Oil Filter Machine for Deep Frying with Smartphone Control and Monitoring using Client-Server Communication Protocol

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***Abstract* – The prevalence of fried snack consumption in our surroundings has become a widespread phenomenon. These fried snacks, commonly relished by many, are frequently served as side dishes with our main meals and are also a popular choice for satisfying quick hunger cravings. By utilizing the client-server communication method, this device can be assisted in its operation. The device employs ESP8266 as both the transmitter and receiver, while a smartphone serves as the control and monitoring tool. The primary purpose of this setup is to enhance the efficiency of oil-based food consumption, promoting healthier habits. The data collected from the device is split into two categories. Firstly, the communication data consists of the average RSSI (-52dBm) measured at a distance of 1 meter, with RSSI values increasing and becoming more susceptible as the distance grows. Secondly, the machine was tested for oil drainage in food, resulting in a weight decrease of 2.6% after 60 seconds of device usage, and the percentage of weight reduction increased with the given time.**

Keywords: *ESP8266, Client Server, Oil , RSSI, Fried Snack, Machine*

I. INTRODUCTION

The phenomenon of fried snack consumption around us has become a common occurrence. These fried snacks, which we often enjoy, serve as accompaniments to our main meals and are also popularly consumed on their own by people as a quick hunger fix.

Based on the 2018 Statistical Data on Food Consumption from the Center for Agricultural Data and Information Systems, Ministry of Agriculture of the Republic of Indonesia, the average per capita consumption growth of fried foods between 2014 and 2018 was 15.083% [1]. Improving the competitiveness of Indonesian society in the industrial sector, particularly small household-scale industries, requires the development of facilities or equipment to assist in the processing of household industrial products. In the production of snacks such as crackers and fried nuts, the food drying process is still done traditionally by air-drying in containers made of woven bamboo or wire strainer, and then left to dry naturally [5][6]. However, using an oil strainer machine in snack production can yield multiple times higher results compared to the traditional method. Experiments show that air-drying fried snacks like fried nuts traditionally takes longer, and the resulting products have lower shelf life due to their relatively higher oil content [2][3][4][5].

However, the discharge of food from most existing strainer machines is still done by spilling the food out from the strainer tube. This is what motivates us to develop an oil strainer machine that makes it easier for users. The advantages of this oil strainer machine design in this research lie in its portability, ease of cleaning the strainer tube as it can be disassembled, and the food discharge from the strainer tube using a pedal. This work also aims to demonstrate a comparison between traditional air-drying results and the results obtained using this oil strainer machine.

Fried snacks are high in fat content. The repeated use of oil in the frying process results in the food absorbing high levels of saturated fat. Consuming these foods can lead to an increase in blood cholesterol levels. Typically, the oil-draining process in fried snack production still relies on traditional methods that utilize gravity for oil removal, which is time-consuming. Consequently, the shelf life of such products becomes shorter. Additionally, oil has negative health implications, as it contains unsaturated fatty acids, trans fatty acids, and saturated fatty acids. Prolonged consumption of oil with high saturated fatty acid content can lead to an increase in cholesterol levels.

Based on previous research [7], the researchers utilized Arduino Uno Microcontroller technology as the main controller, along with a keypad, L298N driver, 16x2 LCD, and DC motor, all connected to create an oil strainer device that can speed up the oil straining process.

In another study [8], the researchers developed a method to control the rotational speed of the oil strainer machine by using a keypad. The microcontroller control circuitry was responsible for driving the Variable Speed Drive (VSD) to adjust the motor's rotation in the strainer machine. A tachometer was employed to measure the motor's speed and provide feedback for speed control. The motor's speed in the strainer machine was displayed on the LCD.

Inspired by these two journals, the researchers aim to create an oil strainer machine that incorporates a Tachometer as a tool to detect the motor's rotation speed. They plan to use the Esp8266 as a software medium to control the functions and features of the oil strainer device.

