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Research Article

Design of Multifunction Paddy Harvester and Harrow Machine

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Abstract

Background and Objective: The rice production of Malang Regency in 2017 reached 493.794 t, so it was necessary to develop paddy harvester machine. This study aimed to design paddy harvesting and harrow machines. **Materials and Methods:** This research method has three stages, i.e., the process of making a design using AutoCAD software, the manufacturing process was carried out starting from the preparation of tools and materials, making the frame, modifying the blade and testing the machine by testing on the farmland. **Results:** The results of this study produce a multifunctional machine that is to harvest paddy and as a rake machine to cultivate the soil. This multifunctional paddy harvesting machine is capable of harvesting 9-11 m² min⁻¹ or increasing by 22.2%. **Conclusion:** Another advantage of the paddy harvester and tillage machine is that it can ease the burden of workers because this machine has two wheels as frame support.

Key words: Design, harrow machine, multifunction, paddy harvester machine, rake machine, farm land

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesia has great potential in the agricultural sector because of the influence of climate, soil fertility and forests as a source of water causes the majority of Indonesia population depend on their livelihoods as farmers. The majority of the population of Malang Regency also works in the agricultural sector. The agricultural sector is a mainstay sector in the economy of Malang Regency. According to the Office of Food Crops, Horticulture and Plantation, most of Malang Regency is agricultural land, which is around 14.31% (45.888 ha) is paddy land, 37.82% (121.286 ha) is gardens, 7.53% (24.142 ha) is plantation areas and 11.30% (36.230 ha) is forests¹. In order to achieve the best objectives, the best method, the best place and the best time is needed. Rice production in Malang Regency in 2018 reached 499.986 t with 70.349 ha of rice plantations area with land typography that was difficult to reach by agricultural machinery¹.

Another problem faced is the lack of labor during the harvest season because in Indonesia the harvest time is almost the same that is why it is difficult to get workers. In Malaysia, to overcome this problem the farming community offers special operators provided by official farmer organizations for hire by farmers during the harvest season². Besides the main problem in post-harvest rice is the high losses both quantitatively and qualitatively³. Chavan *et al.* conducted research on the design of reaper engines to be more efficient, focusing on ease of operational harvesting on small land in a shorter time and at a low cost by considering factors such as power requirements, equipment costs, ease of operation, field conditions, operating time and climatological conditions⁴. Dinesh *et al.*⁵ conducted research on the design of small-scale harvesting machines to harvest rice very efficiently. Focus on operational ease of harvesting rice in less time and low cost by considering different factors such as equipment costs, ease of operation, operating time and climate conditions.

In addition, the use of land facilities that are not optimal can be caused by many things. The limited funds of farmers in the supply of agricultural machinery are the main causes that must be tolerated. In order for activities to achieve the best goals, it requires the best method, the best place and the best time⁶. The ability of the government to provide agricultural equipment and machinery must also be improved. The agricultural equipment or machine is a means of processing agricultural land which absolutely must be owned by every farmer. In soil processing activities carried out manually, agricultural tools used are usually made by small industries, where the shape and size of the tools made are determined on the basis of the condition of agricultural land in the area and

based on their body size, so that agricultural equipment on the market is very diverse in shape and its size⁷. Furthermore, the diversity of agricultural equipment in circulation causes a system integration between agricultural machines and farmers, because the size of the body of farmers using the equipment used tends to be inappropriate. As a result, the actual work capacity produced by farmers using these tools is not optimal. In general, agricultural land management activities are carried out in two stages, i.e., primary processing (plowing) and secondary processing (harrowing)⁸. Depending on soil conditions and local customs, plowing and harrowing work can be done more than once until the land is ready for planting. In the process of growing plants, land requires a process of loose soil and weeding. After the plant grows big and is ready to be harvested, it needs a harvesting machine. Therefore it is necessary to develop a paddy harvester and a soil flouring machine. Because product design is basically used to improve product quality for consumers⁹. This study aimed to design a paddy harvester and a soil mixer.

MATERIALS AND METHODS

Study design: This research method consists of three stages, i.e the process of making a design using AutoCAD software, the manufacturing process is carried out starting from the preparation of tools and materials, making the framework, modification of the blade and soil tiller, testing the machine by testing on the farmland¹⁰.

Study area: The location of this research was agricultural land in Malang Regency, East Java, Indonesia.

Data analysis: Data analysis, is a preliminary analysis to find out what needs to be done, ranging from layouts, work movements to existing facilities. This stage of the data was analyzed for the suitability of the design. Implementation of rice harvester and earth melting machines, namely testing the engine on the results of redesign by the operator as a substitute for the previous machine and then comparing the output with the previous machine so that the productivity ratio can be known.

RESULTS AND DISCUSSION

The land after being process in the first tillage, in general, is still a large lump of soil. For further destroy and level the surface of the land, the second tillage is processed. The tools and agricultural machinery used to do the second soil treatment are harrow type soil processing equipment

(harrow). The use of rakes as a second soil processor, aside from aiming to further destroy and level the soil surface for better growth of seeds and plants, also aims to preserve soil moisture and increase nutrient content in the soil by further destroying crop residues and mixing it with soil. Rakes are the most common machine used in tillage¹¹. The various types of rakes used for processing second soil are: disk harrow; toothed rake spikes (spikes tooth harrow); springs toothed per (springs tooth harrow); and rakes for special work (special harrow).

Disk harrow, in principle, this tillage equipment is almost like a disc plow, especially a vertical disk plow. The difference only lies in the size, concavity and number of disks. Disk rakes have smaller disc sizes and concavity compared to plows, this is because the second tillage is done more shallow and no effective land reversal is required as the first tillage. Like a disc plow, the main parts of a disk rake consist of: the disc; disk shaft; disk separator; framework. Sometimes it is also equipped with a supporting wheel, if the coupling system with the traction uses a trailing system. Disk rakes are usually not equipped with stabilizing grooves. Disk rakes are very suitable for use in sandy soil¹².

