Modification and Performance Evaluation of an ExistingPrototype Mechanical Rice De-Stoner

Abstract

An existing mechanical rice de-stoner was modified for the purpose of improving its efficiency. Some challengeswere discovered with the performance of the existing machine that did not make it to perform effectively. The spring, cushion rubber, coil, capacitor, cable and plug were incorporated to modify the existing mechanical rice de-stoner. After modification of the machine, performance evaluation was carried out.A total of 6kg of threshed rice sample was mixed with stones sized 2.36mmand was divided into three parts of 1.5kg, 2.0kg and 2.5kg and labelled A, B and C respectively. Eachpart was fed at different times into the rice de-stoner and de-stoned.Also, 200g of the threshed rice were taken for hand-picked which served as the control for separating and other foreign materials from the rice. This wasused to compare the result of the efficiency of the machine. The efficiency of the handpicked method was determined to be 80% whilethat of the modified de-stoner was determined to be 66.7%, 60% and 64% respectively. Thus the performance evaluation of the mechanical rice de-stoner was rated above average but not as effective as the hand-picked method.Also, the machine`s throughput capacity was 13.60 kg/hr, 15.38 kg/hr and 15.38 kg/hr for the feed rates of 1.5kg, 2.0kg and 2.5kg respectively.. Thus, the modified mechanical rice de-stoner machine was to be used as a template for other new rice de-stoner to be constructed.

Keywords: Rice, Threshing, De stoner, Efficiency, Capacity

1.0 Introduction

Rice (*Oryza sativa)* has been the most staple food in NigeriaNwosu and Obinwa (2022).Hence, it is a universal food grown and eaten allover parts of the world. The rate of rice consumption differs from one country to another and from one continent to anotherAdetola and Akindahunsi, (2020).Almost all ethnic groups in the country take rice in one form of delicacy or the other and has been a standard of wealth and often used in place of money for centuries. The country is blessed with abundant fertile, arable land and the farmers produce adequate quantity of rice which should be enough for local consumption. The popular cereal crops of the world include wheat, barley, oats, rice, maize, sorghum, and millets, but the major cereals of the developing countries are rice, maize, sorghum and millets Olugboji, (2004).

Major rice-importing countries include Cote d’lvoire, Philippines, Saudi Arabia, Indonesia andNigeria. Some rice-importing countries buy rice when drought, floods, or any other condition reduces the yield of their own rice crop. Indonesia had been the world largest importer of rice until 2004 when it becomes self-sufficient in the commodity (FAO, 2004). Nigeria is currently the largest rice importer in the world to the tune of 1.8 million dollars alone in 2002. The annual demand for rice in the country is estimated at 5 million tons, while domestic production is 3 million resulting in a deficit of 2 million tons Erenstein*et al.*, (2003). However, government embark on importation of rice on a regular basis due to poor quality of the locally produced rice which is usually contaminated with stones, therefore making them undesirable by Nigerians Agidi*et al.*, (2015).

Harvesting and Post Harvesting handling methods of local rice encourage the presence of contaminants such as stones, sticks, chaff, and sand. Traditional methods of removing contaminants include hand picking (sorting and separation of stones from rice manually) which is tedious Agidi*et al.*, (2015).Hence, cleaning, as a preliminary operation, must be extensively carried out to remove unwanted materials or impurities from rice.This can be done through the use of mechanical de-stonerwhich is the process of removing stones or contamination from various crops of different sizes and colors through the use of machines. This to increase the quality of locally produced rice and also, to increase its acceptability by consumers. Stanley *et al.*, (2022).

Threshed grains require considerable additional cleaning before it can be used as food. The cleaning process presents more difficulties than the actual threshing process. Pneumatic cleaning is the process of using air to lift light, chaffy and dusty materials out of the grain while heavier materials move downward. Air is generated by natural or mechanical fan. However, the limitation of natural wind method for cleaning is its unpredictable direction, speed and continuity, high labour requirement and rather imprecise degree of separation Okechukwu and Umezrike, (2010). The flow chart of processing of rice can be shown in Figure 1.

