SUSTAINABLE PACKAGING SOLUTIONS FOR AUTOMOTIVE PRODUCT TRANSFER

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ABSTRACT

Most goods or products, especially economic or automotive items, are transported, distributed, and stored using corrugated packaging materials as the main choice. At all stages of distribution, corrugated material packaging is used to protect the loaded goods from structural loads. Containers containing these products are subject to various risks, including falling from great heights, transport shocks, compression during stacking and exposure to the weight of other packaging products, all of which can cause damage to the item. Based on that, this study aims to investigate problems related to product packaging, designing a new packaging box concept using recycled materials, and evaluating the product packaging capabilities based on packaging performance tests. The results of the evaluation show that the appearance, structural stability and content protection by using recycled corrugated paper board packaging is very satisfactory, able to reduce the cost of raw materials and meets the needs of the industry.

1. Introduction

Packaging is the process of enclosing a product or item in a container to protect it from damage during transportation, handling, and storage. Packaging for product transfer refers to the packaging used to transport goods from one place to another, such as from a manufacturing facility to a distribution centre, or from a distribution centre to a retail store(Schoormans & Robben, 1997). Effective packaging for product transfer should be designed with several factors in mind, including the size and weight of the product, the mode of transportation, the distance to be travelled, and the potential hazards the product may encounter during transit (Perez 2018). The packaging should be strong and durable enough to withstand the rigors of shipping, handling, and storage, while also being cost-effective and easy to handle.

Sustainable packaging solutions can take many forms, including using recyclable or biodegradable materials, reducing the amount of packaging required, and designing packaging that is reusable or refillable(Boz et al., 2020). One popular sustainable packaging solution is using recycled or biodegradable materials such as paper, cardboard, or plant-based materials, which can reduce the amount of waste generated and minimize the use of non-renewable resources(Chauhan et al., 2023). The choice of packaging material will

depend on the specific requirements of the product being shipped, as well as the mode of transportation and any regulatory requirements that must be met(Biegańska, 2018).

Another sustainable packaging solution is reducing the amount of packaging required, which can be achieved through better product design, optimized packaging shapes and sizes, and using materials that are lightweight but still provide adequate protection to the product(Shi, 2022). This approach not only reduces waste but can also lead to cost savings in transportation and storage. Reusable and refillable packaging is also a growing trend in sustainable packaging solutions, which allows customers to reuse the packaging for other purposes or refill the product within the packaging(Granato et al., 2022).

While sustainable packaging solutions for product transfer have many benefits, there are also some challenges and issues that businesses and manufacturers may face when implementing these solutions. Some of the problems include cost, compatibility with existing systems, performance, regulatory compliance and availability of sustainable materials(Morgan et al., 2022). Based on the issue, this study was conducted in the logistics department of an automotive parts manufacturing company to solve their packaging problems. Due to the new production of automotive spare parts, their company faced problems related to the packaging of the products for the delivery process to customers. The current packaging box is not neatly arranged and does not have enough space, which can cause damage to the product. Therefore, this study aims to design a new cost-effective packaging solution using recycled corrugated boxes to provide optimal spacing and adequate protection for product transfer.

This research paper is structured as follows. Section 1 presents the introduction of the study; Section 2 covers the methodology of the research work; Section 3 discuss the finding results, and Section 4 presents the conclusion and suggested recommendations for future work.

2. Methodology

2.1 *Concept and Ideation*

The first step in developing a new packaging solution is to generate ideas. Brainstorming sessions, and customer feedback is used to generate ideas for new packaging solutions. After generating ideas, select the most promising ones and develop them into concrete concepts. This can involve prototyping, material testing, and cost analysis to determine feasibility. The packaging should provide sufficient protection to the product during transportation and storage. The packaging must be designed to protect the product from damage, spoilage, or contamination during transit. The packaging should maintain the integrity of the product throughout the entire transfer process. The packaging should not allow any leakage, breakage, or damage to the product. The packaging should be efficient in terms of cost and space utilization. The packaging should be designed to minimize the amount of material used, reduce packaging waste, and optimize the use of transportation space.

