



DEVELOPMENT

DESIGN MODIFICATION AND FABRICATION OF A DUAL-PURPOSE RICE PROCESSING MACHINE

A. Afolabi, I. B. Yakubu, M. Liman\*, S. M. Gana, I. S. Aji

Department of Mechanical Engineering, University of Maiduguri

\*Corresponding author's email: [musaliman12345@gmail.com](mailto:musaliman12345@gmail.com)

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ABSTRACT

This study presented the design, fabrication, and performance evaluation of a dual-purpose rice processing machine that integrated threshing and milling operations into a single unit to address the inefficiencies of conventional post-harvest rice processing. The machine was designed using standard mechanical design principles and fabricated with locally available materials to ensure affordability, durability, and ease of maintenance for small- and medium-scale rice processors. A 1.5 hp electric motor served as the prime mover, driving both the threshing drum and milling rollers through a belt and pulley transmission system. Performance evaluation was conducted through a series of preliminary and formal tests using paddy rice samples. Experimental results showed a threshing efficiency of 66%, milling efficiency of 69.69%, and rice husk recovery of 39.6%. When operated as an integrated single-pass system, the machine achieved an overall operational efficiency of 46%, producing 2.3 kg of milled white rice from 5.0 kg of paddy. Although this overall efficiency is moderate and lower than that of many optimized conventional rice processing systems, it remained acceptable for a low-cost prototype and demonstrated the feasibility of integrating threshing and milling in a compact unit. These results highlighted the potential of the machine to reduce processing time, labor, and equipment cost. However, further optimization particularly in grain transfer mechanisms, threshing consistency, and milling clearance adjustment is required to improve performance. It is therefore recommended that future designs should focus on improving component alignment, enhancing separation efficiency, and conducting extended field testing under varying moisture and load conditions to achieve higher overall efficiency and reliability. Overall, the developed machine offered a practical and cost-effective solution for improving local rice processing and enhancing food security in rural communities.

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1.0 Introduction

Rice (*Oryza sativa*) is a fundamental staple food, feeding more than half of the global population and ranking third in worldwide production after wheat and maize (Statista, 2025). In Nigeria, rice consumption has grown significantly due to rising incomes and changing dietary preferences. However, domestic production continues to face challenges, particularly in post-harvest processing, where traditional threshing and milling methods remain labour-intensive, inefficient, and often produced low-quality rice contaminated with dirt and stones. This has contributed to consumer preference for imported rice over local varieties (Otubo & Boniface 2025).

Mechanization of rice processing is crucial to improving both productivity and grain quality. Threshing, which separates rice grains from stalks and husks, and milling, which removes the husk and bran layers, are essential stages that determine final quality. Historically, the mechanization of threshing dates back to Andrew Meikle's invention in 1786, while recent innovations have focused on solar-powered and motorized machines aimed at

improving efficiency and sustainability (Adefidipe & Adetola, 2022). Despite technological advances, Nigeria’s rice sector continues to underperform. In the 2024/2025 season, production fell by 7% to 5.23 million metric tons (the lowest output since 2020) due to high production costs, insecurity, climate change, and competition from cheaper imports (Okojie & Jaiyesimi, 2025). With local production meeting only about 57% of annual demand, the country faces a widening supply gap (Agbayewa, 2024). Studies on indigenous rice threshing technologies highlight the potential of mechanized solutions to improve efficiency. For instance, Adefidipe & Adetola (2022) achieved a threshing capacity of 167.3 kg/h and efficiency of 83.66%, while Ani *et al.* (2020) developed a mobile thresher with 92.7% efficiency compared to 66.7% for manual systems. However, traditional methods and limited access to affordable mechanized equipment remain widespread, contributing to post-harvest losses and reduced competitiveness of local rice.

