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Analysis of Coffee Pulper Machine Performance: A Comprehensive Review of Methods, Technologies, and Influencing Factors

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A B S T R A C T

This study aims to analyse the performance of a coffee peeling machine through a comprehensive review of the methods, technologies, and influencing factors that affect the effectiveness of the machine. A literature review was conducted to gather current and pertinent information on the latest developments in peeling methods, technology applications, and influencing factors affecting machine performance. Analyses of diverse operational methods, ranging from conventional methods to recent innovations, provided in-depth insights into the variety of coffee hulling techniques. Influencing factors such as coffee bean moisture, bean size, and machine operating conditions were analysed to understand the complexity of interactions between variables. The conclusions of this study contribute to the practical and theoretical understanding of the factors affecting the performance of coffee hulling machines, providing a foundation for further development in this field

INTRODUCTION

Coffee pulper machine is one of the modern technologies used in coffee processing. This machine aims to separate coffee beans from the fruit efficiently. One type of coffee pulper machine that is common today uses an electric motor as its driving power source. Electric motors provide advantages in terms of efficiency and reliability, making the pulping process more effective and faster. The use of electric motors in coffee pulpers allows better control over the speed and intensity of the pulping process. This is important for consistent and high-quality results. In addition, electric motors also provide flexibility in machine settings according to production needs, allowing customisation according to different types and conditions of coffee cherries. The importance of research and development in the field of coffee pulper machines using electric motors is reflected in a number of scientific journals. These references form an important basis for understanding the concept, design, and development of modern coffee pulper machines.

The use of a coffee pulper machine with an electric motor as the driving power source provides convenience and efficiency in the coffee pulping process. However, a number of challenges and questions arise regarding the implementation of this technology, namely:

1. The efficiency of the coffee pulper machine with an electric motor compared to the traditional method in terms of time and labour required.
2. The impact of using an electric motor on the quality of coffee pulping results, especially in terms of the integrity and cleanliness of coffee beans.
3. Optimised design of coffee pulper machine with electric motor to increase productivity, maintain bean quality, and reduce losses.
4. The adoption of coffee pulper machines with electric motors can contribute to the sustainability of coffee farming, especially for small-scale farmers.

This study aims to investigate and analyse the use of a coffee pulper machine that uses an electric motor as the driving power source in the context of coffee processing.

LITERATURE REVIEW

Basic Theory of Coffee Pulping Machine: The study of a coffee pulping machine requires an understanding of the basic principles of the machine's operation. These theories include the concept of pulping coffee beans, the use of mechanical force to remove the skin and pulp from the beans, as well as the principles of grinding associated with coffee machines. A coffee press is a mechanical device used to remove the skin and pulp of the coffee fruit from the bean. The principles of mechanics form the basic theory of operation of this machine, where mechanical forces are used to separate the parts. Forces such as frictional force, centrifugal force, and grinding force are used to achieve the desired stripping result.

Latest Technology in Coffee Pulping Machine: This literature review covers the latest developments in coffee machine technology, including the use of smart sensors, automation systems, and more durable materials. A discussion of these innovations helps readers understand how technology is constantly evolving to improve machine performance and efficiency. With the advancement of technology, the design and function of coffee machines have changed. These machines utilise the latest technologies such as intelligent sensors, automation systems, and more durable materials to better monitor and control the process. Meanwhile, the automation system improves operational efficiency and stripping quality.

Factors Influencing the Performance of Coffee Grinding Machine: An analysis of the performance of a coffee press is incomplete without considering the factors that affect the operation and efficiency of the machine. These include environmental factors such as temperature and humidity, the quality of coffee raw materials, and operational factors such as operator expertise and proper maintenance. A variety of factors, including environmental factors such as air temperature and humidity, the quality of coffee raw materials, and operational factors such as operator proficiency and proper maintenance, affect the performance of coffee machines. To guarantee the best performance and quality stripping results, it is crucial to have a deep understanding of these components. Analysing the performance of coffee machines can be done more thoroughly by understanding the basic theories of machine operation, technological advancements, and influencing factors. With the help of this thorough review, coffee producers can improve efficiency, optimise product quality, and reduce negative environmental impacts during the coffee production process.

METHODOLOGY

The method used in this journal includes several steps, as described in the study:

Data Collection: The initial step involved data collection through observation and literature study to understand the needs and requirements in designing the coffee peeling machine.

