Design and Implementation of an Internet of Things (IoT)-Based Real-Time Monitoring System on a Water Hyacinth Fiber Drying Machine: A Small Industry Case Study

Khakam Ma'ruf
Industrial Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
hakammaruf70@gmail.com

Rizal Justian Setiawan
Asia and China Studies, College of Law and Politics, National Chung Hsing University, Taichung, Taiwan | Industrial Engineering and Management, College of Engineering, Yuan Ze University, Taoyuan, Taiwan
rizaljustiansetiawan99@gmail.com (corresponding author)

M. Ridho Ramadhan
Electrical Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
mridhoramadhan@mail.ugm.ac.id

Arbain
Electrical Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
arbain@mail.ugm.ac.id

Maycshall Dwi Putra Lay Kanny
Electrical Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
maycshalldwiputralaykanny@mail.ugm.ac.id

Martinus Kual
Electrical Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
martinuskual@mail.ugm.ac.id

Received: 20 August 2025 | Revised: 7 September 2025 | Accepted: 24 September 2025

ABSTRACT

Manual drying of water hyacinth typically takes up to three days and is highly dependent on weather conditions, making the process inefficient for industrial use. This study presents the design and implementation of an Internet of Things (IoT)-based real-time monitoring and control system to improve the drying process of water hyacinth using a dedicated drying machine. The development process follows the four stages of IoT system development, such as identifying IoT objectives, selecting necessary IoT components, implementation and prototyping, and integrating the IoT system with the machine. The proposed system integrates a DS18B20 temperature sensor, an ESP32 microcontroller, a solenoid valve for

multilevel gas control, and the Blynk cloud platform. This integrated system allows remote temperature monitoring and automatic burner control through a smartphone application. The drying temperature is maintained within the optimal range of 70–85°C with a maximum deviation of 1.7°C, and the sensor system shows a high accuracy with a temperature variance of only 0.1–0.2°C compared to a standard analog thermometer. The system enables precise gas regulation through a tiered solenoid valve mechanism (small, medium, and large flow) based on real-time temperature feedback. Furthermore, it features an automated timer that can be configured based on the quantity of material that is being processed. The system demonstrates strong reliability (99.2% uptime), low latency (210 ms), and high user satisfaction (95%), indicating practical acceptance in the industrial context. The findings suggest that the implementation of IoT technology significantly enhances the efficiency, consistency, and usability of industrial drying machines, particularly in small to medium-scale enterprises processing natural fiber materials. This study also introduces novelty in three aspects: (i) a multi-stage solenoid valve mechanism (small, medium, and large flow) that allows precise real-time gas regulation; (ii) a lightweight IoT integration framework specifically designed for SMEs using low-cost components (ESP32, DS18B20, solenoid valve, and Blynk cloud); and (iii) the first documented implementation of IoT technology in water hyacinth fiber drying, addressing a critical gap in natural fiber processing for small industries.

Keywords-drying machine; Internet of Things (IoT); monitoring; sensor; water hyacinth

I. INTRODUCTION

Rapid technological advances mean that almost everyone now has a smartphone, which can support digital technology such as the Internet of Things (IoT) [1-3]. The IoT is a system of devices that are connected to the Internet and integrate data automatically without human intervention. IoT has made human life easier in various aspects [4], including the industrial and manufacturing fields [5]. One of the main functions of the IoT is to enable machines to connect and operate automatically [6], while using sensors and actuators connected to the internet to remotely monitor and control them. In addition, sensors and actuators can collect and analyze data in real time. Thus, the IoT can improve operational efficiency, productivity, and security [7, 8].

The implementation of IoT in industrial machines has a significant impact on their practicality [9]. With IoT, machines can be adjusted to adapt to environmental conditions, such as temperature, humidity, or other factors that influence the production process [10, 11]. In addition, data on IoT systems collected by these machines can be used to optimize processes, simplify control, and reduce waste of resources [12, 13]. One sector that can be developed to utilize IoT is Small and Medium Enterprises (SME), which already use drying machines as tools, such as the food drying industry [14]. SMEs that use natural fibers have implemented drying machines, but have not yet integrated the IoT [15].

