significant number of prominent enterprises is known as technology roadmap management (TRM) [3]. In addition to facilitating the planning and execution of technology management, this strategy also facilitates the connection between product and technology development and the aims of the firm and the prospects of the market. According to research conducted in 1999 by manufacturers in the United Kingdom, around ten percent of medium to large manufacturing businesses in the country have adopted roadmapping [4].

* *Corresponding author.*
E-mail address: Dr.algawi@bauc14.edu.iq

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Additionally, this percentage has unquestionably increased over the years. There has been a significant amount of time and money put in research and development (R&D) to encourage innovation [5]. One example of this is through technology-driven manufacturing (TRM), which has allowed large corporations to continue developing new products and technologies [6]. On the other hand, small and medium-sized firms (SMEs) frequently do not possess the personnel and material resources that are required to carry out these exploration activities [7]. Another difficulty that causes an obstacle for the TRM method is the absence of appropriate input data about a variety of factors, including technology, competitors, and markets. Most of the time, this information is derived from the knowledge that is provided by specialists in forums and conferences. Consequently, in order to increase a company's economic profit, market share, and technical standing, it is becoming increasingly important to have adequate and effective knowledge management in addition to technology and product planning [8]. This is because of the relationship between the three factors. Small and medium-sized businesses (SMEs) should make it a priority to prioritize sustainability and low costs when it comes to research and development (R&D) management if they want to increase their capacity to capture new opportunities in future markets, technologies, and products. The four-layer TRM model, which has been widely used in research and development management, is a tool that assists businesses in the planning of their innovations by offering an explanation of the technologies, products, services, and markets involved [9]. The top-level market layer, for example, contains information on future development, present and potential customer desires, and market trends. Each layer possesses its own set of distinctive characteristics. You will discover the service and product layers in the middle of the structure [10,11]. These layers are concerned with the existing service as well as the possible features and functions of products that customers want. The technology layer is located closer to the bottom of the hierarchy, and it is connected to important information concerning the advancements in technology and the worries that may arise in the future [12].

Authors [13] proposed MA-based TRMs as a means of assisting small and medium-sized enterprises (SMEs) in planning and forecasting. A technique that combines MA and Delphi was proposed by [14] as a means of enhancing the findings of the analytical examination and providing businesses with information of superior quality. I would like to summarize that previous research has made substantial use of MA integration in TRMs. The use of the MA approach becomes obvious when other technical forecasting (TF) methodologies are taken into consideration, as does the demand for the assistance of specialists in fields of study for the construction of TRM. The dissection of possibilities into four distinct layers is a defining characteristic of TRMs [15]. After the target item has been broken down, the MA approach makes an attempt to reconstruct it in order to investigate the possibility of discovering new structures [16]. Because MA's essential components include the visual examination of the subject of interest and the methodical development of innovative ideas, there is the possibility that it may be integrated with TRMs. This is due to the fact that MA's fundamental components consist of both of these things. As a result, integrating TRMs with other prospecting strategies, such as MA, TRIZ, and text mining, can be an effective strategy to increase the efficacy of these strategies. This will make it possible to perform a more systematic search for new opportunities to develop the firm, as well as to conduct a more in-depth study of huge amounts of data, such as patent documents, product manuals, customer feedback, service instructions, and so on [17]. Additionally, this will make it possible to conduct a more complete examination of the data [18].

On the other hand, there are not a lot of publications that explain how to find new chances to combine MA and TRMs. This is a relatively unknown topic. A strategy that incorporates the findings of the MA into the process of establishing an existing TRM is provided by the findings of this study, which present an approach towards doing so [19]. After that, the process of prediction is carried out with the aid of maps based on SGTM and TRIZ. This article pursues the following three objectives in order to accomplish its goals: (a) provide a TRM-based platform that is capable of integrating other techniques such as TRIZ, mapping, and computerized tools in order to make each component realize its full potential; (b) investigate a simplified pattern in the application of TRIZ based on the frequency of keywords; and (c) demonstrate and discuss how to apply the MA-based TRM methodology to analyze trends in the development of underwater vehicles in order to visually seek out new technologies and products [20].

