www.rericjournal.ait.ac.th

Smart Data Management for Charcoal Briquettes Manufacturing using IoT Technologies

Taweesak Thongsan*, [1], Niwat Angkawisittpan*, Kaned Thung-Od*, and Nattaon Techasarntikul^

Abstract *–This research presents the design and implementation of a smart data management system tailored for charcoal briquette manufacturing. The system integrated a load cell, an HX711 amplifier, and a NodeMCU ESP8266 microcontroller to collect and transmit real-time data to the Google Sheets. Additionally, it employed LINE Notify for instant alerts on production status. The prototype system was tested on two briquette sizes (10 cm and 12 cm), yielding average weight deviations of 2.50% and 2.29%, respectively, and count deviations of less than 1.00%. Real-time data display, cloud-based storage, and automatic alerting significantly improved operational efficiency, accuracy, and monitoring capability. The proposed system was modular, scalable, and provided practical implications for low-cost digital transformation in biomass energy and similar industries.*

Keywords –Charcoal briquettes, cloud data management, internet of things, load cell, microcontroller.

1. INTRODUCTION

In an era where technology pervades all aspects of modern life, agriculture and industrial sectors have increasingly adopted digital innovations to enhance operational efficiency. Among these, smart farming has emerged as a promising approach by leveraging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and big data to optimize production and resource management. These technologies support data collection related to soil health, weather, and crop performance, enabling precise interventions and decision-making processes that lead to sustainable agricultural practices [1]-[3].

Big data analytics and machine learning further augment this framework by enabling predictive modeling, anomaly detection, and automated control of agricultural systems [4]. Despite its potential, smart farming faces barriers such as high implementation costs and limited digital literacy among users in rural areas, thereby restricting broader adoption [5].

Beyond agriculture, the integration of IoT has found applications in various manufacturing domains. One underexplored area is the charcoal briquette manufacturing industry, which traditionally relies on manual methods for production tracking, such as handwritten logs and physical counting. These methods are prone to human error, loss of data, and inefficiencies in responding to market demands [6].

Charcoal briquettes remain a widely used biomass energy source due to their clean-burning properties, high calorific value, and minimal smoke production [7]. However, the lack of smart data management in production environments poses a critical bottleneck in ensuring quality, consistency, and traceability.

Recent advances demonstrate the potential of combining load cells for precise weight measurement and Wi-Fi-enabled microcontrollers such as the NodeMCU ESP8266 to create cost-effective, real-time monitoring systems [8], [9]. Such systems have been implemented in smart inventory and industrial monitoring but have yet to be widely applied in the biomass briquette sector [10].

This research addresses the gap by proposing a smart data management system for charcoal briquettes production. The system integrates load cells and the NodeMCU microcontroller to measure and record product's weight and quantity. The measured data was transmitted in real time to the Google Sheets for cloud storage and trend analysis, and production alerts are delivered through the LINE messaging platform. This approach aimed to improve accuracy, reduced labor demands, and provided actionable data for production planning. Ultimately, this work contributed to the ongoing evolution of smart manufacturing in energy-related industries by demonstrating a scalable and efficient IoT-based solution.

2. METHODS

This study developed and implemented a smart data management system using IoT technologies to support charcoal briquette manufacturing. The system was designed to enhance measurement accuracy, reduce human error, and provide real-time data visibility. Key aspects of the methodology included system architecture, hardware integration, data acquisition and processing, prototype development, and cloud-based analysis.

2.1 System Architecture

The system comprised four main components: (1) load cells for weight measurement, (2) a NodeMCU ESP8266

DOI: https://doi.org/10.64289/iej.25.03A11.9182674

*Faculty of Engineering, Mahasarakham University, 41 Kantarawichai, Maha Sarakham, 44150, Thailand.

^D3 Center, The University of Osaka, 5-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan.

[1]Corresponding author;
E-mail: taweesak.th@msu.ac.th

microcontroller for data processing and wireless communication, (3) the Google Sheets as a cloud storage platform, and (4) the LINE Notify for daily production alerts. A 1602 LCD display was also installed for on-site data visibility.

Figure 1 illustrates the overall system architecture, including the physical prototype (10 cm and 12 cm briquette test units) and the connectivity between hardware modules and data interfaces.