Water hyacinth fiber is widely used as a raw material for handicrafts and has quite a high demand in Indonesia [16]. Water hyacinth craft products have attracted a lot of interest in the export market [17, 18]. However, the production process for water hyacinth fiber raw materials is still conducted manually, specifically the drying process, which only relies on sunlight heat [19]. This manual drying method is highly dependent on weather conditions, which often hamper production and reduce profits. The average drying time for water hyacinth in the sun is 3 days [20, 21]. Thus, developing and implementing a machine that can efficiently dry water hyacinth fiber can speed up the drying process. The proposed machine is designed with sensors to monitor the temperature, humidity, and other variables that affect the drying process. In addition, actuators can be programmed to automatically regulate operations, accelerating the drying process, improving fiber quality, and reducing energy waste. The use of IoT technology in water hyacinth drying machines is very desirable because it can simplify the production process, increase efficiency and effectiveness, contributing significantly to the economic growth of rural communities that rely on natural fiber crafts.

This study developed an IoT-integrated monitoring and control system using sensors and solenoid valves on a water hyacinth drying machine to simplify the process. This study introduces novelty in three aspects: a multi-stage solenoid valve mechanism that allows precise real-time gas regulation, a lightweight IoT integration framework specifically designed for SMEs using low-cost components, and the first documented implementation of IoT technology in water hyacinth fiber drying, addressing a critical gap in natural fiber processing for small industries.

II. METHOD

This study used the IoT system development stages presented in [22] as shown in Figure 1. This process consists of four stages in IoT development, which can be explained in detail as follows.

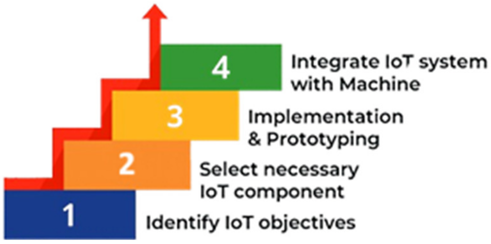

Fig. 1. IoT research and development stages.

A. *Identify IoT Objectives*

In this stage, the main objectives of IoT system development must be clearly defined. The specific goals to be achieved are:

- Real-time temperature monitoring on the dryer.

- Control the flame automatically using a solenoid valve integrated with IoT.
- Provide an easy-to-access user interface to monitor and control the dryer remotely.

B. Select Necessary IoT Components

After determining the objectives, the next step is to select the required components:

1. The ESP 32 microcontroller functions as the brain of the IoT system, processing data from sensors and controlling other components.
2. The DS18B20 temperature sensor is used to measure the temperature of the dryer accurately and in real time.
3. A solenoid valve is used to automatically control the flow of gas or hot air to the dryer based on the desired temperature.
4. A Timer is used to regulate the drying duration and prevent overheating of the dryer.
5. A WiFi or Ethernet module is used to connect the IoT system to the Internet, so that data can be sent and received remotely.
6. A user interface, such as a web or mobile application.

After identifying the primary components for the drying machine's IoT system, a comprehensive design is drafted, encompassing both the key components and their supporting counterparts. Figure 2 illustrates the electronic circuit's design, which shows the complete schematic of an IoT system consisting of various components, such as a power supply 12V microcontroller, a 9V step down module, an ESP 32 microcontroller, a DS18B20 temperature sensor, an LCD 16×2, a step down 9V relay module, a relay on/off solenoid valve, a solenoid valve 220 V, and a relay on/off timer system.

C. Implementation and Prototyping

After selecting the IoT components and finalizing the system design, the next step is to implement a prototype system [15]. In this step, the activities are divided into the implementation of hardware prototyping and the implementation of software prototyping.

1) Implementation of Hardware Prototyping

All IoT components were assembled and integrated based on the final design. The first step involved connecting the DS18B20 temperature sensor to the ESP32 microcontroller. Code was written to obtain temperature data from the sensor in real time and transmit it to the user interface through an internet connection. The solenoid valve and the timer were also connected to the microcontroller, with code added to control the automatic opening and closing of the solenoid valve based on the desired temperature. The timer was configured to regulate the drying duration. A WiFi module was integrated into the microcontroller to connect the system to the Internet. Interfaces, such as web or mobile applications, were developed to allow users to monitor temperatures and control temperature settings, solenoid valves, and timers remotely in real time.