In order to systematically search for new opportunities, this study will make use of the updated TRIZ unique ideas that have an influence on the TRM platform that is based on MA. This is one of the ways in which this study differs from others that have been conducted. This examination makes use of a heuristic technique to simplify the implementation of the TRIZ system and conducts exploratory research [21]. This is done while taking into consideration the vast TRIZ system. In order to handle the field of diverse underwater vehicles, it provides a novel and innovative solution to the problem. Furthermore, the implementation of the technique is bolstered by the fact that it incorporates both MA and TRIZ creative concepts [22]. This is in addition to anything else. In this approach, a novel and conventional method of thinking about the connection between innovation algorithms and innovation dimensions is proposed. As a result, the applicability of the procedure is improved. Furthermore, the hierarchical structure of TRM's organizational structure is a perfect match for the two qualitative innovation methodologies that are being discussed here [23]. These two qualitative methods are enhanced by applying a wide variety of text mining tools in order to lessen the influence of the experiences of experts. This is done in place of depending solely on the inspiration and understanding of technicians. When applied to the investigation of complex systems, this renders the techniques more scientific and facilitates their reproducibility [24].

This study makes a theoretical contribution in the form of a prescription for a methodology that combines TRMs with other management strategies. This is a contribution to the field of management theory [25]. As a result, the skill to evaluate product and technological trends, as well as the ability to search for new prospects, will be enhanced [26]. In order to find new prospects for governments and enterprises, this work simplifies the use of TRIZ compared to traditional TRIZ and improves the process of constructing morphological matrices with computerized tools. It also adds to the refining and maximizing of applicable approaches [27]. Finding untapped opportunities in the target industry has never been easier than with the use of case studies and submersible vehicles. It seeks for technologies and products that could be profitable using an experimental and heuristic approach. Moreover, open-source data retrieved from internet databases forms the basis of this method's architecture [28]. Together, this helps SMEs save money on R&D, improve their capacity to recognize technical trends, and grasp market developments [29]. Therefore, this study used static structural tools to conduct numerical analysis of the aluminum alloy structure of the brackets in accordance with the conceptualization techniques.

2. Research Methodology

2.1 Process of Conceptual Design

The technological solution that the TRIZ method implements is built on the base of this issue description, which acts as the foundation. In this study, the first step is to characterize the technical problem and the elements that contribute to its improvement. This is the first stage. The results of simplifying the matrix table to determine the components that are required to modify the deteriorating features are displayed to the right in Figure 1. The next thing that has to be done is to determine which TRIZ solution principle most closely corresponds to the cross-arm idea design. The primary purpose of this project is to develop a conceptual design that is suitable for a cross-arm made of wood that will be utilized in transmission towers.

