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## Design and Analysis of Garlic Peeler Machine

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**Abstract.** The purpose of this research is to design and analysis of a Garlic Peeling Machine. The traditional hand peeling garlic method is very tedious and time-consuming work once a bulk quantity of garlic to be peeled, especially for restaurants. The pungent smell of garlic will make the uncomfortable for user's hands and eyes. Hence, the goals to be achieved in this research are to design a garlic peeling machine to replace the manual working in order to reduce the time taken compared to the hand peeling method. The research scopes involved of design and generate idea concepts, simulation and analysis structure and undergo experiment. The process flow of this research begins according to the standard design process flow. A survey was conducted to collect the customer's requirements. After idea generation, the final concept was selected using Pugh method and weighted method. Simulation of fluid flow was carried out using computational fluid Dynamic (CFD) software.

### 1. Introduction

Garlic also called *Allium sativum* L. in the scientific name is a cooking ingredient for humans in daily life. In the lily family named Liliaceae, garlic is one of the important perennial bulb crops [1]. The garlic bulb is covered by a thin papery skin which cannot be eaten. In the culinary arts, normally it is used as a flavoring ingredient in recipes rather than as the main ingredient itself. The peeling of garlic cloves is the unit operation through which papery outer skin is removed to facilitate further processing [2]. Garlic peeling is a tedious, key, costly, and time-consuming unit operation in garlic processing [3]. Since garlic has thin skin which is not easy to peel cleanly and fast by hands and can cause finger injuries. There are different types of garlic peeler machines that have been created with different design concepts such as using dry peeling and wet peeling methods [4-6].

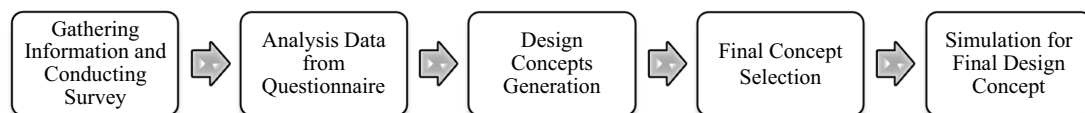
Surveying is the research methodology that gathers the information by preparing the questionnaire [7]. There are a few questions including the condition of the environment restaurant, condition of the workers and also opinions of the respondents to fabricate a garlic peeling machine. Product design development is a sequence of steps or activities for the conceptual ideas, creative design, and commercialism for a product [8-10]. In general, there are six phases in a product development process including planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up [11]. From previous research [9-10, 13], the use of 3D CAD software in



designing the product can make the designer easier to view the model in a variety of representations and can make the simulation to the model by simulating the real condition. One of the powerful and widely used range of analysis process in engineering applications which is Computational Fluid Dynamics (CFD) [12,14]. ANSYS Workbench is used to set up and simulate the three dimensional laminar or even turbulent fluid flow while the type of ANSYS CFX is suitable used to run the fluid flow simulation.

## 2. Experimental

This research starting by gathered information from the previous case studies, journals and the existing of garlic peeling machine. Other information gathered by conducting the survey at restaurants and cafeteria which are to collect some customer's requirements. After that, analyse the result of questionnaire and brainstorming of design concepts for garlic peeling machine. The final design concept will be selected by using the Pugh's method [15-18]. The final design is then simulated and analysed by using the Ansys software. Figure 1 shows a flow process of product development for garlic peeling machine.



