International Journal of Agricultural Sciences ☞DOI:10.15740/HAS/IJAS/19.1/254-260
Volume 19 | Issue 1 | January, 2023 | 254-260 ■ ISSN : 0973-130X Visit us : *www.researchjournal.co.in*

RESEARCH PAPER

Development and performance evaluation of shelling unit of power operated groundnut decorticator

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Abstract : Decortication is an operation in which the shells of groundnut are separated with least damage to kernels and it involves a lot of drudgery when done manually. Decortication of groundnut is an essential operation prior to use of kernel in any form. Kernel breakage is an important parameter for developing a suitable groundnut decorticator. As a result, a research to develop a power operated groundnut decorticator as an upgrade to the existing 1 hp power operated commercially available groundnut decorticator was undertaken in the Department of Farm Machinery and Power Engineering, CAET, Junagadh during 2021–2022. To start with, the moisture content and feed rate of existing cast iron blade type groundnut decorticator were optimized for better performance for the variety GJ-21. Thereafter, the performance of rubber padded blade, wooden blade and rasp bar type blade of groundnut decorticator was studied and compared. From the analysis of data, it was found that the optimized moisture content and feed rate of groundnut pods for getting better performance of existing cast iron blade type decorticator were respectively in the range of 9.5 % (w.b.) and 90-95 kg/h. Similarly, power operated groundnut decorticators, it was found that there was 94.0 %, 92.8 % and 90.4 % decorticating efficiency in rubber padded blade, wooden blade and rasp bar type blade, respectively. Breakage per cent was found 3.91 %, 5.66 % and 7.80 % in developed power operated groundnut decorticator for rubber padded blade, wooden blade and rasp bar type blade, respectively.

Key Words : Groundnut decorticator, Shelling of groundnut, Rubber padded blade, Decorticating efficiency, Per cent broken kernels

View Point Article : Lakhani, A. L. and Vagadia,V. R. (2023). Development and performance evaluation of shelling unit of power operated groundnut decorticator. *Internat. J. agric. Sci.*, **19** (1) : 254-260, **DOI:10.15740/HAS/IJAS/19.1/254-260.**

Article History : Received : 20.09.2022**; Revised :** 15.11.2022**; Accepted :** 16.12.2022

INTRODUCTION

Groundnut, 'the unpredictable legume' is also known as earthnut, peanut, monkey nut and manilla nut. It is the 13th most important food crop and 4th most important oilseed crop of the world. The botanical name *Arachis hypogaea* L. has been derived from the Greek words, Arachis meaning a legume and hypogaea meaning below ground referring to geographic nature of pod formation. The groundnut reached Eastern Asia from South America and from there came to India on the East Coast of Madras State by Spaniards (Reddy, 1988).

Groundnut is a species in the legume or beans family. It was first cultivated in Peru. Its seed contains about 63% carbohydrate, 19% protein and 6.5% oil. Groundnut

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is the sixth most important oilseed crop in the world. As the groundnut seed is contained in pod, which is usually developed underground, the pod is harvested by pulling or lifting the plant manually or by using the machine. The pods are stripped from the plant, dried, stored and processed.

Groundnut kernels contain 43 to 49 per cent of oil, 28 to 30 per cent of proteins which is 1.3 times higher than meat, 2.5 times higher than eggs and 8 times higher than fruit, and 16 to 24 per cent of carbohydrates. They are rich source of vitamins A, B1, B2 and E. The kernels are especially valued for rich and high quality fat and carbohydrates. Groundnut cake is also rich in protein content and utilized as concentrated organic manure. The creepers are used as cattle feed and shells as fuel. Groundnut is not only used as edible oil but also used in manufacturing of soap, hydrogenated vegetable oil and also used for culinary purpose as well. Therefore, groundnut crop plays an important role and has got immense importance in the national economy of our country (Salve, 2008).

