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Solid Waste Management – Compact Twin Shaft Shredder

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ABSTRACT
The key objective of the article is to design and build a small shredding machine that is conceptually designed with a focus on the production of dry leaves, areca leaves, chopped dry materials, and worm compost. This idea was produced by taking into account four slicing machines with various operations and operating procedures. The idea was designed with consideration for the customers' safety. A three-stage motor, bearings, cutter, structural frame, spur gear, and dual shafts make up the machine. High carbon steel, which is also used to make cutter tips and soft steel, is applied for making the machine's frame. Two shafts with sixteen cutters placed on them rotate parallel to the spur gear. The cutter shaft receives power from the electric motor through the belt drive. Tensile and friction inside the cutting house cause the cutting process. The chopped powder is gathered in a dish at the bottom after the dried leaves are chopped and reduced in size. It is simple to use and has a small footprint.
Keywords: Hexagonal Shaft, Blade, Spacer, Spur Gear, Shredding Machine, Agro Waste

Introduction

In many regions of the world, agriculture is the most intense business, producing a wide range of wastewater that needs to be treated and managed using several approaches. In India, the principal occupation accounts for 70% of the population. In India, many different crops are grown, but after harvest, crop wastes are burned or discarded without consideration for their nutritional worth. Sustainable agriculture not only balances population increase but also compels us to grow food sustainably.

Pesticides and fertilizers used in excess will lower crop yields and lower product quality. To preserve health and property, the natural equilibrium must be kept at all costs.

Agro waste, also known as agricultural waste or crop residue, refers to the by-products or leftovers from agricultural activities. It includes various organic materials that are generated during the cultivation, processing, and utilization of crops and animals in agriculture.

Agro waste can come in various forms, such as crop stalks, husks, shells, leaves, stems, roots, straw, chaff, and animal manure. These materials are typically considered waste ausasey are not directly used for food or feed purposes and are often left unused or burned in the field, leading to environmental and health issues.

However, agro-waste can also have potential uses and benefits. It can be utilized for various purposes, such as bioenergy production, animal feed, composting, soil enrichment, and pro-rod production-based materials. For example, crop residues can be converted into biofuels, such as bioethanol or biomass pellets, through processes like fermentation or pyrolysis. Animal manure can be used as fertilizer or converted into biogas through anaerobic digestion. Crop residues and agro waste can also be used to improve soil fertility and structure, reduce erosion, and support sustainable agricultural practices.

The core objective of the paper is to create a shredding machine that can produce tiny pieces of vegetables, leaves, and coconut leaves and turn them into fertilizer for crops. The hopper, spur gear, dual shaft, frame, motor, cutter, belt, and coverings are all part of this machine. The machine is constructed utilizing a tungsten carbide cutter and the cutting point of a light steel frame. A 10-HP power supply with 1 stage powers the device. The hopper of this machine is vertically inserted with leaves of coconut powder. The motor rotates at a predetermined speed of 1440 rpm. Maintain an about 120:1 speed ratio such that the belt and the shaft are driven at 520 revolutions per minute. Coconut leaves and vegetable waste are hacked and dried later for use as manure due to its strong rotating force.

EXISTING METHODOLOGY

The paper was made from bits of dried coconut leaves, which were then composted. The disposal of traditional and ancient trash, in which agricultural waste is degraded, is known as traditional agro-waste disposal. Waste is thrown away; thus, it takes longer to disintegrate and as a result, it could harm the ecosystem. By using the crumble machine, less agricultural waste will be needed as fertilizer. The cutter, mounted on the dual shaft, fixed to the motor base, and the V-belt, which is supported by a large pulley connected to the small pulley gear at the end of the motor, are the key components of a little piece of machinery, according to the knowledge acquired about it. The barrel revolves in the transmission because one gear drives the other gear.

