IoT-Based System for Detecting Grain Moisture Content to Improve Rice Harvest Quality

Eka Ismantohadi[1], Fachrul Pralienka Bani Muhamad[2], Fauzan Islakhuddin[3], Budi Warsito[4], Oky Dwi Nurhayati[5], Ade Alvi[6], Ikhwan Maulana Wachid7

[1-3,6-7]*Informatics Department, Politeknik Negeri Indramayu*
Lohbener Lama Street No 8, Indramayu, West Java, Indonesia
[4-5]*Information System Department, Universitas Diponegoro*
Imam Bardjo SH Street No. 5, Semarang, Central Java, Indonesia

[1]eka@polindra.ac.id
[2]fachrul.pbm@polindra.ac.id

Abstract— **Drying grains serves to remove excess moisture, prevent rot, and increase shelf life for farmers. The duration of time required to dry rice is a critical parameter affecting grain quality and sale value. To achieve ideal grain moisture content, various farmer groups utilize grain drying machines such as Bed Dryers. However, drying machines are currently unable to automatically learn the characteristics of the moisture content of the grain being dried, necessitating human input to determine the optimum moisture content. To address this challenge, we propose the creation of an Internet of Things (IoT)-based grain moisture content measuring device, which can be integrated into a Bed Dryer machine. The resulting IoT tool can be augmented with machine learning, web, or mobile applications. However, this research is solely focused on IoT tools design and manufacturing. The ESP32 module functions as a data control and communication device for each sensor connected to the internet network in IoT devices. The sensors utilized for measuring grain moisture content are BME280, Capacitive Soil Moisture, and Negative Temperature Coefficient (NTC) sensors. The findings present data on grain temperature values, grain drying environmental temperatures, and grain moisture content. This information can serve as a reference point for developing machine learning algorithms, web applications, and mobile applications that guide the ideal water content value of grains.**

Keywords— **BME280 Sensor, Capacitive Soil Moisture Sensor, ESP32 module, Grain Moisture Content, IoT-based System, Negative Temperature Coefficient (NTC) sensors**

I. Introduction

West Java produces the largest amount of rice in Indonesia, with a contribution of 12,299,701 tonnes of milled dry unpeeled grain (GKG) in 2017, representing 15.16% of national rice production (Rasmikayati et al., 2020). Indramayu Regency is one of the regions in West Java with the highest rice productivity, with a rice harvest area of 227,051 hectares in 2021, which increase by 8% to 245,222 hectares in 2022. In 2021, Indramayu Regency produced 1,319,624 tons of milled dry grain (GKG) of rice. The following year, production increased by 179,697 tons to 1,499,321 tons (BPS, 2023). Indramayu Regency has been designated as one of the national rice granaries in Indonesia due to the stable growth of rice harvests every year.

The quality and selling price of rice are affected by the drying process of the grain. In many regions of Indonesia, including Indramayu, farmers still rely on conventional solar heat drying methods. However, this is considered inefficient due to the unpredictable weather. To address this issue, farmer group associations in Indramayu, such as Sri Makmur, have started using bed dryers, which are oven-based grain drying machines. By using this technology, farmers can dry their grains regardless of the weather or the availability of sunlight.

Bed dryers are unable to provide information on the moisture content of grain during the drying process. Deviations from the ideal moisture content of 14% (source: bp2tp.litbang.pertanian.go.id) can negatively impact the quality and selling value of the grain. Farmers typically assess the level of dryness by cutting and nibbling the grain. Determining the moisture content of grain presents a challenge due to potential inconsistencies in the accuracy of human sensory organs (Gunawan, I Ketut Wahyu & Bella Cinthya, 2021).

When using a bed dryer, farmers must pay a rental fee based on the desired duration of use. However, farmers often struggle to accurately predict the necessary drying time, leading to additional costs. To address this issue, alternative drying methods may be worth exploring. Checking the moisture content of grain can only be done after the drying process is complete. Inspection is carried out by using inconsistent methods such as cutting and biting the grain. If the moisture content of the grain is not ideal after the initial drying duration, farmers must pay additional rental fees for the next drying duration. This is a cost consideration for farmers.

Grain with moisture content below the ideal level is often sold at a lower price to potential buyers. Wet grain is not only considered low quality, but it is also at risk of being attacked by pests or fungus during storage. Additionally, wet grain can negatively impact the quality of the rice produced during the milling process. Conversely, grain that is too dry can cause the resulting rice to crack.

A tool is required to measure and monitor grain moisture content to address the presented issues. This research proposes an Internet of Things-based system for detecting grain moisture content. The aim is to assist farmers in improving the quality of their grain yield, affecting the quality of milled rice.

