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OPTIMIZATION OF A TWO-STROKE GASOLINE GRASS CUTTER INTO A RICE HARVESTING MACHINE

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Abstract

In Indonesia, rice harvesting in rural areas is still largely done manually, resulting in low efficiency and high labor demands. This study aims to provide a practical solution by optimizing a two-stroke gasoline-powered grass cutter into a functional rice harvester. The research was conducted through stages including literature study, problem identification, design, fabrication, and performance testing. Mechanical analysis shows that the modified machine produces 47.7 N·mm³ torque and a cutting speed of 40.05 m/min, adequate for cutting rice stalks without stalling. Fuel tests revealed Pertamax offers better combustion efficiency than Pertalite. The balancing system improves operator comfort, while field trials showed a reduction in harvesting time by over 55% and labor costs by 50%. These results indicate that the optimized machine is effective, low-cost, and suitable for smallholder farmers.

Keywords: *Rice harvester, grass cutter modification, two-stroke engine, low-cost farming tool..*

INTRODUCTION

Indonesia is known as an agrarian country, where the majority of the population relies on agriculture as their main source of livelihood[1]. With vast agricultural lands stretching from Sabang to Merauke, the agricultural sector plays a crucial role in ensuring food security, driving economic growth, and supporting social stability. Among the staple crops cultivated in Indonesia, rice holds a central position as the primary food source for most of the population[2]. Therefore, improving efficiency in every stage of rice cultivation especially during the harvesting process is of great importance.

However, in many rural areas, rice harvesting is still performed manually using traditional methods. This situation persists due to limited access to modern agricultural machinery[3]. One of the main constraints is the high cost of rice-harvesting machines manufactured by large companies, which makes them unaffordable for small-scale farmers. In fact, the use of machines in the harvesting process has proven effective in accelerating work and increasing crop yields[4]. This reality highlights the need for practical, low-cost innovations that can address the everyday challenges faced by local farmers.

Interestingly, most small-scale farmers already own grass-cutting machines, typically used for trimming field borders[5]. This presents an opportunity for innovation by modifying existing grass cutters into rice-harvesting machines. Such a modification not only aims to simplify and speed up the harvesting process but also helps to enhance productivity and reduce operational costs. In the long term, this can significantly improve the welfare of farmers[6]. To ensure the effectiveness of the modified tool, careful design and appropriate material selection are essential so that the machine can operate efficiently, remain portable, and be user-friendly[7].

The urgency of this research lies in the real and growing need among small farmers for affordable, functional agricultural tools that can be developed from materials already available in the field[8]. This innovation represents a practical application of appropriate technology that supports agricultural productivity while also fostering self-sufficiency among farming communities[9]. Moreover, this research contributes to the development of simple engineering solutions with broad social and economic benefits[10].

The objective of this research is to design and evaluate the modification process of converting a grass-cutting machine into a rice-harvesting tool, using a two-stroke gasoline engine with a power output of 1.4 HP and a maximum rotational speed of 6000 rpm. The core focus is on the addition of a guilder to the gear case, allowing the machine to function efficiently for cutting rice during the harvesting stage[11].

RESEARCH METHODS

This study is a type of applied experimental research (*applied research*) that aims to develop and optimize a functional tool by modifying an existing machine. The research involves the design, fabrication, and performance testing of a modified rice-harvesting device based on a two-stroke gasoline-powered grass cutter. The goal is to solve a practical problem faced by small-scale farmers by applying engineering principles and mechanical analysis[12].

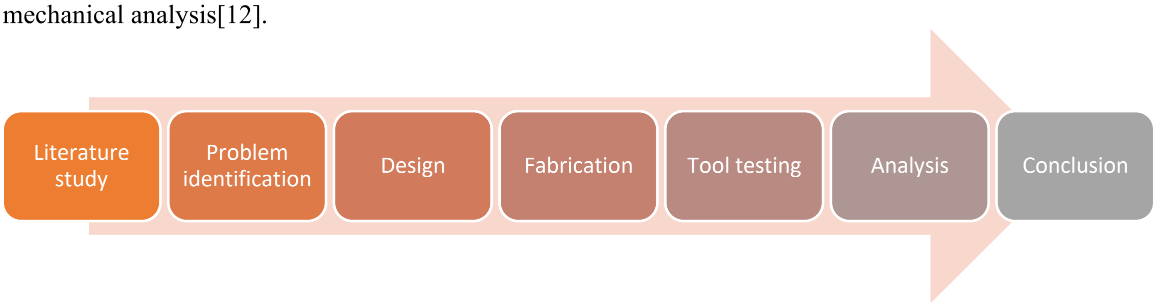

Fig 1. Flow Chart

2.1 Literature Study

A study was conducted on the principles of grass-cutting machines, rice-harvesting techniques, and relevant previous innovations. This stage also involved identifying appropriate engine types, power requirements, and ergonomic considerations.

2.2 Problem Identification

The problem lies in the lack of affordable rice-harvesting equipment for small-scale farmers. Most farmers only have grass cutters, which are not designed for harvesting rice. Therefore, a practical and economical solution is needed by modifying the available tools.

