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Mechanical Feed System Performance Test on Household Grain Grinding Machine

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***Abstract*—Grain grinder technology is very influential in determining the quality of rice produced. To support this potential, various things are taken, one of them is by increasing rice farmers to process their harvests independently in households. This thing must be encouraged so that we can process agricultural commodities in Indonesia by ourselves and provide added value for the welfare of the community, especially rice farmers in Bali. The grain grinding machine that is widely used nowadays is roll type. The purpose of this study is to calculate the efficiency of the grain crusher machine (husker). This research was conducted in several stages including the stage of collecting tools and materials. The parameters for analyzing grind capacity, rice yield were observed for grain weight to be milled, weight of milled rice, and time to grind grain rice into rice. Based on the results of data processing, it was found that the machine grinding capacity was 50 kg / hour, the power of the combustion engine was 5.5 hp of premuim fuel, the sample of rice inpari 43 varieties, the rice yield was 71.2% better at 2925 rpm engine rotation speed, 41.62% stripping efficiency higher when using an engine rotation speed of 2925 rpm. The difference in the used of a manual grind system averages 4.86 kg at 2936 rpm and a mechanical feeder system averages 4.89 kg at 2936 rpm. Economics analysis of used grain grinding machine with a capacity of 50 kg/hour, the price of the machine is IDR 8,500,000.00 per unit within 2 years 4 months the investment costs will be return.**

Keywords—grinder, grain, mechanical

I. INTRODUCTION

Paddy is a strategic commodity that directly affects the lives of most of the Indonesian population, therefore the program to increase paddy production has received top priority from the government to achieve food security and farmer welfare. The quality produced by paddy into rice will be very influential for farmers in terms of the sale value of rice. The harvested area for rice in Bali in 2019 is estimated at 95.319 hectares, or has decreased by 15.659 hectares or 14.11 percent compared to 2018. Paddy production in Bali in 2019 is estimated at 579.321 tons of GKG or has decreased by 87.749 tons or 13.15 percent compared to the year 2018. If rice production in 2019 is converted, rice production in Bali in 2019 will amount to 325.028 tons or a decrease of 49.231 tons or 13.15 percent compared to 2018 [1].

According to Rachmat stated that grinding paddy at an optimal moisture can provided benefits, namely good quality rice and high selling value. Furthermore, the optimal water content for the paddy grinding process is 14% [2].

According to Thahir stated that increasing rice production and quality can be done by improving rice yield. The yield can be obtained from the quotient between the output of grinding in the form of rice and the input material in the form of grain multiplied by 100% [3].

The percentage of head rice is strongly influenced by the large percentage of broken rice. One of the causes of the high percentage of broken rice is in the process of breaking the skin and brushing it during milling, which generally have not implemented a quality assurance system, even most of them do not know the quality standards of rice, so the rice produced is of low quality [4].

Each grain grind unit has different specifications, starting from the unit model, rice grinding brand, rice grinding capacity, to the capacity of the driving machine [5]. The owner of the grain grinding operates the grind on a large scale and the grinding machine is very large and cannot be moved and the grinding process is usually carried out in one place. Based on those conditions, it is necessary to study the performance of small scale (household) operating in Kerambitan district, Tabanan regency to determine the working capacity of the machine, the quality of rice grinded by the machine and the value of the economic aspects of the machine's presence.

II. RESEARCH METHODS

A. Tools

The tools used in this research were a roll type grain grinding machine, blower conveyor scales, stopwatch, moisture tester, tachometer.

B. Materials

The material used in this study was grain from 43 inpari varieties produced by rice farmers in Kerambitan District, Tabanan Regency.

C. Research Procedures

This research was conducted in several stages including the stage of collecting tools and materials. Parameters for analyzing grinding capacity, rice yield were observed for grain weight to be grinded, weight of grinded rice, and time to grind grain into rice.

