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Design and Fabrication of Double Actions of Agricultural Waste Chopper: a Community Empowerment Inspired

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ABSTRACT

Agricultural waste is huge in the villages as a by-product of harvesting. Without proper management, they become useless or even a danger to the society and environment. This paper aims to describe a report on the community service activities of the authors in an attempt to resolve the agricultural waste in the Villages of Sempu-Banyuwangi and Arjasa-Jember, East Java, Indonesia. Two types of wastes were identified: cattle dungs and by-products of the agricultural harvests. These two wastes would be chopped or crushed to reuse either as compost or cattle feed. Therefore, a double function machine was designed and manufactured. The main cutters were made of a used chainsaw blade. A strainer was added to sieve the crushed cattle dung. This machine was powered by a 6.5 HP gasoline engine. Both cattle dung and agricultural waste could be crushed or chopped into small pieces. It is double hoppers: upper and side for different tasks.

Key words: agricultural waste, compost, chopping machine.

1. INTRODUCTION

Waste or rubbish is among the main problems in nowadays society. The problems increase day by day as the human population escalated. Outlined, there are two types of waste: organic and non-organic. The non-organic mostly comes from plastic and its variety. While, the organic ones come from agricultural waste, such as vegetables, fruits, leaves, etc.

Whether in the cities or the villages, both kinds of waste were not properly managed. In cities, there were 1.12 kilograms of waste/capita produced daily that must be managed[1]. Regarding treatment facilities, 47% of the landfills do not have appropriate supporting facilities and where supporting facilities do exist, 10% of them do not work properly [1].

In rural areas, most of the waste falls the organic ones. It may by-product of harvestings such as paddy straw, corn leaves and corn stalks, cassava trees and cassava skin. It may also be from rich greenery leaves such as bamboos, trembesi, mangos, rambutan, mangosteen, etc. Others come from cattle dungs as most of the villagers have cattle such as cows, lambs or even little ones, like rabbits or Guinea pigs. It was also almost impossible to find a house in the village without having poultry such as chicken, ducks, or goose. Most of the country folk do not care about this type of waste. They just leave them or stuck them in the corner of their field. Some of them just burn it.

Some efforts have been made by communities in different regions. In the city, they made biogas from food waste [1]. More efforts were made reported for the villages, such as training in waste management[2], trash bank [3], or composting[4].

Organic waste is valuable if managed properly. It may the raw material of compost for organic fertilizer or manure, which reduce petro fertilizer dependency. Alternatively, the by-product of harvest can be used for cattle feed and stored for the dry season. It may be fermented as the fermented cattle feed is more nutritious [5].

To ease the composting process or fermentation, the raw material made of agricultural wastes has to be in a small size. Therefore, they need to be chopped or crushed. There are many kinds of machines to comply with this job. Three categories of the working principles: cutting [6], shredding[7]–[13], crushing [14], [15], chopping[16]–[18]. All of those machines are single functions. A paper mentioned being a multi-purposed organic chopper [18], however, it was only could chop a variety of organic wastes, not a multi-functions.

To be able to chop the plants' based-waste and crush the cattle dung, it needs a new design the machine. This paper aims to design and fabricate a machine, which can do both tasks in one machine. Then followed by testing it and handover it over to the farmer group in Villages Sempu-Banyuwangi and Arjasa-Jember, East Java, Indonesia.

2. METHODS

The project started by finding the actual problem of the peer, i.e. the Melati's farmer group at Sempu Village, Banyuwangi, Indonesia. The intensive discussions concluded that they need a machine that can work as the chopper for the by-products of their farms and the crusher for the cattle dung. They are already somewhat familiar with the composting process and utilize the leaves for their cattle feed. They wanted to have a machine to cut or crush the wastes into small pieces to reduce the composting time. The literature studies the carried out and found some designs of the choppers with their uniqueness. Then, it was modified by adding a strainer to sieve the crushed dung.

The design was based on a calculation of the force needed to chop the hardest material, in this case, it was the corn stems. The dynamic components were designed first, followed by the hopper-drum. Then, the frame was designed to carry and support all the mechanisms including the motor for the prime mover. The body of the machine is made of a steel plate 0.3 mm thick. Two hoppers were designed to feed the machine, (i) cattle dung from the top and (ii) others from the side. The design was made using the Autodesk Inventor Fusion 360 of the free student version.

3. RESULTS AND DISCUSSION

The most important component is the cutter. The design is based on the calculation of the force needed to chop grass (Figure 1). All of the calculation of force to motor needed was following the steps and formula in[19]. According to a simple force formula, it was found that the force needed is 94 N. Then torsion (T) is 13.16 Nm. The power of the motor needed is equal to 16.46 Watt or equal to 4.34 HP. Therefore, the motor chosen was 6.5 HP based on the availability.