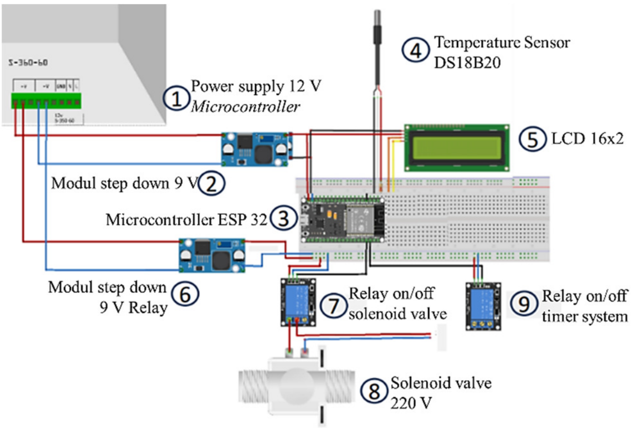

Fig. 2. IoT electrical system design and components.

Figure 3 displays a control panel box that is intended to be integrated into the IoT system to monitor and regulate the water hyacinth drying process. This system is installed on the box panel of the drying machine according to functional and safety considerations. The system design involved several key components, including a power supply, LCD, a step-down module, a DS18B20 temperature sensor, a timer sensor, a microcontroller, an IoT communication module, the machine heating system, and the Blynk IoT platform. The DS18B20 temperature sensor plays a crucial role in this system, as it measures the temperature inside the drying machine in real time. This sensor was selected for its high accuracy and digital communication capabilities with the microcontroller.

Fig. 3. IoT electrical assembly (left) and panel box (right).

2) Implementation of Software Prototyping

The coding process was conducted for the oven temperature monitoring system with DS18B20 using ESP32 and Blynk. The program reads the temperature from the DS18B20 sensor, displays it on the LCD, and sends it to the Blynk application.

Blynk is used to monitor temperature in real-time and display local time. The program also has a function to retrieve local time through the TimeZone API. The aim was to create an application that allows users to interact with the system. The application is designed to monitor the temperature of a drying process and regulate the gas system using a solenoid valve and a timer. To access the monitoring system, users must enter the username and password of the account they have previously created. Next, the IoT system on the drying machine can be used. This IoT is integrated by implementing the Blynk application, shown in Figure 4, which provides a visual representation of the status of the system.

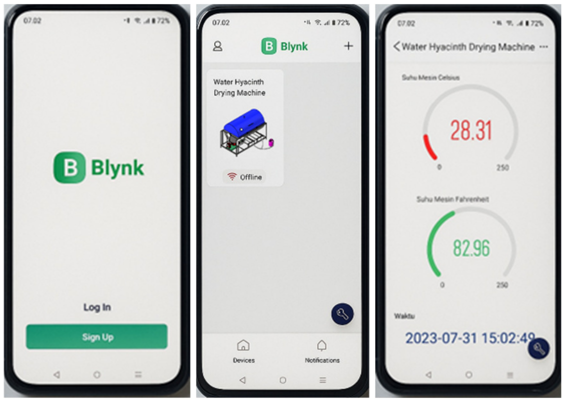

Fig. 4. Blynk application design view.

Figure 4 shows the results of the IoT monitoring and control system design using the Blynk IoT platform. Blynk is often used because it saves development time, makes it easier to create IoT interfaces, and supports a wide range of hardware in a flexible way [23-25]. This stage was an important aspect of the implementation of this system. Through the Blynk platform, temperature sensor data can be sent in real-time from the microcontroller to the Blynk cloud server using the ESP8266 IoT communication module. This data can then be accessed and visualized through Blynk's user interface, both on the mobile app and the web interface. Blynk's user interface provides an intuitive and easy-to-use display for monitoring sensor data in real-time. Users can view historical temperature graphs and receive notifications if specific parameters exceed preset thresholds. In addition, the Blynk interface also allows users to remotely control heating actuators through virtual buttons or set target temperatures. IoT connectivity in these systems depends on the availability of a stable Wi-Fi network. During testing, IoT connectivity performance was evaluated by monitoring the stability of data transmission from the microcontroller to the Blynk platform. Security aspects were also considered when implementing this system.

