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Modification of Corn Shelling Machine in Merauke Regency

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A R T I C L E I N F O

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A B S T R A C T

Manual corn shelling requires considerable time and labor with low productivity. This study aims to design a modification of a corn shelling machine for greater efficiency and to measure the working capacity of the machine after modification. Modifications were carried out on an existing corn shelling machine by enlarging the hopper size from 0.021 m³ to 0.024 m³, enlarging the shelling screen, replacing the motor pulley to increase rotational speed from 350 rpm to 584 rpm, and adding a rice thresher fan as a cleaning blower for shelling output. Testing was conducted in 9 trial runs at La Guy Workshop, Garuda Mopah Lama Street, Merauke, using dried corn with a diameter of 40–80 mm and length of 50–200 mm. The results show that the modified machine can shell 11 kg of corn per minute with a total capacity of 660 kg per hour, far exceeding the pre-modification performance of 3 kg per minute or 180 kg per hour. The applied modifications are proven to significantly improve the capacity, speed, and cleanliness of corn shelling results.

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INTRODUCTION

Merauke Regency is one of the largest corn-producing regions in South Papua Province. In areas such as Gurinda Jaya Village, Jagebob 7, Jagebob District, many residents work as corn farmers, cultivating approximately 16 hectares of farmland [1]. Corn (*Zea mays* L.) is an important cereal crop used for both food and feed. More than 55% of Indonesia's corn production is utilized as animal feed, while approximately 30% is used for food products [3].

One of the main challenges in the corn production chain is the shelling process. Manual shelling requires considerable time and labor while yielding relatively low productivity, ranging from only 5–20 kg per hour per worker [4]. This condition negatively affects farmers' economic efficiency due to high labor costs and the slow pace of post-harvest processing.

Previous research conducted by Dwi Purnomo Aji developed a corn shelling machine using a chain-iron threshing mechanism, with machine dimensions of 100 cm × 50 cm × 130 cm and a rotational speed of 350 rpm. However, the machine's capacity was limited to 3 kg per minute or 180 kg per hour, and the shelling results still contained a significant amount of impurities because no cleaning system had been incorporated [2].

Based on these issues, this study was conducted to modify the existing corn shelling machine with the aim of improving working capacity, shelling speed, and the cleanliness of the output. The modifications included enlarging the hopper, replacing the motor pulley, and adding a rice-thresher fan as a blower system. It is expected that this research will make a practical contribution to improving the productivity of corn farmers in Merauke Regency.

RESEARCH METHOD

This study employed an experimental research method with a design and fabrication approach. The object of the study was a semi-mechanical corn shelling machine modified by utilizing a 1 HP electric motor as the main driving source. The research was conducted from May 2024 at La Guy Workshop, located on Garuda Mopah Lama Street, Merauke.

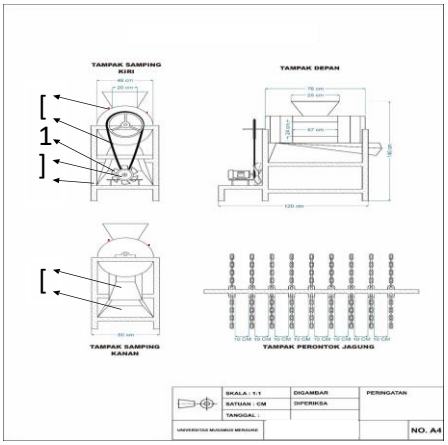

Figure 1. Equipment Design

LITERATURE REVIEW

Materials and Equipment

The materials used in the machine modification process included 1 mm galvanized steel sheet, bolts and nuts, angle iron, flat bar steel, RB 2.6 mm and RB 3.6 mm welding electrodes, cutting wheel and grinding wheel discs, a rice thresher fan, a new motor pulley, and paint. The equipment used consisted of a 900-watt Lakoni welding machine, a Makita handheld grinder, a Makita bench grinder, and a Makita hand drill equipped with 8 mm and 16 mm drill bits.

Modification Procedure

The modification procedure was carried out systematically through the following steps: (1) cutting and removing the existing hopper; (2) drilling the corn kernel separation screen to enlarge the screen openings; (3) redesigning and fabricating a larger hopper using galvanized steel sheet; (4) cutting and reshaping the discharge chute; (5) drilling the motor pulley to accommodate the fan mounting connection; (6) installing an air duct made of galvanized steel sheet; (7) assembling and joining the components using welding and bolts; and (8) painting the machine.

Machine Element Design

The shaft material used was S45C steel with a tensile strength of σ = 24 kg/mm². The allowable stress was calculated using safety factors of Sf_1 = 6 and Sf_2 = 1, resulting in an allowable stress of σ_a = 4 kg/mm². The electric motor had a power output of 1 HP = 0.735 kW, with a correction factor of fc = 1.2, resulting in a design power of Pd = 0.882 kW. The design torque was calculated using the following equation:

$$T = 9{,}74 \times 10^5 \times (Pd / n_1) = 613{,}6 \text{ kg·mm} \quad (1)$$

Using correction factors of Kt = 2.0 (heavy shock load) and Cb = 1.5 (heavy impact load), the minimum shaft diameter obtained was ds = 12.4 mm. Therefore, a shaft diameter of 20 mm was selected [5].

The transmission system employed a pair of pulleys consisting of a motor pulley with a diameter of d_1 = 127 mm and a shaft pulley with a diameter of d_2 = 304 mm. The shaft rotational speed was calculated as follows:

$$n_2 = n_1 \times (d_1 / d_2) = 1400 \times (127/304) = 584 \text{ rpm} \quad (2)$$

The V-belt used had a linear speed of v = 10.2 m/s and a belt length of L = 919.3 mm. The bearing selected was a UCP 212 bearing with an equivalent load of P = 32.71 lbf and a nominal service life of Lh = 16,355 hours, equivalent to approximately nine years of operation at five hours of daily use [6].

