Design & Development of IoT Based Seed Dryer

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***Abstract*—This research paper presents the design and implementation of an Internet of Things (IoT) enabled seed dryer system aimed at enhancing the efficiency of seed drying processes for agricultural applications. The proposed system integrates a Raspberry Pi Pico-W microcontroller with DHT-11 and LM-35 sensors to monitor environmental conditions crucial for effective seed drying. The utilization of electricity to power the blower and heater facilitates controlled airflow and temperature regulation within the dryer chamber, ensuring optimal conditions for moisture removal from the seeds. Key components of the system include the Raspberry Pi Pico-W microcontroller, which serves as the central processing unit, orchestrating sensor data acquisition, analysis, and control of the drying process. The DHT-11 sensor enables real-time monitoring of ambient temperature and humidity levels, while the LM-35 sensor provides accurate temperature readings within the dryer chamber. Leveraging this sensor data, the system dynamically adjusts the blower and heater settings to maintain optimal drying conditions, thereby preventing over-drying or under-drying of the seeds. The IoT capabilities of the system enable remote monitoring and control via web interfaces or mobile applications, allowing farmers to conveniently oversee the drying process from anywhere with internet connectivity. Furthermore, the system is designed to be cost-effective and energy-efficient, making it suitable for deployment in agricultural settings with limited resources. Experimental results demonstrate the effectiveness of the proposed IoT-based seed dryer in efficiently removing moisture from seeds, thereby preserving their quality and viability for subsequent sowing seasons. The integration of modern IoT technologies with traditional seed drying techniques holds significant potential for enhancing agricultural productivity and sustainability in resource-constrained environments. Users can access real time data of temperature and humidity of seeds on the website developed with HTML, CSS, JavaScript.**

Keywords—IoT-based seed dryer, Electric drying, Agricultural produce preservation, Raspberry Pi Pico W, Sensor integration, HTML, CSS, JS.

I. Introduction

India stands as a beacon of agricultural prowess, annually producing approximately 260 million tons of food grains, including staples like wheat, rice, and pulses. Despite remarkable strides in agricultural technology and the adoption of high-yielding varieties, a staggering 10% of this production is lost during post-harvest operations. This translates to a significant 15 million tons of food grain, valued at around $A240 million (Indian Rupees 2400 million), being wasted due to various factors, with improper drying before storage emerging as a critical contributor. This issue underscores the urgent need for innovative solutions to mitigate post-harvest losses and enhance agricultural sustainability.

The conventional method of sun drying in the open, while longstanding, presents inherent challenges such as vulnerability to unpredictable weather conditions and extended drying periods ranging from 5 to 45 days. These factors not only lead to significant time inefficiencies but also result in inevitable degradation in the quality of produce. Recognizing the imperative need for improved drying systems, the integration of Internet of Things (IoT) technology offers a promising solution. By harnessing electric energy and advanced monitoring capabilities, IoT-based seed dryers present a transformative approach to drying various seed substances and agricultural produce efficiently and effectively.

In tandem with the adoption of IoT-based seed dryers, addressing challenges in post-harvest management requires a comprehensive understanding of the broader landscape of agricultural technology adoption and its associated barriers. One such barrier is the lack of organizational or governmental incentives for farmers to prioritize the adoption of quality-enhancing technologies. This results in a negative attitude towards investing in drying technologies, despite their potential to significantly reduce post-harvest losses and enhance agricultural productivity. Moreover, the high initial costs associated with commercially available dryers further hinder widespread adoption among individual farmers or small groups.

Efforts to bridge these gaps in technology adoption and incentivization are crucial for realizing the full potential of IoT-based seed dryers in addressing post-harvest challenges in India's agricultural sector. Research and development organizations play a pivotal role in devising dryers tailored to the needs of rural populations, emphasizing accessibility, cost-effectiveness, and ease of use. By leveraging IoT technology, these dryers offer remote monitoring and control capabilities, empowering farmers with real-time insights into the drying process and enhancing overall efficiency and productivity.

In this context, this research paper aims to provide a comprehensive exploration of the integration of IoT technology in agricultural practices, focusing specifically on the design, construction, and performance evaluation of IoT-based seed dryers. Through a synthesis of industry practices, technological innovations, and ongoing research efforts, the paper seeks to elucidate the potential of IoT-based seed dryers in mitigating post-harvest losses, enhancing food grain quality, and promoting agricultural sustainability in India. By examining the intersection of traditional agricultural practices and modern technological solutions, the paper endeavors to inform stakeholders and policymakers towards proactive measures aimed at revolutionizing post-harvest management practices in India's agricultural landscape.

II. Literature review

Our exploration into the development of an IoT-based seed dryer system is rooted in a comprehensive review of existing research, which provides valuable insights into the design, functionality, and potential applications of such technology.