D. Integrating the IoT with the Machine

The integration of an IoT system on a machine was conducted to evaluate the system developed, so that it can be properly used for the operational process [26]. Thus, after the IoT system prototype for the drying machine was assembled, the next step was to integrate it with a real machine.

Figure 5 shows integration activities between the IoT system and the components in the drying machine. This stage aimed to align the working system between the two components, the IoT and the drying machine. In this stage, calibration was also performed to ensure that data measurements can be conducted validly and accurately. Integration of the IoT system into the device must be completed before operation. The device can then be controlled and monitored with the IoT, following examples of an IoT gateway to monitor an electric vehicle charging communication system [27] or the operation of a CNC machine [28].

Fig. 5. Integrating an IoT system with a drying machine.

The system does not include local storage. However, the Blynk cloud platform automatically records historical temperature and control data for up to 30 days, which can be exported in CSV format. This enables traceability and performance analysis.

System performance was evaluated using quantitative parameters, such as (i) latency, measured as the round-trip delay from ESP32 sensor reading to Blynk application response (average: 210 ms), (ii) communication reliability, with 99.2% successful packet delivery during continuous 8-hour operation, (iii) power consumption, averaging 28 W during heating and 8 W in idle mode, and (iv) scalability, tested with simultaneous data transmission from three prototype nodes, with no packet loss observed.

III. RESULTS

A. IoT Working System on Drying Machine

The system is initiated through an On/Start command, activating the machine and directing power to the main supply unit, which steps down the voltage from 220 V to 12 V. Subsequently, the voltage is further reduced to 9 V using an additional step-down converter to align with the safe operating limits of the microcontroller. The ESP32 microcontroller serves as the core processing unit, responsible for acquiring real-time temperature data from the DS18B20 sensor, processing the data, and transmitting it to the Blynk cloud platform through an IoT communication module. Temperature monitoring outputs are displayed simultaneously on an LCD screen and the Blynk mobile application, allowing for both local and remote supervision. The microcontroller also regulates the gas solenoid valve to maintain the oven temperature within an optimal range for effective drying. Additionally, a timer is incorporated to automate the system's shutdown upon completion of the drying process, thereby enhancing safety and operational efficiency.

B. IoT Performance on Temperature Monitoring

Following the installation of the IoT system on the drying machine, a comprehensive evaluation of the system's performance in the water hyacinth drying process was conducted through a series of tests. The initial test focused on assessing the precision of the DS18B20 temperature sensor in monitoring the parameters of the drying process. Table I shows the test results, which demonstrate that the DS18B20 temperature sensor has very good accuracy, with an average difference of 0.1-0.2°C compared to a standard analog thermometer. The accuracy of these sensors is critical to ensure that the data obtained represents the actual conditions inside the oven. Further tests were conducted to evaluate the effectiveness of the control system in maintaining the temperature at an optimal level during the drying process. The control system was set to maintain the temperature in the range of 70-85°C. The test results show that the control system can maintain the temperature at the reference temperature (70-85°C), with a maximum deviation of 1.7°C.

TABLE I. PERFORMANCE TESTING OF TEMPERATURE SENSORS AND GAS MODE SOLENOID

	Machine temperature (°C)		**Status machine / Gas solenoid mode**
	On the IoT application	**On an analog thermometer**	
1	36.2	36.2	off
2	40.5	40.4	on / big solenoid
3	45.8	45.8	on / big solenoid
4	55.7	55.6	on / big solenoid
5	63.8	63.6	on / big solenoid
6	65.2	65.2	on / big solenoid gas
7	70.8	71	on / medium solenoid
8	75.3	75.4	on / medium solenoid
9	80.3	80.3	on / medium solenoid
10	85.6	85.6	on / medium solenoid
11	86.7	86.7	on / small solenoid gas

The system's response to changes in the drying process conditions was evaluated, and it was found that it can quickly adjust the gas solenoid valve whenever significant temperature changes occur in the processing tube in the drying machine. This real-time control of the parameters allows the system to optimize the drying process. Furthermore, the drying system is equipped with a timer that sets the time parameter for the drying process, which is adjusted according to the weight of the water hyacinth material being dried. The test results showed the effective drying time and weight of dry water hyacinth during the drying process.

