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Review on Design and Analysis of a Multifunctional Cutting Machine for Agricultural Uses

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Abstract-

The operation of traditional farming methods requires farmers to spend their entire workday which leads to either slow progress or a lack of workers. The development of an agricultural cutting machine which provides multipurpose capabilities enables farmers to boost their work efficiency while simplifying their farming tasks. Automated systems face adoption challenges in rural areas because of their expensive price tag and limited equipment availability which prevents farmers from using these modern technologies. Rural areas cannot implement new technologies because they face two main obstacles which are high expenses and restricted access to resources. The project consists of three agricultural automation processes: The system includes three mechanisms which operate Sugarcane Seed Cutting through a motor-driven gearbox that transforms rotary motion into reciprocating motion for accurate cutting purposes while Groundnut Stripper uses its rotating shaft and cylinder system to extract groundnuts from their original plant locations and Straw Cutting functions through its circular ring system which drives rotating blades to cut straw into fine pieces through a belt-driven motor system. The equipment uses high-speed grass stem cutting technology which features self-sharpening blades that can be adjusted together with a safety guard to provide efficient and secure agricultural trimming operations. The design provides essential functions through its simple structure which maintains low production costs while enabling farmers to operate the system with basic operational skills. The machine improves work efficiency through its ability to save time and decrease waste while providing advanced technological capabilities to solve major agricultural sector problems.

Keywords: *Sugarcane Seed Cutting, Grass Stem Cutting, Groundnut Stripper, Solid Works, ANSYS, Finite Element Analysis, Static Structural Analysis etc.*

1. Introduction

Agriculture is one of the most vital sectors of the Indian economy, serving as the primary livelihood for nearly two-thirds of the population. Agricultural activities occupy about 43% of India's land area while generating 16.1% of the nation's GDP. The sector faces critical obstacles because it experiences labor shortages that occur during its most active times. The issue is made worse because non-farm jobs provide better pay which leads workers to leave their agricultural jobs to work in cities because they believe farming has lost its social value. The expansion of cities has reduced the amount of land suitable for farming so farmers must now implement agricultural mechanization as their only option to achieve better productivity results. The use of contemporary farming methods together with mechanized tools offers farmers a valuable chance to solve their existing difficulties and boost their farm production [1][2].

India produces various important agricultural products, with sugarcane, straw, and groundnut being among the most significant. The sugarcane industry serves as a vital component of India's agricultural sector because the country produces approximately

300 million tons of sugarcane each year which makes it one of the top sugarcane producers worldwide. The planting process involves cutting sugarcane into smaller segments, each containing 2-3 seeds, and then sowing them into moist soil. The traditional method requires more than three times the manpower needed for other methods. Approximately 4 million farmers together with agricultural workers participate in sugarcane cultivation which accounts for 7.5 percent of the rural workforce. Straw cutting serves as a vital agricultural method which farmers use to prepare their fields for maize and Jowar planting. Farmers use the remaining maize straw which measures 150 to 200 centimeters to create smaller pieces which they feed to their livestock including buffaloes and cows and oxen and goats. The manual cutting process for straw becomes difficult because it requires machines to achieve better productivity. Farmers need to spend considerable effort to separate groundnuts from plants because it stands as another important agricultural crop. The procedure requires 20 to 30 workers to manually separate groundnuts from one acre of land because it needs extensive time and effort to complete. The use of mechanized equipment for agricultural work operations would decrease the need for workers while boosting work output [3][4].

A. Sugarcane

India, a leading sugarcane producer, yields 300 million tons annually. Sugarcane requires traditional planting methods which demand workers to cut the plant into 5-6 segments that contain 2-3 seeds. Approximately 4 million growers and agricultural workers, forming 7.5% of the rural workforce, are involved in sugarcane cultivation and related activities.

B. Straw Cutting

Farmers cut straw into small pieces which they use as livestock feed for buffaloes and cows and oxen and goats because the initial measurement of the straw pieces is 150-200 centimeters. Groundnut farming in India involves labor-intensive manual separation which demands 20-30 workers to work on each acre of land and results in extremely lengthy operations.

C. Groundnut

Groundnut farming in India involves labor-intensive manual separation which demands 20-30 workers to work on each acre of land and results in extremely lengthy operations.

