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Paddy Moisture Content Detector

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Abstract: Electrical conductivity is a measure of a materials ability to conduct an electric current hence a resistance type instruments measure the ability of a sample to conduct a current relative to its moisture content. When minerals or impurities from materials or substances are added, water becomes a good conductor. This paper discusses the detection of moisture content of paddy. The device detects the presence of moisture in paddy sample in the range of wet, 20% moisture content, medium, 18% moisture content and dry, 14% moisture content. The device uses the probes as sensing element and the outputs of the device are represented by three LEDs which are red for wet sample, yellow for medium wet sample and green for dry sample.

Key words: Paddy, electrical conductivity, moisture content, detector

INTRODUCTION

In industry, determining the moisture level in substances has variety of purposes. In agriculture, moisture level in grain such as paddy, beans or corn is measured to control the quality of products and facilitate in research and development. Besides, agriculture researchers perform assessment of soil quality and organic resource quality by monitoring the moisture level.

To measure the moisture content, the conductance of a substance must be determined. The electrical conductivity or resistance type instruments measure the ability of sample to conduct a current relative to its moisture content. In addition, conductivity of the substrate increases as the moisture content increases. Based on Ohm's Law $V=IR$, lower resistance gives higher voltage drop and thus measures higher moisture level.

Some devices use sophisticated methods for instance infrared, radio frequency, or microwave techniques to evaporate water from a sample. This latest technology determined the high production cost of the detector.

Moisture content of agricultural products is one of the most important for determining proper time for harvesting and the potential for safe storage.

The objective of this paper is to discuss the design of a device that can measure moisture content in order to help farmers. This requires determining the percentage of moisture in the paddy after drying process in order to prevent from too much breakage during milling process. The device must be easy to use and cost effective.

For this study, factors that can affect the measurement such as sample temperature, soil mineral and pH value are held constant. Some other factors such as distribution of moisture in sample, size and density of sample are considered insignificant to the measurement. The specific measurement range of the detector for this research is from 20-25% of moisture content before drying and 14% moisture content after drying.

In line with the new emphasis to revitalize agriculture sector as the third engine of growth, Malaysia government allocated a total of RM 11.4 billion in the 9th Malaysia Plan (9 MP) to implement various agricultural programs and projects. To develop and modernize the agriculture industry, the government is focusing on automation, precision farming and implementing various mechanisms.

Rice production is one of the agriculture sectors in Malaysia that play an important role. The country will be able to achieve self-sufficiency in rice production provided farmers incorporate the latest farming technologies in paddy cultivation as mentioned by Oryza (2004).

Also, researches have proved that moisture content in soil also affect the agricultural process as water is essential in plant growth. Without water, normal plant functions are disturbed, and the plant gradually wilts, stops growing and dies. However, Scherer *et al.* (1996) mentioned that excessive moisture may lead to destruction of the roots by root rot and the yellowing of plant leaves.

According to Davis (1944), the optimum harvest moisture content for the paddy of the Caloro variety was 20-24%. Pominski *et al.* (1961), showed that the paddy moisture content had a significant effect on milling yields

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of Bluebonnet 50 long grain rice. They selected samples with moisture content ranging from 10-14% and concluded that for each 1% decrease in moisture content, head yields and total yields increased 3 and 0.7% respectively.

As for rice breakage, samples with moisture content of 12-16%, Dilday (1987) concluded that rice breakage decreased with increased paddy moisture content.

Afzalinia *et al*. (2004) found that the paddy moisture content had a significant effect on rice breakage of the whitener and the entire milling system so that the rice breakage decreased with increased paddy moisture content. As mentioned by Luh (1991), the minimum total rice breakage occurred at the range of 12-14% moisture content; therefore this range was optimum moisture content for the paddy and the milling time.

It was reported by Peuty *et al.* (1994) that the paddy drying conditions affected the breakage of rice during the milling process so that the rice breakage increased rapidly with decreasing moisture content of the air used to dry the paddy.

MATERIALS AND METHODS

Interviews were done to gather information from the farmers and the MARDI (Malaysian Agricultural Research and Development Institute) official. Then a survey was done on the existing devices like moisture analyzer, sensor and software. The detector circuit is designed and later proceeds with a laboratory experiment to determine the relationship between voltage and moisture content. The experiment was based on Gravimetric technique, i.e., removing water from sample to determine moisture content. For the sample preparation, the procedures of the experiment are as follow:

- Weigh sample and container in grams
- Soak sample in water
- Remove excess water
- Dry sample in oven
- Reweigh sample
- Calculate moisture content

The percentage of moisture content is calculated by equation:

$$MC(\%) = \{(W-D)/W\}\times 100$$

Where:

MC : Moisture content
W : Wet weight sample in grams
D : Dry weight sample in grams

The grain will lose weight due to loss of moisture. To determine the final weight of grain, it will be:

$$\text{Final weight of grain} = \frac{\text{Initial weight}\times(100\%\text{-Initial MC\%})}{(100\%\text{-Final MC\%})}$$

For instance, to dry 500 grams of paddy harvested at 25%MC and dried down to 14%MC, this will result to:

$$\text{Final weight of grain} = \frac{500\times(100\%\text{-}25\%)}{(100\%\text{-}14\%)} = 375.4\text{ g}$$

The method used in determining the moisture content is using the principle of electrical conductivity. By applying Ohm's Law, wet sample has higher moisture content and has lower resistance than dry sample. The measured parameters are the moisture content and voltage relationship.