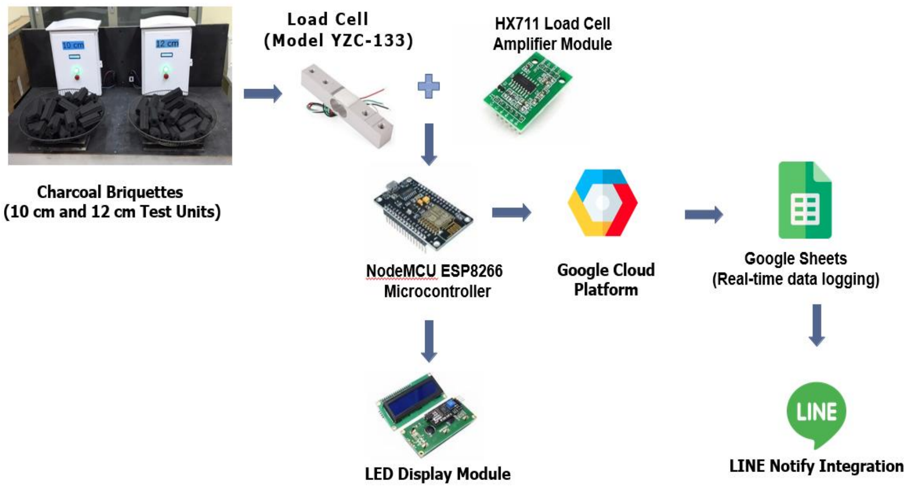


Fig. 1. Prototype setup and system architecture for charcoal briquette testing, including physical test units for 10 cm and 12 cm briquettes together with the block diagram of the integrated system using load cells, NodeMCU ESP8266, Google Sheets, and LINE Notify.

This architecture was adapted from prior work on smart inventory systems and further optimized for charcoal briquette manufacturing within energy-related production environments [8]-[10].

2.2 Hardware Configuration

The load cells used in this study had a 10 kg capacity and were selected for their accuracy and cost-effectiveness. Each load cell was connected to an HX711 amplifier module to convert analog signals into digital input suitable for microcontroller processing. The load cells were calibrated using standard test weights to ensure reliable output [9].

The NodeMCU ESP8266 was selected for its integrated Wi-Fi capabilities, low power consumption, and compatibility with cloud-based platforms [11]. The entire assembly was enclosed in a durable housing to protect against external disturbances such as dust, vibration, and heat.

2.3 Data Acquisition and Transmission

During operation, each charcoal briquette placed on the weight platform was measured using the load cell system. The microcontroller applied smoothing algorithms to filter noise and increase data stability before packaging the readings for transmission [12].

All data were wirelessly uploaded to the Google Sheets in real time using the ESP8266 Wi-Fi module. This approach allowed remote access to production logs and summary reports. The LCD displayed current weight and count values for operator verification. The LINE Notify service was used to deliver daily production summaries, such as total production weight and briquette counts, allowing operators to remotely monitor production performance, as shown in Figure 9 [13].

All weight values recorded in Google Sheets were expressed in kilograms (kg). The column labeled "Amount" refers to the number of briquette pieces produced. This information has been included to clarify data interpretation for both operators and future analyses.

In Google Sheets, the "weight" value represents the total weight of all briquettes placed on the platform at a given time interval, rather than the weight per piece. For example, a reading of weight = 1.41 kg and amount = 8 means that eight briquettes together weigh 1.41 kg.

Instances where both weight = 0 and amount = 0 occur when no briquettes are placed on the platform during that specific logging interval. These zero values were intentionally created during specific intervals by placing empty trays on the weighing platform without any briquettes inside, as part of testing the system's ability to correctly record zero weight when no actual briquettes were present. This procedure was included to confirm the system's measurement accuracy and to ensure no false weight readings occurred. Such records are automatically generated as part of the continuous data logging process, even when no products are present on the weighing platform.

Figures 7 and 8 illustrate how the system records, summarizes, and visualizes daily production data in Google Sheets, enabling operators to easily monitor both the total weight and the number of briquettes produced each day.

The overall setup and functional workflow of the system, including the physical layout of components and operator interface, are presented in Figure 2.

