Multidisciplinary Applied Research and Innovation Vol. 2 No. 1 (2021) 277-283

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN : 2773-4773

Semi-Automatic Potato Peeler and Cutter: An initial development

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DOI: https://doi.org/10.30880/mari.2021.02.01.025
Received 11 November 2020; Accepted 01 January 2021; Available online 03 February 2021

Abstract:
French fries are popular dishes in the world. Raw French fries preparation requires several methods that are tedious and time-consuming if it is done manually. The main intention of this project is to develop a semi-automatic machine that is able to peel and cut potatoes to French fries. The project is focused on small and medium-size potato, a portable and low fabrication cost machine, and targeted to small and medium enterprise industries. To achieve the project aims, a semi-automatic machine is developed that capable of peel and cut potato to French fries shape. The machine peeler uses an abrasive technique and rotation in removing the potato skins while the cutter uses a rotating crank with pusher connected to an electric motor to push potato to the cutting blade. The machine was tested to its functionality and the outcome was compare to the manual methods. For the comparisons, the machine capable of peeling up to 135% more potato weight and an average time improvement to cut potato is up to 62%. This machine is capable of reducing manpower effort in the preparation process and provides an improvement in production for small and medium scale industries.

Keywords: Potato, Cutter, Peeler, Semi-automatic

1. Introduction

French fries are served with a various method which is hot, soft, or crispy. It generally serves as a side dish for lunch or dinner. French fries are also one of the best methods that convert raw potato for storage. It is reported in Asia countries that cultivate potatoes, for example, Bangladesh, they are facing losses of postharvest due to lack of storage for raw potatoes [1]. The machine or devices used to cut potato shall be able to produce even and preserve the quality of potato [1, 2]. The methods in cutting potato for French fries can be either by manual or fully automatic methods. For a company with big capital and more resources, the method of producing French fries is by a fully automated machine

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capable of producing a large number of fries production per day. However, for smaller companies and individual sellers, the most preferable methods are still conventional which is using manpower manually to produce the French fries [3]. In Malaysia, there are many Small and Medium Enterprises (SME) that still using conventional methods in producing french fries.

In manual methods, the potatoes need to be peeled off before it can be cut to specific sizes. This method requires human manpower to do the peeling and cutting the potatoes. Thus it makes this method time and energy-consuming methods. It also requires skilled manpower to reduce the time taken in production. In the market, manual potato cutters to produce French fries came with various designs from simplest to almost complicated in design. The cheapest manual potato cutter and most available in the market are shown in Figure 1. The manual potato cutter is shown in Figure 1(a) requires human energy to press the cutter by hand above peeled potato to produce French fries. In traditional design, the sharp cutter is exposed and can be dangerous to the operator. The more complex in design for the manual cutter is shown in Figure 1 (b) where it is equipped with a handle to ease the operator in pressing the potato to the cutting blade and has a stand that can be fixed to the floor. In this design, it uses a lever concept to amplify the pressing energy exerted by the operator. Variation in this design includes different stands, handle sizes to hold the cutter main body, and amplify the force exerted [4].

The other alternative method and cost higher than the conventional method is a fully automatic machine. An example of this machine is shown in Figure 1 (c). This machine is basically an integrated design for potato peeler and cutter to produce French fries. This machine is suitable for mass production output. However for SME's the price of the machine is not affordable, big in size that makes it not portable and requires high-cost periodic maintenance.

(a) **(b)** **(c)**

Figure 1 : (a) Manual potato cutter device [5] (b) Manual Potato cutter with level handle [5] (c) Fully Automatic Potato Cutter [5]

The intention of this innovation is to ease, fasten the method of producing the french fries at a lower cost compared to the fully automatic machines. The main objectives of this project are to design and develop a prototype of a semi-automatic potato peeler and cutting machine for producing French fries. At the same time, the machine will be tested in terms of its functionality, production rate, and performance. By using this machine, the production rate can be increased and at the same time reduces the manpower required in production.

2. Methods and Materials

The development of the machine can be divided into several design stages, starting from idea generation, preliminary design to detail design including material selections. At an early stage of design, brainstorming and idea sketching and evaluation was part of the stage. The best idea was chosen and improvise to the next design stage. The detail design stage, the functionality of the machine, machine component sizing and material for each machine part and components were specifically selected. CAD software used in producing this detailed design drawing is SolidWorks 2019. The isometric view of the machine is shown in Figure 2. Once the detailed design established, the next stage in producing this

machine is the material selection for each machine part and components before it can proceed for fabrication stages that involve metal fabrication, electric wiring, and assembly. The cutter of the motor is designed by implementing the concept of crank rotation with a pusher used to push potato to the cutting blade. The crank is directly attached to a 12 V DC motor. A potato peeler is located on top of the machine body and rotated by an AC electric motor. The PVC brush is installed inside the peeler to create an abrasive effect on the potato skin when the peeler rotates.