To establish the experimental relationship for a motorized chaff cutter powered by a flywheel motor powered by a human, the authors developed an experimental setup design in. The main purpose of this machine is to chop up food so that animals can consume it conveniently. Cycling is suggested as a means of converting and transmitting human force into the rotational dynamics of a flywheel by paddling in the concept of a man-powered flywheel motor. The flywheel's stored energy is utilized during the cutting operation. It was discovered that the driver used a gear ratio of 1: 2 for the paddle and the flywheel shaft to maintain a speed of 350 RPM for 1 minute. After one minute, the paddling ceased, and the experimental setup's free operation was confirmed. The flywheel shaft rested after 25 minutes. This demonstrates that the alignment of the bearing with the other test setup elements results in satisfactory performance.

Organic waste is fed to drums and trays equally in their research on the Methodology for the Design and Fabrication of a Portable Organic Waste Chopping Machine. An electric motor then rotates the shaft through the pulley at 1440 revolutions per minute, pushing the cutting drum to shear the organic wastes with the help of the shearing blades. Because of the tensile, friction, and impact effects of the cutting process, the chopping is also done inside the cutting house. After passing through the sieve's dipped holes with the chopped pieces of organic waste, the machine releases them. Different-sized holes can be used. The construction of the machine for extracting areca fiber was the authors' main emphasis.

Its main job is to take the fiber out of the area. A straight shaft and a 3-phase, 5 HP AC motor are attached to the machine. An enclosure casing is joined to the driving shaft. The rectangular duct at the bottom of the fiber casing is where the casing emerges. It is designed to solely remove dust. Two bearings and blades that were modified from the blades of the machine used to extract coconut fiber support the driving shaft. The machine produces good-quality areca fiber with a diameter of 0.39 to 0.12 mm and a length of 5 to 6 cm. Therefore, farmers and rural business owners profit from this fiber extraction machine.

The machine for extracting coconut fiber that can be used by small-scale coir manufacturing enterprises was invented and developed by the acts in. With the aid of a V-belt, the drive shaft is connected to the engine in this model at the other end of the drive shaft, where the drive shaft is coupled to a heavy-duty, one-phase AC motor at the base. This allows the barrel to rotate at 240 rpm. The spherical coconut shell mechanically slides to the opposite end of the barrel as the coconut is fed from one end to the other, and the separate is collected in the bag provided below. The indicator hole on the surface of the barrel is where the cutting pins are attached to this concept removing the fiber by cutting the pin supports To establish the experimental relationship for a motorized cutter powered by a flywheel motor powered by a human, the authors of developed an experimental setup design. The main purpose of this machine is to chop up food so that animals can consume it conveniently. Cycling is the idea of a man-powered flywheel motor.

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Paddling was suggested as a way to transform and transmit human power into the rotating dynamics of the flywheel. The flywheel's stored energy is utilized during the cutting operation. It was discovered that the driver used a gear ratio of 1: 2 for the paddle and the flywheel to reach a speed of 350 RPM. The indicator hole on the surface of the barrel is where the cutting pins are attached to this concept removing the fiber by cutting the pin supports To establish the experimental relationship for a motorized chaff cutter powered by a flywheel motor powered by a human, the authors developed an experimental setup design in. This device is. After one minute, the paddling ceased, and the experimental setup's free operation was confirmed. The flywheel shaft rested after 25 minutes. This demonstrates that the alignment of the bearing with the other test setup elements results in satisfactory performance.

Organic waste is fed to drums and trays equally in their research on the Methodology for the Design and Fabrication of a Portable Organic Waste Chopping Machine. After that, the shaft is turned through the cutting drum to chop the organic wastes with the impact of shear generated by the shearing blades by turning the pulley at 1440 revolutions per minute (rpm). Because of the tensile, friction, and impact effects of the cutting process, the chopping is also done inside the cutting house. After passing through the sieve's dipped holes with the chopped pieces of organic waste, the machine releases them. Different sizes can be used. The construction of the machine for extracting areca fib-fibers is the authors' main emphasis. Its main job is to take the fiber out of the area. A straight shaft and a 3-phase, 5 HP AC motor are attached to the machine. An enclosure casing is joined to the driving shaft.

