DESIGN AND FABRICATION OF A SINGLE-SHAFT SHREDDER MACHINE

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Abstract:

Currently, the largest source of pollution that produces dangerous pollutants that have an immediate impact on both the environment and human health is the way in which trash is disposed of. The majority of this trash is made up of plastic, rubber, paper, and soda cans. Nowadays, the majority of waste products are either non-biodegradable or take decades to breakdown, which increases the volume of rubbish in landfills. The ongoing processes of making and using rubber, plastic, and paper products as well as the intensified construction contribute to a significant buildup of waste, an imbalance, and a hazard to the environment. The requirement for decreasing domestic and technological waste and reintegrating them into the manufacturing process is evident in all industrial civilizations. This shredder machine assists with waste management and disposal by crushing used bottles and cans. This machine is inexpensive to operate and repair because it was built with locally accessible raw materials. The machine is made up of a three-phase electric motor, shaft, bearings, structural frame, cutters, a hopper, a shredding unit, and a discharge chute. The shaft has four cutters placed on it; they are driven by a belt to rotate. With a belt drive, the cutter shaft receives power from the electric motor. An internal cut is made due to the effects of tension, friction, and impact during the shredding process; cuts are created inside the shredding device. The twigs are crushed, and the little fragments are gathered in the shredder's discharge chute. The device is user-friendly and suggested for farmers and small and medium-sized business owners.

Key words: Recycling, Three phase motor, Plastic, Shredder machine

1. Introduction:

A shredder is a piece of machinery or gear used to shred things. While most online dictionaries define the shredder as "a device used for shredding documents as a security measure

to avoid identity theft," shredders can be of numerous varieties depending on the material being processed. Shredding systems are used to minimize the size of a given material. Shredders are available to facilitate material reduction in a variety of recycling applications, including the recycling of plastics, electronics, scrap metal, tyres, agricultural waste, and wood. Both completed goods, such as landscape mulch, and raw materials to be reintroduced into production are produced during the shredding process. Size reduction machinery is referred to by a number of terms, such as grinders, chippers, granulators, and hammer mills. Overall, their main function is to reduce the size of a given material.

There are significant amounts of agricultural waste produced. Large volumes of it go wasted and frequently present a disposal issue, while some of it is recycled into agricultural produce as fertilizer. It has been determined that a significant amount of agricultural waste is still being stored, handled, and managed inefficiently. Its low bulk density and huge area/volume for storage are the causes. Most of these wastes are burned by farmers in the fields after crops are harvested. As a result, the phenomenon of burning agricultural waste happens every year. The need for such a machine to employ all types of agricultural waste after shredding, which might be inexpensive and practical, was felt in order to utilize these wastes for some economical benefits.

Product, market, literature, and user studies, among other methods, were used to conduct the survey. Farmers used to manually trim the agricultural remains after harvesting their crops in the beginning. It was also a tedious task to shred the dried stems the old-fashioned way, by putting them in a cloth bag and driving a bullock cart over them or beating it on the ground. This method worked well to chop the stems (avoiding the painful fingers issue), but we still needed to turn the cloth occasionally to keep it from pulling out because the stems used to come out and do that. The farmers also beat the stems with bamboos, which was a Herculean task. Thus, these are not trustworthy methods for shredding crop leftovers to produce high-quality compost in a timely manner. Hence, it informs us that cutting crop leftovers using standard methods is neither adequate nor satisfactory. Due to these human methods, certain significant issues have been discovered, and in order to address these issues, the concept of a shredder machine to slice twigs into effective fertilizer was invented.

The shredding machine can be used in both a commercial and aiding capacity for farmers by establishing small businesses, providing organic compost to different farmers who, due to their poverty, consider making the hasty and senseless decision to commit suicide as they are poor and are unable to produce their own organic fertilizer and are also unable to afford chemical fertilizers to increase and meet their minimum crop yield demand, thereby providing farmers will gain from using a shredder machine to effectively employ twigs for compost production and sustainable agricultural production. The objective of this work is to fabricate the multipurpose shredder.