Its oil is now used in pharmaceutical as a substitute to oleic oil. The groundnut is dug, extracted, processed, and consumed as a snack food, peanut butter, and a candy. Groundnut kernels are consumed directly as raw, roasted, boiled or fried. Groundnut haulms is a very good palatable (8-11% protein) fodder for cattle, when fed in green state. The groundnut cake have immense value as feeding material for livestock and organic manure. It contains 8% N, 1.4% P_2O5 and 1.2% K_2O.

Groundnut is very important as far as the oil seed is concerned, Developing countries constitute 97 % of the global area and 94 % of the global production of this crop. The production of groundnut is concentrated in Asia and Africa (56 % and 40 % of the global area and 68 % and 25 % of the global production, respectively). It grows best on soils that are well drained, loosely textured and well supplied with calcium, potassium and phosphorous (Ntare *et al.*, 2008).

Gujarat is the largest producer contributing 33 % of the total production of groundnut followed by Rajasthan (21 %), Tamil Nadu (14 %), Andhra Pradesh contributes (7 %) and Telangana contributes (5 %) to total Groundnut production. Groundnut contributes 19.1 % area and 21.3 % production to total oilseeds area and production in India, respectively.

Groundnut is a principal crop of the saurashtra region of Gujarat state and is grown extensively since 1910. Groundnut is an important crop grown worldwide in more than 100 countries. Groundnut is considered as the world's fourth largest source of edible oil and the third most important source of vegetable protein. It is also a major oilseed legume crop in India and meets about 30 % of the edible oil requirements in the country.

The Groundnut is one of the major seed crop. This product in the cultivated in abundant quantity. As the groundnut seed is contained in pod, which is usually developed underground, the pod is harvested by pulling or lifting the plant manually or by using the machine. The pods are stripped from the plant, dried, stored and processed. Shelling is a fundamental step in groundnut processing. There is lot of time waste in old method of groundnut pod separating. The time required for 1 Kg of groundnut pod separating from this groundnut is about 1 to 1.5 hours. So we have we have produces new machine for fast groundnut pod separating.

Shelling is the removal of grains from their stalk, pod or cub, either by stripping, impact action and rubbing or any combination of these methods. Kulbhushan *et al*., (2017) reported that based on the shelling action, decorticator can be divided into two categories. Hand operated groundnut decorticator 50-75 kg/h capacity was evaluated, whereas a pedal operated groundnut decorticator was found to have capacity of 75 kg/h (Usman *et al.,* 2020).

The major objective of shelling, threshing, de-hulling or decorticating of most farm products is to improve their value by detaching or dissociating their kernels or seeds from their enclosure. The principle of operation of a sheller usually involves application of impact force with partial shear force depending on the hardness of the shell of the seed while that of a thresher involves application of impact force only. Decorticators apply combination of impact with compressive force while dehullers apply abrasive force to operate in most cases (Kabir and Fedele, 2018).

The decorticating of groundnut pods is meant to remove the shell with no damage to seed or kernel. Groundnut pods are broken easily at 8 to 10 % moisture content. The common methods for decortication are

Traditional method of decortication :

Groundnut shelling has been done by hand (manually) and also simple machines have been devised for use in shelling. For example, in the North -Eastern part of India, groundnut shelling was done using a bamboo

crusher.

Decorticator :

Power shelling means breaking of shells without hurting or damaging the kernels which are in relative motion with one another. Generally, power shelling is used for large scale separations for industrial purposes. As initial investment is higher in power shelling, it is not affordable to small and marginal farmers. Power operated machines are generally run on either electricity or diesel engine.

– Centrifugal impact decorticator
– Peg and drum decorticator
– Bar and drum decorticator
– Parallel gap disc decorticators.

Problem identified :

– Too much time is required in traditional method
– Labour requirement is very high
– Efficiency is low
– Harvesting cost is high.

It was necessary to determine the main characteristics for increasing the efficiency of the existing machinery in order to solve this issue. Two forces, such as impact and shearing, fundamentally control how the pods are arranged. To achieve the least amount of seed damage, it is essential to apply the least amount of impact with more rubbing action (Singh *et al*., 1985).

