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The design of pulper machine to increase coffee production capacity in realizing people's economy

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ABSTRACT

The planning and making the peeler machine for coffee skin are aimed at completing the needs of SMEs at Pagerharjo, Samigaluh, and Kulonprogo. The manual Process is the main obstacle in peeling coffee sheets in SMEs. The main objective of creating technological innovation is to assist workers in the production process using appropriate technology to make their work more qualified, effective, and efficient. In planning and making coffee pulper, we must study some literature, make plans, calculate the Process of creating tools, and evaluate the tools' trial and error. The picture design use application, namely Autodesk Inventor. The size of the machine is 110 cm x 127 cm x 130 cm; using a motor with gas oil, and the first circle is 3600 rpm, used to pull components with the ratio 1:6, v-belt the type A 75, one solid ship with the diameter of 20 mm. the final result is that the capacity of the pulper machine for coffee is 610 kg/hour.

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INTRODUCTION

A community economy means all carry out production. The benefits can be enjoyed by all and under the supervision and leadership of community members (Mubyarto, 2005: 5). In line with this understanding, the Triple-Co concept describes the principles of co-ownership (shared ownership), co-determination (joint determination/decision) and co-responsibility (shared responsibility) (Swasono: 2017). Thus, all economic actors are involved in economic activities.

Kulon Progo is one of the regencies in the Special Region of Yogyakarta, a coffee producer since the Dutch colonization. The area of coffee plantations in DIY reaches 1652.41 Ha. Kulon Progo contributes the most extensive plantations among other districts in DIY, which covers an area of 1422.51 Ha or around 86% of the total area of coffee plantations in DIY (BPSprovincial DIY, 2016). One of the areas in Kulon Progo that can produce coffee from plantation land is Samigaluh District, Pagerharjo

Village, to be precise. In Samigaluh District, 22,065 people work in the agriculture, fishery, or animal husbandry sectors. The total population of Pagerharjo Village who work in the agriculture, fishery, or livestock sector is 3,721 residents (DIY Population, 2021). Pagerharjo is one of the villages in Samigaluh District, on the border of Yogyakarta and Purworejo. The contour of the area is in the form of hills, which hold a lot of potential biological resources, especially coffee commodities.

Coffee is a favorite drink for both the upper and lower classes and is even favored by men and women. According to dataInternational Coffee Organization (ICO), in 2020 - 2021, Indonesian people consumed up to 5 million bags of coffee, measuring 60 kilograms. Even though coffee is a growing commodity, coffee entrepreneurs in the Pagerharjo area experience many problems in increasing their business. It is due to the need for more equipment to support the smooth running of his business.

Pagerharjo is a village in the Samigaluh sub-district where most of its economic activity is supported by the cultivation of coffee and its processed products, on the creative initiative of the youth, MSMEs, and KWTs in the Pagerharjo area, who were guided by the local urban village government and Bumdes (Village Owned Enterprises) Binangun Raharjo, conserved natural resources by planting 24,000 coffee plants in Pagerharjo.

Based on observations, the size of the market potential has yet to be matched by an increase in production capacity. The processing of coffee cherries dramatically affects the quality of the coffee produced. The constraints faced are in the stripping of the coffee skin, where the time and energy needed are still too much, so the stripping of the coffee is felt to be inefficient, and the coffee bean processing techniques that the people of Pagerharjo have carried out are generally still manual in contrast to the dry processing method. In using this method, after harvesting the coffee, it is immediately dried in the sun without going through the process of peeling the fruit skin in the sun for 12-14 days which will take quite a long time, so there is potential for the growth of fungi which can damage the coffee beans. In addition, the results of the coffee peeling quality could be better because there is still a lot of coffee that breaks after going through the manual peeling process. These constraints will increase the stripping process's time, effort, and cost. To meet the high demand, the community needs technological innovation. With assistance from the UNY MATCHING FUND team, the MSME group in Pagerharjo village is expected to be helped and developed.