With the development of this tool, the author hopes to provide benefits to the Small and Medium Enterprises (UMKM) industry, enabling them to enhance the quality and standard of fried products while reducing health risks. Therefore, the author intends to submit a scientific report entitled: "Design and Construction of an Oil Strainer Machine for Fried Snacks with Smartphone Control and Monitoring Using Client-Server Communication Protocol.

II. Basic Theory

Fried snacks are food products that are prepared by frying them in oil. The majority of Indonesian society uses cooking oil to process both main dishes and small snacks. There are various types of fried snacks commonly encountered by the Indonesian people. The flavor resulting from the frying process is what makes these additional food items highly favored as complements to the meals frequently consumed by the community. An electric motor is a device that converts electrical energy into mechanical energy. The device that converts mechanical energy back into electrical energy by working in the opposite direction is called a generator or dynamo. Electric motors can be found in appliances such as electric fans, washing machines, water pumps, and vacuum cleaners. In an electric motor, electrical energy is transformed into mechanical energy. This transformation is achieved by converting electrical power into a magnetic force known as an electromagnet. As you know, magnetic poles with the same name repel each other, while poles with different names attract each other. You can generate motion by placing a magnet on a rotating shaft and positioning another magnet fixedly [9].

Figure 1. Electrical Motor

The ESP8266 is a completely integrated chip with a processor, memory, and GPIO access. This enables the ESP8266 to immediately replace Arduino while also supporting direct WiFi communication.The Internet of Things (IoT) is expanding in tandem with the advancement of microcontrollers [12]. There are numerous Ethernet and WiFi modules available, ranging from Wiznet and Ethernet Shield to the most recent WiFi module, the ESP8266. There are several types of ESP8266 on the market, with the most common in Indonesia being the ESP-01, ESP-07, and ESP-12. These classes perform identical functions, with the key difference being the number of GPIO pins they provide [10].

Figure 2. ESP8266 NodeMcu

In general length measurements can only be taken manually by measuring the device whose length is to be known. However, in today's digitized world, measurements can be done without physically touching the object to be measured. One way to achieve this is by utilizing sound waves, commonly known as ultrasonic waves. Ultrasonic sensors can convert sound waves into various units such as distance, height, and speed. The technique used for measuring distance/length involves sending ultrasonic waves through the air, using the method of echo pulses. A pulse is transmitted to the transmission

Figure 3. PZEM-004T

Medium and then bounced back by an object at a certain distance. The time taken from the transmitter to the receiver is proportional to the object's distance [14]. The HCSR04 ultrasonic sensor is a device used to measure the distance from an object. The measurable range is approximately 2-450 cm. This device uses two digital pins to communicate the measured distance. The principle of operation for this ultrasonic sensor involves transmitting ultrasonic pulses around 40 KHz, receiving and calculating the time taken in microseconds, as depicted in Figure 1. We can trigger pulses up to 20 times per second and can accurately determine objects up to 3 meters away [15].

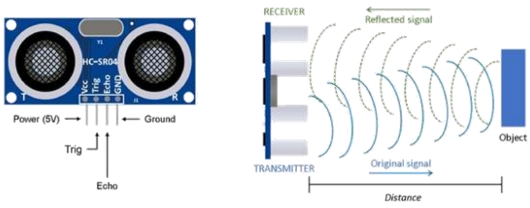


Figure 4. HCSR-04

PZEM-004T is a sensor that can be attached to Arduino or other open-source platforms to detect RMS voltage, RMS current, and active power. The PZEM-004T board has physical dimensions of 3.1 7.4 cm. The PZEM-004T module includes a 3mm diameter current transformer coil capable of measuring a maximum current of 100A.

This module's primary function is to measure alternating current voltage, current, active power, frequency, power factor, and active energy. The module lacks a display function; data is read via the TTL interface. This module's TTL interface is a passive interface that requires an external 5V power supply. This means that when communicating, all four ports (5V, RX, TX, GND) must be connected; otherwise, it will not communicate (innovatorsguru, n.d.). PZEM-004T-10A: 10A measuring range (built-in shunt). PZEM-004T-100A (External Transformer): Measurement Range 100A.