2. Materials and Methods:

The availability, cost, durability, and ease of manufacture of materials were taken into account. The machine's effective operation and acceptability by the farmers and households who would utilize it were important factors that needed to take centre stage. Farmers may readily buy the machine because of its affordable price. Also, if necessary, it is simple to run, even by uneducated farmers. Reasonable design, compact construction, safety and durability, only one motor drive, low noise, ease of operation, compact layout, stable work, portability, low energy consumption, high production efficiency, and affordable price were acquired from design considerations. The design factors can be summed up as follows:

i. Accessibility of construction materials: The machine was built with components that were simple to find. The materials used in the fabrication are easily sourced, such as metal sheet, angle bar, band saw, etc., which are widely available in the nation, for the convenience of future fabrication and development.

ii. Affordability: The machine is made reasonably reasonable by using inexpensive yet effective materials and components to achieve cost effectiveness throughout the project.

iii. Ease of use: The machine will be simpler for the operator to use and comprehend if an electric motor with the necessary horse power is provided to run it.

iv. Strength and durability: Materials with significant strength and durability were used to improve the device's service life.

Figure 1: Sectional Views of Single-Shaft Shredder Machine

Figure 2: Sectional Views of Single-Shaft Shredder Machine

3. Working Principle

The single-shaft shredder is equipped with only one moving shaft, and the blades are installed on this shaft to form a mutual shearing form with the fixed blades on the box. The main shaft is driven by the motor and the reducer, and the material is driven by the spiral blade to enter the gap between the movable blades and the static blades. Because the blade is spiral, the material will be squeezed, torn, and sheared at the same time, so that the material can enter the equipment well and complete the work smoothly. The multi-shaft shredder has two moving shafts, both of which are inlaid with blades, and the two shafts rotate relative to each other to perform operations similar to a single-shaft shredder.

Single shaft shredders are suitable to process waste materials which cannot be cut by using other types of size reduction machines. A waste material which is very large in size or resistant to cutting action of other types of crushers and shredders can be recycled with single shaft shredders. Small sized rotating blades of single shaft shredders tear a small particle of material in each pass. By this way hard to process material sizes can be reduced easily and effectively. They are constructed very strong to last longer Single shaft shredders are equipped with sieves. By changing with proper hole sized sieves output material particle size can be determined.

3.1. Shredder Blades

The single-shaft shredder blade, as its name suggests, is mounted on the shaft of a single-shaft shredder, known as a moving blade. The shape is square, the knife edge has an arc on all sides, and the middle tapping hole, the edge to the middle whole part is inwardly recessed, and is

used with the fixed knife on the knife holder. Single shaft shredder blade is used for waste plastic film, plastic pipe, plastic bags, woven bags, plastic lumps, wood pallets, wood boxes, waste cable, wire, copper, plastic bottle, plastic floor, plastic foam, plastic bucket drum barrel, plastic chair, etc.

3.2. Fixed Blades

The document shredding machine has a rotor with circular blades which are equally spaced along the length of the rotor. These rotating blades cooperate with a row of fixed blades which are mounted along the side of the rotor. The fixed blades are formed from a sheet of metal in which rectangular holes are stamped. The holes are equally spaced and arranged in a row with a bar of metal that forms a fixed blade, separating adjacent holes. A shaft shredder is a machine used for reducing the size of any type of material. The materials that are generally shredded using a shaft shredder include tires, wood, plastics, metals, car wrecks, and garbage

4. Design of Component:

Speed of the belt on driven pulley
Determine the speed of belt on driven Pulley $V_2 = (\pi \times d_2 \times N_2)/60$

