Design and Fabrication of Areca Nut Tree Climber and Harvesting Machine

Shivdeep D R[1]

[1]*Shivdeep D R, Student Dept. of Mechanical Engineering, JSS Academy of technical Education, Karnataka, India.*

ABSTRACT - *India earns most of its lively hood by agriculture. It ranks second in worldwide in agricultural output. Agriculture accounts to 10% of our annual GDP and it provides 50% of work to the citizens of our country. Global production of areca nut estimated to be around10.33 lakh tones and constituted an area of around 8.29 lakh hectares back in 2009-10. Areca nut is a medium sized tree, the tree bark diameter varies from 10 to 20 cm in diameter. The tree's diameter is larger at the base and the diameter is smaller at the top. That is as the tree grows its diameter decreases. The harvest is three to four times in a year. This requires skilled workers to harvest, which is hard to find. To solve this problem a device was designed and fabricated which does not require any skill to operate and works on electricity.*

KEY WORDS: Areca nut, Circular frame, Roller, Roller assembly

INTRODUCTION

Areca nut known by its biological name Areca catechu, is a species of palm tree which mainly grows in tropical Pacific region, south East Asia, Indian subcontinent and parts of eastern Africa. Areca nut known by its biological name Areca catechu, is a species of palm tree which mainly grows in tropical Pacific region, south East Asia, Indian subcontinent and parts of eastern Africa. It is a medium-sized tree, growing straight up to 20-meter-tall, with a trunk diameter varying from 10–15 cm. The leaves are 1.5–2 m long usually present in the top region of the tree. The tree bark is usually narrow and grows vertically, with a medium soft trunk and isn't rough like other tree out barks. The trunk diameter varies constantly from the bottom narrowing towards the top.

Global production of areca nut estimated to be around 10.33 lakh tones and constituted an area of around 8.29 lakh hectares back in 2009-10. India holds is the first place globally when it comes to both land area (47% of global) and production (47% of global production) of areca nut. India's average productivity is on par if not a bit higher with when compared globally and stands at 1.27 tones/ha.

Reasons for choosing Areca nut tree harvesting machine for study.

India earns most of its lively hood by agriculture. India ranks second in worldwide in agricultural output. Agriculture accounts to 10% of our annual GDP and it provides 50% of work to the citizens of our country. Areca nut is a mostly grown in south India and is a widely grown crop to grow in states like Karnataka, Kerala and various other states. Though there has been a lot of development in the agro industry when it comes to various machinery used in all the stages of farming, there isn't much development in terms of machines used in the areca nut industry and it still continues to depend on traditional methods and primitive tools for harvesting. But the motivating factor that led us to choose this field and come up with a better solution to existing problem is that we wanted to do our bit to society and help in whatever little way we can by giving farmers a cheaper and a more practical and economic alternative, thus reducing the stigma that farming is more of a burden than a profit-oriented profession.

LITRATURE SURVEY

Areca nut harvesting season comes once a year, but is split over the course of few months where in harvesting is done four times per tree. The most widely used process is to use manual labor to harvest the nut. In this process a skilled worker has to climb the tree with a cutting tool and harvest one tree and then he jumps to the adjacent tree. It is said that one worker can harvest up to an acre a day i.e. 400-500 trees. The main issue in this process is lack or scarcity of labor and the cost of labor per day. The process of harvesting is very laborious and requires a lot of man power as they have to manually climb the tree. Due to this the younger generations are not taking up this work or looking for more lucrative stable and safe professions. This along the increase in the number of people planting areca nut crop is resulting in high demand but acute shortage of labor.

Fig 1 Man harvesting the areca nut

Economics of Present-day Harvesting

The cost of labor varies from Rs1000 to Rs1500 per day for the person who climbs and cuts the areca nuts and Rs500-750 per person who comes to collect the fallen nuts and put them in rags. They come in groups of 4-5 members, with 1 person climbing up the tree to cut and jumps from one tree to another and couple of people to collect the fallen nuts and bag them and few more to carry the bags. This comes up to around Rs2500-3000 a day wherein they can do up to an acre. Thus, the cost of harvesting per acre is almost around Rs3000. This in turn is done 4 times a year per acre, thus making it an expensive affair. More over keeping in mind that any little accident due to slip can result in fatality of the person climbing the tree; traditional process proves to be very unsafe. And in the event of a fatality all the expenses and compensation are usually taken up by the landowner.

