MALAYSIAN JOURNAL OF APPLIED SCIENCES 2022, VOL 7 (2): 93-102
E-ISSN:0127-9246 (ONLINE)
http://dx.doi.org/10.37231/myjas.2022.7.2.340
https://journal.unisza.edu.my/myjas

ORIGINAL ARTICLE

CONCEPTUAL DESIGN AND SIMULATION ANALYSIS OF DOUGH MIXER-MAKER MACHINE

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Received: 29/10/2022, Accepted: 30/10/2022, Published: 31/10/2022

Abstract

Collecting information on the use of kitchen appliances such as dough mixers is important to provide a more efficient and high-quality system and design. Nowadays, dough mixers that can only knead the dough are widely used to get complete dough while saving time. Therefore, a dough mixer machine that operates with two functions such as dough mixer-maker machine is developed to save cost and save users time in kneading the dough as well as forming the finished dough into a cake according to the set mould. Currently, the machines developed in the market have one function that only work for kneading dough. Therefore, this machine is developed to produce a machine that can operate with two functions namely mixing the dough and forming the dough into a cake. Structural analysis via simulation approached had been done using Fusion 360 Software to evaluate the properties. Results performance indicated that the production of cakes can be made completely on one machine for the processes involved both kneading the dough and forming the dough into cakes.

Keywords: Dough mixer-machine, Mixing and forming dough, Structural analysis, Simulation approached

Introduction

Machine is the scientific term for any device or appliance that generates or converts energy. But in everyday use, a machine is an appliance that has parts that can move and can do or help do work. Appliances that do not have parts are commonly called tools. In every industry there must be the use of machines according to the process to be done. The same goes for the cake making industry which requires dough mixing process such as doughnut, kuih peneram, pau, cakoi and others. Based on Hasbi Apaydin (2003) dough emerges as a quite significant product at flour and bakery manufacturing plants and factories. There are various stages during dough making. Primarily, it is required storing dough in moisture free environments then transporting to dough

kneaders at intended amounts and mixing with proper rates of water in order to become dough. Even if this process seems to be easy, it is very exhausting.

Baking industry and especially pastry industry are using small capacity dough-kneading equipped with kneading arms with planetary motion. Different points of the kneading arm describe normal hypocycloids, shortened and elongated; the kneading machine can work both on baking and pastry operation line, due to the possibility to use three kneading arm types: spiral, paddle or whisk for semi-liquid dough; these mixing and dough kneading machines eliminate undesirable dough variations and may be superior to batch mixing (Dixon et al., 2000). Batch mixing often leads to dough variations from batch to batch that affect the consistency of finished products. Lozenec (2011) had stated that even if the dough leaved the batch mixer in perfect condition, changes can occur to the dough during waiting period before being processed.

Often, kitchen machines occupy large areas work space available in smaller apartments. Since they are usually heavy and bulky seen as “clumsy” to store and remove. Therefore, in smaller households it may seem impossible to invest in a kitchen machine (Magomedov et al., 2013). Various brands of dough mixers have been marketed in the market but the machines are sometimes large in size. The size of the machine is influencing the area to store it (Pinthus et al., 2012). There are also small -sized mixers, however they only work for one purpose; mixing only. The manufactured machine can operate for one function. Not only that, there is also a dough mixer machine that can shape dough into cakes, but it is an industrial level machine. This is impossible for consumers such as housewives and cake traders to buy it due to its oversized size and high purchase cost. Most of these industrial machines are only used in the cake making industry to increase their cake production in a short time.

From the industrial point of view, the requirements for the mixing process can be formulated as a cost effective way for processing of dough with proper quality. The requirements of the dough for the mixing energy are related to the dough strength; therefore the costs of the end-products of mixing are different. Different industrial mixers can be evaluated through their efficiency (Wooding et al., 2002). The energy consumption (work input) for the dough formation at the peak resistance depends on the flour used, mixer speed, and mixer type. During mixing, the energy flow and the hydration processes are accompanied with a temperature increase. The temperature growth is dependent on the speed of mixing, but it is assumed that heating of dough during mixing is influenced by the type of the flour used and also by the type of mixer (Wilson et al. 2006).

