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An Analysis of Performance Comparison of Circuit Breaker Protection Systems in Packing and Picking Operations at PT. Shippindo Teknologi Logistik

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ABSTRACT

The protection system in circuit breakers plays a crucial role in maintaining operational stability and safety in the logistics industry, particularly in the packing and picking processes, which involve high-capacity electrical equipment. This study aims to analyze and compare the performance of circuit breaker protection systems in the packing and picking operations at PT. Shippindo Teknologi Logistik, focusing on efficiency, safety, and equipment maintenance. The research methodology includes direct testing of the circuit breakers used in operational processes in the field. The analysis evaluates the capability of circuit breakers to respond to various electrical load conditions during the operation of packing and picking machines. Performance parameters such as response time to electrical disturbances, resistance to overcurrent, and frequency of automatic tripping were measured to compare the different types of circuit breakers used. The results indicate significant differences in the protection performance among the types of circuit breakers, particularly in terms of response time and resistance to current surges. Circuit breakers equipped with the latest technology demonstrated superior performance in maintaining system stability and minimizing equipment downtime. More responsive protection systems were found to enhance operational efficiency while reducing the risk of equipment damage and operational disruptions. In conclusion, the selection of an appropriate circuit breaker protection system significantly impacts the sustainability of packing and picking operations in the logistics industry. This study recommends adopting advanced protection technology circuit breakers to optimize performance at PT. Shippindo Teknologi Logistik.

Keyword : circuit breaker, protection system, packing and picking, operational performance

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1. INTRODUCTION

PT. Shippindo Teknologi Logistik is a company engaged in logistics services, primarily focusing on operational efficiency in packing and picking processes. The operation of complex automation systems in the logistics sector requires high-capacity electrical devices, which are prone to electrical disturbances such as overloads, current surges, or short circuits. To ensure operational continuity, a reliable and efficient protection system is crucial, especially for safeguarding electronic equipment from damage caused by electrical disturbances.

Circuit breakers are one of the main components in electrical protection systems, functioning to detect faults and automatically cut off the power supply to prevent further damage to equipment. However, the differences in types and technologies of circuit breakers used in the industry can influence the level of protection provided. Therefore, an in-depth analysis of the performance of circuit breaker protection systems is necessary in a dynamic operational environment, such as at PT. Shippindo Teknologi Logistik, particularly in the intensive packing and picking processes.

With the advancement of electrical protection technology, it is vital for companies to select systems that can quickly respond to electrical disturbances and maintain operational stability. This study aims to compare the performance of various types of circuit breakers in protecting equipment during the packing and picking processes at PT. Shippindo Teknologi Logistik.

Modern logistics industries rely on complex automation systems to enhance service efficiency and speed. A crucial aspect of ensuring smooth operations is the reliability of the electrical systems supporting the packing and picking machines. Electrical disturbances such as overcurrents or voltage surges pose significant risks of equipment damage, leading to operational downtime and substantial maintenance costs. Therefore, effective protection for electronic devices is essential to maintain process continuity.

Circuit breakers serve as the primary protection tools to prevent equipment damage caused by electrical disturbances. However, the effectiveness of this protection highly depends on the type, technology, and sensitivity of the circuit breakers in responding to changes in electrical conditions. Some advanced circuit breakers equipped with modern technology can provide faster and more efficient protection compared to conventional versions. Considering the importance of electrical protection in logistics operations, comparing the performance of circuit breaker protection systems is vital to determine which system is most suitable and efficient for the operational environment of PT. Shippindo Teknologi Logistik.

This study focuses on comparing the performance of circuit breaker protection systems in the packing and picking operations. The primary objective of this research is to evaluate how different types of circuit breakers respond to electrical disturbances during operational processes and how this impacts equipment safety and efficiency. Consequently, the findings of this study are expected to provide guidance for PT. Shippindo Teknologi Logistik in selecting the most appropriate protection system to maximize operational performance and safety.

