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Automation of Solar Dryer

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ABSTRACT

The automation of solar dryers improves their efficiency, reliability, and usability by incorporating modern technology into traditional drying methods. This project aims to design an automated solar dryer system that utilizes a PIC16F877A microcontroller, DHT22 sensors for monitoring temperature and humidity, and a stepper motor for stirring. The system features a heating mechanism and a pulley system to avoid overheating, while LoRa communication and the Blynk app facilitate real time data transmission and notifications. The proposed solution seeks to optimize drying processes, enhance energy efficiency, and minimize manual intervention. This research underscores the potential of automated solar dryers in both agricultural and industrial settings, highlighting their sustainability and scalability for wider adoption.

Keywords – *Solar Dryer, Automation, PIC16F877A Microcontroller, LoRa Communication*

I. INTRODUCTION

The drying process plays a vital role in preserving agricultural and food products, especially in areas with significant agricultural production. Traditional drying methods typically depend on sunlight, which can be unreliable and susceptible to contamination, or on energy-consuming electric dryers. Solar drying presents a sustainable and economical alternative by utilizing renewable solar energy. Nevertheless, the manual operation and limited control features of conventional solar dryers can hinder their efficiency and scalability. By automating the drying process, we can improve precision and productivity, ensure consistent drying, minimize spoilage, and enhance product quality.

This research aims to create an automated solar dryer that enhances both efficiency and accuracy in the drying process. The system utilizes a PIC16F877A microcontroller to monitor temperature and humidity using DHT22 sensors, controls a heating element through a relay module, and ensures even drying with a stepper motor. It transmits real-time data to a LoRa gateway, allowing for remote monitoring and notifications via the Blynk app, providing a sustainable and user-friendly approach to food preservation. [2]

II. RESEARCH ELABORATION

Identifying the Problem

Traditional drying methods, like open sun drying, often prove to be inefficient, time-consuming, and heavily reliant on weather conditions. These techniques can expose produce to contamination, lead to uneven drying, and risk the loss of nutritional value due to either overheating or inadequate moisture removal. Additionally, the need for manual monitoring drives up labor costs and limits scalability. This situation underscores the necessity for an automated solar drying system that can monitor and control the drying process, ensuring consistency, quality, and energy efficiency.

Automation and IoT Integration

The integration of automation in solar drying has the potential to transform traditional practices by incorporating IoT and microcontroller-based systems.
Current solutions typically focus on basic temperature monitoring and manual control, lacking real-time data processing or proactive control features. This project investigates how automation, utilizing a PIC16F877A microcontroller and IoT-enabled communication, can greatly improve the efficiency and reliability of solar dryers.

The system includes several essential features:
Environmental Monitoring: DHT22 sensors continuously monitor temperature and humidity levels within the drying chamber to maintain optimal drying conditions.
Heating Mechanism Control: A relay module automatically adjusts the heating mechanism, ensuring consistent drying temperatures.
Remote Monitoring: Data is sent via the RA02 LoRa module to a LoRa gateway, allowing for real-time monitoring and notifications through the Blynk app.
Overheating Prevention: A buzzer and pulley system provide safeguards against overheating, enhancing safety and maintaining product quality.

III. LITERATURE SURVEY

Research in the area of solar drying automation reveals notable inefficiencies in conventional drying methods, including extended drying times, risk of contamination, and inconsistent drying, all of which can negatively affect product quality and nutritional value. Various studies highlight how automation and IoT-enabled systems can address these issues. By integrating microcontrollers, sensors, and real-time monitoring systems, the goal is to improve the efficiency and reliability of solar dryers through the automation of essential processes such as temperature and humidity control, uniform drying, and prevention of overheating. The system is built around a PIC16F877A microcontroller paired with DHT22 sensors to monitor temperature and humidity. A RA02 LoRa module facilitates secure data transmission to the Blynk app, allowing for remote monitoring and alerts. It includes features such as a relay-controlled heater, a stepper motor for tray rotation, and an overheating prevention mechanism to ensure efficient and safe drying. The results indicate shorter drying times and reduced energy consumption while preserving quality, highlighting the potential of automating solar dryers to enhance traditional methods and promote sustainable agriculture.