The active power limit can be set, and if the measured active power exceeds the limit, it can be released. Below is the syntax library for the PZEM-004T module's Arduino program: "PZEM004Tv30.h" [11].

MIT App Inventor is one of the tools used to design Android applications. MIT App Inventor does not require programming knowledge because users may design applications that operate on Android devices by simply dragging and dropping visual components. The benefit of using MIT App Inventor is that users do not have to memorize and write code instructions, which saves time and effort during application development.

The creation of Android-based applications is enjoyable because users can develop applications that cater to learning needs. With Android applications, teachers can innovate in designing engaging and enjoyable learning media for students. With a good understanding of information technology advancements, Android-based learning media can stimulate students and facilitate their understanding of all the materials being taught [13].

Figure 5. MIT Inventor

III. METHOD AND DESIGN

In the picture 3.1, there is a research methodology framework that consists of various stages for the author to prepare the research in order to achieve the expected results. This research framework is presented in the form of a block diagram that depicts the relationships and interconnectedness of the tasks that will be carried out throughout the research process, as shown in the following image.

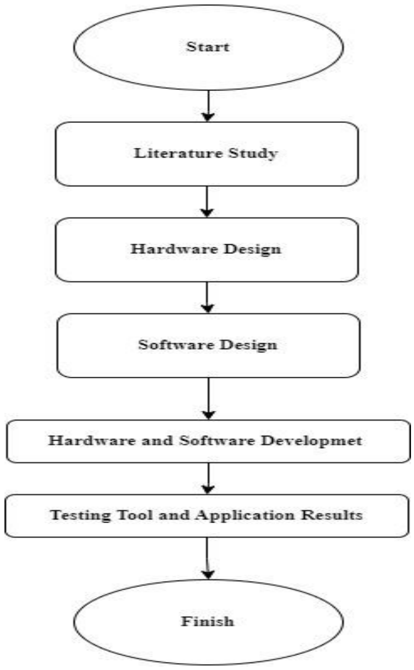
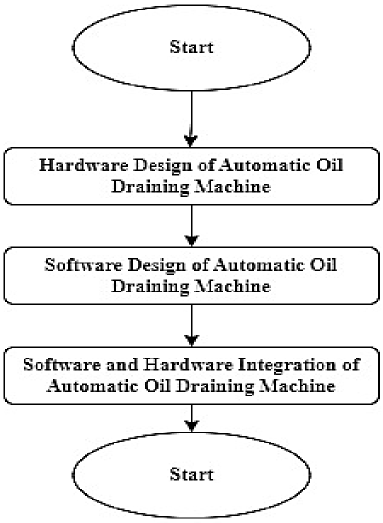


Figure 6. Research Freamework

Starting with a literature study to gather data from various sources such as books, theses, journals, and the internet, which will serve as the reference for this writing. The design of the hardware is depicted in the form of a flowchart that supports the creation of the device. The design of the software application is illustrated through a flowchart that demonstrates the application's functionality and user interface design. The construction of both the hardware and software components is integrated into a single system. Testing and data collection are the testing processes used to assess the performance of the system, including the device, Android application, and website.

The design of the device in this research is divided into two parts, namely hardware design and software design. The hardware design will be carried out by creating a block diagram of the entire system. From this block diagram, the working system of the entire circuit will be produced. The block diagram will result in a system that will be useful in achieving the goals of the design and construction. Figure 3.2 represents the overall stages of the research process.



Figue 7. The overall stages of the research process.

In the hardware design phase, there are several components that support and will be used to create a circuit design depicted in a block diagram. This will result in the creation of a device that aligns with the intended specifications.