The rectangular duct at the bottom of the fiber casing is where the casing emerges. It is designed to solely remove dust. Two bearings and blades that were modified from the blades of the machine used to extract coconut fiber support the driving shaft. The machine produces good-quality areca fiber with a diameter of 0.39 to 0.12 mm and a length of 5 to 6 cm. Therefore, farmers and rural business owners profit from this fiber extraction machine.

The indicator hole on the surface of the barrel is where the cutting pins are attached to this concept. Cutting the supports for the pins will allow the fiber to be extracted and will provide the fiber with a linear path to leave the coconut shell. The cutting pin indexing angle and space between them are crucial considerations in the construction of the machine that extracts coconut fiber.

They created a concept for a machine for crushing trash. The waste-crushing machine can be employed as a plowing attachment-style device. The shredder will be run by a tractor's power take-off shaft (PTO). Five circular blades and one fixed blade make up this machine. They cut up organic material into tiny pieces so the farmer could use it to make vermin compost.

This work's scope includes conceptualizing and the indicator hole on the surface of the barrel is where the cutting pins are attached in this concept. Cutting the supports for the pins will allow the fiber to be extracted and will provide the fiber with a linear path to leave the coconut shell. A shredder machine focused on producing dry leaves, areca leaves, thus chopped dry, vermin compost, was developed in the design of coconut fiber end. They base their work on information and data gathering about consumer lifestyles. Safety Aspect The concept was created with the management of customers and the working environment in mind.

In this section, a gear and pulley mechanism with a belt drive is employed. The solid wastes that are too inflexible to digest and degrade are broken down into manageable pieces by this machine. The agricultural waste can break down needed by domestic animals and livestock as a wholesome diet.

Plastics are one of the most significant technical tools utilized in a variety of applications. Cutting plastic materials to the appropriate size is one of the crucial factors to consider while processing them. Both a handsaw and an automobile machine can be used for this cutting. The shredder machine is frequently used to separate garbage and the production's basic plastic for further processing. Thrown-in pollutants have an impact on the ecosystem and produce pollution. Reducing waste from plastic recycling is a crucial task. However, one of the issues with recycling these waste goods is the multi-bladed and compressed shredder size machine.

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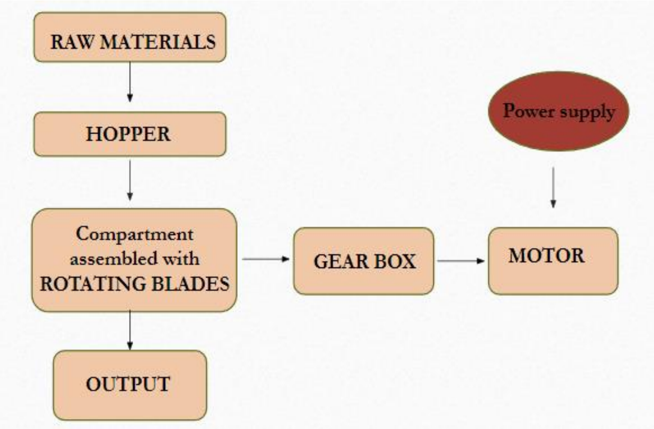
Therefore, this project aims to create a twin shaft in-shafted laded shredding machine that runs on electricity and uses local machinery to recycle waste plastic for future use. This study was carried out using the experimental methodology needed for variable and parameter control. The sample was 1227x854x700 mm in size and was drawn using a purposeful sampling technique. The required factors include the blade's angle, sharpness, spacing, etc., while some criteria include cutting speed and revolutions per minute. Small portions have been constructed using common production techniques, such as machinery and measurement instruments.
They must package this garbage and deliver it to nearby processing facilities. So, the cost of shipping and packaging also increased. As a result, the authors try to make processing plastic waste as inexpensive as possible to cut labor costs. A cutting device is used to reduce the size or number of fragments of big solids. The introduction of the plastic bottle-cutting machine and an investigation of the mechanical system are both covered in this project. A machine called a plastic bottle cutter is used to shred plastic into tiny bits for garbage disposal. The authors created a cutting machine prototype for home plastic trash recycling. This device is beneficial for both industries and
Loss of heat is a significant factor in the performance of internal combustion engines. In addition, a heat transfer phenomenon causes mechanical stresses that are thermally induced, compromising the efficiency of engine components. In engine design, the capability to determine heat transfer in engines plays a vital role. Today, the simulations are progressively being made at a much earlier stage of engine production with numerical simulations In the current research V type multi-cylinder assemblage is modeled.
This model is introduced to ANSYS and completed the consistent state thermal and constructional investigation for anticipating heat stress, heat transference, and heat flux in contrasting and two distinct materials (FU 4270, FU 2451) from the presented material (Aluminium). Heat transfer is a significant part of power change in internal ignition engines. Finding problem areas in a strong wall is utilized as a driving force to make a plan a superior chilling system. Quick transitory heat fluxes with the ignition chamber and the strong divider have to be explored to comprehend the impacts of non-consistent temperatures.