The system requires several electronic components, including input, processor, and output components. The input sensors consist of the Capacitive Soil Moisture Sensor, BME280, and Negative Thermistor Coefficient (NTC). The Capacitive Soil Moisture Sensor measures the moisture level or water content of the grain. The BME280 sensor measures the ambient temperature of the Bed Dryer, while the NTC sensor measures the room temperature.

To achieve real-time monitoring of measurement results that can be used by farmers, an Internet of Things (IoT) based monitoring tool is proposed. The ESP32 series NodeMCU microcontroller will be used for data processing, and the information output will be displayed on a 16x2 LCD. The aim is to improve the accuracy of grain moisture content monitoring by obtaining real-time data. Apart from that, assisting farmers in determining the optimal dryness level will increase the quantity and quality of the grain produced.

II. Method

This section explains the design thinking method, which consists of five stages: empathize, define, ideate, prototype, and testing (see Fig. 1).

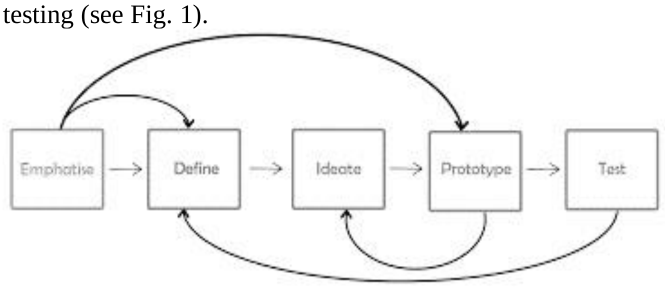

Fig. 1 Stages of design thinking

A. Emphatise

During this stage, observations were made on the challenges farmers face when monitoring grain moisture content. Empathy activities were conducted at Sri Makmur, a Farmer Group Association (Gapoktan) located in Krasak Village, Jatibarang District, Indramayu Regency.

B. Define

Based on the observed data, we analyze and synthesize to identify core problems. However, the process of monitoring grain moisture content remains conventional, involving cutting or biting the grain.

C. Ideate

At this stage, we generate ideas to offer solutions to the problems faced by farmers. We propose a tool design that monitors grain moisture content in real-time using Internet of Things (IoT) technology. The design includes several features to address the issues that arise in monitoring grain moisture levels.

D. Prototype

At this stage we created a prototype of an automatic monitoring tool as follows:

- Design of tool prototype dimensions,
- Design of automatic control systems,
- Integration of IoT tool communication to the server,
- Sustainable prototype operational design.

E. Testing

Testing was conducted with the Sri Makmur farmer group to evaluate the effectiveness of a tool for monitoring grain moisture levels. The tool was tested by measuring the water content of samples of wet grain or Harvested Dry Grain (GKP) and comparing it with Milled Dry Grain (GKG). This test served as a parameter for determining the tool's quality and readiness for implementation in the community. The test results yield the grain's moisture content value and temperature in Celsius, displayed on the LCD screen.

III. Result And Discussion

This section describes the tool, outlines the stages of its creation, explains its functionality, and provides instructions for installation.

A. Tool Description

This tool proposes a solution for monitoring rice seeds or grain, which is currently done manually through biting. This tool aims to mitigate issues related to excessive water content or overly dry grain. It utilizes an Internet of Things-based system that is integrated with a data storage server, providing farmers and local grain producers with real-time monitoring data. Fig. 2 shows the 3-dimensional model of the tool.

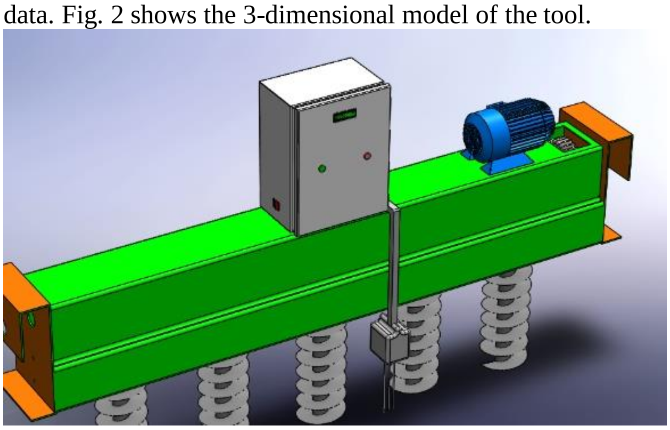

Fig. 2 The 3-dimensional model

B. Tool Development Stages

This section explains the supporting components utilized in the preparation of IoT tools.