**Figure 1.** Flow chart of research

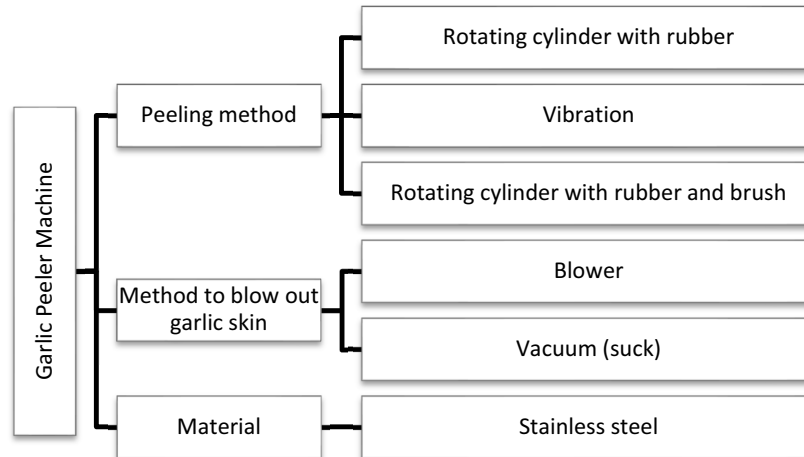
### 2.1. Analysis data from Questionnaire

There are 20 questionnaires provided and distributed to various types of restaurants and cafés including stalls, restaurants and weddings. The staff at the restaurant had contributed their time and cooperated to complete the questionnaire provided. The questionnaire is divided into several key areas for data analysis such as garlic needs as a main ingredient, daily quantity, peeling method, peeling time, price and mobile.

### 2.2. Design Concepts Generation

The creative of 'think out of the box' must involve in this step of brainstorming for new design concepts. At least three design concepts will come out according to the previous information gathered and suggestions of respondents which collected from the survey in order to have a better understanding on the customer requirements and hence to allow generation of idea to take places. Some design considerations should be taken in idea generation such as which method is suitable for peel off the garlic, which way and component are suitable to blow out the garlic skin and also the material selection which durable to achieve the sustainability.

The design of the garlic peeling machine should has a corrosion resistance material that contact with garlic, an effective of peeling garlic and also a good flow arrangement for collect garlic skin so that to produce a good performance of garlic peeling machine. Figure 2 shows a mind map for design concepts generation of garlic peeler machine.



**Figure 2.** Mind Map for Design Concepts Generation.

### 2.3. Quality Function Deployment

Quality Function Deployment (QFD) is a method to transform the customer needs into desired design and then produce product into design quality which to satisfy the customer demands. A product is to be designed and developed according to the voice of customers. The voice of customers about garlic peeling machine is captured from conducting a survey in various types of restaurants. The customer's needs are to be understood, summarized it and then linked it to the relevant engineering specifications that will perform in the next planning, House of Quality (HoQ) or QFD Matrix. By implement QFD, it able to reduce the unnecessary cost during the production process. QFD also helps to clarify the customer's requirements and eliminate the misunderstanding of customer's needs.

HoQ is a quality planning tool based on QFD. Its purpose is to define the relationship between customer desires and the product capabilities. A planning matrix is undergoing to link the list of customer needs to produce a product is going to meet those needs. The customer requirements about the garlic peeling machine are listed out after analysis data from questionnaire and then transfer it into HoQ. The structure of HoQ just looks like a house. Top roof is set for "correlation matrix", customer needs versus product specifications as the main part and competitor evaluation as the balcony of the house. The HoQ regarding to the customer wants on the garlic peeling machine is showed in figure 3.

