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Conceptual Design of an Integrated Bus Passenger Seat

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Abstract: Travel by bus with long hours will create discomfort feeling for bus passenger. Long hour travel will create physiological stress and psychological stress on bus passenger. It may due to vibration, noise, as well as seat comfort. Seat comfort is a subjective feeling of bus passenger. In this research, air cushion was used to replace the part of the seat foam. During the development of the integrated bus passenger seat, total design technique was used. Four conceptual designs were generated for selection. To determine the final design of integrated bus passenger seat, the matrix evaluation method was used. The weight of the concept was obtained through weight analysis.

Key words: Conceptual design · Air-based · Gel-based · Bus passenger seat

INTRODUCTION

Nowadays, the bus passenger seats are very important for passenger who travelling in long journey. Long-distance coach services, e.g. express buses, are transporting passengers from city to city and serve as main commuter for towns without any railway service [1]. The coach passenger seat is one of the important features to ensure the comfort of the passenger for long distance travel. In the long journey, the bus passengers may seat more than 10 hours and above. The bus passengers can perform activities like reading, listening music or sleeping on the selected bus seat. The bus passengers will experience the discomfort level during the travelling in the bus. In Malaysia, the current express coaches are using polyurethane foam as the based cushion on the seat. The polyurethane seat padding will cause a bus passenger who sits for long journey feel uncomfortable and fatigue.

To develop an integrated design of bus passenger seat, the total design technique was used in this chapter. The process of the total design including the market survey, identify product requirements, conceptual design and final concept evaluation. All of the process will elaborate detail in design methodology. Besides, the ideas to design are generated from the group discussion and brainstorming. All the features and functions that are essential on the new design generated and selected by the morphological chart method.

Based on the results from the morphological chart method, there are total 4 different designs needed to be select. The evaluating alternative used in this chapter is using the weighted objectives method to decide which conceptual design is the best design among the other design. The 5-point evaluation scales were used to rate each of the objectives of the design. Lastly, the final conceptual design will conclude in the summary.

Seat Cushion: There are two type of the air seat cushion which is active and passive air cushion. The active air seat cushion is come with the air cushion control system. This system obtains sensor and an air pump to inflate the air chamber to release air. Besides, it controls the inflation and the air release by using a microprocessor. This advanced of the air cushion control system has an

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automatic adjustment system can provide a comfortable seat to a passenger [2]. On the other hand, the passive air cushion is invented in 1970s. The invention of air seat cushion had provides an extremely simple and lightweight seat construction. By attached the seats with the air inflatable cushion, the cushions have individual sections which are separately inflatable according the contour [3]. Nowadays, the air seat cushion is applied on variety of the public transportation for example in the automobile and aircraft seat cushion. The air cushions preferable use to apply in the seating cushion because there are several advantages. One of the advantages is air cushion can minimize moving shock energy and maximize a compressible area. It also provides a great stability by convert the shock energy into side support energy [4].

The gel cushion is invented by a pad containing a layer of resilient gel. Most of the material used to build up the gel will be silicone, thermoplastic elastomer or other soft rubber [5]. By using the gel cushion, it had overcome the problem for who spend a long time in the sitting life. The gel cushion may transform to provide pressure relieving areas or appropriate support and it very effective to reduce the painful pressure sores [6].

Design Methodology: In the design methodology, the total design process as shown in Fig. 1 is start with the market survey. The market study is collected the information from internet or library. Most of the information is patents, thesis, website or any study related the proposed product in the current market. The information collected is the input for the design process and all the information are compiling as literature review.

The next step will be the product requirement. After study the market of the current product, the output for the design process is the product requirement. The requirement is the guideline to contribute the design idea. Based on the product requirement, the conceptual design of bus passenger seat must take note in the performance, materials, size and design. Besides, when the product produce in high amount, the ease of assemble and manufacture are play important role in product requirement.

Then, the third step is generating several conceptual designs based on the brainstorming and group discussion. The sub-function of these conceptual designs is selected from the morphological chart method.

After that, all conceptual designs will evaluated by weighted objective method to define the best design. Based on the 5-point evaluation scale, the most suitable bus passenger seat will developed in three-dimensional views for detail evaluation purposes.

