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# Innovation in the Design and Manufacture of Rice Fan Tools

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**Abstract:** Rice is an agricultural product that is the staple food of the Indonesian people, the quality of rice yields is often unsatisfactory, because some of them have empty grains. So that farmers have to separate the filled rice grains from the empty ones manually, this process is considered less efficient. This process takes quite a long time. Therefore, a machine design is needed that can separate the filled grain from the empty grain. This research aims to design a rice fan machine, to make time efficient and to know the comparison between the manual process and the rice separator machine. This tool serves to separate good quality rice grains from grain (empty or imperfect rice grains), so that crop yields can be optimized. The working principle of this tool generally utilizes the difference in density between rice and grain with mechanisms such as air filtration (blower), vibration, or gravity. In testing, the rice and grain fan showed a high level of accuracy in separation, with a capacity that can be adjusted based on the needs of farmers. This machine is able to separate rice 10kg/minute, which previously only 6kg/hour, there is an increase in the work efficiency of the tool in separating rice.

**Keywords:** Design; Grain; Innovation; Rice fan

## Introduction

Rice is an agricultural product that is the main consumption of Indonesian people. Rice can also be a raw material for making a variety of foods (BPS Jawa Timur, 2009; Prambudi et al., 2021). Based on data obtained from the Central Bureau of Statistics (BPS) of West Sumatra Province, rice production in West Sumatra Province in January-April 2023 and January-April 2024 was 528,716 tons of GKG, while Solok Regency still consistently contributed the largest rice production compared to other districts/cities in West Sumatra, namely 69.87 tons of GKG per January-April 2024 (Arianto, 2023; Iskandar et al., 2022; Nugraha, 2020). The average Solok citizen is a farmer because Solok has a very large land area (Susanti et al., 2022; Susanti, Oktafiandes, et al., 2020).

Post-harvest handling of rice includes several stages of activities, namely temporary stacking in paddy fields, collecting rice in threshing places, delaying threshing, threshing, transporting grain to farmers' homes, drying grain, packaging and storing grain, milling, and storing rice (Djamalu, 2016; Padafani, 2022; Rachmayani, 2017; Rahmatunnisa et al., 2022). Each stage of the activity requires handling with different technologies (Sanjaya et al., 2024).

Grain cleaning is the process of separating the filled grain from the empty grain and unwanted materials (Imansyah et al., 2024; Suhendra et al., 2023; Ulfa et al., 2014; Ulfiyah et al., 2023). The separation process carried out by the household industry is still carried out in the traditional way, namely the rice grains are placed in a tampah and then moved with both hands following the up and down direction swing repeatedly, so that the capacity achieved is only 6 kg/hour by one worker (Alfina, 2020; Hariyadi et al., 2014; Windarta et al., 2016a). The traditional separation process is less efficient because it can cause difficulties such as losses, requires a lot of energy, relatively long time, a large place, and depends on the weather conditions (Juliyasri et al., 2019;

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Rizki et al., 2022; Rofarsyam, 2008; Ulfiyah et al., 2023; Windarta et al., 2016b). Farmers still do post-harvest processing manually, especially in the process of separating rice (Fatmawaty et al., 2023). This manual method causes ergonomic problems for farmers and is not effective (Mulyadewi et al., 2023; Susanti & Arif, 2020). Farmers need to be introduced to with technological innovations that can increase efficiency in producing rice (Assani et al., 2022; Kristanto et al., 2015).

Source:
**Figure 1.** The traditional rice winnowing process (Nugroho, 2022)

The traditional rice separation process has now been widely abandoned and switched to the conventional way, namely with the help of a rice fan, this tool works by utilizing the wind blowing from the fan to separate the filled grain and empty grain, by turning the lever with the help of human power to operate the tool (Iswantoko et al., 2010; M. A. Prasetyo et al., 2024; Salim et al., 2018; Sudirman et al., 2014; Surbakti et al., 2023).

**Figure 2.** Conventional rice fan

Seeing the above phenomenon, an idea emerged to design a tool for separating filled rice with empty rice whose work process no longer uses human power, but is assisted by a motor that comes from electric power to drive the fan (Affandi et al., 2014). The use of this rice fan is expected to be increasingly relevant in the midst of demands for increased agricultural productivity and the need for good quality agricultural products (Maier et al., 2004; Munde et al., 2023).

The purpose of this research is to design a simple machine to help simplify work for farmers and be able to save time. This machine system serves to separate the rice harvest that has been dried between the rice that is filled with empty rice (Imansyah et al., 2024; D. H. Prasetyo, 2021; Sudirman et al., 2014). This machine will produce wind rotation which will be directed to separate the filled rice with empty rice with a capacity of 10 kg/minute.

