RESEARCH PROGRESS IN MECHANICAL AND MANUFACTURING ENGINEERING VOL. 4 NO. 2 (2023) 236-244

RPMME

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Design of A Cooked Rice Dispenser Device for A Small Food Business

Olivia Chemma Anak Cosleycan[1], Mohd Azwir Azlan[1*]

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2023.04.02.030
Received 10 Sept 2023; Accepted 15 Dec 2023; Available online 31 Dec 2023

Abstract: Rice is a starchy cereal that is edible and also the main staple for most of the countries all around the world. Many food businesses still serve rice and make it as the main dish in their restaurants but still use the traditional method (manual) to scoop the rice and this causes the price inconsistency, inefficient and low production during peak hour. Manual method also less in aspect of hygiene. The research aims to design a cooked rice dispenser that is able to dispense various amounts of rice faster based on the setting provided and meet the characteristic food hygienic equipment design that can be use in any small food business. By referring design process by George E. Dieter, there is three main part that had been generated in order to complete this project, which is conceptual design, embodiment design and detail design. Other than that, engineering calculation and SolidWorks software are needed in this project for develop the analysis and simulation for the component. The purpose of engineering analysis and simulation is to evaluate the product specification whether it fulfil the requirements or vice versa. The final design of cooked rice dispenser device is expected to dispense cooked rice less than seven seconds. The overall dimension for the device will be 380mm (L)×550mm(W)×606mm(H) with total weight of 23.26 kg. This design is expected to be more efficient when compared to the traditional methods in scooping the cooked rice**.**

Keywords: Small food business, Cooked Rice, Dispenser, SolidWorks

1. Introduction

Rice, which is the scientific name of Oryza Sativa is a starchy cereal that is edible. Until now rice has been the main staple for most of the countries all around the world, particularly in Asia, Latin America, and parts of Africa. The highest rice consumption in Asia was recorded by China with 174,687 kilotons in 2017, followed by India and Indonesia [1] (Helgi, 2020). Meanwhile Malaysia on average consumed 2.5 plates of rice per day [2] (R.B. Radin Firdaus, 2020). The most common rice that are consistently consumed in Malaysia is white rice, ponni rice, basmathi rice, brown rice, and jasmine rice.

**Corresponding author: azwir@uthm.edu.my*

Rice is the main source of energy since it consists of 80% carbohydrate, 7-8% protein, 3% fat and 3% fiber and been served in almost every restaurant and any small food industry for so many years. As it is the food that people can devour the most easily and because it never tastes bad, rice always ends up as the main meal. This is particularly true when it is combined with other foods like vegetables, protein, and sauce. Rice is located at the second bottom of the diet pyramid in Malaysia, which implies that it needs to be consumed in moderate amounts, which is approximately three to five servings per day [3] (Parenting, 2022). Rice is unsafe to be eaten after being left exposed to the air for more than two hours at room temperature ($19℃ - 32℃$) since bacteria will grow rapidly between ($4℃ - 60℃$). To ensure the rice is in good condition for a long time, it is better to store it in a fridge with temperature lower than $4℃$. The other way to maintain the condition of the rice is store it inside the rice cooker, which is around ten to twelve hours at maximum, but the temperature must be more that $60℃$ but less than $66℃$. It is the perfect temperature to serve the rice. If the rice cooker cannot maintain that high temperature, the numbers of hours to store the rice inside it must be reduce [4] (Jamie, 2022). In Japan and Singapore, there is a new technology which is an automated device that able to store and dispense the rice. The dispenser has variety setting which is able to dispense rice with according to desired amount without required any manpower. The problem is they still use manual method (scooping) which causes price inconsistency, inefficient and low productivity during peak hours. This causes the length of time to serve takes a little bit longer which one of the problems in food business [5] (Franklin, 2022). Manual method also less in aspect of hygiene especially for those who handling the food. The objective of this project is to design a cooked rice dispenser that is able to dispense various amounts of rice faster based on the setting provided and meet the characteristic food hygienic equipment design. This device can be used in any small food industry such as restaurant, catering, or any food franchise. The significant of this project is to study on the knowledge of the technology that capable of storing and dispensing rice based on the needed amount. At the end of this study, it is hoped that Malaysia will be able to produce a new local product which is Cooked Rice Dispenser.

