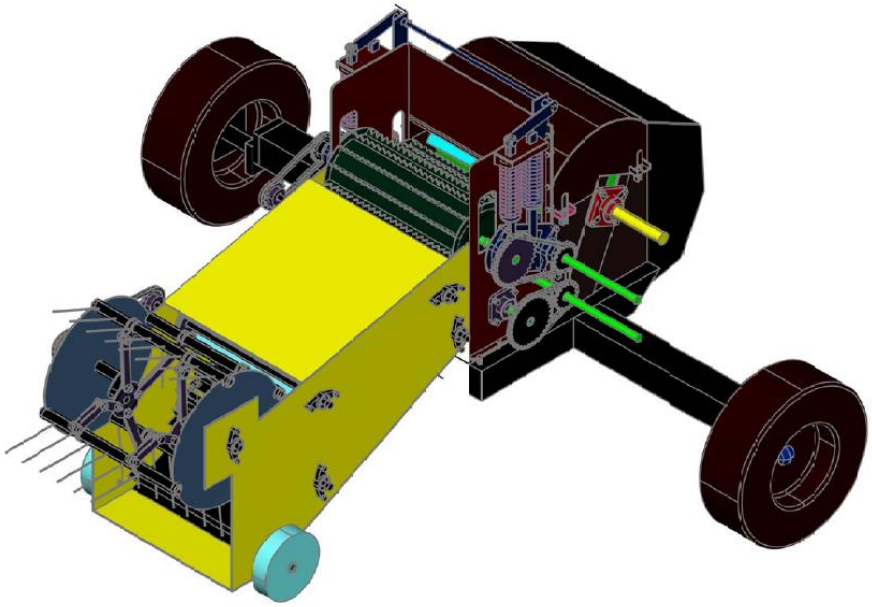
DESIGN OF SUGARCANE LEAF TRASH SHREDDER



Wawan Hermawan

Department of Mechanical and Biosystem Engineering
Faculty of Agricultural Engineering and Technology
IPB University

DESIGN OF SUGARCANE LEAF TRASH SHREDDER

Wawan Hermawan

Department of Mechanical and Biosystem Engineering
Faculty of Agricultural Engineering and Technology
IPB University
Email: w_hermawan@apps.ipb.ac.id

Abstract

A prototype of shredder for cutting up sugar cane leaf trash has been designed and constructed. The machine was designed for gathering the sugar cane leaf trash that was piled up on the field, conveying it to the feeder and chopping it into short pieces. The machine consisted of: a gathering cylinder, a conveying unit, a pairs of feeding cylinders, a reel type chopping cylinder, a main frame and wheels. The prototype has been tested and showed a good functional performance. In a stationary working test, the gathering unit and the feeding unit could work properly. The chopping unit could cut stems of sugar cane tip into 2-3 cm length of pieces. However, the dry leaf of sugar cane could not be chopped well. The working capacity of the machine was 400-500 kg/hour.

Keywords: sugar cane, leaf trash, shredder, reel-type chopping, gathering unit.

Introduction

Sugarcane is the main sugar-producing plant which is an important food commodity both for direct consumption and for industrial purposes in Indonesia. The area of sugarcane plantations has increased from 335 thousand hectares in 2004 to 400 thousand hectares in 2007 (Ditjenbun 2007). One of the major problems experienced by sugarcane plantations is the handling of the remaining sugarcane leaf trash left after harvesting. Sugarcane leaf trash that has accumulated on the land after harvest has been handled by burning, which can have adverse effects on health and the environment (Wiedenfeld, 2009). Meanwhile, the use of sugarcane leaf trash as a source of nutrients for soil is increasingly being investigated and it is proven that sugarcane leaf trash can be composted and is very useful for adding nutrients to the soil. The felled leaf trash in sugarcane fields can reach 20-25 tons/ha (Toharisman, 1991), as stated by the President Director of Jati Tujuh Sugar Company (2008).

According to Yuwono (2005) compost is useful as organic material that has a contribution to prevent erosion, soil movement and soil cracks. In addition, compost is also a supplier of essential micro nutrients. The requirement for making organic fertilizer (compost) is that the organic material must be in the form of small pieces

before being decomposed into compost (Indriani, 2005). To chop sugarcane leaf trash and bury it into the ground, an effective machine is needed according to the leaf trash and land conditions.

