Design and IoT-Based Monitoring of Salt Refining and Stirring Machine Using SUS 316L Material

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***Abstract*—The salt industry faces declining sales due to the lack of automated processing machines, affecting efficiency and market readiness. This study develops a salt refining and stirring machine using SUS 316L, known for its durability and hygienic properties. The machine, with a maximum rolling speed of 3800 rpm, refines salt to a smoothness level of 50-100%, depending on the roller gap density. Testing shows that refining 1 kg of salt with a 1 mm roller density takes 6.01 minutes (5mm gap), 1.13 minutes (10mm gap), 0.1 minutes (15mm gap), and 0.07 minutes (20mm gap). For a 1.5 mm roller density, times reduce to 5.2, 0.95, 0.08, and 0.04 minutes, respectively. The integration of IoT-based monitoring with ThingSpeak enhances efficiency through real-time voltage and current tracking, predictive maintenance, and remote monitoring, reducing downtime and optimizing performance.**

***Index Terms*—Salt Refining Machine, IoT Monitoring, ThingSpeak, Network Performance.**

I. Introduction

THE rapid development of technology has significantly influenced various industries, including agriculture, logistics, and manufacturing. The integration of technology in industrial processes enhances efficiency and productivity, meeting the increasing market demand. One of the technological advancements widely adopted in industrial and agricultural applications is the Internet of Things (IoT). IoT enables real-time monitoring and automation, optimizing resource utilization and minimizing human error. The implementation of IoT in monitoring systems can improve security, efficiency, and data management [1][2].

In the context of monitoring and data acquisition, platforms such as ThingSpeak provide cloud-based services that facilitate data collection, visualization, and analysis [3]. ThingSpeak, integrated with sensors and microcontrollers such as Arduino and Raspberry Pi, allows real-time monitoring of environmental parameters such as temperature, humidity, and air quality. This capability is particularly beneficial in precision agriculture, smart irrigation, and industrial process monitoring [4][5].

The agricultural sector, particularly salt production, requires technological innovations to enhance production efficiency and maintain product quality. Salt is an essential commodity used in food, chemical, and medical industries. The production of high-quality salt necessitates monitoring environmental parameters such as temperature, humidity, and solar radiation, which can significantly affect the crystallization process [6]. The adoption of IoT-based monitoring systems, such as those using Arduino and solar-powered sensors, provides an efficient solution for real-time environmental monitoring in salt production [7].

A recent study on the Design and Build of a Portable Solar Dryer for Drying Urea Molasses Block with an Arduino-Based Solar Power Plant highlights the effectiveness of IoT-based systems in agricultural applications. The study demonstrates how integrating Arduino with a solar-powered drying system can optimize drying efficiency while reducing energy consumption [8]. This approach can be extended to salt production, where controlled drying processes ensure high-quality output and minimize losses due to environmental fluctuations [9].

Furthermore, the use of corrosion-resistant materials such as SUS 316L stainless steel is crucial in salt processing and storage. This material provides high durability and resistance to oxidation, ensuring hygiene and preventing contamination [10]. The combination of IoT-based monitoring and high-quality materials enhances the overall efficiency and sustainability of salt production systems.

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II. Literature

A. Salt Farmer and Salt Function

The main component of salt, namely minerals that come from seawater. Therefore, it is not surprising that traditional salt processing is carried out by people who live near sea water. There are two types of salt-making processes in the traditional way, namely the first method of evaporation with sunlight, which is usually done in salt ponds by means of boiling techniques, which can be called boiled salt. The process of producing salt by utilizing the steam process from sunlight, salt farmers usually make salt by plotting method for evaporation, to get good salt yields and produce large crystals. Salt farmers usually directly evaporate seawater which will be flowed on the plot, to produce the baume level or density of the liquid, or it can be called a high density or viscosity around 20-25 Be measured using Baumemeter [11].

After flowing the water in each plot to produce the desired baume level with the sun evaporation technique, after that the sea water is put into a special plot for the salt table then evaporated with sunlight for 7 days then the water will automatically decrease and become salt crystals. Unlike the case with the salt boiling process, for the process of making salt with the traditional boiling method, the first is usually by using salt that is still coarse that has been finished and then dissolved with water, after the water has been mixed and the salt has dissolved, the water is usually filtered so that the clear water, after going through the filtering process the water is boiled using hot coals for about 3-4 hours or more, after that it becomes boiled salt. The difference between boiled salt and salt making using the solar thermal evaporation technique is that if the boiled salt is smoother, the salt using solar heating will be coarser (salt crystals) [12].