D. Peel Capacity

- Provide as much as 5 kg of grain per one grind.
- Grain is put into the tool in a closed hopper. On both feed systems.
- After the pulping machine has run at operating speed, the hopper is opened and the rollers are reset to the position where the stripping force is highest.
- After the stripping power runs smoothly and stably, the BPK is accommodated in a certain time unit (depending on the capacity of the machine to be tested) [6], then the calculation:

1) Peel capacity

$$K = \frac{Bk}{t} x\ 60 \quad (1)$$

Where:

K: peel capacity (kg / hr)

Bk: the resulting BPK weight (kg)

t: time taken (hours)

2) Yield rice grind
The calculation:

$$R(\%) = \frac{BTB\ produced}{BGKG} x\ 100\% \quad (2)$$

BTB produced: Total weight of rice produced (kg)

BGKG: Weight of grinded dry grain (kg)

3) Stripping efficiency

$$Stripping\ Efficiency = \frac{Weight\ BPK}{Weight\ BPK + Grain\ Weight} x\ 100\% \quad (3)$$

4) Grain cleanliness degree

- Take a sample of 100 grams of grain.
- Peel the grain sample.
- Separate between grains of chalk, broken grains, foreign grains.
- Weigh each part.

Calculation:

$$Bs = \frac{Bm}{Bc} X\ 100\% \quad (4)$$

Where:

Bs = percentage of each share (%)

Bm = weight of the component concerned (grams)

Bc = sample weight (grams)

III. Results and Discussion

A. Analysis the Performance of the Milling Machine

Machine performance testing is done to find out how much the engine works in quantity and quality.

1) Peel capacity: The hopper capacity is 5 kg. The previous test result time was 1kg for 1.20 minutes.

$$K = \frac{5\ kg}{6\ minute} \text{x } 60$$

= 49,999

= 50 kg/ hours

So the milling machine capacity is 50 kg / hour.

2) Yield rice grind
BTB produced: Total weight of rice produced 3.56 kg.

BGKG: Weight of grinded dry grain 5 kg.

$$R(\%) = \frac{3{,}565\ kg}{5\ Kg} X100\%$$

= 0,713

= 71,3%

Rendemen Milling of 71.2%.

3) Stripping efficiency

$$\text{Stripping Efficiency} = \frac{3{,}565\ kg}{3{,}565\ kg + 5\ kg} X100\%$$

= 41,62 %

The efficiency of the grinding machine is 41.62%.

4) Grain cleanliness degree
Sample 100 grams.

The components weigh 9.870 grams.

$$\text{Bs} = \frac{9{,}870\ \text{grams}}{100\ \text{grams}} \text{ X } 100\%$$

= 9,87%

So the Degree of Grain Cleanliness is 9.87%.

B. *Analysis of Manual Feed Grinding Machine*

In testing the grain feeder with a hopper (funnel on the machine), the grain will enter the grinding room directly from the top of the machine. The test results are 3 times, the types of inpari paddy varieties are 43 in Fig. 1.

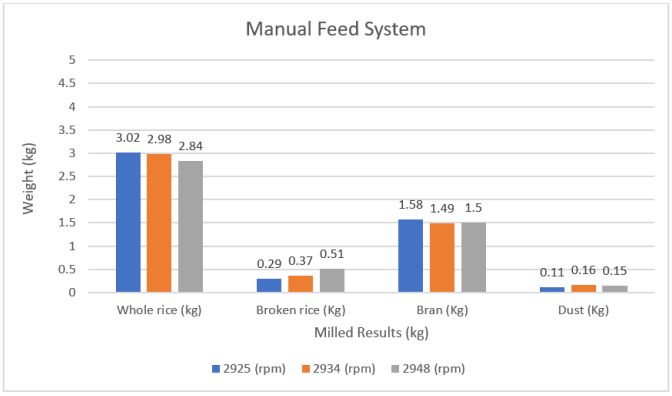

Fig. 1. Manual feeder graph.

The grinding result data in Fig. 1 can be concluded that the yield of whole rice 3.02 kg at a milling speed of 2.925 rpm, whole rice 2.98 kg at a milling speed of 2934 rpm and whole rice 2.89 kg at a milling speed of 2948 rpm decreased at high rotation, broken rice 0.29 kg at a milling speed of 2925 rpm, broken rice 0.37 kg at a milling speed of 2934 rpm and broken rice 0.51 kg at a milling speed of 2948 rpm had an increase in high turnover, the yield of bran was 1.58 kg at a speed of 2925 rpm, 1.49 kg of bran at 2934 rpm and 1.50 kg of bran at 2948 rpm did not increase, while the grinding dust did not increase at all speeds.

C. *Manual Feeder Peel Capacity*

The research sample tested inpari 43 grain varieties was 3 times repeated at each engine rotation speed using engine rotation speeds of 2925 rpm, 2934 rpm, and 2948 rpm, Figs. 2 and 3.