The shelling unit must be constructed out of softer but solid material in order to produce less impact force and more rubbing action, which will separate the kernels from the pods. To minimize kernel breakages, rubber materials with a cushioning effect may be applied. Kernel breakages are mostly caused by the hardness of the shelling unit and reduced rubbing action as a result of the pods' lower contact area for friction.

The cast iron sheller produces more impact and less shearing, leading to large kernel breakages, as seen by the existing decorticator. In light of the previous knowledge, an effort was made to evaluate the developed power driven groundnut decorticator by using rubber instead of cast iron as the shelling unit. Rubber is also chosen and it is easily and affordably available in the market.

MATERIAL AND METHODS

In the beginning, the physical properties of the groundnut (variety GJ-21) pod and kernels were studied for developing a suitable machine for effective decortications. In the preliminary study, the existing commercially available cast iron (CI) blade type power (1 hp) operated groundnut decorticator procured from Farm Machinery and Power Engineering Department, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh was evaluated at different cylinder speed for decorticating capacity, decorticating efficiency, breakage per cent and cleaning efficiency. On the basis of improved quality, the groundnut pod's moisture content was increased for the described machine. The pod's feed rate was then also optimized after that. The performance of the described machine was corrected while maintaining the moisture content and pod feed rate, and any necessary improvements were added to further enhance performance.

Major modification was the replacement of cast iron blade with rubber padded blade, wooden blade and rasp bar type blade. The data collected for the existing and modified groundnut decorticator were statistically analyzed and compared. The results of the experiments were statistically analyzed using a complete randomized design and the simple subjected to statistical technique. GJ-21 groundnut, which is the most widely grown cultivar in Gujarat, was chosen for this research. The design of the experiment followed for the study is two factor CRD and the independent and the dependent variables for the study were Independent Variables: rpm of cylinder shaft of groundnut decorticator (R1 = 125, R2 = 150, R3 = 175); concave clearance (C1 = 15 mm, C2 = 20 mm, C3 = 25 mm); Types of blade (Rubber padded blade, Wooden blade and Rasp bar type blade) and Dependent variables: decorticating capacity; decorticating efficiency; breakage percentage of kernels; cleaning efficiency of decorticated pods.

Main frame :

The frame of the machine is fabricated with mild steel angle iron. It supports the entire machine and is made by joining 910 mm × 455 mm and 840 mm height angle iron into shape by welding. It carries the shelling unit, the hopper and the fan.

Hopper :

This structure is the unit in which materials to be shelled is regulated and channeled into the shelling chamber. It is made of 20 gage metal sheet into a

rectangular section with dimensions of 460 mm × 330 mm and 190 mm height which tippers towards the shelling mechanism for easy flow of the materials by gravity.

Feed rate controlling flap and flap assembly :

The feed rate controlling flap was created from a 360 × 445 mm rectangle of MS sheet.

It was positioned above the hopper to regulate the feed rate.

Decorticating cylinder :

Decorticating cylinder was made of concaves of MS sheet of 20 gauge (2 mm thickness). Concave had a maximum radius of 175 mm and a minimum radius of 150 mm, as well as a width of 460 mm. The decorticating unit's concave was permanently welded to the decorticating unit's supporting frame, with provision for sieve replacement. 4 Nos. of 35 x 35 x 4 mm MS angle bar were welded at the corners of the concave to make a groove for fitting sieves with various slot sizes. The decorticating cylinder's center line was 840 mm above the ground and was supported by the decorticating unit frame. Size of blade was 430 mm length, 40 mm width and 10 mm thickness.