## Method

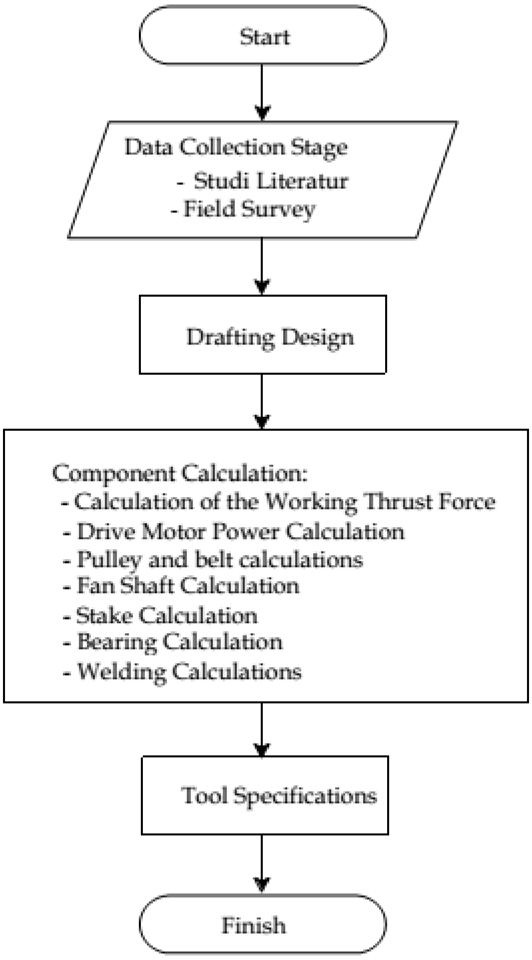


**Figure 3.** Diagram Alir

Data collection techniques in this design are carried out through 2 stages, namely Study Literature and Field

Survey. Study Literature is done by looking for books, scientific journals, and pre-existing documents that are relevant to the design topic, studied and the results of the Study Literature are used as a reference to complete this design (Sahir, 2022). While the field survey was carried out by visiting one of the rice mills in Padang City, from the observations obtained that there are obstacles in post-harvest activities, namely the process of rice husking carried out by farmers is still traditional, namely by swinging the lever connected to the chain so as to produce air rotation, the air produced is used to separate the rice husks. This means that the process of separating rice husks from the beginning was carried out traditionally with human power, so an idea emerged to make a more efficient rice husk separator by no longer utilizing human power, with the help of a motor drive so that the process of separating rice husks could be done on a larger scale and was not time consuming.

*Component Calculation Formula*

*Finding the Thrust Force of the Rice Fan Machine*

*Calculating the Volume of the Inlet Funnel*

$$l_{base} = \frac{1}{2} \times (sum\ of\ parallel\ side\ lengths) \times height \quad (1)$$

After knowing the base area of the inlet funnel, the volume of the inlet funnel can be calculated as follows:

$$Volume = l_{base}\ x\ length\ of\ prism \quad (2)$$

*Calculating the Weight of Empty Rice or Grain*

The weight of 1 empty rice grain or grain is 0.02 grams (Nurmandi, 2013). To find the weight of grain that is not filled can be calculated using the following formula:

$$F = m\ x\ g \quad (3)$$

Where:
$m$ = empty paddy mass (kg)
$g$ = gravitasi (9.81 $^{m}/_{s^2}$)

*Calculating the Weight of Filled*

Rice The weight of 1 filled rice grain is 0.03 grams (Hazton Technology, 2014). Then the weight of the paddy can be calculated using the following formula:

$$F = m\ x\ g \quad (4)$$

$m$ = massa padi isi ( $kg$ )
$g$ = gravitasi ( 9.81 $^{m}/_{s^2}$)

*Calculating Fan Rotation Speed*

Where:
D = Fan diameter (m)
N = Planned rotation (rpm)
F = Number of turns per second (rpm⁄s)

$$f = \frac{N}{60s} \quad (5)$$

Calculating the angular velocity uses the following equation:

$$\omega = \frac{2\pi}{T}\ x\ f \quad (6)$$

Where:
ω = Calculated angular velocity (rad)⁄s)
f = Number of revolutions per second (rpm⁄s)
T = Period (s)

*Calculating Linear Velocity*

Where r is the radius of the fan, the linear velocity can be calculated using the following formula:

$$V = r\ x\ \omega \quad (7)$$

Where:
r = radius of the fan (m)
ω = angular velocity (rad)⁄s)

*Calculating Relative Velocity*

Where sin β (blade tilt angle). Then the relative speed can be calculated using the following equation:

$$W = \frac{V}{\sin\beta} \quad (8)$$

Where:
V = Calculating the Relative Speed (m⁄s)
sin $\beta$ = Angle of inclination

*Calculating the Absolute Speed of the Fan*

Where cos β (blade tilt angle), the absolute speed of the fan can be calculated as follows:

$$C_1 = W.Cos\ \beta \quad (9)$$

Where:
W = Calculating Relative Speed (m⁄s)
Cos β = Angle of inclination of the blade