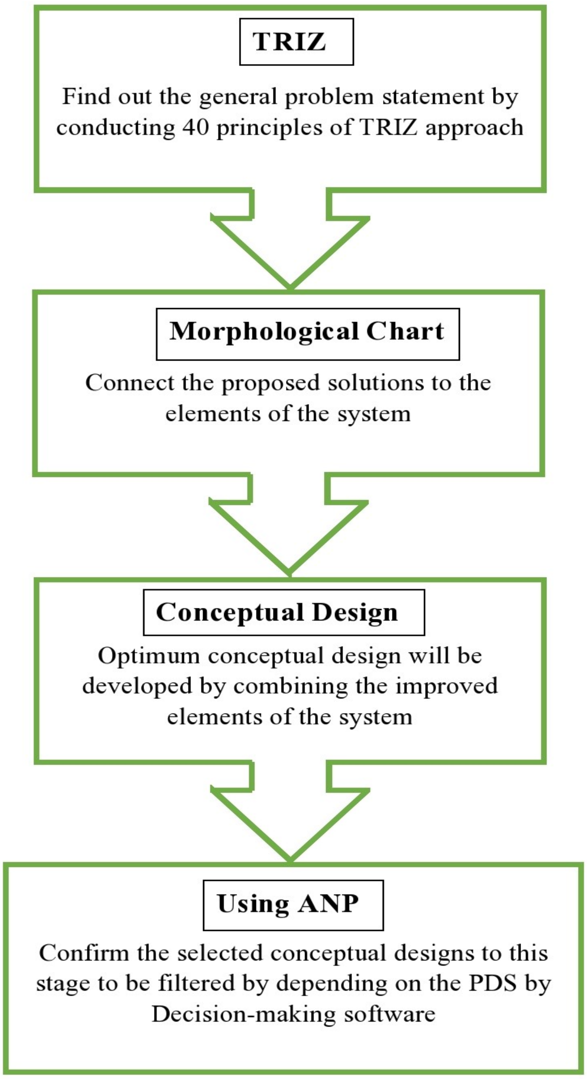

Fig. 1. Process of the main project

2.2 Configurations of Final Stage of Conceptual Design by ANP

Authors [30,31] state that the Analytical Network Process (ANP) is a selection method that is applied extensively in a variety of engineering areas. The conceptual design that is presented in this article is determined by the requirements of the product design. The ANP methodology has a number of advantages, one of the most important of which is the ability to design a methodical and all-encompassing multi-criteria decision-making process. This capability is proven by the consistency index indication and the pair-wise comparison procedure developed by the technique. The ANP approach was utilized in order to determine the design that would ultimately be successful for this project out of the three (3) initial idea concepts that were considered. According to a number of studies, the data that is frequently utilized in the PDS stage, which is helpful in the conceptualization phase, has been collected through structural analysis by utilizing the ANSYS program.

As can be shown in Table 1, the PDSs for the wooden cross arm are utilized in the production of the selectivity technique. In order to choose three (3) core components and their related sub-components, the overall PDS report is utilized presented in Table 1.

Table 1
Configuration-based ANP -PDS approach

Main components	Minor components	Tree
Efficiency	Stress analysis	Deformation (mm)
		Eq.Stress (N/m2)
Others	Specify density	Volume (m3)
		Mass (Kg)

2.3 Geometry and Software Configuration

The AutoCAD program was utilized in order to carry out the geometry (Figure 2). In accordance with the requirements, the geometry of the bracket has been meshed using the Ansys program. In accordance with this, the regular construction of the mesh has been utilized. In Ansys, the triangular kind of element has been chosen automatically for implementation. There was a consideration given to the anthropomorphized nature of the mesh. The application procedure has been carried out with the assistance of a static structural tool.

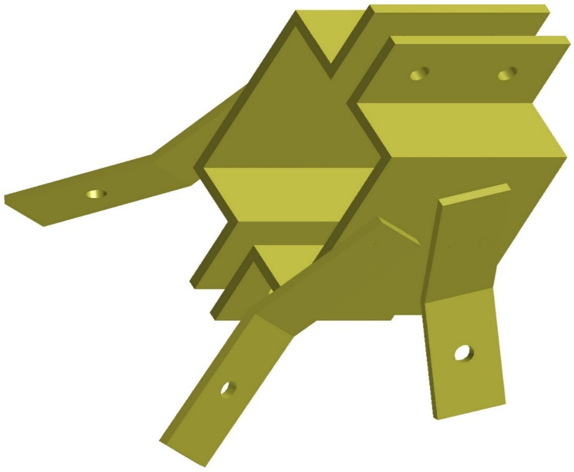

Fig. 2. The main geometry

3. Results and Discussion
3.1 Explanation of Completed Designs

Historically, results have corroborated the selection method's predictions and have been in agreement with ANP results. The most highly ranked concept layout 2 at the end of the selection process is basically a reference to the bracing sections that were effectively accomplished as shown in Figure 2. The three designs will be evaluated by conducting an examination into deformation and Von-mises stresses using the ANSYS program.

