Multidisciplinary Output Research For Actual and International Issue (MORFAI Journal) ISSN (e): 2808-6635
Volumes 5 No. 4 (2025)

INTERNET OF THINGS (IOT) BASED SMART CHOPPER SYSTEM WITH WEIGHT MONITORING TO IMPROVE PRODUCTIVITY

Rudy Mustaqim[1], Irma Salamah[2], Ahmad Taqwa[3]
[1,2,3]Politeknik Negeri Sriwijaya, Indonesia.
Corresponding Email: rudymustaqim0601@gmail.com, irma_salamah@polsri.ac.id, taqwa@polsri.ac.id

Received	: 21 April 2025	Published	: 14 June 2025
Revised	: 30 April 2025	DOI	: https://doi.org/10.54443/morfai.v5i4.3225
Accepted	: 17 May 2025	Publish Link	: https://radjapublika.com/index.php/MORFAI/article/view/3225

Abstract

The food processing industry faces challenges in enhancing efficiency and productivity, particularly in raw material processing. This research addresses the limitations of manual cutting processes, which lead to inconsistencies, human error, and prolonged production times. By integrating Internet of Things (IoT) technology into a smart chopper system with weight monitoring, the study aims to automate cutting speed, reduce waste, and improve product quality. The developed system incorporates sensors for weight measurement and voltage monitoring, controlled by an ESP32 microcontroller for real-time adjustments and monitoring. The system's performance was evaluated based on material hardness and weight, demonstrating its ability to optimize cutting processes and provide consistent results. The IoT integration enables remote control and monitoring, enhancing productivity, reducing waste, and ensuring seasoning quality in the food processing industry.

Keywords: ***Internet of Things (IoT), smart chopper system, weight monitoring, food processing industry, automation, productivity improvement***

INTRODUCTION

The food processing industry always faces major challenges in increasing efficiency and productivity, especially in the raw material processing process. One aspect that is often an obstacle is the process of cutting raw food materials, which in many industries is still done manually. This manual process leads to non-uniformity in cutting results, potential human error, and longer production times. This certainly has an impact on operational efficiency, which ultimately affects product quality and company productivity. However, advanced technology allows the food production process to be more efficient, by speeding up production times, reducing waste, and increasing productivity [1]. Along with the development of technology, the use of the Internet of Things (IoT) has begun to be applied in various industrial sectors to increase efficiency and productivity. IoT allows for more sophisticated system integration, so that it can monitor and control processes in real-time [2]

In the context of the food processing industry, IoT technology can be used to optimize the cutting process by automating the cutting speed setting, which will help in producing more consistent cuts, reducing waste, and speeding up production time. In addition, IoT also offers other benefits in the food industry, such as monitoring product quality through connected sensors, controlling temperature and humidity in the raw material storage process, and real-time stock management [3]. The use of this technology can provide a competitive advantage for companies that want to maintain high quality standards and increase production capacity. For example, by using IoT devices, raw material management can be done more precisely, reducing dependence on manual labor, and avoiding errors in the production process.

The fineness of spices is a crucial factor in various types of cooking, both in household and food industry scales. Inconsistencies in the level of fineness can affect the taste, aroma, and absorption of spices to other food ingredients. In conventional systems, operators often have to manually check or repeat the chopping process to achieve the desired level of fineness. This is not only time-consuming, but also causes inefficiency in the use of energy and raw materials. In addition, uncontrolled material loads can affect machine performance, which ultimately has an impact on the service life of the tool and operational costs. The solution offered in this study is the development of an Internet of Things (IoT)-based Smart Chopper system with automatic material weight monitoring and time settings. This system allows users to adjust the chopping speed based on the type of material used, so that the fineness of the results can be precisely adjusted. Monitoring the weight of the material entering the machine also ensures that the optimal capacity is not exceeded, so that the performance of the tool remains stable and efficient. In addition, IoT integration allows users to monitor and control the chopping process in real-time through an application or digital platform. With the application of this technology, it is expected that productivity in the food processing industry can increase, reduce production waste, and ensure more consistent seasoning quality. Thus, the application of IoT-based Smart Chopper which can control cutting speed automatically is expected to increase efficiency and productivity in the food processing industry. This system not only functions to speed up the process, but also ensures the consistency and quality of the cutting results, and provides a sustainable automation solution for the growing food processing industry.