Many investigators have designed and constructed machines for the removal of stones and other impurities from processed rice to meet consumers' demand for a clean product. This has contributed to many technological advancements and methods of removing impurities from rice

Ilechukwu *et al.,* (2023). (Bolaji*et al.,* 2008)have reported that for mechanization of agriculture in Nigeria to succeed, it must be based on indigenous designs, development and manufacture of most of the needed machines and equipment to ensure their suitability to the crops as well as to the farmers' technical and financial capabilities. Hence, in this work, an existing mechanical rice de-stoning machine with vibrating sieves was modified using locally sourced materials for the purpose of improving its efficiency and capacity.

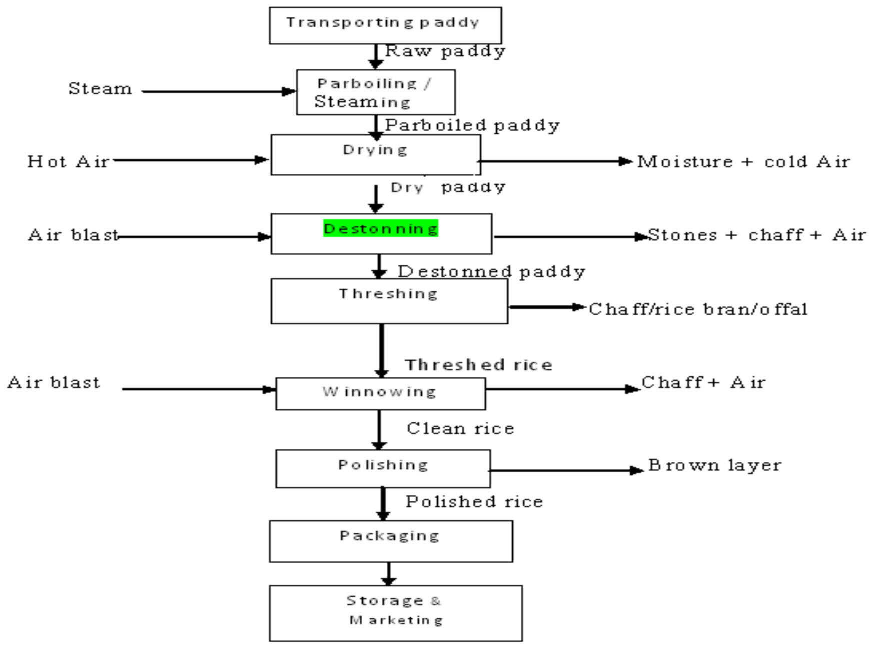

Figure 1: Rice Processing Flow Chart

Source: Ohwofadjeke and Paul O. (2020).

2.0 Methodology

2.1 Materials

The followings were the essential materials selected and used for this project work to modify the mechanical rice de-stoner, as well as to determine its performance evaluation.

2.1.1 Rice sample

Locally produced rice (*Oryza sativa*) as shown in Figure 2was obtained from Igbemo market to evaluate the performance of the mechanical rice de-stoner

Figure2: Rice Sample

2.1.2 The existing mechanical rice de-stoner

The existing rice de-stoner as shown in Figure 3needed to be modified in the department of Agricultural & Bio-Environmental Engineering workshop.

Figure3: The Existing Mechanical Rice de-stoner

2.1.3 Component parts incorporated into existing mechanical rice de-stoner and their functions

The diagrams below show the components (coil, capacitor, spring and cushion rubber) respectively that were incorporated into the existing mechanical rice de-stoner as shown in Figure 4.

(a) (b) (c) (d)

Figure 4: (a) Coil (b) Capacitor (c) Spring (d) Cushion rubber

Coil: Itconsists of a copper wire of 24 Size Wire Gauge (SWG) was used for 100 turns for the main winding, a copper wire of 25 Size Wire Gauge (SWG), 120 turns was used for auxiliary windings.It is usedin the vibrator andis usually a roughly circular or cylindrical current-carrying wire designed to produce a magnetic field or to provide electrical resistance or inductance.

