

Design of Motor Control System of Plastic Waste Shredders based on Internet of Things (IoT)

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ABSTRACT

The study aims to design and build a motor control system on a plastic waste counting machine based on the Internet of Things (IoT) in order to improve efficiency, security and ease in the process of monitoring and control. This system uses a microcontroller as a control center integrated with current and voltage sensors to monitor the working condition of the motor in real time. The methods used include the design stage of the system, hardware and software implementation, as well as testing the system with load variations the test results show that the increase in load causes an increase in current and power srta decrease in motor rotation speed. In overload conditions, the system is able to detect an increase in current that exceeds the safe limit and automatically cut off the electricity as protection. The results show that the IoT-based system is designed to be able to monitor and control the motor in realtime through a digital platform .in addition, the system can also improve operational safety with the automatic protection feature against abnormal conditions. Thus, this system can improve the reliability and efficiency in the operation of plastic shredding machines.

Keywords

IoT, Motor Control, Plastic shredders, Monitoring, Protection.

1. INTRODUCTION

The problem of plastic waste has become an increasingly serious environmental issue in many countries, including Indonesia. Plastic is often used in everyday life because it is lightweight, durable, and resistant to damage. However, plastic is difficult to decompose, causing waste to accumulate and pollute the environment, both on land and in water [7]. One way to reduce the impact of plastic waste is to manage it more effectively. In general, the operating system of this plastic waste counting machine still relies on manual motor control. This system has several limitations, such as low operational efficiency, difficulty in monitoring machine conditions, and safety risks for operators. By using an IoT-based motor control system in plastic counting machines, operators can manage the machine's processes more flexibly and efficiently [4].

2. METHODOLOGY

2.1 Identification of Problems

The main problem of this study is the absence of monitoring and protective equipment on the motor of the plastic waste

shredder. This issue mainly concerns electrical monitoring, specifically current and voltage. When the machine is operating, it is often subjected to excessive loads [1], [3]. This causes the current to increase significantly and the voltage to become unstable. As a result, the motor may operate less effectively, overheat, or even become completely damaged. In addition, inspections are still carried out manually. This method is less effective and can pose risks during operation. Therefore, a device is needed that can be connected directly and provide automatic protection when a problem occurs.

2.2 System Monitoring Issues

Based on observations, plastic waste counting machines still use traditional methods. Then, the microcontroller is connected to an internet module so that data can be sent to the IoT platform. After that, the microcontroller is programmed to process sensor readings, manage data, send information, and control the relay as a system protection mechanism [4]. Once the system is installed and programmed, it is integrated with IoT applications. That way, the user can monitor the current and voltage conditions in real time. They will also receive a notification if a problem occurs. Through this implementation step, the developed system can be directly tested on the counting machine. The aim is to ensure that the monitoring and protection functions operate in accordance with the study's expectations

2.3 Motor Protection Issues

Since a problem has already been identified, a system is needed. This system must be able to monitor and maintain the current and voltage of the motor at any given time. The system needs to measure electrical usage using a current sensor and a voltage sensor. Then, the microcontroller, acting as the system's brain, will process all the information. These systems also require actuators such as relays or contactors. This device functions to automatically cut off the electrical current if abnormal conditions occur, such as excessive current or unstable voltage. To enable remote monitoring, the system must be connected to the Internet of Things (IoT). Thus, the data can be viewed in the application, and the user can access it at any time.

2.4 Test Method

The implementation of this system includes the installation of hardware. Current and voltage sensors are installed at the motor inlet to obtain real-time data. Then, the microcontroller

software is connected to an internet module so that the collected data can be sent to the IoT platform. Then, the microcontroller is programmed to process sensor readings, manage data, send information, and control the relay as a system protection mechanism. The program is integrated with IoT applications so that operators can view current and voltage conditions and monitor them in real time

3. SYSTEM DESIGN

From the tests conducted on the IoT-based control system of the plastic counting machine, the system operates in accordance with the programmed design. Testing is carried out by applying different loads in order to observe how the system performs under each condition, as well as to monitor changes in current, voltage, and motor speed for each load. The diagram illustrates a three-phase motor control system integrated with IoT technology. In the power section (three-phase supply), the electrical source lines R, S, T, and N pass through an MCB/MCCB as the main protection, then continue to the

contactor and overload relay before entering the VFD (inverter), which regulates the motor speed. From the VFD, the outputs U, V, and W drive the three-phase motor, for example in a plastic shredding machine, while proper grounding (PE) is applied for safety. In the control section (220 VAC), there are push buttons such as start (NO), stop (NC), and alarm, which are used for manual system operation. Meanwhile, the input sensor section includes an emergency stop, overload relay signals, a temperature sensor, and a jam sensor that monitor the machine's condition. All these signals are connected to an IoT gateway module based on ESP32, which processes the data and transmits it via Wi-Fi to cloud platforms such as ThingsBoard or Blynk. Through the cloud, users can access a dashboard to monitor key parameters such as speed, current, and temperature, receive alarm notifications, view historical data, and perform remote control (start/stop). With this integration, the system not only operates automatically and safely but also enables real-time monitoring and control from anywhere [4].