Formulation of the problem

Based on the background described above, the problems that will be discussed in this research can be formulated, namely:

1. How to integrate the Smart Chopper system with Internet of Things (IoT) technology to enable real-time monitoring and control?

Scope of problem

To focus this research, several problem limitations were set as follows:

1. This study will only discuss the fineness of spices in the chopping process, without covering other aspects such as the composition or chemical content of the spices.
2. The system developed will only use load cell sensors to measure the weight of materials and sensorsZMPT101Bto read the voltage as a reference in calculating the rotation speed (RPM) of the shredder machine.
3. The integration of the Internet of Things (IoT) in this study is only focused on monitoring and controlling the Smart Chopper system, without covering other aspects such as artificial intelligence or advanced data analysis.

Objective

The objectives of this research are as follows:

1. Building a Smart Chopper system equipped with Internet of Things (IoT) technology to automatically control cutting speed, by utilizing sensors and actuators connected in real-time.
2. Developing a cutting speed control mechanism that can be adjusted and automatically controlled based on data or operational conditions monitored by the IoT system.
3. Assessing how the implementation of an IoT-based Smart Chopper system can improve efficiency and productivity in the food processing industry, especially in terms of cutting process speed and resource management.

LITERATURE REVIEW

The following research is previous research related to this research. The research entitled "IoT Based Monitoring and Control System for Food Processing" by Harisha investigates the development and integration of IoT-based monitoring and control systems in food processing to improve efficiency, safety, and quality. The results and findings of this study are that the quality of food products becomes more consistent due to more precise control of key parameters during the processing process and This system allows more efficient control of raw materials, reducing waste due to errors in the process such as improper cutting of materials or too much waste. Another study entitled "Design and Implementation of an IoT Based Control System for Precision Food Manufacturing" by Gowda explores the creation and integration of IoT-based monitoring and control mechanisms in food processing to improve quality, safety, and efficiency. The results and findings of this study are In food processing, processing speed can be controlled automatically, reducing cycle time and increasing productivity and IoT provides more precise control to maintain food product quality standards, such as control of the fermentation or baking process, which greatly affects the final result [21].

METHOD

This study uses an experimental method because it involves testing and observation under controlled conditions. The data collected during the experiment will be analyzed to determine the direct impact of IoT technology in improving machine performance and reducing waste of raw materials.