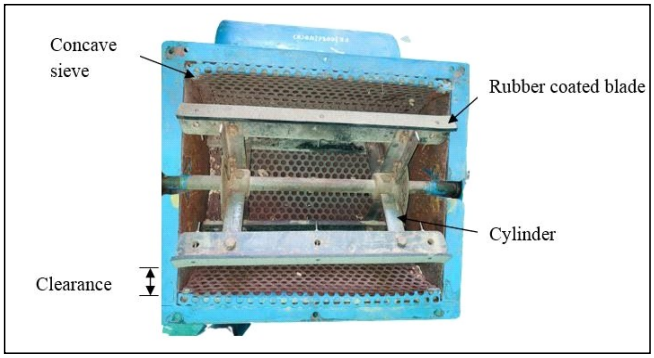

Fig. 1: Decorticating cylinder

Rotary unit shaft :

The rotating unit was installed and driven by a main shaft with a diameter of 25 mm and a length of 700 mm. It was built from white drawn bar with a diameter of 25 mm. Two P- 205 pedestal with bearings were used to drive the shaft. The bearings were supported on one side by the main shaft supporting frame and on the other by the decorticating unit supporting frame.

Rubber padded blade :

A blade 10 mm thick rubber strip was given widthwise on the outer edge for rubbing action. Rubber patches were 430 mm and 25 mm in length and breadth, respectively. This rubber structure aided in the good crushing of the pods while causing little or no damage to the kernels.

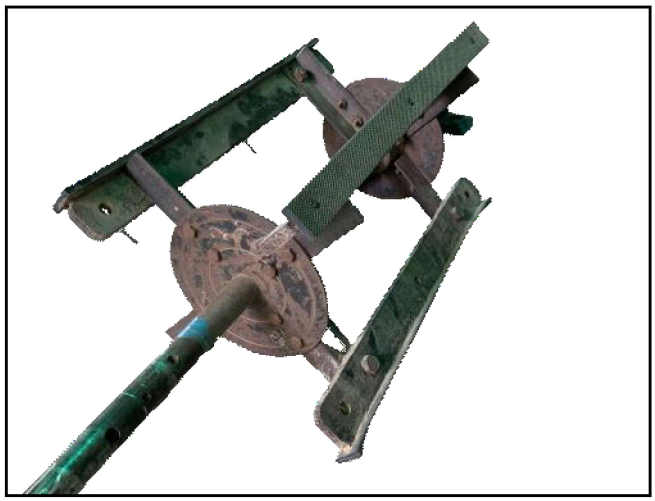

Fig. 2: Rubber padded blade

Wooden blade :

This blade was made from the wooden material and its dimensions were 430 x 40 x 10 mm. Suitable hole and slot also provide through machine for fitting in cylinder. It was used for minimum damage of seed.

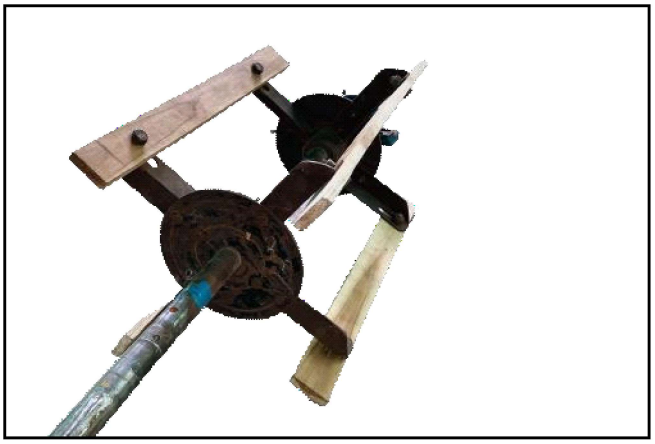

Fig. 3 : Wooden blade

Rasp bar type blade :

Blade was made from cast iron material and accurate groove on the blade face which contact to groundnut pods. Dimensions of rasp bar type blade were 430 x 40 x 10 mm. Suitable slot also provide for fitting in cylinder.

