Construction Design and Performance of Dry Leaf Shredder with Vertical Rotation for Compost Fertilizer

Syawaldi
Department of Mechanical Engineering, Universitas Islam Riau, Pekanbaru, Indonesia

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Abstract: One of the large private universities (PTS) in Riau Province is known as Universitas Islam Riau (UIR). UIR is a large university and has extensive land infrastructure that is planted with a variety of green plants such as trees and flowers. These trees have encountered many problems, namely producing leaf litter and causing problems. Lots of leaf litter is collected and disposed of at the final disposal site. Some can be processed into compost manually and some are burned. In the composting process, the processing time is too long, so it is necessary to design a construction machine for crushing dry leaves. This machine consists of an inlet and outlet, a tube made of drums, a five-level shredder and with an electric motor. From the results of the design of the construction size length 60 cm width 60 cm and height 100 cm made of angle iron L profile size 40 x 40 x 4 cm with a power of $\frac{1}{2}$ HP and 1400 rpm motor drive rotation. From the results of engine performance tests, the production capacity of 40 kg/hr in the form of final process chips size of 5-10 mm and 92% efficiency. From the results of this machine design can accelerate the process of making compost and can be used by students in developing the entrepreneurship unit of the Faculty of Engineering students.

1 INTRODUCTION

One of the private Universitas Islam Riau (UIR). UIR is the oldest university in Riau Province. In addition, the university has large land and green land. So that many found in the rubbish foliage. This garbage is a problem that is collected every day by campus cleanliness. This the garbage is disposed of at the final disposal site. Some can be processed into fertilizer manually and some are burned. So the waste has not been used much for the more efficient once such as compost.

The use of waste from leaves can be used as compost, known as leaf compost. This can be a good and creative solution so that the campus becomes clean, it also empowers the community and students to become Student Entrepreneurship Enterprises. (Setyaningsih et al., 2017).

As for organic waste such as fallen leaves, waste from agricultural residues, garbage from kitchen vegetables, and other types of organic waste. Can be processed by the community itself into compost, which will certainly provide more benefits to the community and students (Nasution et al., 2013; Yamin et al., 2008). One of the processing must use technology to speed up work. This technology has also been and many are made in the form of chopped /flake. Besides technology also helps the composting process (Hande & Deshpande, 2014; Kumar & Kumar, 2015).

In managing traditionally destroying leaves and organic waste by the community, there are those who do it by manually storing up the tones. Traditional management requires large labor and long time. The design of a leaf chopper in increasing the business of making compost. The special garbage shredder for the leaves has not been sold in the market. Existing machines are made in multi-use so that the price of the machine is quite expensive. In addition, the research into the manufacture of dry leaf shredder has been carefully studied by several researchers (Hande et al., 2015). In addition, research on the manufacture of dry leaf shredder has been studied thoroughly by several researchers (Nithyananth et al., 2014).

The purpose of this study is to design a shredder to form flakes / fine grains to facilitate and speed up the process of making compost. Besides that, from the design results in the form of leaf crusher in order to build a compost processing center in the Entrepreneurship Unit of the Faculty of Engineering, Universitas Islam Riau.

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2 LITERATURE REVIEW

Garbage from the campus field or yard is generally rubbish from leaves (organic waste). Where waste is managed properly will get high benefits. Waste from leaves is very good to be used as compost fertilizer. Compost will be able to fertilize the agricultural area in the form of land acquisition (Budihardjo, 2006; Sulistyorini, 2005).

The leave are of the leaves are burned by the community, which also causes air pollution. The management of these leaves if done properly through an appropriate process will have a positive impact in the form of compost (Nasution et al., 2013; Setyaningsih et al., 2017). The management process is by constructing a technology to destroy leaves. The results of the work process of the machine depends on the results of the design (Nwakaire et al., 2011). Much research has been done on the design and construction of machinery related to demolition (Hassan et al., 2009). In the process of crushing the engine components are needed to produce power.(Nwakaire et al., 2011). Power can be determined by the following equation:

Power,P = work done/second

= work done/time

= (Force x distance)/time

= Force x velocity

$$P = F.V \tag{1}$$

Where, P = Power (Nms^{-1}), F = Force of crushing (N), and Velocity is , V = r.ω (m/s).