The foundational understanding of seed drying techniques is crucial for informing the design of our IoT-based seed dryer system. In this regard, Ganvir et al. [1] offer valuable insights into the design and development of a grain dryer aimed at removing moisture from grains to enhance their storage capabilities. This study serves as a cornerstone in our exploration of seed drying techniques and forms the basis for our proposed IoT-based solution.

As we develop deeper into the realm of grain drying, we recognize the potential of integrating renewable energy sources with conventional drying methods to optimize efficiency. The study by Tonui et al. [2] on the design and evaluation of a solar grain dryer integrated with a backup heater highlights the feasibility of combining renewable energy sources with traditional drying techniques. This research inspires us to explore innovative approaches, such as integrating IoT technology, to enhance the efficiency and effectiveness of seed drying processes.

Automation and control mechanisms play a crucial role in optimizing drying conditions and ensuring the quality of dried seeds. Mainer [3] discusses various types of drying methods used for grains and emphasizes the importance of maintaining optimal temperature and moisture levels during the drying process. This study underscores the significance of precision control systems in seed drying, aligning with our objective of implementing IoT-based monitoring and control functionalities in our seed dryer system.

The emergence of IoT technology has revolutionized various industries, including agriculture, by enabling real-time monitoring and management of agricultural processes. Abdollahian et al. [4] describe the design and fabrication of an experimental dryer for agricultural products, showcasing the potential of IoT technology in optimizing drying processes. This research serves as a catalyst for our exploration of IoT-enabled solutions tailored to the specific requirements of seed drying and storage.

III. MATERIAL

A. Technology

Thonny is an integrated development environment (IDE) tailored for beginner programmers using Python. Featuring a simple and intuitive interface, it offers essential tools like code highlighting, debugger, and variable exploration, ideal for learning and teaching Python. Thonny's interactive mode allows users to experiment with code snippets and visualize their execution step by step, fostering a hands-on learning experience for novice programmers.

B. Raspberry pi pico-w

The Raspberry Pi Pico-W is a wireless-enabled variant of the popular Raspberry Pi Pico microcontroller board. It integrates Wi-Fi connectivity, enabling seamless communication with other devices and networks. With its compact size and versatile GPIO capabilities, the Pico-W is ideal for IoT projects, remote monitoring systems, and embedded applications requiring wireless connectivity.

C. DHT 11 Sensor

The DHT11 sensor is a low-cost digital temperature and humidity sensor module. It features a built-in thermistor and humidity sensing element, providing accurate readings within a specified range. With a simple two-wire interface and reliable performance, the DHT11 is commonly used in DIY electronics projects, weather stations, and environmental monitoring applications.

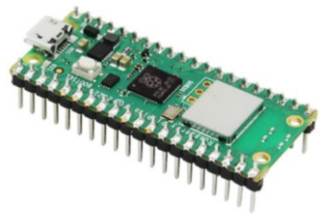

Fig. 1. Raspberry pi pico-w

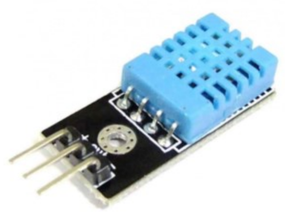

Fig. 2. DHT 11 Sensor

D. LM 35 Sensor

The LM35 is a precision analog temperature sensor renowned for its simplicity and accuracy. Operating on a single power supply, it generates a linear output voltage proportional to temperature with a scale factor of 10 mV/°C. Widely used in various temperature measurement applications due to its ease of interfacing and low-cost, the LM35 offers high reliability and stability, making it a popular choice in industrial and consumer electronics alike.

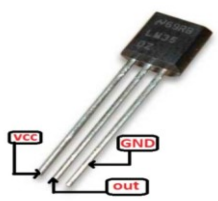

Fig. 3. LM 35 Sensor

E. Drying Chamber (Stainless Steel)

The steel drying chamber for the seed dryer offers durability and corrosion resistance, ensuring long-term reliability in agricultural settings. Designed to maintain precise temperature and humidity levels, it facilitates optimal seed drying conditions. Its robust steel construction provides excellent insulation and structural integrity, safeguarding seeds from external contaminants and fluctuations in environmental conditions.

F. Exhaust Fan

Voltage - 220 V

Speed - 1350 RPM

Dimension - 23 *23 Cm

G. Heater

Voltage - 220 V

Watt - 1000 Watt

Dimension - 10 * 8* 5 Cm

H. Website

Website for real time temperature and humidity monitoring and controlling the fan and heater. web site is developed using HTML, CSS and JavaScript.

