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Design of Cilembu Sweet Potato Cleaning Machine

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Abstract: ***Sweet potato is a food local product that it is very popular in domestic and foreign consumers. This is because the unique sweetness taste when consumed directly by the consumers. Cilembu Village, in Sumedang is a center of sweet potato production which has been exported to Malaysia, Japan, Korea and Singapore with a production capacity of 10 ton.ha^{-1}. Unfortunateyl, sweet potatoes cleaning process is still low, with about 50 kg.day^{-1} - 70 kg.day^{-1} because of it's manually and conventional processed. In order to increase the cleaning capacity, it was neccesary to do the the research of sweet potato cleaning machine technology . The aim of this study was to design a prototype of sweet potato cleaning machine with a capacity of 100 kg.hr^{-1}. The method conducted in this research was engineering design with observation of research, characteristics with sweet potato, design criteria, functional and structural design, figure design, technical analysis, mechanism process, functional machine and performance test. The measurement results of sweet potato showed that the bulk density, angle of repose, roundness are 562.52 kg.m^{-3}, 70.50^{0}, 0.1. The clening machine prototype was produced with dimension of 400 mm (length) x 490 mm (height) x 400 mm (width) with a power source generator using 1 HP electric motor. The resulted of sweet potato cleaning machine functional test showed that actual capacity was 103 kg.hr^{-1} . In general, the results of engine performance testing can be concluded that the machine can function properly, which can clean sweet potatoes from soil dirt***

Keywords: Cilembu Sweet Potato, Cleaning Machine, Electric Motor

I. INTRODUCTION

Sweet Potatoes (ipomoea batatas L) is a plant originally from tropical America. Sweet potatoes can grow both in the lowlands and in the mountains with temperatures of 27^{0}C and irradiation time of 11 until 12 hours.day^{-1}. In 1960, sweet potatoes had spread to almost every area of Indonesian islands such as West Java, Central Java, East Java, Papua and Sumatra. But so far only Papua island has been using sweet potatoes as a staple food, although it has not yet matched rice and corn [1]. The composition of sweet potatoes is very dependent on the variety and level of maturity and storage time [2]. Currently the potential of sweet potato is one of the agricultural products that has quite potential business opportunities both at domestic and overseas.

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The Cilembu Village, in Sumedang is the centre producetion of cilembu sweet potato with a capacity of 10 tons.ha^{-1} for (Figure 1). Beside as local consumption, Cilembu sweet potatoes are also exported to Malaysia, Singapore, Korea and Japan. This is because cilembu sweet potato has a distinctive taste (5). Some home industries in the village of Cilembu are also has process cilembu sweet potatoes became another valueable products such as sweet potato chips, snack, tape, gaplek and others. Snacks have been growing rapidly both from the type, taste and packaging. Either of food that has good prospects for the future is sweet potato chips, cake sweet potatoes and whole potatoes in the oven [3]. Snack products in its development can be produced from a variety of raw materials including snacks made from cilembu sweet potatoes[4].

Figure 1 . The post harvest sweet potato

The production of sweet potatoes in the village of Cilembu could supply domestic and overseas customer [5]. Demanding of cilembu sweet potatoes will increases during Eid Al Fitr day. Meanwhile, the cleaning process of sweet potato cleaners will still weak. It was low the capacity is at 50 kg.day^{-1} until 70 kg.day^{-1} compared by The actual demands need about 500 kg.day^{-1}. Especially in Eid Al Fitr day costumers's demand will be more than 1000 kg.day^{-1}. One of the causes of the cleaning of cilembu sweet potato capasity is the conventional method of the working (Figure 2). It was due to the limited human resources and low production facilities [6]. Several studies regarding cleaning machines such as potato cleaning machines, cassava cleaning machines and taro cleaning machines have been carried out, but there is no specific sweet potato cleaning [7]. For this reason, it is necessary to conduct a research regarding the technology of Cilembu sweet potato cleaning machine technology. The machine will be designed with a capacity of 100 kg.hour^{-1} with the assumption that if the farmers work 5 hours.day^{-1}, then the market share needs of 500 kg / day will be achieved.

