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Ideas and Solutions for Nation-building

Design and Implementation of an Automated Stirring Robot for Rice Paddy Sun Drying

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Abstract: This study addresses the many problems present in the labor intensive traditional rice paddy drying process-sun drying. This process exposes many Filipino workers to the harmful rays of the sun and when not properly managed, can risk the quality of the paddy. Rice paddy sun drying or solar drying is the cheapest and most economical process of drying paddy. This only requires an open area where the rice paddy can be laid and workers to monitor the drying. To maximize the heat provided by the sun and to achieve better quality rice paddy, the International Rice Research Institute (IRRI) recommends to stir the paddy every 30 minutes to 1 hour for even drying. Due to the intensity of the task as well as the laying and collection process, millers fail to follow this recommendation. Thus, this affects the quality and leading them to the inclination of using mechanical dryers which are more expensive and have lower capacities. A design for an automated stirring robot will be give accuracy to this traditional drying process as it constantly checks the percent moisture of the paddy, monitors the field for even drying, and collects the paddy once it has dried. This study discusses the process of designing, fabricating, and analyzing the performance of the automated stirring robot for rice paddy sun drying.

Key Words: paddy; stirring, moisture level; collecting; bagging; sun drying

1. INTRODUCTION

A study from the World Bank suggested that, on average, 8% to 26% of the world's rice is lost in developing countries because of poor harvest and post-harvest management (IRRI, 2013). The moisture level of the paddy rice is one of the qualities keenly observed because it is affected by several factors and procedures. If the rice paddy is too moist, the rice is more susceptible to spoilage once stored. Lack of moisture, however, results in the breaking of the grain (IRRI, n.d.).

The large size of the drying pavement will make it more difficult to manage the timing and stirring sequence of the grain and this also means the exposure of the workers to the intense and dangerous rays of the sun (IRRI, n.d.). Producing rice paddy that is evenly dried while controlling its change in moisture level to a specific percentage is labour intensive so the researchers' general objective is to design and construct an automated robot that uses vision systems for movement and localization in order to stir moist paddy laid in a pavement and use data gathered by the sensors to activate either of the aforementioned functions and prepare it for collection.

2. METHODOLOGY

The size of the mechanical design is based on the targeted storage capacity of the robot based on the regular size of a sun drying field used by millers. It aims to collect a *1x1 m* area of paddy with the height of 4 cm, which requires a capacity for approximately *22 kg* of paddy.

2.1 Robot Mechanical Design

It was designed as a mobile robot (See Fig. 1) to be able to move freely along the field as it demands the use of solid frame strong enough to support the major mechanisms of the robot. The frame has a total length of 1.95 m, a total width of 1.32 m, and a total height of 0.4 m.

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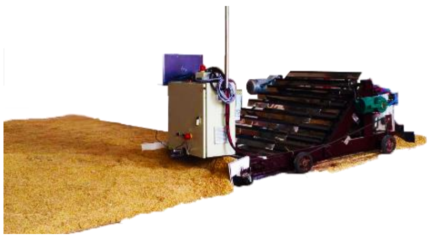

Fig. 1. Final mobile robot design

The conveyor is the central and most important mechanism of the robot as it is designed to accomplish the objectives of the robot, which is to stir and collect the paddy (See Fig. 2). Stainless steel L-bars were used as conveyor flaps wherein the longer side of the L-bar will be where the brush strips are secured using rivets, while the shorter end will be bolted on the chain belt. The height of the conveyor is based on the target volume of the collecting bin that will dictate the height of the ramp that catches the paddy being swept by the conveyor.

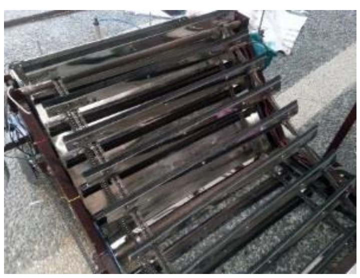

Fig. 2. Mobile robot design (left), Conveyor mechanism (right)

Similar to the ramp, the bin is made of stainless steel sheets formed into a hollow trapezoidal prism with two openings. One opening at the top where the paddy from the conveyor will enter and another opening at the bottom side facing away from the conveyor where the paddy will exit. This second opening is covered by a hinged door made from the same sheet metal, which remains closed to keep the paddy inside as dictated by the program (See Fig. 3).

