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Design Improvement of Disposable Food Containers to Improve Weight Capacity AndReduce Structure Flimsy

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Abstract

The project aims to address the limitations of current disposable food containers by focusing on two key aspects which are weight capacityand structural integrity. The design enhancements are intended to revolutionise the packaging industry, providing a more robust and reliable solution for transporting and storing various food items. Through a comprehensive analysis of existing materials and manufacturing processes, new approaches will be explored to optimise the containers' strength-to-weight ratio, ensuring the disposable food container can withstand heavier loads without compromising sustainability. The project will also investigate innovative structural configurations to reduce the inherent flimsiness associated with disposable containers, thereby enhancing consumers' experience, and reducing the likelihood of spillage or damage during loading and handling. By applying innovative design principles that enhance the product's strength without adding any materials or compounds and only altering the curve sidewalls' diameter size, the improved disposable food containers aim to meet the growing demand for eco- friendly, durable, and high-performance packaging solutions in the food industry. This project is under the overarching goal of advancing sustainability and effectiveness in the packaging industry, all the while addressing the changing demands of both consumers and businesses.

1. Introduction

Disposable food containers have emerged as a pivotal factor in the modern food consumption environment, resulting in an unprecedented period of food distribution, storage, and convenience. For the purpose to fulfil the needs of takeaway restaurants and food delivery services, their pervasive utilisation has escalated. [2] Notwithstanding their exceptional convenience, however, these receptacles impose an ecological burden, which calls for innovative solutions and careful deliberation. Disposable food packaging is the predominant method of transporting meals and "ready-to-eat" consumables in Malaysia. Significant for their cost-effectiveness, portability, and one-time usability, these containers ensure contentment among consumers through their ability to avert food deterioration, effectively encapsulate meals, and maintain optimal temperatures and whether in ambient environments, refrigerators, or freezers. [10] As a result, the food disposable containers have become permanent fixtures in properties, offices, hospitals, hotels, and restaurants.

Although visually appealing, the curvature of the container frequently compromises its rigidity, which gives rise to concerns regarding food preservation, utilisation, and environmental impact as a whole. Curved sidewalls, which are intentionally constructed to enhance ergonomics, introduced irregularities in storage capacity and inefficiency. Generally, the fixing capabilities of these designs are inadequate, leading to wastage of space and logistical issues, especially when it comes to large-scale storage. In addition, the fragility of specific containers, which is exacerbated by curves, affects their ability to retain food safely, resulting in increased food waste and early decomposition. [7] The objective of this project paper is to enhance the design of the PP-LB02T food disposable container model by employing the identical material as the prior iteration, albeit with an innovative structure characterised by a greater diameter of the curves and an all-around more durable design capable of withstanding the applied stress. Furthermore, it is critical to consider that unforeseen outcomes or circumstances beyond one's control may also have an impact on the outcome.

2. Literature Review

2.1 Food Disposable Container

Food disposable containers are items intended for transporting and packaging food for a single use. Typically manufactured from biodegradable materials such as paper, plastic, or homoplastic, it provides convenience but contributes to environmental waste. Reusable alternatives, recycling, and biodegradable alternatives are all measures to reduce their environmental impact. [2]

2.2 PP-LB02T

The PP-LB02T is a tough plastic container made of polypropylene, known for its strength in various uses. It has atight lid that seals well, perfect for storing food, liquids, or small objects. Its clear design lets you see what's inside, making it easy to organize. You can stack these containers, saving space when storing them. Polypropylene is popular for home, restaurant, and business use due to its usefulness and reliability in storage.