In everyday life, the need for salt is never ending, even there are many salt entrepreneurs with various brands and forms, still for the needs of kitchen salt needs will always be needed. In 2016, salt has started to become scarce because the number of salt needs has increased drastically to 4.1 million tons, while the country, although it already has a large factory for salt production, can only produce 1.8 million tons of salt, which is still far from the main requirement salt per year [13]. Currently, the need for salt is dominated by industrial needs. Of course, this can be a great opportunity for the community and salt farmers to open new salt processing businesses, because the demand for salt will not stop, it will increase every year [14]. With the opening of a new business in the form of salt production, especially on a medium or small scale, it will be more helpful in fulfilling people's need for salt. Salt itself is actually needed by the body to balance the fluid levels in the body, because we also know that the main component of salt is the minerals in seawater [15]. Although salt can also have negative effects if too much is consumed, our bodies also need salt. Here are the benefits of salt for health:

-- To Smoothen Body Metabolism, some of the GPS capabilities, among others, can provide information on the health benefits of salt, which can help in accelerating your body's metabolism. Good body metabolism will increase the function of the systems in the body. Salt can help you absorb water in the body for the smooth work of the organs. This is caused by the minerals and nutrients contained in salt which can easily be absorbed in the blood.

-- To Relieve Bronchitis and Other Respiratory Problems, salt also works to relieve the symptoms of bronchitis and respiratory ailments, which will certainly help you overcome these respiratory problems. Salt is useful for absorbing harmful ions in the air that you will breathe and helps fight these harmful ions from being easily absorbed into your body. Therefore, it is not uncommon for salt to relieve asthma, bronchitis, and other symptoms related to our breathing.

-- To Prevent Hyponatremia, hyponatremia is a condition in which the patient's body experiences a lack of salt in the body's cell fluids. Usually, the liquid will come out in the form of sweat, diarrhea, or what is commonly known as water intoxication. The body needs salt because it is needed to maintain healthy blood pressure and smooth nerve and muscle function. If the salt is not balanced or not fulfilled, there will be an imbalance in the body's water content and eventually there will be swelling in the body because the cells will have excess water.

-- To Clean Oral and Dental Problems, another health benefit of salt is that it can kill bacteria that can cause infections around your mouth, and reduce pain if you have pain in your teeth or gums. Toothache pain will be relieved by just gargling with a salt solution or salt water. The trick is to mix ½ teaspoon of salt mixed with a cup of warm water. Swelling of the gums can be prevented, and also reduce the pain.

-- To maintain Digestive Health, the body will not produce enough HCl (hydrochloric acid) in the stomach. This condition will get worse if you previously have a history of poor digestive health, such as stomach acid. With enough salt, the body will prevent stomach acid from rising up into the throat.

-- To Clean and Brighten Face, salt water can help brighten your face. Salt water has very important properties to kill and clean dirt and germs, so it will be very effective for those of you who always want to look fresh and bright.

-- To Reduce and Also Get Rid Acne, salt water for beauty is able to treat and also get rid of acne. Some skin types as well as other types of acne will be very effective if treated with natural salt water. Salt itself is a very good mineral to help cleanse and also kills germs. Therefore, salt water will also be very good to use in the fight against acne, which is mostly caused by bacterial and bacterial infections on the face.

-- To Remove Blackheads, Blackheads are a form of collection of dirt that accumulates in one or more parts of the face. You don't need to buy expensive face wash to get rid of blackheads on your face. It is enough to wash with salt water, the blackheads will disappear more quickly, because it is in accordance with the natural nature of salt water, which is able to clean and also kill bacteria, bacteria, and impurities that stick to the face.

-- To Whiten Teeth, teeth that are white and also clean, then someone will be more confident and not ashamed to show their teeth. This of course will add to one's beauty in the eyes of others. To get white teeth, you do it by making salt water as a rinsing medium, and also processing the salt into a paste, then you use the salt water paste as a substitute for a toothbrush. The natural nature of salt, can help kill bacteria and also clean, will make your teeth whiter, cleaner, and of course will look more beautiful than usual.

-- To Overcome Dry Skins Problem, salt water has very good benefits to help keep your skin moist, so this will cause dry and scaly skin to disappear, and will increase your self-confidence.