C. Solenoid Valve Control System Result

A gas control system based on a gas solenoid valve was used to adjust the combustion gas conditions in the water hyacinth drying machine. This system used a DS18B20 temperature sensor integrated with IoT and an ESP32 microcontroller to monitor the temperature in the drying machine.

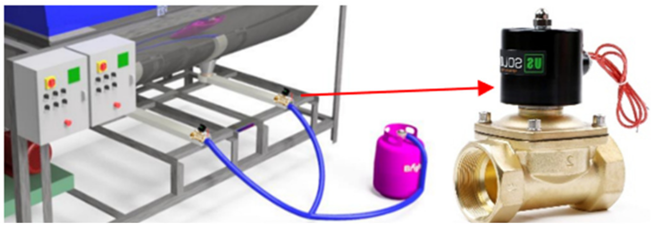

Fig. 6. Gas solenoid valve design on the machine in valve control.

Figure 6 shows the use of the solenoid valves in the heating system of the drying machine. The system works by regulating the flow of the gas through the solenoid valve based on the temperature inside the processing tube of a drying machine. If the temperature exceeds 85°C, the solenoid valve will reduce the gas flow to a small level to prevent excessive heat that can damage the water hyacinth material. When the temperature is between 70-85°C, the solenoid valve will regulate the gas flow to the medium. This is considered optimal for the water hyacinth drying process, as it maintains the desired temperature. If the temperature drops below 70°C, the solenoid valve will increase the gas flow to a large level. Figure 8 visualizes the working scheme of the solenoid valve. This solenoid valve automatic control system can maintain and increase the stability of the heat produced from burning gas so that the temperature inside the processing tube remains at a medium temperature. By implementing a solenoid valve and IoT, the flame on the burners can open small and large according to the drying process. Thus, the temperature in the vacuum processing tube can rise and fall according to the needs of the drying process. The actual condition is a temperature of 70-85°C in a vacuum in the water hyacinth processing tank. With this system, the temperature in the oven can be maintained automatically and efficiently, so that the water hyacinth drying process can run optimally according to the medium temperature.

Fig. 7. Gas solenoid valve work scheme.

D. User Response to IoT Implementation

User satisfaction was assessed with 48 respondents, consisting of 44 craftsmen, 2 university students, and 2 engineers. A five-point Likert scale was used, ranging from "Very Dissatisfied" (1) to "Very Satisfied" (5). Responses were analyzed using descriptive statistics, with 50% reporting "Very Satisfied" and 45% "Satisfied." The mean satisfaction score was 4.47/5, indicating strong user acceptance. These results show that the implementation of the IoT system installed on the water hyacinth drying machine met the expectations of respondents as machine users.

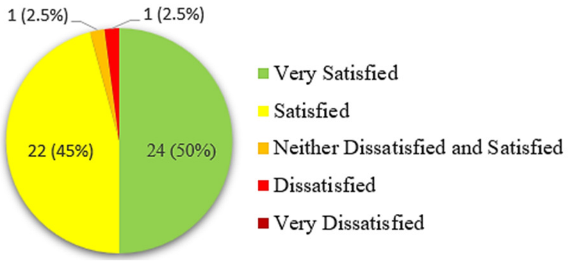

Fig. 8. User responses on the IoT system.

IV. COMPARISON WITH EXISTING WORKS

IoT-based drying systems have been developed in several domains, such as for food processing [14, 29]. However, most of these systems focus primarily on single-parameter monitoring and lack multi-stage gas control mechanisms. As a result, temperature regulation tends to be less consistent, while user satisfaction has not been systematically evaluated. Table III presents a comparison between the proposed system and existing methods. Manual sun drying requires up to three days and is highly weather-dependent, resulting in very low temperature stability and low user satisfaction. In contrast, IoT on a food dryer [15] can shorten the drying time to 6-10 hours and achieve moderate stability (±3-4°C), although it typically relies on single-valve control and lacks reported data on user acceptance. Similarly, IoT applications in a maize dryer [26] employ temperature and humidity sensors but have not been tested for temperature stability and user satisfaction. The proposed IoT system demonstrates solid improvements, such as testing the drying time with 4-5 hours, maintaining stable temperature conditions (±1.7°C), having a multi-stage solenoid, and monitoring and controlling temperature and humidity. Additionally, the proposed IoT system can operate with relatively low energy consumption (28 W on average) and received strong positive feedback, with 95% of users reporting satisfaction. These results underscore the novelty and practical advantages of the proposed system for small-scale industrial applications.