Electrical Design

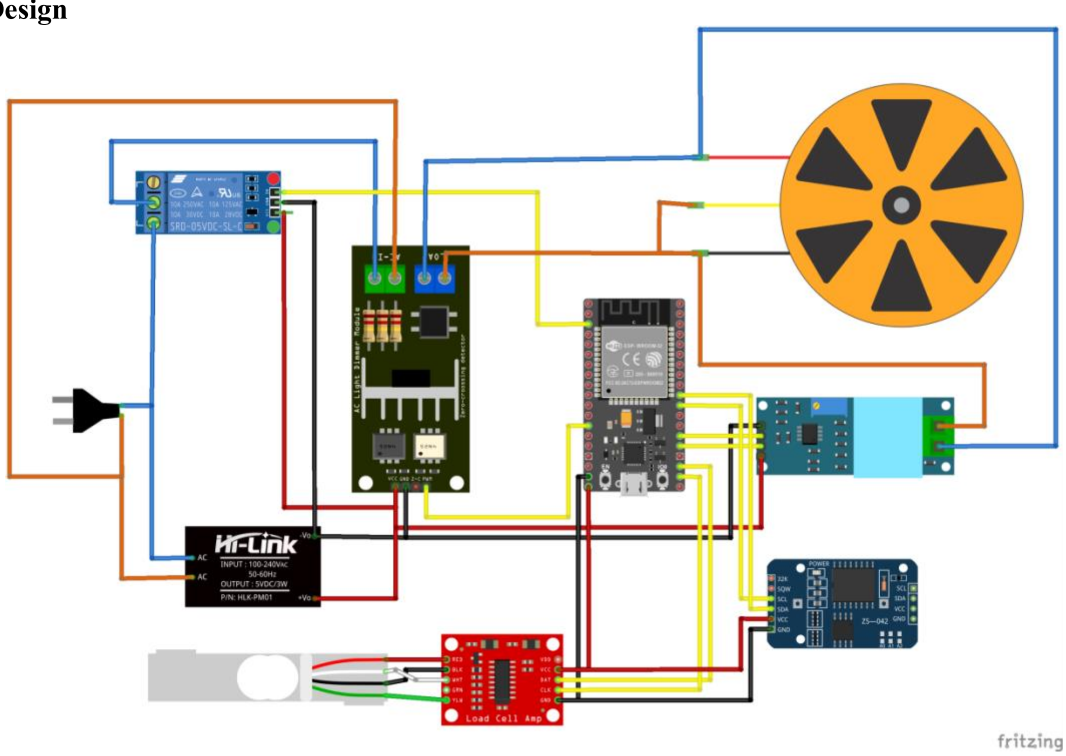


Figure 1 Electrical Design

This system uses a voltage source from household electricity (PLN) as the main supply to operate all components. The 220V AC voltage from PLN is converted to DC and reduced to 5V using the Hi-Link converter module, which is then used to supply power to the ESP32, load cell sensor, RTC module, ZMPT101B voltage sensor, relay, and AC Light Dimmer module. The AC voltage going to the chopper is first controlled by the relay to control its on and off, then passes through the dimmer module so that its speed can be adjusted before finally entering the chopper. With this system, the voltage can be distributed according to the needs of each component so that it can work optimally. In addition to voltage distribution, this system also manages various data inputs and outputs. The load cell sensor is used to detect the weight of the chopper container and sends the data to the ESP32 for processing. The RTC module provides time information used for scheduled system operation settings. The ZMPT101B voltage sensor functions to measure the incoming AC voltage and sends data to the ESP32 as a monitoring parameter. The ESP32 acts as a control center that receives all data from the sensors, then controls the relay to turn the power to the chopper on or off. In addition, the ESP32 also regulates the speed of the chopper through the AC Light Dimmer module using control signals as needed. With this system, chopper operation becomes more automatic and efficient according to the data obtained from various sensors.

Block Diagram

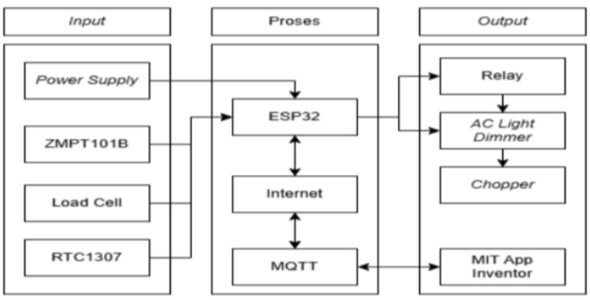


Figure 2 Block Diagram

This system is designed to automatically control and monitor the chopper using IoT technology. In the input section, there is a power supply that provides power for the entire system to operate. The ZMPT101B sensor is used to read the AC voltage entering the system, while the load cell functions to detect the weight of the chopper container. In addition, the RTC1307 is used to provide real-time time information that is sent to the ESP32. All data from this sensor is sent to the ESP32 for processing and analysis. In the process section, the ESP32 acts as the main control center responsible for reading and processing data from the sensor. The ESP32 is then connected to the internet to enable online data communication. The MQTT protocol is used as a communication intermediary between the ESP32 and the IoT-based monitoring application, namely MIT App Inventor, which allows users to view system data in real-time. In the output section, the ESP32 controls the relay to turn the power to the chopper on or off. In addition, the ESP32 also regulates the AC Light Dimmer to control the speed of the chopper according to the data received from the sensor. With this system, users can monitor and control the chopper remotely via the application, making the process more efficient and automatic.