-- To Kill Bacteria That Causes Body Odor, salt water also has very important benefits to kill bacteria and germs that cause body odor. You can make a paste out of the brine, and use it like a deodorant. Thus, the germs and bacteria that cause body odor in your body will die, and the odor will disappear.

B. The Process of Making Salt

Basically, the table salt is an advanced process of making salt using sea water. This is because ocean salts are still considered to have insufficient iodine levels, so it is necessary to carry out further processing by adding iodine in it until it becomes suitable for consumption [16]. Reporting from the website of the Tegal City Fisheries Training and Extension Center (BPPP), here are some steps in making iodized salt:

--Salt Washing Process, the first process is to clean the salt from various impurities, such as sand and mud. This washing also aims to reduce the content of calcium (Ca), sulfate (SO4) and other insoluble compounds.

Use a saturated salt solution or Brine with a concentration of 20-25 Be as a washing solution with a magnesium (Mg) content of a maximum of 10 PPM. The ratio of washing solution and salt is 1: 6. The washing process is carried out by inserting salt crystals into the reservoirs that already contain the washing solution [17][18]. To get maximum results, washing should be done 5-6 times. Salt washing is carried out with the help of devices such as a Static Drainer, Screw Conveyor or Mixing Chamber [19][20].

-- Drying Salt, after the washing is done, it is then dried by making mountains of salt and then leave it for a few days. To shorten drying, it can also be done using a furnace or oven until the salt water content reaches 5%.

-- Iodization, iodization is the process of mixing iodine into salt. The iodine content in salt is good 50 ppm per kilogram of salt. The mixing of salt, potassium iodate and water must be carried out until it is homogeneous in the iodizer machine.

-- Packaging, the final step that must be done is salt packaging. The requirements for good packaging are that the packaging or container must be tightly closed, waterproof and have a plastic thickness of about 0.45 to 0.6 mm with a transparent color.

C. Engineering Design

In general, the stages in a design process are as follows:

-- Problem Analysis, Product Specifications and Project Planning, the design is done because of the need for a new product. In the design process, the need for the new product is used as a design problem or design problem. The problem or design problem is then solved using the solution obtained through problem analysis. The solution generated during the analysis process can consist of several alternative solutions. The solution chosen is the best alternative solution. The main result of the analysis is a problem statement about a new product. The statement of the problem is not in the form of a new solution / product, but only contains information about the product to be designed. The problem statement contains at least three elements, namely:

-- Constraints that limit the solution to the problem and product specifications

-- Acceptability criteria and other criteria that the product must meet

-- Product specifications, contain what users want about the product to be made. Product specifications are the basis and guide for designers in designing products and product specifications will be a benchmark for evaluating the results of designs and evaluating finished products. Product specifications contain the performance or performance that a product must achieve, environmental conditions such as temperature, pressure and others that the product will experience, other operating conditions, the number of products to be made, product dimensions and product weight, ergonomics and safety, and prices.

-- Product Concept Design, the product concept is the best alternative solution to a design problem. At this stage, the product concept is sought so that it fulfills the functions and characteristics of the product as stated in the product specifications. The product concept is presented in schematic form.

-- Product Design, in the product design stage, alternative solutions in the form of schemes are further developed into products or more tangible engineering objects. The product design stage ends with a detailed design of the product components, which will then be outlined in detailed drawings for the manufacturing process.

-- Evaluation of Product Design Result, before a product is made based on a product design drawing, the product must be evaluated first. The product must be evaluated whether it meets the product specifications determined in the first phase of product design. A product meets specifications if it can fulfill its function, has the This stage summarizes all the design results.

-- Product Design Documentation, product design documentation is carried out to create product archives, thereby facilitating the mass production process later.