Mixing flour to make bread and cakes becomes necessary; therefore the need for affordable flour mixing machines is increasing. Although there are so many dough mixers on the market, many small and medium scale production and in developing countries still use traditional methods of mixing dough in an economical way. The challenge of producing low -cost mixers led to the development of mega dough mixer machines that gained popularity in highly intensive bakeries (Vincent, 2008). However, the cost of mixing dough remains economically unaffordable for small and medium -sized bakeries (Godwin, 2011). The main objective of an improved machine is to reduce energy consumption and save time. To meet this requirement, the dough mixer machine is made to enable it to operate with two functions, namely mixing the flour mixture and forming the finished dough into a cake shape according to the set mould. This is not so easy, as it requires research on the design of the product in accordance with its operating system.

Materials and Methods

In the development and construction of the mixer machine, a DC motor with components shown in Figure 1 was used based on the specifications as stated in Table 1. This system is important to enable the mixer to work semi-automatically, that is, it can work automatically when the flour mixing process is done, while it works manually when the process of pressing the dough to form

a shape for the cake according to the mold. Therefore, consumers will consume less time for preparing their dough and cakes making.

Table 1. Specification of the DC Motor Electric

No.	Parameters	Capability Values
1	DC Motor Type	180 w
2	Two Thread cable	Connected with motor
3	High speed	1-3 level speeds

No.	Component
1	Motor
2	Gear
3	Fan
4	Turbo switch
5	Speed button
6	Three-core wire
7	Supporter

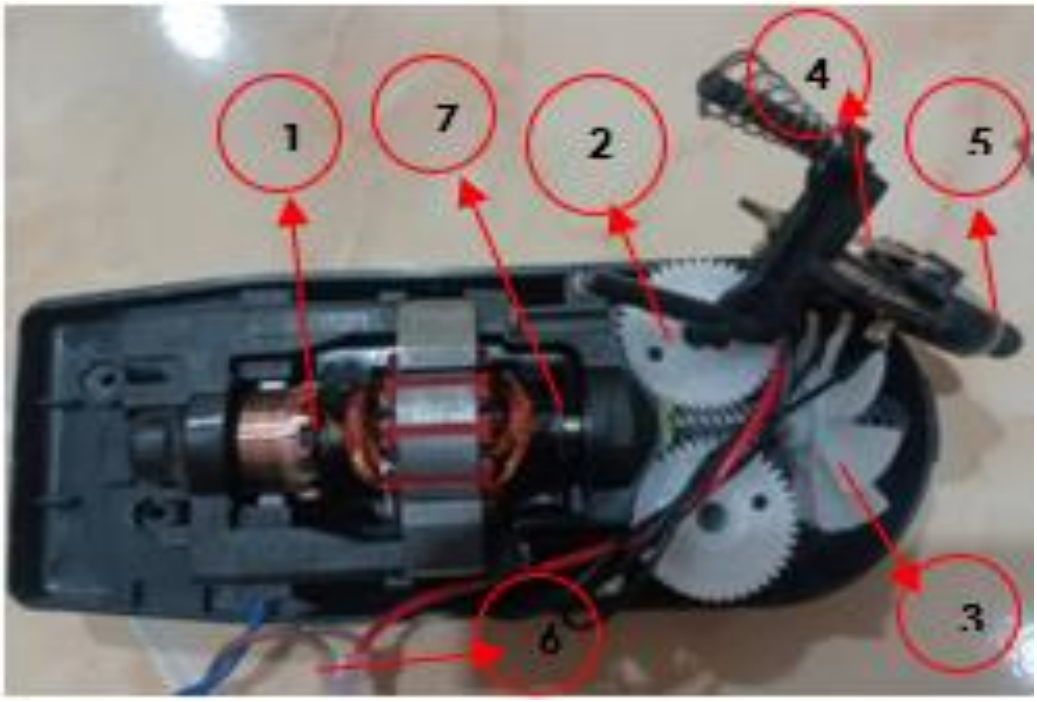

Figure 1. DC Motor Configuration and Components

Figure 2 indicated regarding the system used to determine the movement flow and function of the machine according to its mechanical system. While, the properties of flour used in determining the machine works before the machine is developed is shown in Table 2.