2.2.1 Application of PP-LB02T

Disposable food containers ensure convenience and sanitation for consumers by sealing food from external elements. Their primary role is to prevent contamination and ensure product safety. These containers revolutionize food storage and transport across industries, reducing waste and aiding convenience. They're essential in restaurants, households, and delivery services, promoting sustainability with eco-friendly options and simplifying food organization and storage. [9]

2.2.2 Function of PP-LB02T

Food packaging serves to protect, enclose, and inform consumers about meals, meeting industry standards and preferences. Convenience features like resealing, microwave capabilities, and easy disposal shape packaging designs, simplify consumers' experiences. Innovations such as microwave-friendly options streamline cooking, catering to busy lifestyles. Disposable containers safeguard food, ensuring freshness during transport, aiding portion control, and upholding hygiene. Their eco-friendly versions align with sustainability goals, contributing to food quality and convenience across industries and households. [9]

2.2.3 Advantages of PP-LB02T

Disposable food containers offer practical benefits like convenience, cost-effectiveness, lightweight nature, and durability. They save time and labour, especially in hospitality, with lower initial costs compared to reusable options. Their lightweight quality eases handling and transportation, while their strength protects contents from damage during handling and storage. However, it's vital to weigh these benefits against environmental impacts and sustainability concerns. [11]

2.3 Curve Reinforcement

Mechanical reinforcement enhances substance durability through added support, common in engineering and fabrication. When designing internal curves, a slight expansion of reinforcement may cause gaps. Thermoplastic reinforcement uses diverse components like fibres or particles to bolster strength, stiffness, and impact resistance. Curve, reinforced sidewalls in disposable food containers offer added strength for heavier meals, aiding transportation and stacking. This design optimises material usage, provides grip for handling, and ensures durability, enhancing food storage and takeout options.

2.4 Curve Reinforcement in Food Disposable Container

Curved reinforcement in disposable food containers strengthens their curved parts to withstand external forces. Manufacturers employ methods like adding lines or ridges to enhance rigidity. Strategic placement ensures even force distribution, minimizing stress concentrations. Techniques may include using thicker or reinforced materials like polypropylene. This reinforcement aims to prevent deformation or collapse, enabling containersto support food weight and maintain shape during use, ensuring reliability and safety for food storage and serving [7].

2.5 Function of Curve Sidewalls

Curve sidewalls in food containers serve key functions such as securing food, adding durability, and enabling stack-ability. The features prevent spills, support heavier meals during transport, and aid compact storage. The invention focuses on containers with curved sidewalls and an external flared arcuate flange, aiming to improve their stability and production feasibility. Ultimately, these curved designs ensure food integrity and offer practical advantages like durability and ease of storage.

3. Methodology

3.1 Flow Chart

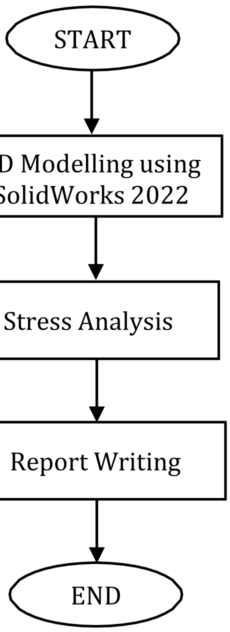


Figure 1 *Flow chart process*

3.2 SolidWorks 2022

SolidWorks 2022, a computer-aided design program, enables engineers and designers to craft, simulate, and refine 3D models efficiently. Its user-friendly interface supports precision through parametric modelling, allowing easy modifications. The software offers a full suite of tools for modelling, simulation, rendering, and collaboration. Its simulation capabilities verify design functionality while rendering aids in visual presentations. It serves as a robust platform, accommodating diverse design needs from conception to product completion.

3.2.1 Finite Element Analysis

Finite Element Analysis (FEA) predicts an item's behaviour through mathematical simulations. It uses the Finite Element Method (FEM) to divide objects into smaller elements, creating equations to analyse their behaviour. This involves meshing, creating equations based on physics, solving equations numerically, and post-processing for insights into the system's performance under varied conditions.

