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Design and Development Of Agricultural Waste Shredder Machine

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Abstract
The scope of this project was to design and development of Shredder machine focus on chopping of coconut leaves, areca leaves, this chopped powder to prepare the vermin compost. The project began with collection of information and data on user lifestyle and current process by which they perform their job. Concepts was developed with reference of four different shredder machine and operating processes. Concept was developed considering the safety factor users operating environment and maintenance. Considering the users' needs and buying capacity, a prototype was fabricated. The machine consists of single-phase motor, spur gear, bearings, structural frame, cutter and dual shaft. The machine frame is built using mild steel and tungsten carbide is used for cutter tip preparation. Eight cutters are mounted on two shafts, which rotate parallely driven by a spur gear. The power from the electrical motor is transmitted to cutter shaft through a belt drive. Cut is made inside the chopping house due to the effect of tensile, friction, and impact effect in chopping process. The coconut leaves get chopped and powder is collected at the bottom.

Keywords: Agro waste; shredding machine; Cutter; spur gear, Single-Φ motor, shaft, Compost.

I.INTRODUCTION

The conventional agro-waste disposal is a traditional and oldest method of waste disposal in which agriculture wastes are dumped as it is to degrade in a particular place for decomposing. As the wastes are dumped as such, it takes more time to degrade and it causes environmental pollution. The waste shredder machine aims to reduce the agro waste and convert it into useful nourishing fertilizer. Agriculture is one of the most important sectors in the Indian economy. Coconut palm cultivation is one of the major livelihoods of farmers of Kerala and Karnataka. It has been realized that large quantity of agricultural wastes remains being unutilized because handling, storage and management related difficulties. The reasons are their low bulk density, large area/volume for storage. The farmers on the field burn most of these wastes after the harvesting of crops. Thus the agricultural waste burning phenomena is being repeated every year. In order to use these wastes for some economic benefits, so the necessary of such machine was felt to utilize all kinds of agricultural waste after shredding, which could be economical and practicable.

II.LITERATURE REVIEW

Agriculture is now one of the most important sectors it plays a vital role Indian economy. In order to further develop this sector technology has become one of the main components. Typically, dealing with the agriculture sector can entail difficulties relating to a number of factors. Consequently, to overcome such problems, farmers are being encouraged to adopt innovative technology that suits their farm. Survey was carried out through product study, market study, literature

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review and user study etc. Quality function deployment (QFD) was prepared were the customer voice were converted into technical voice. Detailed product design specification (PDS) was created as per the data's from QFD.

P.B. Khope et al, Proposed the Design of experimental set-up for establishing empirical relationship for chaff cutter energized by human powered flywheel motor. This machine used to chop the forage into small pieces for easy consumption by the animals. In the human powered flywheel motor concept, the bicycle mechanism for converting and transmitting human energy through paddling to rotational kinetic energy of flywheel is hereby proposed. The energy stored in the flywheel can be used for actual cutting process. The driver paddles for 1 minute and it was noticed that the flywheel shaft reached a speed of 350 RPM with a gear ratio of 1:2. The paddling was stopped after one minute and the set-up was checked for its free running. The flywheel shaft came to rest after 25 minutes. It proved that the alignment of bearing and other parts of the experimental set-up was satisfactory[4].

Ajinkya s. Hande et al, in their research work carried out project on Methodology For Design & Fabrication of Portable Organic Waste Chopping Machine.Organic waste is fed uniformly through feeding drum and tray. Then the Shaft rotated at 1440 rpm through electric motor by means of pulleys makes the chopping drum to cut the waste by the effect of impact shear obtained from the shearing blades. The cut is also made inside the chopping house due to the effect of tensile, friction, and impact effect in chopping process. Then the cut pieces pass through the concave holes of the sieve & come out of the machine. The sieves of different sized holes can be used[5].

Kishan Naik et al, they are focused project on Fabrication of areca fiber extraction machine. This is basically removing fiber from areca husk. This machine consists of 3 phase 5 hp ac motor which is directly coupled to driven shaft. The driven shaft is enclosed in a casing which is designed in such a way that only dust is removed and fiber comes out of rectangular duct at lower side of casing. The driven shaft is supported by two bearings and has blades which are designed by modifying the blade design of coconut husk decorticating machine. The areca fiber obtained was of good quality with diameter varying from 0.39 ± 0.12mm and length varying from 5-6cm. Thus this machine will be helpful for rural entrepreneurs and farmers[6].