The purpose of this research is to develop a machine capable of chopping and immersing leaf trash into the soil properly and quickly. The machine must be able to pick up and lift sugarcane leaf trash from the field, then chop it to a size of about 2 cm. The chopped leaf trash can then be buried relatively evenly at a certain depth into the ground. All these activities are carried out using a power source of motion and pulling a 4-wheel tractor. At this stage, the research focused on the design of the shredder unit.

Research Methods

Research Stages

In the first year, the research focused on designing a sugarcane leaf trash chopper unit. The stages of the activity are as presented in Figure 1.

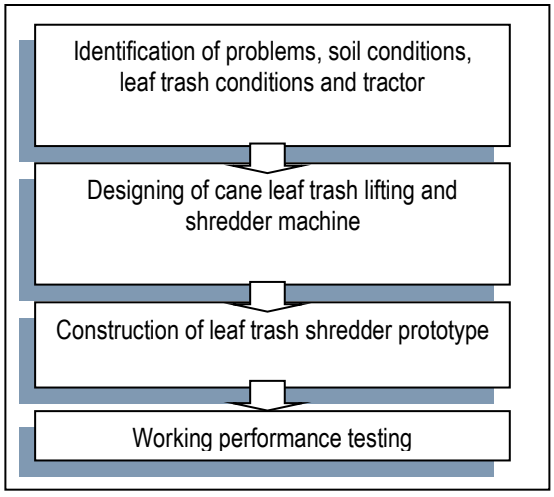


Figure 1. Research stages.

Identification of Sugarcane Leaf Trash Conditions in the Field

The condition of leaf trash after sugarcane harvesting was surveyed directly at Subang Sugarcane Company, West Java, as well as the profile of ridges measured using a relief meter and a ruler/meter (Figure 2). Leaf trash conditions were identified by measuring leaf trash weight and leaf trash height in an area of 2 m × 2 m at ten different locations.

Figure 2. Measurement of leaf trash conditions and ridge profiles using a reliefmeter.

Design Considerations and Requirement Specifications

The sugarcane leaf trash shredder is designed with the following basics.

1. The machine is operated using a 4-wheel tractor using a tractor PTO drive, with a forward speed of 0.3 m/s.
2. The machine lifts the leaf trash that has accumulated on the land, chops it up and immediately immerses it into the soil in a simultaneous process (Figure 3).
3. Leaf trash handled with conditions (measurement results): the average height of the sugarcane leaf trash pile in the field is 0.36 m, the average density is 7.7 kg/m^3, the average shoot length is 162.5 cm, the average number of leaves per shoot is 4.1 leaves, average leaf width is 5.0 cm, leaf thickness average is 0.3 mm, shoot base average diameter is 21.3 mm, and shoot weight is 57.3 g. Sugarcane leaf trash has a leaf length of 161.1 cm, a leaf base width of 4.4 cm, a leaf width of 4.1 cm, a leaf tip width of 3.9 cm, a leaf thickness of 0.3 mm, and a leaf weight of 8.9 grams.

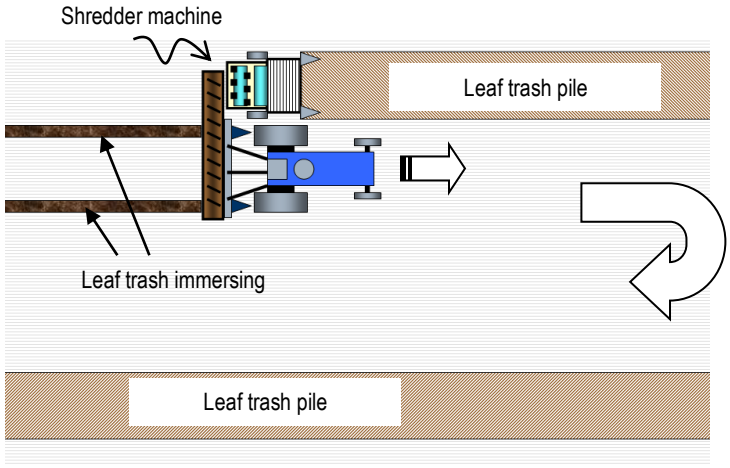


Figure 3. Operational scheme of sugarcane leaf trash shredder.