III. Research Method

A. Design

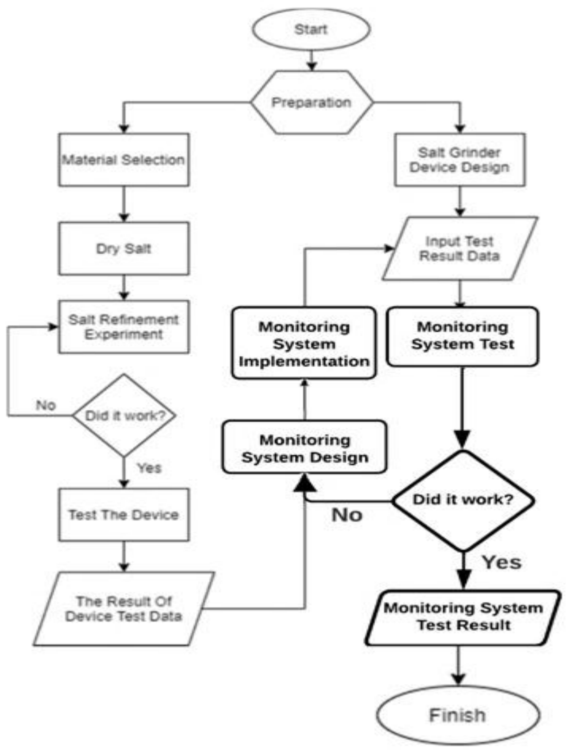

Fig. 1. Design Flowchart.

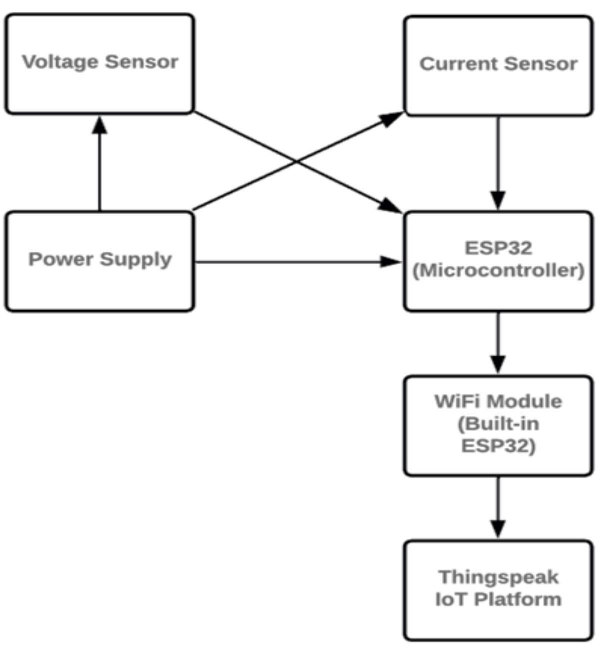

Fig. 2. Block Diagram of IoT System.

B. Operation Device Design Methods

The method in this design is to obtain information and data related to the problem of making a salt refining and stirring device as shown in figure 19. The steps taken before making a design device are:

-- Conducting a field survey to Muarabaru Village, Cilamaya Wetan District, Karawang Regency

-- Observing how salt is made it

-- Observing the problems of the salt farmers in the village

-- Carrying out data collection and data processing to determine the devices to be designed for salt farmers

-- Designing a salt refiner and stirring device

-- Testing devices

-- Calculating the use and function of the device

-- Done.

C. Place and Time of Research

This research was conducted at CV Indexindo, Pangulah Utara Village, Kota Baru District, Karawang and Muarabaru Village, Cilamaya Wetan District, Karawang in a period of approximately 1 month by direct survey to the village to obtain accurate data to support the manufacture of devices.

IV. Discussion and Result

A. Testing the Physical Properties of a Salt Refining Device

The test uses a device that has been designed to be able to produce maximum salt, initially the salt before being milled is dried first by drying it to reduce the water content in the salt. After the coarse salt is dried, then it can be milled to be pulverized, this is done so that machine performance can be maximized. From the test results of the machine to refine the dried salt, it is obtained that the engine performance data able to smooth the salts as follows:

By using a roller gap size of 1 mm.

TABLE I
THE RESULTS OF THE DEVICE TESTING USED A 1 MM ROLLER GAP AND 1 KG OF SALT

Roller gap	**1 mm**				**Unit**
Hopper Valve gap	5	10	15	20	mm
Time	6.01	1.13	0.1	0.07	Minute
Roughness	0.01 – 0.5	0.01 - 0.5	0.01 - 0.5	0.01 - 0.5	mm

By using a roller gap size of 1.5 mm.

TABLE II
THE RESULTS OF THE DEVICE TESTING USED A 1.5 MM ROLLER GAP AND 1 KG OF SALT

Roller gap	**1.5 mm**				**Unit**
Hopper Valve gap	5	10	15	20	mm
Time	5.2	0.95	0.08	0.04	Minute
Roughness	0.02 – 1.2	0.02 – 1.2	0.02 – 1.2	0.02 – 1.2	mm

By using a roller gap size of 2.0 mm.