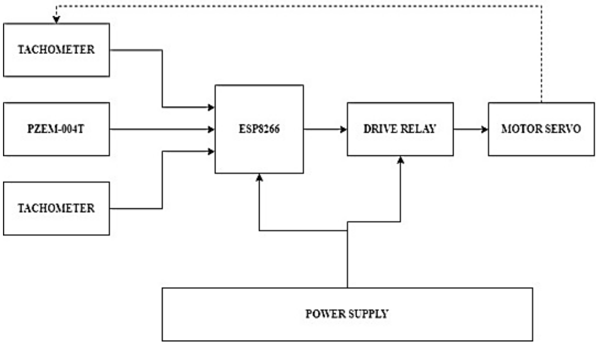


Figure 8. Hardware Block Diagram

After all the tools and components to be designed have been identified, the application design process will be conducted, along with finding the electrical wire paths. In this phase, the wire design and cable placement will be accomplished using the Fritzing application.

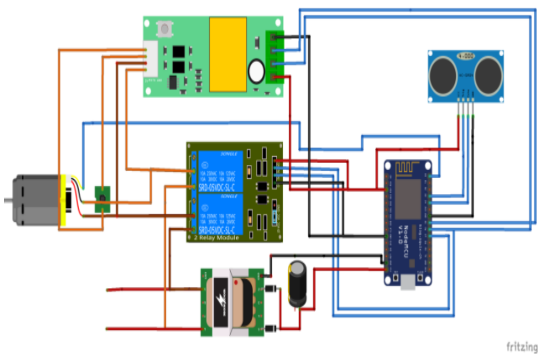


Figure 9. App Design Sketch

The design of the software that is created is crucial in terms of mathematical processing within a program. The core of this program design is to understand the workflow of the automatic oil filtering machine.

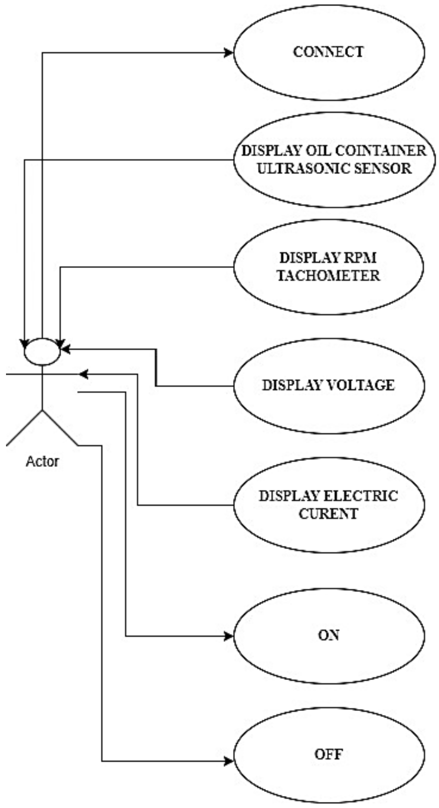


Figure 9. User Case Diagram

In this case and for the needs of the device to be created, a direct command from the user to activate the device is required. Therefore, an integrated source code is needed to be implemented into the device. However, considering the importance of User Interface (UI) in facilitating the encryption process of commands from the user to the device, a UI is designed through the MIT Inventor website.

Figure 10. UI App Design

To create this device's design, both a circuit schematic and a flowchart are required. The circuit schematic serves as a guide in constructing the circuit, while the flowchart aims to design the step-by-step processes of this device to ensure it produces the desired outcomes.