Capacitor: A capacitor was incorporated into the vibrator to stores and releases electricity in a circuit. Itis an electrical component that stores potential energy. It holds positive and negative energy on two separate plates separated by an insulator.It also passes alternating current without passing direct current.

Spring:A spring of 20 mm was incorporated to the component of the rice de-stoner in order to maintain the load on the mechanical rice de-stoner and to allow even distribution of the material during processing.

Cushion:A Cushion rubber was incorporated to the component of the mechanical rice de-stoner in order to cushion the impact load, Also, to cushion against shock and vibration.

2.2 Methods

In the course of achieving the aim and objectives of the project, the following methods were used to modify the mechanical rice de-stoner, as well as to determine the performance evaluation.

2.2.1 Modification of the existing mechanical rice de-stoner

The vibrator was first dismantled to remove the previous coil while a copper wire of 24 Size Wire Gauge (SWG) was used for 100 turns for the main winding and that of 25 Size Wire Gauge (SWG), 120 turns was used for auxiliary windings; was used to recoil the vibrator. This was done in addition with the capacitor to aid the flow of electric current. The winding was inserted into the stator, which was connected in parallel along with the capacitor then connected to the auxiliary winding. The insulator was placed into the stator channel for the insulating of the copper wire. This is to prevent it from being exposed to the earth. The main winding consists of two poles of which it has four leads and connected in parallel (end-to-end). The two poles and two leads were brought out from the terminal's connections to the main supply. The same connection was also carried out on the auxiliary winding, whereby the leads from the main winding was joined together with other leads from the auxiliary winding to the main supply. The second leads of the main winding were connected to the capacitor from there to the supply. The second leads of the auxiliary windings were connected to the capacitor only, after which the vibrator was coupled back to the rice de-stoner in conjunction with the blower devices fixed at the vibrator mill for blowing off the particles.

2.2.2 Test run of the rice de-stoner

The mechanical rice de-stoner was tested after which the vibrator was coupled back to the machine. The machine was tested empty for about 10minutes to observe the sound and vibration. The bolts and nuts were properly tightened while washers and canvass were used to reduce the unnecessary sound and the vibration.

2.3 Experimentation

2.3.1 Experimentation using hand-picking method

Some quantity of stones of different sizes were taken from the field for size determination, using a mechanical sieve as shown in Figure5. The stone size of 2.36mm weighing 200 g was chosen and mixed with the igbemo rice of 6kg making a total of 6.2kg. The mixture of the rice and stones were thoroughly mixed together. 200g of the mixed rice with stone was measured and it was handpicked to separate the rice, chaff, defective and stone. This was used to serve as the control for the efficiency of the machine.

Figure 5: Mechanical Sieve Shaker

2.3.2 Experimentation using of the modified mechanical rice de-stoner

The remaining 6 kg of the thoroughly mixed igbemo rice and sand were divided into three parts of 1.5kg, 2.0kg and 2.5kg and fed into the operated rice de-stoner and the time for de-stoning each of these samples were recorded. Thus the machine`scleaningefficiency and through capacity were determined.

2.4 Determination of Parameters of the De-Stoning Machine

2.4.1 Determination of the cleaning efficiency of the handpicked method

The cleaning efficiency of the handpicked method were determined using the below parameters:

$$CE = M + F \times 100 \qquad 1$$

Where,

CE is the Cleaning Efficiency

M is the Quantity of clean grain obtained from the sample taken of the main grain outlets.

F is the Total quantity of the sample taken of the main grain outlet

The handpicked method was used for the control of the rice de-stoner efficiency.