2. Literature Review

A literature review is the method of collecting information on all relevant subjects or requirements of the project. It is carried out by collecting data through patent analysis, books, journals, and current products that would be comparable and used for product design. This invention is to provide a device that capable to dispense a predetermined weight of cooked rice to a container. There are three main mechanisms that can be used in this device which are transfer mechanism, weighing mechanism, and dispensing mechanism [6]. Main function of transfer mechanism is to push the cooked rice forward to the dispensing area, while for the dispensing mechanism is to dispense or drop the cooked rice to the container which located below the dispensing components.

Weighing mechanism is to measure the desired amount cooked rice selected by the customer and there are varies of option for the weight [6]. Type of sensor that is used detect the weight of cooked rice is strain gauge load cell also as a transducer or sensor that capable to converts force to an electrical signal. Type of force are such compression, tension, pressure, or torque [7,8].

The availability of product means, the commercial product that can be sold, rather than one still being developed. Basically, this cooked rice dispenser device is existed in market especially in Japan and Korea with different performance. In this subtopic, study and review on the available product is significant to collect the data and specifications of the related machine. This will improve and develop the idea to produce a new design and better performance. Table 1 shows the available product in the market.

Table 1: Available Product in the Market

Specifications	Fuwarica Rice Serving Machine	Rice Dispenser Machine	Rice Weighing and Serving Robots	Rice Dispenser
Figure				
Hopper capacity	10kg	22kg	3.5L	10kg
Capacity	720 meals (250g)	1 200 meals (140g)	-	200 gram/3seconds
Dimension	(394W×526D×609.5H) mm	(392W×592D×756H) mm	(380W×530D×570H) mm	(380W×575D×620H) mm
Power	AC110-120V	AC110-220V	100V	Single phase 100V
Weight	32kg	35kg	45kg	53kg
Power Consumption	360W	230W	150W	150W
Price	RM11 470.41	RM 47 474.07		RM528 022.80

3 Design process

3.1 Methodology

The project was conducted using a design process model from George E. Dieter as shown in Figure 1. Based on the design process that develop by George E. Dieter, it mainly consists of three phases of design which is conceptual design, embodiment design and detail design. Conceptual design is defining problem, gather information, concept generation and evaluation of concepts. The second stage is embodiment design and it consist of three stages which is product architecture, configuration design and parametric design. The last phase is detail design which only have one stage [9].