Addressing these inefficiencies through the development of cost-effective and locally fabricated processing machines is vital to enhance rice production, bridge the supply gap, and strengthen food security in Nigeria. Therefore, this study aimed to design, fabricate, and evaluate a dual-purpose rice processing machine capable of integrating threshing and milling operations into a single compact unit. The specific objectives were to develop a cost-effective machine using locally available materials, assess its operational performance in terms of threshing and milling efficiencies, and evaluate its potential to reduce processing time, labour requirements, and post-harvest losses among small- and medium-scale rice processors.

## 2. Materials and Method

### 2.1 Material selection

Material selection plays a vital role in the performance, durability, and cost-effectiveness of the rice processing machine. A 1.5 hp electric motor at 2800 rpm was employed as the power source, selected based on design calculations to ensure adequate power delivery for both milling and threshing operations. Power transmission was achieved through a V-belt, while center bearings were adopted to support the shaft and provide smooth rotation, owing to their versatility, load-carrying capacity, and widespread availability (SKF Bearing Catalogue, 2023).

**Table I:** Summary of design analysis of material selection

S/N	Machine Part	Material Selection	Dimension	Quantity
1	Frame	Angle Iron	50x50x5 mm	2 length
2	Hopper	Mild Steel	2mm	¼ sheet
3	Threshing Drum	Mild Steel	2mm	¼ sheet
4	Threshing Drum Beater	Mild Rod	16mm	¼ length
5	Sieve	Galvanize Sheet	2mm	¼ sheet
6	Milling Drum	Galvanize Sheet	2mm	¼ Sheet
7	Milling Drum Beater	Mild Rod	16mm	¼ length
8	Center Bearing	Cast Iron	25mm Dia.	6pcs
9	Pulleys	Cast Iron	120mm, 60mm, 50mm, and 50mm	4 pcs
10	Blower Housing and blade	Mild Steel	2mm	¼ sheet
11	Shaft	Mild Steel	25mm	¼ length
12	Bolt and Nut	Mild steel	17 and 13	50pcs

Mild steel was chosen for the fabrication of the hopper because of its high corrosion resistance, adequate strength, and durability under long-term use. Mild steel was adopted for the shaft material, as it offers high tensile strength, good machinability, and excellent fatigue resistance, unlike cast iron which is more brittle under tensile loading. Cast iron, however, was utilized in the fabrication of components subjected primarily to compressive stresses, taking advantage of its stiffness, compressive strength, availability, and relatively low cost. Overall, the material choices, guided by design calculations, mechanical loading conditions, corrosion resistance, availability, and affordability were aimed at ensuring that the fabricated machine is reliable, durable, and well-suited to local operating conditions.

### 2.2 Design consideration

In designing the dual-purpose rice processing machine, several key considerations were taken into account to ensure efficiency, reliability, and user-friendliness. The machine was designed with weight and space limitations in mind, making it compact for ease of storage and stable enough for operation without excessive vibration.

The clearance between rollers was optimized to achieve effective husk removal during milling while minimizing grain breakage. Locally sourced materials such as mild steel, galvanized steel, and cast iron were selected to reduce cost, simplify fabrication, and ensure easy replacement when needed.

Ease of operation was prioritized by incorporating a straightforward belt and pulley transmission system, allowing users to operate the machine with minimal technical expertise. Safety considerations were addressed by providing protective covers for moving parts and positioning rotating elements away from the operator's direct contact. Reliability and cost-effectiveness guided every aspect of the design, with affordable components chosen to make the machine accessible to small- and medium-scale rice farmers. Finally, aesthetic was also considered, ensuring that the machine has a clean and appealing appearance in addition to its functional performance.