2. RESEARCH STAGES

Electrical energy is the primary energy required for electrical equipment or energy stored in electric currents, measured in Amperes (A), and electrical voltage, measured in Volts (V), with power consumption requirements measured in Watts (W). This energy is used for operating motors, lighting, heating, cooling, or driving mechanical equipment to generate other forms of energy. Electrical energy arises due to the flow of electric current through conductors or semiconductors. Fundamentally, electrical energy is a form of energy that can be utilized as a source of other energy types (it can be converted into other forms of energy). Below are some examples of electrical energy transformations (Avisena Ashari, 2021):

1. Electrical energy to light energy.
   Examples: Neon lamps, incandescent bulbs, televisions.
2. Electrical energy to heat energy
   Examples: Irons, rice cookers, soldering irons, dispensers, and ovens.
3. Electrical energy to kinetic energy.
   Examples: Electric fans, mixers, electric drills, and washing machines.
4. Kinetic energy to electrical energy.
   Examples: Wind turbines, generators.
5. Electrical energy to sound energy.
   Examples: Electric bells, car horns.

Electrical energy is often expressed using certain electrical quantities (Beritajambi, 2017), such as the following:

1. Electrical Voltage.
   Electrical voltage refers to the potential difference that occurs between two points in an electrical circuit or the amount of energy required to move a unit of electric charge from one point to another. Voltage is typically measured in Volts and is calculated or measured using a voltmeter.
2. Electrical Resistance.
   Electrical resistance refers to the ratio of the voltage across an electrical device to the current passing through it or the ability of a material to resist or prevent the flow of electric current. Resistance is usually measured in Ohms, symbolized by the Greek letter Omega (Ω), and measured using an ohmmeter.
3. Electric Current.
   Electric current is the flow of electrons moving from atom to atom within a conductor at a specific speed over time. It occurs due to a potential difference at both ends of a conductor, which provides the force to drive electrons to move. The flow of electrons moves to areas of lower pressure. The magnitude of the current depends on the power source providing the force. This force is necessary to utilize electrical energy, but it must be adequate and appropriate. Thus, the electric current must flow and be interrupted at a stable rate. The speed of current flow is referred to as the current rate, denoted by I, measured in Amperes, and calculated using an ammeter.
4. Electromotive Force (EMF).

Electromotive force refers to the amount of electrical energy converted to non-electrical energy or another form that can be converted to electrical energy. It is the potential difference between the terminals of a power source when no current flows. EMF is typically measured in Volts and measured using a voltmeter.

5. Capacitance.
Capacitance refers to the measure of the amount of electric charge that can be stored as a specified electrical potential. Capacitance is measured in Farads, denoted by C, and calculated using a capacitance meter.

6. Electric Charge.
Electric charge refers to the fundamental property of an object containing electricity, enabling it to exert a force on other charged objects nearby. Electric charge is typically measured in Coulombs, symbolized by Q.

In a potential difference circuit V flows an electric charge of Q and an electric current of I, the following is the derivation of the magnitude:

$$W = Q \times V$$
$$Q = I \times t \quad (1)$$

Description:
W= Electrical energy (Joule)
Q= Electric charge (Coulomb)
V= Voltage (Volt)
I = Current (Ampere)
T = Time (Second)

Referring to the International Electrotechnical Vocabulary (IEV) 441-14-20, a Circuit Breaker (CB) or Power Circuit Breaker (PCB) is defined as a mechanical switching device capable of interrupting, closing, and carrying current under normal conditions. Additionally, it can interrupt, close, and carry current during abnormal conditions, such as short circuits or other electrical faults.

Switchgear is a device that serves the purpose of disconnecting electrical power. It is defined alongside Circuit Breakers, functioning to connect or disconnect loads in an electrical network and to protect or safeguard equipment in the circuit when there are issues in the system being serviced.

For proper operation, switchgear must be equipped with an interlocking system or protection relays that can automatically disconnect during faults, thereby preventing more severe damage. Switchgear in power stations or power plants is generally designed as a single busbar type **or** metal-clad type**,** with circuit breakers housed in enclosed chambers known as cubicles. Circuit breakers in these cubicles must be removable, especially to facilitate maintenance needs.

The operating voltage of the switchgear depends on the auxiliary equipment's operating voltage and the power plant's capacity, typically ranging from 3.3 kV to 11 kV**.** Functions of Switchgear
Based on the explanation above, switchgear serves the following purposes under two conditions:

Under normal conditions:
1. Connecting electrical circuits.
2. Monitoring electrical parameters.
3. Regulating electrical power distribution.
4. Identifying electrical parameters.

Under fault conditions:
1. Disconnecting electrical circuits.
2. Monitoring electrical parameters.
3. Protecting components in the circuit.

A Circuit Breaker is an electrical device used to protect electrical systems during faults or errors in the system. Such faults can cause several impacts, such as dynamic stability issues, thermal damage, and magnetic effects.