Figure 2. Sweet potato cleaning with conventional

II. MATERIALS AND METHODS

This study used an engineering method namely, making a design irregularly so that there were a new contribution both in the process and form (Figure 3).

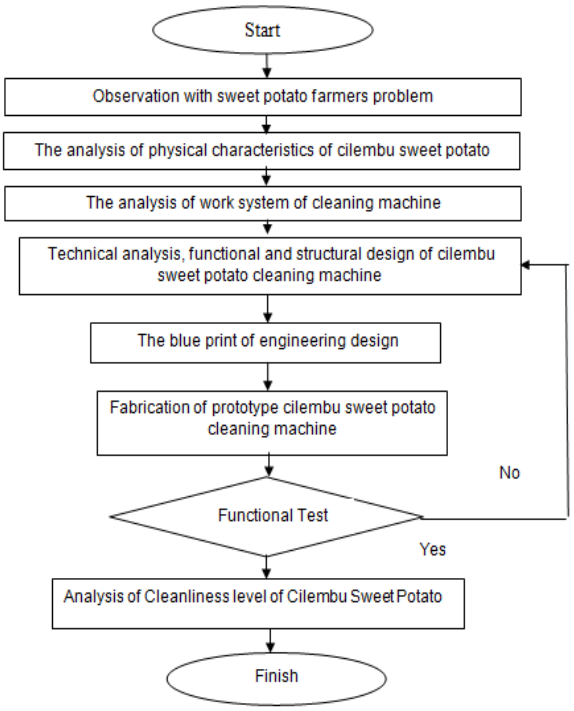


Figure 3. The research stage of cilembu sweet potato cleaning machine.

In detail the stages of research in Figure 3 can be explained as follows:

1. Problems Identification: Observations about the problems that existed in the Tawakal Mandiri sweet potato farmer group in the village of cilembu, providing solutions, especially handling post-harvest sweet potatoes and conducting a study and research intensively in relation of cleaning cilembu sweet potatoes.
2. Studying the Characteristics of Cilembu Sweet Potato: Measuring dimensions, bulk density and water content of cilembu sweet potato as a basis for designing the cilembu sweet potato cleaning machine.
3. Work System Analysis of Cilembu Sweet Potato Cleaning Machine: What kind of cleaning mechanism is suitable for sweet potato cleaning, with the expected yield of over 70%.
4. Functional Design: The functional design was emphasized on the machine functionalities as a whole and the produced output. Meanwhile, this functional design consists of the mechanism analysis of the cleaning sweet potato, round cleaning brush analysis, the machine construction analysis, the transmission system analysis, the cleaning power analysis, and the cilembu sweet potato cleaning machine ergonomic and anthropometrics analysis.
5. Structural Design and Technical Analysis: Structural design was an important in stage determining the final cleaning machine design because the hoper position, the brush cleaning, the cylinder position, the engine frame, the driving motor holder and the discharge hole are assembled into a unified form and placed in accordance with the original functions and design. Meanwhile, technical analysis was more about the calculation of shaft, pegs, bearings, cylinder dimension, brush cleaning, frame, weld and lathe.
6. The Blue Print Figure of Machine Design: The whole process of structural design of cilembu sweet potato cleaning machine will be presented in 2D and 3D using AutoCAD software
7. The Manufacturing of Sweet Potato Cleaning Machine: After figure design was made perfectly, the next step was making and assembling the sweet potato cleaning machine.
8. Machine Functional Test : Machine functional test will be done to determine the function of sweet potato cleaning machine when it operates. It had the chopper functioned according to the initial planning. If not, a more detail design study will be done.