## 2.3 Method

### 2.3.1 Design analysis and calculations

#### i. Design analysis of the threshing unit

The formulas used in this work was as described by Khurmi & Gupta (2005)

#### Power required to drive the threshing unit

The required capacity (Power) was calculated from equation 1

$$P = \frac{2 \times \pi \times N \times T}{60} \quad 1$$

where P = power required (Watts), T = Torque of the drum (Nm),  $\omega$  = angular velocity (rad/s), N= speed of the threshing drum (after pulley reduction).

$$T = F \times r \quad 2$$

where F = The force required by the shaft, r = Radius of the threshing shaft.

$$F = \frac{MV^2}{r} \quad 3$$

where M = mass of grains engaged per seconds (kg)

Mass of unthreshed rice in the hopper (M) is 0.5kg (this can vary depending on feed rate)

$$F = \frac{0.5 \times 16.76^2}{0.2} = 702N$$

From Equation 2,  $T = F \times r$

$$T = 702 \times 0.2 = 140.4 Nm$$

$$P = \frac{2 \times \pi \times 800 \times 140.4}{60} = 1176.2 W$$

$$P = \frac{1176.2}{746} = 1.5hp$$

Thus a 1.5hp electric motor was required.

#### Threshing drum volume

Taking  $D = 0.25 m$  (Mijinyawa et al., 2006) and  $L = 0.5m$  (Gbabo et al., 2013),

Volume of the threshing drum was calculated from equation 4 (Straud, 2003)

$$V = \pi \times \left(\frac{D}{2}\right)^2 \times L \quad 4$$

$$V = \pi \times (0.125)^2 \times 0.5 = 0.0628 m^3$$

#### Linear velocity

Linear velocity of the pulley for the threshing unit was calculated from the formula stated in equation 5

$$v = \omega \times r \quad 5$$

$$v = 83.78 \times 0.2 = 16.76 m/s$$

### Pulley design

The diameter of the pulley was calculated from equation .6

$$D_1 N_1 = D_2 N_2 \quad 6$$

$$D_1 = 0.4m$$

$$N_1 = 1400rpm$$

$$D_2 = ?$$

$$N_2 = 800rpm$$

$$D_2 = \frac{D_1 N_1}{N_2} = \frac{0.4 \times 1400}{800} = 0.7m$$

### Belt design

The coefficient of friction ( $\mu$ ) between the belt and the pulley surface was calculated from Equation 7.

$$\text{Coefficient of friction } (\mu) = 0.54 - \frac{42.6}{152.6 + v} \quad 7$$

$$\text{and } V = \frac{2.5m}{s} = 2.5 \times 60 = 150M/min$$

Therefore:

$$\mu = 0.54 - \frac{42.6}{152.6 + 150} = 0.399 \approx 0.4$$

$$\text{Power } (P) = (T_1 - T_2) V \quad 8$$

$$\frac{1176.2}{2.5} = (T_1 - T_2)$$

$$T_1 - T_2 = 411.87$$

Also from equation 9

$$\frac{T_1}{T_2} = e^{\mu\theta} \quad 9$$

And from equation 10,

$$\theta = (180^\circ - 2\alpha) \frac{\pi}{180} \text{ rad} \quad 10$$

$$\text{and } \alpha = \sin^{-1} \left( \frac{r_1 - r_2}{c} \right) \quad 11$$

$$c = \left( \frac{D+d}{2} \right) + d \quad 12$$

$r_1$  and  $r_2 = 0.125m$  and  $0.05m$  respectively (standard pulley size (Khurmi and Gupta, 2005))

The center distance between the two pulleys

$$(c) = \left( \frac{0.25 + 0.1}{2} \right) + 0.1 = 0.275m$$

$$\text{Angular acceleration } (\alpha) = \sin^{-1} \left( \frac{0.125 - 0.05}{2} \right) = 15.83^\circ$$

therefore

$$\text{Angle of contact } (\theta) = (180^\circ - 2(15.83)) \frac{\pi}{180} = 2.59 \text{ rad}$$

$$\text{Thus } \frac{T_1}{T_2} = e^{0.4 \times 2.59}$$

$$\frac{T_1}{T_2} = 2.82$$

$$T_1 = 2.82T_2$$

$$2.82T_2 - T_2 = 411.87$$

$$1.82T_2 = 411.87$$

$$\text{Tension on the slack side of the belt } (T_2) = \frac{411.87}{1.82} = 226.3N$$

$$\text{Tension on the tight side of the belt } T_1 = 2.82 (226.3) = 638.17 N$$

The maximum tension on the belt can be was calculated from equation

$$T_{max} = \sigma_b \times b \times t \quad 13$$

$$\text{Thickness } (t) = 10mm \text{ (Khurmi and Gupta, 2005)}$$

$$t = 0.01m$$

since the belt velocity was less than 10m/s, centrifugal tension was neglected.