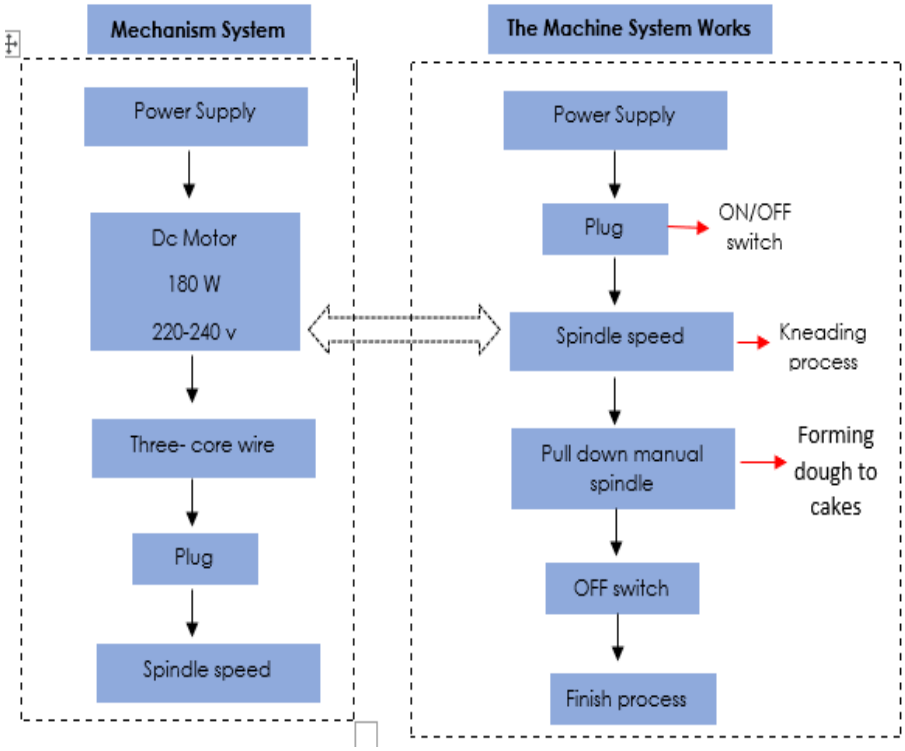

Figure 2. Machine Movement Flow System

Table 2. Properties of Flour Used

Test	Flour	
	Bakers	Soft
Optimum mixing (w.h/kg)	18	9.7
Water absorption (db %)	59	59
Protein (%)	12.6	10.4
Ash (%)	0.46	0.52
Moisture (%)	14.1	14.5
Texture	8	8.5
Baking score	28	26

14% Moisture basis

The properties of flour used were studied to determine the level of capability of the machine developed according to the process to be used. Various factors are taken such as the capacity of the substances placed in the machine, the time taken by the machine for each process, and the ability of the machine to rotate depending on the type of motor used. Therefore, the analysis made on the machine depends on the load/ capacity of the substances placed. In addition, the texture of the dough is also taken to see the level of ability of the machine developed in preparing complete dough and can produce dough into a cake shape according to the molds.

Fabrication is the process of building a structure from the raw material to the final product by going through several important processes such as measurement, cutting, assembling and finishing. Based on these processes, there are two product divisions, namely original equipment manufacturer (OEM) part and fabrication parts as shown in Table 3 and Table 4. Both the OEM and fabrication part were involved in each process that has been carried out in the workshop. Machine development was then continued by simulation approach using Fusion360 software.

Table 3. Original Equipment Manufacturing (OEM) Part

No.	Part name	Material	Quantity
1	Kneading bowl	OEM	1
2	Electrical motor	OEM	1
3	Control box	OEM	1

Table 4. Fabrication Parts

No.	Part name	Material
1	Base	Mild steel plate (200mm x 230mm x 6mm)
2	Side, round & top holders	Steel (600 mm)
3	Electrical wiring	Electrical wire
4	Electrical motor	Motor
5	Control box	Plastic (150mm x 120mm x 150mm)
6	Spiral mixer	Stainless steel
7	Lock spiral mixer	Steel
8	Forming dough molds	Stainless steel (diameter- 30 mm & 25mm)
9	Manual spindle	Plastic
10	Molds clamp	Stainless steel
11	Dough flow plates	Stainless steel
12	Finishing	Painting

Results and Discussion

Kneading and Forming Dough into Cakes Processes

This section will describe the whole process for dough kneading products and the formation of dough into cakes starting from the energy produced by the motor to the final output. The first process of using this machine is to add flour and other ingredients to be kneaded into complete dough to obtain the perfect dough to go through the first process. The main process of this machine is to produce complete and good dough by mixing the ingredients placed automatically until the dough is ready to be kneaded. Once the dough is kneaded perfectly and well, the dough can be formed into a cake according to the mold. The dough that has been kneaded is still placed in the kneading bowl to continue with the further process.

After undergoing the first process, which is to knead the dough from the ingredients that have been mixed. There is a part called a spiral mixer that serves as a grinder so that the flour mixture is mixed thoroughly until it becomes complete dough. The empty space at the bottom was used to maximize the use of available space. The dough that has undergone this first process will still be placed in the kneading bowl to continue for the second process.