The Physical Characteristics of Sweet Potato

The physical characteristics of agricultural products are very important factors in matters relating to the design of a special tool or machine for agricultural products or materials. Physical characteristics of agricultural products were included shape and size, volume, surface area, color, roundness, and density of material [8].

The shape and size of the sweet potato

The shape and size of the sweet potato were two inseparable characteristics in getting the criteria for the physical characteristics of the sweet potato. In the determination of several parameters including shape and size, it was necessary to measure three axes that were perpendicular to each other using a calipers, namely the a axis (major), the b axis (intermediate) and the c axis (minor) [8]. To determine these axes more clearly could be seen in Figure 4.

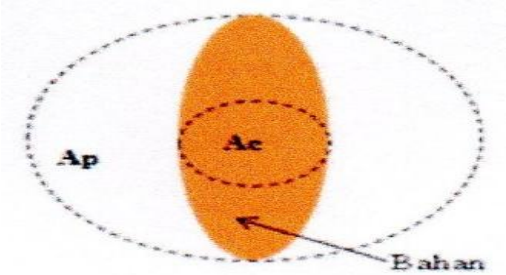


Figure 4. Shape and Size of Sweet Potato

Sphericity

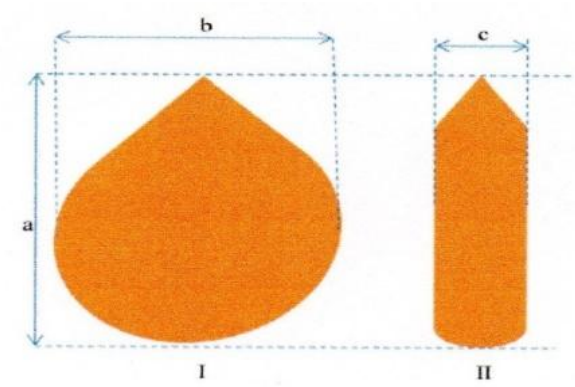
According to [8], sphericity can be defined as the ratio between the diameter of a sphere that has the same volume as an object with the smallest sphere diameter that can surround an object. The value of roundness ranges from 0-1. If the roundness value is close to 1, the shape is closed to the spherical shape. Assuming the volume of the object was equal to the volume of the ellipse with three axes each a, b, c, the roundness can be calculated using Equation 1 as follows:

$$Sphericity = \left(\frac{\text{volume of solid}}{\text{volume of circumscribed sphere}}\right)^{1/3} = \left[\frac{(\pi/6)abc}{(\pi/6)a^3}\right]^{1/3} = \left(\frac{bc}{a^2}\right)^{1/3} = \frac{\text{geometric mean diameter}}{\text{major diameter}} = \frac{(abc)^{1/3}}{a} \quad \text{..... (1)}$$

Note :
a = the longest axis (major axis)
b = the longest axis normal to a (intermediate axis)
c = the longest axis of normal with respect to a and b (minor axis)

Roundness

According [8], roundness is a measurement of the sharpness of the angle of a solid object. The roundness is determined by the ratio between the largest projection surface area to the smallest projection surface area. The roundness back value ranges from 0-1. If the roundness value is closed to 1, the sweet potato is round. How to determine the largest and smallest area t can be seen as in Figure 5.



.Figure 5. Determine of Value Ap and Ac for Calculation if roundness

There were several methods for being used in estimating backwardness, including:

$$Roundness = \frac{r_1^2}{r_2^2} \quad \text{.....(2)}$$

Note :
r1 = radius of inner circle (cm)
r2 = radius of outer circle (cm)

Bulk Density

One important property of a substance was density[9] (9). The unit weight of granular materials was also called bulk solid and can be divided into two types namely the unit weight of the particle (single grain) was called solid or particle density (γp) and the unit weight of bulk (bulk density).