Flow chart

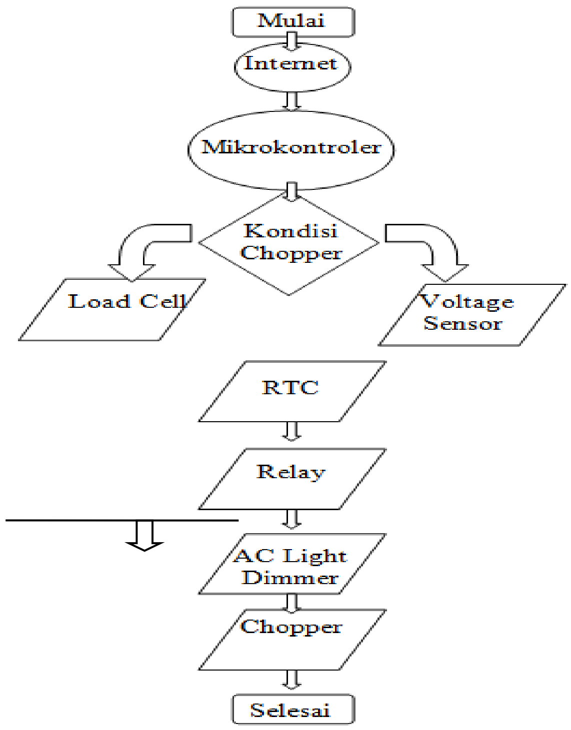
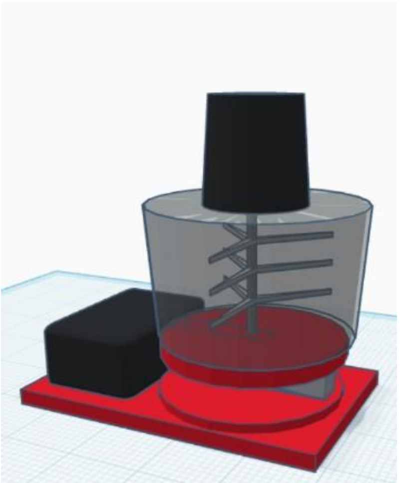


Figure 3 Flowchart

This flowchart illustrates the system that will be created to automatically control and monitor the chopper using IoT. The system starts by plugging the device into a power source or turning it on. Once the system is active, the first step is to find an internet connection, which serves to connect the microcontroller to the monitoring application and allows real-time data communication via communication protocols such as MQTT. After the internet connection is successfully connected, the microcontroller will start carrying out its task of controlling and managing the system. One of the main tasks of the microcontroller is to evaluate the condition of the chopper using two main sensors, namely the load cell and the voltage sensor. The load cell functions to detect the presence of goods or loads placed on the chopper container, so that the system can determine whether the chopper needs to be operated or not. The voltage sensor is used to read the electrical voltage entering the system, which is later used to calculate the chopper's operating speed based on the voltage value received.

After the chopper condition is analyzed, the system will set the operating time based on the values determined through previous experiments. The microcontroller then activates the relay, which functions as an electronic switch to connect power to the AC Light Dimmer. The AC Light Dimmer is responsible for controlling the voltage supplied to the chopper motor, so that its speed can be adjusted according to system needs. After this process is complete, the chopper will work according to the predetermined parameters, and the system will continue to operate automatically to maintain the performance and efficiency of the chopper according to the data received from the sensor.

3D Design



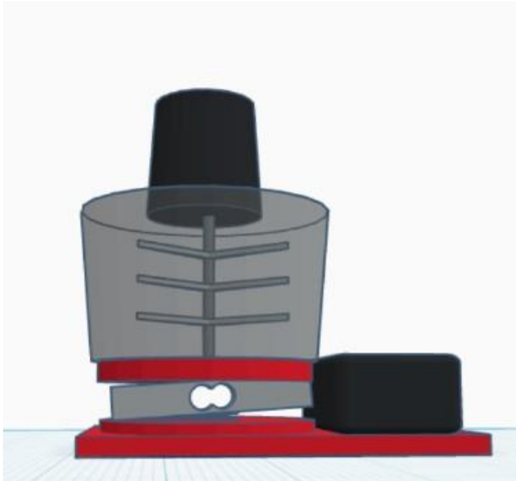


Figure 4 Chopper 3D **Figure 5 Chopper 3D**

The image above shows a 3D design of a chopper system that has been modified to suit the project needs. This modification was done to adjust the standard chopper settings to work with the automated system that has been designed. This design was created using Tinkercad software to provide a visual representation of the structure and layout of the components that will be used.

