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Selecting Materials Using Fermatean Fuzzy Hybrid Aggregation Operators for Maximum Optimisation

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Abstract

Materials selection is a fundamental aspect of engineering design and plays a pivotal role in determining the performance, durability, and cost-effectiveness of a product or structure. The process of selecting the right materials for a particular application involves evaluating multiple criteria, such as mechanical properties, cost, environmental impact, and availability. To make informed decisions in material selection, engineers and researchers employ various methods and tools. In recent years, there has been a growing interest in applying advanced mathematical approaches, such as Fermatean fuzzy hybrid aggregation operators, to enhance the optimization of material selection processes. This article explores the concept of material selection, the challenges it poses, and how Fermatean fuzzy hybrid aggregation operators can be applied for maximum optimization.

Keywords: Fermatean fuzzy hybrid • Materials selection • Fuzzy logic

Introduction

Materials should have the necessary mechanical properties, such as strength, stiffness, and toughness, to meet the requirements of the application. Increasingly, materials must be selected with consideration for their environmental impact, including recyclability, energy consumption in production, and the emission of harmful substances. Material selection must also account for cost constraints. The goal is to find materials that meet performance requirements while staying within budget. Some materials may be scarce or subject to geopolitical instability, making their availability a significant consideration in material selection. Materials should be selected with an eye on long-term durability to minimize maintenance and replacement costs. The ease of manufacturing and processing materials is a key factor, particularly in industrial applications. The complexity of materials selection arises from the need to balance multiple, often conflicting criteria. Additionally, the vast array of available materials, each with its unique properties and characteristics, can make the process overwhelming. Traditional methods, such as the Ashby approach and materials selection charts, have been useful, but they are limited in handling the inherent uncertainties and fuzziness associated with real-world material data. This is where advanced mathematical tools, such as fuzzy hybrid aggregation operators, come into play [1-3].

Literature Review

Fermatean fuzzy logic is an extension of classical fuzzy logic that introduces the concept of Fermi function-based membership functions. This approach enables the modeling of uncertainty in a more versatile and realistic manner. Fermatean fuzzy logic is particularly suitable for dealing with imprecise or incomplete information, making it well-suited for material selection, where data may not always be exact or complete. Fermatean fuzzy logic employs Fermi functions as membership functions. These functions are defined by a sigmoid shape and allow for the representation of vague or uncertain information. Fermatean fuzzy logic provides aggregation operators that can be used to combine and aggregate uncertain or fuzzy information in a way that respects the Fermi membership functions. Fermatean fuzzy logic excels at modeling and handling uncertainty and imprecision, which are prevalent in material selection processes [4,5].

Discussion

To illustrate the application of Fermatean fuzzy hybrid aggregation operators in materials selection, consider a case study in aerospace engineering. The selection of materials for aircraft components is a complex task, involving a range of criteria, such as mechanical properties, weight, cost, and environmental impact. Using Fermatean fuzzy hybrid aggregation operators, engineers can aggregate these criteria to identify materials that best meet the requirements of a specific aircraft component. The operators take into account the imprecise nature of data and provide a systematic approach to optimizing material selection. Material selection is a critical aspect of engineering design that directly influences the performance, reliability, and cost-effectiveness of various products and systems. The process of selecting the right materials for a particular application involves balancing multiple criteria, such as mechanical properties, environmental impact, cost, and availability. Traditional material selection methods often rely on deterministic, crisp values, which can be limiting when dealing with the inherent uncertainties and imprecise nature of real-world data. This article explores the application of Fermatean Fuzzy Hybrid Aggregation Operators (FFHAO) for material selection, aiming to achieve maximum optimization while considering the complexities and uncertainties inherent in the decision-making process [6].

Conclusion

Materials selection is a critical aspect of engineering design that requires the consideration of multiple criteria, often in the face of uncertainty and imprecision. Traditional methods have limitations in dealing with these challenges, but advanced mathematical tools like Fermatean fuzzy hybrid aggregation operators offer a promising solution. These operators enable engineers and researchers to make informed decisions by effectively modeling uncertainty, aggregating multiple criteria, and optimizing the material selection process. As materials science continues to evolve, the integration of Fermatean fuzzy logic and aggregation operators provides a valuable path toward more efficient and effective materials selection, ensuring that engineering designs meet performance, cost, and environmental objectives to the maximum extent.

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Conflict of Interest

None.

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