Y. Prashant et al, they carried out a project on Design and Develop a Coconut fiber extraction machine for small scale coir industries. In this machine ¼ HP Single phase AC motor, heavy duty, is attached at the base, smaller pulley at the motor end gives drive with the help V-belt to bigger pulley at the other end of the driven shaft gear are connected, hence one gear will give drive to other gear, so barrel rotates in opposite direction at speed of 240 rpm. Coconut husk is fed from one end in between barrels and round coconut shell is moved automatically towards other end and separated fiber material is collected in sack below. In this concept cutting pins has been press fitted on indexed hole on barrel surface. Cutting pins helps to remove fiber and to give linear motion to coconut shell to exit. Cutting pin indexing angle and distance plays the major role to extracting the coconut fiber[7].

S.Nithyananth et al, they are developed a Design of waste shredder machine. The waste shredder machine is an attachment as like a ploughing attachment. Shredder can be operated with a Tractor – power take off shaft (PTO).The Power from the Tractor – 35 HP and above - is transmitted to the shredder assembly. The Assembly consists of one fixed blade and five circular blades. The organic matter shredded will be in small pieces to enable the farmer to make use to prepare for vermin Compost[8].

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III. Scope of shredder machine

Literature study is carried out based on various existing shredder machine, and field survey it is observed that labour is widely used for chopping agro waste, and cost of the existing machine also expensive some of the machines are operate by manually it enhances the human fatigue to overcome these difficulties to design the machine using electric power. While designing the machine safety factor also considered such as covering the belt and pulleys, and gears.

IV. Flow chart for agricultural waste shredder machine

The figure 2 shows the assembly procedure of coconut leaves shredder. Quality of the material has been checked at purchase level to meet the design needs. In this step a skeleton of the section is fabricated according to dimensions mentioned as per the design

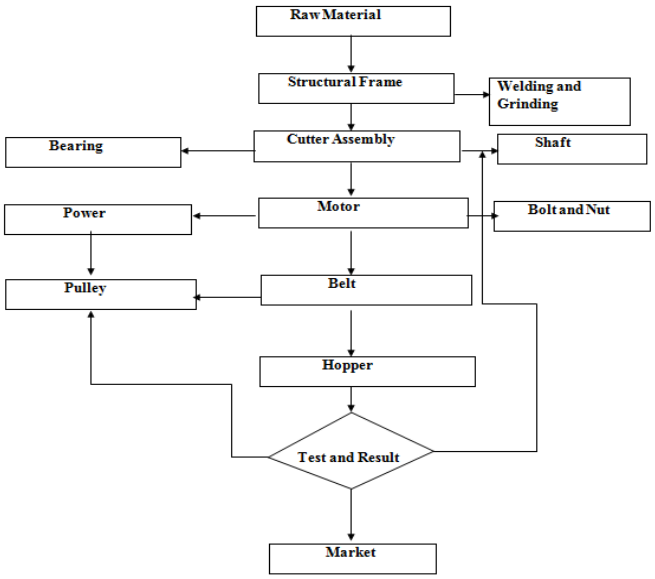

Fig 1: Flow Chart for Agricultural waste shredder machine

In this step a skeleton of the section is fabricated according to dimensions mentioned as per the design. Frame is fabricated according to specified design and material. Then move on to cutter assembly here first to prepare the cutter container after that inset the shaft then cutter are mounted on shaft with key and spacer be ensure all the cutter tightened are not otherwise cutter may cause damage and also it create more noise and vibration. Motor has been mount on the other side of the frame with help of bolt and nut. Hopper can be mounted on the cutter assembly to feeding of coconut leaves properly. Then mount the pulleys and v- belt to set the belt proper tensioning otherwise slipping of belt occurs. Finally all the assembly work is done machine is ready work.

IV.PRODUCT DESIGN SPECIFICATIONS (PDS)

Product Design Specification will give clear idea for the designer to understand the required specification to design the product. Based on the QFD results, which are derived from the vendors and customer voices market study, user study, PDS will be generated. Here are some of the major criteria considered for product design specification as shown in Table 1.