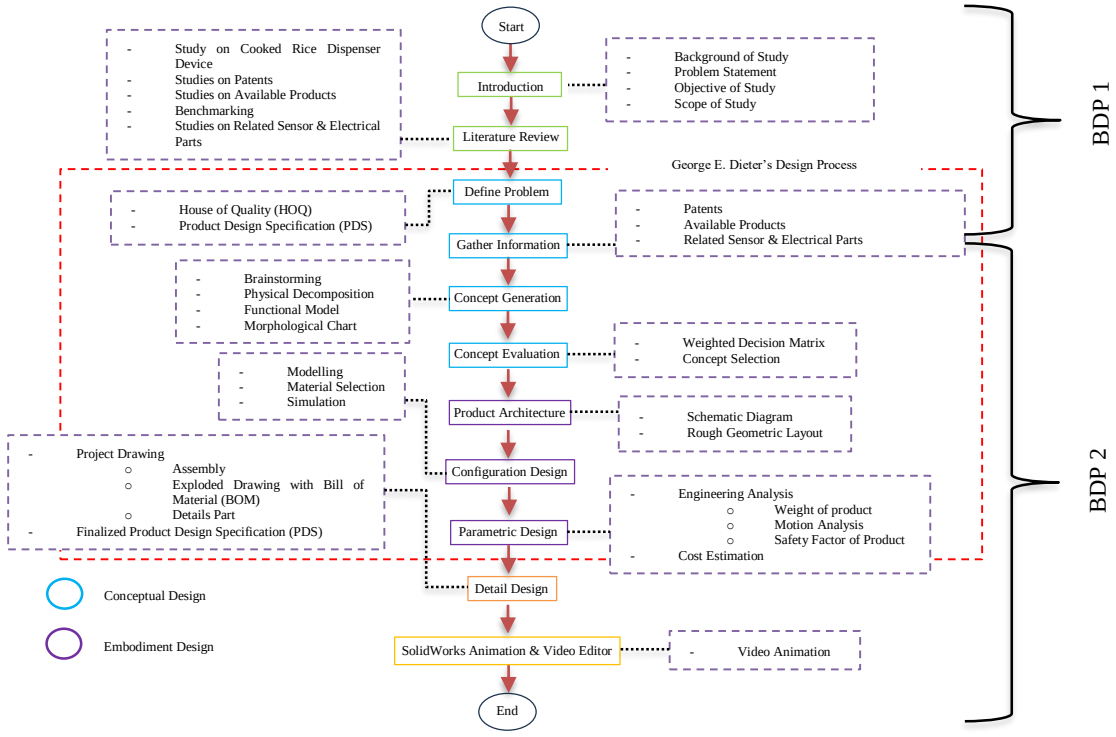


Figure 1: Project Flowchart of Design Process

3.2 Product Design Specification

In order to collect information, interview session is conducted with Ms. Nur Nabilah Huda, which is the representative the Arena Maya, where there provides a catering service. The question is given by using questionnaire and it is divided into four sections. The first, second, third and fourth sections is general information, priority requirement expectation toward product and satisfaction of user, respectively. The data from this interview is used to obtain the objective tree and generate Product Design Specification (PDS). Figure 2 and Table 2 below shows the objective tree and PDS.