Where d_2 = diameter of driven pulley, N_2 = speed of driven pulley.
$d_2 = 82$ mm = 8.2 cm = 0.082 m, $N_2 = 1200$rpm
$V_2 = (\pi \times 0.082 \times 1200)/60$, $V_2 = 5.15$ m/s
Tension in tight side of driver belt $T1 = T - Tc - - - (2)$
$T = \sigma a$ (3), $T_c = mv^2$
Where T = tension in tight side of the belt, T = maximum tension in tight side of belt,
$\quad$ T_c = centrifugal tension, m = mass of belt per meter length, V = velocity of belt,
$\quad$ a = cross section area of belt.
$a = 8.477 \times 10^{-3}$ m^2 = 84.77 mm^2, m = 103gm/meter = 0.103 kg/m
If $\sigma = 1$Mpa, than-
$T = 1 \times 84.77 = 84.77$ N, $Tc = mv^2 = 0.103 \times (5.15)^2 = 2.73$ N, $T_1 = T - T_c = 84.77 - 2.73$
$\quad\quad\quad = 82.04$ N

Tension in the slack side of drive belt
Using $L_n(T_1/T_2) = \mu \times \theta - - - (5)$,

Where T_2 = tension in slack side, θ = angle of contact in radians, μ = coefficient of friction between the rubber belt and the cast iron pulley,
If $\mu = 0.4$ than
$L_n (\frac{T_1}{T_2}) = \mu \times \theta$, $(L_n (\frac{82.04}{T_2}) = 0.4 \times \pi$, $T_2 = 23.37$ N

Power transmitted by the belt

$$P = (T_1 - T_2) \times V - - - (6)$$

$$P = (82.04 - 23.37) \times 5.15 = 304.00 \text{ W}$$

The twisting moment or torque on the shaft (M)

$M = (T_1 - T_2) \times R_2 - - -(7)$

$M = (82.04 - 23.37) \times 0.041 = 2.405$ N $-$ m $= 2.405 \times 10^3$ N $-$ mm.

The bending moment on the shaft. (M_n)

$M_n = F \times L - - - (8),$

Where F = load on shaft, L = perpendicular length,

$F = T_1 + T_2 - - - (9)$

$F = 82.04 + 23.37 = 105.41$

$Mn = F \times L = 105.41 \times 0.0385 = 4.058 \, N - m$

$$= 4.058 \times 10^3 N - mm$$

The equivalent twisting moment (M_e)

$M_e = \sqrt{[(K_m \times M_n)^2 + (K_t \times M)^2]} - - - (10),$

Where Km = combined shock and fatigue factor of bending, Kt = combined shock and fatigue factor for twisting.

Let $K_m = 1.5$, $K_t = 1.5$

$$M_e = \sqrt{[(1.5 \times 4.085 \times 10^3)^2 + (1.5 \times 2.405 \times 10^3)^2]} = 7110.57 N - mm$$

The diameter of the driven shaft

$M_e = d^3 \times \tau \times \pi / 16,$

Where τ = allowable shear stress on the shaft, d = diameter of shaft.

$\tau = \tau_u / fos$, where τ_u = ultimate shear stress on the shaft, FOS = Factor of Safety.

The material used for shaft is carbon steel of grade 45C8, which has $\tau_u = 750 Mpa$, and FOS=4

$\tau = 750/4 = 187 \, Mpa$

$M_e = d^3 \times \tau \times \pi / 16,$ $d^3 = (M_e \times 16)/(\pi \times \tau) = (7110.57 \times 16)/(187 \times \pi), d = 5.785 \, mm$

5. Conclusion:

Instead of just using manually operated procedures, a proper examination of the design is performed and something even better is generated. Eventually, we draw the conclusion that the farmer would be better off using the machine than chopping twigs manually. The equipment was created with the diverse needs of farmers and other clients in mind. The job that this machine performs is minimal because it was designed for small business owners or farmers. The capital investment needed to buy larger crop residue shredding or chopping equipment is very high, and the alternative use of chemical fertilizers is also highly expensive.

i. It was possible to cut the way that was wanted.

ii. It had a low price.

It gave the necessary Material cutting Rate, or iii.

iv. Blades are simple to clean.

The use of highly skilled operators is not necessary

6. References

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