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MEC25

Methods of Idea Generation: Case Study of Conceptual Design of Banana Peeler Mechanism

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ABSTRACT

In Malaysia, banana chips industry is widely commercialized due to high demand in both local and international markets. A various mechanism of banana peeler is designed to remove banana skin from flesh in high number of volume to help these industries optimize their productions level. However, there were some problems identified during the process especially to peel the green banana skin off the flesh. Currently, banana peeling process is done manually using several number of human operator/labour and hence, it may slow down the operation process, which in turn increase the whole operating cost. Besides, cutting tools used are unergonomic and may cause potential hazard and injury. In order to overcome this problem, a conceptual design of Banana Peeler Mechanism has been developed to produce banana peeler to fulfil consumer requirement. These idea generation methods involved three (3) sequential methods. Firstly, Requirement Analysis & Market Survey has been conducted via questionnaire to identify product specifications by considering customer needs. Followed by Morphological Matrix and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) analysis to choose the best design solution. As a result, throughout these three methods of idea generation, an effective and feasible conceptual design of Banana Peeler Mechanism has been developed to solve the stated problem and hopefully this can contribute to enhance the level of production for this industry.

Key Words: Idea generation, Requirement Analysis & Market Survey, Morphological Matrix, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

1.0 INTRODUCTION

In Malaysia, banana is considered as one of the important potential economic crops. Besides eaten raw, ripe banana can be made into cakes meanwhile the green banana is usually made into chips. According to the Department of Agriculture and The Federal Agricultural Marketing Authority (FAMA), banana chips are the largest sales contributor in the industry's growth with sales target of RM102.1 million and rising every year [1]. The success of overall sales for the Malaysian snack industry was at an excellent level due to high demand in both local and international markets.

Through fieldwork and site visit to the food industries have found that most of peeling and slicing process for making chips still in traditional method by using peeler, kitchen knife or other peeling tools without any proper peeling mechanism/machine. Banana chips industries need to cater a huge amount of green banana daily, which would consume times and labour for the purpose of peeling and causes exhaustion to the worker.

1.1 Problem Statement

The industry still faces some problems along the process to produce the banana chips especially during the peeling of the green banana skin. Designers and inventors facing a critical process to generate ideas based

to customer requirement because of lack of knowledge on how idea generation can help. Moreover, a lot of time a needed to produce a good concept design due to the uneven, irregular shape and certain kind of cellular fibre around the flesh and need tools and techniques to produce creative solutions.

1.2 Objectives

The idea of this project is to design and develop a banana peeler mechanism with little effort compared to doing it manually and can operate with many types and shapes of banana. The project will include several objectives to achieve including identify the customer's needs of a product, by conducting a market surveys to the target respondents. After that addressing the problem and generate idea for a solution. Finally producing a concept design drawing of the product-based requirement analysis.

2.0 LITERATURE REVIEW

2.1 Idea Generation

The idea generation process is the main activity of conceptual design where the ideas are developed. Sketching technique is the most frequently used by designers and engineers because of it is simple, cheap, and can be practised all the time[2]. However, from time to time the designers and engineers developed several activities including requirement analysis, product concept generation, and concept selection.

Through various methods, for example, Quality Function Deployment (QFD) is used to identify product specifications by considering customer needs and satisfaction and transform into specific engineering process [3]. For the transformation of customer needs to technical features, several methods have been developed to assist generate the ideas including mind mapping [4], brainstorming [5], TRIZ [6] or Morphological Matrix [7]. The reliability and suitability of the concept can be analysed by Pugh concept [8], TOPSIS [9] or AHP [10]. All the techniques work as a guidance for designers and engineers to select or combine the suitable techniques in order to get a best solution.

3.0 METHODOLOGY

The effective process of design is developed which involved a combination of problem solving and product improvement strategies to create conceptual design of banana peeler mechanism. Various design methods and tools were used to stimulate the ideas, to point out essential problems, design characteristics, and most important how to fulfil customer requirement to produce an effective design. In this study case, the design process activities involve Requirement Analysis & Market Survey, Morphological Matrix, TOPSIS analysis and finally develop a conceptual design.

3.1 Requirement Analysis and Market Survey

Requirement analysis is the process of defining, identifying, and documenting various requirements related to the design of a product according to customer's needs. It is important to know the implementation of requirement analysis process to avoid project failure. When it is done properly, the requirement analysis will help for better understanding of customer's needs and expectations. It is a primary phases of product design process which requires not only considering the function and structure of the product but also the user and environmental impacts. Conceptual design helps to provide an explanation of the proposed invention by integrated the concept ideas to satisfy the requirement [11].