DESIGN

The first main set of challenges were to come up with an idea for a mechanism that is simple and feasible to manufacture, easy to operate and service, and quick to mount on the tree and yet economical to manufacture.

1. First Phase of Design

It is a device which has a circular frame work with retractable arms to make the accent of a tree. The first design iteration had a circular plate with a simple locking mechanism. This concept gave the device a feature of a quick attach and release from the tree. The design had two large rollers which were powered by the motors to make the accent of the tree. It had small rollers housed in an assembly for orientation and adjustment of the device.

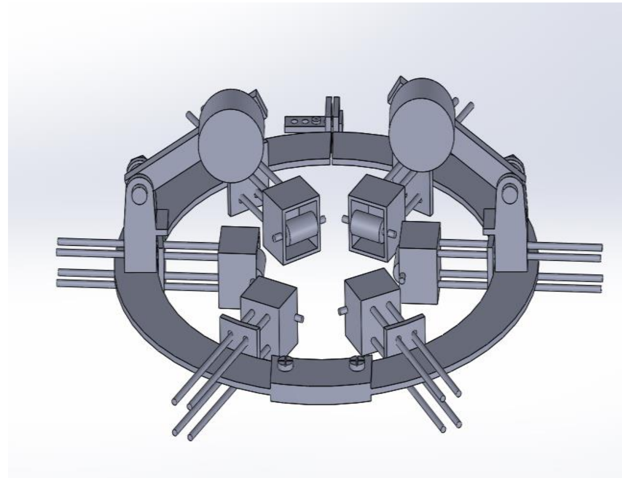

Fig 2 ISO View of first design iteration.

2. Second Phase of Design.

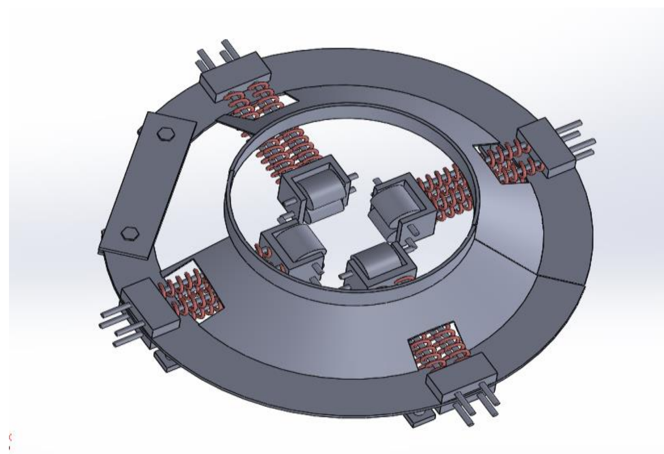

Fig 3 ISO view of second design iteration.

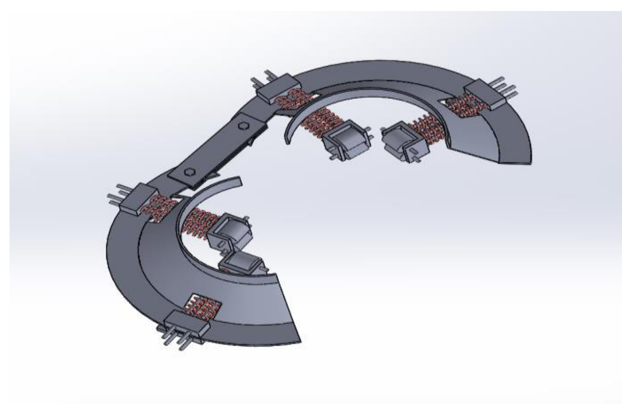

Fig 4 ISO view of opening and closing mechanism.

Problems in the first iteration were fixed in the second. The two large rollers were removed. The device was now powered by the rollers in the roller assembly and compression springs were designed. A new cutting blade was developed for harvesting. The new mechanism proved promising and had better orientation and easy deployment of power by the motor.