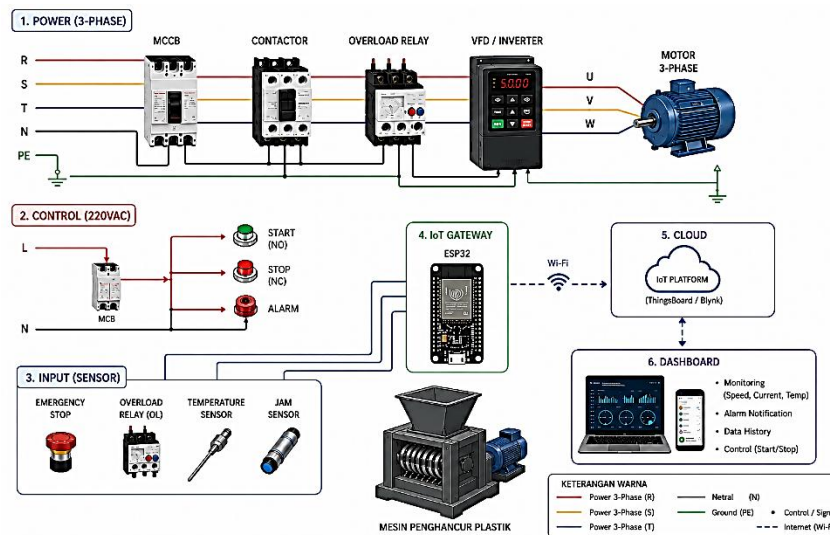


Fig 1: Control System

4. RESULTS AND DISCUSSION

From the tests conducted on the IoT-based control system of the plastic counting machine, the system operates in accordance with the programmed design. Testing is carried out by applying different loads in order to observe how the system performs under each condition, as well as to monitor changes in current, voltage, and motor speed for each load [6].

4.1 Without Load

The first test is conducted with the motor running without any load. The aim is to observe the current, voltage, and rotational speed of the motor when it is not subjected to any load. The data can be seen in the following table:

Table 1. Table Without Load

Time (Minute)	Current (A)	Voltage (v)	Rpm
0	0,40	380	1398
10	0.45	379	1395
20	0.42	380	1397
30	0.43	378	1398
40	0.44	379	1396

It can be seen from the table above. When the motor operates without a heavy load, the current, voltage, and rotational speed appear stable and normal as observed through the IoT system. This shows that the motor performance without any load is very good and stable at the initial stage of operation.

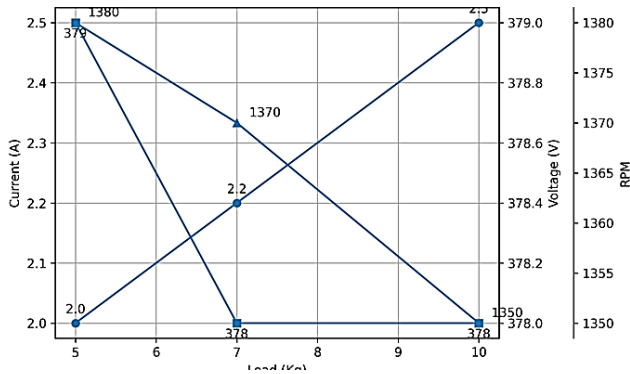
4.2 Minimum Load

After the no-load test is completed, the next step is to test the motor by applying an initial load

Table 2. Table Minimum Load

Load (Kg)	Current (A)	Voltage (v)	Rpm
5	2.0	379	1380
7	2.2	378	1370
10	2.5	378	1350

Fig 2: Graphic Minimum Load



At minimal load conditions, the electric current increases slightly compared to the no-load condition, rising from approximately 2.0 A to 2.5 A. The motor speed also decreases slightly from the initial condition but remains stable. The voltage also shows a slight decrease but is still within normal limits. This condition indicates that the motor has begun operating to perform the counting process; however, the applied load is still relatively light, so it does not have a significant effect on the motor's performance. In terms of the IoT system, changes in current, voltage, and speed values can be monitored, allowing operators to observe the machine's performance in real time and ensure that the system is operating properly. Data under minimal load conditions can also serve as a reference for future use when anomalies or disturbances are detected. With this data, the designed control system can be optimized. This shows that IoT integration is not only for monitoring, but also serves as a basis for decision-making in operating the machine.