This machine consists of several main parts, namely: 1) a leaf trash picker and lifter, 2) a clamp-feeder section, 3) a chopper section, and 4) a transport frame section as shown in Figure 4.

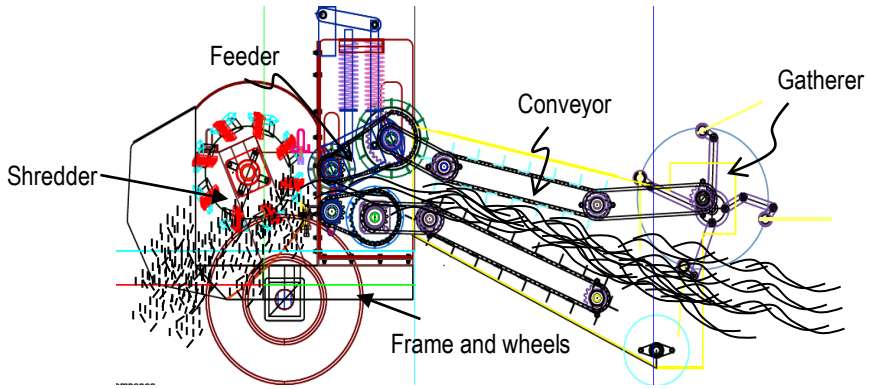


Figure 4. The design of the working mechanism and the main parts of the machine.

The take-up cylinder works with a spoke mechanism on the take-up cylinder which is equipped with a four connecting rod mechanism, so that it is able to pull and then push the leaf trash towards the lifting conveyor. A pair of conveyors (top-bottom) continue the transfer of leaf trash towards the clamping cylinder and feeder. After passing through the clamping cylinder, the leaf trash is fed to the chopping cylinder. The chopping uses a reel-blade type knife (Srivastava, et al., 1993) as shown in Figure 5. The cylindrical chopper unit is designed with attention to the speed of feeding and the length of the pieces to be produced. With the analysis can be calculated the rotational speed of the cylinder, the number of blades, and the diameter of the cylinder.

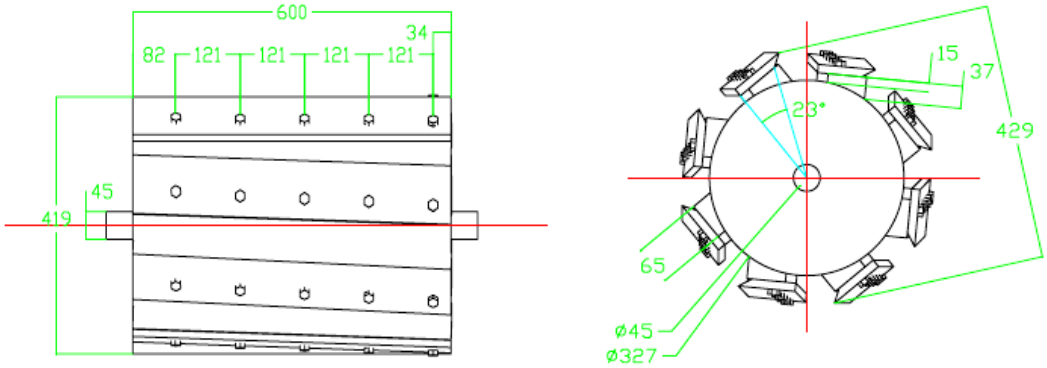


Figure 5. The design of the leaf trash chopper cylinder.

Performance Test Method

The machine prototype that has been made was tested to determine its functional performance and chopping performance. The engine is driven by a Diesel motor so that all parts can move according to their movements, then the work (function) of each part is identified. Then, to measure the performance of the chopping, the pile of sugarcane leaf trash is fed to the towing section (machine mouth) and the leaf trash flow is observed, as well as the results of the chopping. The working capacity of the machine is measured by measuring the results of the chopping in a certain time interval.

Results and Discussion

Machine Prototype

From the results of the design (Figure 6), a prototype machine has been made as shown in Figure 7.