RESULTS

Interview: According to the farmers that were interviewed, drying of paddy takes 2-3 days while dryness determination is by using heels or biting a kernel of paddy. Breakage of rice will occur if the moisture content in paddy is too high during milling process.

From the MARDI officer, the moisture content of paddy before milling process is said to be 13% in order to prevent from rice breakage. The price of the existing devices in the market is very expensive.

The correct moisture content is needed to obtain high yields as it is essential to mill paddy rice. Paddy is at its highest milling potential when its moisture content is at 14%. The paddy will be affected whether the moisture content is too high or too low (Table 1).

Delays in drying of wet paddy cause quality deterioration and discoloration which will occur within 2-3 days after threshing. Paddy with high moisture content (>20%MC) must be dried down to 18% which is known as skin dry then to 14% to preserve milling, cooking smell and eating qualities. The key to post production is correct timing of operations and grain moisture content.

Moisture detector for paddy: The detector is capable to measure the moisture content of paddy. The main component used is LM3914, LED dot/bar display driver.

Table 1: Effects of high and low moisture content

If	Then
Moisture too high	Grain too soft to withstand hulling pressure without breakage and may be pulverized
Moisture too low	Grain become brittle and is susceptible to greater breakage

Table 2: Sample type according to moisture content

Type of sample	Moisture content (%)
Dry	14
Medium	18
Wet	20

Table 3: Weights of paddy in the experiment

Moisture content (%)	Initial weight (g)	Final weight
14	500	375.4
	550	479.65
	600	523.4
18	700	640.0
	750	686.0
	800	731.7
20	850	797.0
	900	844.8
	950	890.6

It is a monolithic integrated circuit that senses analog voltage and drives 10 LEDs, providing a linear analog display. It has an adjustable voltage reference that is divided by series resistors and used as the reference voltages for 10 comparators that drive the LEDs, with their current determined by the load. The outputs from LM 3914 are grouped together to become only 3 final outputs which represent red, yellow and green LEDs. It is also acting as the voltmeter with 10 equal steps and each LED indicated 125 mV across the sample. An 1.2 kΩ resistor is LED brightness controller.

The probes: A pair of probes is used as the sensing element to detect the moisture content in the sample. This is a pair of steel nails with 7cm. long and 4mm. in diameter and was chosen as it has good electric conductivity. The probes are inserted into the substances to measure the electrical resistance/conductance between them. The probes apply DC current to the sample that is between them and the LM 3914 displays the resulting voltage. The function of the probes depends on the nature properties of water. Water contains electrolytes, which are compounds that ionize in water, and produce a solution that conducts electricity. Wet sample has higher moisture content which has more ions and be able to conduct electricity well. By applying Ohm's Law, it has lower resistance compared to dry sample which has less ions and higher resistance.

Experimental results: Gravimetric measurement technique is used in the experiment. This is removing of water from the sample. The percentage of moisture content for dry, medium and wet sample has been set based on the results of the experiment (Table 2).

The data in Table 3 indicates the initial weight and the final weight of the paddy used in the experiment in accordance to the target moisture content of 14, 18 and 20% which were classified as dry, medium wet and wet sample, respectively.

Three trials had been completed through the experiment. The sample resistance was calculated based on the circuit configuration. Ten LEDs were used and the output of the circuits were grouped in order to have the final output of only 3 and these are as follows:

- From 1st -4th LEDs lighted-wet sample-Red on
- From 5th-8th LEDs lighted-medium wet sample-Yellow on
- From 9th-10th LEDs lighted-dry sample -Green on

CONCLUSION

The Theory of Conductivity was implemented to detect the wetness or dryness of paddy in order to design a paddy moisture content detector. Gravimetric technique was applied in the conduct of the experiment in order to calculate the percentage of moisture content for calibration purposes.

The detector was able to measure the moisture content of paddy. It was shown that the percentage of moisture content for the paddy was detected using LEDs, red, yellow and green for wet, medium wet and dry samples respectively. In order to enhance the accuracy of the detector, further laboratory testing must be done and also, its usage could be extended to other agricultural products.

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