JOURNAL OF APPLIED MECHANICAL ENGINEERING INNOVATION

Journal homepage: https://journal.uny.ac.id/publications/jamei

Design and manufacture of a semi-automatic cassava chips slicing machine

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ARTICLE INFO

Article history:

Received	07.10.2024
Revised	27.10.2024
Accepted	05.11.2024

Keywords:

Cassava chip, slicing machine, semi-automatic system

ABSTRACT

Cassava is one of the commodities that is widely processed in Pagerharjo village, especially by the Madu Lestari Women Farmers Group (WFG). The problem found in WFG is that the production process of cassava chips is still done manually and has not been touched by the appropriate technology desired by KWT. This affects the capacity produced in production not much and limits labor. The purpose of this research is to explain the design process or design, explain the process of machining and test and analyze the factual capacity produced by the semi-automatic system cassava chips slicing machine. The research method used is research and development. The research process starts from observation, needs analysis, design, machine building, assembly, performance testing, data collection and analysis. Data analysis uses descriptive and quantitative theoretical considerations. The results of the study produced a cassava chips slicing machine semi-automatic system capable of producing a production capacity of 62.1 kg/h with a driving motor power of ¼ Hp.

1. Introduction

Pagerharjo Village, located in Samigaluh, Kulon Progo, lies in the Menoreh Mountains at an elevation of 600-700 m above sea level. The area of Pagerharjo Village covers 1,140.52 hectares and consists of 20 hamlets, 42 neighborhood units (RT), and 87 community units (RW). The residential land area reaches 351.2335 hectares [1]. According to the 2021 population census, the majority of Pagerharjo residents work in the agriculture, livestock, and fisheries sectors as farmers and livestock keepers. Cassava, bananas, and coffee are commonly found in the yards of residents' homes [2]. These crops, especially cassava, are primarily processed by the residents into boiled and fried dishes for family consumption.

With the abundant potential of the residents' plantations, the government of Pagerharjo Village, in collaboration with the Village-Owned Enterprises called as *BUMDes*, established the Women Farmer Group (WFG). The establishment of the WFG aims to assist female farmers in processing agricultural and plantation products effectively, providing them with an additional source of income. Another reason for the formation is to ensure that processed products have a longer shelf life compared to those that are only boiled or fried [3]. Madu Lestari, one of the WGF's fostered by *BUMDes*, is located in Sarigono Hamlet and is led by Mrs. Hariyati. The products produced include cassava chips, rempeyek (crispy fried snacks), and grubi (traditional snacks). The tools used in the production process include knives, a pestle, and a simple grater, which have limited production capacity.

The results of the interview with the Chairperson of the Madu Lestari Women's Farmers Group, Haryati, revealed that appropriate technology has not been implemented in the Madu Lestari WFG due to limited knowledge on the matter. A common issue faced in the production process, often complained about by the community, occurs when there is a high demand for products. The labor required increases significantly when using tools that can only be operated by one person, and the capacity produced is limited by the number of workers involved in the production process. The products most in demand from Madu Lestari WFG are cassava chips, taro chips, and banana chips. A challenge faced in producing cassava chips is that the shape and

thickness of the chips are inconsistent. It is hoped that the WFG will be able to acquire appropriate technology that can help speed up the production process, especially for cassava chips.

The problem that will be addressed is how to design a semi-automatic cassava chip slicer machine. Another issue to be addressed is the actual slicing capacity of the cassava chip slicer machine.

The objective of this research is to design and create a cassava chip slicer machine that meets the expectations of the Madu Lestari Women's Farmers Group. The machine specifications are expected to produce uniform slices, have dimensions that are not too large and space-consuming, include components that are easy to find in the market for convenient maintenance, and be capable of producing a production capacity of over 50 kg/h.

2. Method

The method used in this research is a type of research and development (R&D) for the cassava chip slicer machine. The data obtained comes from the design of the machine, which includes the machine's design and component calculations. Data collection techniques involve experimental methods to test the actual capacity with varying cassava weights. The data analysis method used is quantitative descriptive analysis. Descriptive methods are also used to highlight the advantages and limitations of the Semi-Automatic Cassava Chip Slicer Machine.

The calculation of machine elements uses the following formulas:

Torque

$$T = \frac{P \times 72585.1}{n} \quad (1)$$

Power required

$$Pd = fc \times P \quad (2)$$

Torque required

$$T = 9.74 \times 10^5 \frac{Pd}{n1} \quad (3)$$

V-belt speed

$$V1 = \frac{\pi \times dp \times n}{60 \times 1000} \quad (4)$$

V-belt length

$$L1 = 2C + \frac{\pi}{2(d_{p1}+d_{p2})} + \frac{1}{4c(d_{p1}+d_{p2})^2} \quad (5)$$

The calculation for the design of the shaft is performed using the following equation:

Rotational speed

$$n = \frac{1000 \times Cs}{\pi \times d} \quad (6)$$

Slicer speed

$$fc = f \times n \quad (7)$$

Dept of cutting

$$a = (\frac{dm-do}{2}) \quad (8)$$

Time of cutting

$$tc = \frac{lt}{vt} \quad (9)$$

3. Result and discussion

The research on the Design and Development of a Semi-Automatic Cassava Chip Slicer Machine was conducted according to the procedures outlined in the research methodology.