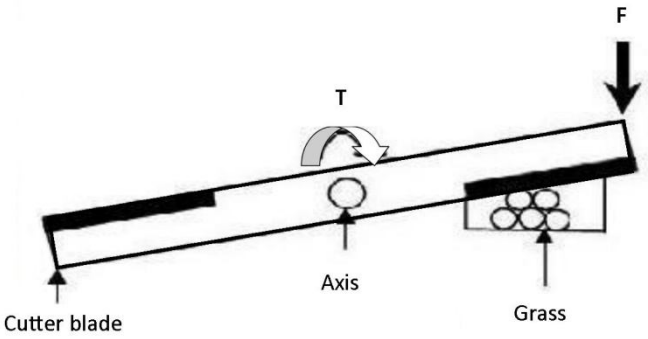

Figure 1: Schematic of cutting grass on a single a single blade

The chopper was designed as a multi cutter, as shown in Figure 2, to ensure it can cut the intake materials (wastes) into pieces. The cutter is made of used chainsaw blades because it is made of high-quality steel that will keep an edge well, yet is flexible enough to bear the stress rather than break or crack[20]. The design calculation of each component was not presented in this paper for simplicity reasons. The chopper arrangement is fixed in a shaft. The shaft is supported by a ball-bearing on both sides. At a side after bearing, a pulley is mounted to link it with a V-belt to the motor.

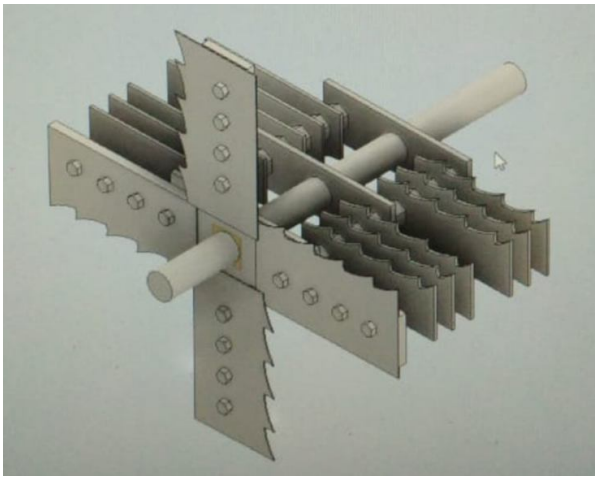

Figure 2: The multiple cutter arrangement

The second crucial component is the hopper-drum system. It is double inlet hoppers, the upper one for cattle dung fed and the side for the branches and leaves. When the second hopper is in use the fascia to the strainer should be closed using a slot plate to avoid congestion. The hopper-drum system is made of galvanized steel plate. Two main parts of the hopper-drum, are the upper part for feeding and the lower part for the crushed or chopped products outlet. Each part was formed and electrically welded. Then both are fixed to the frame using the bolts mechanism. This bolts mechanism was chosen for the easiness of the cleaning and maintenance of the machine. The 2D view of the hopper-drum part is presented in Figure 3. The dimension of this component is 810 x 460 x 810 mm.

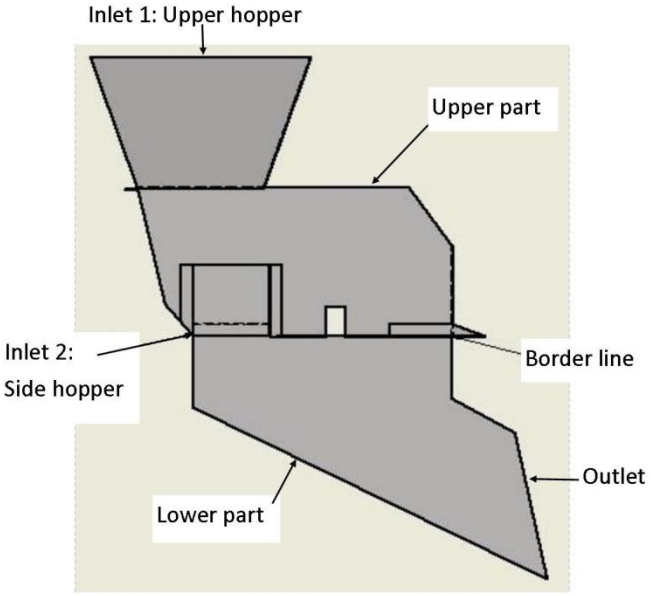

Figure 3: The hopper-drum component

The strain is made of the same plate as the hopper drum. It drilled neatly in two ways. It is curved to be fixed on the strain stand inside the lower drum. Special attention is needed when crushing the cattle dung, it has to be dry enough, otherwise, the crushed dung will not be able to pass the strain, as the holes in strain are quite small only 8 mm in diameter. The

strain itself should be cleaned after being used to prevent corrosion.