2.2 *Materials selection: recycled corrugated box*

Corrugated packing is most used for secondary shipment boxes. This is a very tactical and utilitarian use of corrugated, where the maximum level of protection at the lowest cost takes precedence above all other considerations. These boxes are rarely, if ever, printed. Hand stamping of boxes with the firm emblem and contents is still widespread, and stencilling plays a significant role(Biegańska, 2018). Corrugated boxes are required by all sorts of businesses, whether they are huge, small, or medium-sized. Wholesalers and retailers both

require them. Movers and packers utilise corrugated boxes as well. As a result, corrugated boxes have a sizable market.

A corrugated box is a recyclable container with three layers of material on the sides: an inner layer, an exterior layer, and a middle layer. Fluted arches offer cushioning and stability for weighted materials arranged in a corrugated box in the middle layer, which is positioned between the outer and inner layers. Corrugation flutes were originally added during the first industrial revolution. Since its invention, the corrugated box has evolved into the most prevalent type of shipping container, with applications in every sector of material management and transportation(Shi, 2022).

2.3 *Design and development*

Once the concept has been refined, it can be designed and developed into a functional prototype. The packaging can be tested for its ability to protect the product and its suitability for transportation, storage, and handling. After that, we plan and discuss the process that requires packaging design and the design requirements of what must be completed. Even if the projects are simple and the specifications are basic, there is still a conceptual design process that takes place between learning the requirements and beginning to build. As the project grows and complexity, the importance of design grows. The methods and resources you'll use, the solution's scalability, and the structure of the components you'll create are all options. The Design Phase is where we can examine all the possible solutions and narrow down an option to find the most effective and efficient approach to create a solution.

During this step, we are creating the design using the characteristics listed in the literature review sections. We build models that convey process requirements and offer a framework for the system's physical design. This project resulted in the creation of a prototype method. The development stage is when planners work on projects and implement the application based on the design studies and requirements that were created previously. Whatever necessary to complete the job has been established. Potential suppliers are contacted, a timeline is created, equipment and materials are purchased, and team are given instructions, among other things. When the implementation phase is ready to begin, the development phase is over. For the people who will carried out the implementation, everything must be clear. We are beginning to construct the models after analysing the data and information required, which is accomplished via analysis on packaging box delivered by truck. The project has been completed properly.

2.4 *Performance testing and evaluation*

Performance testing is critical to ensure that the packaging solution meets its intended purpose. Testing can include drop testing, compression testing, and vibration testing, among others. Packaging solutions should be evaluated for their cost effectiveness. This can include an analysis of the materials used, manufacturing costs, transportation costs, and other associated expenses.

To evaluate the performance of packaging for product transfer, you can conduct various tests, such as drop tests, compression tests, vibration tests, and temperature tests, to determine the packaging's ability to protect the product during transportation and storage. You can also conduct customer surveys to gather feedback on the packaging's convenience and overall satisfaction. Additionally, you can evaluate the environmental impact of the packaging by conducting a life cycle assessment to determine the packaging's carbon footprint and other environmental impacts.

3. Results and discussions

3.1 *Schematic design of the packaging box*

a. Substrate air vent cover

This concept has 12 pcs per layer (Figure 1). It comes with 3 layers in 1 box. Size for this box is 69 x 40 x 54 cm.

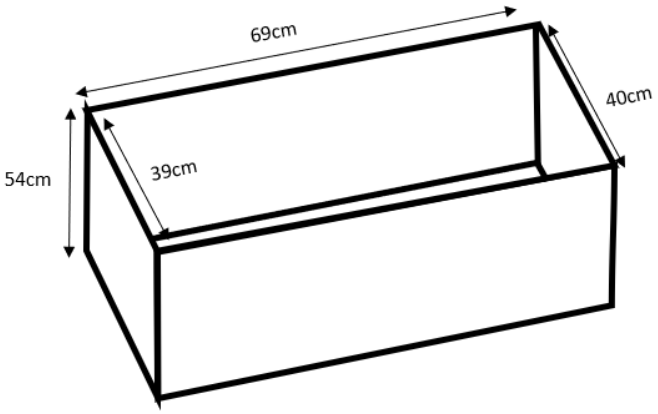

Figure 1. Schematic design Airvent Cover

b. Armrest assembly and rear storage cover

This concept uses inner nesting slot that have 30 pcs for 1 layer (Figure 2). Size for this box is 73 x 41 x 43 cm.