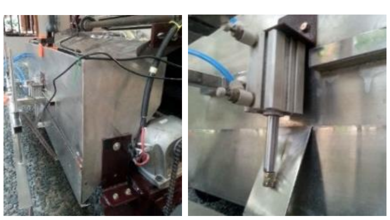

Fig. 3. Bin design (left), bin door mechanism (right)

2.2 Bagging Mechanical Design

This is an area and a function that is separated from the robot as it is positioned on the bagging ramp for the elevation needed during bagging. The paddy pours down the funnel to the bag from the robot bin while the suction pads powered by a compressor will move forward as triggered by a pushbutton and will open a size-customized sack fed by the dispensing hooks as seen in Fig. 4. The bag will be retrieved by a worker once filled.

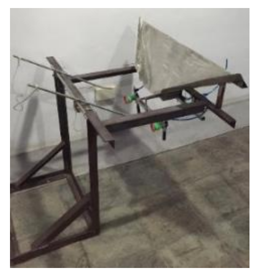

Fig. 4. Bagging mechanism

2.3 Program

In order to easily control all components and allow the computer to communicate to these components, a microcontroller is used, in this case, an Arduino Mega 2560. The robot initially closes its collection bin and collects one 1 x 1 sq. meter plot and then checks its moisture content while in the bin. After identifying that the moisture content is above the accepted dry value of 14% moisture content, it returns the collected paddy to the ground and continues the stirring module for every column. The robot uses the cones as a reference for straight movement along each column, leveling the paddy in the process. When the robot finds a dry value, it will finish its stirring module then return to the starting position and begin its collection module which is the second setting.

The robot then proceeds to move backwards until it is in position near the bagging ramp. After the manual control of the robot up the ramp and the bagging, the robot program takes over and would proceed to collect the next plot of rice paddy and returns near the bagging ramp. The collection and manual bagging cycles until the entire drying field is collected.

The vision system of the robot will make use of the Roborealm Vision system program. The parameters of the color filter were fixated on the color RED – the color of the cone shows the common parameter values used for

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detecting the cone in the field. The Center of Gravity (COG) module is used for the size of the image of the cone tells the distance and the straightness of the robot towards its direction.

3. EXPERIMENTS

The experiments conducted were used to test the functions of the robot based on the objectives of the project. The robot's capability to stir and flip the paddy was tested and compared to outcome of the manual process. Colored paddy layered on ordinary paddy was set for the experiment to criticize the outcome. Visual evaluation can conclude that the conveyor stirring process mixes and flips the paddy more effectively. Also, the effectiveness of the leveler for the 4cm targeted height and the collecting process was also experimented on in a 5x3 m field set up as it is the size initially programmed. In the leveler experiment, the drying field was mostly consistent in height, close to 4cm, throughout the experiments, there were measured height as low as 1.5 cm and as high as 5 cm.

As for the collection experiment, the leftover paddy was due to multiple factors such as the robot path, spaces for the sweeping ramp and paddy being dragged by the plows. The experiment was done thrice with a mean left over of 2.88%. The bagging aspect of the collection module was tested in the experiment. The average amount collected by the bagging mechanism was 15.55kg. The average loss per bagging collection is 2.81%.

4. CONCLUSIONS

The Automated Stirring Robot for Rice Paddy Sun Drying was able to achieve its objectives in designing and fabricating a robot that will perform the task of stirring and collecting in an ideally set field of paddy. In a 3 by 5-meter plot, the robot had above average stirring performance and was able to reach an ideal total time 24 minutes and 48 seconds, with little to no technical problems. The test field was maintained with only slight displacements of paddy from the original field using only a program guided by vision and values from a probe moisture meter. The performance of the design in collecting has successfully attained a percent error of less than 5%. These results support the effectiveness of the design and may be used as a promising start in the development of this robot.

5. REFERENCES

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