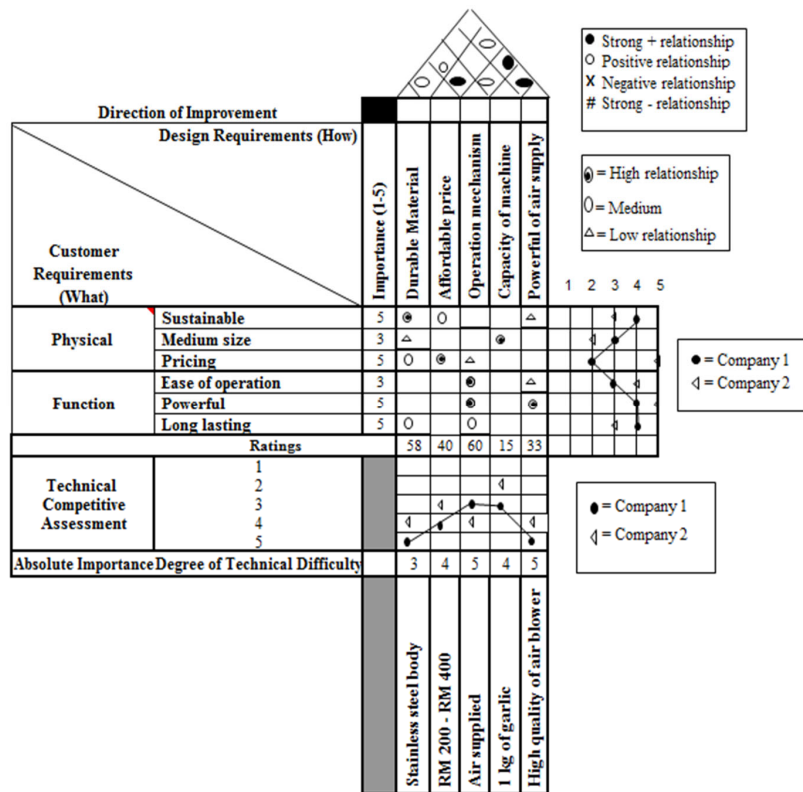


Figure 3. House of Quality for Garlic Peeling Machine.

2.4. Final Concept Selection

For final concept selection, there are different types of methods used for making final concept decision such as Pugh method and Weighted method [19-20]. The final concept design of the garlic peeling machine will be decided among the three designs by using either Pugh method or Weighted method. The alternative names for Pugh method and Weighted method are called Concept Screening and Concept Scoring respectively. Both methods are quantitative technique and very useful for engineers which to help them make design decisions by undergoing a few of steps to choose the best design from the design concepts generation. For the Screening method is used to judge the proposed concept designs based on the selected datum while for the Scoring method is used by putting the score of relative importance to the selection criteria and then carry out the comparison among the three designs concepts. The criterion selected for the comparison can be price of the machine, time consuming, ease of production, manpower, and any important characteristics of the machine.

2.4.1. Pugh Method/ Concept Screening

Based on the evaluation criteria on the customer requirements mentioned previously, the Concept 1 is selected as the initial datum because it is the first idea generated. The criterions that to be considered are functionality, ease for maintenance, safety product, aesthetic value, costing, eases for operation and so on. The Pugh concept selection matrix shown in table 1 resulted from our first analysis. The final design concept will be concept 3 because it has a suitable size as customer’s need, nice appearance, durable material, affordable price considering from parts selection and also easy for maintenance and operation.

**Table 1.** Screening Table for Concept 1 as DATUM.

Engineering Criterion	Concept 1	Concept 2	Concept 3
Size		+	+
Safe for use		s	+
Ease of Maintenance		s	+
Ease for operation		+	+
Aesthetic value	DATUM	s	+
Sustainability		s	s
Functionality		s	s
Pricing		+	+
Sum +		3	6
Sum -		0	0
Sum s		5	2
Concept Rank		2	1

#### 2.4.2. Weighted Method/ Concept Scoring.

Another method used to select the final design concept which is Concept Scoring. Table 2 shows the selection matrix for garlic peeler machine. The criteria that to be chosen for compare between the three of design concepts are size, safety product, ease of maintenance, ease for operation, aesthetic value, sustainability, functionality and pricing. After that, all the criteria are to be rated and ranked by calculation of the weighted scores and the result showed in table 3.