Bulk density,is $\rho_b = \frac{\text{weight particle}}{\text{volume particle}} + cavity$ .....(3)

Technical Analysis

Technical analysis is considered in this sweet potato cleaning machine includes force requirements, shaft analysis, pin analysis, spi analysis, bearing analysis, transmission unit analysis, frame strength analysis and weld strength analysis [10]. Technical analysis examines the strength of the material of each cleaning machine component by performing dimensional measurments, theoretical calculations and direct observation when the machine operating.

1) The Requirement of Driving Force

Force requirements analysis was required to determine the amount of energy or force required by the machine when starting the cleaning process from the beginning of ingredient input to the end of cleaning process [11]. The force generated when the machine was being operated comes from the movement of the machine transmission along with other machine components that were interconnected with another one.

The requirements of force to drive the work mechanism of the sweet potato cleaning machine are calculated using the follow equation[11]:

$$P_t = \frac{2\pi \times M_t \times n_c}{60} \quad \text{.....(4)}$$

Note :
P_t = theoretical force (W)
n_c = cleaning cylinder rotational speed (rpm)
M_t = torque moment (Nm)

2) Transmission Unit Analysis

The sweet potato cleaning machine uses belt and pulley as its transmission units. The transmission comparison of in belt-pulley transmission system can be calculated by the equation as follows [12]:

$$\frac{n_m}{n_c} = \frac{D_p}{d_p} \quad \text{.....(5)}$$

Note:
n_m = rotating speed of the driving motor (rpm)
n_c = rotating speed of cleaning cylinder (rpm)
dp = diameter of drive motor pulley (mm)
Dp = diameter of cleaning cylinder pulley (mm)
The length of belt used can be calculated by the equation as follows (9)

$$L_b = 2C_p + \frac{\pi}{2}(D_p + d_p) + \frac{1}{4C_p}(D_p - d_p)^2 \quad \text{.....(6)}$$

Note:
L_b = belt length (mm)
C_p = distance between pulley centers (mm)
D_p = diameter of cleaning cylinder pulley (mm)
d_p = diameter of driving motor pulley (mm)

III. RESULTS AND DISCUSSION

The Physical Characteristics of Sweet Potato

The measurement results of the cilembu sweet potatoes characteristics showed that the roundness, bulk density, average angle of repose were 0.1, 562.52 kg.m^{-3}, 70.5^0. These characteristic values ware used as a basis for designing the cleaning sweet potato machines.

Design Criteria

The design criteria for cilembu sweet potato cleaning machine were as follows:
1. It can remove soil attached to the skin sweet potato.
2. The capacity of the designed is 100 kg.hour^{-1}.
3. The cleaning mechanism used a water spinner type and a tool brush as a cleaning.
4. Amount of brushes is 1 piece which is placed right in the middle of the cleaning cylinder.
5. The cleaning machine had an output hole at the bottom of cylindrical for sweet potato output.
6. The cleaning machine had a removed water from the cleaning of sweet potatoes.
7. The cleaning machine used 1 HP electric motor.
8. The transmission system uses pulleys and belts
9. Machine was designed to be easy overhaul for easy maintenance.

Functional Design

The functional design stage was carried out to determine what components must be selected that refer to the system mechanism and initial functions that must be achieved by this machine [12]. The cleaning function requires a cleaning brush and a more practical removal process and a practical exit was needed as shown in Figure 6.