D. *Grass Stem Cutting*

A grass stem cutter with a high-speed DC motor and sharp blades offers efficient, precise cutting. The product has adjustable blade height and self-sharpening blades and a safety guard and portability features. DC power enhances mobility, making it ideal for trimming grass, weeds, and residues.

The project goal is to create a multipurpose cutting machine which will solve these existing problems. The machine integrates sugarcane seed cutting, groundnut stripping, and straw cutting into a single system which enables small-scale farmers to operate their business more efficiently while keeping their costs down.

2. Problem Statements

- The agricultural sector currently deals with a major labor problem which worsens during its busy periods because more workers choose to move to urban areas and take better-paying jobs outside of agriculture.
- The traditional approach to agriculture requires farmers to dedicate excessive time and resources for complete procedures of material installation and field operation through manual work.
- The high expense of advanced agricultural equipment prevents small-scale and marginal farmers from purchasing essential farming tools.
- Rural farmers face two main obstacles with modern farming technology because they lack knowledge about it and they cannot access its modern equipment.
- Urban areas grow rapidly which results in reduced farming space that requires farmers to adopt more effective agricultural techniques.
- Farm equipment needs optimization to safeguard against breakdowns which result in business losses and operational interruptions.
- There is a necessity to develop and test agricultural equipment using Finite Element Analysis (FEA) to

improve durability and performance before field deployment.

3. Literature Review

Prof. Dipak U. Adhapure, et al [1]. In this paper, we have studied the one alternative to reduce the mass and improve the quality of seed for sugarcane would be to plant excised axillaries nodes of cane stalk, popularly known as node chips. These node chips are less bulky, easily portable and more economical material. The node chip technology holds great promise in rapid multiplication of new sugarcane varieties: The problem of establishment and initial growth could be addressed by application appropriate plant growth regulators and essential nutrients. Construction of the sugar cane eye cutter is simple pedal operated machine is used in this sugar cane node cutter. Through the development of sugarcane node cutting machine, slicing the inter- node is made possible, sugarcane stalk can be utilized which is considered as wastage in traditional method.

Krishna Prasad et al [2]. In this paper, the semi-automated sugarcane node chipping machine is fabricated and assembled as per the proposed design. Through the development of sugarcane node cutting machine, slicing the inter-node is made possible, so that nearly 1.8 tons of sugarcane stalk can be utilized which is considered as wastage in traditional method. With the development of the sugarcane node cutting machine the workload on the labour is reduced and the productivity increased. The sugarcane node cutting machine based on the required consideration and objective is made ready with all the required connection and support on the mild steel frame. The outcome of the fabricated machine is to separate the buds from the sugarcane stalk. In the traditional way of plantation, nearly 3 tons of sugarcane is used for plantation per acre. The sugarcane with 2 to 3 buds known as seed is planted continuously. In this traditional method, nearly 1.5 tons of useful sugarcane stalk is being wasted per Acre for plantation.

Suraj S. Magdum et al [3]. In that machine, we are using a platform, hemisphere chipping knife of GI pipe and roller follower with a simple harmonic motion belt drive used for speed reductio. It is used to chip out the node from sugarcane for sowing purpose. Most of the machines available are using flat cutters that separate the node completely. But in this project using two hemisphere chipping knifes which provides gentle cutting of node without extra loss of sugarcane during sowing. G 1 cutting Blades are using to cut the buds. Blade tip used is sliding which will give a smooth cutting and increase the blade life. The cam and roller follower transmit the rotary motion of gear shaft in to a reciprocating motion of the cutter. The machine is powered by electric motor. Cutting speed can be calculated as per our motor and reduction gear boxes. Large number of buds can easily be chipped off in this way in a short period of time. They are using two cutters to double the capacity than that of single bud chipper machine. By this sugarcane bud chipper machine, we can separate 30 buds of piece within one minute time, away that it can handle various sugarcane sizes and diameter.

Sanjay Patil et al [4] studied that Sugarcane planting with traditional methods is costly, time-consuming and necessary compression of buds in the field is not achieved easily because of stalk planting in sugarcane. In tradition planting method, great human forces and high volume of sugarcane stalk in hectare are required. To solve this problem and mechanizing of sugarcane planting, we suggest the application of machine vision system and Image Processing methods to identify nodes from sugarcane and to plant it as a seed by planting machines.