The author found the existing problems, and the appropriate technology that is suitable to be developed in the Pagerharjo community is a coffee skin peeler machine (pulper). A coffee skin peeler is a machine to assist a wet coffee production process. Coffee made into powder and then consumed must go through this Process. This peeling machine has a transmission system in the form of pulleys, with a drive in the form of a gasoline motor transmitted from pulley 1 to pulley 2 using a v-belt. When the engine is turned on, the motor will rotate then the v-belt transmits the rotation to drive the peeler shaft. If the peeler shaft has rotated, the coffee is ready to be put into the hopper, and the coffee entrance will be peeled off.

The application of a peeler in the form of a perforated cylindrical blade rotating on an axis is expected to be able to replace the function of the existing manual tool. Applying this hollow cylindrical knife can maintain coffee quality and increase the effectiveness of coffee bean stripping production. The coffee farming community needs a machine design pulper that can automatically separate coffee beans and skins, is easy to operate, and is simple to maintain to achieve the expected production targets.

METHOD

This study uses a Research and Development (R&D) approach, which refers to the research design of the 4-D model development (Four D Models) according to Thiagarajan with modifications. At the Define stage, information was obtained that the processing of coffee beans in Pagerharjo Village requires a touch of technology that can assist the community in increasing production capacity. Fundamentally, the people of Pagerharjo do not yet have the technology to process fresh coffee beans because, so far, they are still dried in the sun first, after which they are processed in a mill to separate the coffee beans and skins. Based on the observations and interviews, information was also obtained that the geographical location of Pagerharjo, where most of the land contours are hilly, has a relatively high level of electrical disturbances. Moreover, using energy sources other than electricity needs to be considered. The people of Pagerharjo want the coffee bean processing to be carried out directly after picking, with a capacity of over 400 kg per hour. In general, the technology must be easy to maintain and safe to operate by the people of Pagerharjo but has high productivity.

Based on the information obtained at the Define stage, the researcher then carried out the Pulper machine Design step coffee for the people of Pagerharjo. This stage focuses on selecting materials with corrosion resistance, machining techniques, frame construction and solid driving mechanics, selection of prime movers, operating systems, and machine productivity. All activities at the Design stage are reviewed through appropriate literature.

At stages *Develop* (Development), researchers carried out the process of making a prototype coffee bean Pulper machine according to the results of the Design stage. The development product in the form of a pulper machine is then validated by an Expert (Expert Appraisal), and the machine's function is tested. Engine testing uses indicators (1) engine capacity, (2) component calculations, and (3) hopper capacity. (1) the average size of coffee beans (length, thickness, and average width of coffee beans), (2) the density of coffee beans, (3) the percentage of peel yields per kilogram, and (4) hopper capacity.

The place and time research was carried out in the CAD laboratory and Machine Workshop, Department of Mechanical Engineering Education, FT UNY, and Pagerharjo Village from 1 September to 30 October 2022.

The design tools used are meter rollers, electric welding tools, wrenches, screwdrivers, grinders, electric drills, pincers, pliers, angled lines, roll taps (forming taps), saws, lathe calipers, milling machines, and grinding machines. This research and experiment use writing tools, design-making

software, pencils, erasers, rulers, and Autodesk Inventor software. Measuring instruments used include a stopwatch, tachometer, and balance. The design materials used are box iron, angle iron, plate iron, PVC pipe, round steel, v-belts, v-belt pulleys, and pillow blocks. The experimental material used was Robusta coffee fruit weighing 20 kg with a harvest age of 9-10 months which was imported directly from Pagerharjo village, Samigaluh sub-district. The criteria for the coffee beans used in this machine experiment were red ripe coffee beans or soft skin texture. It cannot use green coffee beans or dry coffee beans.

The flow of machine design activities pulper briefly as follows.