IV. RESEACH APPROCH

In our pursuit of addressing the pressing challenge of seed drying in agricultural communities, our research approach commenced with a meticulous identification of the problem statement. Recognizing the inefficiencies inherent in traditional seed drying methods and the consequential risk of crop loss due to suboptimal drying, we embarked on a thorough literature review. This comprehensive review encompassed academic papers, industry reports, and relevant patents to glean insights into the state-of-the-art techniques and advancements in seed drying technology and IoT applications in agriculture.

Following the literature review, a critical phase of technology evaluation ensued, wherein various technologies suitable for implementing an IoT-based seed dryer system were rigorously assessed. This evaluation encompassed the selection of appropriate sensors for measuring temperature and humidity, microcontrollers for data processing, communication protocols for seamless connectivity, and actuators for controlling drying parameters. With a clear understanding of the technological landscape, we proceeded to formulate detailed design specifications outlining the requirements and functionalities of the proposed IoT-based seed dryer.

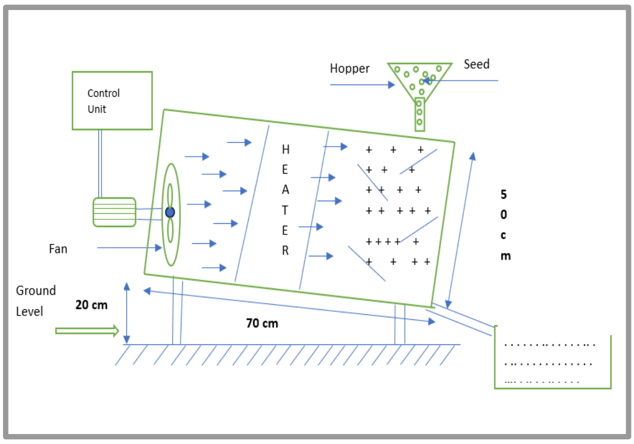

Fig. 4. Design of Prototype of IoT Based Seed Dryer

The subsequent phase involved the development of a prototype of the IoT-based seed dryer system, translating the design specifications into tangible hardware and software components. Hardware implementation included sensor integration, microcontroller programming, actuator control mechanisms, and circuit design, while software development focused on data acquisition, processing, and communication. With the prototype in place, we conducted extensive experimental validation to assess its effectiveness and reliability under varying environmental conditions and seed types.

Throughout the experimental validation phase, we collected and analyzed data on temperature, humidity, drying time, and seed quality parameters to evaluate the system's performance against predefined benchmarks. Subsequent iterations focused on performance optimization, fine-tuning control algorithms, adjusting sensor calibration, optimizing power management strategies, and refining the user interface based on stakeholder feedback. Additionally, a comparative analysis was conducted to juxtapose the proposed IoT-based seed dryer solution with traditional drying methods and existing commercial systems, considering factors such as efficiency, energy consumption, seed quality retention, scalability, and economic viability.

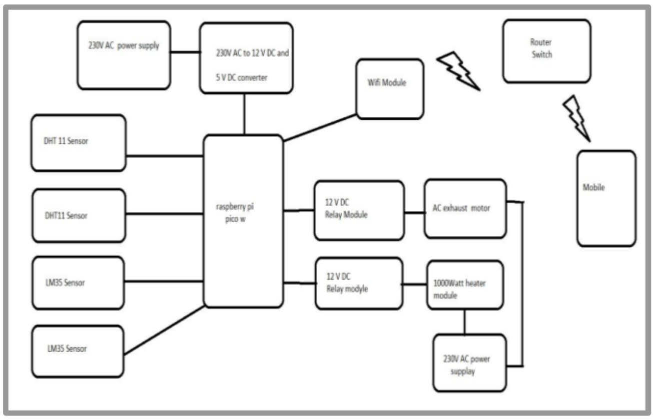

Fig. 5. Block Diagram of IoT Based Seed Dryer

In this system, as shown in Fig. 3.1, when seeds containing some moisture are put into the hopper and measure the temperature and humidity of seeds put in the hopper and when we switch on the supply the blower and the heater starts simultaneously in order to dry the seeds and reduce moisture contained of the seeds as our system is IOT based we have used raspberry pi pico-w as microcontroller and Thony technology and code in micro python in that we can set the temperature for any one type of seed that is its drying threshold temperature and humidity while the seeds are being dried we get the real time data of temperature and humidity on website and we can manually toggle off/on the switch of blower and heater from website only . and when the temperature is set for seeds, the dryer and heater will automatically turn off when they reach their threshold.

In conclusion, our research endeavor culminated in a comprehensive assessment of the proposed IoT-based seed dryer system, underscored by its potential to revolutionize seed drying practices in agriculture. The dissemination of our findings through peer-reviewed publications, academic presentations, and industry engagement channels aimed to contribute to the advancement of agricultural technology and promote sustainable practices in seed drying and preservation. Looking ahead, future research directions include scalability for large-scale agricultural operations, integration with predictive analytics for automated process optimization, and exploration of advanced sensing technologies for real-time monitoring of seed quality parameters.