2.3 Design

In this stage, a design concept was developed to convert a grass-cutting machine into a rice harvester. The design includes adjustments to the blade system, frame support, and the addition of a guilder for balance and stability.

2.4 Fabrication

The machine was fabricated using the modified design. Components such as the cutting blade, drive shaft, and guilder system were assembled, and the engine was mounted to ensure optimal performance.

2.5 Tool Testing

Testing was conducted to evaluate cutting performance, engine efficiency, operator comfort, and structural integrity. Observations were made under field-simulated conditions.

2.6 Analysis

The performance of the modified machine was analyzed using the following formulas:

a. Load (Weight) of the tool

$$W = m \times g \tag{1}$$

Where:
W = Load (N),
m = Mass (kg),
g = Acceleration due to gravity (10 m/s²)

b. Torque on the shaft

$$T = \frac{P \times 60}{2\pi n} \tag{2}$$

Where:
T = Torque (N·m),
P = Power (kW),
n = Rotational speed (rpm)

c. Dynamic balance (moment equilibrium):

$$W1 \times L1 = W2 \times L2 \tag{3}$$

Where:

W1, W2 = Weights (kg),
L1,L2 = Arm lengths (cm)

d. Cutting speed

$$\omega = \frac{2\pi n}{60}, v = \omega \times r \quad (4)$$

Where:
ω = Angular velocity (rad/s),
v = Linear cutting speed (m/s),
r = Radius of blade (m)

2.7 Conclusion

The modified machine successfully meets the intended objectives in terms of function, efficiency, and usability. The performance parameters such as torque and cutting speed are within the expected range, and the balance design ensures operational safety.

RESULTS AND DISCUSSION.

4.1 Results

The optimization of a two-stroke gasoline-powered grass cutter into a functional rice harvesting machine was successfully carried out through a comprehensive design and engineering approach. This transformation process focused on adapting the original structure to suit the physical and operational demands of rice field harvesting. Key modifications included the integration of a cutting blade system tailored for stalk crops, reinforcement of the structural frame to withstand continuous vibration, dynamic balance adjustments to ensure stability during operation, and ergonomic improvements to reduce operator fatigue. These enhancements were aimed at maintaining the compactness of the original machine while delivering adequate torque, mechanical strength, and field reliability for small-scale agricultural applications. **Figure. 2** presents the conceptual design layout, illustrating vital components such as the drive arm, gear case, cutting blade, guider, and pushing hood, all of which were designed for seamless functional integration.

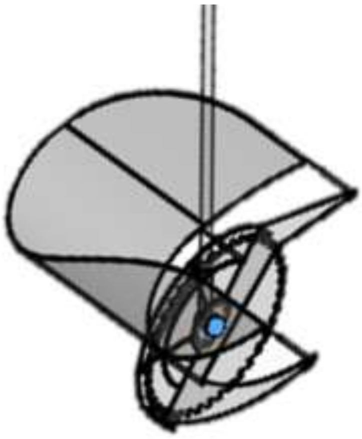

Fig. 2 Design 3D

The construction phase culminated in the assembly of the final prototype, shown in **Figure. 3**, which depicts the complete system prepared for field testing. The finished machine retained its portability while exhibiting upgraded harvesting performance, proving it to be a practical and efficient solution for labor reduction and operational time-saving in rice harvesting tasks.

Fig. 3 Grass Cutter

Based on the analysis and testing, the following results were obtained:

a. Mechanical Load

The total load acting on the system was calculated as 100 N using the equation $W = m \times g = 10 \times 10$, accounting for the engine and frame mass.

b. Torque at Shaft

With a motor power of 1.0 kW and effective rotation speed of 200 rpm, torque was calculated using the formula

$$T = \frac{P \times 60}{2\pi n} = \frac{1000 \times 60}{2 \times 3.14 \times 200} \approx 47.7\, N/mm^3 \quad (5)$$

c. Dynamic Balance Configuration

To ensure comfortable and safe operation, especially during the semi-circular swinging motion of the cutter, the tool was dynamically balanced. With a main load W1= 6 kg, placed at L1=50 cm, a counterweight W2 = 2 kg was added at L2 = 150 cm to maintain equilibrium.

d. Cutting Speed: At 3000 rpm and a blade radius of approximately 0.1275 m, the linear cutting speed was calculated using

$$V = \omega r = \frac{2\pi n}{60} \times r = 2\pi \times \frac{3000}{60} \times 0.1275 \approx 40.05\, m/\min \quad (6)$$

1. Fuel Efficiency and Time Analysis

Experimental trials were conducted in a 25 m² test field with two fuel types (Pertalite and Pertamax) at two engine speed settings (3000 and 6000 rpm). The performance data are as follows **Table 1.**

Table 1. Fuel Efficiency and Time Analysis

Engine Speed	Fuel Type	Fuel Used (ml)	Operation Time
3000 rpm	Pertalite	500 ml	5 minutes 44 seconds
3000 rpm	Pertamax	487 ml	5 minutes 39 seconds
6000 rpm	Pertalite	937 ml	4 minutes 54 seconds
6000 rpm	Pertamax	900 ml	4 minutes 49 seconds

These results indicate that higher rpm increased fuel consumption but slightly reduced operating time.

