

# Design and development of smart cashew nut shelling, inspection & grading machine

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## ABSTRACT

The present approach aims at the development of cashew nut shelling machine suited for cashew nuts assimilating a new shell mechanism. The major risk involved being spilling of fluid from the shell that causes partial/permanent blindness to workers and a harmful effect on the skin. The machinery involved with processing is bulky, costly, imported as well as need regular maintenance. This approach intends to build a smart machine that can fulfill requirements of the farmer as well as provide additional functions such as inspection, packaging and online maintenance (through the internet). The machine allows the users to monitor and sorts out any issues or faults if occurs during shelling process. Since the orientation of the machine was to be in a vertical direction, it influences gravity. Thus inverse slider crank mechanism is used to actuate the oscillator unit that drives the scrapper. Once oscillator and feeder units are powered up as the feeder loads nuts one by one, oscillator brings it down and fixes at a position and scrapper forces the cashew nut to pass between blades for performing shelling. An optional attempt to grade cashew nut using image processing through template matching was proposed for w180 and w210 grades. Apparently, some cashew nut which is counted by proximity sensor sends the signal of counts to Arduino UNO board; this information is then sent through the transmitter to the website. A smart phone which uses HTTP and Android application protocol are used to display data of weight so far shelled and thus, can be used for bidding in the market directly to the government or consumers. This adds up transparency and money flow towards the producers. The machine was tested, and the shelling efficiency was found to be 70% greater than the conventional method of cracking nuts.

**KEY WORDS:** Agriculture, Cashewnut, Template matching, Wireless control.

## 1. INTRODUCTION

The conventional method of shelling the cashew nut has been done by manually beating the cashew along its axis. However, for very small-scale producers, the collection of cashew nut shell oil requires additional high-cost specialized equipment. Cashew nut farmers don't earn enough profits in spite of being a producer of dry fruits due to lack of facilities in technical as well as the managerial side. The prime objective of this approach is to design and develop a smart cashew nut machine for shelling, packaging, sorting and execute it for better performance. MATLAB, SOLIDWORKS & ARDUINO turned out to be the best platforms for implementing the solution. The structure was supposed to be robust as well as cheap. The BOX CHANNEL bars seemed the ideal choice for the structure of the machine. The single phase AC motors were capable enough to produce required force and can be controlled by ARDUINO UNO using an Ethernet Shield and Relay. The selection of controller was done by certain requirements such as wireless control and Data logging on Android Smartphone. The feature which is intended to add is an online diagnosis of the system for which the required sensors are proximity sensors, counters, timers, encoders, cameras, etc. The major hardware components used in the machine are ARDUINO UNO, Ethernet Shield, Motor Driver, AC Motors, and Relay.

## 2. MATERIALS AND METHOD

**Materials:** The component selection for the system such as selection of motors, guides, springs, etc. was selected based on the best configuration of components regarding reliability, life, ruggedness, etc.

**Single Phase Face mounted AC Motor:** The advantage of having single phase AC power as input means high torque generation and fewer conversion losses. It is commercially available and can be repaired by any technician with little expertise in electrical machines.

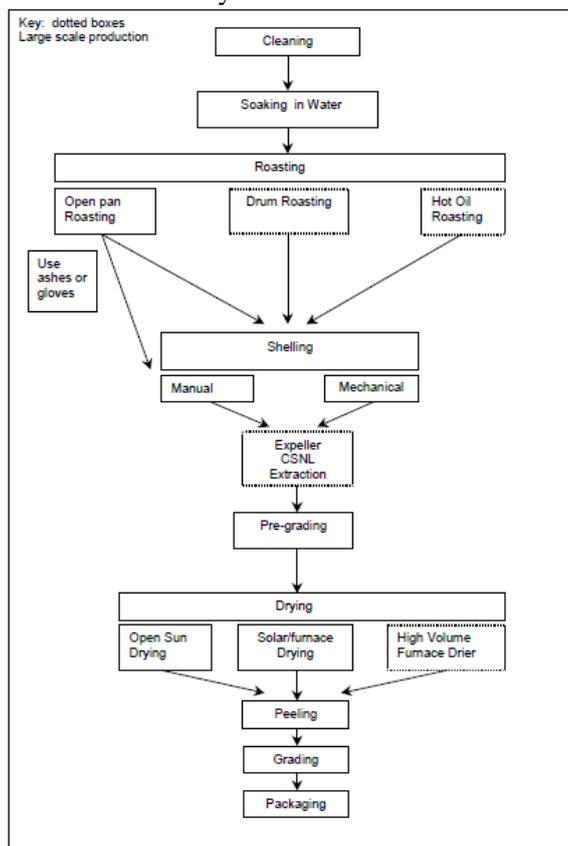
**A 20:1 Reduction Worm Gear Box:** The input speed of single-phase AC motor is 1440 rpm; it is much higher than the speed required for the machine. Also, the torque generated is not sufficient, and thus, the use of worm gear box is needed. Therefore the speed can be reduced to 72rpm. After considering the losses, the speed turns to be roughly 65 rpm.