$$T_{max} = T_1$$

$\sigma_b = \text{safe stress for the belt}$

$$\sigma_b = 2.5 \text{MPa} = 2.5 \times 10^6 \text{ N/m}$$

$$638.17 = 2.5 \times 10^6 \times b \times 0.01$$

Width of the belt (b) = 0.02553m = 25.53mm

The standard width of the belt required was 30mm.

### **Belt length**

The length of the belt was calculated from Equation 14

$$L = 2C + \frac{\pi}{2}(d_1 + d_2) + \frac{(d_2 - d_1)^2}{4C} \quad 14$$

$$L = \frac{\pi}{2}(0.275) + 2(0.2875) + \frac{(0.275)^2}{4 \times 0.2875} = 1.1 \text{ m}$$

### **Wrap angle**

Taking  $\alpha = 20^\circ$  (Khurmi & Gupta, 2005 – For small center distances and moderate pulley size differences)

$$\theta = (180 - 2\alpha) \frac{\pi}{180}$$

$$\theta = \frac{(180 - 2 \times 20)\pi}{180} = 2.44 \text{ rad}$$

### **Belt cross-sectional area**

$$A = 0.03 \times 0.005 = 1.5 \times 10^{-4} \text{ m}^2$$

Density of belt = 1200kg/m<sup>3</sup> (Beer et al., 2005)

### **Mass of the belt**

The mass of belt per unit length was calculated from equation 15

$$M_b = \rho \times A \quad 15$$

$$M_b = 1200 \times 1.5 \times 10^{-4} = 0.18 \text{ kg/m}$$

### **Design of the shaft of the Threshing Unit**

The diameter (d) of the shaft was calculated from equation 16

$$d = \sqrt[3]{\frac{16T_e}{\tau_{max}}} \quad 16$$

and

$$T = (T_1 - T_2) \times R_p \quad 17$$

$$T = (638.17 - 226.3) \times 0.11$$

$$T = 41.31 \text{ Nm}$$

The shaft length was taken to be 1meter

The maximum bending moment occurred at the center of the pulley where the overall weight of the drum acted.

Tangential force of the drum

$$F_t = \frac{2T}{D}$$

$$F_t = \frac{2 \times 45.31}{0.22} = 411.91 \text{ N}$$

Maximum moment

$$M = 216.1175 \text{ Nmm}$$

The equivalent twisting of the shaft was calculated using the equation below;

$$T_e = \sqrt{(2 \times 45.31)^2 + (2 \times 216.1175)^2}$$

$$T_e = 441.63 \text{ Nm}$$

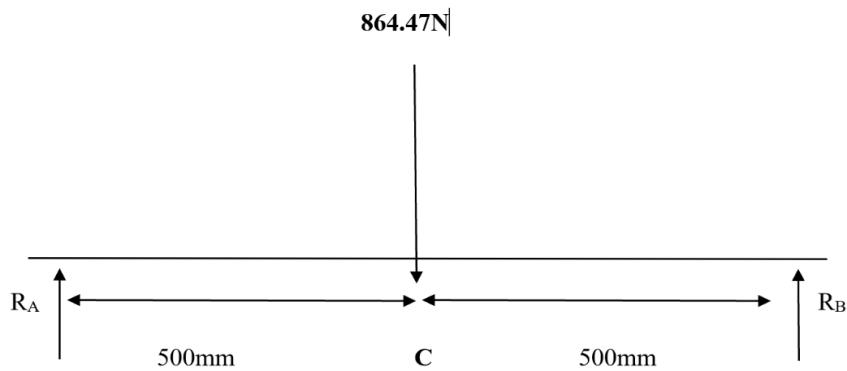
$K_t = 2.0$ ,  $K_m = 2.0$  (Khurmi and Gupta, 2005)

$$d = \sqrt[3]{\frac{16 \times 441.63}{\pi \times 45 \times 10^6}} = 0.0368 \text{ m} = 36.8 \text{ mm}$$