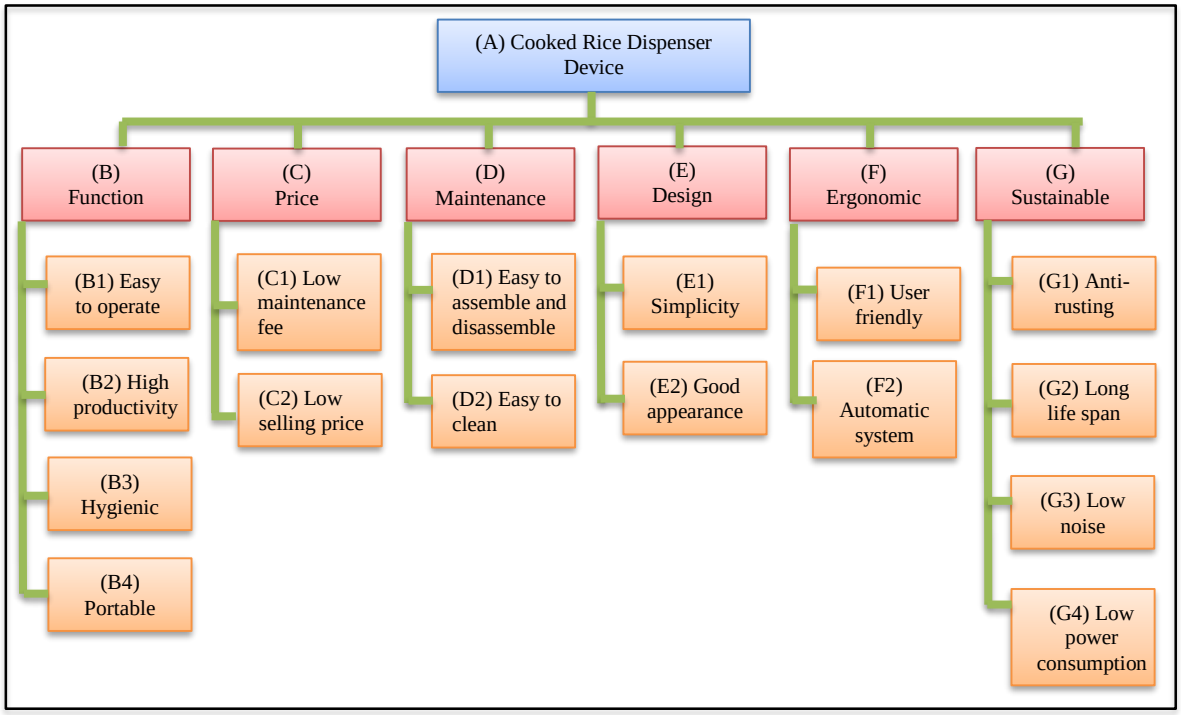


Figure 2: Objective Tree

Table 2: Product Design Specification

Introduction	
Title	Cooked Rice Dispenser Device
Design Problem	Design a cooked rice dispenser device that has the ability to dispense various amounts of rice faster based on the setting provided.
Intended Purpose	To dispense cooked rice faster and hygiene to customer. To promote a technology that related to food industry.
Special Features	Consist of heat insulator. Able to check the remaining cooked rice in device.
Customer Requirement	
Functional Performance	• The machine should be able to dispense cooked rice less than seven seconds. • The capacity of hopper must be bigger than 20kg.
Operating Environment	• Suitable in food business environment (hygienic)
Economic	• The selling price of the machine should be less than RM15 000. • Low maintenance cost. • Life span more than ten years.
Geometric Limitation	• Total weight of the device should be less than 30kg. • The size of device should be (380W×550D× 700H) mm
Maintenance, Repair, Retirement	• The device's part should be easy to assemble and disassemble for cleaning and maintenance purpose. • No major repair is required during product economic life. • The cooked rice must stay safe and clean from dirt.
Safety	• The device is stable and without any major failure occurs within economic life. • No sharp edges that cause danger to user or customer. • Food grade is used to keep the cooked rice hygienic.
Pollution	• Low noise generated from the machine.
Ergonomics	• Simple operation steps and user-friendly. • Device is easy to assemble or disassemble for cleaning purpose.
Appearance	• The appearance should be attractive in terms of shape. • Simple colour will be chosen for the customer.

3.3 Concept Generation

Techniques such as brainstorming, physical and function decomposition, and morphological charts were used and debated during this phase. This is to develop ideas for products that can do the functions that the product requires. Figure 3 shows the function structure of Cooked Rice Dispenser Device.