TABLE III
THE RESULTS OF THE DEVICE TESTING USED A 2.0 MM ROLLER GAP AND 1 KG OF SALT

Roller gap	**2.0 mm**				**Unit**
Hopper Valve gap	5	10	15	20	mm
Time	3.2	0.81	0.05	0.02	Minute
Roughness	0.4 – 1.75	0.4 – 1.75	0.4 – 1.75	0.4 – 1.75	mm

In the three tables above, we can see that the tighter the roller density, the smaller the salt roughness. Likewise using roller the greater the density level, the lower the level of fineness of the salt produced. Apart from the advantages of a high level of salt fineness when using a tighter roller, using a roller that tends to be tighter will also increase the salt grinding time which is slightly longer than using a roller that is not too tight.

TABLE IV
COMPONENTS AND SPECIFICATIONS OF THE SALT GRINDING MACHINE

No.	Component	Specification	Quantity
1	Engine	Gasoline, 5.5 Hp	1
2	Gearbox	Worm Gear, 1:10	1
3	Roller Crusher	SUS 316 Ø89 x 400 mm	2
4	Agitator Shaft	SUS 316 Ø25,4 mm	1
5	Bearing Roller Crusher	6205 zz	8
6	Bearing Agitator	P205	4
7	Pulley Engine	CS, B, 3"	1
8	Pulley Gearbox to Engine	CS, B, 4"	1
9	Pulley Gearbox to Roller Crusher	Alum, A, 6"	1
10	Pulley Roller Crusher	CS, A, 3", 2 Way	1
11	Pulley Agitator	Alum, A, 12"	1
12	V-Belt Motor to Gearbox	B 37	1
13	V-Belt Gearbox to Roller Crusher	A 49	1
14	V-Belt Roller Crusher to Agitator	A 81	1
15	Mirror Drive Gear	Spur Gear M5xT20	2
16	Hopper	SUS 316 thk2mm	1
17	Mixing Chamber	SUS 316 thk2mm	1
18	Frame	MS, L Bar 40x40xt4mm	1
19	Cover Pulley	MS, L Bar 40x40xt4mm	1
20	Cover Mirror Drive Gear	MS, L Bar 40x40xt4mm	1

The result of this design is a salt refining and stirring device that is ready to print or ready for consumption using stainless steel SUS 316L which is can with stand corrosion as shown in Fig 2.

Fig. 3. Machine Design Result.

B. Monitoring Display

To further enhance real-time monitoring capabilities, the IoT system is integrated with the ThingSpeak platform, which provides a user-friendly and visually intuitive way to track sensor data. ThingSpeak is an open-source IoT analytics platform that allows for the collection, visualization, and analysis of real-time data from connected devices. By utilizing this platform, operators can monitor voltage and current variations effectively and respond promptly to anomalies detected in the system.

The IoT system is configured to transmit voltage and current sensor data to the ThingSpeak cloud in real time. The implementation involves the following steps:

1. Sensor Data Acquisition: The voltage sensor (ZMPT101B) and current sensor (ACS712) collect real-time electrical data from the system.
2. Microcontroller Processing: The ESP32 microcontroller reads sensor values, processes the data, and formats it for transmission.
3. Data Transmission to ThingSpeak: Using the ThingSpeak API, the processed data is sent to a dedicated channel at predefined intervals.
4. Visualization: ThingSpeak generates graphical visualizations, including time-series plots, live dashboards, and statistical analytics for monitoring trends in voltage and current fluctuations.