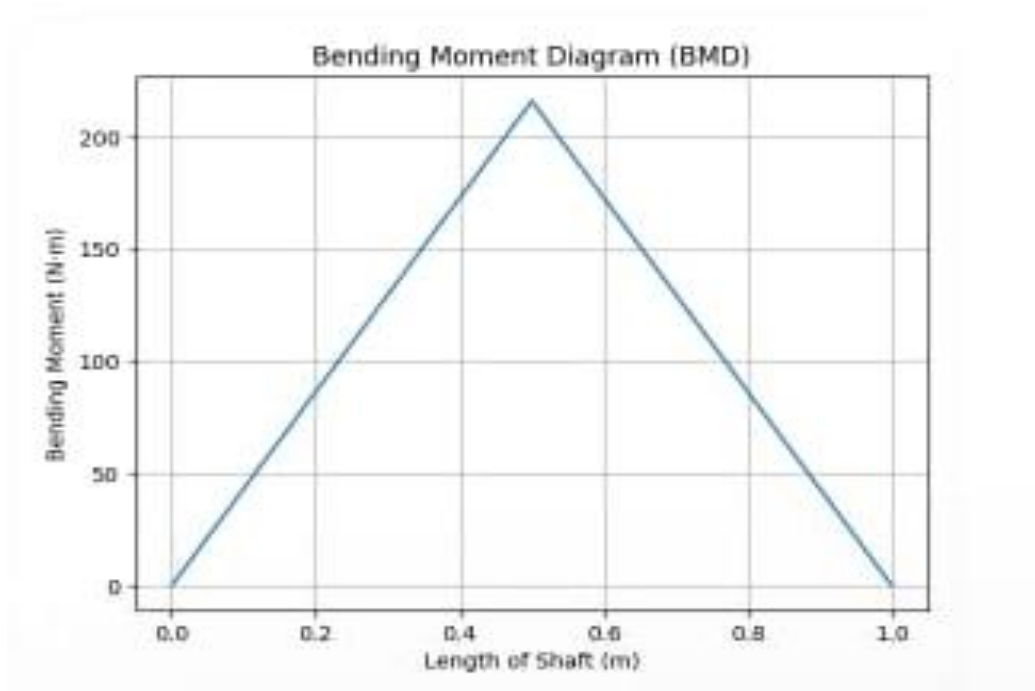
**Table 2.:** Summary of the design analysis of the Threshing unit

Components	Parameters	Value
Electric motor	Power	1.5 hp
Threshing drum	Force	702 N
	Volume	0.0628 m <sup>3</sup>
	Linear Velocity	16.76 m/s
Pulley	Diameter	0.7 m
	Center distance	0.275 m
	Angular acceleration	15.83°
Belt	Coefficient of friction	0.4
	Tension on the tight side of the belt ( $T_1$ )	638.17 N
	Tension on the slack side of the belt ( $T_2$ )	226.3 N
	Maximum tension on the belt	638.17 N
	Length	1.1 m
	Wrap angle	2.44 rad
	Cross-sectional area	0.18 kg/m
Shaft	Diameter	0.0368 m
	Maximum moment	216.1175 Nmm

**Bending moment on the shaft**



**Figure 1:** Free body diagram of the threshing unit



**Figure 2:** Bending moment diagram of the threshing unit shaft

**ii. Design analysis of the milling unit**

**Angular velocity**

The angular velocity for both threshing and milling units should be the same (Gbabo et al., 2013)

$$\omega = 83.78 \text{ rad/s}$$

**Torque (T)**

Torque from Equation 2

$$T = F \times r$$

$$T = 45 \times 0.05 = 2.25 \text{ Nm}$$

**Roller Diameter**

Velocity of rubber roller in rice milling is typically between 1.5–2.5 m/s (Truegometry, 2024).