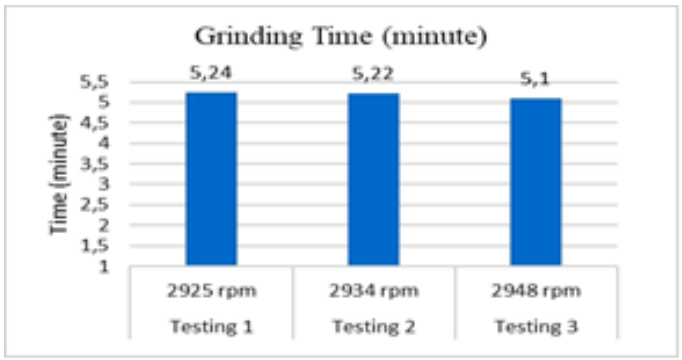

Fig. 2. Manual milling time graph.

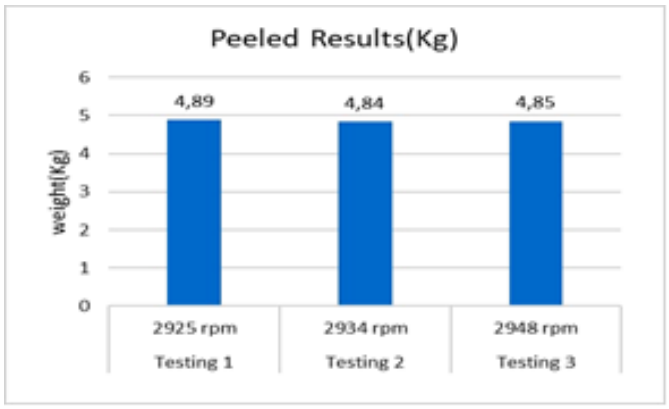

Fig. 3. Graph of manual peeling results.

Based on Figs. 2 and 3 can be concluded the manual feeder system at 2925 rpm grinding time 5.24 minutes, peeling result 4.89 kg, 2934 rpm grinding time 5.22 minutes, peeling 4.84 kg, 2948 rpm grinding time 5.10 minutes, peeled 4.85 kg.

D. *Analysis of Mechanical Feed Grinding Machines*

In testing the grain feeder with a suction system using a blower, the grain will enter the grindinh room directly from the shelter. The test results are 3 times, 43 types of inpari rice varieties, in Fig. 4.

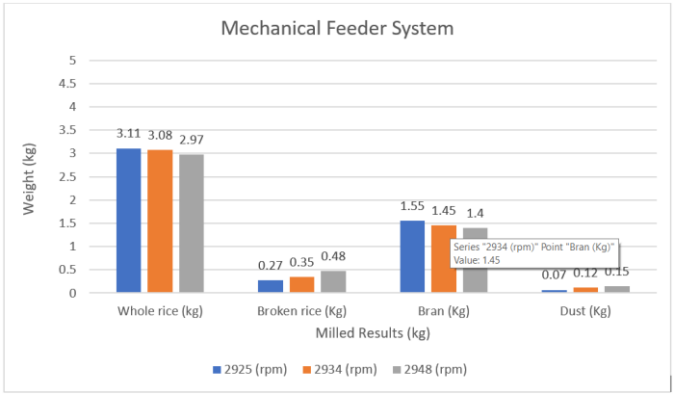

Fig. 4. Mechanical feeder system graph.

The data from grinding results in Fig. 4 can be concluded that the yield of whole rice is 3.11 kg at a milling speed of 2925 rpm, whole rice is 3.08 kg at a milling speed of 2934 rpm and whole rice is 2.97 kg at a milling speed of 2948 rpm has decreased at high rotation, results of broken rice 0.27 kg at 2925 rpm, broken rice 0.35 kg at 2934 rpm and broken rice 0.48 kg at 2948 rpm increased at high rotation, bran yields 1.55 at 2925 rpm, bran 1.45 kg at a speed of 2934 rpm and bran 1.40 at a speed of 2948 decreased at high turnaround, while the dust resulting from grinding increased at high speed.

E. Mechanical Feeder Peel Capacity

The results of the study were tested inpari 43 grain varieties 3 times at each engine rotation speed using engine rotation speeds of 2925 rpm, 2934 rpm, and 2948 rpm, Figs. 5 and 6.