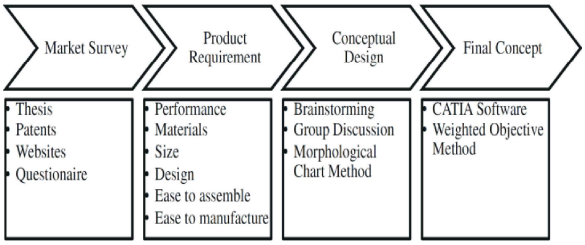

Fig. 1: The Total Design Process of Bus Passenger Seat

Conceptual Design: After a review on the market survey, the product requirements had finalized as shown in the Table 1. There are total 6 product requirements and these will be the guideline to develop the bus passenger seat integrated design.

There is a brainstorming session to generate more idea on the proposed product. About 5 mechanical engineering students use the creative thinking way to discuss on the product to generate more ideas on it.

After all the ideas are list down, the morphological chart method will combine all the design ideas in a systematic way. The aim of using this method is generate a complete range of alternative design solutions to the product. In this morphological chart will list down all the essential functions and characteristic of the product. Besides, it also includes some new ideas or sub solutions. After that, the conceptual design will base on the combination of principles in the morphological chart method as shown in Table 2.

The final concept of the bus passenger seat is using the polyvinyl chloride as material because it is low cost and easy to purchase in the current market. The medium as the cushion are air and gel and the shape for air cushion is hemisphere because bus passenger feels the softness when sit on the air cushion. The shape of gel cushion in rectangular because ease to prototype. The size of the integrated design is about 500cm^2 to 1000 cm^2, because this size will fit to the bus passenger buttock part. The arrangement of the air cushion and gel cushion are top and bottom, this is because the bus passenger feel the cooling effect when the gel cushion on top and the softness of air cushion on bottom.

Final Concept and Design: There are total 4 conceptual designs generated as final concepts. The conceptual designs explanations as the following:

Conceptual Design 1: The concept 1 is the air cushion on the front part of the polyurethane foam and two pieces of the gel cushion on the top of the polyurethane foam.

Table 1: The Description of the Product Requirements for Bus Passenger Seat

No.	Product Requirements	Description
1.	Performance	The integrated design of bus passenger seat must be responsive to the passenger's buttock part and ensure a more comfortable seating during travelling in the bus.
2.	Materials	The materials to build up the air based cushion and gel based cushion are made from materials that ease to obtain, low cost and suitable for prototyping purposes.
3.	Size	The size of the integrated design of bus passenger seat must fit to the passenger's buttock part.
4.	Design	The design of the new bus passenger seats must simplicity, functionality and ease to prototype.
5.	Ease to assemble	The integrated design contain air based cushion and gel based cushion and polyurethane foam, the way to assemble these item must be ease and simplicity.
6.	Ease to manufacture	The design on air based cushion and gel based cushion must ease to manufacture so that the cost of manufacture is lower.

Table 2: The Morphology Chart for Bus Passenger Seat Prototype

Sub-function \ Solution	1	2	3	4
Material	Polyurethane	Polyvinyl Chloride	Natural rubber	Neoprene
Medium	Air + Gel			
Shape (Air Cushion)	Hemisphere	Rectangular	Triangular	Round
Shape (Gel Cushion)	Hemisphere	Rectangular	Triangular	Round
Size	Less Than $500cm^2$	$500cm^2$ to $1000cm^2$	More Than $1000cm^2$	
Arrangement	Top and Bottom	Row by Row	Center and Surround	Side by Side

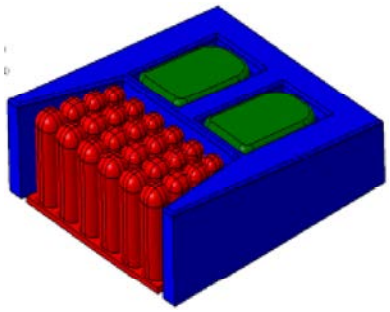

Fig. 2: The Conceptual Design 1

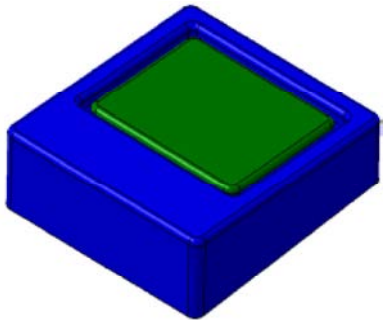

Fig. 3: The Conceptual Design 2

The thighs part will more contact with the air cushion and the buttock will more contact on the gel cushion as shown in Fig. 2.