Assume roller velocity = 2m/s

The diameter of the rollers was calculated from equation 18, (Truegometry, 2024)

$$v = \pi \times D \times \frac{N}{60} \tag{18}$$

$$D = \frac{60 \times 2}{\pi \times 800} = 0.0477 \text{ m} \approx 48 \text{ mm}$$

**Clearance between the two rollers**

Assume the thickness of the grain = 2mm (Singh, 2019 – Rice grain thickness typically ranged from 1.8 to 2.2 mm; average used)

The clearance between the two rollers was calculated from equation 19, (Singh, 2019)

$$C_0 = t - (0.3 - 0.7\text{mm}) \tag{19}$$

where  $C_0$  = Clearance and

t = thickness of rice grain

$$C_0 = 2 - 0.5 = 1.5\text{mm}$$

**Speed of the roller**

Assuming  $d_1 = 0.1\text{m}$ ,  $d_2 = 0.05\text{m}$  assumed standard based on pulley catalogs for 1400 rpm motor (Khurmi & Gupta, 2005).

The speed of the rollers was calculated from equation 20

$$d_1 N_1 = d_2 N_2 \tag{20}$$

$$0.1 \times 1400 = 0.05 \times N_2$$

$$N_2 = 2800 \text{ rpm}$$

**Cross belt friction**

$$\mu = \frac{\ln\left(\frac{T_1}{T_2}\right)}{\theta} \tag{21}$$

$$\text{Taking } \frac{T_1}{T_2} = 2.2$$

$$\text{Coefficient of friction } (\mu) = \frac{\ln(2.2)}{\theta} = \frac{0.7885}{2.44} = 0.323$$

**Belt length (L)**

Length of the belt was calculated from equation 22

$$L = 2C + \frac{\pi}{2}(d_1 + d_2) + \frac{(d_2 - d_1)^2}{4C} \tag{22}$$

Assume  $d_1 = 0.1 \text{ m}$ ,  $d_2 = 0.05 \text{ m}$

$$L = 2C + \frac{\pi}{2}(0.1 + 0.05) + \frac{(0.05 - 0.1)^2}{4C} = 1.11\text{m}$$

**Table 3:** Summary of the design analysis of the Milling unit

Components	Parameters	Value
Pulley	Angular velocity	83.78rad/s
	Torque	2.25Nm
Rollers	Diameter	0.0477m
	Clearance	1.5mm
	Speed	2800rpm
Belt	Coefficient of friction	0.323
	Length	1.11m





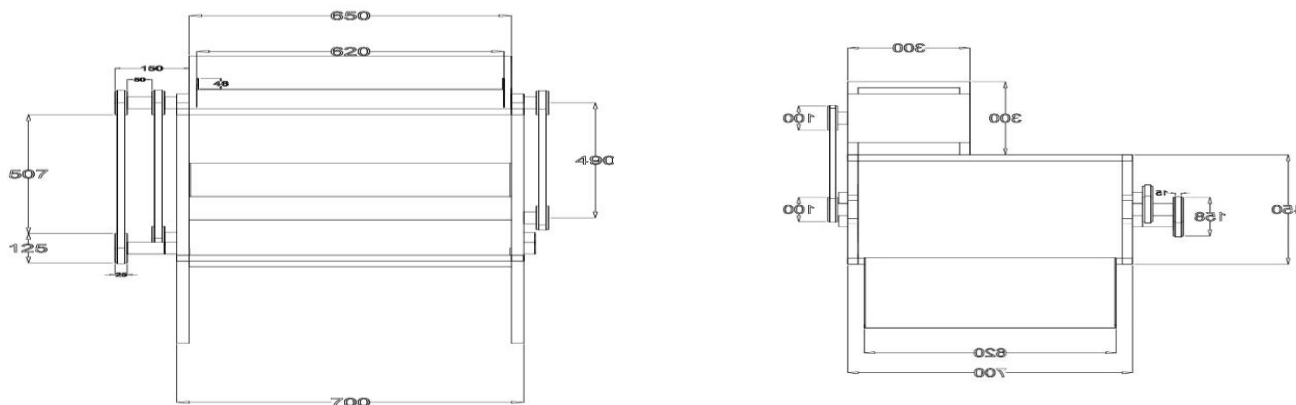
**Plate 1:** Dual rice processing machine