**Guides:** The guides were needed for "to and fro" motion of the oscillator unit. Thus, a pair of cylindrical rods with linear bearing was selected for the guide. The material needed to be light and sturdy at the same time economic. Therefore stainless steel pipe of having 19 mm external diameter and 20mm internal diameter bearing were selected.

**Oscillator:** The oscillator unit drives the scrapper where the force needed to push the cashew nut between the knives. The oscillator is heavy hence it offers resistant to vibrations and also the counter force encountered by the knives is balanced by its weight.

**Scraper:** The scraper is responsible for cutting cashew nut which is always normal to the cashew profile. It applies force in the forward stroke and moves over cashew nut in the return stroke. Thus, the scraper needs a soft tensile spring and a pivot joint to create such motion.

**Knife:** Movable and stationary knives are used. The movable knife “to and fro” is connected to a compression spring, and the other knife which is fixed remains stationary.



**Figure.1.Cashew nut processing diagram**

**The design of scraper:** The force required to crack cashew nut shells are provided by scraper as an impact load. Therefore considering no conservation of kinetic energy, the velocity of impact is calculated, because nuts are cracked plastically.

Impact Energy = Kinetic Energy

Sharma and Aggarwal (2006):

$$\text{Impact Energy} = \frac{mv^2}{2} \text{ J}$$

Where, m is the mass of cashew nut, v is the velocity of scraper.

Considering average weight of cashew nut is 2.4g:

$$\text{Impact energy} = 0.0012v^2 \text{ J}$$

Assuming that the colliding force of the nut with the shelling wall is entirely plastic, then:

$$\text{Impact Energy} = \text{Work of deformation}$$

Sharma and Aggarwal (2006) where:

$$\text{Work of deformation} = (0.5 F) \times e \text{ J}$$

Where, F is the applied force and e is the deformation.

Work of deformation thus is given as:

$$\text{Work of deformation} = P \times e \text{ J}$$

Where, P is the load applied in impact and is equal to the impact load required to shelling the nut (Sharma and Aggarwal, 2006).

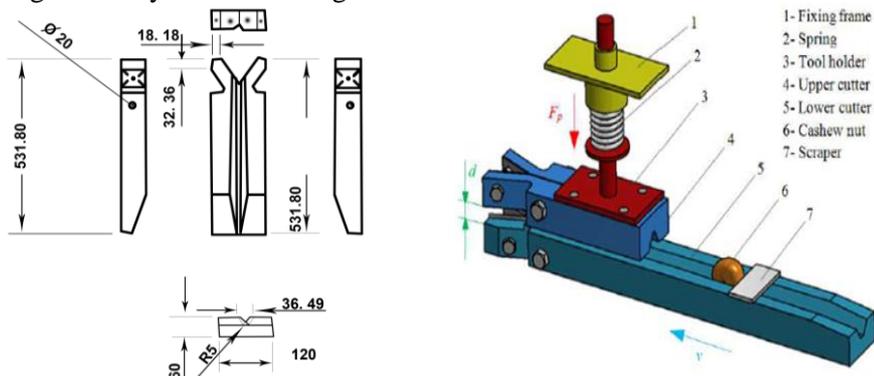
The impact load of 142 N, and the maximum deformation of the nut and determined to be 12.58 mm (semi-automatic cashew nut shelling method).Therefore,

$$\text{Work of deformation} = 1.78 \text{ J}$$

Equating the kinetic energy gives:

$$\text{Velocity of the scraper} = 38.51 \text{ ms}^{-1}$$

The velocity of shelling scrapper can be determined if the deformation is recorded and tested for a given load. The calculation of scrapper velocity will be helpful while selecting motor in such a way that the speed of scrapper can be determined as it is being driven by a motor through Inverse Slider-Crank Mechanism.



**Figure.2. (a) Cashew nut shelling unit, (b) Assembled view of shelling unit**

**Testing:** The main parameter involves the size and configuration of oscillator and scrapper unit of the machine; it was designed to allow only one cashew at a time to accomplish efficient cracking. The mechanism used for the machine was supposed to be compact as well as reliable. The moving components such as Motor, Gearbox, Couplers, Oscillator, and Feeder were decided to proceed to sort out this problem. Two mechanisms were found to be convenient for transmitting motion from motor to scrapper unit is as follows,

- Scotch Yoke Mechanism
- Inverse Slider Crank Mechanism

If the orientation of the machine was made to be in a vertical direction, then this makes the gear box to be placed in horizontal position. Thus, the Scotch Yoke mechanism was rejected due to its incapability, to function under the influence of gravity. Thus, inverse slider crank mechanism was selected to actuate the oscillator unit. The shelling unit was tested to regulate the shelling efficiency of the machine.