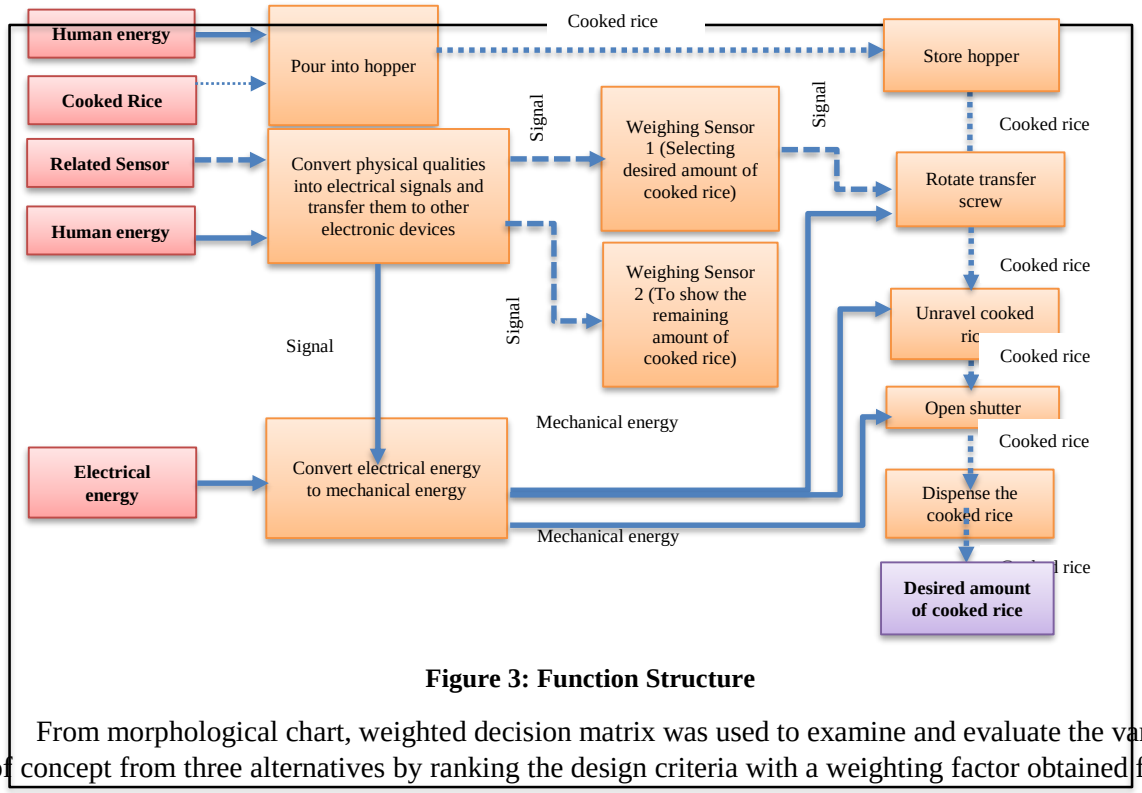


Figure 3: Function Structure

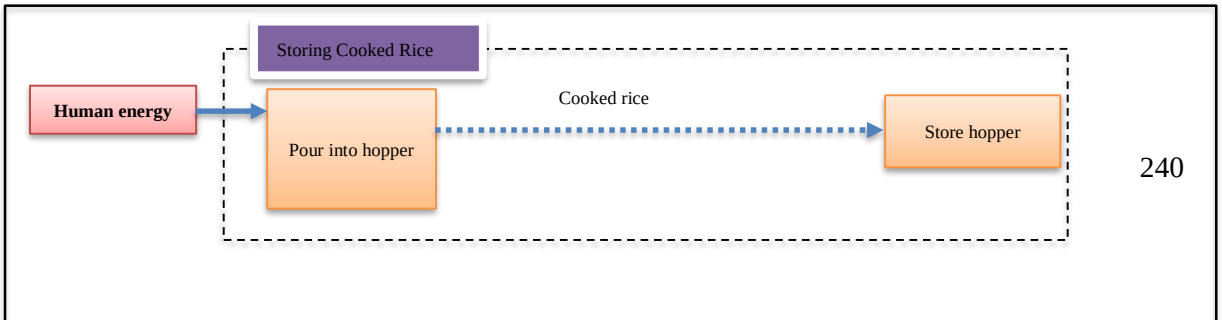
From morphological chart, weighted decision matrix was used to examine and evaluate the variety of concept from three alternatives by ranking the design criteria with a weighting factor obtained from the objective tree questionnaire. This method allows to find the best concepts that fulfill the customer requirements. After evaluating, the combination of concept with the highest rating will be selected to proceed on the next stage. Table 3 shows the combination of concept for the device.

Table 3: Concept Selection of the Device

No	Function	Selection Concept
1.	Power Source for transfer screw	Stepper motor
2.	Power Source for beater and shutter	High Power Brushed DC Geared Motor
3.	Power Source for roller	Brushed DC geared motor
4.	Transfer Mechanism	Transfer screw and beater
5.	Unravel Cooked Rice	Horizontal roller
6.	Dispense Mechanism	Semi-circular shutter
7.	Weighing Mechanism for dispensed cooked rice	Single point weighing load cell
8.	Weighing Mechanism to measure remaining cooked rice	Planar load cell
9.	Shutter mechanism	Gear system

3.4 Product Architecture

Product architecture ensures that the product is able to perform its intended function. Designer need to establishes the geometric boundaries of the product and lays out the proposed design components within its envelope. The purpose of this step is to arrive at an arrangement of design elements (clusters) that will become modules. Figure 4 shows the schematic product of cooked rice dispenser device with clustered elements.