(a) (b)

Fig. 2. Physical schematic of the weight measurement system: (a) control box with breaker control; (b) operational view showing control box and dual weight platforms for 10 cm and 12 cm briquettes.

2.4 Prototype Development

A physical prototype was constructed and tested to validate system performance. The platform was designed to support two standard sizes of charcoal briquettes: 10 cm and 12 cm. The device was enclosed in a protective casing, integrating the load cell, an HX711 module, a NodeMCU, and an LCD display. The prototype system is illustrated in Figure 3, which presents the device structure and its functionality during production.

Figures 3 to 5 illustrate the experimental setup, including the measured briquettes, the physical prototype of the weighing system, and the test trays containing the charcoal briquettes. The 10 cm briquettes weighed approximately 0.1753 kg (175.3 g) per piece, and the 12 cm briquettes weighed about 0.1760 kg (176.0 g) per piece, as measured using a standard industrial scale. These values were adopted as the reference standards for all analyses and evaluations in this research.

Production trials were compared with industrial scale using trays of approximately 20 to 25 briquettes per size. The results were compared against readings from a standard industrial scale to evaluate measurement deviation and system consistency [7].

Fig. 3. Charcoal briquettes used in the study (10 cm and 12 cm).

Fig. 4. Physical prototype of the weighing system for 10 cm and 12 cm briquettes.

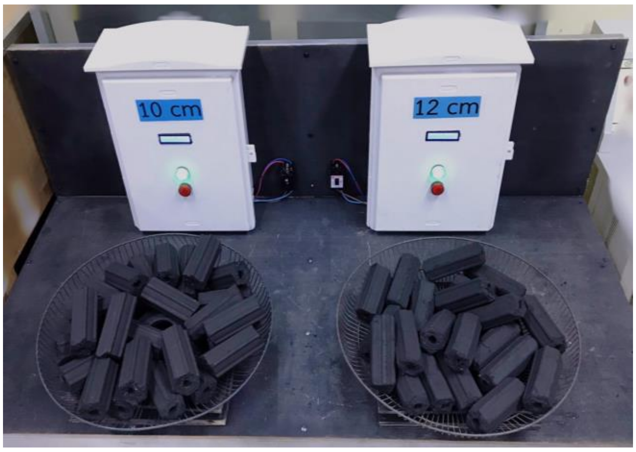


Fig. 5. Sample charcoal briquettes used in the experiments (10 cm and 12 cm).

2.5 Data Logging and Analysis

All production data, including timestamp, weight, and count, were recorded in the Google Sheets. The dataset enabled the creation of automated dashboards and trend summaries for operational review. This structure supports predictive analysis, production forecasting, and anomaly tracking to inform future improvements [4].

3. RESULTS AND DISCUSSION

3.1 System Performance and Visualization

The performance of the smart data management system was evaluated using two commonly produced sizes of charcoal briquettes: 10 cm and 12 cm. The system successfully measured weight and quantity in real time and transmitted the data to the Google Sheets for storage and visualization. Weight and count information were also displayed on the integrated LCD screen at the production site, allowing operators to verify outputs immediately.

Figure 6 presents the LCD output during measurement. Figures 7 and 8 illustrate production logs and trend visualizations captured in the Google Sheets for each briquette size, including total daily production. Additionally, Figure 9 shows real-time notifications sent via the LINE application, which provide operators with daily production summaries, including total weight and briquette counts.

These outputs confirmed the system's ability to facilitate real-time monitoring and secure digital documentation of production activities.

3.2 Accuracy Analysis

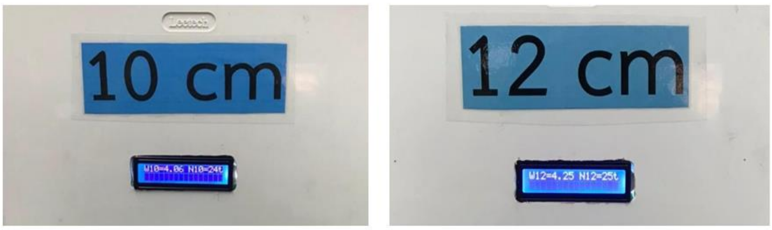
To assess measurement accuracy, results from the prototype system were compared with those from a calibrated industrial weighing scale. Tables 1 and 2 summarize test results from 10 trials per briquette size, comparing actual weight, system-recorded weight, and briquette count.