IV. SYSTEM ARCHITECTURE

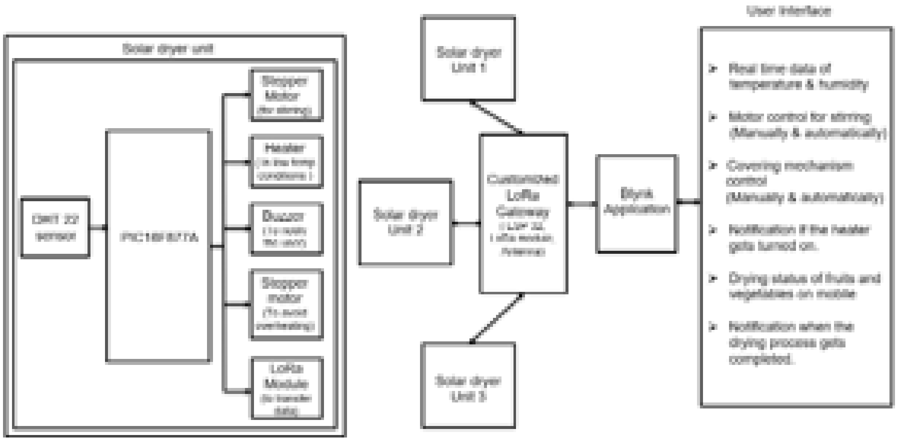

Figure 1: System Architecture of Automated solar dryer

The system architecture of the automated solar dryer includes three main components: the solar dryer unit, a tailored LoRa gateway, and a user interface through the Blynk application.
Solar Dryer Unit: The solar dryer unit is designed with several key components for optimal performance:

a. A PIC16F877A microcontroller serves as the main controller.
b. A DHT22 sensor continuously monitors temperature and humidity.
c. A stepper motor ensures even drying by stirring the contents.
d. A relay-controlled heater activates when temperatures drop too low.
e. A buzzer alerts the user to important events.
f. Another stepper motor operates the covering mechanism to avoid overheating.
g. An RA02 LoRa module facilitates secure data transmission to the LoRa gateway.

Customized LoRa Gateway:
Constructed with an ESP32 microcontroller and an RA02 LoRa module with an antenna, the gateway collects data from various solar dryer units.
It sends this information to the user interface for real-time monitoring and control.
User Interface (Blynk Application): The Blynk app empowers users to effectively monitor and manage the solar drying process:
It shows real-time data on temperature and humidity.
It allows both manual and automatic control of the stirring and covering motors.
It sends alerts when the heater is turned on or when the drying process is finished.
It provides remote updates on the drying status of fruits and vegetables.
This architecture guarantees:

Efficient data communication, Improved automation, Remote monitoring, and Consistent, high-quality results in solar drying.

V. DATA SECURITY AND SCALABILITY

Effectively managing environmental data in a secure and scalable manner is essential for an automated solar drying system. The proposed system tackles this challenge through:

Secure Data Transmission: The RA02 LoRa module encrypts temperature and humidity data prior to transmitting it to the customized LoRa gateway. Remote Monitoring: The Blynk application allows for real-time data access, ensuring that only authorized users can view and control the system.

Scalability: The architecture accommodates multiple solar dryer units connected to a single gateway, making it ideal for both small-scale farms and larger agricultural operations.

VI. MONITORING DRYING TRENDS AND ENVIRONMENTAL ANALYTICS

The system uses sensor-based analytics to monitor drying efficiency and environmental conditions, offering valuable insights for users. By examining real-time temperature and humidity data, the system maintains optimal drying parameters. Historical data enables farmers to refine their drying strategies, making adjustments based on seasonal and environmental changes. Ongoing tracking of heater usage and system performance minimizes energy waste while ensuring effective drying.

VII. FINDING AND RESULTS

Reduction in Drying Time

The automated control of stirring, heating, and airflow leads to a significant reduction in drying time when compared to traditional solar drying methods. Initial experiments indicate a decrease in drying duration by 30-40%, all while maintaining the quality of the product.

Improved Drying Consistency

With real-time monitoring, uniform drying is ensured across all trays, which helps to avoid both over-drying and under-drying of food products. The stirring mechanism, controlled by a stepper motor, promotes even heat distribution.

Enhanced User Convenience

Integration with the Blynk app enables farmers to monitor drying conditions remotely, receive notifications, and manage system operations. Additionally, the automated overheating prevention feature boosts safety and reliability, minimizing the need for manual intervention.

VIII. CONCLUSION

This review emphasizes the advantages of using an automated solar dryer to improve the drying process for agricultural products. By incorporating a PIC16F877A microcontroller, DHT22 sensors, RA01 LoRa module, and the Blynk app, the system provides efficient, remote-controlled drying with better monitoring, heating control, and protection against overheating.

Future enhancements could involve AI-based drying optimization, improvements in energy efficiency, and scalability for larger agricultural operations, making solar drying more sustainable, dependable, and user-friendly.

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