Force required to thresh the leaf is given by

$$F = m.\omega 2.r \tag{2}$$

Where F is the force needed to chop leaves in containers, m is the mass of the chopper, ω the angular velocity on the shaft with equation 2.π. N / 60, where n is the round per minute. Power on the shaft can be F.ω.r. For the motor drive, the electric motor is determined based on the power contained in the shaft. (Suga et al., 2004). The relation of the pulley to the one driven through the driving force is:

$$N_1 D_1 = N_2 D_2 \tag{3}$$

Where N_1 is the driving speed, the driven N_2 speed, D_1 the drive pulley diameter and D_2 are the driven pulley diameters. The mass weight (m) of pulleys in the shaft can be determined,

$$m = \rho v \tag{4}$$

where ρ pulle density and v are pulley volume. Pulley weight,

$$Wp = \rho \times (\pi.d^2/4) \times l_p \tag{5}$$

Where d is the pulley diameter and lp pulley length. If the pull on the pull side and the slack side of the pulley are F_1 and F_2 respectively, then the magnitude of the tensile is effective (F_e),

$$F_e = F_1 - F_2 \tag{6}$$

T_sp (torque on the shaft) is:

$$T_{sp} = F \times r \tag{7}$$

where F force works counting leaves, this is the same as torque (T_s) in the system.

$$T_s = F \times r \tag{8}$$

Where T_m (motor torque) = F × r
where

$$T_s = T_m \tag{9}$$

Power required,

$$P_m = \omega.T_m \tag{10}$$

Tensile is effective F_e is

$$F_e = P_m/(\omega.r) \tag{11}$$

MT (torque moment) = $(F_1 - F_2)\ r_1$. The power transferred to the belt is:

$$P = (F_1 - F_2).V \tag{12}$$

Where, V (Velocity)

$$V = (\pi.D.n)/60 \tag{13}$$

Also

$$F_1/F_2 = exp(\mu\ \theta) \tag{14}$$

Where θ the contact angle of the belt on the driving pulley groove, and μ is the real friction coefficient between the belt and pulley, the dry surface μ = 0.3. The magnitude of the contact angle on the drive belt is ;

$$\theta = 180 - (57(D_1 - D_2)/C) \tag{15}$$

Determining the pulley length is as follows,

$$L = 2C + \pi/2(D+d) + 1/4C(D-d)^2 \tag{16}$$

The minimum diameter of the shaft can be determined:

$$d^3 = [(5,1/\tau_a)K_tC_bT]^{1/3} \quad (17)$$

Where d is the shaft diameter, K_t collision correction factor (1.0) if the load is applied subtly (1.0-1.5) if there are a few surprises and collisions and (1.5-3.0) if the load is subjected to a shock or a large collision. If indeed it is expected that usage will occur with a flexible load, it can be considered the use of the C_b factor (1.2-2.3). For general use on a shaft with a strength marked with a permit voltage τa are:

$$\tau_a(kg/mm^2) = \sigma B/(Sf_1 xSf_2) \quad (18)$$

Where :

Sf_1 (6,0)

Sf_2 (1,3-3,0)

is safety factor.

The leaf chopping machine is tested to determine the effectiveness of the equipment performance in its use with respect to engine performance. One of the performance carried out is the production ability of $Q_T = W_T/t_T$, where W_T is the weight of the process and t_T is the process work time in units (kg/hr)

3 MATERIALS AND METHODS

3.1 Design Considerations

The method used in the construction design consists of:

- Field survey
- Coordination with related institutions and the cleanliness of the field at Riau Islamic University.
- Coordination with student entrepreneurship units.

3.2 Calculating Design

The spin speed of the dry leaf chopper knife is 1866 revolution per minute (rpm), with a counter force of 13.05 Newton is blades, angular velocity (ω) 195.3 radians per second.

3.3 Description of Machine Parts

In the figure 1.1. explained that some machine and construction parts of the design.

- The Main Frame
  The main frame work functions as a buffer for components or machine elements that work. This counter frame is made of structural steel with a size (60 mm x 60 mm x 100 mm) and a right angle iron profile (40 mm x 40 mm x 4 mm).
- The Hopper
  The hopper function is where the channel enters the leaves into the drum for the destruction/enumeration process. Where this carriage has a diameter of 27.5 mm and a height of 25 mm which is made of carbon steel while being shaped sheet plate with a thickness of 2 mm. The position of the design hopper is placed at the top of the tub.
- The Screen
  The Screen located inside serves to filter or separate granules and debris from the results of enumeration by the chopper knife. The results will come out through the outlet in fine grains and with a size of 5-10 mm.
- The Outlet
  The outlet is designed as a place to exit the results of the leaves counting. Where the design is made of steel plate sheets with a size of 2mm thick.
- Shaft Design
  Shaft is a very important element in machine movement in moving power and rotation. Usually on installed shafts such as gears, pulleys, sprocket and other engine elements. The shaft is made from ST 37 Steel with a length of 65 cm and a diameter of 19 mm and is mounted on the middle side of a leaf chopping tool using a bearing. The bottom and middle end of the bearing is attached and the upper end of the blade is attached on position vertical.
- The Cutter
  The knife is a machine element for chopping leaves. The design of this knife is used as many as 5 (five) levels (as shown in figure 2). The blade material is made of steel plate from the spring of the vehicle. This knife is connected by welding and in the middle is given a hole to insert the shaft and locked.
- The Pulley
  - Drive Pulley, The drive pulley is enabled to continue the 1400 rotation per minute and the power of the $\frac{1}{2}$ HP Electric motor drive. Where is the size of the pulley diameter of the 75 mm drive made of aluminum.
  - Movable pulleys, The driven pulley is used to rotate the shaft to chop leaves of leaves. In the pulley there is a rotation of 1400 rpm to 1866 rpm with a diameter of 100 mm and made of aluminum.
  - The Bearings Bearings are the main parts of the engine component. It functions as a rotating and stationary shaft position. From the results