These trials were conducted under actual production conditions in a charcoal briquette manufacturing facility. Each record in Tables 1 and 2 represents one production tray, with each tray typically containing between 20 and 25 briquettes after the cutting process.

In these tables, the “Actual Briquette Count” refers to the physical number of briquettes manually counted for each tray. The “Recorded Briquette Count” is calculated by dividing the total weight of briquettes on the weighing platform by the average weight per briquette determined from preliminary measurements. Differences between the manually counted number and the system-calculated number are shown as “Count Deviation (pcs)” and “Count Deviation (%)”, indicating how closely the system’s calculations match the actual production counts.

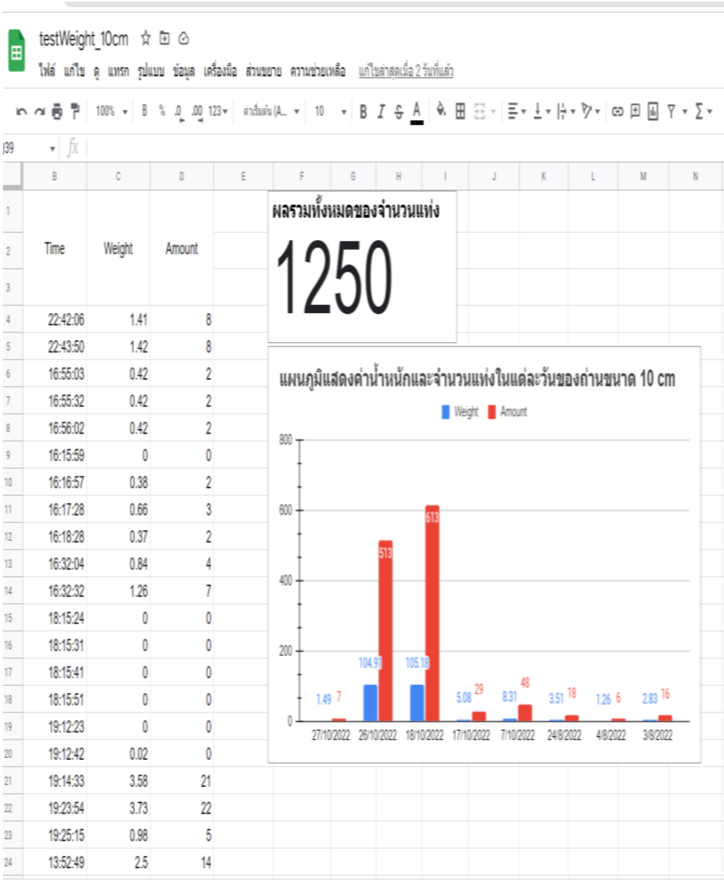
Minor deviations between the manually counted number and the calculated count occur because the weight of each briquette can vary slightly from the average due to differences in cutting size, moisture content, or small surface residues. These factors can result in small discrepancies of approximately ±1 piece in most trials, which is considered acceptable within production tolerances.

This analysis helps evaluate the precision and reliability of the proposed weighing and counting system.



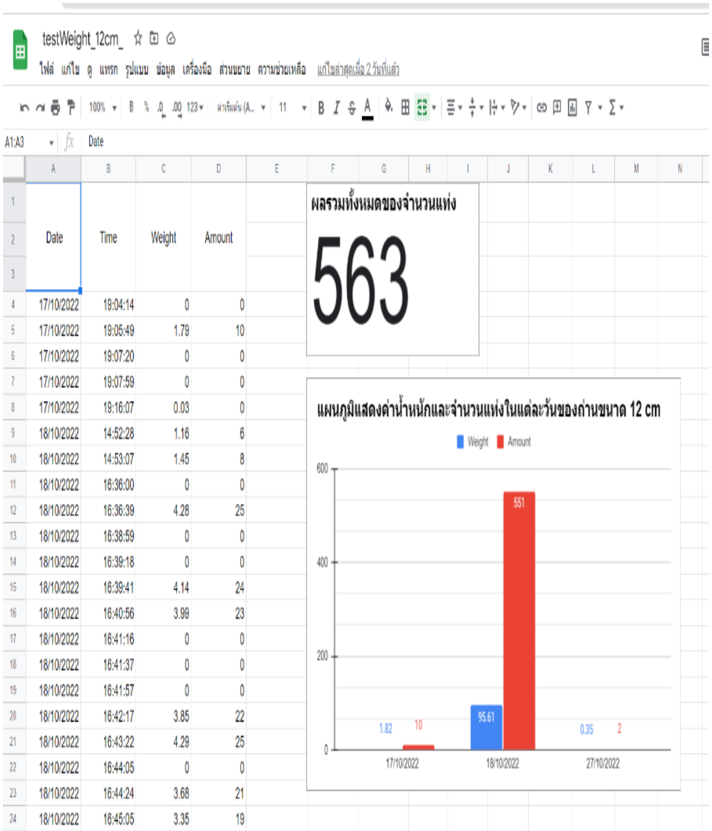
(a) (b)