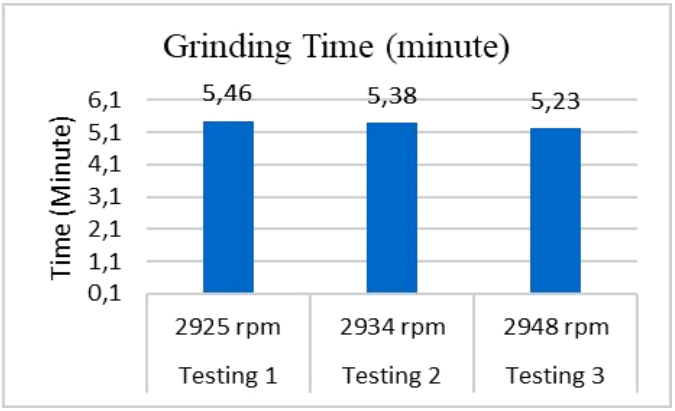

Fig. 5. Mechanical grinding time graph.

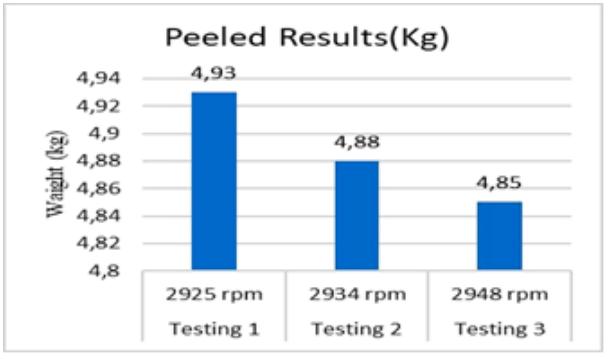

Fig. 6. Mechanical peel result graph.

Test results Figs. 5 and 6 can be concluded mechanical feed system at 2925 rpm grinding time 5.46 minutes, peeling 4.93 kg, 2934 rpm grinding time 5.38 minutes, peeling 4.88 kg, 2948 rpm grinding time 5.23 minutes, peeled 4.85 kg.

F. Analysis of the Results of Manual and Mechanical Feeder Systems

In the rice grinding process, to determine the performance of the two systems used in each of them to produce good quality grind, it can be seen the average results of the two tests in table 1.

TABLE I. AVERAGE MANUAL AND MECHANICAL FEEDER TEST RESULTS

System	Hopper Capacity (Kg)	Grinding Speed (rpm)	Grind Time (Minute)	Whole Rice (Kg)	Broken Rice (Kg)	Bran (Kg)	Dust (Kg)	Total Grinding (Kg)
Mechanical	5	2936	5,36	3,05	0,37	1,47	0,11	4,89
Manual	5	2936	5,19	2,95	0,39	1,52	0,14	4,86

Based on table 1 it can be concluded that the mechanical system has an average grinding speed of 2936 rpm with a grinding time of 5.36 minutes, whole rice is 3.05 minutes, broken rice is 0.37 kg, bran is 1.47 kg and the total result of grind is 4.89 kg and the average manual system speed of milled 2936 rpm with a grinding time of 5.19 minutes, 2.95 minutes of whole rice, 0.39 kg of broken rice, 1.52 kg of bran and a total yield of 4.86 kg of milled. From the two systems, it can be seen that the total grinded yield is only 0.03kg difference, so there is no big difference.

G. Economic Analysis

The calculation of the Break Even Point is intended to determine the period of return of capital used for household paddy grinding machines, in the procurement of equipment/machines [7].

1) Fixed cost: The cost of procuring machines and equipment is IDR 8,500,000 per unit.

2) Variabel cost, include:

- Operator fee per day (8 hours of work) of IDR 25,000.00 / person. Monthly operator fee of IDR 25,000.00 x 22 working days / month = IDR 550,000.00 / month.
- Monthly maintenance costs are assumed to be 2% of the purchase cost of machines and equipment at 2% x IDR 8,500,000.00 = IDR 170,000.00 / month.
- Depreciation of machines / equipment is (10% x IDR 8,500,000.00): 12 = IDR 70,800.00 per month.
- Fuel consumption costs:

P = generator power (KVA = KiloVolt Ampere)

t = time (hours)

Fuel requirement = 0.21 x P x t

= 0.21 x 5.5 x 8

= 9.24 liters (per day)

Fuel consumption cost per day:

9.24 liters x IDR. 6,450 = IDR 59,598, -

22 working days in a month:

22 x 9.24 liters = 203.28 liters

So the cost of premium usage for one month = (203.28 liters x Rp. 6,450) of IDR. 1,311,156 / month.