*Calculating the Axial Fan Cross-Sectional Area*

The equation for the cross-sectional area of the fan:

$$A = \frac{1}{4}\ x\ \pi\ x\ (D)^2 \quad (10)$$

Where:
A = Fan Cross-sectional Area ($m^2$)

D = Fan diameter (m)

*Calculating the Density of Air*

Then the density of air can be calculated by the following formula:

$$\rho = \frac{\rho}{R.T} \quad (11)$$

Where:
ρ = Standard air pressure 1 atm (N/m²)
R = Air constant ((N.m)/Kg.k)
T = Normal air temperature (K)

*Calculating Mass Flow Rate*

$$m = \rho. A. C_1 \quad (12)$$

Where:
ρ =Standard air pressure 1 atm (N/m²)
A = Fan cross-sectional area (m²)
$C_1$ = Fan absolute speed (m/s)

*Calculating the Thrust Force*

To know the thrust force we must know the value of $C_2$, where the value of $C_2$ = V. Then the thrust force can be calculated by the following formula:

$$F_{fan} = m \; x \; C_2 \quad (13)$$

Where:
m = Mass flow rate (Kg/s)
$C_2$ = Linear Velocity (m/s)

*Calculating the Force Working on the Rotating Shaft the Force*

Acting on the rotating shaft can be found using the following equation:

$$F = (m \; x \; g) + f_{fan} \quad (14)$$

Where:
$m$ = Fan mass + shaft mass (kg)
g = Gravity (9.81 m/s²)
$F_{fan}$ = Thrust force (N)

*Calculation of Motor Power*

To find out the torque of the drive motor shaft can be calculated by the following equation:

$$T = F.r \quad (15)$$

After getting the T value, the motor power (P) can be found with the following equation:

$$P = \frac{T.2\pi.n}{60} \quad (16)$$

Where:
T = Torque (N.m)
F = Force acting on the rotating shaft (N)
r = radius (m)
n = motor rotation speed (rpm)

Pulley and Belt Calculation
Calculating the Pulley Round used (rpm).

$$\frac{n_1}{D_p} X \frac{d_p}{n_2} \quad (17)$$

Where:
$n_1$ =rotation of the drive motor
$n_2$ = rotation of the drive motor
$d_p$ = Diameter of the driving pulley
$D_p$ = Diameter of the driven pulley

Calculating the Linear Velocity of the Belt,

$$v = \frac{\pi.d_p.n_2}{60.1000} \quad (18)$$

## Result and Discussion

*Design of Rice Fanning Tool*

The tool design process considers the efficiency of production time, production capacity, and fanning results. The following is the design of the rice fan tool carried out in this design.

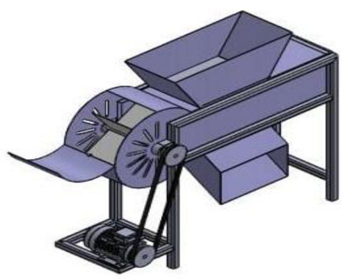

**Figure 4.** Design of rice fan tool

*Design of Rice Fan Front View*

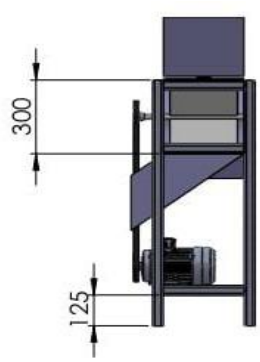


**Figure 5.** Design of rice fan front view

*Design of Rice Fan Top View*

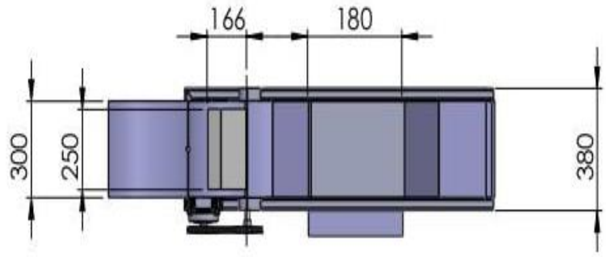


**Figure 6.** Design of rice fan top view

*Design of Rice Fan Side View*

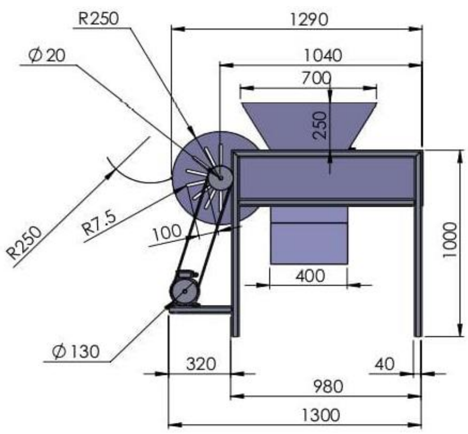


**Figure 7.** Design of rice fan side view

*Technical Data Of The Designed Tool*

This tool has a frame with a length of 980 mm (98 cm), a width of 380 mm (38 cm), and a height of 1000 mm (100 cm). The hopper section is divided into the entry hopper and the out hopper. The hopper entry has an upper side length of 700 mm (70 cm), a lower side length of 400 mm (40 cm), a width of 380 mm (38 cm), and a height of 250 mm (25 cm). Meanwhile, the hopper out has a length of 400 mm (40 cm), a top side width of 150 mm (15 cm), and a bottom side width of 550 mm (55 cm).