3.3 Curve Sidewalls Size Enlargement

The redesign process optimises operations effectively. Making disposable containers involves material selection and various manufacturing techniques. Redesigning involves modifications and enhancements, with a user-centric and collaborative approach. Designing disposable food containers requires utility and sustainability considerations. Proposed changes in curve sidewall size aim to address customer dissatisfaction and food waste issues in Malaysia. Increasing the sidewall size may assist hand-eating habits and gravy consumption, potentially reducing food waste. The redesign focuses on user comfort and food consumption habit

3.4 Strengthen the Flimsy Structure

The demand for stronger polypropylene has surged, especially for specialized foam packaging. Adjusting material interaction can benefit various packaging scenarios, like preventing film rolls from unrolling excessively. To reinforce delicate structures, identifying weaknesses and providing additional support or reinforcements are vital steps. This might involve adding supports, aligners, or extra layers to enhance structural integrity and prevent displacement.

3.5 Modelling and Simulation

SolidWorks 2022 utilises modelling to create three-dimensional virtual representations, supporting various applications like product design and engineering. Modelling involves specifying object shapes, sizes, and properties, using 2D sketches to construct 3D figures. The software offers tools for advanced surfacing and realistic material representation. It enables assembly modelling and relationships between parts. Simulation in SolidWorks assesses 3D models under real-world scenarios, aiding in decision-making and enhancing design quality. Simulation mimics real-world phenomena, offering a risk-free environment to test ideas and understand complex systems across multiple fields. Models are developed based on assumptions, input data, and mathematical formulas, allowing users to manipulate variables and foresee system reactions, providing insights and aiding decision-making before real-world implementation.

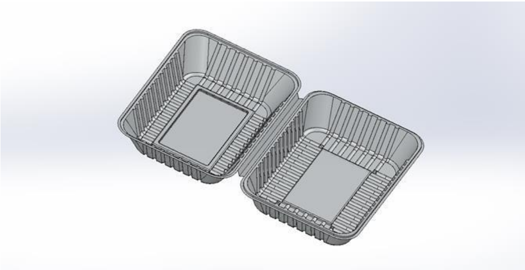


Figure 2 *Food Disposable Container*

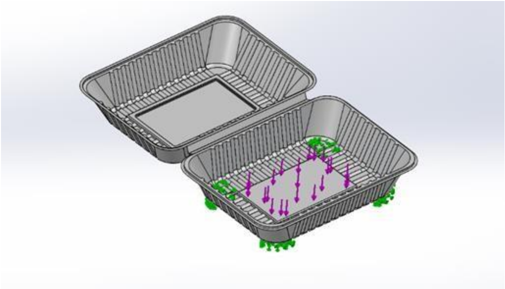


Figure 3 *Product before Simulation*

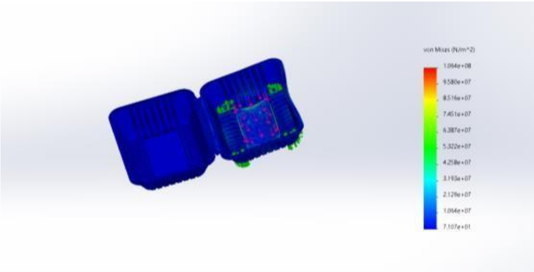


Figure 4 *Product after Simulation*

3.6 Material Selection

It is crucial and involves choosing materials based on the design's purpose, structural needs, and environmental conditions. The software offers a diverse material inventory including metals, polymers, and composites. Users assign materials to model components, impacting visual appearance and mass properties. Engineers assess how material choices affect weight, centre of mass, and inertia, ensuring accurate physical descriptions. The program provides predefined materials and customization options, useful for unique or proprietary materials. Material selection evolves with the design process, allowing quick updates to align with project requirements and new material considerations, ensuring accurate model representation.

4. Result and Analysis

4.1 Simulation Analysis

Simulation analysis is integral for predicting 3D model behaviour. Static Analysis, a key method, anticipates stress and strain under external forces. The process includes material characterization, boundary condition application, meshing, and analysis. The results aid in identifying stress distribution, safety elements, and vulnerable areas within the design, vital for improving product performance and safety.