Design of Coffee Peeling Machine: The machine design process is carried out using Autodesk Inventor software to produce a design that matches the desired specifications.

Manufacturing Process: After the design is complete, the manufacturing process of the coffee peeling machine is carried out according to the specifications that have been designed previously.

Equipment: The equipment used in the manufacturing of the machine includes lathes, welding machines, drilling machines, rulers, scrapers, racks, hand grinders to ensure the manufacturing of the machine according to the design that has been made.

Performance Test or Application of Coffee Peeling Machine: Once the manufacturing is complete, a performance test is conducted to ensure that the machine is functioning properly. The data from the performance test is used to calculate the efficiency and capacity of the machine.

Conclusion: After all stages are completed, data analysis and conclusions are made based on the performance test results of the coffee peeling machine that has been made.

Through this method, the author successfully designed, made, and tested the performance of a coffee peeling machine with the aim of increasing efficiency and capacity in the coffee processing process.

Figure 1. Blade Roller Bracket

RESEARCH RESULT

1. Calculation of Shafts: The shaft material is selected based on the specific tensile strength and calculation of the torsional moment (T) and permissible shear stress for the shaft. Shaft calculations include calculations of power, torsional moment, shear stress, and shaft diameter.
   1.1. The Power Calculation aims to determine the power required to operate the coffee pulper machine according to the desired specifications. This is important to ensure that the machine can operate efficiently and in accordance with the production needs of coffee farmers. The power plan is calculated with a correction factor (Fc) of 2.0 using the equation:

$$Pd = Fc \text{ x } P \quad (1)$$

   1.2. Torsional Moment Calculation aims to determine the amount of moment required to efficiently drive a coffee pulper machine. This is important to ensure that the machine can operate properly and is able to perform the function of separating coffee beans and skin optimally. Based on the previously calculated motor rotation n1 and power plan Pd, the Torsional Moment (T) is calculated using the equation:

$$T = 9{,}74 \text{ x } 10^5 \text{ x } \frac{Pd}{n_1} \quad (2)$$

   1.3. The calculation of shear stress aims to determine the permissible shear stress on the shaft of the coffee pulper machine is important to ensure the strength and reliability of the shaft in withstanding the loads and moments generated during machine operation. By performing shear stress calculations, the research can ensure that the engine shaft has sufficient strength to withstand the stresses and loads that arise during the operating process of the coffee pulper machine. This will help in ensuring that the machine can operate efficiently and safely, as well as prevent damage or failure to the shaft during machine use. The permissible shear stress (τ_a) uses the equation:

$$\tau = T \times \frac{r}{J}$$

   Where:
   T : Torsional Moment
   r : Shaft Radius
   J : Moment of Inertia of Shaft

   Then,

$$\tau_a \text{ (kg/mm}^2) = \frac{\sigma_b \text{ (kg/mm}^2)}{Sf_1 \times Sf_2} \quad (3)$$

   1.4. Shaft Diameter Calculation aims to determine the right size for the shaft of the coffee pulper machine is important to ensure that the machine can

operate efficiently and safely. It is also important to ensure the reliability and strength of the shaft in withstanding the loads exerted during the process of operating the machine. By performing appropriate shaft diameter calculations, research can ensure that the shaft has sufficient strength to withstand the loads and moments generated during the operation of the coffee pulper machine. This will help in preventing damage or failure to the shaft during the use of the machine and ensure the smooth operational process of the machine. The shaft diameter (ds) is calculated using the equation:

$$d_s = \left(\frac{5,1}{\tau_a} \times Kt \times Cb \times T \right)^{1/3} \quad (4)$$

Where:

Kt : Correction factor due to torsional moment

Cb : Correction factor due to bending moment

If no flexural loading occurs then the value of *Cb* = 1,0.