This machine uses a motor with a power of 220-240 Volt and a rotation speed of 800 rpm. For the shaft support, this tool is equipped with Pillow Block Bearing type bearings, specifically type UCP 204, which ensure stability and smooth rotation.

The shaft used has a length of 450 mm (45 cm) and a diameter of 20 mm (2 cm). The pulley attached to the shaft has a diameter of 50 mm (5 cm). The drive system uses a belt with a length of 1000 mm (1 meter) and a diameter of 20 mm (2 cm), which functions to efficiently transmit power from the motor to other components.

*Material Selection Criteria*

*Frame*

The frame material used is angle iron, which has several advantages. The triangular structure formed by the right angles provides excellent stability, allowing the angle iron to withstand heavy loads without deformation. In addition, angle iron has high resistance to pressure, making it suitable for construction that requires long-term durability. Angle iron is also easy to cut to the desired size and easy to weld, making the process of creating joints in the frame easier.

*Frame.Wall*

For the frame wall, iron plates with a thickness of 1 mm are used. This iron plate has high mechanical strength, allowing it to withstand heavy loads and high pressure without easily cracking or breaking. In addition, iron plates can be cut, welded, bent, or drilled according to needs, providing high flexibility in design and application.Iron plates—especially black plates—also have competitive prices compared to other materials with similar strength.

*Hopper*

The material used to make the hopper is the same, namely iron plates. This hopper functions to store, direct, and flow various types of materials, whether in liquid, powder, granular, or solid form.With its simple design and utilization of gravitational force, the hopper is capable of reducing additional energy requirements and maintenance costs, thereby increasing operational efficiency.

*Motor*

The motor used has a rotation speed of 800 RPM. At low speeds like this, the motor usually produces higher torque compared to higher-speed motors. In addition, low-speed motors tend to be more energy-efficient because they do not require a large amount of power to maintain high speeds, thus providing good energy efficiency.

*Bearing*

The type of bearing used is the Pillow Block Bearing, which is a bearing housing designed to safely support a rotating shaft. This pillow block bearing has an integrated housing and bearing, making the installation process easier without the need for additional components. Made from strong materials such as cast iron or steel, these bearings can effectively withstand radial and axial loads. Pillow Block Bearing is also widely used in various sectors, including the agricultural sector, due to its reliability.

*Belt and Pulley*

The belt used is a type of V belt or V-Belt with the consideration that the V-shaped design allows the belt to grip the pulley better, resulting in more efficient power transmission without slippage. The pulley used is the radius pulley type.

*Testing Results of Rice Fan Tool*

Based on the tests conducted, this rice fan tool shows excellent performance with a high level of separation accuracy. Its processing capacity can be customized according to farmers' operational needs, providing flexibility in its use.

The machine is capable of processing raw materials at a capacity of up to 10 kilograms per minute, a significant increase compared to conventional methods that can only separate about 6 kilograms per hour. This increased capacity indicates a much higher work efficiency.

Therefore, this tool provides a practical and economical solution for farmers, especially for small to medium scale businesses, in increasing the productivity and effectiveness of the rice and grain separation process.

## Conclusion

The designed rice fan has been successfully and effectively tested. The machine is capable of processing raw materials at a capacity of up to 10 kilograms per minute, which is a significant improvement compared to the traditional way of separating only about 6 kilograms per hour. This shows a very high increase in working efficiency for this device. In terms of separation efficiency, it can separate filled and empty rice with good accuracy, resulting in better rice quality and reduced yield loss. This increase in capacity and efficiency makes the rice fan very suitable to support the productivity of farmers, especially on a small to medium scale. Overall, the device not only succeeded in being created but also provided a practical and economical solution with much better performance than conventional rice separation methods.

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**Author Contributions**

Conceptualizing research ideas, O. S, H. Y; research methodology, O. S, R. A, F. F. R; data analysis, O. S; securing funding, O. S; writing original drafts, O. S; R. A, F. F. R; management responsibilities, O. S, Y; coordination for research planning and implementation of activities, O. S, H, Y. Y.

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**Conflicts of Interest**

The authors declare no conflict of interest, financial or otherwise.

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