Fig. 6. LCD display showing weight data for 10 cm (a) and 12 cm (b) briquettes.



Time	Weight	Amount
22:42:06	1.41	8
22:43:50	1.42	8
16:55:03	0.42	2
16:55:32	0.42	2
16:56:02	0.42	2
16:15:59	0	0
16:16:57	0.38	2
16:17:28	0.66	3
16:18:28	0.37	2
16:32:04	0.84	4
16:32:32	1.26	7
18:15:24	0	0
18:15:31	0	0
18:15:41	0	0
18:15:51	0	0
19:12:23	0	0
19:12:42	0.02	0
19:14:33	3.58	21
19:23:54	3.73	22
19:25:15	0.98	5
13:52:49	2.5	14

Fig. 7. Google Sheets record and graph of 10 cm briquette production. Weight values are recorded in kilograms (kg), and Amount refers to the number of briquette pieces produced.



Date	Time	Weight	Amount
17/10/2022	19:04:14	0	0
17/10/2022	19:05:49	1.79	10
17/10/2022	19:07:20	0	0
17/10/2022	19:07:59	0	0
17/10/2022	19:16:07	0.03	0
18/10/2022	14:52:28	1.16	6
18/10/2022	14:53:07	1.45	8
18/10/2022	16:36:00	0	0
18/10/2022	16:36:39	4.28	25
18/10/2022	16:38:59	0	0
18/10/2022	16:39:18	0	0
18/10/2022	16:39:41	4.14	24
18/10/2022	16:40:56	3.99	23
18/10/2022	16:41:16	0	0
18/10/2022	16:41:37	0	0
18/10/2022	16:41:57	0	0
18/10/2022	16:42:17	3.85	22
18/10/2022	16:43:22	4.29	25
18/10/2022	16:44:05	0	0
18/10/2022	16:44:24	3.68	21
18/10/2022	16:45:05	3.35	19

Fig. 8. Google Sheets record and graph of 12 cm briquette production. Weight values are recorded in kilograms (kg), and Amount refers to the number of briquette pieces produced.

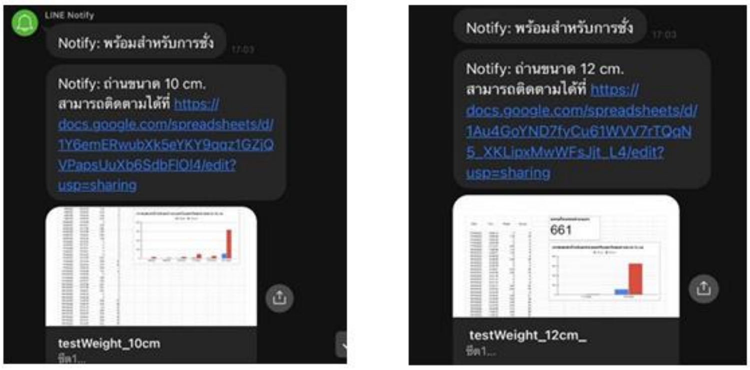


Fig. 9. Sample daily production summary via the LINE notification.

Table 1. Test results for 10 cm briquettes.