Market research is the initial stage during conceptual design process is to get better understanding of the current problems. There are several techniques can be categorized in market research including surveys, interviews and observation. For market survey, a questionnaire is constructed to identify customer and end-user views of a problem and its possible solutions [12]. In this case feedbacks are obtained from user regarding their satisfaction of current peeling tools that they have used, seek the views of consumer on fruit peeler in the

current market referring to the price, features and functions, and identify consumer view of the problem faced when they are using it.

3.2 Morphological Matrix and Concept Idea

The Morphology Matrix method is a tool for generating many possible options in every function of Banana Peeler Mechanism. It provides a structured and systematic way to get many possibilities including unusual options. Basically, this matrix involves identifying three to six major parameters of task, choose possible attributes each parameter might have, and then exploring the combinations of attributes by selecting one attribute of each parameter/function for every combination. It is important do a discussion and brainstorming in team while conducting the morphology Matrix to ensure the possible solutions made are more creative.

3.3 Analyse Concept Selection

After Morphological Matrix has been done and concept ideas have been developed, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is constructed. TOPSIS was developed by Hwang & Yoon and is a technique for evaluating alternative performance through similarity with the ideal solution. As stated by [13], this technique, the best alternative would be one that is closest to the positive-ideal solution and farthest from the negative-ideal solution. This technique consists of formula and calculation to analyse the solution.

Step 1: Create decision matrix

In the first step of this evaluation process, the decision matrix was created based on concept idea generation. The qualitative aspect of all four concepts were quantified using rating from 2 to 8, with 2 being the lowest and 8 being the highest.

Step 2: Non-dimensionalize the attribute value

The values from the decision matrix is the non-dimensionalize by dividing each value with the norm of the total outcome vector of the particular criterion. Table 4.6 shows the non-dimensionalized value for each concept.

Step 3: Assign weighted values

Each function is given a weightage that in total has the value of 1 to establish the relative importance of the function. Each of the function was assigned a weightage and the non-dimensionalize attribute value obtained previously is multiplied with the weightage and the weighted values.

Step 4: Establish positive and negative ideal solution

Based on the results obtained, the positive ideal solution and the negative ideal solution for each function was determined. This can be done by identifying whether the benefit of the function is maximized or minimized. In this case, the benefit of all functions is maximized.

Step 5: Calculate separation distance

Separation distance was then calculated using the following formula:

$$Separation\ distance, S = \sqrt{\Sigma(Alternative\ value - positive/negative\ value)^{\ 2}}$$

Step 6: Calculate closeness rating

Finally, the closeness rating value in Table 4.10 is calculated using the following formula:

$$S = \frac{S\ negative}{S\ positive\ +\ S\ negative}$$

3.4 Conceptual Design

Pisang Nangka, Tanduk, dan Berangan are selected to determine their physical and mechanical properties. The fruits are cleaned and then classified according to their size and type from the same group. The dimensions of green banana include length, thickness of skin peeled, diameter with and without peel were measured by using Vernier calliper. 20 pieces of Pisang Tanduk are selected randomly to measure the dimensions. Since banana fruit does not have uniform shape, it was cut into two parts middle and tail end. The data are recorded and analysis for further process.

Computer Added Design (Solidwork Version 2018) is used to draw parts and assembly design. The drawing based on the concept that generate thru the previous technique. After sketching process has been done, the product will be construct using 3D printer.

4.0 RESULT AND DISCUSSION

4.1 Questionnaire

The questionnaire consist of 7 questions was distributed to 50 respondents which are involved in banana chips industries The target respondents are owner of banana chips companies 19 respondents (38%) and the workers 31 respondents (62%). From the survey, bar graph in Fig 1 shows that 30 and 28 respondents strongly agree that high productivity and reasonable price are the most important feature that they want in a product, meanwhile 18 respondents agree that they want the peeler to be low maintenance, 19 respondents are neutral on the peeler to be user friendly.

