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Abstract

People engage in creativity for a multitude of reasons and express it in various ways, often by designing or altering products, processes, or systems. This study specifically focuses on modifying a commonly used kitchen tool by changing its physical characteristics. Our investigation involved examining similar items in order to identify crucial questions pertaining to our objective of modifying the material of a mixing bowl. After evaluating a range of possible materials, Polyvinyl Chloride (PVC) and Polyether (PEEK), were selected, that would enable us to achieve our research goals. To aid in our research, we employed the material selection technique known as "Ashby Charts." Through comparing and analyzing the physical properties of different materials, we discovered a promising option that could effectively serve as an alternative for creating a versatile mixer that is both safe for human health and environmentally friendly.

Keywords: Design, Competitive advantage, Software, Market

Introduction

When it comes to product design, it's crucial to choose the appropriate engineering materials. This task can be difficult and crucial since designers have a vast array of materials to choose from. However, it also provides opportunities for innovative and creative design. Materials serve as the basis for all physical objects, so selecting the right ones is vital throughout the design process. This multidisciplinary task involves input from various stakeholders, such as product designers and end users. Choosing the best materials for a design project can be challenging due to several factors, including design specifications and material properties. It requires considering the interaction between different material characteristics from both a technical and user-focused perspective. The ultimate objective is to find a group of potential materials that meet performance and design requirements, resulting in the creation of a multifunctional mixer that is safe for human health and the environment.

The subject of the research, the kitchen mixer serves as handheld tool crucial for tasks such as whipping, kneading, and mixing [1]. These tools are frequently listed as essential in kitchen toolkits, helping home cooks create consistent batters and dough with ease. They streamline cooking processes, as highlighted by 100daysofrealfood.com, making mixers a must-have for anyone aiming to enhance their culinary skills [2].

Thermoplastic polymers can be viewed as highly ideal materials for the subject of this research in terms of design. They represent a class of versatile materials that can be softened through heating and reshaped using techniques like extrusion and injection molding [3]. Specifically, two candidate materials such as Polyether Ether Ketone (PEEK)which stands out for its exceptional mechanical strength and heat resistance, making it a preferred choice in aerospace and medical applications [4], and Polyvinyl Chloride (PVC), known for its cost-effectiveness and versatility, finds uses in construction and healthcare industries [3]. These polymers are molded to desired forms when heated and return to a solid state upon cooling, allowing for recycling [5]. PEEK and PVC's diverse applications underscore the significance of thermoplastics in modern industries.

However, multiple approaches are required to choose the sort of material most suited for a design requirement. In this regard, the Ashby technique is one of the most well-known modern approaches. The Ashby Chart is a prominent tool in materials science, which simplifies the intricate process of material selection by visually representing the relationship between material properties. This research work delves into the Ashby Chart's application, focusing on Polyether Ether Ketone (PEEK) and Polyvinyl Chloride (PVC).

In "Materials Selection in Mechanical Design," Ashby introduces a comprehensive framework for material selection. Performance indices, quantifying material attributes, enable direct comparisons between diverse materials. The method's practical application is emphasized in the same work, where the charts and tables aid in real-world materials and process selection. Ashby's approach is also showcased in "MATERIALS SELECTION MECHANICAL DESIGN," offering insights into materials selection considerations and processes "[6].

The Ashby Chart offers a structured approach to material selection, significantly benefiting the engineering community. With a focus on PEEK and PVC, its application is evident in choosing suitable materials for diverse industries. To conclude, let's explore a significant definition that captures the significance of the method: "Citation examples (Harvard style) - Citing references" suggests, referencing is crucial to acknowledge the origins of concepts like the Ashby Chart. By leveraging both the chart's graphical representation and established citation practices, engineers can confidently make materials selection decisions that align with project requirements [7].

Research work

In our pursuit of creating an innovative and multifunctional mixer, a concept test was conducted. To achieve better results, the research was carried out in selecting various materials for more complete and desired outcomes. After the model was concepted, adjustments were taken into account. To do this, the product's construction process was reviewed, and questions on potential changes were developed. On the other words, the chosen material's ability to endure the necessary temperatures and sustainability, electrical resistance, thermal conductivity, mass, weight, volume, and recyclability were taken into consideration.

Upon analyzing the aforementioned questions, all components of the (existing) mixer were thoroughly assessed and arrived at the conclusion to investigate potential materials that can enhance its working capacity, stability, and overall value of our product. Understanding that materials used in product construction are important for ranking among competitors in the market, considering that buyers are well-informed about materials and their positive and negative properties, the research was focused on both producers and consumers, respecting kind of a biological cycle of the product. To address this concern, we have narrowed our search to materials that are similar to the current ones, but have lower weight, higher stability, and are cost-effective. Additionally, they must be recyclable, which will benefit both the user and environment in terms of positive properties.