PROPOSED METHODOLOGY



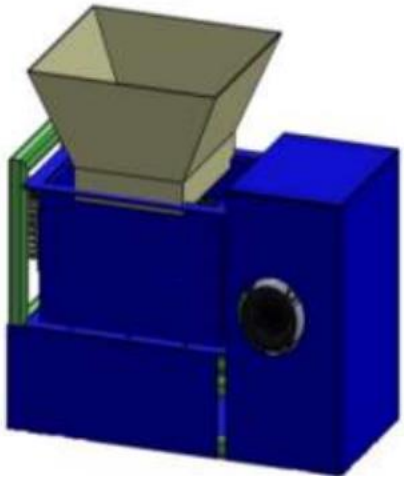
Representation in Block Diagram

DESIGN CALCULATIONS

To determine the mass of the compartment
Material choice for compartment = Mild Steel.
Properties of Mild Steel to be used:
- Density = 7850 kg/m3

• Young's Modulus = 2.08×105 N/mm2
• Poisson's Ratio = 0.3

Mass = Density * volume
Volume = length *breadth * height
= (0.35*0.32*0.32) Volume =0.03584 m3
Mass = 7850 * 0.03584
= 281.34 kg
Mass of compartment = 281.34 kg
Shaft calculations 3D
Representation of Machine



A hexagonal shaft is chosen
Weight of shaft = A/F * A/F * length of shaft* 0.0078
Across face (A/F) = 36 mm
Length of shaft = 400mm
Weight of shaft = 0.036 *0.036 *0.4 *0.0078
Weight of shaft = 3.52 kg
Torque = Force * perpendicular distance
Force = Weight * center of gravity
= 15.67 * 9.81
Force (F) = 153.72 N
Torque = 153.72 * 0.4
= 61.488 Nm
Torque transmitted by shaft = 61.488*103 Nmm
The material of the shaft is mild steel
Yield strength (σy) = 250N/mm2
Designed shear stress(τ) = τy / FOS
τy = 0.5 * σy
= 0.5 * 250 τy
= 125 N/mm2 τ
= 125 / FOS FOR
= 3 τ = 125 / 3 τ = 50 N/mm2
Across face factor of the shaft is 36 mm

Blades and spacer calculation

Thickness of blade= 10 mm
Weight of one blade = 0.75 kg
Weight of one spacer = 0.2 kg
For one shaft 12 blades and 13 spacers
So total weight= [(12*0.75) + (13*0.2)]
Total weight = 12 kg
So