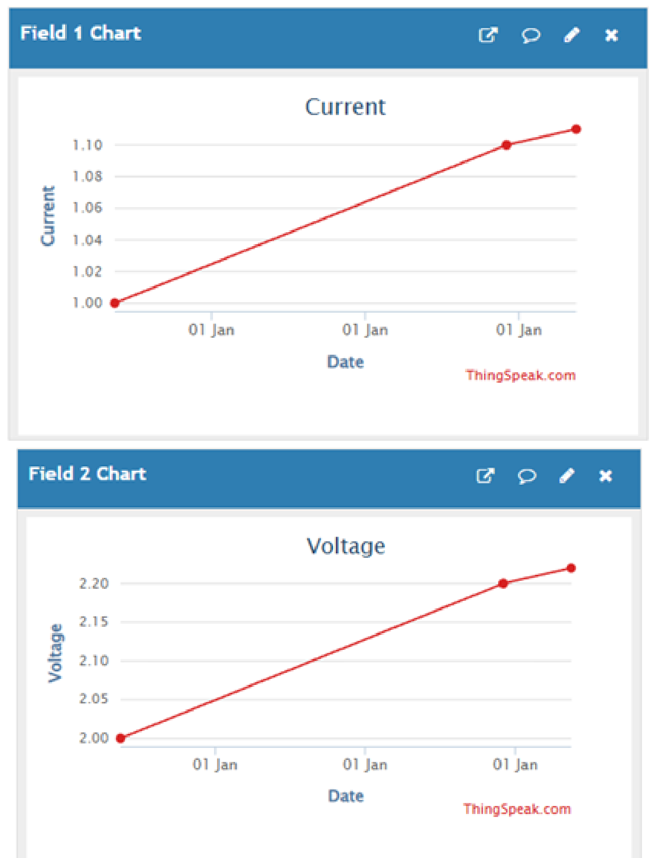

Fig. 4. Chart View for Monitoring System.

C. Sensor Testing: Accuracy, Precision, and Responsiveness

Further analysis was conducted to assess the accuracy, precision, and responsiveness of the sensors used in the IoT-based monitoring system. These parameters are critical in ensuring the reliability of data acquisition and transmission, which directly impacts the efficiency of real-time monitoring. The results of the evaluation are summarized in the Table V.

TABLE V
THE RESULTS OF THE SENSOR TESTING

Sensor	Accuracy (%)	Precision (%)	Status
Voltage (ZMPT101B)	98.5	97.8	110 ms Response Time
Current (ACS712)	98.8	98.2	105 ms Response Time
Voltage Sensor Accuracy	±1.5% deviation	±2% deviation	Good
Current Sensor Accuracy	±1.2% deviation	±2% deviation	Good
Precision (Voltage)	97.8%	>95%	Good
Precision (Current)	98.2%	>95%	Good
Response Time (Voltage)	110 ms	<150 ms	Good
Response Time (Current)	105 ms	<150 ms	Good

Accuracy is one of the most critical aspects of a sensor's performance, as it determines how close the measured values are to the actual values. In this study, the voltage sensor (ZMPT101B) achieved an accuracy of 98.5%, while the current sensor (ACS712) reached an even higher accuracy of 98.8%. Both sensors demonstrated deviations well below 2%, which falls within acceptable industry standards for reliable data acquisition. The high accuracy levels ensure that voltage and current readings taken from the system closely represent actual operating conditions, minimizing errors that could lead to incorrect interpretations or system inefficiencies

Precision refers to the repeatability and consistency of sensor measurements over multiple trials. The voltage sensor exhibited a precision of 97.8%, while the current sensor showed 98.2%. These values indicate that the sensors produced highly consistent readings, with minimal fluctuation between successive measurements. High precision is essential in industrial applications where stability in sensor readings ensures smooth system operations, reducing the likelihood of incorrect alerts or misinterpretations. The low variation in repeated measurements confirms that the sensors can be relied upon for continuous monitoring without significant drifts in data.

The response time of a sensor is a crucial factor in real-time monitoring systems, as it determines how quickly the sensor reacts to changes in the measured parameter. The voltage sensor recorded an average response time of 110 milliseconds, while the current sensor had a slightly faster response time of 105 milliseconds. Both values fall well within the acceptable range for industrial monitoring applications, where response times under 150 milliseconds are generally considered sufficient. Fast response times ensure that sudden fluctuations in voltage or current can be detected promptly, allowing for timely interventions to prevent potential system failures or inefficiencies.

The combined results of accuracy, precision, and response time evaluations confirm that the IoT-based monitoring system effectively captures and transmits sensor data with high reliability and low latency. The accuracy levels indicate that the system provides precise voltage and current measurements, reducing errors and enhancing decision-making processes. The high precision ensures stability in readings, which is crucial for detecting anomalies or gradual changes in machine performance. Furthermore, the fast response times support real-time applications by providing near-instantaneous updates on machine status, enabling operators to respond proactively to fluctuations.

These findings establish the effectiveness of the IoT monitoring system in industrial environments where precise, stable, and real-time data collection is essential. Future improvements may focus on further reducing response times, integrating additional sensor redundancy mechanisms, and incorporating advanced data analytics to enhance predictive maintenance capabilities.