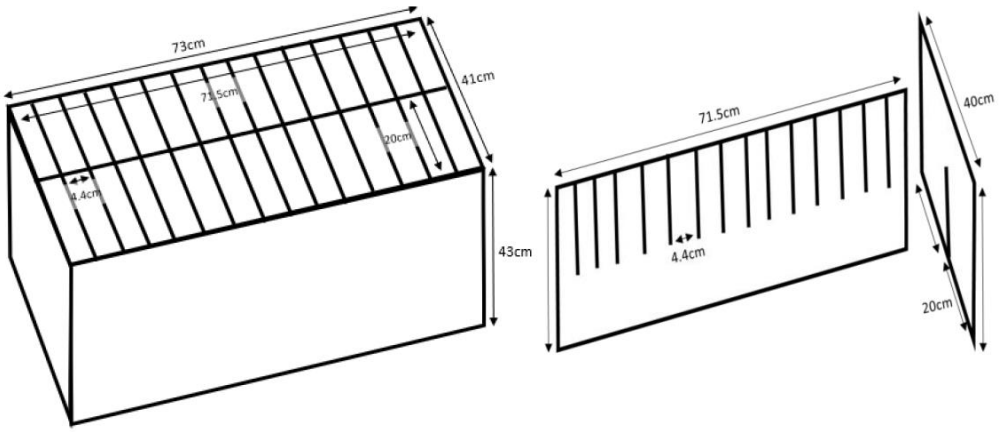

Figure 2. Schematic design Armrest & Rear Storage

c. Front bezel assembly

This concept is slot vertical per layer (Figure 3). The total for 1 box is 100pcs. Size for this box is 69 x 40 x 54 cm.

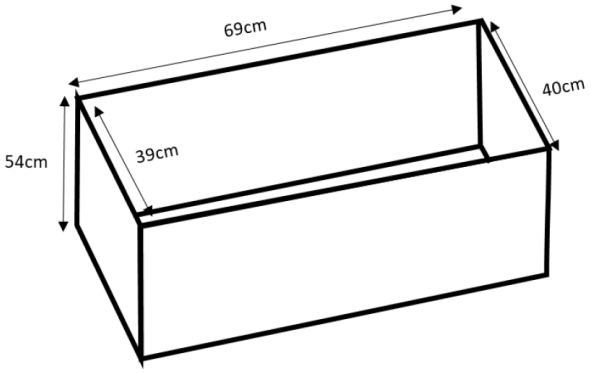

Figure 3. Schematic design Front Bezel

d. Side Panel Upper RH & LH

This concept has slot to hold partition (Figure 4). It comes with 1pcs per layer. The total for 1 box is 10pcs. Size for this box is 112 x 80 x 40 cm.

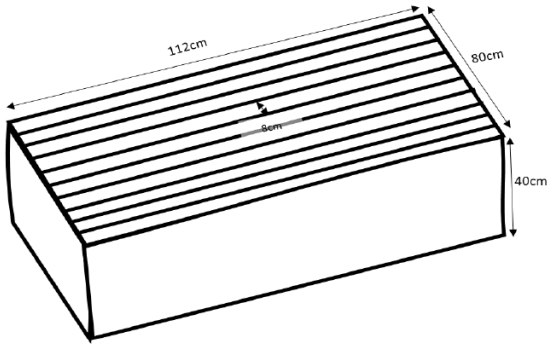

Figure 4. Schematic design Side Panel Upper RH & LH

e. Side Panel Bolster RH & LH

This concept has a slot to hold for partition (Figure 5). It comes with 8pcs per layer that 3 layers include in this box. The total for 1 box is 24 pcs. The size of this box is 65 x 38 x 57 cm.