The total weight of the shaft with blades and spacer is 15.52 kg

Selection of motor

Weight of shaft = 3.52 kg
Length of shaft = 400mm
Blade and spacer for shaft:
Thickness of blade= 10 mm
Weight of one blade = 0.75 kg
Weight of one spacer = 0.2 kg
For one shaft 12 blades and 13 spacers
So total weight= [(12*0.75) +(13*0.2)]

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Total weight = 12 kg
So,
The total weight of the shaft with blades and spacer is 15.52 kg Force acting = 153.72 N
Torque = 61.48 Nm (for single shaft)
For both shafts:
T= 61.488 * 2
T= 122.976 Nm (for no load)
With load,
T = 500 Nm (allowable)
P = 2ΠNT / 60
T = P * 60 / 2ΠN
= [((2.2*103) * 60) / (2*Π* 48)]
Torque = 437.89 Nm
3HP motor is selected

Selection of gearbox

We need to shred approximately 300 kg of waste per hour
Which means 8.3 kg/min
Gearbox ratio = 1:30
1440: 48
If 48 revolutions per minute then for a second 0.8 revolutions
0.8/ 8.3 =0.096 kg/s
0.096* 60 = 5.78 kg/min
5.78 * 60 = 346.98 kg
The output per hour will be around 346 kg
A 1:30 ratio gearbox is chosen

Bearing calculations

Diameter of the shaft = 30 mm
A deep groove ball bearing is selected.

Specification of selected Bearing:
d= 30mm
D= 37mm
Approx. life hours = 1440 hrs
(Co) Standard capacity = 14600N
(C) Dynamic capacity = 22000N
$P = (X * F r) + (Y * F a)$
F r = radial force F a = axial force
Fa / Co = 0.102
Fa / Fr = 1.93
Service factor(s) = 1.5 for rotatory
Fa/Fr >e
e = 0.31
x = 0.56 y= 1.4
$P = ((X * F r) + (Y * F a)) * S$
= ((0.56 * 2900) + (1.4 * 1500)) * 1.5
P = 5586 N
Check bearing capacity from the graph
C/P = 2.12
C / 5586 = 2.12
C = 5586* 2.12
C = 11842.32 N

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$C\ calculated < C\ dynamic$
11842.32 < 22000 N
Design is safe

Gear calculations

Deep groove ball bearing SKF 63062Z bearing is selected. Center distance (a)= 125 mm
Z1= 22 teeth
Z2 = 27 teeth
To find module (m)
m = [2a] / [Z1+Z2]
= [2*125] / [22+27]
= [250] / [49]
m = 5.10
Module (m)=5
Diameter of drive and driven gear (d) =m*z
d1 = m*Z1
= 5.10 * 22
d1 =112.2 mm
d2 = m*Z2
= 5.10 * 27
d2 =137.7 mm
i = Z2 / Z1
= 27/22
i = 1.22
Form factor(y) = 0.124 – 0.684/z (for 14o)
= 0.124 – 0.684/22
Y= 0.031
= 0.124 -0.684/27
Y =0.02533
Dynamic load (Fd) = Ft + 0.164Vm*c+ Ft 0.164Vm + 1.485 C+Ft Ft = Hp * 75/Vm
Mean velocity (Vm) = 10 for commercial cut gears
= 3* 75/10 Ft
= 22.5
Expected error =0.056 (for module= 5)
Fd = 22.5 + 0.164*400 (439.6+22.5) 0.164*400 + 1.485 22.5
Dynamic load (Fd) = 417.31 N
Fd calculated value = 417.31N
Fd Maximum = 800 N
Fd calculated < Fd maximum
Design is safe
To Find out whether the frame Design is Safe/Not
RA =Reaction at A
RB = Reaction at A
RA = RB = (W*C)/2
= (3*0.8)/ 2
= 1.2 KN
Fx = RA – W*X = (W*L)/2 – W*X