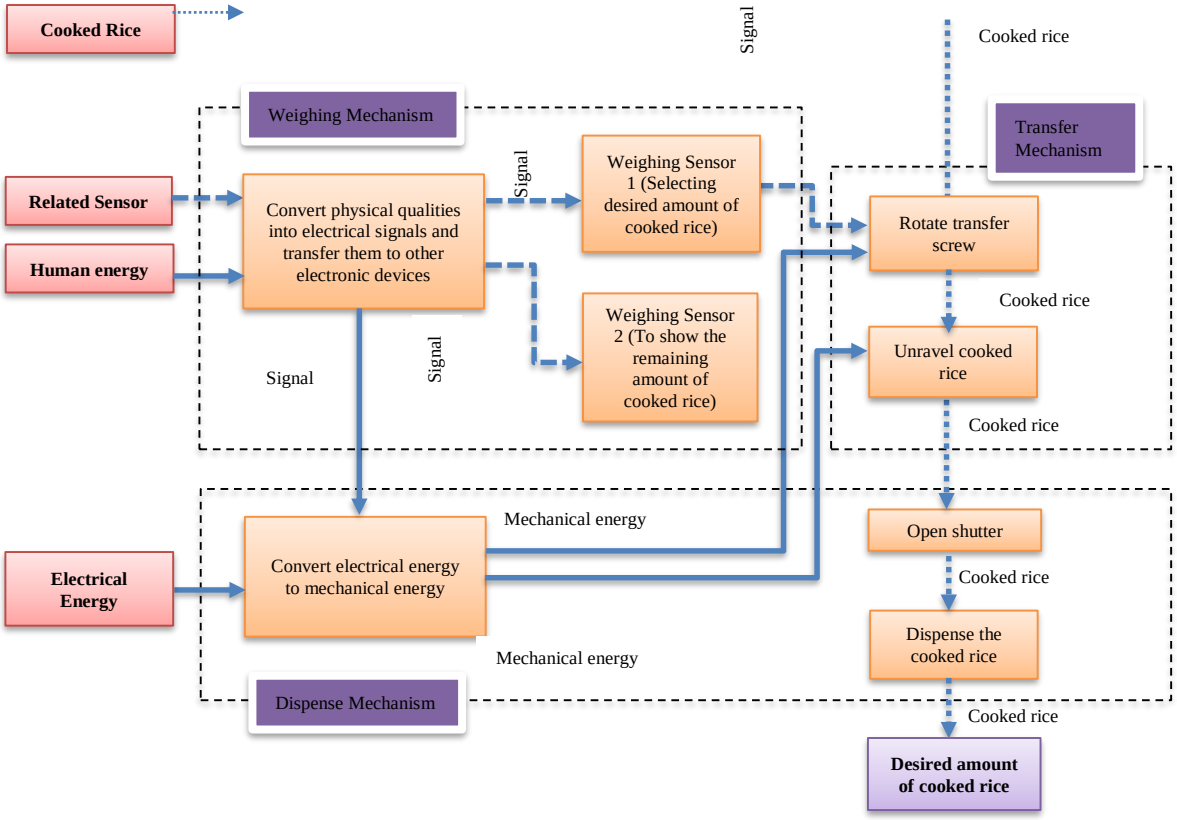


Figure 4: Product Schematic with Clustered Elements

3.5 Modelling

Using the SolidWorks software, all of the concepts chosen for the previous step were transformed into 3D models through modelling. The final product was assembled from all of the components and sub-assemblies. Figure 5 shows the full assembly of the device.