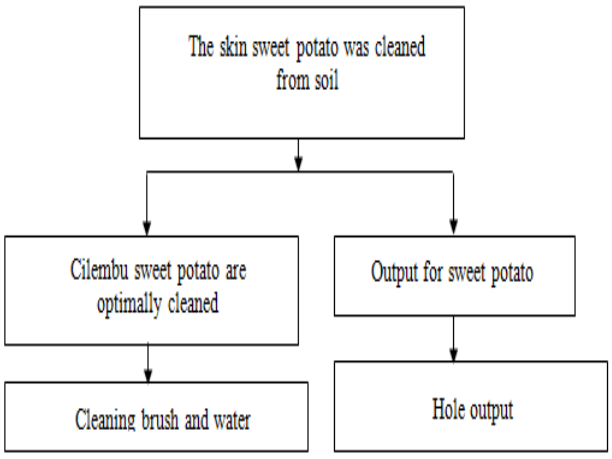


Figure 6 . Scheme of Functional Design for Cilembu Sweet Potato

Structural Design

The design of sweet potato cleaning machine with electric motor force were divided into 4 parts, namely the design of cleaning machine frame and the electric motor seat frame it made (Figure 7), the design of the cleaning cylinder and the design of the cleaning brush. After the design is finished, it was assembled and combined into a single sweet potato cleaning machine.

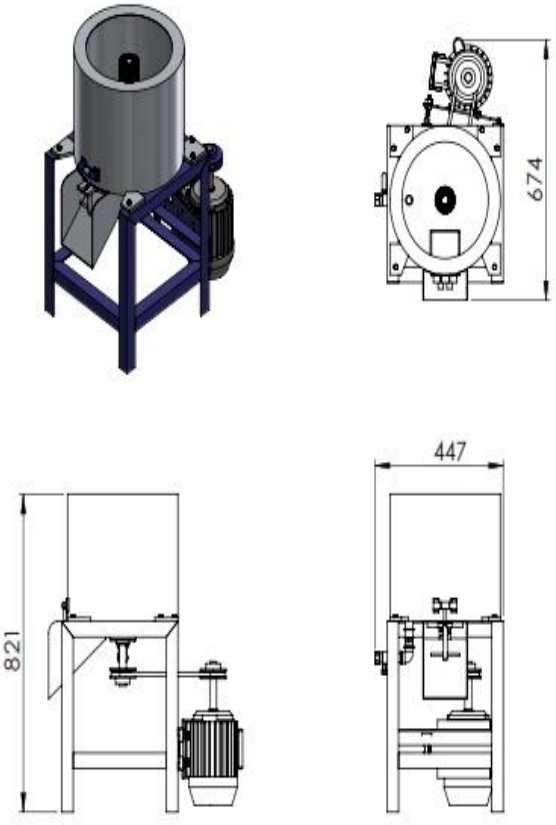


Figure 7. Blue print design of cilembu sweet potato machine with electric motor

The Manufacture of Cilembu Sweet Potato Cleaning Machine.

The cilembu sweet potato cleaning machine is manufactured after the calculations of figure design and technical analysis have been completed. Each component is assembled and arranged in accordance with the figure design made. As for the making of the frame it is made of iron elbow 4 to make it able to withstand the load when machine operates. The load includes electric motors, cleaning cylinders and brush tube.

A wheel was installed to the frame so that the machine can be moved easily from one place to another. The manufacture of cilembu cleaning machine can be seen on Figure 8.

Finally, by following the rules to design machine especially agricultural machines, the cilembu sweet potato cleaning machine can be assembled and functionally tested. The machine can be cleanned cilembu sweet potatoes with a capacity of 103 kg.hour^{-1} as shown in Figure 9.

Figure 8. Manufacture of Cilembu Sweet Potato Cleaning Machine

Figure 9. (a) Cilembu sweet potato cleaning machine (b) Cilembu sweet potato had cleaned

IV. CONCLUSION

The resulted measurements of cilembu sweet potatoes physical characteristics showed that the roundness, bulk density, average angle of repose were 0.1, 562.52 kg.m^{-3}, 70.5^{0}. The cilembu sweet potato cleaning machine prototype is divided into 4 parts, namely the cleaning cylinder, the cleaning brush, the engine frame, and the discharge hole. Dimensions of machine is 400 mm (length) x 490 mm (width) x 490 mm (hieght) and the actual capacity of the sweet potato cleaning machine was 103 kg.hour^{-1} . In general, the results of engine performance testing can be concluded that the machine can function properly, which can clean sweet potatoes from soil dirt

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