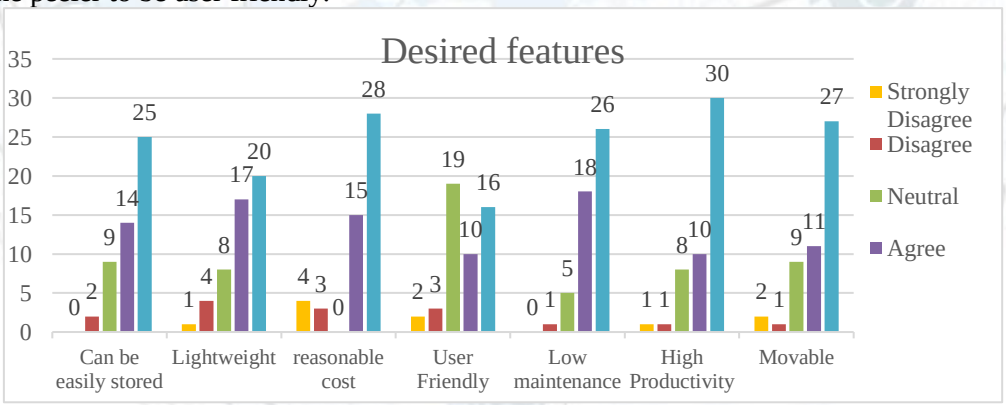


Figure 1: Important Requirements for A Banana Peeler

According to this survey it is found most of the users need a mechanism or machine work faster compare to manual technique but at the same time still maintaining reasonable prices. The banana peeler hopefully can reduce a lot of time and work load to help the industry grown.

4.2 Morphology Matrix for Concept Idea Generation

The idea generation consist of possible solution that can be made from the given parameter. The ideas are written in the table without considering whether there are useful, logic, acceptable or vice versa. For this activity, not all the type of function must be filled in the table. For example, for cutter and machine type there are only two choices available, but it can be selected many times for different concept ideas.

Mode of operation is a type of operating mechanism in the whole system whether manual, semi auto or fully auto. Normally the mode of operation can be affecting the cost of the product which is system in fully automatic mode is more expensive compare to others. For food industry, materials are used must be heavy duty, anti-corrosion and hygiene, therefore stainless-steel, aluminium, plastic and composite are the best solution. The Feeder part acts as a tool for moving bananas into a cutter and can be control by a motor or manual operation. There are two types of feeder which are roller and conveyor.

Using the attributes listed down for each function, 4 concepts were generated using combinations of the different ideas for each function as shown in Table 1. The concepts can be generated with the combination of the ideas to produce several different concepts.

Table 1: 4 Concepts Generated from the Morphological Matrix

Mode of Operating	**Manual**	**Fully Auto**	**Semi Auto**	**Semi Auto**
Material	Stainless	Plastic	Composite	Stainless Steel
Feeder Type	Roller	Conveyor	Conveyor	Roller
Cutter Type	Milling	Blade	Blade	Blade
Frame Type	Desktop	Wall Mounted	Desktop	Floor Standing
Machine Type	Fix	Fix	Portable	Portable
Power Source	Manual	Solar Powered Battery	Rechargeable Battery	Direct Power Input

For concept 1 using manual mode of operating and stainless steel as a material for frame and cutter. Once banana is inserted, roller feeder helps to pull the banana to the cutter. The product can be mounted on a table, so it can be reduced the work area space. This concept cost less because most of the operation is done manually.

For concept 2, the design of the product using solar powered battery as a power source. Even though it is not an efficient solution, but it cannot be denied that the solar power is the best renewable energy. Plastic is chosen as a material and because of lightweight compare to others. It suggested to mount on the wall but should be strong enough to withstand the load, so it does not fall.

The idea of Concept 3 is combination of semi-automatic and rechargeable battery power source. Meaning the product still using an operator in certain section for example operator must feed the banana through the feeder during the cutting process. In this case feeder type is conveyor attached with a motor. The material is made of composite which is quite difficult to find suitable with food industry purpose.

Concept 4 is more likely to conventional banana peeler in current market. It similar to concept 3 in mode of operation, material and feeder type. The advantage of this concept is used a direct power source which is can reduce a cost compare concept 2 and concept 3. But the product is quite big and heavy compare to other concepts because frame type is floor standing.