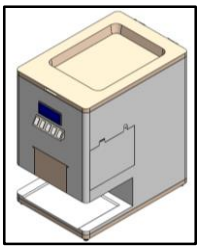


Figure 5: Full Assembly of Cooked Rice Dispenser Device

3.6 Device Process Flow

Transfer mechanism consists of two components which are beater and transfer screw. Beater is rotate to prevent the cooked rice lumpy in the hopper while transfer screw used to push the cooked rice forward. Unravel mechanism consist of roller and pin and it is positioned in perpendicular direction from the transfer screw. Those components rotate in a clockwise direction. Figure 6 shows the rotation for both of the mechanism.

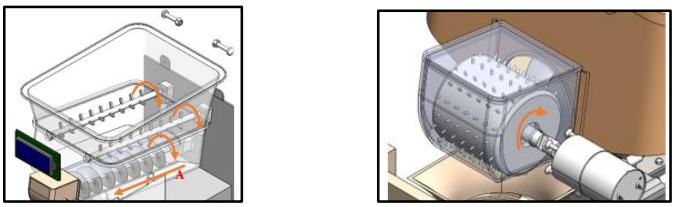


Figure 6: Left: Rotation of Transfer Mechanism, Right: Rotation of Unravel Mechanism

Dispense mechanism consist of upper shutter and lower shutter. Lower shutter is used to store and dispense cooked rice once the desired weight of cooked rice is achieved, while upper shutter allows cooked rice to smoothly move from the dispenser mechanism to the lower shutter. The shaft of the shutter is connected with two pair of gear with different outer diameter. The rotation of shutter and gear is shown in Figure 7.

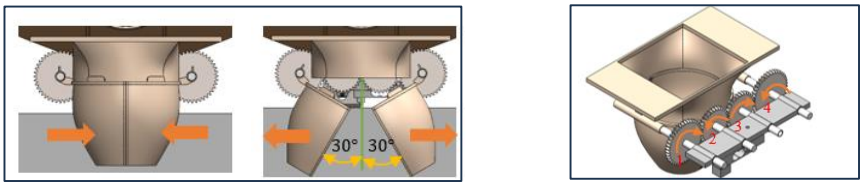


Figure 7: Left: Rotation of Dispense Mechanism, Right: Rotation of Gear

3.7 Torque Analysis

Calculation for torque requirements is carried out to identify the most suitable motor that can be used for this device. The most important part that need to be calculated is transfer screw.

Figure 8 shows the front view of the transfer screw and d_m represent the pitch diameter. The engaged thread for this component is $n = 1$. The coefficient of friction between the cooked rice and hopper is 0.4 (Matouk, M.M , & S.M., 2003). Value for D and d in Figure 8 are 75mm and 15 mm, respectively. Figure 9 shows the side view of the transfer screw. The p is represented for the pitch of each thread and the value is 43.75 mm. The surface area of the transfer screw is 5297.51 mm^2 while the volume is 1811642 mm^3. This value is obtained from the SolidWorks.

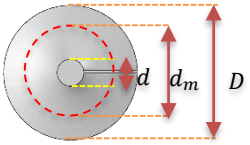


Figure 8: Front view of transfer screw

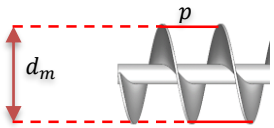


Figure 9: Side view of transfer screw

Formula (Budynas & Nisbett, 2014) that is used to calculate the torque required for each beater is as below:

$$T = \frac{F d_m}{2}\left(\frac{\mathrm{l} + f d_m}{\pi d_m - f\mathrm{l}}\right)$$

Below is the calculation of each parameter to calculate the torque:

$$\begin{aligned} \mathrm{l} &= np \\ &= (1)(43.75) \\ &= 43.75\ mm \\ &= 0.04375\ m \end{aligned}$$

$$\begin{aligned} F &= \mathrm{mg} \\ &= (1.576)(9.81) \\ &= 15.46\ N \end{aligned}$$

$$\begin{aligned} m &= \rho \mathrm{v} \\ &= (870)(0.00181164) \\ &= 1.576\ \mathrm{kg} \end{aligned}$$

$$\begin{aligned} d_m &= D - \frac{(D-d)}{2} \\ &= 75 - 30 \\ &= 45\ mm \\ &= 0.0045\ mm \end{aligned}$$