4.2 Flimsy Structural of Food Disposable Container Upon Load and Force

Unstable disposable food containers disappoint consumers expecting durability. Collapsing or weak containers affect satisfaction and brand impressions. Fragile containers reduce the convenience expected, challenging their role as reliable, quick-use options. This compromises consumer gratification, impacting the product's perceived quality in fast-paced lifestyles focused on ease and reliability.

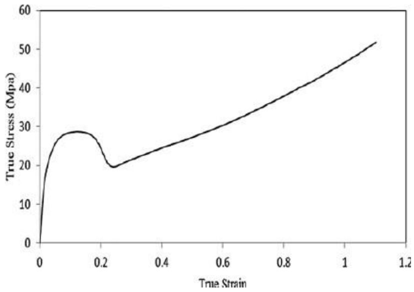


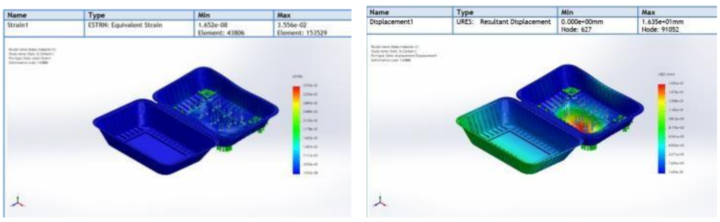
Figure 5 *True stress-strain curve of Polypropylene*

4.3 Proposal of the New Design

Disposable food container design undergoes innovation with expanded curved sides, optimising functionality and environmental consciousness. This groundbreaking approach diverges from traditional methods, increasing sidewall curvature to 5mm and 6mm diameters. Addressing both aesthetics and practicality, this change aims to minimize food waste, enhance user comfort, and fortify structural integrity. Rigorous technical assessments support this balance between strength and material efficiency.

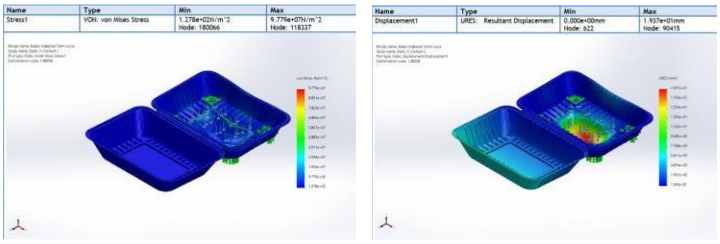
4.4 Finite Element Analysis (FEA) of the Design

Applying a 580-gram load to containers helps simulate item weight. Non-uniform load distribution might cause stress concentrations, potentially surpassing the material's limit. Stress analysis assesses internal forces, flagging areas vulnerable to excessive stress that may lead to deformations or structural failure. The study delves into the structural implications of a 4mm diameter, 580-gram disposable food container, vital for its real-world reliability. Material characteristics, deformation, and fatigue are considered. Keeping stress levels below the material's yield strength is crucial to prevent permanent deformation that could compromise the container's integrity. Ensuring elasticity helps the container return to its original shape after stress.



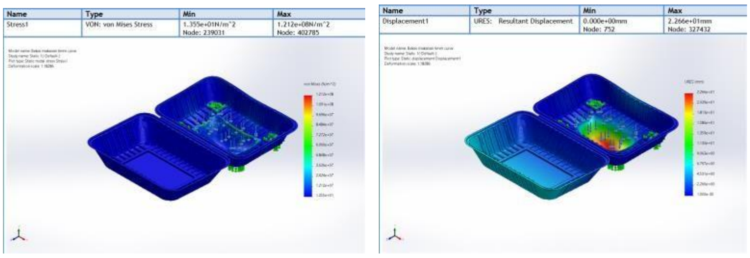
(a) (b)

Figure 6 *Maximum stress (a) and deformation (b) of 4mm*



(a) (b)

Figure 7 *Maximum stress (a) and deformation (b) of 5mm*



(a) (b)

Figure 8 *Maximum stress (a) and deformation (b) of 6mm*

The strain levels in containers with sidewall diameters of 4mm, 5mm, and 6mm vary due to different stress and displacement factors. The 4mm container might experience higher strain with increased stress, indicating potential deformations, while the 6mm one could demonstrate lower strain due to even stress distribution, suggesting better durability. The 5mm container strikes a balance between stress handling and structural integrity, offering a versatile option based on specific needs and materials.