TABLE II. TOTAL VARIABLE COST

No	Cost	Per Machine (Rp)
1.	Operator Fee	550.000,00
2.	Maintenance costs	170.000,00
3.	Depreciation	70.800,00
4.	Premium Fuel Costs	1.311.156
	Total	**2.101.956**

Income from machine operations:

- In this case, the rice grinding machine operator wages are set at IDR 12,000 per hour.
- Income per month = IDR 12,000 x 8 working hours x 22 working days = IDR 2,112,000 per month.

Based on the data above, the BEP is:

$$BEP = \frac{\text{TOTAL FIXED COST}}{\text{INCOME - TOTAL COST IS NOT FIXED}}$$

$$BEP = \frac{8{,}500{,}000}{2.112.000 - 2.101.956}$$

= 28.6 Months, rounded to 29 months

= 2 years 4 months

Therefore, the investment cost for the procurement of equipment and machines for a household scale rice grinding machine is IDR 8,500,000, therefore within 2 years and 4 months the investment costs will return.

IV. CONCLUSION AND SUGGESTION

A. Conclusion

Based on the results of this research, the performance of the grain grinding machine with a mechanical feeder was obtained as follows:

- The engine grind capacity is 50 kg/hour, the power of the combustion motor is 5.5 hp of premium fuel.
- The grinding yield ratio is 71.2% better at the engine rotation speed of 2925 rpm.
- The stripping efficiency is 41.62% higher when using an engine rotation speed of 2925 rpm.
- The degree of grain cleanliness is 9.87% in a sample of 100 grams.
- The differences in the used of the manual feed system average yield of 4.86 kg at 2936 rpm and the average mechanical feeder system yields 4.89 kg at 2936 rpm.
- From the two systems, it can be seen that the total grinded yield is only 0.03 kg difference, so there is no big difference.
- Economic analysis of the used of a grain grinding machine with a capacity of 50 kg/hour, the price of the machine is IDR 8,500,000.00 per unit within 2 years and 4 months the investment costs will return.

B. Suggestion

The process of milling rice to get good quality rice, farmers who use a milling machine need to pay attention to the types of rice varieties, grain quality, and milling speed settings.

REFERENCES

[1] BPS, Luas Panen dan Produksi Padi Propinsi Bali No. 20/03/51/Th. XIII. Jakarta: BPS, 2019.

[2] R.. Rachmat, “Model penggilingan padi terpadu untuk meningkatkan nilai tambah,” Buletin Teknologi Pascapanen Pertanian, vol. 8, no. (2), pp. 99–111, 2012.

[3] R. Thahir, “Revitalisasi Penggilingan Padi Melalui Inovasi Penyosohan Mendukung Swasembada Beras dan Persaingan Global," Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian, vol. 3, no. (3), pp. 171-183, 2010.

[4] A. Handayani, Sriyanto, dan I. Sulistyawati, “Evaluasi Mutu Beras dan Tingkat Kesesuaian Penanganannya (Studi Khusus di Kabupaten Karang Anyar),” Jurnal Litbang Provinsi Jawa Tengah, vol. 11, no. (1), pp. 113–124, 2013.

[5] S. Budijanto and A.B. Sitanggang, “Produktivitas Dan Proses Penggilingan Padi Terkait Dengan Pengendalian Faktor Mutu Berasnya,” Jurnal Pangan, vol. 20, no. (2), pp. 141-152, 2011.

[6] I.H. Utami, A.M. Kramadibrata, A. Widyasanti, and T. Herwanto, “Performance test and economic analysis of compound rice milling (Compact Rice Milling CRM 10)(case study at PT BUMR (badan usaha milik rakyat) Pangan Terhubung Pasirhalang, Sukaraja, Sukabumi Regency),” Journal of Applied Agricultural Science and Technology, vol. 3, no. (1), pp. 15-28, 2019.

[7] I. N. Pujawan, Ekonomi Teknik: Edisi Kedua Jilid Pertama. Surabaya: Guna Widya, 2009.