Toothed rake or commonly referred to as a comb rake, is a type of rake that is commonly used by farmers in Indonesia. Comb rakes that are pulled by animals, generally their teeth are made of wood and commonly used for tillage in wet conditions, as a follow-up work after the soil is processed with singkal plow. Toothed rake nails that are pulled by tractor power teeth made of metal, mounted on a rod (tooth bar) with a clamp or welding. The construction of nailed toothed rakes that are pulled by tractor power usually consists of one placement rod. Dental placement on the placement rods is arranged alternately between the placement rods with one another. The shape of nail teeth varies greatly, some are straight and pointy and some are flat, some are in the form of diamonds. Thus the main parts of a toothed rake or comb rake is composed of; nail teeth, placement rods and reinforcing frames. Nail-toothed rakes are mainly used for leveling and smoothing the soil after plowing, more suitable for fragile soils. This tool is quite effective for eradicating pest plants especially those that are still small, or are just growing.

This toothed rake as a whole is almost like a toothed tooth rake, only its teeth are made of spring or spring. Also used to level and refine the land after plowing. This tool is also more suitable for use in soils that are easily destroyed. Suitable for eradicating weeds that have roots that are strong enough and deep. This is because a toothed rake has a greater penetration depth than a toothed rake. From its flexible and curved shape will be able to lift or uproot the roots of plants so that it is thrown out to the ground surface.

Special harrows are usually used to work on tillage with more specific purposes. For example, tillage with the specific purpose of destroying crops, destroying litter, or for intensive soil enrichment, or perhaps aiming to make seed beds more feasible. The use of special rakes is usually done after the first tillage and second tillage. Specific types of rakes include: weed mulcher; rotary cross harrow; soil surgeon.

The several types of rake engines, which allows to be modified with a rice harvester machine is a type of comb rake. Because the power possessed by the rice harvester is not too large and the type of terrain that becomes the object of the rake is the type of dry soil after the plowing process. Design is an activity or engineering design that starts from the ideas of design innovation, or the ability to produce works and inventions that can really describe the market demand because of the research and development of technology^{13,14}. Following are the steps in designing the modification of multifunctional paddy harvester and harrow machine.

Create designs using AutoCAD software: A multi-function paddy harvester machine is a machine designed to be used in two functions, which can be used to harvest paddy and can also be used to loosen soil¹⁵. In this case, there is a part in the machine that can be replaced by a rice harvester and a land spinner. The following designs are modified designs of multifunctional rice harvester and harrow machines using AutoCAD software as shown in Fig. 1.

Manufacturing process: The manufacturing process starts from the preparation of tools and materials. The manufacture of a multifunctional paddy harvester machine as described below:

- **Frame manufacturing:** Making the framework for this machine that is using hollow iron with an iron size of 20×20 mm, which is then carried out the process of joining or forming with the welding process and in accordance with the design drawings
- **Full handle manufacturing:** The control handle is made using iron pipe with a diameter of 2.5 cm and with a thickness of iron that is 2 mm, a length of 50 cm which is then welded at the back of the machine
- **Wheel Axle Manufacturing:** In the axle section, the axle used is the axle that is sold on the market. In order to get a good holder and strength, then connected with concrete steel and with a diameter of 15 mm, by doing the welding process
- **Machine stand manufacturing process:** On the engine seat bench, the material used is the same as the mainframe that is hollow iron with a size of 20×20 mm

Fig. 1: Design of paddy harvester and harrow machine

Fig. 2: Paddy harvester and harrow machine

Fig. 3: Testing of paddy harvester and harrow machine

Making rice directors that use iron plate material measuring 2 mm thick iron with an iron length of 100 cm

- **Making blade replacement slots:** Modify the blade and loose ground at the tip of the steering guide by using nuts and bolts
- **Testing machines by testing on farmland:** The test is carried out to find out whether the engine that has been designed is able to work optimally and to find out the obstacles faced. Figure 2 and 3 is the process of testing rice harvesting machines and ground scrubbing machines.

- **Making rice guidance:** The wipers are placed on the front side of the machine, the wipers are made using 2.5×2.5 cm elbow plates and iron thickness plates of 2 mm

The results of testing the rice harvester machine and the earth melting machine were able to harvest is significant area of $11.9 \text{ m}^2 \text{ min}^{-1}$ or an increase of 22.2%. This is consistent

with Tang *et al.* research that the development of a multi-function combination harvester with wheat harvest and binding of straw can reduce labor and energy costs¹⁶. Other studies by Sukcharoenpharath *et al.* that there is a real difference in work output but there is no real difference in the comparison of rotary tiller and power harrow¹⁷. Another advantage of the rice harvester and earth melting machine is that it can ease the burden of workers, because this machine has two wheels as a pedestal frame.

CONCLUSION

The conclusion of this study resulted in one rice harvester machine and a soil mixing machine that is to harvest rice and as a rake machine to cultivate the soil. This multifunctional rice harvester is capable of harvesting 11-9 m² min⁻¹ or experiencing an increase 22.2%. Another advantage of the paddy harvester and harrow machine is that it can ease the burden of workers, because this machine has two wheels as a support frame.

SIGNIFICANCE STATEMENT

This study discovers the design multifunction paddy harvester and harrow machine is redesign agriculture machine in Indonesia land that can be beneficial for Indonesia farmers. This study will help the researcher to uncover the critical areas of development paddy harvest machine, because so far there has been no research in Indonesia that has developed a multifunctional paddy harvester.

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