3.1. Design and manufacture

The design was carried out using SolidWorks 2021 software. The Cassava Chip Slicer machine will operate once the plug is connected to the power outlet. Then, press the on button located on the machine's switch. After the machine starts, continuously feed the peeled and washed cassava into the hopper. Gently push the cassava until it is finished, and the cassava slices will come out from the front of the machine. The result of cassava chips slicing machine design is presented in Figure 1.

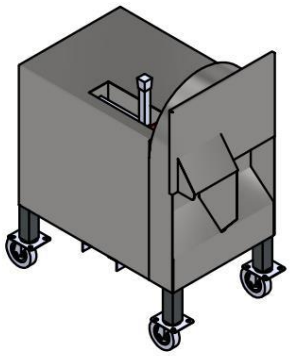

Figure 1. Cassava chips slicing machine design

The components of the cassava chip slicer machine, based on Figureure 1, consist of frame as the main component in the machine functions as a support for all the other machine components. The frame is made from hollow steel and 3 x 3 mm angle iron with a thickness of 3 mm. Electric motor used is an AC electric motor. The power of the drive motor is ¼ Hp. The pulley and V-belt are used in the transmission components of the semi-automatic cassava chip slicer machine. This consideration is because pulleys and V-belts have the advantage of not producing noisy sounds. A knife is used as the cutting tool in the cassava chip slicer machine. The cutter is the type of blade used. This is because this type of blade is easy to find in the market and is affordable. The power transmission components are the shafts. There are two shafts used in the system.

3.2. The results of machine element calculations

a. Shaft

A shaft is one of the components of a machine element that rotates and functions to transmit power from one place to another [4]. In the application of a cassava chipper machine, it serves as the power transmitter from the drive motor to the reduction shaft, which is then transmitted to the blade rotating shaft. The rotation of the electric motor is connected to the reduction shaft via a 2-inch A1-type pulley, an

A34-type V-belt, and a 10-inch diameter A1-type pulley, supported by two UCP 204-12 bearings.

The rotation from the reduction shaft is transmitted to the blade rotating shaft through two 2-inch A1-type pulleys, an A20-type V-belt, and a 3.5-inch diameter A1-type pulley, supported by two UCP 204-12 bearings. The analysis of the reduction shaft calculation is done using the following equations:

The power reduced by the reduction shaft:

$$P = 0.25\ Hp$$
$$= 0.18\ kW$$

Shaft rotation:

$$n = 347\ rpm$$

Torque output:

$$T = \frac{P \times 72585.1}{n} \quad (10)$$
$$= \frac{0.18 \times 72585.1}{280}$$
$$= 37.65 \frac{kg}{cm}$$
$$= 376.5\ kg/mm$$

Correction factor:

$$fc = 1.2$$

Power required:

$$Pd = fc \times P \quad (11)$$
$$= 1.2 \times 0.18$$
$$= 0.216\ kW$$

Torque required:

$$T = 9.47 \times 10^5 \frac{Pd}{n1} \quad (12)$$
$$= 9.47 \times 10^5 \frac{0.216}{347}$$
$$= 9.74 \times 62.247$$
$$= 606.29\ kg/mm$$

The analysis of the calculation for the drive shaft of the slicer can be calculated using the following formula equation:

Power reduction by slicer shaft:

$$P = 0.25\ Hp$$
$$= 0.18\ kW$$

Shaft rotation:

$$n = 280\ rpm$$

Torque output:

$$T = \frac{P \times 72585.1}{n} \quad (13)$$
$$= \frac{0.18 \times 72585.1}{280}$$
$$= 46.66\ kg/cm$$
$$= 466.6\ kg/mm$$

Correction factor:

$$fc = 1.2$$

Power required:

$$Pd = fc \times P \quad (14)$$
$$= 1.2 \times 0.18$$
$$= 0.216\ kW$$

Torque required:

$$T = 9.47 \times 10^5 \frac{Pd}{n1} \quad (15)$$
$$= 9.47 \times 10^5 \frac{0.216}{280}$$
$$= 9.74 \times 77.14$$
$$= 751.37\ kg/mm$$

b. Electric motor

The drive motor is a machine element that functions to convert electrical energy into mechanical energy. This cassava chip slicer machine uses an electric motor with a power of 0.25 Hp as the drive. The specifications of the electric motor are ¼ Hp power, with a motor speed of 1400 rpm and a voltage of 220 volts.