Below is the calculation of the torque required by the transfer screw.

$$\begin{aligned} T &= \frac{(15.46)(0.045)}{2}\left(\frac{(0.04375) + (0.4)(0.045)}{\pi(0.045) - (0.4)(0.04375)}\right) \\ &= \boldsymbol{0.3\ Nm} \end{aligned}$$

3.8 Simulation analysis

There are two analyses has been done to the cover transfer screw and it was stress analysis and factor of safety. The maximum stress has a maximum stress has a magnitude of 6.9 MPa which is less than the material yield strength which is 100 MPa. Hence, the cover transfer screw will not yield and return to initial state after removing the cooked rice. Figure 10 shows the result of the stress analysis.

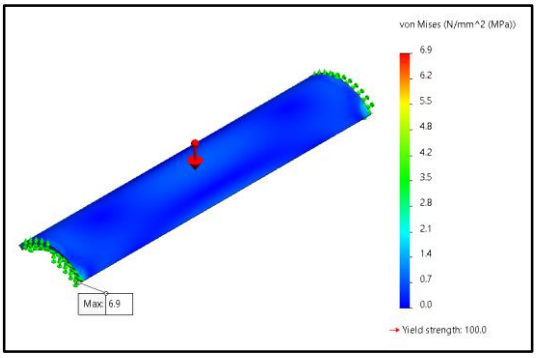


Figure 10: Result of Stress Analysis

Figure 11 shows the result of the simulation for the Factor of Safety Analysis of the cover transfer screw. The minimum safety factor for this component is 14.5 which is above 1, thus, it is safe.

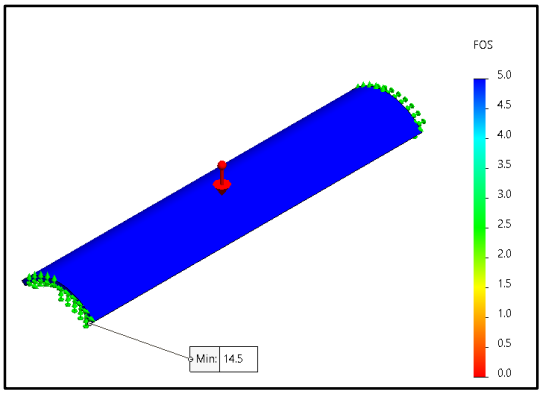


Figure 11: Result of Factor of Safety Analysis

3.9 Product Specification

From all the analysis that have been done, the final product design specification can be obtained. Table 4 shows the final product design for customer information.

Table 4: Final Product Design Specification

Product Specification	Description
Hopper Capacity (kg)	20 kg
Capacity (per hour)	140 serving (320 grams)
Weight (kg)	23 kg
Dimension	380mm (L) × 550mm(W) × 606mm(H)
Power Consumption (W)	153
Price (RM)	RM 15.746.76

4 Conclusion

After completing this project, it can conclude that this project is seen to have been successful by meeting all the objectives that have been set. The objective of this project is to design a cooked rice dispenser that is able to dispense various amounts of rice faster based on the setting provided and meet the characteristic food hygienic equipment design. By using the SolidWorks software, each of the component was being simulated, analysis, and come out with the detail project drawing. Through the calculation, the final design of the device able to dispense cooked rice less than seven seconds, which meets the customer requirements. Furthermore, the overall weight of the device is 23 kg, and the size is (380W×550D×606H) mm. The cooked rice dispenser device weights less than 30 kg, which also meets the customer's criteria. The device can hold up to 21.16 kg of cooked rice, which is more than the 20 kg requested by the customer.

Acknowledgement

The authors would also like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for the support in conducting this research.

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