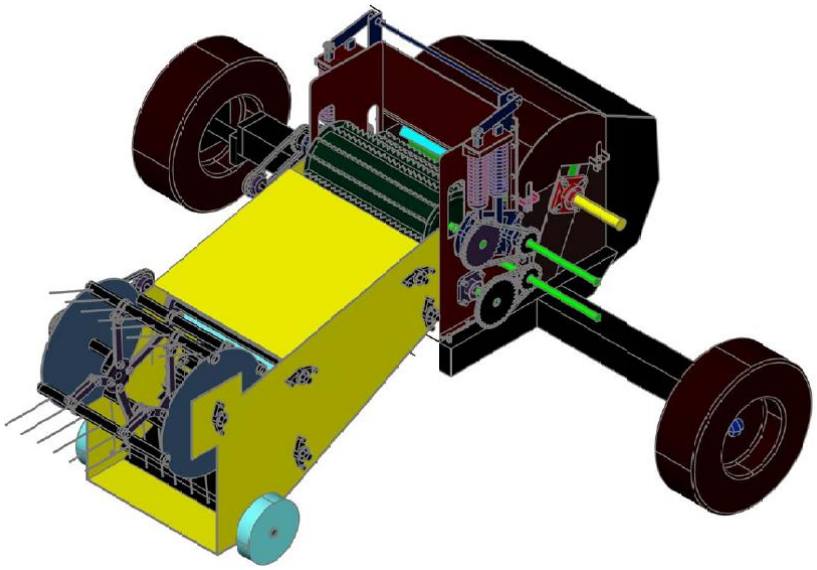


Figure 6. The 3-D model of the leaf trash shredder machine.

Figure 7. Prototype of the leaf trash shredder machine.

The leaf trash collection cylinder located at the very front is 50 cm in diameter, has a four-bar link mechanism so that the spokes can pull the leaf trash and push it into the conveyor section. The mechanism of four connecting rods has a length of connecting rod 1 is 20 cm and connecting rod 2 is 5 cm and the length of the hook blade is 25 cm. The design is the angle between the connecting rod 2 (5 cm) and the hook blade of 54 cm. The goal is that when the hook blade is almost finished throwing leaf trash onto the conveyor, the blade is in a downward position, so that it will reduce the clearance with the conveyor hook blade (4 × 4 cm elbow). The conveying unit (conveyor) is designed with a conveying mechanism followed by a pressing mechanism for sugarcane leaf trash from an input thickness of 30 cm to 10 cm at the conveyor output or clamp input. This mechanism is designed with 2 top and bottom conveyors with an inclination angle of 300 at the bottom and 130 at the top. This slope is acceptable considering that bulky sugarcane leaf trash will not slide down on a flat surface with a slope of about 300. The conveyor is designed using RS 60 sprockets with a diameter of 10 cm and a number of teeth 15. The connecting chain uses a 2 cm pitch equipped with a cap for mounting the hook blade. The diameter of the cap hole is 5 mm. Considerations for selecting the RS 60 are that its tensile strength is 2000 kg/cm^2, a diameter of 10 cm is ideal for narrow cavities, and a 65 mm diameter conduit allows a 25.4 mm diameter steel conveyor axle to be installed.

The clamping and feeding cylinder section consists of two pairs of cylinders which have a spring mechanism to compress the leaf trash to be fed to the chopping cylinder (Figure 8).

The chopping part consists of a movable blade composed of a blade mount cylinder and eight blade blades evenly spaced along the circumference of the cylinder, and a bed knife. The blade material is made of hardened steel (heat treatment). The position of the movable knife is placed on the cylinder so that it forms a cylinder blade with a diameter of 42.9 cm. The cylinder weighs 80 kg with the drive shaft 4.5 cm in diameter. The shape of the blade with a sharp angle of 27^o, blade length 60 cm, thickness 1.2 cm. and weighs 4.3 kg (Figure 9). Mount the blade in such a way that it has an angle of cut relative to the bed knife. The blade used is a straight blade instead of a helical blade. By using a straight blade, a helical knife-like cutting process can still be obtained even with a small cutting angle (3.7^o).