2.4.2 Determination of the cleaning efficiency of the de-stoning machine

The cleaning efficiency of the de-stoning machine was determined using the parameter given below:

$$\eta = \frac{O}{I} \times 100 \qquad 2$$

Where,

η = The efficiency of the modified mechanical rice de-stoner

O = The quantity of clean de-stoned rice (Output)

I = The total quantity of the mixture of rice and sand for each weighed sample fed into the de-stoner (Input)

2.4.3 Determination of the throughput capacity of the de-stoning machine

The throughput capacity is the rate of performance of the modified destoner and it`s determined using the formula below:

$$T_c = \frac{Qs}{Tt} \qquad 2$$

Where,

T_c is the Throughput capacity of the mechanical rice destoner (kg/hr),

Q_s is the Quantity of stoned rice fed into the mechanical rice destoner (kg)

T_t is the Time taken to destone the sample of rice fed into the mechanical rice destoner (hr)

3.0 Results and Discussion

3.1 Results

The mechanical rice de-stoner machine was modified as shown in Figure 6, in which the coil, spring, capacitor, and cushion rubber were incorporated into the machine.

Figure 6: The Modified Rice De-Stoner

Table 1: Handpicked Rice

Total quantity of mixed sand and rice (g)	Cleaned grain(g)	Stone (g)	Chaff (g)	Defective (g)	Cleaning efficiency (%)
200	160.7	8.8	0.8	28.3	80.4

Table 2: Rice De-Stoner Performance Evaluation

Sample (kg)	Main outlet (kg)	Stone outlet (kg)	Chaff outlet (kg)	Time taken (hr)	Throughput Capacity (kg/hr)
A (1.5)	1.0	0.4664	0.0036	0.11	13.60
B (2.0)	1.2	0.7499	0.0068	0.13	15.38
C(2.5)	1.6	0.8269	0.0058	0.16	15.63

3.2 Discussion

The result of the performance evaluation of the modified rice de-stoner is shown in Table 2. The existing rice de-stoner lacked coil, spring, capacitor, and cushion rubber and all these materials have been incorporated into the mechanical rice de-stoner to make it function and more efficient. Therefore, the efficiency of the handpicked method was determined to be 80%, which means that the machine must be at least 80% efficiency on each operation for good performance. Meanwhile, during the operation of the mechanical rice de-stoner, to separate the rice from the stones, it was observed that the rice was received in the main outlet, then chaff was also received separately at its outlet, but at the stone outlet, it was observed that some quantity of rice was received with stones. Therefore, the efficiency of the machine obtained for the first, second and third samples of 1.5kg, 2.0kg and 2.5kg are 66.7%, 60% and 64% respectively. Thus the performance evaluation of the mechanical rice de-stoner was rated above average but not as effective as the hand-picked method.To this effect, the modified mechanical rice de-stoner machine was to be used as a template for other new rice de-stoner to be constructed.From the same Table 2, the machine`s throughput capacity was 13.60 kg/hr, 15.38 kg/hr and 15.38 kg/hr for the feed rates of 1.5kg, 2.0kg and 2.5kg respectively.Then the weight for the recoveries of the main-outlet, stone outlet and chaff outlet were measured and recorded.

4.0 Conclusion and Recommendations

4.1 Conclusion

The modifications of the mechanical rice de-stoner were carried out to make it function, the machine was evaluated to determine the performance of the machine, in which the result of the handpicked method was compared to the performance evaluation of the machine. It was concluded that the efficiency of the machine was above average as compared to the previous rice destoner that had an average value of 52%/but still needed to be improved upon, because the efficiency`s performance evaluation was lesser than the handpicked method. Therefore, from the performance evaluation of the mechanical rice de-stoner, the efficiency is above average.

4.2 Recommendations

It therefore recommended that this machine should be used as a template, to any newly rice de-stoner machine to be constructed. In addition, in constructing a new rice de-stoner machine, the followings were recommended:

1. The machine should be constructed in such a way that the length of sieve should be longer.
2. Different vibration should be used for each of the feeding rate.
3. The machine should be constructed using bolt and nut i.e., not be welded
4. The blower speed should be controlled.
5. The type of mesh grain used must be wide enough for the grain to spread evenly.

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