1) *Node MCU ESP32*: The ESP32 is a low-power system on chip (SoC) series that features dual-mode Wi-Fi and Bluetooth capabilities. It is equipped with a dual-core or single-core Tensilica Xtensa LX6 microprocessor that can reach a clock rate of up to 240 MHz. Additionally, the ESP32 is integrated with built-in antenna switches, RF balun, power amplifier, low noise receives amplifier, filters, and power management modules. This SoC is the successor to the ESP8266, which is widely used for IoT applications. According

to Suharjo I (2020), the ESP32 features a CPU core, faster Wi-Fi, more GPIOs, and Bluetooth Low Energy support.

2) Soil Moisture Sensor: The Soil Moisture Sensor is a module designed to detect moisture in grain. It can be accessed using a microcontroller such as NodeMCU. Therefore, a higher resistance value indicates a higher moisture level. The sensor measures humidity by passing an electric current through the grain and then reading the resistance value to determine the moisture level. The resistance value increases with the amount of water in the grain.

3) Sensor BME280: The BME280 is an environmental sensor that measures temperature, humidity, and air pressure. The temperature sensor provides accurate measurements of environmental temperature with a precision of up to ±1°C. The humidity sensors provide measurements of humidity with a precision of ±3%. Pressure sensors are utilized to measure atmospheric pressure with an accuracy of up to ±1 hPa.

4) Sensor NTC: Negative Temperature Coefficient, is a type of thermistor that experiences a change in resistance based on temperature. Specifically, the resistance of an NTC decreases as the temperature increases. Therefore, the hotter the NTC becomes, the lower its resistance.

5) Step Down 5v MP1584: The MP1584 is a voltage regulator module used to step down input voltage to a lower output voltage. It is commonly utilized in electronic circuits requiring a stable and constant DC voltage, such as microcontroller circuits, sensor modules, and power supply circuits for other electronic devices.

C. Tool Operation

The system for monitoring grain moisture levels using IoT sensors involves interconnecting sensors that measure the moisture content or dryness level of stored grain. The data collected by the sensors is transmitted through an IoT network to a server-connected platform where it is processed using appropriate algorithms to calculate the actual humidity levels. The flowchart of the tool operation is shown in Fig. 3.

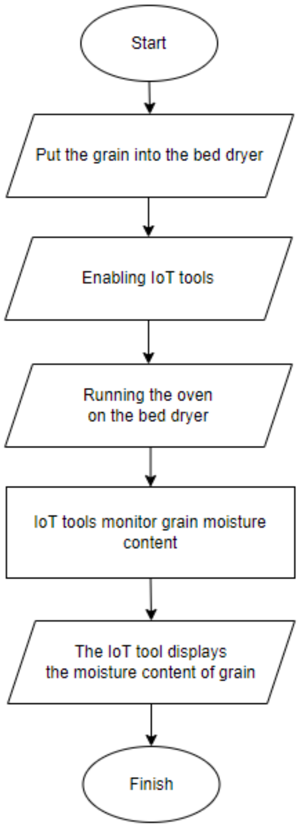

Fig. 3 Flowchart of IoT tool

D. Tool Instalation Guide

To measure an object, place the probe directly on it and activate the tool by pressing the ON switch on the panel. The sensor will then start taking measurement values of objects within its range, and the LCD will continuously display the results of water content readings. The indicator light will provide a message regarding the grain measurement results. The green light is for dry grain, while the red light is for wet grain. The IoT tool has two lights to indicate the moisture content of grain. The tool also sends the moisture content data to the server for monitoring on an LCD display. It is important to ensure that the tool is connected to the internet for this feature to work. The illustration of installation shown in Fig. 4.

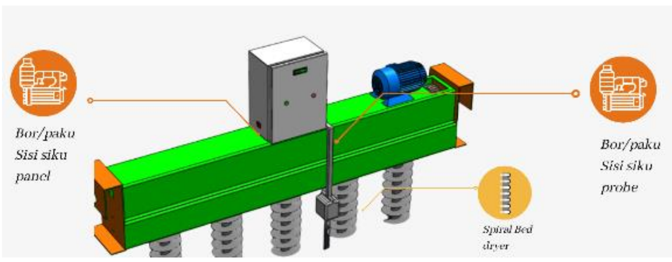

Fig. 4 Tool installation

IV. Conclusions

This tool could benefit from integration with web and mobile applications that provide users with measurement value data. Additionally, data obtained from IoT tools can be used as input for machine learning to predict the duration of grain drying time needed to achieve ideal moisture content. The tool's development has progressed to the point of sending value data to the database server. However, to make the tool available to users, it needs to be integrated with websites and mobile applications.

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