The main part of this design is the chopper, which is located in the middle and has a transparent container with cutting blades inside. This container is designed to hold the material to be processed by the chopper. At the bottom of the chopper, there is a load cell, which is a sensor used to measure the weight of the contents of the container without taking into account the weight of the chopper itself. This load cell allows the system to know the amount of material to be processed and adjust the operating time and speed based on the detected load.

On the right side of the design, there is a black box, which serves as a storage place for all major electronic components, including microcontrollers, communication modules, and other sensors. This box is designed to protect components from external factors such as dust, water, or shocks that can interfere with system performance. With this box, the system can work more stably and durable in various environmental conditions. The overall design is made with ease of access for maintenance and flexibility in daily use in mind.

RESULTS AND DISCUSSION

System Design

Figure 6 Chopper System Design

The design of this system involves the integration of hardware and software to automate the operation of an Internet of Things (IoT) based chopper. Physically, the system consists of two main parts, namely the chopper unit and the electronic control unit located in a black box at the bottom. The modified chopper unit has a transparent container with a cutting blade inside and a load cell sensor installed under the container to measure the weight of the material being fed. This weight data is sent to the ESP32 microcontroller, which functions as the brain of the system. The control unit is equipped with various important components, including a switching power supply module to convert voltage from 220V AC to 5V or 12V DC according to component needs, a relay to turn on and off the electric current to the chopper, an AC dimmer module to regulate the speed of the chopper motor, and a ZMPT101B sensor to monitor AC voltage. All of these components are connected and controlled by the ESP32, which also has Wi-Fi connectivity capabilities to connect to IoT applications such as MIT App Inventor via the MQTT protocol. In the design process, the connecting cables are color-coded to facilitate installation and troubleshooting. The control box is designed to be closed and compact to protect the circuit from dust and impact, and to ensure safety during operation. This design also considers space efficiency and ease of maintenance, with components arranged neatly in the container.

Application Design

Figure 7 Application Design

The application was developed using the MIT App Inventor platform as a user interface to control the Smart Chopper system remotely via an internet connection. The application interface design is made as simple as possible to make it easier for users to operate the device. On the main display of the application (Screen1), there is a switch that functions to activate or deactivate the chopper, marked with the status label "Chopper Off Condition" which will change automatically according to the operational conditions of the device. In addition, there is a slider below it that functions to adjust the chopper motor rotation speed. This slider provides flexibility in choosing the desired speed level according to user needs. The value of the slider will be sent in real-time to the ESP32 microcontroller via the MQTT protocol, so that the motor speed can be changed dynamically without the need for direct manual intervention on the device. The app uses the smartphone's Wi-Fi connection to connect to an MQTT broker (such as Mosquitto or a broker from a platform such as CloudMQTT), which acts as a bridge between the app and the ESP32 device. With this approach, the system becomes real-time and flexible, allowing users to control devices remotely efficiently and accurately.

System Testing

No	Time (seconds)	Actual Weight (g)	Load Cell Reading (g)	Difference (g)	Error (%)	Chopper Status
1	0	0	0.5	0.5	0.42%	OFF
2	10	200	199.3	-0.7	0.35%	ON
3	20	400	398.5	-1.5	0.38%	ON
4	30	600	599.1	-0.9	0.15%	ON
5	40	800	802.2	2.2	0.28%	ON
6	50	1000	1000.4	0.4	0.04%	ON
7	60	1000	999.8	-0.2	0.02%	OFF
8	70	1000	1001.1	1.1	0.11%	OFF
9	80	1000	999.7	-0.3	0.03%	OFF

10	90	1000	1000.0	0.0	0.00%	OFF

Table 1 System Testing

In the system testing phase, the main focus is directed at the Load Cell sensor which functions to measure the weight of food ingredients put into the chopper container. This sensor is an important component because the material weight data is used as the main parameter to determine the duration and speed of automatic chopping. Testing is carried out by placing various weights of ingredients gradually into the chopper container, then recording the readings from the previously calibrated sensor. Data from the Load Cell sensor is sent to the ESP32 microcontroller and displayed via an IoT interface that allows real-time monitoring via the application.