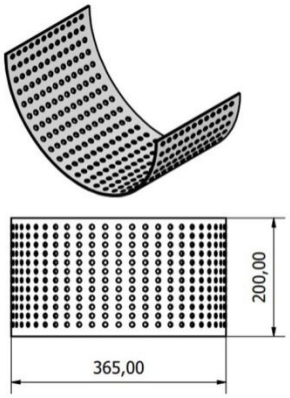

Figure 4: Schematic of cutting grass on a single a single blade

The frame, where all other components are placed, is made of L-shape steel of 50 mm × 50 mm × 5 mm. It was electrically welded (SMAW) to ensure stiffness and strength. It was a stepped structure, with the lower part for placing the motor and the upper for other components of the machine as shown in Figure 5. The total dimension of the frame is 605 mm × 450 mm × 670 mm.

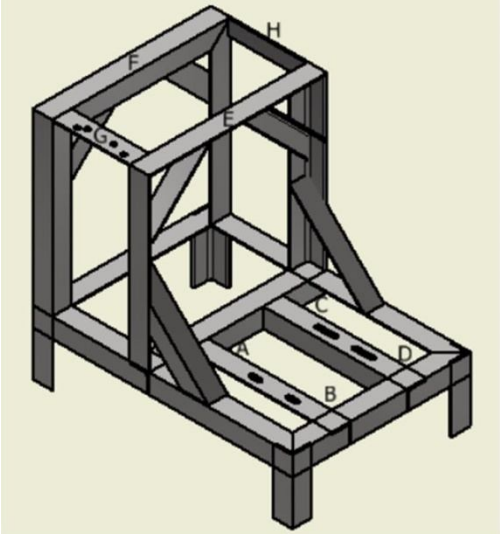

Figure 5: The isometric view of the frame

Figure 6 presents the overall design of the chopper & crusher machine. It comprises of five main components: (i) the chopper to cut and crush, (ii) the strain to sieve the crushed dung, (iii) the hopper-drum to control the material before and after chopping-crushing, (iv) the engine, and (v) the frame to hold all of the system.

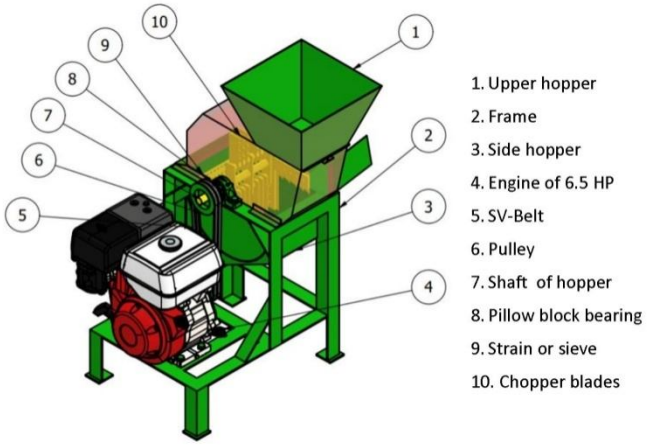

Figure 6: Assembled design with components

The manufacturing was carried out for each component following assembly. The machine, then went to trials. As previously designed it should be able to do both separate jobs: crushing the cattle dung and chopping the agricultural waste. The machine work well. Both type of job were well accomplished as shown in Figure 7. Capacity of the machine is about 130 kg/h, with the efficiency of 90.7%.

Figure 7: The machine in action

The capacity of this machine is lower than the previously designed chopper which is up to 200 kg/h[17] or even up to 600 kg/h [18]. However, this machine has the advantage of being able to crush the cattle dung, which has not been reported by the aforementioned machines.

In terms of efficiency, this newly designed machine has a little lower in comparison to [21] which is up to 93.37%; yet higher in comparison to[16] which was only 87.91%.

This paper is a report based on community empowerment by the lectures team of Engineering Faculty, the University of Jember, Indonesia. The focus of this paper is not on the novelty of the newly designed chopping and crushing machine. For community empowerment, the technology that is transferred to society should be the proofed one. It is not eligible to offer a new technology that is in the developing stage. The peers, most of the time are the active group in the villages, need an appropriate technology that is ready to use.

Figure 8: Handover of the machine from authors to the peer: (a) on Sempu-Banyuwangi& (b) on Arjasa-Jember

In these cases, our peers were very pleased with the new agricultural waste chopper and crusher machine. All of the farmer group members were happy at the time of the handover procession as seen in Figure 8. They hope to another technology to overcome plastic waste. It may plastic chopper to pre-processing of the plastic recycling.

4. CONCLUSION

This report is based on community development activities by authors to the farmer group in Sempu-Banyuwangi and Arjasa-Jember, East Java, Indonesia. Discussion between authors and the peers results in a need for a new design of chopping machine that can double tasks: chopping the agricultural by-products and crushing the cattle dung. Both are to manage and utilize organic waste. The machine was successfully designed and manufactured and comply both jobs. The performance of the machine is calculated by the capacity of 130 kg/h and efficiency of 90.7%. The peers were so enthusiastic to grant the machine. They hope for another appropriate technology for the future to overcome plastic waste.

In these cases, our peers were very pleased with the new agricultural waste chopper and crusher machine. All of the farmer group members were happy at the time of the handover procession as seen in Figure 8. They hope to another technology to overcome plastic waste. It may plastic chopper to pre-processing of the plastic recycling.

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