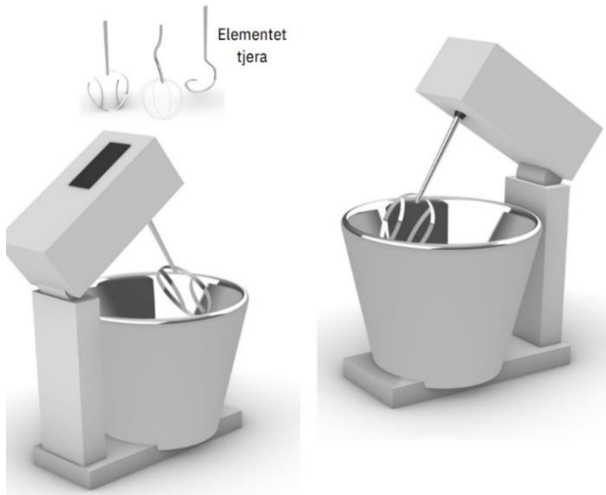

Figure 1 – Virtually Redesigned Multifunctional Mixer (authors - made using Rhino software)

We are considering making modifications to the product, specifically the mixer bowl component, with a focus on the material used. The current material in use is ABS, and we are planning to make changes to it. After analyzing the materials available in our area of interest based on the desired or similar properties, two potential candidates were identified: Polyvinyl Chloride (PVC) and Polyether (PEEK).

When it comes to material selection analysis, it’s important to understand the difference between chosen materials such as PEEK (Polyetheretherketone) and PVC (Polyvinyl Chloride). These are two distinct thermoplastic polymers with varying properties and applications. To make an informed decision, a comparision of some key aspects between PEEK and PVC was provided as following: Chemical resistance: PEEK has great chemical restitanceto making it good choice for environments where it will be exposed to harsh chemicals. It can resist many different types of organic and inorganic chemical, acids, and bases. Whilst, PVS does offer some chemical resistance as PEEK, it may be affected by certain solvents and aggressive chemicals.

Material selsction analysis

To focus on specific materials within the Ashby Chart, a diagram is used to depict limits. The diagram consists of a horizontal axis representing service temperature and a vertical axis representing strength; it's a mechanical system inside the part, so first minimum strength requirements will be provided, which will intersects the vertical line (strength axis), similarly, vertical line intersecting maximum service temperature axis, which altogether represents advantage enabling application of attribute limits into the Ashby plot like in the figure 2.

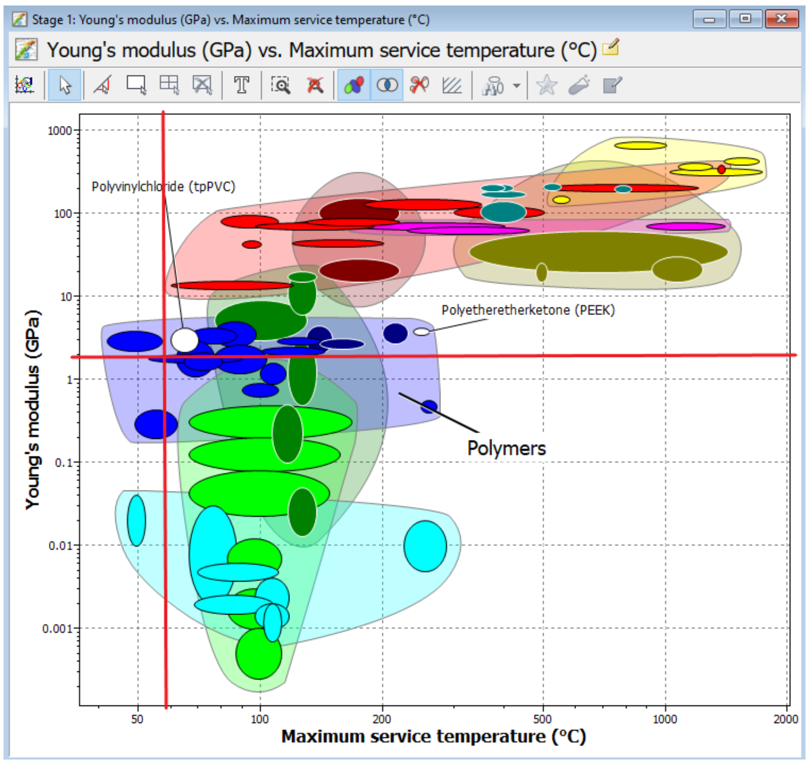

Figure 2 - Ashby plot on temperature and strength of materials (authors)

Then, materials of our interest (PEEK and PVC) within the valid regions will be depicted; those materials will be considered along through the analysis, and eventually, those are materials that are going to be paying attention to.