TABLE II. PERFORMANCE OF TEMPERATURE SENSORS AND GAS MODE SOLENOID

Method	Drying time	Temperature stability	Automation	Energy use	User satisfaction
Manual sundrying	3 days	Very low	None	Weather-dependent	Low
IoT on food dryer [14]	6-10 hours	±3–4°C	Single valve, monitor, and control temperature	Medium	Not reported
IoT on maize dryer [29]	Not tested	Not tested	Monitor temperature and humidity sensor	Not reported	Not reported
Proposed IoT on water hyacinth dryer	4-5 hours	±1.7°C	Multi-stage solenoid, control and monitor temperature and humidity	Low (average 28 W)	95% satisfied

Despite promising results, there are some limitations. First, the IoT system depends on stable Wi-Fi connectivity, which can limit deployment in rural SMEs. Thus, future work should explore LoRaWAN or offline data storage. Second, since the user satisfaction survey involved only 48 respondents, it is necessary to apply machines in other areas for further experiments, especially for respondents who work as craftsmen. Lessons learned include the importance of intuitive user interfaces for non-technical operators and the value of low-cost IoT frameworks in enabling SMEs to adopt digital technologies.

V. CONCLUSION

An IoT system for the water hyacinth drying machine was developed in four stages. The results show that the DS18B20 sensor measured the temperature accurately, with only a 0.1 to 0.2°C difference from a standard analog thermometer, which indicates that the sensor used is accurate. Integrated with a multi-stage solenoid valve, the IoT control system maintained drying temperatures within ±1.7°C, indicating fairly good stability of the dryer IoT system to maintain temperature around the target and ensure consistent quality. The system also enabled real-time monitoring and remote control via the Blynk platform, supported by authentication and data encryption for security.

Overall, this study not only provides a functional IoT-based drying machine but also contributes technically and practically by introducing a multi-stage solenoid control strategy, a lightweight IoT integration framework suitable for SMEs, and the first application of such a system to water hyacinth fiber drying. These contributions advance the adoption of IoT in the natural fiber industries, offering measurable benefits in drying time, energy efficiency, and user acceptance. Future work should validate scalability across multiple SME sites and explore alternative communication networks.

ACKNOWLEDGMENT

The authors express their sincere gratitude to the Indonesia Endowment Fund for Education Agency (Lembaga Pengelola Dana Pendidikan - LPDP) of the Ministry of Finance, Republic of Indonesia, for providing the financial support that made this research possible. This funding has been instrumental in enabling them to conduct research that contributes meaningfully to environmental sustainability, educational advancement, and societal development. Without this generous support, the completion of this study would not have been achievable.

REFERENCES

[1] T. G. Ferris, "Unit cost and hope: Increased NHS resilience through tech-enabled transformation," *Future Healthcare Journal*, vol. 11, no. 1, Mar. 2024, Art. no. 100021, https://doi.org/10.1016/j.fhj.2024.100021.

[2] C. Yang *et al.*, "Portable optical fiber biosensors integrated with smartphone: technologies, applications, and challenges [Invited]," *Biomedical Optics Express*, vol. 15, no. 3, Mar. 2024, Art. no. 1630, https://doi.org/10.1364/BOE.517534.

[3] L. Y. Rock, F. P. Tajudeen, and Y. W. Chung, "Usage and impact of the internet-of-things-based smart home technology: a quality-of-life perspective," *Universal Access in the Information Society*, vol. 23, no. 1, pp. 345–364, Mar. 2024, https://doi.org/10.1007/s10209-022-00937-0.

[4] R. A. Radouan Ait Mouha, "Internet of Things (IoT)," *Journal of Data Analysis and Information Processing*, vol. 09, no. 02, pp. 77–101, 2021, https://doi.org/10.4236/jdaip.2021.92006.