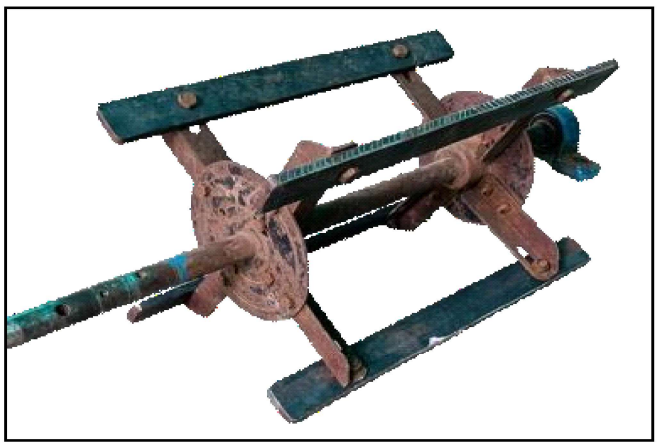

Fig. 4: Rasp bar type blades

Concave sieve :

Concave sieve was made from MS sheet and its 18 gauge. Half circular sieve, made of MS sheet was developed by bending. Dimension of concave sieve was 660 x 460 mm. same size hole provide in area of sheet and circular type hole was provided. The sieve having 13 mm round holes. The modified sieve was created for ease of use and to simplify the groundnut decorticator's design.

To design the concave sieve physical parameter of groundnut pod and groundnut kernels were considered.

Power transmission unit :

This is composed of a 1HP electric motor. The 1HP electric motor transmitted power to shelling unit and blower unit both are interconnected by pulleys and belts.

Two transmission shaft are mounted on the main frame. The diameter of shaft is 25 mm. Three pulley of diameter 228, 254, 305 mm are used to transmit power to decortication from 1 hp motor. Blower shaft having diameter 67 mm double belt pulley. Its transmit power blower shaft to cylinder (main shaft). Pulley of diameter 100 mm is used to transmit power 1 hp AC motor to the blower.

Blower unit:

The blower is located just under the hopper and opposite the slope of the tray. It is a centrifugal fan and is comprised of four straight impellers attached to the shaft, all in an in volute casing. A pulley is attached to the shaft at one of the ends. The fan's maximum diameter was 340 mm. A bolt on the fan's hub was used to secure it to the fan shaft.

The cleaning unit:

The cleaning unit facilitates cleaning of materials passing through the shelling unit. Air blast from the fan is connected across the falling material and effecting separation of chaff from seed. The fan blades are curved backward and made of 20 gauge mold steel sheet and mounted on a shaft. The whole assembly is enclosed in a metal housing termed as the fan housing.

Belt and pulley:

The belts and pulley was selected based on the speed of the driving motor, speed reduction ratio, centre to centre distance between the shafts at the condition under which the shelling action must take place. An AC motor with 1440 rpm was used with a pulley diameter of 100 mm. The shelling unit of 125, 150 and 175 rpm is desired. For varying rpm of the main shaft, B-51, B-53 and B-56 were used. The use of V-belt for power transmission between main shaft, fan shaft and motor reduced slippage percentage as compared to ropes and also added more comfort for operator ensuring maximum utilization of available power.

Fan shield :

Between the decorticating unit and the receiving tray, this component of the machine was installed. It was constructed using a 20 gauge (2 mm thick) MS sheet with dimensions of 1170 x 535 mm. The material was bent to produce a cylinder with a diameter of 460 mm on one end and a rectangular portion with a dimension of 300 x 300 mm on the other. Six bolts were used to secure this assembly to the receiving tray.

Kernel outlet :

This portion of the machine was responsible for transporting the clean groundnut kernels. It had a trapezoidal in shape for easily convey. It was manufactured using 20 gauge MS sheet (2 mm thickness) and 480 x 750 mm rectangle was cut.