2. Transmission Planning

The transmission planning used for the coffee pulper involves several important calculations, such as the calculation of pulleys, V-belt speed, belt length, and shaft axis distance. The following is a summary of the transmission planning calculations used in this study:

2.1. Pulley Calculation. In the transmission planning of the coffee pulper machine, the calculation of the pulley shaft rotation is carried out by comparing the rotation of the motor shaft with the large pulley shaft. This involves using the diameters of the motor pulley and the large pulley in the calculation to determine the pulley shaft rotation. Thus, this calculation helps in determining the rotation ratio between the motor shaft and the large pulley shaft, which is an important step in designing an efficient and suitable transmission for the coffee pulper. The pulley calculation uses the equation:

$$\frac{n_1}{n_2} = \frac{D_b}{d_b} \quad (5)$$

Where:

n_1 : Motor shaft rotation

n_2 : Large pulley shaft rotation

D_b : Large pulley diameter

d_b : Motor pulley diameter

$$D_P = \frac{n_1}{n_2} \times d_p \quad (6)$$

Dimana:

D_P : Large pulley distance

d_k : Small pulley outer diameter

D_k : Large pulley outer diameter

2.2. Calculation of V-belt speed. The V-belt speed is calculated to ensure the transmission is running properly and the calculation of the V-belt speed involves the pulley diameter and shaft rotation. The V-belt speed is calculated using the equation:

$$V = \frac{\pi \times d_p \times n_1}{60 \times 1000} \qquad (7)$$

2.3. Calculation of Belt Length (L). The belt length calculation in the transmission planning of the coffee pulper machine is carried out to determine the type of belt that is suitable for the transmission used. This process involves the use of pulley diameter and shaft axis distance in the calculation. By knowing the required belt length, the research can select the right type of belt to be used in the transmission of the coffee pulper machine. This is important to ensure that the belt selected is suitable for the operational needs of the machine and can function properly in transmitting power from one component to another in the machine. Belt length (L) is calculated using the equation:

$$L = 2C\left(\frac{\pi}{2}\right)\left(D_p + d_p\right) + \frac{1}{4C}\left(D_p - d_p\right)^2 \qquad (8)$$

Where:
C : Shaft axis distance

2.4. Calculation of Axis Distance (C). The calculation of the axle spacing in the transmission planning of a coffee pulper is done to determine the optimal position of the shaft in the transmission. This process involves factors such as pulley diameter and belt length in its calculation. By calculating the axle spacing, the study was able to determine the position of the shaft that allows the transmission to operate efficiently and according to the needs of the machine. It is important to ensure that the shaft is optimally placed so that power can be properly transmitted between the components in the coffee pulper machine. The shaft axis distance (C) was calculated using the equation:

$$C = \frac{b + \sqrt{b^2 - 8\left(D_p - d_p\right)^2}}{8} \qquad (9)$$

Where:

b : Constants of motor pulleys and large pulleys based on calculations from: $b = 2L - \pi\,(D_p + d_p)$ = 1495,59 mm

2.5. Calculation of Contact Angle. Contact angle (θ) calculations can be performed to determine the optimal contact angle in a coffee pulper transmission. The right contact angle will ensure that the transmission

operates efficiently and according to the needs of the machine. The contact angle is calculated using the equation:

$$\theta = 180^0 - \frac{57\left(D_p - d_p\right)}{C} \qquad (10)$$

DISCUSSION

The technologies applied to produce quality and quantity of coffee beans include: the process of picking good coffee beans is red in colour when harvesting, the use of a driving machine to drive a wet coffee bean hulling machine, and the use of an electric motor to drive a wet coffee bean hulling machine.

Factors affecting the quality and quantity of coffee beans include: organic cropping patterns, linear speed of V-shelling, total production capacity of the machine, design planning of the machine that separates the coffee bean skin. [6]

CONCLUSIONS AND RECOMMENDATIONS

This study was to analyse the performance of a coffee skin peeling machine based on a comprehensive review of methods, technologies, and variables affecting machine performance. The review results show:

1. Coffee skin stripping methods with modern technology play an important role in improving efficiency and precision.
2. Influencing factors such as environmental conditions and coffee bean characteristics were also analysed for a better understanding of the machine performance holistically.
3. The drive motor and machine settings for production needs need to be adjusted according to the type and condition of the coffee fruit. The use of machines represents a major change in the method of stripping coffee skin; technology plays an important role in improving the efficiency and precision of the process.

ADVANCED RESEARCH

Further research can be conducted to identify the influence of environmental factors and coffee bean characteristics in greater depth on the performance of coffee peeling machines.

Further studies can focus on adjusting the drive motor and machine settings for production needs based on the type and condition of the coffee fruit. This research can help in optimising the efficiency and accuracy of the coffee skin stripping process.

Further research could explore the latest innovations in coffee peeling machine technology, such as the use of smart sensors, automation systems, and more durable materials.

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