[5] Shruti, S. Rani, and G. Srivastava, "Secure hierarchical fog computing-based architecture for industry 5.0 using an attribute-based encryption scheme," *Expert Systems with Applications*, vol. 235, Jan. 2024, Art. no. 121180, https://doi.org/10.1016/j.eswa.2023.121180.

[6] K. C. Rath, A. Khang, and D. Roy, "The Role of Internet of Things (IoT) Technology in Industry 4.0 Economy," in *Advanced IoT Technologies and Applications in the Industry 4.0 Digital Economy*, CRC Press, 2024.

[7] Z. Aripin, D. Saepudin, and F. Yulianty, "Transformation in the internet of things (IoT) market in the banking sector: a case study of technology implementation for service improvement and transaction security,"

Journal of Jabar Economic Society Networking Forum, vol. 1, no. 3, pp. 17–32, Feb. 2024.

[8] M. Soori, B. Arezoo, and R. Dastres, "Internet of things for smart factories in industry 4.0, a review," *Internet of Things and Cyber-Physical Systems*, vol. 3, pp. 192–204, 2023, https://doi.org/10.1016/j.iotcps.2023.04.006.

[9] S. Elkateb, A. Métwalli, A. Shendy, and A. E. B. Abu-Elanien, "Machine learning and IoT – Based predictive maintenance approach for industrial applications," *Alexandria Engineering Journal*, vol. 88, pp. 298–309, Feb. 2024, https://doi.org/10.1016/j.aej.2023.12.065.

[10] M. R. Islam, K. Oliullah, M. M. Kabir, M. Alom, and M. F. Mridha, "Machine learning enabled IoT system for soil nutrients monitoring and crop recommendation," *Journal of Agriculture and Food Research*, vol. 14, Dec. 2023, Art. no. 100880, https://doi.org/10.1016/j.jafr.2023.100880.

[11] D. Witczak and S. Szymoniak, "Review of Monitoring and Control Systems Based on Internet of Things," *Applied Sciences*, vol. 14, no. 19, Oct. 2024, Art. no. 8943, https://doi.org/10.3390/app14198943.

[12] M. Farjana, A. B. Fahad, S. E. Alam, and Md. M. Islam, "An IoT- and Cloud-Based E-Waste Management System for Resource Reclamation with a Data-Driven Decision-Making Process," *IoT*, vol. 4, no. 3, pp. 202–220, Jul. 2023, https://doi.org/10.3390/iot4030011.

[13] A. Matin, M. R. Islam, X. Wang, H. Huo, and G. Xu, "AIoT for sustainable manufacturing: Overview, challenges, and opportunities," *Internet of Things*, vol. 24, Dec. 2023, Art. no. 100901, https://doi.org/10.1016/j.iot.2023.100901.

[14] N. Mishra, S. K. Jain, N. Agrawal, N. K. Jain, N. Wadhawan, and N. L. Panwar, "Development of drying system by using internet of things for food quality monitoring and controlling," *Energy Nexus*, vol. 11, Sep. 2023, Art. no. 100219, https://doi.org/10.1016/j.nexus.2023.100219.

[15] K. Maruf *et al.*, "Technology innovation of dryer machine based on sustainability automation systems to increase agel fiber production in handicraft SME," *International Journal of Systematic Innovation*, vol. 9, no. 1, Feb. 2025, https://doi.org/10.6977/IJoSI.202502_9(1).0002.

[16] P. Heriyati, L. Sanny, R. Dewanti, and P. M. Anjarani, "Development of Competitiveness and Promotion of Water Hyacinth (Eichhornia Crassipes) Craft Products As Empowerment for Micro Enterprise," in *Proceeding ICCD*, Nov. 2023, vol. 5, pp. 153–159, https://doi.org/10.33068/iccd.v5i1.576.

[17] I. Harun, H. Pushiri, A. J. Amirul-Aiman, and Z. Zulkeflee, "Invasive Water Hyacinth: Ecology, Impacts and Prospects for the Rural Economy," *Plants*, vol. 10, no. 8, Aug. 2021, Art. no. 1613, https://doi.org/10.3390/plants10081613.