Table 1 *Von Mises Stress and Displacement data*

	4mm	5mm	6mm
Von Mises Stress	1.063e+0.8N/m^2	9.779e+0.7N/m^2	1.212e+0.8N/m^2
Displacement	1.635e+01 mm	1.937e+01 mm	2.266e+01 mm
Percentage		15.59%	27.84%

In the presented study, student conducted analysis simulations using SolidWorks 2022, obtaining data for Von Mises Stress and Displacement in disposable food containers with varying diameters which are 4mm, 5mm, and 6mm. An inconsistency was identified in the Von Mises Stress data for the 5mm diameter, potentially stemming from errors in SolidWorks drawings. This discrepancy could impact calculations, leading to incorrect results and misinterpretation of data. However, Displacement data exhibited a consistent increase with larger diameters, facilitating easy evaluation.

The report emphasizes the complex relationship between geometric factors, material properties, and design considerations in stress, displacement, and strain variations during container transport. Food disposable containers with 4mm thickness may be prone to increased stress concentration while 6mm containers offer enhanced stability. The 5mm container strikes a balance, efficiently handling stress distribution for optimal structural integrity. The choice among these containers depends on specific use cases, load requirements, and material considerations to ensure desired effectiveness and safety.

4.5 Final Design

In designing a 6mm curved disposable food container, key considerations include material choice, structural integrity, and functionality. Increasing the curve diameter offers benefits like stress reduction, improved structural stability, and resistance to deformation. A larger curve diameter helps evenly distribute stress, minimising strain and fatigue, while promoting smoother shapes that enhance load-bearing capacity and reduce the risk of failure. The student's choice of a 580-gram load for testing emphasises safety over accuracy, ensuring robustness and reliability in real-world usage.

5. Discussion

The discussion emphasises the critical aspects of designing disposable food containers with a 6mm curve diameter. It highlights material choice, structural integrity, usability, and space optimisation. A larger curve diameter evenly distributes stress, improving container resilience and stability, and reducing potential failure points.It also enhances load-bearing capacity and durability against fatigue, ensuring longevity. Selection of the 6mm curve, based on simulation outcomes and the heaviest load measurement, prioritizes safety and reliability in container design.

6. Conclusion

To sum up, the integration of 6mm curved sidewalls in disposable food containers is a breakthrough in packaging. These containers effectively balance structural strength, material efficiency, and usability. The 6mm curve distributes mechanical stress evenly, reducing stress points and ensuring durability during handling and storage. It also manages strain, allowing flexibility without compromising structural integrity. This design enhances environmental friendliness, minimizing material waste and production costs. Overall, these containers represent a leap forward in packaging technology, embodying durability, resource efficiency, and environmental responsibility. The student advocates for an optimal 6mm diameter curve in disposable food container design, ensuring structural strength, minimizing food wastage, and enhancing consumer comfort. However, practical decisions should be grounded in engineering principles, material properties, and real-world testing for safety and effectiveness in diverse usage scenarios.

7. Recommendation

The recommendation for the analysis process involves using dynamic methods instead of static methods to determine Von Mises Stress and displacement values. The issue arose because a previous student utilized static analysis, neglecting crucial aspects like moments of inertia and damping force, leading to less relevant results, particularly for disposable food containers with a 5mm diameter. Dynamic analysis proves more suitable for evaluating material or product loads due to its ability to consider the dynamic environment of structural and mechanical systems. Additionally, the selection of a static point in the analysis process is emphasized, as choosing the wrong point can impact data relevance and make comparing results for containers with different diameter curves challenging. The size of the curve and static point selection significantly influence the stress on disposable food containers during the analysis.

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