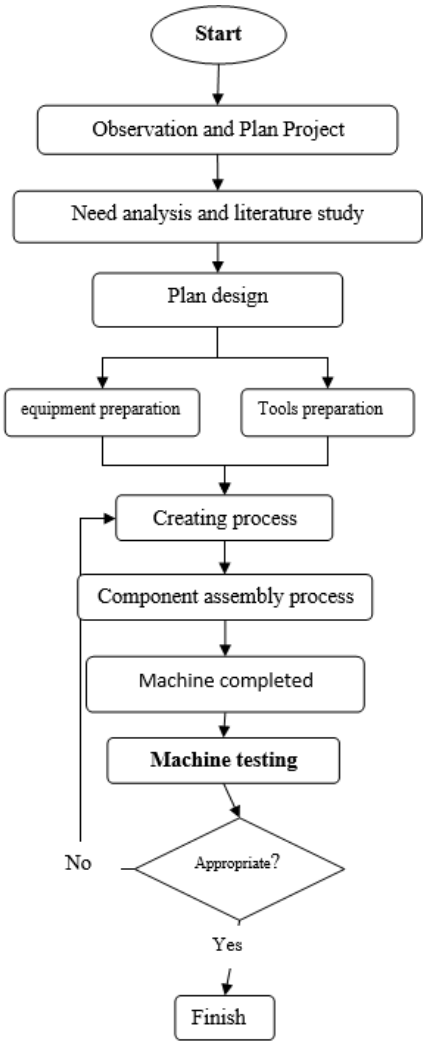

Figure 1. Machine Research Flow

In the design of this coffee pulper machine using research methods, including:

Project Observation and Planning

Direct observations were made through a review of MSMEs coffee drink production entrepreneurs in Kalinongko sub-village, Pagerharjo Village, Samigaluh Kulon Progo, on 17 September 2022. Based on coffee processing production observations, stripping the coffee skin is still manual, so coffee production takes a long enough time. In addition, the results of the coffee peeling quality could

be better because there is still a lot of coffee that breaks after going through the manual peeling process. These constraints will increase the stripping process's time, effort, and cost, so the community needs technological innovation to meet the high demand.

Needs Analysis and Literature Study

This stage searches for data and references related to problems regarding the planning process of coffee pulper machines used as a reference. The literature used is in the form of journals, scientific books, and articles on the internet. This stage produces a design concept, planning for the core components of the coffee pulper machine and the needs of the coffee pulper machine to the existing problems.

Design Plan

Designing the appropriate stripping method focuses on the wet coffee peeling method. Next, the tool design was carried out using Autodesk Inventor software.

Preparation of Tools and Materials

The preparation of tools and materials in making coffee pulper machines uses lathes, saw machines, welding machines, hand grinders, and other workshop tools. The materials used are angle iron frame profiles, cover plates, and other engine components.

Making Process

The prototype machine was worked on at the Fabrication and Machining Workshop at Yogyakarta State University. This stage includes frame welding, shaft turning, blade disc manufacturing, and transmission component preparation.

Component Assembly Process

This process is carried out by combining several parts to form the desired construction. After all the engine components are ready, the assembly consists of welding and installing the frame using nuts and bolts.

Tooling Completed

The coffee pulper machine is ready for testing after all the manufacturing processes have been carried out.

Tool Testing

Testing the coffee pulper machine uses coffee harvested from coffee plantations in the village of Pagerharjo so that the settings for this coffee pulper machine can suit the existing problems. After this coffee pulper machine was tested and its performance followed the wishes of MSME actors and researchers, the data were collected in three tests. Each test used coffee fruit weighing 3 kg with different variations of the rpm of the driving motor.

Finishing

The flow chart above explains the stages of making a machine pulper coffee. The first Process is an analysis process by explaining the steps of stripping the skin of the coffee cherries. Furthermore, the problem formulation stage is formulating the existing problems during the analysis phase.

The next stage is designing the pulper coffee machine with Autodesk Inventor software. The preparation stage for tools and materials and work steps is to prepare the tools to make holes, connect, measure, and cut. Work steps are also determined at this stage, for example, making a frame as the primary support for the machine.