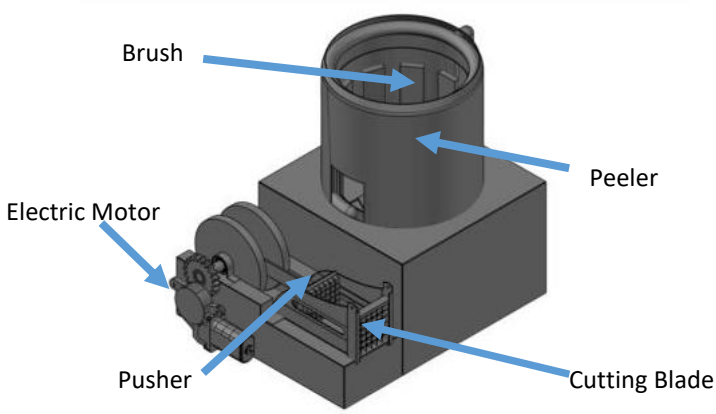

Figure 2 : Isometric view of Semi-Automatic Potato Peeler and Cutter

2.1 Electric motor

The machine is designed to operate using a 12V DC electric motor. In order to determine the torque required for an electric motor to rotate the crank mechanism, the force that is required to cut average size potato is then first determined experimentally. The value of force is determined experimentally by cutting a potato manually on a weighing scale. The test was repeated with varying sizes of potatoes. From the experiment, the amount of average force required to cut an average size potato through a manual cutter is 176.58 N. By referring to pusher crank mechanism and calculating the angle where the maximum force required to push the pusher, the value of torque required by the 12V DC electric motor to rotates the crank mechanism can be calculated using equation 1.

$$\tau = F \cdot r \quad \text{Eq.1}$$

From the calculation, the value of torque required by the electric motor is 9.6 N.m with the assumption of all frictional forces neglected. A suitable 12 V DC motor then selected base on the value calculated with an additional 30 % more torque to counterbalance the variation in potato size, hardness, and also the pusher friction. For the peeler section, a 240 V AC electric motor is used to rotate the peeler drum for the peeling process. The rotational speed of the peeler drum shall not produce a centrifugal force, Fc that is higher than the gravitational force, Fg to the potatoes in the drum as shown in equations 2 and 3.

$$F_g = mg \quad \text{Eq. 2}$$

$$F_c = mr\omega \quad \text{Eq. 3}$$

2.2 Material Selection

The material for each machine component is selected based on the engineering properties, cost, market availability, and ease of fabrication. Table 1 summarized the items used in the development process of this machine prototype with its specification and quantity. The material selected at this stage might be replaced with another material with a specific grade in the next development process.

Table 1: Project Bill of Material

No.	Item	Specification	Quantity
1	AC motor	120V AC	1
2	Power window motor	12V DC	1
3	Power supply	ST3-120W-12V	1
4	Hollow bar	1” x 1” x 1 mm	1 m
5	Angle bar	1” x 1” x 2 mm	4 m
6	Metal plate	1 m x 1m x 1 mm	1
7	Bearing	1635A	3
8	Mounted bearing pillow	Ø35mm	2
9	Oil seal	Ø	1
10	R134a gas container	-	1
11	Rubber pipe	1.5m x Ø1”	1
12	PVC pipe	4m x 15mm	1
13	PVC elbow	15mm	5
14	PVC tee	15mm	2
15	PVC end cap	15mm	1
16	PVC valve socket	15mm	3
17	PVC solvent cement (100g)	-	1
18	Water valve	1/2"	2
19	Rubber lining	1m	1
20	Mini potato cutter	-	1
21	Plywood	300mm x 150mm x 1/2"	1
22	Sprocket	Size 13 & 14	2
23	Spur gear	24T	1
24	Chain	428-120L	1
25	Shaft	Ø15mm	2
26	Thread rod	M8 x 250mm	1
27	Nut	M8 stainless steel	10
28	Cable tie	1” x 3.5mm	1

3. Results and Discussion

The machine peeler and cutter operate by the rotation of an electric motor. The rotation is maintained once the dedicated switch is triggered. The potato is manually fed by the operator into the peeler or cutter. The operation can be either operate synchronous or stage by stage. The output from the peeler and cutter is manually collect by the operator. The complete assembled machine was then test its functionality and capabilities towards project objectives.

3.1 Potato Peeling Test

In this test, the main intention is to compare the performance of the machine peeler to the manual peeling process. The time for peeling operation is set to 5 minutes and the amount of potato that successfully peeled within the time frame is then weighted. This comparison was made by comparing

the machine peeler with average skilled manpower. In the test, the potato that is considered successfully peeled is when 98 % of its skin being peeled. The result obtains from the test is summarized in Table 2. From the table, it shows that the potato peeler is able to peeled an average of up to 135 % more potatoes weight compare to the manual method.

Table 2: Potato Peeling Test

Peeling Test	Machine (kg)	Manual (kg)
1	3.00	1.25
2	2.87	1.34
3	3.25	1.30
4	3.18	1.36
Average	3.08	1.31

The difference in amount peeled by the machine peeler to the manual method ranging from 114 % - 150 % for the duration of 5 minutes. From the result, it shows that the peeler is able to peeled potato up to 0.65 kg per minute. The amount of potatoes that can be filled into the peeler is depending on the potato's sizes. The number of potatoes filled in the peeler shall not occupy more than 70% of the peeler working volume at a time to maintain the peeler efficiency.