**Table 2.** Selection Matrix for Garlic Peeling Machine.

Criteria	Concept 1	Concept 2	Concept 3
Size	Fair	Good	Excellent
Safe for use	Good	Good	Good
Ease of Maintenance	Fair	Good	Good
Ease for operation	Good	Good	Good
Aesthetic value	Good	Good	Excellent
Sustainability	Excellent	Excellent	Excellent
Functionality	Good	Fair	Excellent
Pricing	Fair	Good	Good

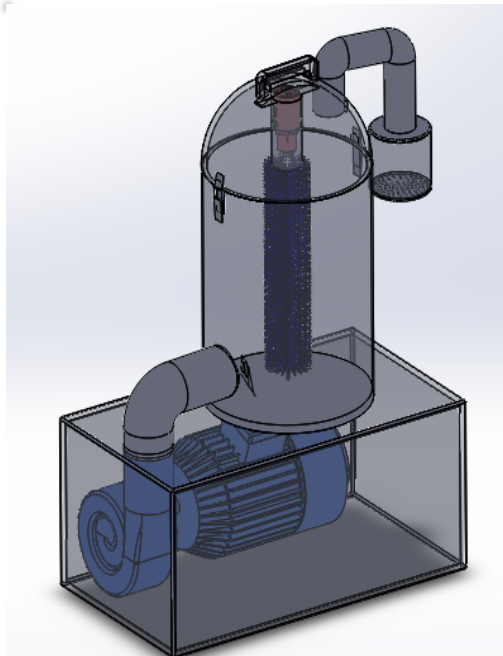
**Table 3.** Scoring Table for Garlic Peeling Machine.

Engineering Criterion	Criteria Weightage	Concept 1		Concept 2		Concept 3	
		Score	Rate	Score	Rate	Score	Rate
Size	0.12	1	0.12	2	0.24	4	0.48
Sustainability	0.20	3	0.60	3	0.60	3	0.60
Pricing	0.08	2	0.16	3	0.24	2	0.16
Ease for operation	0.18	3	0.54	3	0.54	3	0.54
Safety product	0.18	3	0.54	2	0.36	3	0.54
Ease for maintenance	0.24	2	0.48	3	0.72	4	0.96
<b>Total</b>	<b>1.0</b>		<b>2.44</b>		<b>2.70</b>		<b>3.28</b>
<b>Rank</b>			<b>3</b>		<b>2</b>		<b>1</b>

Through the scoring method in table 3, the result shows that concept 3 is the highest ranking, 3.28 following by concept 2 with the rank of 2.70. For concept 1, it is the lowest ranking with only 2.44. As a result, design Concept 3 to be chosen as final design since its overall is better than other concepts.

#### 2.5. 3D CAD Drawing of Garlic peeling Machine.

After generated few of the design concepts of garlic peeler machine using hand sketching previously, the final design concept is also selected. The standard procedure of engineering design concept selection methods are Pugh's method and Weighted method. Next, the final design concept is drawn by using Solidworks software as shown in figure 4.