The assembly stage is to compile and assemble all components into a unified machine. The engine is tested using Robusta coffee raw materials in the performance test stage. The evaluation stage results from a performance test have been carried out to determine whether the machine meets expectations. If not, the engine will be repaired starting from the design, but if it is, it will go to the next stage. The last stage is the finishing stage of the machine starting from painting and delivery of the engine.

Observed indicators

Experiment material (coffee fruit):

- The coffee cherries' average length, thickness, and width
- The density of coffee cherries
- Hopper capacity
- Percentage of peel yield per kilogram

Engine Performance Calculation

- N total (carrier rounds)
- Theoretical engine capacity

Calculation Coffee fruit test material

- Average length, thickness, and width of coffee cherries (measurement with a caliper)
- The density of coffee cherries
- Formula (Idhansyah, 2019):

$$\rho b = \frac{wb}{v} \qquad (1)$$

Information:

pb : *bulk density* (gram/cm³)

wb : mass of coffee berries

v : volume of the container (cm³)

- Percentage of peel yield per kilogram (laboratory test)
- Hopper capacity

The volume of the truncated pyramid formula:

$$v = \frac{1}{3}t\left(L + U + \sqrt{LU}\right)\rho b \quad (2)$$

Information:

t: the height of the truncated pyramid

L: area of the base of the truncated pyramid

U: area of the truncated pyramid

So, the capacity of the hopper can be calculated by the following equation:

$$Kh = Vp \times \rho b \quad (3)$$

Information:

Kh: tamping capacity (grams)

Vp : hopper volume (cm^3)

pb : *bulk density* (gram/cm^3)

RESULTS AND DISCUSSION

Coffee Pulper Machine Design Results

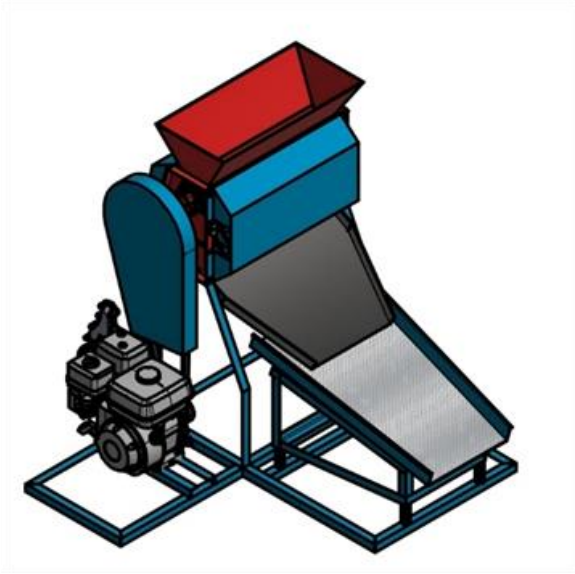

Figure 2. Coffee Pulper Machine Design

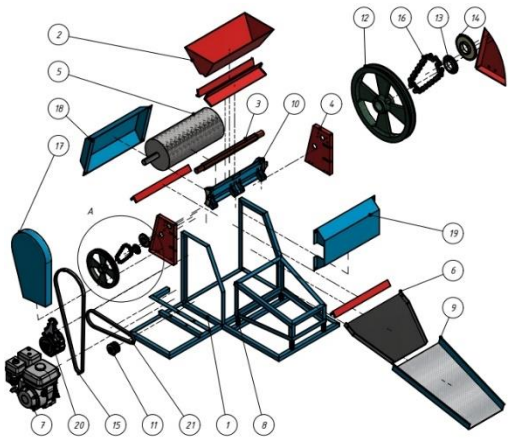

Figure 3. Coffee Pulper Machine Components

The followings are the components and their functions in the design of the *pulper* coffee machine:

1. Main Frame

   The main frame is made of angle iron measuring 3x3 cm to support all components.

2. *Hoppers*(tank)

   It serves as a coffee container that will be peeled, with a prism shape that makes it easier to accommodate more coffee cherries.