[18] D. Agustin, N. Anggriani, and A. S. Dewi, "Training on the Utilization of Water Hyacinth Waste into Handicraft Products for PKK Women in Tambak Oso Village, Sidoarjo," in *Nusantara Science and Technology Proceedings*, May 2023, https://doi.org/10.11594/nstp.2023.3305.

[19] F. Hanafi and D. Irawan, "Temperature and Humidity Control Systems for Dryer Machines in Industrial Salt Factory Based on Fuzzy Logic," *Indonesian Vocational Research Journal*, vol. 2, no. 1, Dec. 2022, Art. no. 112, https://doi.org/10.30587/ivrj.v2i1.5011.

[20] W. Rahmawati, A. Haryanto, and S. Suharyatun, "Development of Biodegradable Board using Water Hyacinth (Eichornia crassipes)," *International Journal of Environment, Agriculture and Biotechnology*, vol. 3, no. 1, pp. 170–174, 2018, https://doi.org/10.22161/ijeab/3.1.21.

[21] E. A. Omondi, P. K. Ndiba, and P. G. Njuru, "Characterization of water hyacinth (E. crassipes) from Lake Victoria and ruminal slaughterhouse waste as co-substrates in biogas production," *SN Applied Sciences*, vol. 1, no. 8, Aug. 2019, Art. no. 848, https://doi.org/10.1007/s42452-019-0871-z.

[22] C. Dilmegani, "IoT Implementation Steps & Best Practices," *AIMultiple*. https://research.aimultiple.com/iot-implementation/.

[23] R. J. Setiawan, K. Ma'ruf, F. R. Ariandhika, L. D. Pratama, Y. Widhiastana, and Darmono, "Design System of IoT-Enabled Early Warning System for Real- Time Air Quality Monitoring Utilizing TGS2600 Sensor Technology," in *2024 International Conference on Decision Aid Sciences and Applications (DASA)*, Manama, Bahrain, Dec. 2024, https://doi.org/10.1109/DASA63652.2024.10836511.

[24] L. Tarjan, I. Šenk, J. Erić Obućina, S. Stankovski, and G. Ostojić, "Extending Legacy Industrial Machines by a Low-Cost Easy-to-Use IoT Module for Data Acquisition," *Symmetry*, vol. 12, no. 9, Sep. 2020, Art. no. 1486, https://doi.org/10.3390/sym12091486.

[25] F. R. Saputri, R. Linelson, M. Salehuddin, D. M. Nor, and M. I. Ahmad, "Correction: Design and development of an irrigation monitoring and control system based on blynk internet of things and thingspeak," *PLOS One*, vol. 20, no. 6, Jun. 2025, Art. no. e0326137, https://doi.org/10.1371/journal.pone.0326137.

[26] R. J. Setiawan, K. Ma'ruf, Darmono, N. Azizah, and N. E. Khosyiati, "Systematic modernization of fish smoking method with the implementation of smoked fish machine based on Internet of Things technology," *International Journal of Systematic Innovation*, vol. 9, no. 1, Feb. 2025, https://doi.org/10.6977/IJoSI.202502_9(1).0005.

[27] S. M. Putri, M. Ashari, . Endroyono, and H. Suryoatmojo, "Optimal Placement of Internet of Things Gateways in Modern Electric Vehicle Charging Communication Systems," *Engineering, Technology & Applied Science Research*, vol. 15, no. 2, pp. 20674–20680, Apr. 2025, https://doi.org/10.48084/etasr.9663.

[28] B. Siddhartha, A. P. Chavan, G. K. Hd, and K. N. Subramanya, "IoT Enabled Real-Time Availability and Condition Monitoring of CNC Machines," in *2020 IEEE International Conference on Internet of Things and Intelligence System (IoTaIS)*, BALI, Indonesia, Jan. 2021, pp. 78–84, https://doi.org/10.1109/IoTaIS50849.2021.9359698.

[29] I. Viviane, E. Masabo, H. Joseph, M. Rene, and E. Bizuru, "IoT-Based Real-Time Crop Drying and Storage Monitoring System," *International Journal of Distributed Sensor Networks*, vol. 2023, pp. 1–11, Sep. 2023, https://doi.org/10.1155/2023/4803000.