In the second process, this machine functioned to form the dough that has been kneaded into a cake shape according to the molds. The manual spindle will be lowered to attach the dough to the molds that has been set on the bottom of the machine. As a result, the dough will form like a round -sized cake with a hole in the middle to fit the molds. Through this process, the machine can produce different sizes of cakes because the molds set are having different sizes. One pressure binder molds will produce two different cake sizes.

This process is done until the dough in the kneading bowl is formed into a cake. The end result of this process is that the dough will be ready to be produced by shaping the cake on the same machine to save time and energy of the user from using different machines for two different processes. If any problem occurred during the process such as accident or the machine stuck, the

user can press the emergency stop button to stop the machine immediately. Table 5 shows the analysis design of the machine.

Table 5. Machine Analysis Design

No.	Description	Capability
1	Capacity of machine	2L – 3L = 3 kg
2	Capacity per batch	1.5 kg
3	Time taken per batch	25 min
4	Time for mixing 3 kg of dough	25 min x 2 = 60 min
5	Efficiency (%)	83 %

The machine that has been developed undergoes testing to determine the level of strength and durability of the machine when the load was placed on it. The structure analysis of the machine was done using Fusion 360 software to ensure that the machine can function/work well and detected or identified any problem in detail. From the analysis, each part of the machine was able to function properly according to the earlier setup. Analytical structure testing was done to ensure the maximum level the machine can withstand the placed load. If the machine faced any problem, then it should be solved by using other alternatives to ensure that the function of the machine is not interrupted.

Structure Analysis of Kneading Process

In this analysis structure, the development and function effectiveness of the machines that have been developed according to the functions setting was obtained using Fusion360 software. Figure 3 shows the structure of the analysis obtained to determine the durability and capability of the machine produced for the process of kneading the dough and forming the dough into cakes.

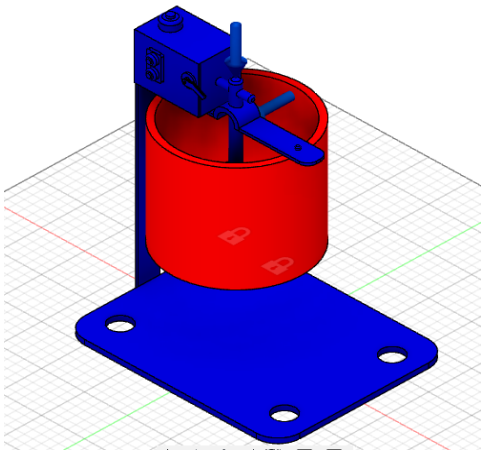

Figure 3. Structure Analysis of Kneading Process

Based on the analysis obtained, it can be seen that the overall color on the machine is blue and red. The colors represent the effectiveness of the machine to perform the process of kneading the dough. The blue color shown is to indicate that the colored machine part is fixed and does not move during the process. While the red color indicates that the part failed in analyzing the part to function properly for the whole process. This is because it is possible that the load placed on the machine reaches the maximum level and the machine is not able to cope with the

high load according to the specified machine capacity. From the analysis, the red color on the kneading bowl indicated that the total load or capacity of the substances placed is exceeding the capacity of the machine.

Structure Analysis of Forming Dough into Cakes Process

The analysis shows the whole machine is green and blue as illustrated in Figure 4. This means that the machine works with the correct function and meets the amount of load placed on it. On the spindle manual, it can be seen that the part is green and proves that the process in the part can be carried out and function/work well according to the manual method that had been set. While the blue color on kneading bowl explains that the part is fixed and does not move when the process of forming the dough into a cake is carried out.