3.2 Potato Cutting Test

For the cutting test, potatoes that are peeled from the peeler is then manually inserted by the operator into the machine cutting section. Amount of potatoes that can be inserted in between cutter pusher and cutting blade also depending on the potato sizes. The operation of the cutter is continuos once the operation switch trigger by operator. This cutting test is to compare the machine cutting performance to the manual cutting process. For the manual cutting process, a manual top pressing cutting device was used to cut the potato. Table 3 shows the result for machine cutting test.

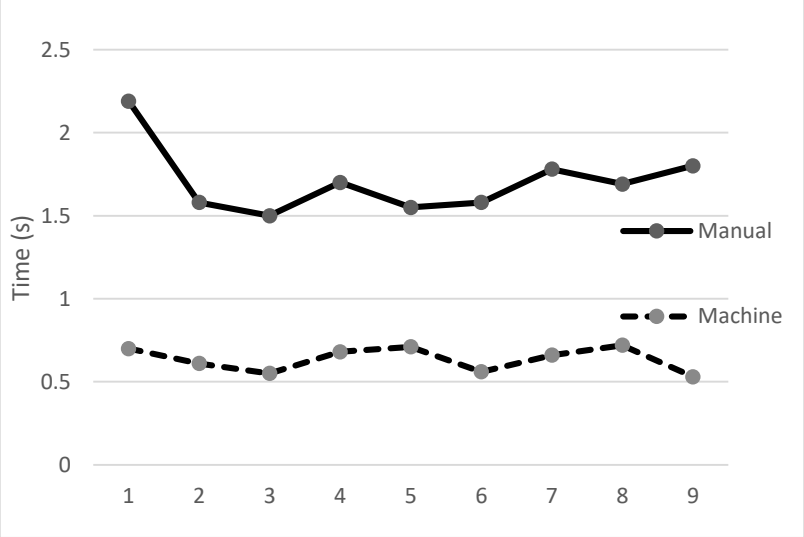

Figure 4 : Potato cutting test

From the figure, it shows that the machine is capable of cutting potatoes based on the test executed without showing any sign off the machine or part breakdown. Machine cutter recorded a time of less than 1 second to cut one potato with an average of 0.64 seconds per cut. The average time recorded by using the manual top cutting device to cut potato requires an average of 1.71 seconds for one potato. The cutting test was done to an average size of potatoes. The average time improvement in cutting a potato compared to the manual method using a device is 62 % faster. This means in 5 minutes, the machine capable to cut more than 450 pieces of average size potatoes. However, a bigger size potato requires more energy for the pusher to push the potato against the cutting blade.

3.3 Functionality

From the machine test that has been executed, the machine operates successfully operates according to design requirements. The designed peeler successfully peeled the potato skin up to 98% by abrasion through a hard PVC brush installed in the peeler. This method of peeling is suitable for purposes [6]. The peeler is equipped with a drain hole to ease the process of cleaning to ensure the cleanliness and hygiene of the peeler. However, the process of cleaning is required to be done manually by an operator. Peeler ideal rotation speed can be obtained from equation 2 and 3 in section 2 of this paper. The peeler ideal rotation speed can be increase by two factors which are by the installation of additional brush on the peeler inner base and the numbers of potatoes included in the peeler during the process. The brush at the peeler base and potatoes function to push potato to the brush at the peeler wall and prevent it from sticking to the wall due to centrifugal force by the inner collision in the peeler. The potato cutting is achieved through a pusher that is connected to a connecting rod and rotating shaft. However, at this stage, the pusher is set to slide on a metal surface which exhibits friction that would reduce the pushing force used to push the potato through the cutting blade. For average size potatoes, this friction can be neglected since the torque produce by the motor is greater than minimum torque requires. For the improvement, the pusher and rotating shaft can be improved to reduce the friction and provide better acceleration and inertia force of the pusher to push potatoes through cutting blade [7]. The machine itself is at an early development process where several improvements can be made to increase machine flexibility, durability, efficiency, and machine safety features. The selection of material and part design can be further improved in the next stage of machine development. Right materials and design are crucial to make sure a fully operated machine with low production and operating cost can be developed.

4. Conclusion

In this paper, the development of a semi-automatic potato peeler and cutter has been described and its performance is tested. Potatoes product as a French fries has been demanded all over the world and became popular dishes. Preparations of the raw product require a specific device or machine to obtain a uniform and constant output. The machine develops is be able to peeled and cuts an average size of potatoes. The average weight of potatoes being peel is significantly improved by 135 % for a specific time measure compare to manual methods. The average size of potatoes cutting time also improved up to 62 % much faster. Although the machine has shown a significant improvement compare to manual methods, there are several improvements that can be imposed on the machine to increase machine efficiency, flexibility, rigidity, and hygiene. The selection of material especially in contact with the product can be replaced with a more suitable material with a specific grade.

Acknowledgement

This project was supported by a TIER 1 grant U925 Combustion Characteristics of Biofuel Derived From Blend of Diesel and Palm Fatty Acid Distillate Oil under UTHM internal grant.

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