**Table 4:** Description of machine parts

S/N	Description
1	Threshing unit hopper
2	Threshing drum
3	Threshing unit pulley
4	Threshing spike
5	V belt
6	V belt
7	Threshing unit bearing
8	V-groove Pulley (threshing unit)
9	Milling unit bearing
10	Milling Unit
11	V-groove Pulley (for driving blower)
12	Bearing housing
13	Milling unit
14	Milling rollers
15	Milling rollers pulley
16	V-groove Pulley (for driving beater unit)
17	Open belt
18	V-groove Pulley (for driven beater unit)
19	Frame
20	Rice mesh

### 3. Results and Discussion

A compact and portable dual-purpose rice processing machine integrating both threshing and milling operations in a single pass was successfully designed to address the inefficiencies associated with traditional post-harvest practices. The machine was constructed using locally available materials to ensure affordability, ease of fabrication, and simple maintenance for small-scale farmers and processors. Its integrated design eliminated the need for multiple processing stages, thereby reducing handling time, minimizing grain losses, and improving overall rice quality. After construction, the machine underwent comprehensive performance evaluation to assess its processing capacity, operational efficiency, and grain output quality, and the results from these tests are presented below.



**Figure 5:** Orthographic Projection of the Machine

### 3.1 Preliminary Test

Following fabrication and assembly according to the final design, the prototype was subjected to performance testing for its threshing and milling functions. The construction adhered to the fundamental design concepts and theoretical calculations; however, achieving a workable prototype necessitated substantial deviations and adaptations during the build phase.

For the preliminary test, a batch of 4 kg of paddy rice was processed. Upon engaging the prime mover, the paddy was fed into the threshing unit, where the spiked drum efficiently separated the grains from the panicles. The process was halted at the milling stage, as the unit failed to function. Preliminary analysis identified an excessively large clearance within the milling mechanism as the root cause, which prevented effective grain milling. The quantitative performance of the threshing unit was evaluated by calculating its threshing efficiency ( $\eta$ ), the core metric for assessing grain separation from the panicle. This parameter was determined in accordance with the national standard for power thresher testing, the Bureau of Indian Standards (BIS), which defines threshing efficiency as the ratio of the weight of threshed-out grain to the weight of total grain in the unthreshed crop.

The efficiency was calculated as:

$$\eta = \frac{2.5}{4} \times 100 = 62.5\%$$

### 3.2 First Test

A significant modification was made to the milling mechanism to address the excessive clearance that hindered the first trial. Subsequent testing with a 3.0 kg batch of brown rice was conducted under the same operating conditions. The result was a total milled product mass of 1.5 kg. Post-process analysis confirmed that the output consisted of white rice intermixed with a residual portion of brown rice, indicating that while the adjustment improved functionality, it did not achieve complete or uniform milling. The performance of the milling unit was quantified using the industry-standard metric for rice processors: Milling Recovery (MR), also termed Total Milling Yield. This is the single most important efficiency metric, defined as the mass of milled white rice obtained as a percentage of the mass of input material.