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Table1.Product Design Specification

SL. No	Description	Specification
1	Name	Agricultural waste shredder machine
2	Mechanism	Gears and Pulley with belt drive
3	Target Customer	Farmers
4	Shredder Process	Motor operated
5	Material	Plain carbon steel for Shaft, Tungsten carbide for Cutting tips, Mild steel for Structural frame
6	Manufacturing	Machining, Indexing, Bending and Fabrication
7	Safety	Avoid sharp corners, Safety guards
8	Cost	Approx. 17000/- INR
9	Life of the product	5-8 years
10	Motor Specification	2 HP Single phase AC motor, 1440 RPM
11	Bigger Pulley diameter	6" (6-B single)
12	Smaller Pulley diameter	2" (2-B single)
13	Spur gear	PCD=112mm, 4 module
14	Bearing	UCFL205 D1
15	Pulley Ratio	1:3
16	Working RPM	550 RPM
17	Weight	60 KG
18	Production Rate	80-90 kg of coconut leaves powder per hour

V. Requirements and design of Agricultural waste shredder machine

Motor, Bearings, Shaft, Cutter, Frame, Hopper, Spur gear,

C. Cutter

Cutter is act as a weapon in shredder machine, used to cut, nurture and finally produce the powder from the coconut leaves. Its density notifies the level of nurturing it can be done to the input. Cutter tip made from Tungsten carbide is a composite material manufactured by a process called powder metallurgy. The term "cemented" refers to the tungsten carbide particles being captured in the metallic binder material and " cemented" together, forming a metallurgical bond between the tungsten carbide particles and the binder (WC - Co), in the sintering process

Cutter Specifications

1. Outer diameter of cutter =150mm
2. Inner diameter of cutter= 32 mm
3. Number of teeth on cutter = 6
4. Thickness of cutter = 25mm

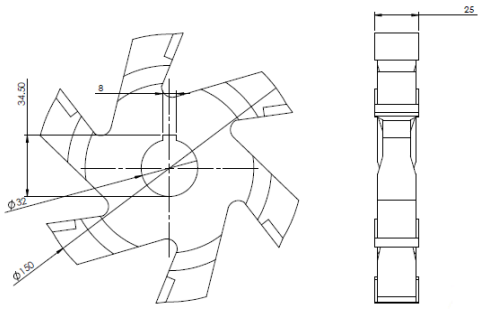

Fig 4: Drawing of cutter

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VII. Design calculations

Cutting force =190 N are taken from reference of wood cutting machine as mentioned in Doctoral thesis,(Lulea University of Technology, Graphic Production 2013)
Cutting force F_C = 190+1 Kg/ Cutter × 9.81
F_C= 205 N

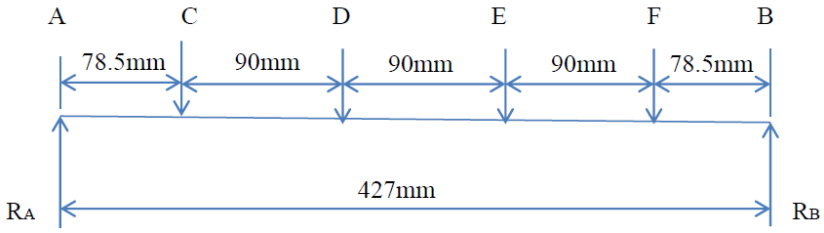

Fig 5: Free body diagram

R_B×427 = (205×78.5) + (205×168.5) + (205×258.5) + (205×348.5) + (205×427)

R_B = 615 N **R_A= 205 N**

Bending moment

M_A= 0

M_B = 0

Momentum= Force×Distance

M_C = 205 × 78.5

M_C= 16092.5 N-mm

M_D = 205 × 168.5

M_D = 34542.5 N-mm

M_E= 615 × 168.5

M_E = 103627.5 N-mm

M_F= 615 × 78.5

M_F = 48277.5 N-mm

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Max B.M at Point E = 103627.5 N-mm

Torque calculation

Power = 2 hp = 1492 W = 1.492 KW

$$T = \frac{60 \times p}{2 \times \pi \times n}$$

Where,

T=Torque transmitted by the shaft(N-mm).

p=Transmitting power(kw).

n= Speed of transmission shaft(rpm).

$$T = \frac{60 \times 1.492 \times 10^6}{2 \times \pi \times 550}$$

T = 28371.24 N-mm

$$d = \sqrt[3]{\frac{(16 \times \sqrt{[(K_b \times M_b)^2 + (K_t \times M_t)^2]}}{\pi \times \tau_{max} \times 0.75}}$$ ------From Design data hand book by K.Mahadevan Eq... (9.10)

Where,

Keyway factor = 0.75

Factor of safety = 3

Max bending moment M_b= 103627.4 N-mm

Max torque M_t Torque = 28371.24 N-mm

τ_{max}= Max shear stress(N/mm^2).