No.	Standard Scale Weight (kg)	Google Sheets Weight (kg)	Weight Deviation (%)	Actual Briquette Count (pcs)	Recorded Briquette Count (pcs)	Count Deviation (pcs)	Count Deviation (%)
1	3.99	3.94	1.25	23	23	0	0
2	3.84	3.78	1.56	22	22	0	0
3	4.13	3.9	5.56	24	23	1	4.16
4	3.98	3.89	2.26	23	23	0	0
5	3.69	3.53	4.33	21	20	1	4.76
6	4.31	4.22	2.08	25	25	0	0
7	4.16	4.08	1.92	24	24	0	0
8	3.59	3.51	2.22	20	20	0	0
9	3.44	3.37	2.03	19	19	0	0
10	3.73	3.66	1.87	21	21	0	0
Avg.	3.85	3.79	2.5	22.2	22	0.2	0.88

Table 2. Test results for 12 cm briquettes.

No.	Standard Scale Weight (kg)	Google Sheets Weight (kg)	Weight Deviation (%)	Actual Briquette Count (pcs)	Recorded Briquette Count (pcs)	Count Deviation (pcs)	Count Deviation (%)
1	4.33	4.28	1.15	25	25	0	0
2	4.18	4.14	0.95	24	24	0	0
3	4.04	3.99	1.23	23	23	0	0
4	3.89	3.85	1.02	22	22	0	0
5	4.33	4.21	2.77	25	25	0	0
6	3.72	3.68	1.07	21	21	0	0
7	3.39	3.35	1.17	19	19	0	0
8	3.72	3.49	6.18	21	20	1	4.76
9	3.57	3.34	6.44	20	19	1	5
10	4.19	4.15	0.95	24	24	0	0
Avg.	3.93	3.84	2.29	22.4	22.2	0.2	0.97

For 10 cm briquettes, the average weight deviation was 2.50%, and for 12 cm briquettes, 2.29%. Briquette count deviations were less than 1% for both sizes. These results demonstrate that the proposed system delivers high accuracy in both weight measurement and item counting, consistent with industrial standards [8], [9]. The average briquette count shown in Tables 1 and 2 is included only to evaluate the system's consistency across multiple trials and is not intended to represent the exact number of briquettes in any individual tray.

3.3 Practical Implications

The system effectively replaced traditional manual recording methods, which are often error-prone and time-consuming. Real-time data logging via Google Sheets and LINE notifications offers several practical benefits:

- Immediate detection of weight anomalies or process interruptions is achieved through system logic and data logging, while LINE notifications are used solely for delivering daily production summaries.
- Centralized access to production data across time periods.
- Reduction of labor required for documentation.

This aligns with trends in smart manufacturing, where IoT-based automation improves traceability, response time, and planning accuracy [4], [10].

Moreover, the system's modular design and cloud integration allow for scalability and adaptation to other manufacturing contexts. For example, additional sensors (*e.g.*, moisture, temperature) or machine-learning modules could be added in future iterations to support quality control and predictive maintenance [2], [12].

Compared to the previous manual approach, the proposed system significantly improves the quality of production operations. Manual weighing and counting were prone to human error, lacked consistent record-keeping, and consumed substantial time for each tray. The automated system reduces measurement deviations, ensures real-time data availability, and enhances traceability across production batches.

While the new system requires additional investment in hardware components (*e.g.*, load cell, HX711, microcontroller) and software integration, these costs are justified by long-term benefits, including reduced labor requirements, higher data accuracy, and faster decision-making capabilities. This makes the system particularly suitable for manufacturers aiming for digital transformation in smart factory environments.

3.4 Limitations and Future Work

While the system achieved strong performance under controlled conditions, field deployment at scale may require improvements in:

- Environmental shielding of components (for dust or heat exposure),
- Integration with local power systems or backup energy sources,
- Usability enhancements for non-technical operators.

Future work may also include developing a web-based dashboard for analytics, integrating machine learning (ML) models to predict production bottlenecks based on historical trends, and incorporating additional sensors, such as DHT11, to monitor temperature and humidity in the charcoal briquette drying facility. Such environmental data could enhance production quality control and support more comprehensive process optimization.

4. CONCLUSIONS

This study presented the development and evaluation of a smart data management system for charcoal briquette manufacturing using IoT technologies. The system integrates load cells, the NodeMCU ESP8266 microcontroller, cloud-based storage via the Google Sheets, and real-time notifications through the LINE Notify. It was designed to replace manual data recording processes with a more accurate, automated, and real-time solution.