RESULTS AND DISCUSSION

The results of the studies on the performance parameters like decorticating capacity, decorticating efficiency, breakage percent and cleaning efficiency of developed power operated groundnut decorticator have been discussed with the help of line diagram at the optimized moisture content (9.5 %) from the Fig. 5-8. Finally, the performance of both the existing decorticator

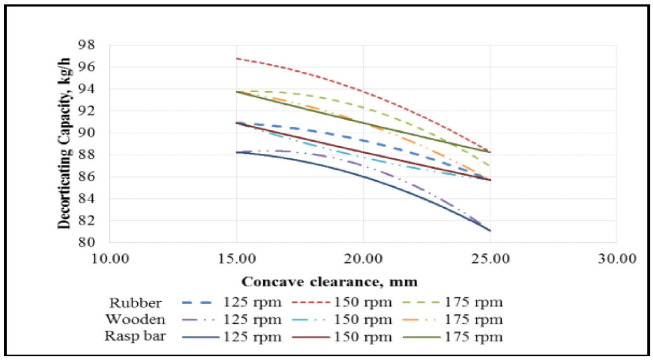

Fig. 5: Effect of concave clearance and rpm on decorticating capacity

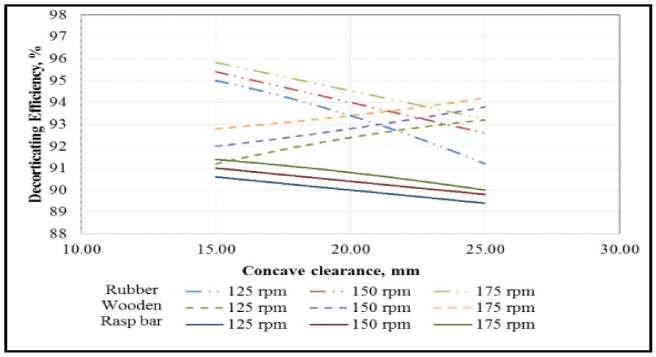

Fig. 6: Effect of concave clearance and rpm on decorticating efficiency

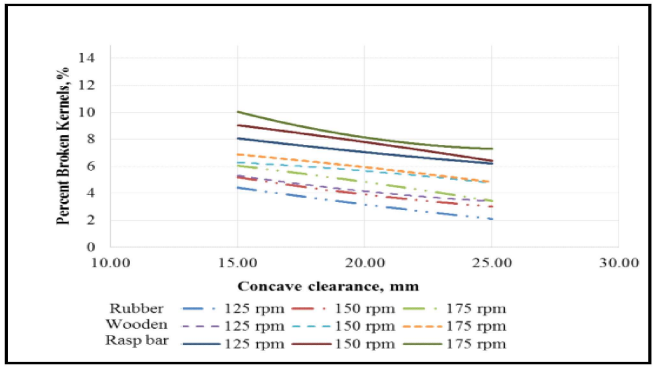

Fig. 7: Effect of concave clearance and rpm on percent broken kernels

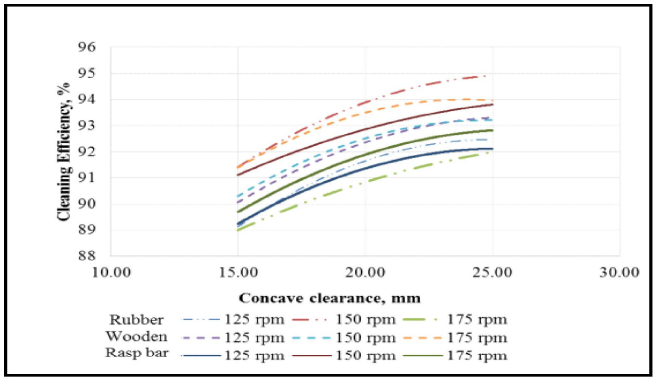

Fig. 8: Effect of concave clearance and rpm on cleaning efficiency

developed power operated groundnut decorticator was compared and presented in Table 1.

With the increase in RPM from 125 to 150 rpm, the decorticating efficiency increased up from 91.2 to 94.0 percent. After that, with an increase in RPM from 150 to 175 rpm, the decorticating efficiency increased from 94.0 to 95.8 percent. This was because operating the cylinder shaft at a higher speed resulted in greater shelling performance than doing at a lower speed. However, when moving at a speed that is slower than normal, it takes less time for pods to be covered, which results in some pods remaining abstract and increases in shelling efficiency.