The test results show that the weight reading by the sensor is quite accurate when compared to reference measuring instruments such as digital scales. The difference in average reading values is in the range of ±2 grams to ±5 grams, depending on the stability conditions of the load and the placement surface. This accuracy is sufficient for the needs of household and small-medium industrial chopper applications. The sensor shows stable performance when the load is in a stationary condition, but slight fluctuations occur when the chopper starts operating due to mechanical vibrations from the motor. To overcome this, the system is designed to automatically read the weight only when the motor is not yet on or is idling, so that the weight data is not distorted by vibrations.

In addition, the initial calibration process is very important so that the Load Cell sensor is able to produce readings that match the actual value. Calibration is done by providing a reference load and adjusting the multiplier constant in the program so that the value read is appropriate. Once properly calibrated, the sensor is able to detect weight changes linearly and consistently. From the programming side, filtering or data rounding is used to avoid small, insignificant fluctuations. The data obtained is then used by the microcontroller to determine when the relay should activate the chopper and how much voltage is given through the dimmer module.

The integration of this sensor with the IoT system went well. ESP32 not only reads the weight data, but also sends it to a monitoring platform such as an Android application based on MIT App Inventor via the MQTT protocol. This allows users to see the weight of incoming materials directly from their smartphones, providing flexibility and ease of operation of the device. The success in integrating this Load Cell sensor proves that the developed Smart Chopper system is able to work automatically and responsively to variations in food input.

In general, testing proves that the use of Load Cell sensors in the Smart Chopper system makes a major contribution to the efficiency and effectiveness of the material chopping process. This sensor is able to provide accurate data to support automatic control of time and motor speed, which results in more uniform spice chopping results, time savings, and increased productivity. With the reliability of measurements that have been proven through testing, this system has great potential to be applied in the automation-based food processing industry.

No	Material Weight (grams)	Material Hardness Level	Milling Results	Level of Fineness
1	50	Gentle	Fine	Very Smooth
2	100	Gentle	Fine	Fine
3	150	Gentle	A Little Rough	Currently
4	50	Currently	Fine	Fine
5	100	Currently	A Little Rough	Currently
6	150	Currently	Rough	Rough
7	50	Hard	A Little Rough	Currently
8	100	Hard	Rough	Rough
9	150	Hard	Not Smooth	Very Rude

Table 2 Grinding Fineness Test

The grinding fineness test on the Smart Chopper system was carried out based on two main parameters, namely the weight of the material and the hardness level of the material. In this experiment, the material was tested in three weight categories (50g, 100g, and 150g) and three hardness levels (soft, medium, and hard). The results showed that materials with a soft hardness level such as spring onions, chilies, or tomatoes, can be ground with very fine to fine results, even at a maximum weight of 150 grams, although at high loads the fineness decreased slightly. Materials with a medium hardness level such as shallots, grated carrots, or potatoes, showed grinding results that began to vary. At light loads (50g), the results remained smooth, but at loads of 100g and 150g, the fineness decreased to medium to coarse, indicating the effect of load on motor and blade performance.

For materials with high hardness levels such as nutmeg, old ginger, or peanuts, the grinding results tend to be coarse, especially when the amount of material increases. At a weight of 150 grams with high hardness, the grinding results tend to be not smooth and some parts are still intact. This indicates that the cutting power of the knife and the torque of the motor are not optimal enough to handle the combination of high weight and hardness without additional chopping time. This test provides a clear picture that system performance is greatly influenced by the load and hardness of the material, so it is necessary to automatically adjust the operating time or motor speed using data from the weight sensor and material categorization. In conclusion, the Smart Chopper system works optimally for soft and medium materials with light to medium loads, but requires increased power or additional operating time for hard and heavy materials to maintain optimal results.