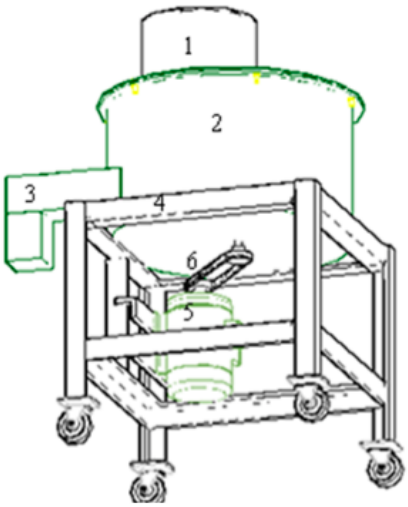
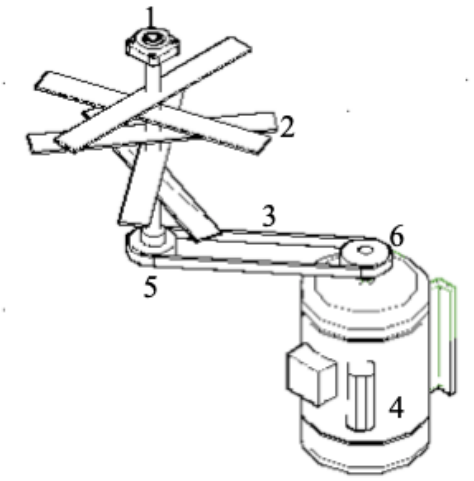


Figure.1.1. Orthographic view Constructions of the machine

Figure 1: Orthographic view Constructions of the machine



1. Bearing 4. Electro Motor
2. Cutter 5. Pulley
3. Belt 6. Pulley

Figure 2: Orthographic view Constructions of the machine

of the design the bearing has a hole diameter of 19 mm. Where these bearings are mounted on the bottom of the engine shells.

- The Prime Mover The starting drive functions to divide the power and rotation to the shaft, which is moved through the pulley. The power and rotation of the machine are used to cut leaf leaves to produce products in the form of fine grains and flakes. The drive used is an Electric motor with $\frac{1}{2}$ hp and 1400 rpm.
- The Transmission System The transmission system on the leaf counter machine consists of an Electric motor as a driver, drive pulleys, driven pulleys, v-belts and shafts. The aim is to regulate the distribution of power and rotation needed in the process of counting leaves. Transmission system as shown in Figure 1.2.

4 DESIGN CALCULATION AND RESULTS

Machines designed using drives are electric motors with $\frac{1}{2}$ HP power and 1400 rpm rotation. Where the rotation is changed from 1400 rpm to 1866 revolution per minute. The average rotational speed of the engine shaft is 1866 rpm, then the results of other engine components with a shaft size of 19 mm, shaft mass and blade is 2.5 kg, with a length of 65 cm, on the shaft there are 5 level crushing blades with size with crushing force 24,5 N.

5 PERFORMANCE TEST

Based on the results of testing the design of dried foliage leaf chopper, the production capacity of 40 kg / day with flake-shaped size of 5 to 10 mm and efficiency of 92% is obtained. In addition there is also vibration in the construction due to the absence of a balance of force between the contraction and the rotating force on the shaft. In addition, the results of the enumeration work process production capacity is still low. Based on the results of testing the design of a dry leaf chopper machine using 5 levels/10 knives, a production capacity of 40 kg/hr in the form of flakes measuring 5 to 10 mm and 92% efficiency. This is compared to a machine that is almost similar to using a chopper as many as 40 knives (Akbar, 2015). Besides that, the corn thresher can efficient of 79.3% (Chuan-udom et al., 2013).

6 CONCLUSION

From the results above, the design of the dried foliage leaf enumeration machine has been successfully made and tested as the central need of the Student Business Unit at the Universitas Islam Riau and the community of making compost fertilizer. Where this machine is easy to use and carry because it has wheels. In addition, usage can be arranged for approximately

8 hours/day. Electricity saving is only 350 watts.

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