2. Field Comparison

A direct comparison between manual harvesting and the use of the modified machine is summarized below **Table 2**.

Table 2 Manual and Machine Harvesting

Criteria	Manual Method	Modified Machine
Labor Requirement	2 workers	1 worker
Time Requirement	9 hours per plot	4 hours per plot
Estimated Cost	Rp300,00	Rp150,00

3. Blade Condition Post-Test

   Visual inspection of the blades revealed that the carbide-tipped blades remained intact and sharp with no signs of deformation or chipping. The unpainted metal surfaces on the frame showed minor oxidation, while the blade components remained rust-free even without post-use cleaning.

4.2 Discussion

The experimental results confirm that the adapted machine performs effectively as a small-scale paddy harvester. Its design, which integrates mechanical components of a grass cutter with an optimized cutting and balancing system, demonstrates a promising alternative to manual harvesting methods in rural agricultural environments. The mechanical computations including torque, load capacity, and dynamic balance indicate that the power output of the original two-stroke engine is sufficient to drive the cutting mechanism with reliable performance under typical field conditions.

The calculated torque of 47.7 $N \cdot mm^3$ shows that the system is capable of delivering the necessary rotational force to cut through mature rice stalks without experiencing engine overload or significant performance drop. This is essential for consistent harvesting, especially when the machine is used over extended periods or across varying stalk densities. Furthermore, the cutting speed of approximately 40.05 m/min, derived from a blade radius of 0.1275 m and rotational speed of 3000 rpm, falls within the ideal operational envelope for manually operated harvesters. This balance ensures that the cutting action remains smooth and effective, minimizing the risk of stalk damage while avoiding excessive engine stress.

From a mechanical stability and ergonomic point of view, the implementation of a dynamic balancing system significantly contributes to user comfort and safety. By applying the principle of moment equilibrium, with a 6 kg load placed at 50 cm and a 2 kg counterweight positioned at 150 cm, the system achieves rotational balance. This configuration reduces operator fatigue by minimizing asymmetric forces and vibrations during operation. In field applications, such balance is critical, especially for handheld or semi-portable machinery, where operator endurance is often a limiting factor for productivity.

The fuel efficiency analysis provides further insight into the machine's operational sustainability. The use of Pertamax demonstrated a slight but consistent improvement in fuel economy compared to Pertalite, likely attributed to Pertamax's higher octane rating and better combustion properties. This efficiency becomes increasingly relevant in rural settings where fuel access and affordability can vary. Operating the machine at 3000 rpm not only conserved fuel but also resulted in only a marginal increase in operation time compared to higher speeds, making it the most efficient setting overall. This finding suggests that moderate engine speed offers the best compromise between performance and resource consumption, which is particularly beneficial for smallholder farmers managing tight operational budgets.

From an economic perspective, the modified harvester presents significant labor and cost advantages. With the ability to reduce the required manpower by 50% and cut harvesting time by more than half, the machine provides clear economic incentives for adoption. For farmers in regions where labor costs are high or labor availability is limited during peak seasons, the machine offers a self-reliant harvesting solution. This directly contributes to improved harvesting efficiency, lower production costs, and ultimately higher net income per harvest cycle.

In terms of durability and maintenance, post-harvest inspection revealed that the carbide-tipped blades retained their sharpness and structural integrity, showing no signs of deformation, chipping, or corrosion. This confirms the suitability of carbide material for repeated use in agricultural environments, where exposure to moisture and organic residue is common. Furthermore, the frame components, though unpainted in this prototype, exhibited only minor surface oxidation, suggesting that future iterations with anti-corrosion coating or stainless materials would enhance the machine's resilience.

The long-term maintenance cost is also expected to be minimal, as the primary moving parts including the shaft and blade system exhibit low wear rates under controlled rpm conditions. This positions the machine as a low-maintenance, high-utility tool for farmers with limited technical resources.

CONCLUSIONS.

Based on the results of experimentation, mechanical analysis, and performance testing, it can be concluded that the conversion of a two-stroke gasoline-powered grass-cutting machine into a small-scale paddy harvester is technically and practically successful. The machine delivers sufficient torque (47.7 N·mm^3) and maintains a cutting speed of 40.05 m/min, which supports efficient and continuous harvesting without stalling or damaging the rice stalks.

The dynamic balancing mechanism significantly enhances operator comfort by minimizing arm fatigue and improving machine controllability, making it suitable for long-duration use in rural field conditions. Fuel efficiency tests show that Pertamax offers better combustion performance, and operation at 3000 rpm provides an optimal balance between power output and fuel consumption. Economically, the machine reduces labor requirements by up to 50% and harvest time by over 55%, enabling small-scale farmers to increase productivity independently. The cutting blade showed strong durability, suggesting low maintenance and long-term usability, which further supports the machine's value as a sustainable agricultural tool. Overall, this innovation offers a cost-effective, ergonomic, and efficient solution for smallholder farmers, particularly in areas with limited access to large-scale mechanization. It contributes positively to improving agricultural productivity and supports the broader goal of rural technological empowerment.

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