No	Test Time (minutes)	Initial Weight (g)	Final Weight (g)	Weight Difference (g)	Early Violence	Final Violence	Difference in Violence	Wear (%)
1	120.0	120.0	119.98	0.02	58.0	57.95	0.05	17%
2	340.0	120.0	119.94	0.06	58.0	57.85	0.15	43%
3	120.0	119.96	119.94	0.02	58.0	57.85	0.15	50%
4	120.0	120.0	119.93	0.07	58.0	57.75	0.25	67%
5	120.0	120.0	119.91	0.09	58.0	57.70	0.30	83%
6	90.0	120.0	119.90	0.10	58.0	57.65	0.35	100%
7	90.0	119.98	119.84	0.14	58.0	57.60	0.40	117%
8	60.0	120.0	119.86	0.14	58.0	57.55	0.45	133%
9	120.0	120.0	119.84	0.16	58.0	57.50	0.50	150%
10	120.0	120.0	119.88	0.12	58.0	57.50	0.50	167%
11	120.0	120.0	119.88	0.12	58.0	57.50	0.50	167%
12	120.0	119.96	119.86	0.14	58.0	57.65	0.35	100%

Table 3 Testing of Material Weight, Material Hardness and Chopper Wear

The test results showed that the longer the use time, the greater the difference in weight and the decrease in the hardness of the material, indicating that the knife was gradually worn. The highest wear was recorded at 167% in the 10th test after 10 minutes of use, with a hardness difference of 0.50. On the other hand, the initial test with a short time (1–2 minutes) showed relatively small wear, namely 17% and 33%, indicating that the knife was still sharp and effective in cutting the test material. These data show consistency between the decrease in hardness of the ground material and the increase in weight difference as an indicator of knife sharpness. As wear increases, cutting effectiveness decreases, causing increased friction and suboptimal cutting results. This test system is considered quite accurate because it combines physical parameters (weight and hardness) that are relevant to operational conditions in the food industry.

Overall, it can be concluded that the Smart Chopper tool is able to detect gradual degradation of knife sharpness using weight sensor data (load cell) and material hardness parameters. With this approach, the system can provide recommendations for periodic knife maintenance or sharpening times based on accurate data, thereby extending the life of the knife and maintaining the quality of the milled product at its optimum. This data can also be used as a standard reference for knife wear testing in the food processing industry environment with the help of IoT-based sensors and monitoring systems.

Iot Testing

No	Parameter	Sensor Input Value	Delivery Time to Excel	Shipping Status	Information
1	Weight (g)	120.0	1.2 seconds	Succeed	Data appears in real-time
2	Violence (H)	58.0	1.3 seconds	Succeed	Stable
3	Wear (%)	50%	1.4 seconds	Succeed	Automatically calculated
4	Operating Temperature (°C)	35.5	1.1 seconds	Succeed	Stable
5	Voltage (V)	5.1	1.5 seconds	Succeed	According to resources

Table 4 IoT Testing

The first test was conducted to evaluate the ability of the IoT system to send data from the sensor to the Excel platform (in this case using Google Spreadsheet as an online data server). Several parameters tested include material weight, material hardness level, knife wear level, operational temperature, and system working voltage. The test results show that the data sending time from the sensor to the spreadsheet takes an average of less than 1.5 seconds for each parameter. For example, material weight data was successfully sent in just 1.2 seconds and immediately appeared on the spreadsheet in real-time. Likewise for material hardness (58.0 H), wear (%), and temperature and voltage. This fast response shows that the system is able to read and process sensor data directly and stably without delay. This advantage is very important in industrial equipment performance monitoring systems such as choppers, because it allows regular monitoring of knife wear and workload conditions without the need for manual intervention. The recorded data can also be used for historical and predictive analysis purposes to support preventive maintenance of equipment.

No	Application Commands	ESP32 Module Response	Response Time	Display Status	Information
1	Turn on Chopper	ON (Relay Active)	1.0 seconds	Display ON	The engine is on
2	Turn Off Chopper	OFF (Relay Off)	0.9 seconds	OFF display	Motor stops
3	Set Speed (Slider)	PWM 75%	1.2 seconds	Active slider	Speed changes
4	Read Material Weight	119.8 g	1.1 seconds	Weight displayed	Accurate and real-time data
5	Send Wear Data	100%	1.4 seconds	Data displayed	Data sync with Google Sheet

Table 5 Testing the Responsiveness of the IoT System When Receiving Direct Commands from Mobile Applications

Next, the responsiveness of the IoT system was tested when receiving direct commands from the designed mobile application. This application has various control features such as turning the chopper motor on or off (via the switch button), adjusting the motor speed (using the PWM slider), and displaying sensor readings such as material weight and wear level. When the user presses the "ON" button, the system responds by activating the relay and turning on the motor in less than 1 second, which is also indicated by a change in the status display on the application. Likewise, when the motor is turned off, the system immediately deactivates the output with a fast response time of 0.9 seconds. When the user adjusts the speed using the slider, the system adjusts the PWM value smoothly without delay, indicating that the analog connection and control are also working well. Sensor data retrieval (weight, wear, etc.) also takes place in real-time, where the data displayed in the application is synchronized with the data entered into Google Spreadsheet. These results prove that the IoT system on the Smart Chopper has strong integration between hardware, cloud platform (Excel), and user interface (mobile application), thus supporting responsive, flexible, and efficient tool operations.