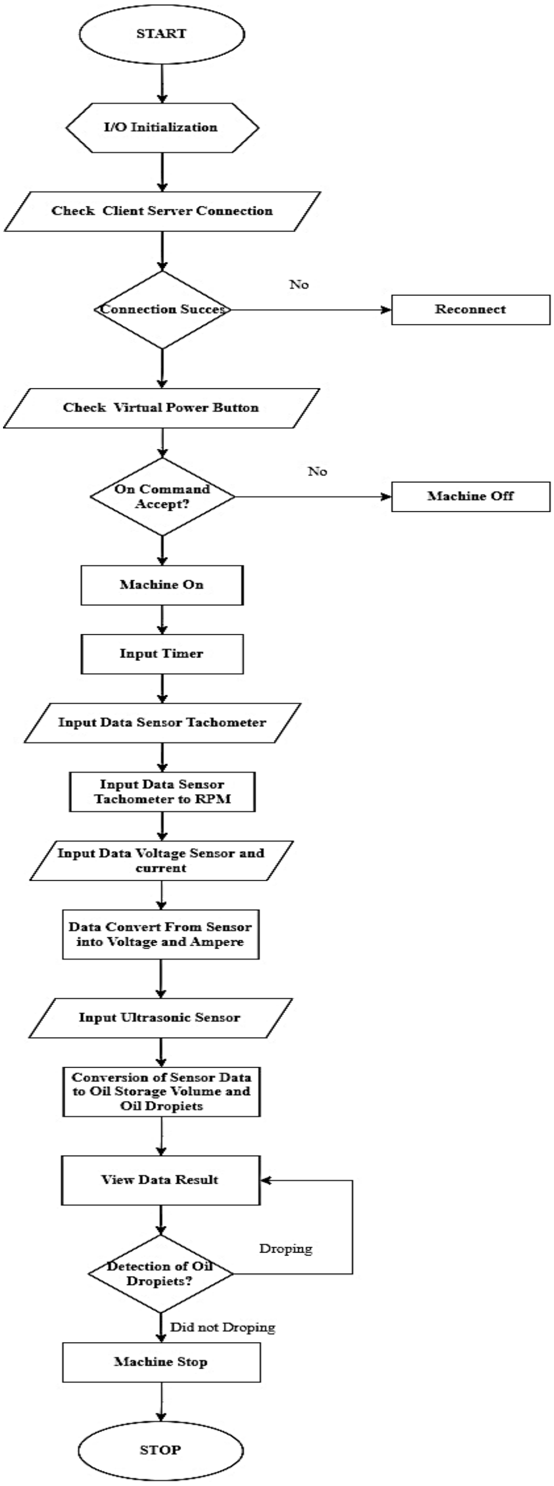


Figure 11. Machine Flowchart

A flowchart for the process is shown above. The machine's operation begins by connecting it to a power source. Once connected, the machine enters standby mode, ready to establish a Client-Server connection. Upon successful connection, the virtual power button becomes active on the smartphone. Pressing the "On" button on the smartphone will turn the machine on, and it can then be integrated with the smartphone. Once the machine is powered on, the user is given the option to set a timer for the equipment. Once the timer is set, the machine will check the input from the tachometer sensor, which measures the rotation or RPM of the filtering tool. Once this process is completed, the machine will proceed to check the voltage and current sensors, preparing the data according to the machine's voltage and current values. During the oil filtering process, an oil reservoir equipped with an ultrasonic sensor will count the amount of collected oil. Once all the input data is collected, it will be converted and displayed, showing the voltage, current, and oil reservoir capacity. The machine will also use the ultrasonic sensor to detect oil droplets falling from the machine, and when it no longer detects any oil droplets, the machine will automatically stop working. The final step in using the machine involves providing a system to turn off the machine by pressing the "Display Off" button on the smartphone. In summary, the oil filtering machine with smartphone control and monitoring utilizes a Client-Server communication protocol to enable the user to operate and monitor the machine remotely. The machine goes through several stages, from startup to data collection and display, and it can automatically stop its operation when the filtering process is completed. The smartphone interface provides a convenient way for users to interact with the machine and control its functionalities.

IV. RESULTS AND DISCUSSION

The results of this design are divided into two parts, namely the hardware design results and the software design results. The hardware design results consist of an oil filtering device for MSMEs (Micro, Small, and Medium Enterprises), while the software design results consist of a UI interface and source code integration to control and monitor the condition of the oil filtering device.