3. *Carrier* (coffee bearer)

   It serves as an introduction to the entry of coffee beans into the peeler cylinder, has a star-like shape, and has six angles, making it easier for the coffee to flow more regularly during the peeling process.

4. Stripping Order

   This frame is made of plates as a support for the peeler component.

5. *Crushers*/Stripping Cylinder

   It functions as a coffee berry peeler, separating the seeds from the fruit skin with a hollow tube shape.

6. *Outlets*/outlet

   It serves as the release of coffee beans after peeling.

7. Drive motor

   The driving motor used in this coffee pulper machine is a gasoline engine with a power of 5.5 PK.

8. Pear

   This pear is used for the foot of the sieve so that the sieve vibrates automatically.

9. Sieve

   The sieve on this coffee pulper machine sorts the coffee beans with the coffee skins that come through the coffee bean outlet.

10. Grinder/roller

    It serves as a coffee bean press with a casting iron peeler cylinder.

11. Motor Pulleys

    It serves as a connecting component of the rotation of the drive motor to the shaft.

12. Big Pulleys

    It is a connecting component of the shaft rotation received from the driving motor.

13. Gear 1

    Small gears with a total of 15 teeth function to continue the rotation of the cylinder shaft to the carrier.

14. Gear 2

    This gear 2 has 30 teeth to receive rotation to move the carrier.

15. V-belt

    A V-belt made of rubber with a trapezoidal cross-section transmits power from one shaft to another.

16. Chain

    It serves to transmit power from one shaft to another shaft.

17. Cover Pulleys

    It serves as a protective cover on the transmission components.

18. Cylinder/crusher covers

    It serves as a protective cover for the moving stripping cylinder component.

19. Cover Grinder

    It serves as a protective cover on the grinder.

20. Water pump

    It serves to send water as an auxiliary medium for the Process of stripping wet coffee pulpers.

21. Pump Belts

    This V-belt functions to transmit power from the driving motor to the water pump.

Component Calculation

Calculating Shafts

The following parts will be calculated:

Transmitted power, it is known that the motor power is 5.5 HP (P), with a rotation of 3600 Rpm (N1)

P = 5.5 HP = 5.5 HP x 746 Watts = 4103 Watts (4.103 kW)

Correction factor (fc)

Average power required 1(fc)

Design power (Pd)

Pd $= fc \times P$

Pd $= 1 \times 5{,}5$

= 4.103 kW

Torsional moment (T)

Known transmission ratio 1:6

$$T = 9{,}74 \times 105\frac{Pd}{N1}$$

$$T = 9{,}74 \times 105\frac{4.103}{3600} = 1110\ kg.mm$$

$$T = 1110 \times \frac{6}{1} = 6660\ kg.mm$$

Permissible shear stress (τ_a)

$$\tau_a = \frac{37}{(5{,}6 \times 3)} = 2{,}2\ {}^{kg}/_{mm^2}$$

Shaft diameter(ds)

Kt = Torque moment correction factor 1.0 when the load is applied smoothly (ASME Standard)

Cb = flexure factor whose value is 1.2 to 2.3. (Cb = 1.0 if there is no bending load)

$$ds^3 = \left(\frac{5{,}1}{\tau_a} \times Kt \times Cb \times T\right)$$

$$ds^3 = \sqrt[3]{\frac{5{,}1}{2{,}2} \times 1 \times 1{,}2 \times 6660} = 26{,}46\ mm$$

Observation result

1. Coffee Fruit

The average measurement of coffee cherries starting from length, thickness, and width, aims to determine the ideal distance for the gap between the peeler drum and the coffee peeler groove in the grinder. Based on the results of caliper measurements with an accuracy of 0.02 mm, the following is obtained:

Table 1. Average Coffee Fruit Size (mm).