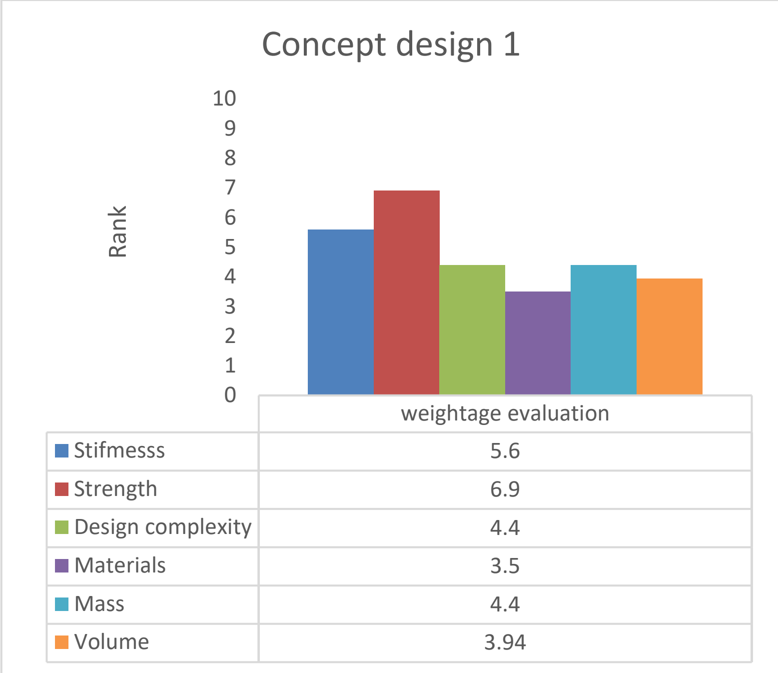

Fig. 2. Explanation of the first conceptual design

In terms of the design features listed in Figure 3, the resultant load with the lowest deflection, at 0.019 millimeters, was created by concept design 2. Ansys was used to conduct numerical calculations within the context of three potential designs for the cross-arm bracket constructions. You may get the ANP comparison method by using this assessment as a starting point. The second design makes use of tees on the main body to facilitate the connection of the bracing member to the main body of the cross-arm structures.

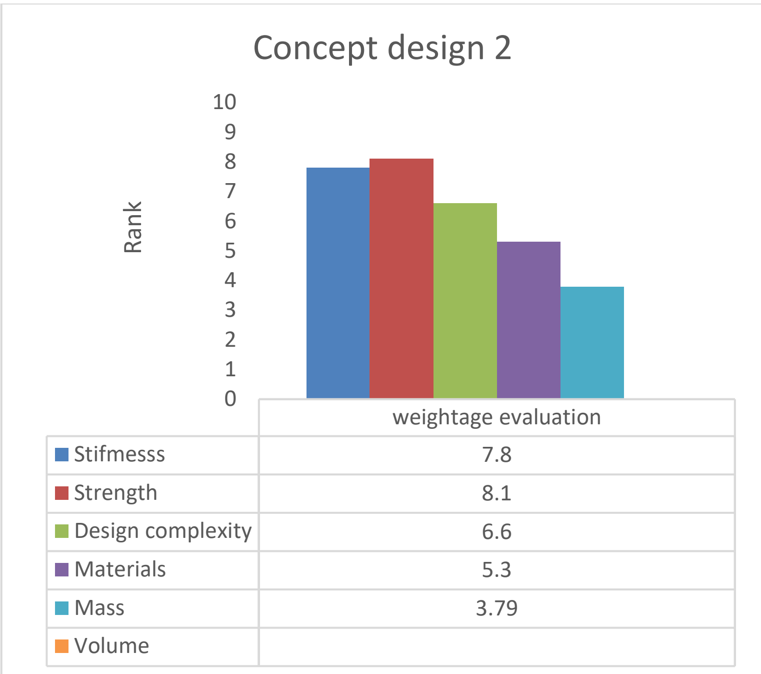

Fig. 3. Second conceptual design

With regard to the characteristics of the design that are described in Figure 4, concept design 2 was responsible for producing the resulting load that had the least amount of deflection, which was