The hardware design of this oil filtering device system utilizes several core components as its building blocks, namely ESP8266, HC-SR04, PZEM-004T Tachometer, Relay Driver, Electric Motor, and Power Supply. By assembling all the components and devices into a unified system, the result obtained is as shown in the image below, which represents the outcome of the design process.

Figure 12. External Appearance Result of the Device.

The internal view of the created filtering device reveals a filter made from the same material, accompanied by a rotating iron component to facilitate oil filtration. The rotation is controlled through a smartphone application, and the device is powered by a 220V AC electric motor with a power rating of 70W to drive the filtering machine.

Figure 13. Internal Appearance Result of the Device.

There are several internal Electrical components, such as ESP8266, serving as the main controller in this device, responsible for driving all the mechanical components and providing information about the device's status. The PZEM-004T sensor is used to measure voltage, current, power, frequency, and power factor of the device. Additionally, there are also relay drivers and transformers accompanying the core components, all housed in a provided enclosure.

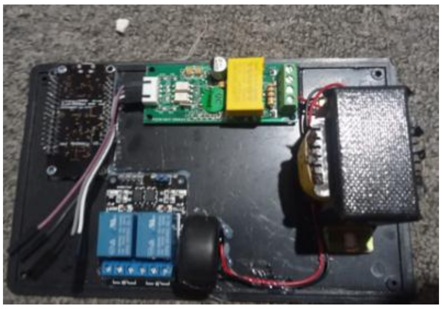


Figure 14. Internal Electrical Components

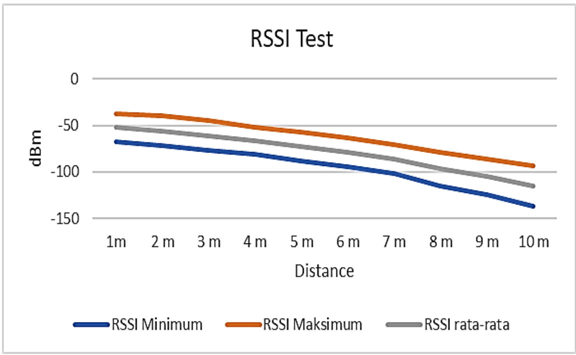
After conducting the testing of the hardware and software components, data analysis was performed to determine the outcomes of the created device. The data testing was carried out in two stages: communication data testing and mechanical machine data testing.

In the data processing results, several aspects need to be considered in measuring communication data, such as RSSI (Received Signal Strength Indicator) and Delay. These measurements are conducted to maximize performance and identify potential issues or conditions that may arise, allowing for prevention and improvements to be made to the oil filtering device.

The goal of RSSI measurement is to ascertain the indicator of signal strength received by a wireless device. RSSI represents the power received by the wireless device at the receiver, which varies significantly due to fading and shadowing effects. The results show that there are differences in the data produced based on the distance variable between the transmitter, which is the mobile phone, and the receiver, which is the oil filtering device. In the table, it is depicted that for each incremental distance taken, ten measurements were conducted, and the results indicate that as the distance between the mobile phone transmitter and the oil filtering device receiver increases, the RSSI generated becomes smaller, indicating a low signal. This situation has an impact on the fact that the further the distance between the transmitter and the receiver, the more difficult it is for the device to receive the signal, leading to disruptions in the functioning process of the oil filtering device.

Tabel 1. Meassuring RSSI

Distance	RSSI Minimum (dBm)	RSSI Maximum (dBm)	Avarage RSSI (dBm)
1 m	-68	-37	-52
2 m	-72	-40	-56
3 m	-77	-45	-61
4 m	-81	-52	-66,5
5 m	-88	-57	-72,5
6 m	-94	-63	-78,5
7 m	-102	-71	-86,5
8 m	-115	-79	-97
9 m	-124	-86	-105
10 m	-137	-93	-115