K_b= stress concentration factor for normal stress

K_t= stress concentration factor shear stress

$$\tau_{max} = \frac{\sigma_y \times 0.5}{fs}$$

Where,

τ_{max}= Max shear stress(N/mm^2).

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σ_y= yield stress.

fs=factor of safety.

$\frac{310\times0.5}{3}$= **33.3 N/mm^2**

σ_y=yield stress = 0.5× $u_{altimate=}$ 200 N/mm^2

For= Mild Steel u_{alt} =400 mpa

$$d = \sqrt[3]{\frac{16 \times \sqrt{[(1.75 \times 103627.4)^2 + (1.5 \times 28371.3)^2]}}{\pi \times 33.3 \times 0.75}}$$

Therefore d = 29.04 mm

Standard diameter of the shaft **d = 32 mm**

Fabrication and working principle

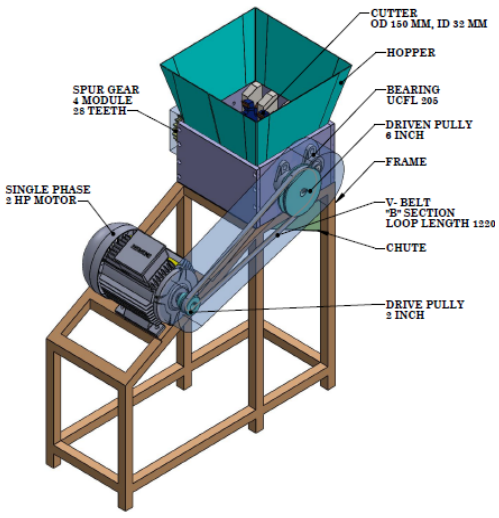

Fig6:3-D model shredder

Fig7: Developed model of Shredder machine

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Working principle gives us the functionality of the developed model. The developed model, acts as an electro mechanical which reduces the human effort as well as human intervention by utilizing the electrical motor for the cutting of leaves. The process is very much simplified as compared to the earlier processes. The machine is first connected to the 1-phase power supply. Cutters are mounted on dual shaft each shaft has 4 cutters. After that dry agro waste are fed through the hopper into the cutter assembly. As the coconut leaves moves towards the cutters, rotating at the speed of 550 rpm, the coconut leaves get chopped and chopped is collected on the other side of the machine.

Result and discussion

The developed model of coconut leaves shredder machine is subjected to performance test. The shredder machine performance was measured using of total quantity of powder chopped for different time duration. Machine has a capacity to cut 80-90kgs of coconut leaves, arecanut leaves powder per hour with considering allowances such as machine set up time, jamming of cutter assembly whereas manually to cut coconut leaves requires many labours and very time consuming. The performance test was conducted on the agro waste shredder machine developed to ascertain its suitability and function ability. The graph 8 shows Time V/s weight of powder. The graph clearly shows that the amount of powder collected with respect to time. The test is conducted for 4 different intervals of times.

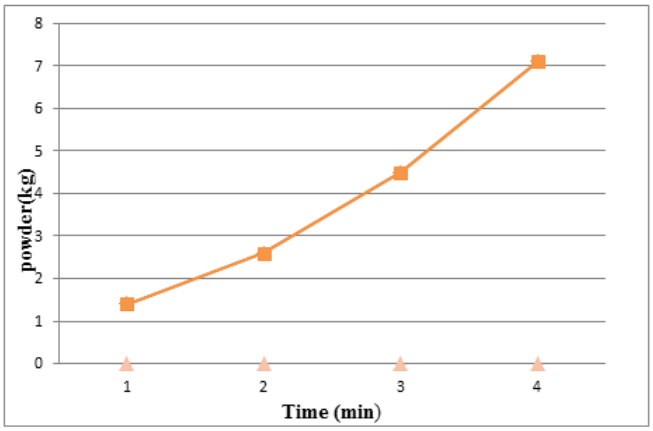

Fig 8: Graphical representation of time(min) v/s weight of powder(kg)

Conclusion

The following important point drawn from our project work as fallows

- The developed model is simple, efficient, requires less time and cost effective when compared to the existing available model.
- Importance is given towards user friendly in operation and mainly towards safety. The rotating elements like belt and pulley and gears are covered, so it is fully safety to operator
- The assembly was checked for its sturdiness and was found to be reliable.
- The overall performance of shredder machine was satisfactory by considering the quantity of powder produced with respect to time.

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