CONCLUSION

The Smart Chopper system successfully operates automatically and is integrated with IoT, both in the device control process and data monitoring. Features such as motor speed control, material weight monitoring, temperature, and blade wear can run in real-time via the application and Google Spreadsheet. The load cell sensor and hardness sensor show good accuracy in detecting the physical condition of the material, such as weight and hardness level, which are directly correlated with the performance of the chopper blade. The test results also prove that the system is able to record changes continuously and detect wear gradually. The system's responsiveness to application commands and the speed of data transfer to the cloud (Excel) are very adequate, with an average response time of less than 2 seconds. This shows that this system can be used in small to medium industrial environments that require fast control and continuous monitoring.

REFERENCES

[1] Ciputra, Universitas (2024). Peran Teknologi Pengolahan Makanan yang Canggih dalam Industri Makanan. Universitas Ciputra.
[2] Area, Universitas Medan (2024). Integrasi IoT dan Sistem Otomasi dalam Teknik Industri, Penulis Biro Pengembangan Minat Bakat & Karir Mahasiswa. Universitas Medan Area.
[3] Center, Binus Enrepeneurship (2024). Potensi IoT pada Bisnis Makanan. Binus University.
[4] Ruparupa (2023). Ini Bedanya Chopper, Blender, dan Food Processor. Ruparupa.com.
[5] Isnaini (2024). Apa Itu Chopper?. Decoruma.com.
[6] Diskominfo (2018). Pentingnya Internet of Things. Dinas Informasi dan Inforatika Kabupaten Bandung.
[7] Selay (2022). INTERNET OF THINGS. Jurnal Karimah Tauhid Hal 860.
[8] Ditempel (2023). Mengenal Timer Tiny RTC DS1307. Ditempel.com.
[9] Technology (2024). Taidacent ESP8266 Papan Mikrokontroler, Papan Pengembangan WiFi Daya Rendah Node Ukuran Kecil MCU ESP8266 12 E CP1202 Lua. Alibaba.com
[10] Nizam (2022). Mikrokontroler Esp 32 Sebagai Alat MONITORING PINTU BERBASIS WEB. Jurnal Mahasiswa Teknik Informatika.
[11] Prafanto (2021). Pendeteksi Kehadiran Menggunakan Esp32 Untuk Sistem Pengunci Pintu Otomatis . Jurnal Teknologi Terapan.
[12] Programming (2020). KONTROL KELUARAN SINYAL AC DENGAN AC Light Dimmer Module. Sinauprograming.com.
[13] Prasojo (2018.) Rancang Bangun Sistem Pengendalian Suhu Pada Inkubator Bayi Berbasis Fuzzy Logic Controller. Jurnal Teknik Elektro hal 166.
[14] Flintec (2025). What is a Load Cell?. flintec.com.
[15] Wahyu (2023). Apa Itu Load cell Sensor? Ini Penjelasannya. SensorIndo.com.
[16] Lampung (2020). ACS712 20A Sensor Arus. Aksesoriskomputerlampung.com.
[17] Prabowo (2020). Pengukuran Arus dan Tegangan pada Prototipe Pltmh Berbasis Arduino dan Multimeter. Jurnal Media Elektro.
[18] Ilmu (2017). Cara mengakses modul display LCD 16×2. Nebarilmu.com
[19] Digital (2025). Apakah arti dari LED Display?. akudigital.com
[20] Robu.in (2025). AC Voltage Sensor Module ZMPT101B (Single Phase). Robu.in.
[21] Gowda (2024). Design and Implementation of an IoT-Based Control System for Precision Food Manufacturing. Springer.

Published by **Radja Publika**