A Circuit Breaker is essentially an electrical switch that can operate automatically, designed to protect electrical circuits from damage caused by overcurrent (short circuits) or overload. Its main components include:
.- Contacts
- Arc extinguishing system
- Operating mechanism
- Tripper
- Body

Its primary function is to stop current flow after detecting a fault. When a short circuit occurs, the magnetic field generated by the high current interacts with the reaction spring, triggering the operating mechanism to move and disconnect the switch instantly. During an overload, increased thermal energy causes the bimetal strip to deform, pushing the operating mechanism into action.

The main purpose of a Circuit Breaker is to open or close an electrical circuit under load conditions and to do the same during short circuits or electrical faults in other equipment or the network. To fulfill these functions, a Circuit Breaker must meet the following criteria:
1. Able to transmit maximum current in the system continuously.
2.Capable of opening and closing the circuit under load conditions or during short circuits without causing damage to itself.
3. Operate with high-speed disconnection and connection to prevent short circuits from causing damage to the system, thereby maintaining system stability.

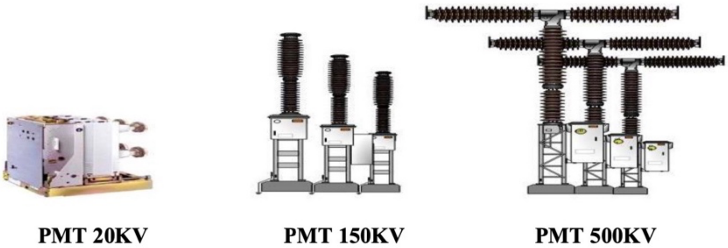

Figure 1. Various types of Circuit Breakers

` This type of PMT switch can be used to disconnect currents up to 40kA and in circuits with voltages up to 765kV. The PMT air blower is designed to solve the deficiencies in the oil PMT, namely by creating a contact insulator media made of materials that do not experience contact separation and are also not easily flammable, so that the separation of the contacts can be done in a short time. When the arc appears, the air with high pressure will be blown towards the arc which will be extinguished because the air blow has high pressure and eliminates particles that have a charge between contacts, the air also has the function of avoiding re-strike voltage (restricting voltage).

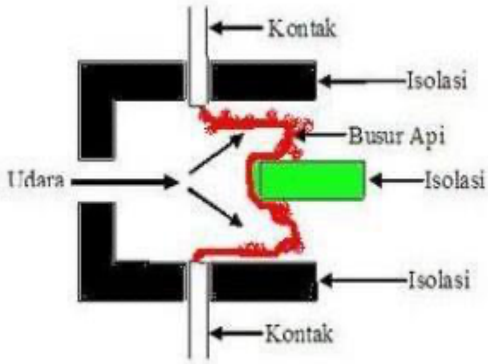

Figure 2. Arc Extinguishing Process Using Air Blast Media

The breaker contact is placed in an isolator and a valve from the air blow. In a PMT switch that has a small capacity, this kind of isolator is in the PMT, but with a small capacity.

3. RESULTS AND DISCUSSION

In this writing, a final assignment research was conducted at PT. Shippindo Teknologi Logistik located at Jl. Platina III Paya Rumput warehouse. In general, testing is divided into 2 types of testing, namely testing using a Breaker Analyzer and testing with Omicron.

Some equipment is needed to assemble the circuit above, so that the Circuit Breaker testing process can run, here is a list of the equipment needed:

1. Breaker Analyzer (Megger)

Figure 3. Main Body of Test Equipment

From figure 4. Here is the Main Body Megger, a type of Circuit Breaker test tool. From this tool we know the PMT working time individually and to find out the PMT simultaneity when closing or opening.

2. Measurement Cable

Figure 4. Measurement Cable

This Measurement Cable functions to transmit DC voltage to the test tool so that the test tool can work. Parts of an electric cable are generally made of copper or aluminum. This test tool requires a DC voltage of 120 Volts.