D. *IoT Sensor and Network Performance Evaluation*

To evaluate the performance of the IoT system, we conducted extensive tests on sensor accuracy, precision, response time, data transmission speed, and network stability. The results are summarized in the Table VI.

TABLE VI
NETWORK PERFORMANCE EVALUATION

Parameter	Measured Value	Acceptable Range	Status
Data Transmission Delay	120 ms (avg)	<200 ms	Pass
Packet Loss Rate	1.5%	<5%	Pass
Network Uptime	99.2%	>98%	Pass

The accuracy of the voltage sensor was measured at ±1.5% deviation, while the current sensor demonstrated an even higher accuracy of ±1.2%. These values fall well within the acceptable threshold of ±2%, indicating that the sensors provide reliable data for monitoring industrial equipment. High accuracy ensures that the voltage and current readings closely match the actual operating conditions, reducing the chances of incorrect interpretations or faulty system responses.

Precision, which measures the consistency of repeated readings, was also evaluated. The voltage sensor exhibited a precision of 97.8%, while the current sensor recorded 98.2%. These values indicate that the sensors produce highly stable measurements, minimizing fluctuations and ensuring that operators can trust the data being received. Precision is especially important in industrial applications where even slight inconsistencies in readings can lead to incorrect diagnoses of system performance.

The IoT system's network performance was tested in terms of data transmission delay, packet loss rate, and network uptime. The results indicate that the system maintains a stable connection with minimal disruptions.

1. Data Transmission Delay: The average delay recorded during the tests was 120 milliseconds, well below the acceptable limit of 200 milliseconds. This ensures that data is transmitted from the sensors to the monitoring platform with minimal lag, preventing delays in decision-making.
2. Packet Loss Rate: The system demonstrated a low packet loss rate of 1.5%, which is significantly lower

than the acceptable threshold of 5%. A low packet loss rate means that almost all data packets sent from the sensors reach the monitoring system without corruption, ensuring high data integrity.

3. Network Uptime: The system maintained a high uptime of 99.2%, exceeding the minimum requirement of 98%. This indicates that the IoT network is highly reliable, ensuring continuous monitoring without frequent interruptions.

A stable network connection is crucial for industrial applications where continuous data flow is required for predictive maintenance and real-time monitoring. The low transmission delay and high network uptime demonstrate that the IoT system is well-suited for environments where timely responses to changes in system parameters are essential.

The findings from this evaluation confirm that the IoT monitoring system provides accurate, precise, and timely data, making it a valuable tool for industrial applications. The high accuracy and precision of the sensors ensure that measurements reflect actual operating conditions, while the fast response time allows for real-time monitoring and quick decision-making.

The network performance tests further validate the system's reliability. With minimal packet loss and low transmission delay, the system ensures that operators receive continuous and uncorrupted data, reducing the risk of unexpected failures due to undetected anomalies.

V. Conclusion

The results of the data obtained from the machine testing indicate that the refining and stirring machine, which has a maximum rolling speed of 3800 rpm, can refine salt with a smoothness level of 50 to 100%, depending on the roller gap density value that is set. By using this device, we can also optimize the salt grinding time. For instance, in 1 kg of salt to be pulverized using a roller with a density of 1mm, the processing time varies as follows: 6.01 minutes for a 5mm hopper valve gap, 1.13 minutes for a 10mm hopper valve gap, 0.1 minutes for a 15mm hopper valve gap, and 0.07 minutes for a 20mm hopper valve gap. Similarly, for a roller density of 1.5 mm, the processing time is reduced to 5.2 minutes for a 5mm hopper valve gap, 0.95 minutes for a 10mm hopper valve gap, 0.08 minutes for a 15mm hopper valve gap, and 0.04 minutes for a 20mm hopper valve gap. The research also confirms that the denser the roller crusher, the finer the salt produced, enhancing product quality and consistency.

Furthermore, the integration of the IoT-based monitoring system with the ThingSpeak platform significantly enhances the operational efficiency of the machine. By continuously tracking voltage and current parameters in real time, the system enables predictive maintenance and immediate detection of irregularities. The visualization tools provided by ThingSpeak, including live graphs and historical data analysis, allow operators to monitor performance remotely and make informed decisions to prevent mechanical failures. The IoT module ensures improved data accessibility, reduced downtime, and optimized performance by enabling real-time alerts and trend analysis. Future enhancements may focus on integrating AI-driven analytics for anomaly detection and automated system adjustments to further improve efficiency and reliability.

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