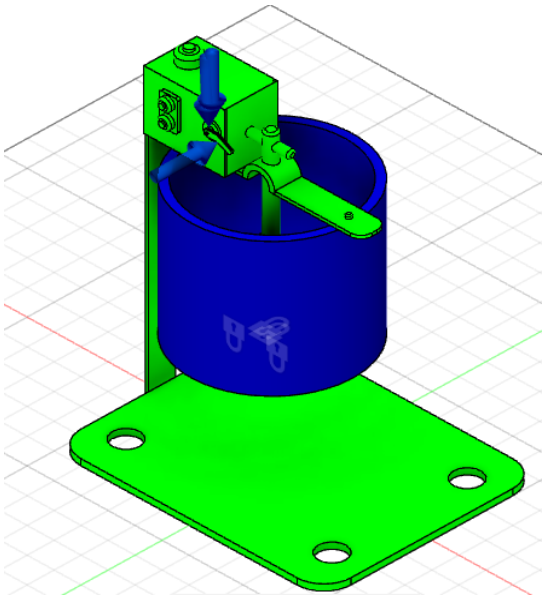

Figure 4. Structure Analysis of Forming Dough into Cakes Process

Result Performance

The performance result of the kneading and forming dough into cake machine is satisfactory because the machine can work well for two different processes. The time allotted to complete the dough kneading process is for 25 min for one batch of 1.5 kg of flour. While to prepare the maximum capacity of 3 kg material is for 50 min for two times the dough. The machine produced is small in size but it is able to increase the production of cakes because this machine is created for two different sizes of cakes at one time when produced.

In addition, it can also save users time and energy because users do not have to use different machines for two different processes. They can proceed to the next process without lifting the dough to another container when the dough kneading process is done. The production of cakes can be made completely on one machine for the processes involved such as kneading the dough and forming the dough into cakes. Figure 5 shows the result performance of the kneading and forming dough into cakes machine.

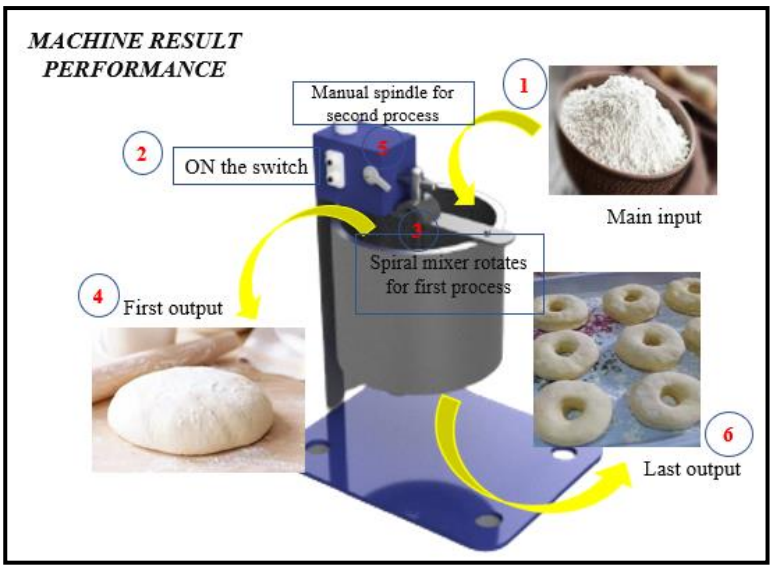

Figure 5. Result Performance of the Machine

Limitations in Developing the Machine

The development and production of each machine usually had some problems and limitations. For the dough kneading machine and shaping the dough into a cake initial planning is to make it function/work automatically for the whole two different processes. However, it is not necessary to use two types of motors on the same machine. This will make the machine too compact and heavy for the user to handle. The use of only one motor for two processes is not appropriate as it will interfere with the internal system of the machine and the machine may not function properly and well. Therefore, changes have been made to the machine by making the machine operate semi-automatically i.e. using only one motor on this machine.

Another critical part is to make sure the manual process for forming the dough into a cake work well on the machine. As improvement, the machine works using a manual spindle for the process of forming dough into cakes. In this process, the manual spindle needs to be lowered down to ensure that the clamps on the mold can stick the dough into a cake according to the size of the mold on the bottom of the kneading bowl. Another addition is the installations of the plate at the bottom of the kneading bowl as a cover on the mold so that the flour mixture does not spill during the kneading process.

Conclusion

In this study, a dough mixer machine integrated with a function that can shape the dough into a cake was developed and simulated to provide complete dough to save users time in shaping the cake. Through this study, the small-sized machine can provide dual functions in accordance with user demand in obtaining the advantage of use on one machine only.

This situation can be used by consumers such as housewives and cake traders in producing cakes in moderate quantities according to the speed and capability of this machine. This will be able to increase the production of their cakes on a modest scale without resorting to manual way and without using two machines to complete two processes.

Acknowledgments

The authors fully acknowledged the Universiti Sultan Zainal Abidin for providing the equipment and facilities that make this research possible, viable and effective.

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How to cite this paper:
Ireana Yusra Abdul Fatah, Nor Izzah Hazirah Abdul Hadi, Razwan Rohimi. (2022). Conceptual Design and Simulation Analysis of Dough Mixer-Maker Machine. *Malaysian Journal of Applied Sciences, 7*(2), 93-102.