	Long	Wide	Thick
Max.	15,36	14.88	16,46
Min.	8,66	6,26	8.36
Average	12.01	10.57	12.41

2. Coffee Fruit Density

From the calculation results, it is known with a measuring cup of 500 cm3. The average number of coffee beans is 325. The weight of the coffee fruit is 518.28 grams. So the density of coffee beans is 1.0365 gram/cm3 or 1036.5 kg/m3.

3. Container Capacity (Hopper)

It is known that the volume of the hopper is 28,045 cm3. Based on the results of calculating the density of coffee cherries, which is 1,036.5 kg/m3, the capacity of the hopper volume X density, which is 28,045 cm3 X 1,036.5 kg/m3, is 29,068.6 grams or 29 kg.

4. Percentage of Peel Results per Kilogram

The average peeling results are measured to determine the weight of the coffee beans after peeling and to find out the importance of the peeled coffee husks—the results of measurements or comparison in the calculation of capacity calculations in theory. Based on the average size of the peeled coffee fruit, it was found that 1 kg of coffee beans after peeling would be 675.80 grams or 675.8%.

Engine Performance Calculation

1. N total (carrier rounds)

It is known as drive rotation N1=1800 rpm. Then Rpm Carrier (N4)

i.e.:

Rpm carrier ($N4) = \frac{N3}{N2} = \frac{D2}{D3}$

$= \frac{N1}{N2} = \frac{D1}{D2}$

$= \frac{1800}{N2} = \frac{1}{6}$

$= \frac{N4}{N3} = \frac{D3}{D4}$

$= \frac{N4}{300} = \frac{15}{35}$

= 128.57 Rpm

2. Theoretical engine capacity.

It consists of as follows.

a. The assumption factor of the fruit rolling in the stripping gap (Da) = 0.17
b. The dimensional factor for one stripping period (Db) = 0.33
c. The efficiency of lifting coffee beans on the carrier = 70%
d. The number of coffee beans stolen by the page = 44 in one basin (Σy)
e. The number of depressions on the carrier = 6 (Σx)
f. Total rotation = 128.57 Rpm (N)
g. The efficiency of friction, stripping, etc. = 80%

The formula used

$$= \frac{Da \times Db \times \eta \times \Sigma y \times \Sigma x \times N}{100}$$

$$= \frac{0{,}17 \times 0{,}33 \times 70 \times 44 \times 6 \times 128{,}57}{100}$$

= 12.7x 60 minutes

= 762 kg/hour

With the potential for friction, stripping, and others of 80%, then 762 kg/hour x 80% = 609.6 kg/hour (610 kg/hour).

CONCLUSION

Results engineering coffee bean peeler (coffee pulper) using a diesel motor as the driving force consists of several constituent components including the mainframe, hopper (reservoir tank), carrier (coffee fruit carrier), stripping frame, crusher (peeler cylinder), outlet (outlet), drive motor, pear, sieve, grinder (roller), motor pulley, large pulley, gears I and II, v-belt, chain, pulley cover, cylinder cover (crusher), cover grinder, water pump (pump water), and belt pump. The results of the observation test on coffee cherries for the peeler machine for coffee berry skin are as follows: (1) The average size of the coffee cherries is 12.01 mm long, 10.57 mm wide, and 12.41 mm thick; (2) The density of coffee cherries is 1.0365 grams/cm3 or 1,036.5 kg/m3; (3) The volume of the hopper, which is 28,045 cm3, can accommodate 29,068.6 grams / 29 kg of coffee; and (4) The average percentage of peeled results obtained from 1 kg of coffee beans is 675.8%. The results of calculating the performance of the coffee bean peeler machine are as follows: (1) The results of the calculation of the rotational speed of the coffee cherries (Rpm) are motor shaft rotation (N1) 1800 rpm, carrier N2 300 rpm, N3 300 rpm, and carrier shaft rotation (N4) 128.57 rpm; and (2) The theoretical capacity of the coffee bean peeler is 609.6 kg/hour. The pulper machine designed by UNY is expected to increase farmer ownership and responsibility for the sustainability of the coffee business in Pagerharjo so that the people's economy can improve.

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