Ashish S. Raghtateet.al [5] designed and fabricated a groundnut sheller machine. It is very cheap and five experiments were performed with peanuts. Since this machine is made for small businessman or for farmers, therefore the work carried out by this machine is less. The decocting process of groundnut by this machine is more economical and faster than manual process or any other processes. "GROUNDNUT SHELLER MACHINE" will save the tremendous time, energy manpower and save financial input of the project, reducing the cost and time considerably which is the backbone of the present world economy.

Javeed Basha et. al. [6] has fabrication and performance test of an ultraportable crop cutter. To increase the productivity and profit. How to cutting reduce the cost and how to solve the problem comes from workers. It is fabricated for cutting various crop varieties during the time cutting.

Adarsh J Jain et. al. [7] has designed and fabricated a machine whose production capacity is more & machine gets operated on 1 H.P. electric. The fresher and small farmer or business man can start business by investing less capital. groundnut decorticator consists of feed hopper with a flow rate control device, shelling unit, separating unit and power system.

Abel Roy J. et. al. [8]. In this research work was made to investigate the cutting energy and force required for the pigeon pea crops. The commercially available blade it has been attached to the lower end of the arm of pendulum type dynamic tester which cut the stalk at 900 to the stalk axis with knife velocity ranging between 2.28m/s to7.23 m/s the diameter of stem at 42.6 % (w b) moisture content. The cutting force I directly proportional to cross sectional area "stem cutter was design.

Research gap :

The different parts of agricultural machinery were studied to determine their practical uses and to test different theories which were used to develop sugarcane seed cutting machines, straw cutting, and groundnut stripper machines which were previously discussed. Agricultural work has provided essential support to Indian society and its economy since ancient times and this connection will continue for many more years.

To ensure safe operation of agricultural machinery we must conduct an assessment of the equipment which requires us to test how much stress and strain and deflection the machine can handle during its normal operation. The research team will test the machine components by developing a CAD model which will be analyzed with ANSYS software to determine stress points and material strain limits and to evaluate safety levels and structural performance under static conditions, which will help detect all stress points and material deformation before product assessment starts to prevent future testing breakdowns.

4. Research Methodology

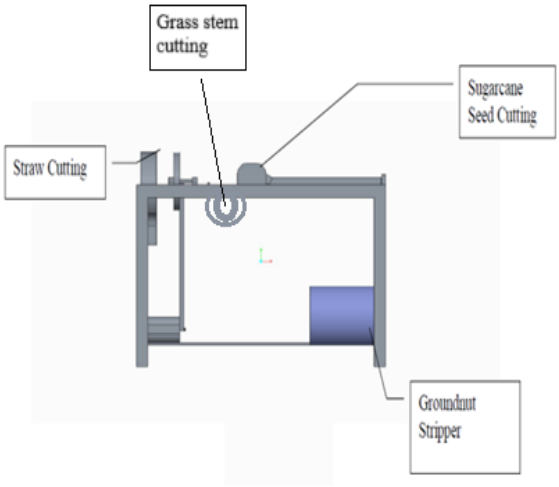

Fig.1. Schematic Diagram

A machine was created through my design and construction work which enables users to execute three specific tasks. The machine components will be installed onto a strong framework. The wheels will be attached to this frame because it serves as a multipurpose cutter machine which operates in various environments.

A. Sugarcane Seed Cutting

The single-phase motor starts to run at 1400 rpm which it decreases to 700 rpm through a belt and pulley system. The speed decreases to 23 rpm because of the gearbox which has a 1:30 worm and worm wheel ratio. The gearbox connects to a cam which transforms rotary motion into reciprocal motion that drives the cutter. The cutter advances to cut sugarcane which workers manually feed into the machine. The cutter releases sugarcane sprouts during the return stroke which get collected into a collector. The system efficiently transforms rotational motion into reciprocal motion which drives the cutting process.

B. Groundnut Stripper

The system includes a hollow cylinder which facilitates the attachment of a rod through its outer edge. The electric motor which is connected to the external power supply transmitted to the shaft. The

system uses a rotating shaft which is supported by a roller cylinder. The system delivers groundnuts through a process which uses rotating blades to remove the plants while shelling the nuts.