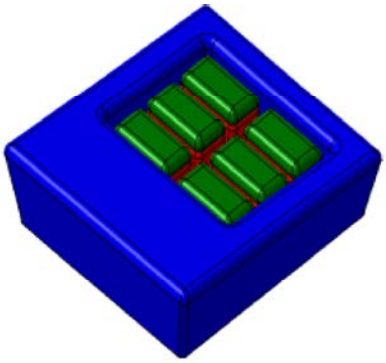

Fig. 4: The Conceptual Design 3

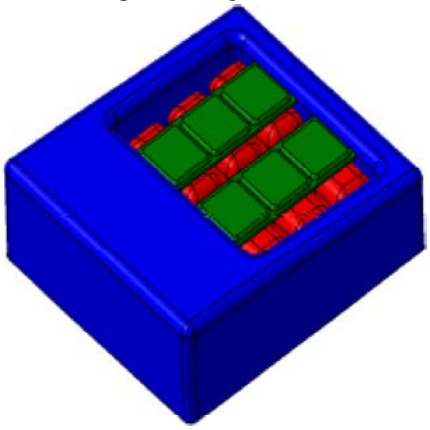

Fig. 5: The Conceptual Design 4

Table 3: The Weighted Objective Evaluation of Prototype Concepts

			Concept 1		Concept 2		Concept 3		Concept 4	
No.	Element	Weight	S	V	S	V	S	V	S	V
1.	Performance	0.25	3	0.75	3	0.75	4	1.00	4	1.00
2.	Materials	0.15	1	0.15	2	0.30	1	0.15	3	0.45
3.	Size	0.15	2	0.30	3	0.45	3	0.45	3	0.45
4.	Design	0.25	1	0.25	2	0.50	3	0.75	3	0.75
5.	Ease to assemble	0.10	1	0.10	3	0.30	2	0.20	4	0.40
6.	Ease to manufacture	0.10	1	0.10	3	0.30	2	0.20	3	0.30
	Total value			1.65		2.60		2.75		3.35

Conceptual Design 2: The concept 2 is the air cushion on the bottom part of the polyurethane foam. It is about four air cell to build up the air cushion as shown in Fig. 3. Then, the air cushion is cover by a piece of large gel cushion on top. This design is more focus on the buttock area and contact between the buttock and gel cushion is larger.

Conceptual Design 3: The concept 3 is the air cushion on the bottom of the gel cushion. Each of the gel cushions is stick on the top of the air cushion as shown in the Fig. 4. There are total 6 cells of the air cushion and 6 rectangular of gel cushions. The bus passenger may feel the cooling effect of the gel cushion and the comfortable effect of each cells of the air cushion.

Conceptual Design 4: The concept 4 is the air cushion build up by 12 air cells as shown in the Fig. 5. The air cushion in the bottom and two pieces of rectangular gel cushion on the top. The larger area of the air cushion will increase the comfortable level to the bus passenger. The gel cushion is fit on the buttock part of the bus passenger.

Concepts Evaluation: There are total 4 final concepts need to evaluate to select the best concept by using the weighted objective method. In Table 4.3, a total six product requirements have been set to evaluate the four concepts. Each of the element was provided with relative weight e.g. performance (0.25), materials (0.15), size (0.15), design (0.25), ease to assemble (0.10) and ease to manufacture (0.10). The total weight in all elements is 1.00, the performance and design element is the highest weight because the bus passenger seat is important to increase the comfortable level and simple to manufacture.

In the scoring session, it is using the 5-point evaluation scales, 0 - Inadequate, 1 – Weak, 2 – Satisfactory, 3 – Good and 4 – Excellent. Each of the concept is rated with scores (S) and multiplied by the objective weight relative values (V). All the value is summed up to get the total value for each concept. Next, the comparison on the total values for each concept and the highest values are selected. Concept 4 as shown in Table 3 scoring 3.35 had represented the highest values and this concept is the best concept compare to the other.

CONCLUSION

The concept 4 has the highest score which is 3.35. This concept selected because the highest performance with suitable material, reasonable size and the design is simplicity which is ease to assemble and manufacture. Based on the evaluation results, the selected conceptual design will proceed with the prototype build up. Finally, the bus passenger seat was successful develop in the total design process. This is start from gathered the product inputs from the market survey and finalize the product requirements on the design concept. The morphological chart used to combine all the principle so that all the conceptual design obtains the similar features and functions. After introduce all the final design, the weighted objective method was used in group discussion to determine the final concept.

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