Note: The approach of limiting boundaries lacks a Value Index, which is commonly encountered in the Ashby Charts method; in the situations where the Ashby Plot lacks a value index, it essentially indicates the absence of a physical relationship between material properties. Consequently, there is no derived equation linking the Maximum Service Temperature and

Strength, meaning there is no derivation connecting the two physical quantities. Nevertheless, the "limiting boundaries" can still be applicable when the relevant materials are considered.

Analyzing the maximal service temperature and strength of Polyether Ether Ketone (PEEK) and Polyvinyl Chloride (PVC) using the Ashby Chart reveals crucial insights. PEEK's placement on the chart signifies its high strength and excellent thermal stability, positioning it in a region where both attributes are optimized. This suggests that PEEK can endure elevated temperatures while maintaining its structural integrity, making it suitable for applications requiring robustness in harsh conditions.

In contrast, PVC's position on the Ashby Chart implies a trade-off between maximal service temperature and strength. It is situated in a region where its maximal service temperature is lower than that of PEEK, and its strength is relatively reduced. This indicates that PVC might experience diminished mechanical performance at higher temperatures.

In summary, the Ashby Chart demonstrates that PEEK excels in both maximal service temperature and strength, making it a preferred material for applications demanding performance under extreme heat and mechanical stress. PVC, while having a lower maximal service temperature and compromised strength, might be more suitable for applications where high temperatures and mechanical stress are not simultaneous factors. This analysis underscores the Ashby Chart's utility in visually representing the relationship between these material properties for informed material selection.

Conclusions

The conclusions drawn in this summary report are a result of a comprehensive analysis focused on achieving our research goals and objectives. The selection of materials was guided by essential qualities such as durability, resistance to high temperatures, recyclability, and improved conductivity.

Material Selection Process: In pursuit of creating an advanced mixer, we adopted a multifaceted approach that involved innovative modifications to its visual design, functional capabilities, and overall aesthetic appeal. Recognizing the mixer's significant role in both household and commercial food preparation, we meticulously compared the attributes of various materials based on temperature resistance, durability, health considerations, and recyclability. This approach enabled us to make a well-informed conclusion.

Temperature Resistance and Stability Comparison: A crucial factor in material selection was the temperature resistance and stability of the chosen materials. Our analysis revealed that PVC, while suitable for many applications, has limitations due to its lower maximum operating temperature of 60-80°C, which can lead to softening, deformation, or loss of mechanical properties. In contrast, PEEK exhibited exceptional temperature resistance, maintaining its mechanical properties and dimensional stability at elevated temperatures ranging from approximately 250-300°C.

Durability and Resistance to Wear and Tear: Durability and resistance to wear and tear are paramount for products like mixers. While PVC can withstand regular use, it showed susceptibility to chemical attacks in specific environments. In contrast, PEEK demonstrated remarkable chemical resistance and mechanical integrity, even in harsh conditions, making it an optimal choice for applications where durability is critical.

Taking into account the various factors considered during our analysis, we have concluded that PEEK stands as the preferred material for our innovative mixer. Its consistent performance at high temperatures and superior durability render it suitable for demanding applications in the food industry. Although PEEK is associated with a higher cost, its benefits far outweigh the expense, making it the most fitting choice for our product.

User Safety and Health Considerations: It's essential to note that the widespread use of the mixer amplifies the impact of our material innovation. By opting for PEEK, we enhance user safety during food preparation and offer added protection against potential complications. PEEK's non-toxic nature during recycling further aligns with health-conscious considerations, contributing to its suitability for our product.

Overall Impact: Our material selection strategy not only advances the performance of the mixer but also aligns with the preferences of informed consumers who seek products with superior attributes. By incorporating PEEK, we have achieved a harmonious blend of innovation, safety, and performance, ensuring the mixer's continued relevance and utility in both household and commercial settings.

Bibliography

[1] En.wikipedia.org - Kitchen utensil

[2] https://www.100daysofrealfood.com/most-used-kitchen-tools-top-15/

[3] https://www.twi-global.com/technical-knowledge/faqs/what-is-a-thermoplastic

[4] Marco Valente, Ilaria Rossitti, Matteo Sambucci, Different Production Processes for Thermoplastic Composite Materials: Sustainability versus Mechanical Properties and Processes Parameter, *Polymers* 2023, *15*(1), 242;

[5] Britannica.com - Plastic | Composition, History, Uses, Types, & Facts

[6] M. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann Linacre House, Jordan Hill, Oxford OX2 8DP, 1992

[7] libguides.reading.ac.uk - Citation examples (Harvard style) - Citing references