CALCULATIONS

Weight Calculation

Frame:

- Area= $\pi(R^2 - r^2)$ .... (1)
  R= Outer radius of frame (cm)
  r = Inner radius of frame (cm)
  Area= 439.60cm^2

- Volume= A x T ....(2)

  A= Area (cm$^{2)}$

  T= Thickness (cm)

  Volume= = 219.8cm^3

- Mass= ρ x V ....(3)
  P= Density of Material (mild steel) (g/ cm^3)
  V= Volume (cm^3)

Mass= 1.725 Kg

Movable Arms:

- Cylindrical Rods

Volume= $\pi R^2 l$ ...... (4)

R= Radius of the Rod (cm)
l = Length of the Rod (cm)

Volume= 11.55cm^3

Mass= ρ x V = 92.443gm

Mass of 16 Rods=1.386 Kg

- Roller House

Volume= (WBH-wbh) ...... (5)

WBH= Volume of outer block

wbh = volume of inner hollow block
Volume=20.71 cm^3

Mass= ρ x V

Mass= 161.616 gm

Mass of 4 Roller housing = 646.464 gm

- Motor =500gm

Mass of 4 motors = 2Kg

Total Weight of the machine without springs = 5.7575 Kg

Estimated weight of the Machine = 6 - 6.5 Kg

Spring Calculations:

After Various trial and error calculations, where in we saw that the entire spring calculations depended upon either the number of coils or amount of minimum deflection, where in we had a minimum number of number of coils, which when exceeded would not allow for further compression, we had to do trial and error on the minimum value of deflection at minimum diameter and with maximum load.

1. Deflection= $Y_{min =}$1.6cm

   Y_{max} = 5.5cm.

2. Free Length= 9.5cm
3. Number of turns=17
4. Number of turns=4.25cm
5. Spring Index C=6
6. Spring Constant= K = $\frac{4C-1}{4C-4} + \frac{0.615}{C}$

   K= 1.2525

7. Shear Stress= τ = 8FDK/πd^3

   (τ) max= 210 N/mm^2

8. Nominal Shear stress= τ = 8FDK/πd^3

   (τ) max= 210 N/mm^2

9. Wire Diameter= d = 2.36mm

   Approx. 2.5mm

10. Mean Diameter= 14.8cm Approx. 15cm

3. Third phase of the design

Some flaws were found in the phase two design and a component was re-designed.

Problems

1) It was found that the sliding roller hosing was creating more friction than expected.
2) The roller housing assembly slides at an average distance of 10cm from the main frame. Therefore, force acting at the roller end including the motor was excess. Hence the roller assembly arms might buckle under load.

Linear motion ball bearing was designed and incorporated into the main frame. The ball bearing reduces the friction and helps in easy motion of the roller assembly.

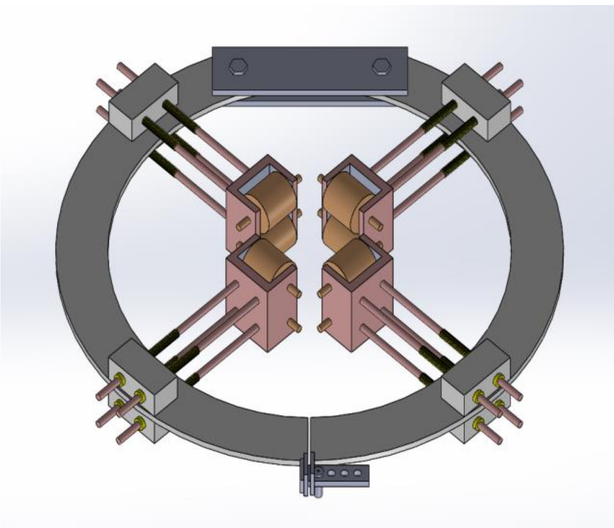

Fig 5 view of the prototype with LMBB (yellow colored rods on the rods are LMBB)

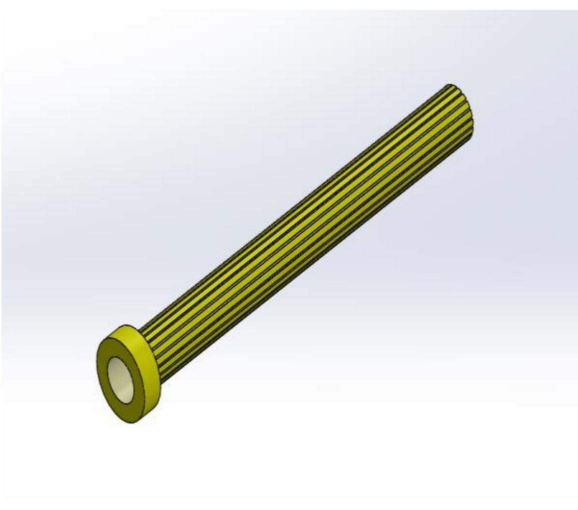

Fig 6 ISO view of Linear motion ball bearing (LMBB)