### 3. RESULTS AND DISCUSSION

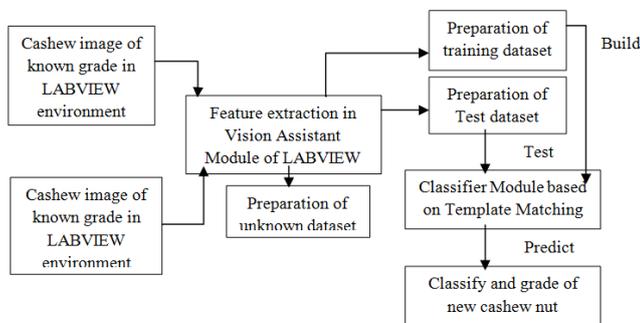
The shelling efficiency was calculated based on the number of shelled cashew nuts and the total number of feed and found better results than manual shelling efficiency. Results shows for every minute feed rate of 20 nuts gave optimum performance.

$$\text{Shelling Efficiency} = \frac{\text{Completely shelled cashew nut}}{\text{Total feed}} \times 100$$

$$\text{Shelling Efficiency} = \frac{14}{20} \times 100 = 70\%$$

Shelling efficiency was found to be 70% which means only six nuts were partially shelled among 20 nuts. The overall efficiency of the machine was found to be equal to the efficiency obtained by Jain and Kumar (1997) for Motorized sheller.

**Image processing:** The grading was used to differentiate between cashew nut based on the texture of cashew nut. The image of cashew nut after shelling is captured by proximity sensor which is placed nearer to the scrapper and its hue & saturation, red intensity mean, green mean, blue mean readings are taken from a graded sample set to do an approximation on grades identified.

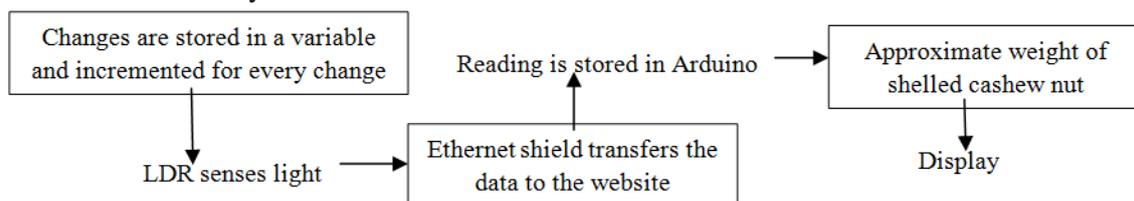


**Figure.3. Classification of cashew nut through template matching**

This is valid for a sample taken from a farm consisting of the same type of cashew nut trees. Thus, template matching can be utilized for the samples from the same farm field.

This prevents the excess processing power and computation is reduced, unlike the neural networks. The integration of Android app with Arduino was a challenge which was supposed to be solved in such a way that, the

machine maintenance can be done by any person with sound knowledge on Electronics. Thus, the flow of information was decided, and the sensor was selected for the purpose of counting input number of nut was a proximity switch. The switch is located vertically to make the count of nut.



**Figure.4. Programming logic for mass indication**

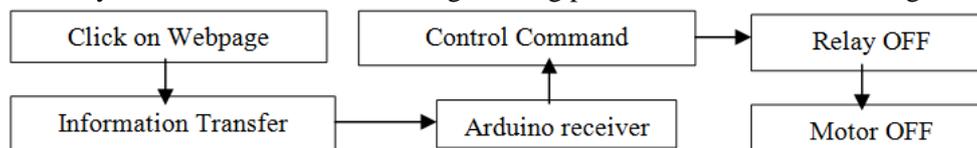
This allows recording input signal whenever the scrapper is near the proximity switch. The number of nuts taken so far is counted, and the information is collected. The counter in the Arduino UNO board measures the information and sends it to the transmitter. The transmitter uses the Ethernet Shield for communication using Network Time Protocol and Web Server to transfer information to the website. This received data at the website will be taken as an input for Approximate Weight indication bar.

Average weight of one cashew nut = 2.4g

The number of nuts shelled = 20

Weight on bar =  $20 \times 2.4 = 48$  g

The information from the website is transferred to mobile using HTTP and Android application protocol, and this leads to transfer information and Data Logging and Display at the remote device like a smartphone. Thus, the device can display data on the weight so far shelled. The machine additionally offers the users to monitor and control or maintain if any issues or faults occurs during shelling process which is shown in figure.5.



**Figure.5. Programming logic for Motor Control**

#### 4. CONCLUSION

This project deals with addressing social issues with the farming occupation and solving these issues using technology. The issue was addressed by redesigning the machine using mechatronics approach. Thus, features such as data logging, wireless control, monitoring, etc. were incorporated in the machine to increase its functionality. This approach involves a minimum number of iterations to get the result. The machine being able to get fabricated at a minimum market cost. To make the lives of farmer better, data logging used for better bidding and avoid middlemen for marketing. Nuts of high quality will be available for consumers at cheaper rates. Thus, the solution developed was feasible and reliable enough to challenge current products available in the market regarding features and support. The implementation of solutions suggested is expected in future

In future,

- The machine can be upgraded and further redesigned in future to make it more lightweight.
- Custom made actuators for the scrapper can be made for the machine to be compact.
- The machine can have further features incorporated that can make it as a smart product such as alerts, decision making, etc.
- Artificial Neural Networks can be integrated with the machine. This will give it more flexibility regarding power utilization and productivity.

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