C. Straw Cutting

The system contains two blades which are fixed inside a circular ring that connects to the motor through a belt drive. Straw will be cut into small pieces by the blades which rotate.

D. Grass stem Cutter

The grass stem cutter operates through a high-speed DC motor which powers its self-sharpening blades to perform efficient precise cutting. The product provides better user experience through its adjustable height feature, safety guard system, and lightweight construction. The device operates on DC power which enables users to move freely from one location to another while using it to trim grass weeds branches and all types of plant residues.

The machine will include a hopper system which contains a high-speed cutter that operates through a motor which delivers 10,000 RPM. The new system will effectively chop agricultural crop stems which will enable the machine to process multiple crop types while boosting its productivity.

5. Components Specification

Power Source (Motor):

- The electric motor is an electric machine used to convert electrical energy into mechanical energy, for
- smaller loads such as in domestic applications. Although traditionally used in fixed speed services, induction motors are
- increasingly used with variable frequency drives in variable speed services. Power of motor= 1 hp. Speed of motor 1400 rpm.

Gearbox:

- A gearbox is used to reduce shaft speed and control rotational movement, increasing torque by lowering the output shaft speed.
- This mechanical advantage enhances torque while reducing speed. Some gearboxes, like helical and worm gear systems, transmit output power efficiently. A worm gearbox, smaller than a spur gear, has its shafts positioned at 90° to each other. With one revolution of the worm, it advances a single gear tooth.

Shaft:

- A solid shaft rotating at 1440 rpm is assumed to be made of mild steel. A Shaft is a rotating element, usually circular in cross section, line shaft is used to transmit power from one shaft to another, or from the machine which produces power, to the machine which absorbs power.

V-Belt Pulley:

- To transmit power from motor to cutter blade shaft this V pulley is used. V belt drive arrangement is used to transmit power from motor to shaft which is connected to cutter mechanism.
- The use of V-belts in multiple, allowed drives with a much variable range of power capacity than ever before obtainable using single belt drives.

Universal Join:

- A universal joint is a joint or joint that connects rigid shafts whose axes are inclined relative to each other. It is commonly used on shafts that transmit rotary motion.

- It consists of a pair of hinges placed close together, oriented at 90 ° to each other, connected by a transverse axis.

Pedestal Bearing:

- It has two Pedestal bearing are extensively used for furnishing support for a rotating shaft with the help of compatible comportments .
- It's used for long shafts taking intermediate support.

Clutch:

- Clutch is used to allows motor power to be applied gradually when a groundnut stripper is starting out it is operate manually by lever. It is connected to the shaft.

High Speed DC Motor & Cutter Blade :

- The cutter /Blade is attached to High power RPM motor. Enough to cut crops.
- It has RPM up to 10000 apro.

- With the help of high speed motor , we can easily harvest the crops.
- As cutting of crop is more easy & low cost for farmers with this technique.
- The cutter blade is size upto 6 inch , easily to cut big crops also.

6. Advantages, Disadvantage and Application Of Machine

A. Advantages

1) Labour cost is reduced.
2) Wastage of sugarcane is reduced
3) Easy in construction.
4) Easy to maintain.
5) It reduces time.
6) It does not create air pollutant.

B. Disadvantage

1) Machine is heavy weight.
2) Machine creates more noise.

C. Application

It is used in agriculture sector.
It helps institutions such as the agricultural university, the agricultural university and, in School children to learn about the agricultural operation of farmers.

7. Conclusion

The robust multi-purpose cutting machine combines three separate functions into one device. The machine helps to solve labor shortages because it speeds up work processes while requiring less staff to run the equipment. The system executes multiple tasks which lead to decreased time spent on work activities. In sugarcane seed cutting, the waste produced from sugarcane can be managed and the cut seeds become easier to sow. The peanut shelling operation requires only two jobs to separate peanuts from the plant using this machine, which produces better results than traditional methods that need 10-20 jobs per acre. The rice husking operation will use conventional techniques to extract rice from grinding waste materials. The machine produces less waste, and it requires only two workers to complete tasks that normally need five to six workers during the shortest period. The machine will help farmers reach their maximum output capacity, which will allow them to solve their employment issues and create more job opportunities. The cost of work decreases while the execution process becomes simpler and quicker to complete.

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