c. Spring

A spring is a flexible machine element that can store energy and generate force and torque in the form of a cylinder. The spring in the slicer machine uses a tension spring type.

d. Pully and V-belt calculation

Pully diameter:

$$d\_p1 = 50\ mm$$
$$d\_p2 = 250\ mm$$
$$d\_p3 = 62\ mm$$
$$d\_p4 = 62\ mm$$

V-belt speed at reduction shaft:

$$V1 = \frac{\pi \times d_{p2} \times n1}{60 \times 1000} \quad (16)$$
$$= \frac{3.14 \times 250 \times 14000}{60 \times 1000}$$
$$= 18.31\ m/s$$

V-belt speed at slicer shaft:

$$V2 = \frac{\pi \times d_{p3} \times n1}{60 \times 1000} \quad (17)$$
$$= \frac{3.14 \times 62 \times 347}{60 \times 1000}$$
$$= 272.395\ m/s$$

Length of v-belt reduction

Length of v-belt reduction as shown in Figure. 2. can be calculated by following equations:

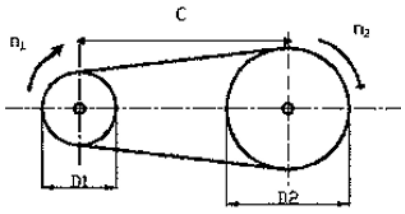

Figure 2. V-belt reduction

$$L1 = 2C + \frac{\pi}{2}(d_{p1} + d_{p2}) + \frac{1}{4c}(d_{p1} + d_{p2})^2 \quad (18)$$

$$L1 = 2 \times 140 + \frac{3.14}{2}(50 + 250) + \frac{1}{4\times140}(50 + 250)^2$$

$$L1 = 911.71\ mm$$

Length of v-belt slicer

$$L2 = 2C + \frac{\pi}{2}(d_{p3} + 4) + \frac{1}{4c}(d_{p3} + d_{p4})^2 \quad (19)$$

$$L1 = 2 \times 162 + \frac{3.14}{2}(62 + 62) + \frac{1}{4\times162}(62 + 62)^2$$

$$L1 = 542.4\ mm$$

3.3. Calculation of shaft turning for the slicer

The slicer shaft uses ST 60 material which has diameter 19 mm. The calculation can be done by equation following:

a. Rotation speed

$$n = \frac{1000\times Cs}{\pi\times d} \quad (20)$$

$$= \frac{1000\times 20\frac{m}{min}}{3.14\times 19\ mm} \mathbf{335.2\ rpm}$$

b. Cutting speed

$$Vf = f \times n \quad (21)$$

$$= \mathbf{0.2\ {}^{mm}/_{rotation} \times 335 rpm}$$

$$= \mathbf{67\ mm/min}$$

c. Depth of cutting

$$\boldsymbol{a = \frac{dm-do}{2}} \quad (22)$$

$$= \frac{19-12}{2}$$

$$= \mathbf{3,5mm}$$

d. Cutting time

$$\boldsymbol{tc = \frac{lt}{vt}} \quad (23)$$

$$= \frac{12}{67}$$

$$= \mathbf{0,17\ min}$$

3.4. Machine capacity

The test was conducted by peeling the cassava first, then weighing the cassava using a scale according to its weight. The slicing process was performed in 9 test repetitions. Each variation of cassava weight was tested 3 times, with the weights being 1 kg, 2 kg, and 3 kg. The electrical voltage used is 215-216 volts, with a shaft speed of 280 rpm. The time for each slicing was then recorded. The average capacity of the cassava chip slicer machine was 1.035 kg/ min or 62,1 kg/h. The test data results are presented in Table 1.

Table 1. The slicing process test

Mass (kg)	Iteration	Time (s)	Time average (min)	Capacity average (kg/min)
1	1	64	1.005	0.995
	2	61		
	3	56		
2	1	137	1.98	1.01
	2	119		
	3	101		
3	1	150	2.7	1.1
	2	160		
	3	178		
Average capacity				**1.035**

4. Conclusion

The research can be concluded that the cassava chip slicer machine that was designed meets the needs of the Madu Lestari Women's Farmers Group. The actual production capacity achieved by the machine is 62.1 kg/hour. The machine manufacturing process includes design, literature study, problem formulation, preparation of tools and materials, fabrication, and assembly. This research can still be developed by designing a fully automatic cassava chip slicer machine. Additionally, modifying the blade into a permanent blade with long-lasting sharpness could be used to further improve the cassava chip slicer machine.

Acknowledgements

The author is grateful to the Department of Mechanical Engineering and Automotive, Universitas Negeri Yogyakarta for all the support extended in conducting research.

Conflicts of Interest:

None.

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