$$MR = \frac{1.5}{3} \times 100 = 50\%$$

### 3.3 Second Test

Following the individual assessment of the threshing and milling units, the integrated performance of the single-pass machine was evaluated. The overall effectiveness of the system, processing raw paddy to milled rice in one continuous operation, was quantified by calculating the Overall Operational Efficiency ( $\eta_{\text{overall}}$ ). This metric, defined as the ratio of the mass of the final, usable product to the mass of the initial raw material, is the principal indicator of total system performance for combined operations. The governing equation is:

$$\frac{M_{\text{final}}}{M_{\text{initial}}} \times 100$$

For this evaluation, the machine was tested with a 5.0 kg batch of paddy. The process yielded 2.3 kg of milled white rice at the final discharge.

$$\frac{2.3}{5} \times 100 = 46\%$$

Table 5.: Performance metrics

Performance Metric	Formula	Measured Value	Efficiency
Overall Operational Efficiency	$\frac{M_{final}}{M_{initial}} \times 100$	$\frac{2.3}{5} \times 100$	46%
Threshing Efficiency	$\frac{M_{brown\_rice}}{M_{initial}} \times 100$	$\frac{3.3}{5} \times 100$	66%
Milling Efficiency	$\frac{M_{Milled\_rice}}{M_{brown\_rice}} \times 100$	$\frac{2.3}{3.3} \times 100$	69.69%
Head Rice Recovery	$\frac{M_{head\_rice}}{M_{initial}} \times 100$	$\frac{1.98}{5.0} \times 100$	39.6%

The performance evaluation of the machine was conducted using FARO-44 paddy rice variety obtained from local farmers in Maiduguri. The threshing efficiency of 66% and milling efficiency of 69.69% recorded in this study are lower than the 83.66% reported by Adefidipe and Adetola (2022) and the 92.7% reported by Ani *et al.* (2020). This variation in performance may be partly attributed to the characteristics of the FARO-44 variety, which possesses medium grain size and relatively strong husk–kernel bonding strength, thereby requiring greater impact and compressive forces for effective threshing and husk removal. The lower efficiencies may also be linked to design and operational limitations of the prototype. Grain losses during transfer between the integrated threshing and milling units, non-optimized roller clearance, and the limited power capacity of the 1.5 hp motor likely affected the effectiveness of the processing operations. In addition, the fixed roller clearance may not have adequately accommodated variations in grain dimensions, resulting in incomplete husk removal and increased grain breakage during milling. Unlike the referenced studies, which employed dedicated single-function machines optimized for either threshing or milling, the present design prioritized compactness, affordability, and integration of both operations into a single-pass system, which may have reduced overall processing efficiency. The overall operational efficiency of 46% indicated that the integrated system converted less than half of the input paddy into milled white rice. This reflects cumulative losses arising from incomplete threshing, grain separation losses, bran removal, and grain breakage during milling. Although the result demonstrated the technical feasibility of integrating threshing and milling operations into a single locally fabricated machine, it also highlighted the need for further optimization, particularly in grain transfer mechanisms, roller clearance adjustment, and reduction of grain breakage to improve overall machine performance.

#### 4. Conclusion

The design and fabrication of the dual-purpose rice processing machine successfully integrated both threshing and milling operations into a single unit, providing an efficient and practical solution for small-scale rice farmers. By utilizing locally sourced materials and straightforward fabrication techniques, the machine is cost-effective, durable, and easy to maintain. The selected components including the electric motor, shaft, and V-belt transmission were carefully chosen based on design calculations to ensure reliable operation and efficiency. This innovation has the potential to reduce grain losses, minimize processing time, and improve the quality of locally processed rice. Ultimately, the machine offers a sustainable and affordable alternative to separate threshing and milling systems, thereby supporting food security and enhancing agricultural productivity in rural communities. Future development should focus on optimizing the roller clearance adjustment mechanism, improving grain transfer between the threshing and milling units, and minimizing grain breakage and separation losses during operation. These modifications are expected to improve threshing and milling efficiencies,

increase overall operational performance, and enhance the machine's suitability for small- and medium-scale rice processors.

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