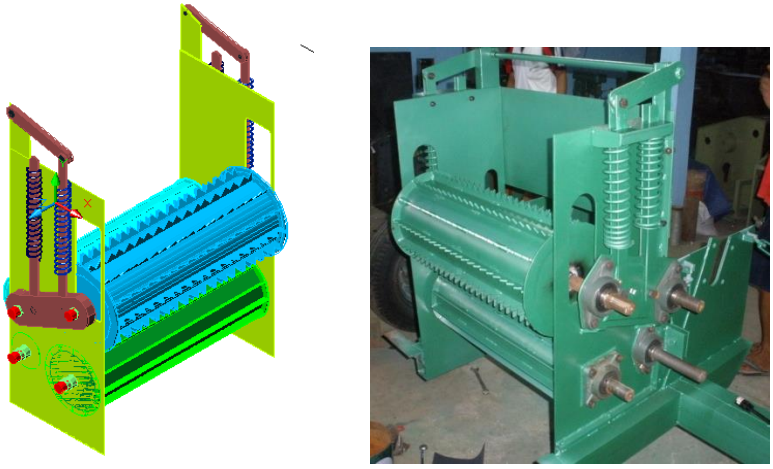


Figure 8. Clamp and feeder parts design and prototype.

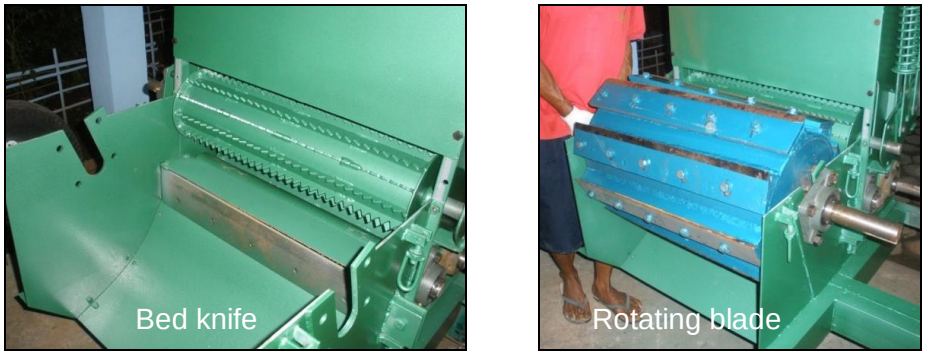


Figure 9. The prototype of the leaf trash chopper section.

Machine Performance

The prototype machine has been tested off-farm and the results show that the lifting part has functioned properly, as well as the clamping and chopping parts. The chopping results showed that the base and shoots of sugarcane were finely chopped at a size of 2-3 cm (Figure 10). However, dry leaf leaf trash has not been cut properly. This is due to the straight blade shape that is paired at an angle, resulting in a gap in the center with a straight stationary blade. The improvement that will be made is to modify the blade surface of the bed-knife so that it is slightly curved and the rotating blade (reel) can be closer to the bed-knife (functions like scissors). The chopping capacity is 400-450 kg/hour. This machine still needs to be coupled with a towing tractor and tested directly on sugarcane plantations.

Figure 10. The results of cutting the shoots of sugar cane.

Conclusions

1. The condition of the sugarcane field and the condition of the sugarcane leaf trash after the harvest have been observed and used as a prerequisite in designing a sugarcane shredder machine to be applied to the sugarcane field after the harvest season.
2. In this step, the cane leaf trash chopper was designed and prototyped. The main parts of this machine are: (1) parts for collecting, lifting and distributing leaf trash, (2) parts for clamping and feeding leaf trash, (3) parts for shredding leaf trash, and (4) parts for transporting (carriage).
3. The machine prototype can function properly and the sugarcane leaf trash can be chopped to a size of 2-3 cm. The chopping capacity is 400-450 kg/hour.

References

Ditjenbun, 2007. Potensi Dan Prospek Pabrik Gula Di Luar Jawa. Makalah Presentasi di Seminar Gula Nasioanal Perhimpunan Teknik Pertanian (PERTETA) di Makassar, 4 Agustus 2007.

Indriani, Y. 2005. Membuat Kompos Secara Kilat. Penebar Swadaya, Jakarta.

Srivastava.1993 Engineering Prinsiple of Agricultural Machine.ASAE Textbook Number 6 Published by American Society of Agricultural Engineers

Toharisman, A., 1991. Pengelolaan Tebu Berkelanjutan. Pusat Penelitian Perkebunan Gula Indonesia (P3GI).

Wiedenfeld, B. 2009. Effect of Green harvesting vs burning on soil properties, growth and yield of sugarcane in South Texas, Journal of American Society of Sugarcane Technologist 29:102-109.

Yuwono, D. 2005. *Kompos*. Penebar Swadaya, Jakarta.