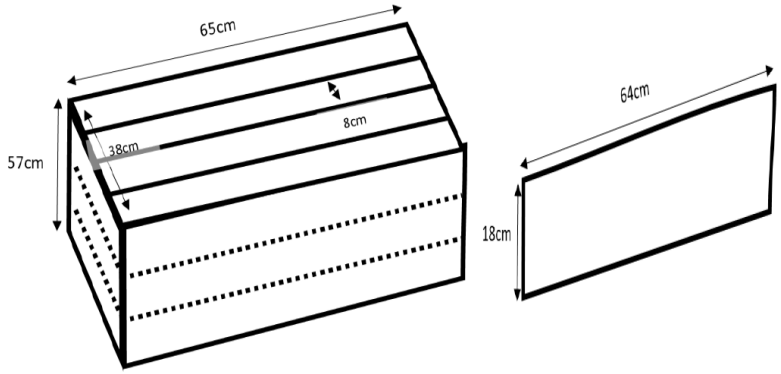

Figure 5. Schematic design Side Panel Bolster RH & LH

3.2 *Performance analysis*

a. Resistance Analysis using Mullen Test

The Mullen Test involves applying compression pressures to a cardboard sample to determine its resistance and bursting point. This test should be considered when the packaging box is projected to be stacked throughout the distribution cycle. It necessitates using a compression tester, which exerts compression forces on the box's bases until they fail. This method to analyse our Sub Assembly Lucid Armrest packaging box is shown in Figure 6.

Figure 6: Lucid Substrate Sub Assembly Armrest stacked for Mullen test

The **r**esults from Mullen test are shown in Table 1 and Table 2.

Table 1: Mullen test result for first level until third stacking level

	Stacking Level					
	1st Level		2nd Level		3rd Level	
Packaging side	**Outer**	**Inner**	**Outer**	**Inner**	**Outer**	**Inner**
On top	No damage	No damage	No damage	No damage	No damage	No damage
On bottom	No damage	No damage	No damage	No damage	No damage	No damage
On long side	No damage	No damage	No damage	No damage	No damage	No damage
On short side	No damage	No damage	No damage	No damage	No damage	No damage
On corner	No damage	No damage	No damage	No damage	No damage	No damage

Table 2: Mullen test result for fourth level until sixth stacking level

	Stacking Level					
	4th Level		5th Level		6th Level	
Packaging side	**Outer**	**Inner**	**Outer**	**Inner**	**Outer**	**Inner**
On top	No damage	No damage	No damage	No damage	Broken, Torn	Damage Goods and partition
On bottom	No damage	No damage	No damage	No damage	Torn apart a little	Good will be mess
On long side	No damage	No damage	No damage	No damage	Torn, Deflected	Broken Goods
On short side	No damage	No damage	No damage	No damage	Torn, Deflected	Damage
On corner	No damage	No damage	No damage	No damage	The nails will be pulled out	Torn, Broken

The result shows that from the first stacking level until the fifth stack, there is no damaged sign on the top, bottom, long side, short side and corner of the new packaging box, neither inner nor outer part. Only after the sixth stacking level the damaged sign appeared, such as broken, torn, deflected and extracted nails on all the packaging sides. In comparison to the previous design of the packaging box, where the damaged sign appeared as early as the fourth stacking level, these findings prove the effectiveness of the new packaging box design.

4. Conclusion

Overall, although sustainable packaging solutions for product transfer have many benefits, it is important to carefully consider the potential challenges and issues associated with implementing these solutions to ensure their effectiveness and sustainability in the long term. Based on the performance evaluation using the Mullen test, it is evidence that this type of packaging is a suitable solution for packaging automotive products. The evaluation results also prove that the appearance, structural stability and content protection by using recycled corrugated paper board packaging is very satisfactory, able to reduce the cost of raw materials and meets the needs of the industry.

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