4.3 Maximum Load

Further testing is carried out at maximum load. The aim is to determine how far the machine can operate under maximum working conditions. It also aims to determine how the IoT monitoring system responds to the maximum load. The data from the maximum load tests are presented in the table below.

Table 3. Table Maximum Load

Load (Kg)	Current (A)	Voltage (v)	Rpm
25	3.1	380	1350
28	3.1	380	1350
30	3.3	380	1342

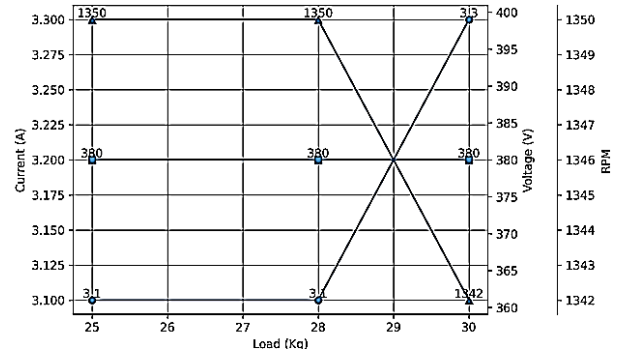


Fig 3: Graphic Max Load

5. SECTIONS

Based on the study results, the Internet of Things (IoT)-based motor control system for the plastic waste counting machine is capable of operating effectively in real-time monitoring and control. The system is able to accurately measure current and voltage parameters and regulate the motor in accordance with its operating conditions. With the implementation of the Internet of Things (IoT) system, monitoring and control processes become more efficient and easier to perform, while also enhancing safety and reliability in the operation of plastic waste counting machines [4]. Based on the efficiency analysis results, the motor demonstrates relatively good efficiency under normal operating conditions. The test results also indicate that the machine's motor operates in accordance with the programmed control system. Furthermore, the selected motor and the implemented program are appropriate, as demonstrated during no-load, minimum-load, and maximum-load testing conditions

6. ACKNOWLEDGMENTS

We would like to express our sincere gratitude to Manado State Polytechnic, especially the Department of Electrical Engineering, for their knowledge, guidance, and support in the completion of this project. We also extend our appreciation to all contributors whose support has led to the successful completion of the project entitled "Design and Development of a Motor Control System for a Plastic Waste Shredder Machine Based on the Internet of Things (IoT).

7. REFERENCES

- [1] R. Sumanjaya and E.Susanto, "Perancangan Simulasi Sistem Kontrol Kecepatan Motor Induksi 3 Fasa dengan Metode Kontrol Saklar," eProceeding..., 2015.
- [2] I. G. S. Sudaryana, "Pemanfaatan relai tunda waktu dan kontaktor pada panel hubung bagi (phb) untuk praktek penghasutan starting motor star delta," J.Pendidikan. Teknol. Dan ..., 2015.
- [3] R. Sumanjaya, F. T. Elektro, U. Telkom, and K. Skalar, "Perancangan Simulasi Sistem Kontrol Kecepatan Motor Induksi 3 Fasa Dengan Metode Kontrol Skalar," eProceedings Eng., vol. 2, no. 3, pp. 1-8, 2015
- [4] L. D Xu et al., "Internet of things in industries: A survey," IEEE Transaction on Industrial Informatics, vol. 10. No. 4. Nov 2014.
- [5] D.Setijowarno Aguado, J., Serrano, D.P., San Miguel, G., Castro, M.C., Madrid, S. (2007) Feedstock Recycling of Polyethylene in A Two-Step Thermo-Catalytic Reaction System, Journal of Analytical and Applied Pyrolysis, 79, pp.415-423.

- [6] Nur I., Nofriadi, Rusmardi (2014) Pengembangan Mesin Pencacah Sampah/Limbah Plastik dengan Sistem Crusher dan Silinder Pemotong Tipe Reel, Seminar Nasional Sains dan Teknologi, Fakultas Teknik Universitas Muhammadiyah Surakarta.
- [7] Al-Salem, S.M., Lettieri, P., Baeyens, J. (2009) Recycling and Recovery Routes of Plastic Solid Waste (PSW): A Review, *Waste Management*, 29, pp. 2625-2643.
- [8] Seo, Y.H., Lee, K.H., Shin, D.Y. (2003) Investigation of Catalytic Degradation of High-Density Polyethylene by Hydrocarbon Group Type Analysis, *Journal of Analytical and Applied Pyrolysis*, 70, pp. 383-398.