**Figure 4.** final design garlic peeler machine.

### 3. Results and Discussions

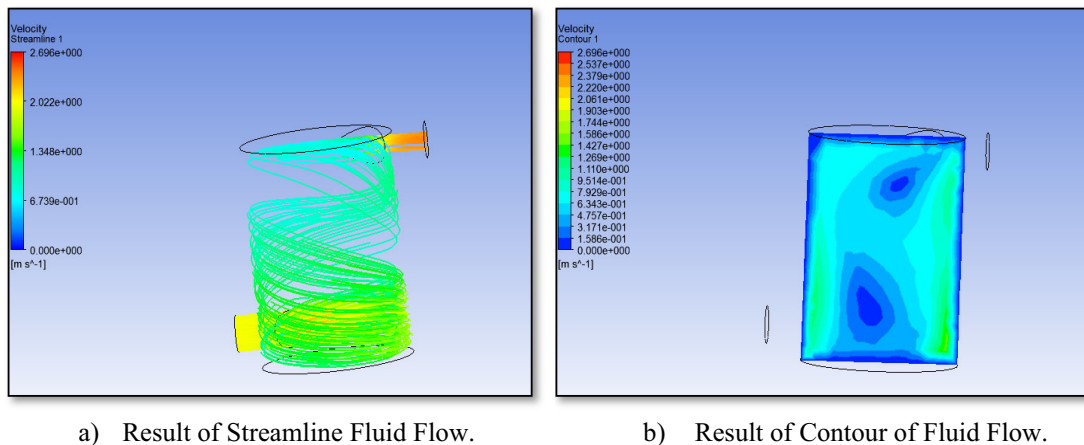
#### 3.1. Result of Simulation CFD

The fluid flow of the new design of garlic peeling machine is analysed using by ANSYS software. ANSYS Workbench is used to set up and simulate the three dimensional laminar or even turbulent fluid flow while the type of ANSYS CFX is suitable used to run the fluid flow simulation. The fluid can be even air or liquid [10]. The product, garlic peeling machine is necessary to undergo the simulation of computational fluid flow (CFD) due to the air will supply from one of the product's component which is blower. Blower is able to supply enough of air from the machine's inlet and form a flow in the peeling chamber. After that, the air from the blower is then removed the garlic skin out from the peeling chamber through the outlet.

The fluid flow that applied into the garlic peeling machine to peel off the garlic skin is pure air. The density of air is approximate to  $1.225 \text{ kg/m}^3$  and also has a viscosity of  $1.983 \times 10^{-5} \text{ Pa.s}$ . The diameter of the air inlet of the new design garlic peeling machine is 50 mm and has a diameter of outlet with 50 mm. The design of peeling chamber has a diameter of 220 mm with height of 300 mm. The information of this new design parameter is then used into the simulation of fluid flow. The fluid flow simulation is able to show that how the streamline of the fluid flow formed in the peeling chamber and also how the air blows the garlic skin out from the peeling chamber.

Figure 5a) shows that the streamline of the air flow is formed in the spiral shape. The air comes from the bottom inlet and then goes out from the top of outlet. This result of streamline proves that the air flow is able to blow the garlic skin follows up with the spiral air flow and goes out through outlet. Once the air goes in, the velocity in yellow region with 2.022 m/s is considered in medium velocity. The yellow region getting reduces to green region of 1.348 m/s at bottom. While the air flow getting go up to the top, the air flow continues to slow down with only 0.6739 m/s in the region of light blue. After that, the air meets the outlet and ready to flow out, it becomes faster in red region and the velocity reaches 2.696 m/s. Figure 5b) shows the result of contour of the air flow formed in the design model. The blue region means that there is no contour produced at the area without velocity, 0 m/s.

The surrounding of the model and the center are not involved due to there has the brushing rod is rotated at the center region. Besides that, there has only a little of velocity in the region of light green at the corner with 1.269 m/s. Hence, the major area that involved in the contour which is the light blue region with velocity of 0.7929 m/s.



**Figure 5.** Result of simulation.

#### 4. Conclusions

The final design of garlic peeling machine is generated and selected according to the standard of design procedure, Pugh method and Weigh method. The way to be used and applied on this new design is using the concept of supply sufficient of air from blower to blow out the garlic skin from peeling chamber. On the same time, a brushing rod is rotating at the center of the peeling chamber to peel off the garlic skin.

From the aspect of result obtained from simulation CFD, the new design of garlic peeling machine is acceptable. The streamline of the air flow produced in the model is able to form in the spiral structural. From the spiral result gained showing that a vortex of air will be performed in the model. The air flows in from the inlet and then leaves the main body through outlet. This brings the meaning that the air supply from the bottom, inlet is able to blow the garlic skin goes out from the top, outlet due to the lightweight of the garlic skin. The concept without using water can be maintained the hygiene of garlic and also keep longer time in storage. In conclusion, the new design of garlic peeling machine is definitely suitable to replace the traditional of hand peeling method in the business of restaurant and cafeteria. The simulation of fluid flow proves that the air flow in from the bottom, inlet is able to produce a vortex in the peeling chamber and then the garlic skin goes out through the top, outlet. There is able to separate the peeled garlic and the garlic skin and hence this design is generated.

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