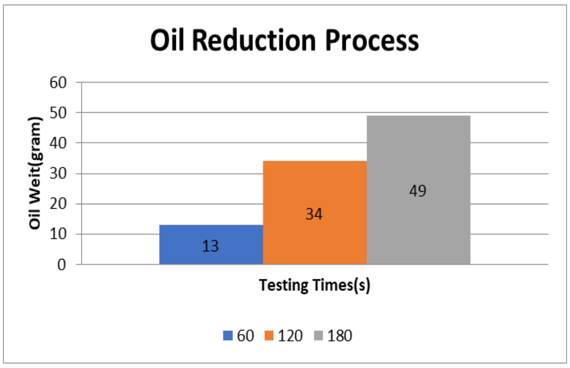


After obtaining all the data from the communication part, the next step is to conduct data testing for the oil filtering process mechanically. There are several variables of data that will be collected, namely the mass of the food in grams. Data will be collected both before and after filtering to calculate the mass of the oil extracted from the difference between the food's mass before and after filtering. Another variable to be measured is the time required for the filtering process. Finally, the percentage of oil mass reduction after the process is completed will be calculated.

There are 3 trials in the oil filtering process, and there are 3 different variables grouped into 2 variables: variable X represents the reduced oil mass, and variable Y represents the testing time. From the data obtained above, we can analyze that the initial weight of the fried food used was 500 grams. After conducting trials 1 to 3, a decrease in the mass of the fried food was observed. During trial 1, which lasted for 60 seconds, the mass of the fried food decreased from 500 grams to 487 grams, indicating a reduction of 13 grams of oil. After trial 1, another trial (trial 2) was performed with a different set of fried food with the same weight. This trial lasted for 2 minutes or 120 seconds, and the result showed a decrease in the mass of the fried food to 466 grams, resulting in 34 grams of oil extracted from the filtering process. The same method and measurements were applied to trial 3, which resulted in a decrease of 49 grams in the mass of the fried food, starting from 500 grams and ending at 451 grams.

Table 2. Testing of the Oil Filtering Machine for Draining Oil from Fried Foods.

TESTING	Food Mass (Grams)		Outgoing Oil Mass M_0-M_1 (Gram)	Time(s)	Percentage Reduction Oil $\frac{m0 - m1}{m0} \times 100\%$ (%)
	M_0	M_1			
1	500	487	13	60	2,6%
2	500	466	34	120	6,8%
3	500	451	49	180	9,8%



From the testing of several samples and results conducted on the Automatic Oil Filtering Machine using a Smartphone with the Client-Server communication method, the function of data communication reception between the transmitter and receiver works well. The measured RSSI helps determine the strength of the Transmitter device (Machine) and can be reached at a distance of up to 10 meters without affecting the machine's performance. However, it is noted that the maximum effective working distance without significant delay is up to 5 meters.The oil filtering process in the mechanical machine runs smoothly, as evidenced by the maximum filtering process with the provided data.

V. CONCLUSION

Based on the results and evaluations conducted on the device and machine, it can be concluded that the automatic oil filtering machine using smartphone control can be effectively used in the MSME (Micro, Small, and Medium Enterprises) industrial sector, based on the data obtained from the conducted tests. The design process utilized basic electrical and aluminum components as the fundamental materials for the machine. The data communication testing using the client-server communication method was conducted successfully, considering key aspects such as RSSI and delay of the transmitted and received signals between the transmitter (smartphone) and receiver (machine). The device serves as an access point to establish communication between the user's remote side and the machine, as indicated in the data testing results provided in this report. The oil filtering test results were also positive, demonstrating effective oil filtering with valid and consistent data validation. It can be concluded that the longer the filtering process, the better the quality of the extracted saturated oil, as shown in the data table of the testing results provided in the attached report. The improved effectiveness of the machine is due to minimizing excessive vibrations during the filtering process, achieved by optimizing the machine's load or mass, with the aim to increase its capacity and prioritize user comfort and safety during operation. Efforts are made to search for or upgrade the components used to enable communication at distances greater than 10 meters without worrying about data delays between the user and the device being used. The author suggests further development of the client-server communication method to enhance its application in designing and building tools for other sectors.

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