The increase in clearance decreased breakage percent for a given speed of the cylinder shaft, but the increase in speed for the same clearance increased breakage percent because of a higher impact force on the pods. The rpm of 125 rpm produced an ideal force to split the pods to seeds and shells with the least amount of breakage because the results were a result of the combined effects of both rpm and concave clearance. Therefore, the rubber-padded blade operating at speeds over 125 rpm had the lowest breakage rate.

The cleaning efficiency also increased from 89.13

Table 1 : Comparative performance analysis of developed power operated groundnut decorticator with existing groundnut decorticator

Sr. No.	Particulars (Average fromthree test)	Existing decorticator	Developed power operated groundnut decorticator		
			Rubberpadded blade	Woodenblade	Rasp bar type blade
1.	Moisture content (w.b.) of pods (%)	9.5	9.5	9.5	9.5
2.	Concave clearance (mm)	20	20	20	20
3.	Speed of cylinder (rpm)	150	150	150	150
4.	Decorticating capacity (kg/h)	85.71	93.75	88.23	89.33
5.	Decorticating efficiency (%)	92.8	94.0	92.8	90.4
6.	Percent broken kernels	6.85	3.91	5.66	7.80
7.	Cleaning efficiency (%)	90.33	95.37	88.04	92.45

to 94.92 per cent with the increase in RPM from 125 to 150 rpm. As the results were again the results of the combined effects of rpm and concave clearance. With the increase in concave clearance from 20 to 25 mm, the cleaning effectiveness decreased from 94.92 to 89.06 percent. This was due to the fact that as the clearance grew, the pods were squeezed against the sieve with less force, resulting in reduced cleaning and shelling efficiencies.

Accordingly, the results showed that the developed power operated groundnut decorticator with rubber padded blade exceeded the cast iron blade type of groundnut decorticator with a 1.3 per cent increase in shelling efficiency, a 75.91 per cent decrease in breakage per cent, and a 5.28 per cent increase in cleaning efficiency. It was observed that the recently founded power-operated groundnut decorticator with a rubber padded blade performed better than one with a cast iron blade.

Conclusion :

The constant moisture content and feed rate of groundnut pods for improving the performance of the existing cast iron b type blade decorticator were found to be between 9.5 per cent (w.b.) and 75 kg/h based on the analysis of the data gathered throughout the research activity.

In order to get the best decorticating efficiency, acceptable breakage per cent and cleaning efficiency in the cast iron blade type groundnut decorticator, the cylinder shaft rpm of 150 and concave clearance of 15 mm were found to be better. Similar to the above, in the designed power operated groundnut decorticator with rubber padded, it was discovered that the cylinder shaft rpm 175 and concave clearance 15 mm were better in terms of acceptable shelling efficiency, least breakage percent, and highest cleaning efficiency.

While comparing the developed power operated groundnut decorticator with rubber padded blade to the existing cast iron blade type of groundnut decorticator, it was found that there was a 1.3 per cent increase in shelling efficiency, a 75.91 per cent decrease in breakage per cent, and a 5.28 per cent increase in cleaning efficiency. In comparison to existing groundnut decorticator's output of 75 kg/h and the manual decorticator's output of 35 kg/day, the improved rubber sheller bar type produced 95 kg/h of groundnuts.

Future scope :

A large portion of the world's population makes their living primarily through agriculture. This machine may be modified and it will be utilized on a large scale. This technology offers farmers additional help so they can profit appropriately from their product. The agricultural industry has a large scope. It will obviously take a lot of work to reduce labour requirements, increase productivity, reduce prices, and minimize the total cost.

Everyone wants healthy food to live a healthy life while the world is developing so fast. This food is produced by agriculture. So, in maintaining the crop's health, crop handling methods should be effective. The current developments in the agricultural sector will benefit both farmers and consumers by increasing production without raising prices.

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