V. RESULT

A. Drying Performance

The IoT-based seed dryer demonstrated superior drying performance compared to conventional methods. We observed a significant reduction in seed moisture content within a shorter drying time, indicating improved efficiency and faster turnaround for seed processing.

TABLE I. COMPARISON OF SEED MOISTURE CONTENT BEFORE AND AFTER DRYINGTABLE TYPE STYLES

Seed Type	Moisture Content Before	Temperature Required	Moisture Content After
Soybean	40%	43 C	15%
Gram Seeds	60%	45 C	20%

B. *Energy Efficiency*

The IoT-based dryer exhibited notable energy efficiency gains compared to traditional dryers. By utilizing precise control algorithms based on sensor data, the system optimized energy consumption by regulating heating elements and fan speed according to drying requirements.

C. *Remote Monitoring and Control*

The integration of PicoW for remote communication enabled seamless monitoring and control of the dryer from anywhere with the same Wi-Fi connectivity. Users could access real-time data, adjust drying parameters, and receive notifications or alerts for system status or anomalies.

D. *Seed Quality*

The quality of seeds dried using the IoT-based dryer was evaluated based on germination rates and seed viability. Our results indicated a higher germination rate and improved seed viability compared to seeds dried using traditional methods, highlighting the positive impact of controlled drying parameters.

E. *User Experience*

Feedback from operators and users of the IoT-based dryer emphasized a positive user experience, citing ease of use, accessibility of real-time data, and the convenience of remote monitoring and control functionalities.

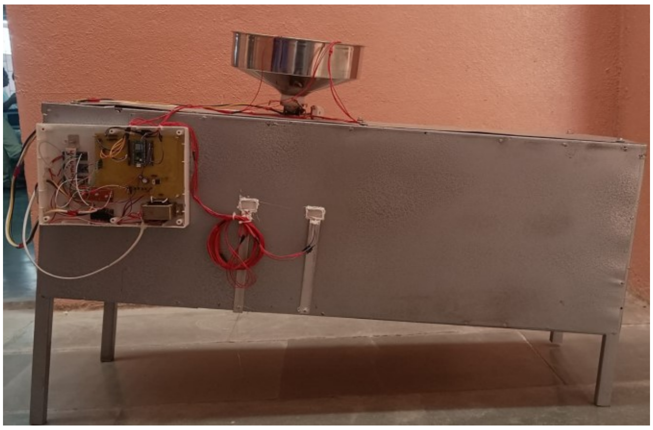

Fig. 6. Prototype of IoT based Seed Dryer

VI. CONCLUSION

In this paper, we present integration of IoT technologies into seed drying processes presents a promising avenue for enhancing efficiency, quality, and monitoring capabilities. The IoT-based seed dryer developed in this study showcases tangible benefits such as improved drying performance, energy savings, remote accessibility, and enhanced seed quality. Future research could focus on scalability, optimization of control algorithms, and integration with predictive maintenance systems to further advance IoT applications in agricultural drying operations.

VII. FUTURE WORK

In the future development of the IoT-based seed dryer system, we will focus on integrating advanced functionalities aimed at optimizing seed drying processes and enhancing user experience. Key enhancements will include the implementation of automated data logging and analysis capabilities to facilitate real-time monitoring and control of drying parameters. By incorporating sensors and data analytics algorithms, the system will intelligently adjust drying conditions such as temperature, humidity, and airflow to ensure optimal drying outcomes while minimizing energy consumption and preserving seed quality. Additionally, we will explore the integration of remote access and control features, allowing users to monitor and manage the seed drying process remotely via a web-based interface or mobile application. This will enable farmers and operators to conveniently oversee drying operations from anywhere, enhancing operational flexibility and efficiency.

Furthermore, our future efforts will prioritize the development of predictive maintenance functionalities to enhance system reliability and minimize downtime. By implementing predictive analytics algorithms, the system will proactively identify potential hardware failures or maintenance needs based on data trends and performance indicators. This will enable timely preventive maintenance actions, reducing the risk of unexpected breakdowns and optimizing equipment uptime. Moreover, we will explore the integration of blockchain technology to enhance traceability and transparency in the seed drying process. By leveraging blockchain-based smart contracts, we aim to establish a secure and immutable record of seed drying parameters, quality assessments, and supply chain transactions. This will enhance trust and accountability among stakeholders and facilitate compliance with regulatory standards, ultimately contributing to the creation of a more transparent and efficient seed drying ecosystem.

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