The experimental results demonstrated that the proposed system achieved a high level of accuracy, with average weight deviations of 2.50% for 10 cm briquettes and 2.29% for 12 cm briquettes. Briquette counting accuracy was within 1% of the actual count. The integration of real-time monitoring, cloud-based storage, and instant notifications significantly enhanced operational transparency, reduced manual error, and supported production planning.

The proposed system not only meets the functional demands of small-scale biomass energy production but also establishes a foundation for scalable, low-cost digital transformation in similar industrial contexts. With its modular design, the system can be extended to include additional sensing and predictive analytics capabilities in future iterations.

Overall, this research contributes a practical and adaptable IoT-based solution to the field of smart manufacturing, particularly within the domain of biomass processing, and supports broader trends in sustainable and data-driven production systems.

ACKNOWLEDGEMENTS

This research project was financially supported by Mahasarakham University.

REFERENCES

[1] Said Mohamed E., Belal A.A., Abd-Elmabod S.K., El-Shirbeny M.A., Gad A., and Zahran M.B., 2021. Smart farming for improving agricultural management. *The Egyptian Journal of Remote Sensing and Space Science* 24(3): 971–981.

[2] Shahab H., Iqbal M., Sohaib A., Khan F.U., and Waqas M., 2024. IoT-based agriculture management techniques for sustainable farming: A comprehensive review. *Computers and Electronics in Agriculture* 220: 108851.

[3] Liakos K.G., Busato P., Moshou D., Pearson S., and Bochtis D., 2018. Machine learning in agriculture: A review. Sensors 18(8): 2674.

[4] Wolfert S., Ge L., Verdouw C., and Bogaardt M.J., 2017. Big data in smart farming – A review. Agricultural Systems 153: 69–80.

[5] Bekee B., Segovia M.S., and Valdivia C., 2024. Adoption of smart farm networks: A translational process to inform digital agricultural technologies. *Agriculture and Human Values* 41: 1573–1590.

[6] Obi O.F., Olugbade T.O., Orisaleye J.I., and Pecenka R., 2023. Solid biofuel production from biomass: Technologies, challenges, and opportunities for its commercial production in Nigeria. *Energies* 16: 7966.

[7] Jula G., Kim D.G., and Nigatu S., 2024. Potential of floriculture waste-derived charcoal briquettes as an alternative energy source and means of mitigating indoor air pollution in Ethiopia. *Energy for Sustainable Development* 79: 101390.

[8] Mansor M.N., Talib N.A.A., Saidi S.A., Mustafa W.A., and Zamri N.F., 2023. Arduino IoT-based inventory management system using load cell and NodeMCU. *Journal of Advanced Research in Applied Sciences and Engineering Technology* 32(3): 12–25.

[9] Al-Dahiree O.S., Tokhi M.O., Hadi N.H., Hmoad N.R., Ghazilla R.A.R., Yap H.J., and Albaadani E.A., 2022. Design and shape optimization of strain gauge load cell for axial force measurement for test benches. *Sensors* 22(19): 7508.

[10] Rezwan S., Ahmed W., Mahia M.A., and Islam M.R., 2018. IoT-based smart inventory management system for kitchen using weight sensors, LDR, LED, Arduino Mega and NodeMCU (ESP8266) Wi-Fi module with website and app. In: *2018 Fourth International Conference on Advances in Computing, Communication & Automation (ICACCA)*. IEEE, pp. 1–6.

[11] Sujiwa A., Musthofa A.N., and Marta B.T., 2024. Baby weight and length based on Arduino Uno with combination of ultrasonic sensor HC-SR04 and weight sensor (load cell). *Journal of Applied Electrical & Science Technology* 6(1): 7–13.

[12] Doshi J., Patel T., and Bharti S., 2019. Smart farming using IoT: A solution for optimally monitoring farming conditions. *Procedia Computer Science* 160: 746–751.

[13] Takaeng C. and Aurasopon A., 2021. Monitoring system for a bucket milking machine based on IoT. *International Journal of Engineering Trends and Technology* 69(9): 29–33.