The blower added to the machine was a rice thresher fan with a fan diameter of 340 mm. It was directly connected to the electric motor pulley and produced a measured airflow velocity of 3.9 m/s, as determined using an anemometer.

Testing Procedure

The testing process was conducted through nine experimental trials using dried corn with a moisture content of 18–20%, a diameter ranging from 40–80

mm, and a length of 50–200 mm. Each trial used 9 kg of corn per batch, with testing durations of 30 seconds, 40 seconds, and 50 seconds.

The data collected during each test included the amount of corn fed into the hopper (kg), shelling time (s), quantity of shelled corn (kg), and quantity of unshelled corn (kg). Machine capacity was determined based on the average shelling rate obtained from the nine test runs and was subsequently converted into kilograms per hour (kg/h).

RESULTS AND DISCUSSION

Specifications of the Modified Machine

The modified corn shelling machine has the following specifications: machine dimensions of 120 cm × 50 cm × 140 cm, a 1 HP electric motor operating at 1400 rpm, a motor pulley diameter of 127 mm, a shaft pulley diameter of 304 mm, a shaft rotational speed of 584 rpm, a V-belt circumference of 919.3 mm, a hopper capacity of 9 kg, UCP 212 bearings, an S45C steel shaft, and a rice thresher fan blower with a diameter of 340 mm and an airflow velocity of 3.9 m/s.

Compared with the machine before modification, four major improvements were made: (1) the hopper volume was increased from 0.021 m^3 to 0.024 m^3; (2) the shelling screen openings were enlarged to improve throughput capacity; (3) the motor pulley was replaced, increasing the shaft rotational speed from 350 rpm to 584 rpm; and (4) a rice thresher fan was added as an automatic cleaning blower system.

Test Results Data

The testing was conducted in three groups based on different operating time variations. The complete results are presented in Table 1, Table 2, and Table 3 below.

Table 1. Results of the Corn Shelling Machine Performance Test at a 50-Second Operating Time

No	Input (kg))	Shelled Corn Output (kg)	Unshelled Corn (kg)
1	9	7,2	0
2	9	7,2	0
3	9	7,2	0

Table 2. Corn Shelling Test Results (40-Second Operating Time)

No	Input (kg)	Shelled Corn (kg)	Unshelled Corn (kg)
1	9	7,1	0,3
2	9	7,0	0,4
3	9	7,1	0,2

Table 3. Corn Shelling Test Results (30-Second Operating Time)

No	Input (kg)	Shelled Corn (kg)	Unshelled Corn (kg)
1	9	6,8	0,6

No	Input (kg)	Shelled Corn (kg)	Unshelled Corn (kg)
2	9	7,0	0,4
3	9	6,9	0,3

Machine Capacity Analysis

Based on the test data, the average shelling rate for each testing group was calculated as follows:

- 50-second group: 7.2 / 50 = 0.144 kg/s
- 40-second group: 7.06 / 40 = 0.1765 kg/s
- 30-second group: 6.9 / 30 = 0.230 kg/s

The overall average value is (0.144 + 0.1765 + 0.230) / 3 = 0.1835 kg/second. Converted to minutes, it becomes 0.1835 × 60 = 11 kg per minute, so the machine capacity in one hour is:

Capacity = 11 × 60 = 660 kg/hour (3)

This result represents a 266.7% increase in capacity compared to the machine before modification, which was capable of shelling only 180 kg/h. The substantial improvement was mainly attributed to the increase in shaft rotational speed from 350 rpm to 584 rpm resulting from the replacement of the motor pulley, as well as the enlargement of the hopper, which enabled a faster feeding rate and improved processing efficiency.

Comparison with Previous Research

Table 4. Comparison of Machine Performance

Parameter	Before Modification	After Modification
Dimensions (cm)	100×50×130	120×50×140
Shaft rotation	350 rpm	584 rpm
Hopper volume	0,021 m^3	0,024 m^3
Capacity	180 kg/hour	660 kg/hour
Cleaning system	none	Treser fan

The addition of a thresher fan as a blower provides additional benefits that cannot be directly quantified from capacity data, namely the automatic separation of dirt and cob debris from corn kernels. This improves the quality of the shelled corn and reduces the need for manual cleaning after shelling [8].

Figure 2. Equipment Testing

In addition, the enlargement of the sieving screens also contributes to increased throughput because corn kernels can pass through the screens more quickly without causing blockages. The combination of the four modifications made has been proven to complement each other and result in a significant improvement in machine performance .

Economic Analysis

The total cost of engine modification is IDR 1,562,000, consisting of design drawing costs of IDR 100,000 and component costs of IDR 1,462,000. The largest components are galvanized plates (IDR 600,000) and a new motor pulley (IDR 250,000). With an increase in capacity from 180 kg/hour to 660 kg/hour, this modification investment can be paid off in a short time through labor cost savings and increased production volume.

CONCLUSION

The modification of the corn shelling machine carried out successfully improved the machine's performance significantly. The modified machine has dimensions of 120 cm × 50 cm × 140 cm with a shaft rotation speed of 584 rpm using a 1 HP electric motor. The shelling capacity increased from 180 kg/hour to 660 kg/hour, representing an increase of 266.7%. This improvement was achieved through four main modifications: enlarging the hopper from 0.021 m^3 to 0.024 m^3, enlarging the shelling sieve, replacing the motor pulley to increase rotation speed, and adding a rice thresher fan as an automatic cleaning system. The results of this study are expected to serve as a technical reference for the development of small to medium-scale corn shelling machines in Merauke Regency and other areas with similar agricultural characteristics.

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