0.0018 millimeters. Within the framework of three possible designs for the cross-arm bracket structures, numerical calculations were carried out with the help of Ansys. When you use this evaluation as a starting point, you will have the opportunity to obtain the ANP comparison approach. The second design makes use of tees on the main body in order to make the connection between the bracing member and the main body of the cross-arm constructions easier to accomplish.

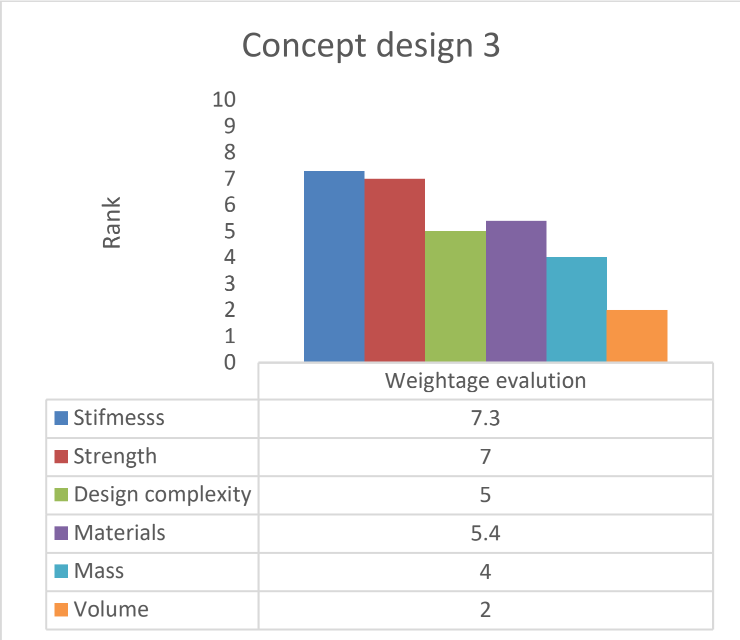

Fig. 4. Second conceptual design

3.2 Bracket Conceptual Design Attributes

At the fourth level of the hierarchy, all three of the conceptual design concepts for the wooden cross arm are deemed to be valid possibilities. In order to evaluate each design, we evaluated it using a pair of approaches for each of the selection criteria and sub-criteria. The ANP methodology served as the basis for this comparison. There are a substantial number of numbers that have been allocated to each suggested layout in accordance with the specifications of the prototype (see Table 3). The translation of the design into three-dimensional models.

Table 3
Summary of bracket conceptual design attributes

Main	Sub Design	Design 1	Design 2	Design 3
Performance	Normal stress (N/m2)	9.43	7.76	10.4
	Max. Deformation (mm)	0.093	0.019	0.077
Weight	Volume (m^3)	0.00131	0.00129	0.00135
	Mass (Kg)	3.5	3.82	3.98

4. Conclusions

In conclusion, a numerical study has been conducted on three hypothetical designs of bracket structures composed of aluminum alloy. The Ansys application was applied in conjunction with the static structure tool in order to conduct an analysis of the von Missies stresses that are present throughout the whole structure. Both of these key components are responsible for determining the selection criterion. The first of these components is the performance of the design, which is exemplified by the normal stresses and deformation that occur as a consequence of the load that is applied. The second criterion is the volume, and it is reliant on the volume, which is itself represented by a certain density of metals. The other criterion is the density of the metals. This operation has been carried out using the ANP approach in order to pick an appropriate design for the aluminum brackets. The objective of this procedure is to select a suitable design. Through the utilization of the conceptualizing technique, it has been proved that the second design is the more superior of the two designs.

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