Shear force:
At A X=0
FA = [(W*L)/2] – [(W*X)/2]
= (3*0.8)/2 - (3*0)/2

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= 1.2 – 0 FA
= 1.2 KN
At B X=L
Hence FB = [(W*L)/2] – W*B
= (3*0.8)/2 – 3*0.8
= 1.2 – 2.4
FB = -1.2 KN
At C X=L/2
Hence FC = [(W*L)/2] – [(W*X)/2]
= (3*0.8)/2 - (3*0.8)/2
= 0 KN
Bending moment:
At A X=0
Hence MA = [(W*L)/2]* X * [(W*X)/2]
= (3*0.8)/2 * 0 * (3*0.8)/2
= 0 KNm
At B X=L
Hence MB = [(W*L)/2]* L – W/2 *L2 = (3*0.8)/2 * 0.8 – 3/2 * (0.82) = 0 KNm
At C X=L/2
Hence MC = [(W*L)/2] * L/2 – [W/2 * (X2)]
= (3*0.8)/2 * 0.8/2 - (3/2) * (0.8/2)2
= 1.2 * 0.4 – 1.5*0.16
MC = 0.24 KNm
To Find whether the shaft
Design is Safe/Not
RA + RB = 29 N
Shear force:
(29*200) * (RB *400) = 0
RB = 5800/400
= 14.5 N
Bending moment: M= (29*200)
= 5800 Nmm

Key and keyway calculation

Diameter of shaft (d) = 30 mm
Key cross-section:
Breadth = 10 mm
Height = 8 mm
In shaft = 5 mm (Tolerance +0.2)
In gear = 3.3 mm (Tolerance +0.1)
Length (L) = 40 mm (from design data book)
Shear stress in key:
Mt = T= L * W * τK *(d/2)
P = 2πnMt/60
Mt = P*60/2Πn
= [(2.2*103)*60] / [2*π*48]
= 437.67 Nm Mt
= 437.67*103 Nmm
Mt = T= L * W * τK *(d/2)
437.67*103 = 40*10* τK * (30/2)
τK = 72.945 N/mm2
σy = 330 N/mm2 at C40

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$\tau y = \sigma y / 2$
$= 330/2$
Yield shear stress (τy) = 165 N/mm2
$\tau K < \tau y$
72.945 N/mm2 < 165 N/mm2
Design is safe

Selection of bolt

Bolt material is mild steel
Shear stress of mild steel (τ) = 250 N/mm2
Yield stress (τy) = 250 / 2
= 125 N/mm2
Designed shear stress = τy/ FOS
= 125/3
= 41.6 N/mm2
Load acting on the single bolt is 17 N
$\sigma = PS / A$
41.6 = 17/A
Area = 0.408 mm2
Based on the area value bolt will be chosen (from the design data book)
A 5/8" bolt is chosen
Calculation of welding fillet
$\sigma = P/(h*l)$
P =200 Kg (200*9.81)
= 1962 N
To find stress acting on a plate:
$\sigma = P/A$
= 1962/17500
Stress acting on a plate (σ) = 0.95 N/mm2
Applying stress value in welding formula
0.95 = 1962/ (h*l)
Welding length = 350 mm
h = 1962/ (0.95*350)
Size of the weld (h) = 5.9 mm

TWIN SHAFT SHREDDER MACHINE

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CONCLUSION

The major goal of this article is to build and develop a small shredding machine that can chop up vegetables, leaves, and coconut leaves into tiny bits and use those pieces as fertilizer. The public and private sectors can both employ this small cutting device. Every day, waste is gathered from homes and flats in the public sector and crushed into equipment. After being combined with coconut pits for a few days, the substance is eventually transformed into organic fertilizer. The compact shredding machine's design and construction for the on-site composition Centre were given in this study. A model was created, and the machine's efficiency was judged to be good.

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