4. Fourth phase of design (FINAL)

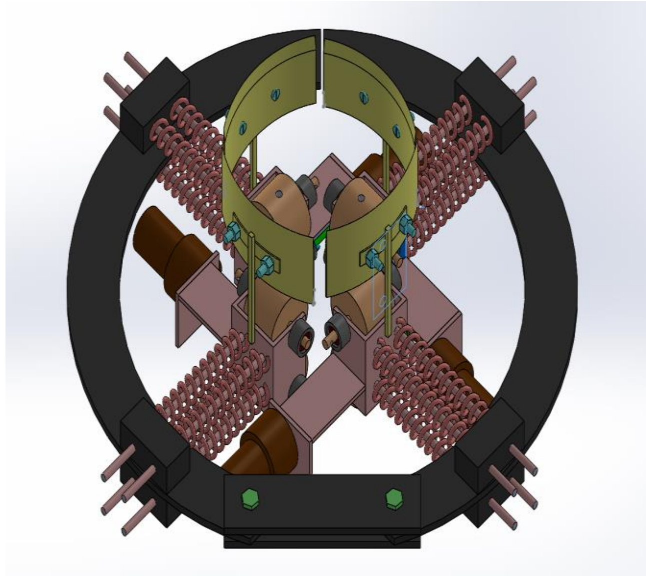

Fig 7 View of final prototype design.

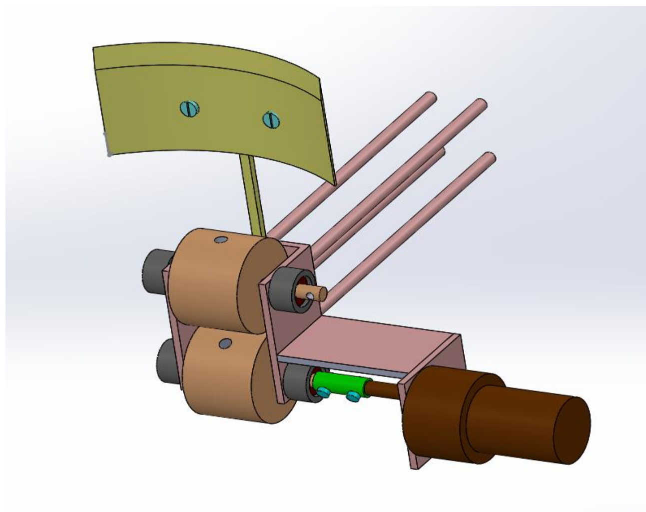

Fig 8 Redesigned Roller house which also houses the new cutter

All the final details such as motor, motor mounting and alignment, coupling, power transmission were taken into account to get the finished end of the line design. The Cutter Design that was present in phase 2 of design was removed and a new simpler and sturdier design was done which can be fabricated easily and replaced and sharpened easily and also is dynamic, i.e. moves and adjusts along with the diameter of the tree.

WORKING OF THE MACHINE

- The latch is removed and basket is opened, and the frame is wrapped around the tree, and the springs get compressed, and the frame is then locked.
- A button is pressed which closes the circuit there by making sure that the motor spins in anti-clockwise direction thereby spinning the wheel and track belt, thus making the machine move up the tree
- The button is held until the cutter blades reach the lowest bunch of nuts and it thrusts up and cuts them, as soon as they are cut, thumb is removed from the button thereby stopping upward movement and preventing damage or cutting of pre-mature areca nuts.
- Then by pressing another button the polarity is reversed in the circuit and the motors spin clock wise direction and the machine comes down along with the harvest.
- All of the above is run circuitry is powered using a 12V DC battery and capacity ranging from 6.5AH to 15AH depending on the user needs and budget.

Fig 9 View of prototype climbing a Areca tree

Fig 10 View of Prototype harvesting a areca branch.

CONCLSUION

The prototype climbed the tree and harvested the dried and ripe areca branches. The results were satisfactory with a huge scope for improvement and up gradation. The prototype was found to be effective and very robust. The electrical connections made were optimized to reduce the number of wires which the prototype had to carry. Since the battery is at ground level it allows for more effective control.

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