4.3 TOPSIS Evaluation Analysis

Table 2: TOPSIS Decision Matrix

Function	**Mode of Operation**	**Material**	**Feeder Type**	**Cutter Type**	**Frame Type**	**Machine Type**	**Power Source**
Concept 1	4	8	8	6	6	4	4
Concept 2	8	2	4	8	2	4	2
Concept 3	6	2	4	8	6	8	6
Concept 4	6	8	8	8	8	8	8

Table 3: TOPSIS Decision Matrix with Non-Dimensionalize Values

Function	Mode of Operation	Material	Feeder Type	Cutter Type	Frame Type	Machine Type	Power Source
Concept 1	0.3244	0.6860	0.6325	0.3974	0.5071	0.3162	0.3651
Concept 2	0.6489	0.1715	0.3162	0.5298	0.1690	0.3162	0.1826
Concept 3	0.4867	0.1715	0.3162	0.5298	0.5071	0.6325	0.5477
Concept 4	0.4867	0.6860	0.6325	0.5298	0.6761	0.6325	0.7303

Table 4: TOPSIS Decision Matrix with Weighted Non-Dimensionalize Values

Weightage	**0.2**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.2**
Function	Mode of Operation	Material	Feeder Type	Cutter Type	Frame Type	Machine Type	Power Source
Concept 1	0.0649	0.1372	0.0632	0.0397	0.0507	0.0316	0.0730
Concept 2	0.1298	0.0343	0.0316	0.0530	0.0169	0.0316	0.0365
Concept 3	0.0973	0.0343	0.0316	0.0530	0.0507	0.0632	0.1095
Concept 4	0.0973	0.1372	0.0632	0.0530	0.0676	0.0632	0.1461

Positive Ideal Solution = {0.1298, 0.1372, 0.0632, 0.0530, 0.0676, 0.0632, 0.1461}
Negative Ideal Solution = {0.0649, 0.0343, 0.0316, 0.0397, 0.0169, 0.0316, 0.0365}

And the results obtained for both positive and negative ideal solution for all concepts are shown in Table 5.

Table 5: (a) Positive Ideal Concept, (b) Negative Ideal Concept

	Positive ideal	**Negative ideal**
Concept 1	0.1067	0.1151
Concept 2	0.1659	0.0678
Concept 3	0.1195	0.0724
Concept 4	0.0329	0.1444

Table 6: Closeness Rating

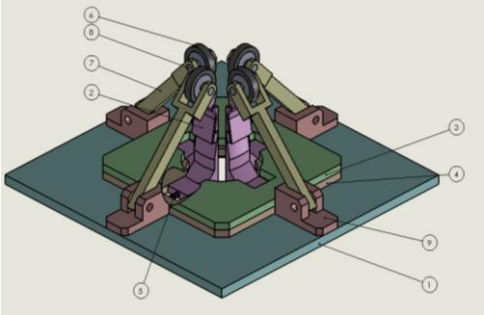
Concept	**Closeness Rating**	**Rating**
Concept 1	0.5190	2
Concept 2	0.2901	4
Concept 3	0.3773	3
Concept 4	0.8144	1

Based on the four concepts generated from the Morphological Matrix, evaluation using TOPSIS shows that Concept 4 has the highest closeness rating.

Table 6 shows the comparison of closeness rating value where the most ideal solution is the closest to value 1. In this case, concept 4 which has the value of 0.8144 is the closest to the positive ideal value.

4.4 Concept Design

According to the results obtained from the evaluation using TOPSIS, Concept 4 is chosen as the best alternative solution. Therefore, the attributes of this concept are used in the conceptual design of the product. There are two steps in producing this product design which are draw using SolidWork software and construct a prototype using 3D. Fig. 2 below are 3D assembly drawing consist of 3 main parts: cutter, feeder and plate. Cutter and feeder mechanism can be adjusted according to the shape and size of banana. Meanwhile, the plates are used as a base for each component and parts.



Item No	Description	Quantity
1	Base Plate	1
2	Tracer & Cutter	4
3	Cover Plate	1
4	Ejector Plate	1
5	Compression Spring	4
6	Roller	4
7	Roller Arm	4
8	Roller Pin	4
9	Arm Holder	4

Figure 2: Isometric View of Banana Peeler and BOM

5.0 CONCLUSION

The process of ideas generation to design & develop a banana peeler mechanism using an effective design process that incorporates problem solving strategies, product improvement strategies and finally create a conceptual design of a mechanism was achieved. The design technique used in product development process allowed to reach good result concerning the conceptual design phase.

To develop and generate the ideas numerous design tools and methods were used to generate idea, identify essential problems, customer requirement, function structures, solution, characteristics, and most important these activities help to build an effective design process. This process helps to evaluate the requirement and attributes of the product to identify effective design trade-off. As a result, the best alternative solution is determined.

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