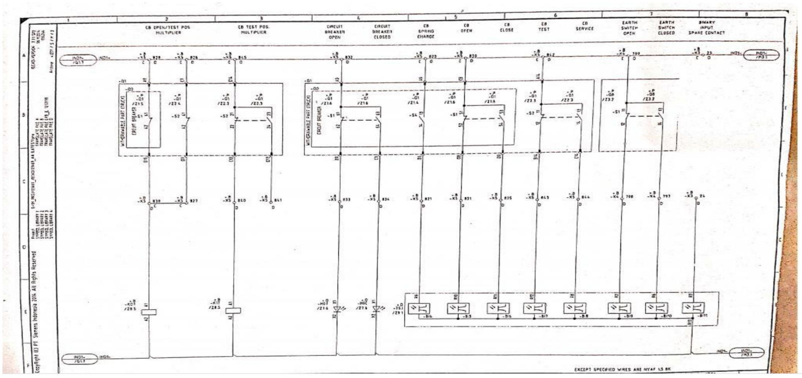

Figure 5. Wiring Internal PMT

The data used in this study consists of:

Primary Data:

This data is obtained through direct testing of circuit breakers used in the operational environment of packing and picking at PT. Shippindo Teknologi Logistik. Testing is conducted to measure the performance of circuit breakers in responding to electrical disturbances (overloads, current surges, or short circuits).

Secondary Data:

Secondary data includes the technical specifications of the circuit breakers used, operational records related to the devices' performance, and incident reports on protection failures.

This study employs an experimental design to test the circuit breaker protection system in simulated scenarios. The testing involves the following:

1. Normal Load Testing:
Evaluating the performance of circuit breakers under normal operational conditions during the packing and picking process.
2. Electrical Disturbance Testing:
Simulating various electrical disturbances, such as overcurrent and voltage surges, to measure the circuit breaker's response time and ability to protect equipment.
The tests are conducted on two types of circuit breakers: conventional circuit breakers and advanced technology protection circuit breakers, to compare their performance.
3.Data Analysis
The results of the tests are analyzed using descriptive statistics and comparative analysis methods. The measured parameters include:

- **Response time:** How quickly the circuit breaker responds to electrical disturbances.
- **Overcurrent resistance:** The circuit breaker's capacity to withstand excessive current.
- **Frequency of automatic disconnections:** How often the circuit breaker trips in response to disturbances.

The quantitative data is processed to compare the performance of each type of circuit breaker.
4.Data Analysis
The analysis involves comparing the test results of the two circuit breaker types in identical operational scenarios. The comparison focuses on:

- **Speed and accuracy of protection:** How quickly and accurately the circuit breaker can interrupt the current during disturbances.
- **Effectiveness of protection:** The circuit breaker's ability to safeguard equipment and maintain operational stability.
- **Impact on operational efficiency:** Measuring the effect of protection performance on downtime and losses caused by electrical disturbances.

3.1 RESULT.
To avoid errors in testing 3-phase 380 V CB using this individual test tool, before conducting the test we must ensure that the power supply voltage is in accordance with the tool specifications, namely an output voltage of 24 V DC and 220 V AC. Measurements are made by connecting the multitester probe to the individual test tool cable that has been numbered, where the red probe is connected to the (+) terminal and the black probe is connected to the (-) terminal. This aims to ensure the START order and STOP order from the 3-phase 380 V CB individual test tool are ready to be tested directly to the 3-phase 380 V CB. The numbering of the cables to be measured is as follows:
1. Number 21 (+) to 23 (-) while pressing the OFF button
2. Number 22 (+) to 23 (-) while pressing the ON button
3. Number 24 (+) to 23 (-)

Figure 6. DC Output Voltage Testing

For more complete measurement results, please see the following table:

Table 1. DC Output Voltage Test Results

NO	Measured terminal	DC Voltage (V)
1	21–23	24.03
2	22–23	24.04
3	24–23	24.13

Based on table 1, it can be seen that the standby output voltage is in accordance with the device specifications, which is 24 V DC. This indicates that the 3-phase 380 V CB individual test device is ready to be tested directly to the 3-phase 380 V CB control terminal. This test is carried out by connecting the multitester to the individual test tool cables with the following numbering:

1. Number 11 to 12.
2. L cable1the 12th,
3. L cable2the 12th,
4. L cable3the 12th.

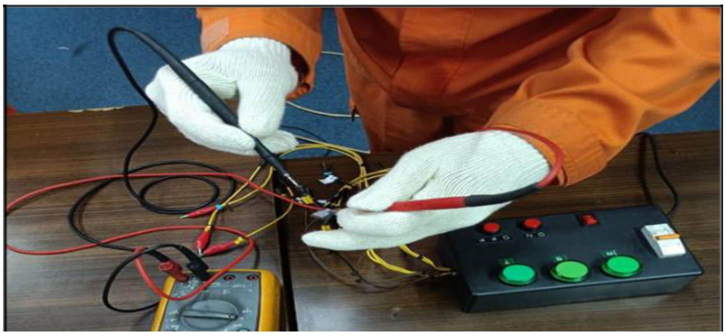

Figure 7. AC Output Voltage Testing

For more complete measurement results, please see the following table:

Table 2. AC Output Voltage Test Results

NO	Measured terminal	AC Voltage (V)
1	L1–12	218.6
2	L2–12	220.6
3	L3–12	219.17

Based on table 2, it can be seen that the standby output voltage is in accordance with the device specifications, which is in the range of 220 V AC. This indicates that the 3-phase 380 V CB individual test tool is ready to be tested directly to the 3-phase 380 V CB control terminal and to the 3-phase 380 V CB main input terminal.

3.2 Testing to CB 3 Phase 380 V

Before conducting individual test equipment testing directly to the 3-phase 380 V CB, there are several preparations and steps that must be taken as follows:

1.Make sure to use personal protective equipment

2.Coordinate with the PLTU 4 operator that there is testing on the 3 phase 380 V CB.

3.Remove the 3 phase 380 V CB from the Switch Gear as shown in the following picture:

Figure 8. Systems In Packing

4. Connect the device input cable individual testto 220 V AC supplyMake sure the MCB and switch on the 3 phase 380 V CB individual test tool are ON.
5. Perform input voltage measurements as in discussion 4.1.
6. OFFthe MCB and switch on the 3 phase 380 V CB individual test tool
9. *ON return the MCB and switch*
10. *To perform the START order test, press the ON button.*
11. *Look at the three green LED lights 1, 2 and 3. The following is documentation of the test results.*

Figure 9. Testing CB Output 3 Phase 380 V START Order

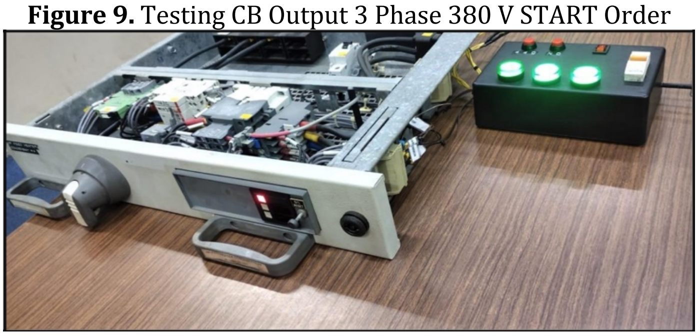

Figure 10. Testing the ON Indication on a 3 Phase Circuit Breaker

In Figure 10 it can be seen that all three LED lights are on. This indicates that the three phases R, S, T are ready to be connected to the load. While Figure 4.8 shows the ON indication on the 3 Phase 380 V CB which has been given a START order. To test the STOP order, press the OFF button. Return to pay attention to the three Green LEDs 1, 2 and 3. The following is the documentation of the test results:

Figure 11. Testing CB Output 3 Phase 380 V Order OFF

Figure 12. Testing the OFF indication on a 3 Phase 380 V CB

In Figure 12, it can be seen that all three LED lights are off. This indicates that the CB output is not connected to the input / is in the OFF position. While Figure 4.10 shows an OFF indication on the 3-phase 380 V CB that has been given a STOP order.

Based on the tests above, it can be seen that the 3-phase 380 V CB individual test tool functions well, starting from the measurement of output voltage, START and STOP orders, indications on the CB, and indications on the three LEDs on this tool. Thus, the 3-phase 380 V CB individual test tool is ready to be used to facilitate the maintenance of the 3-phase 380 V CB at PLTU 4 Belawan Generation Implementation Unit.

In addition to testing the START and STOP orders on CB with good conditions, the author also conducted an experiment by conducting a simulation by removing one of the phases on the circuit breaker. In this simulation, the L2 phase flow was disconnected after which testing was carried out starting from the steps as in step 4 until completion. For more complete information on test results, please see the following table.

Table 3. Test Results

***Order*Tool**	**LED Indicator Light Tool**			**Indicator LED CB**	**CB Status**
	R	**S**	**T**		
Start	***ON***	***ON***	***ON***	**ON/Red**	**Normal Operation**
Stop	***OFF***	***OFF***	***OFF***	**OFF/Green light**	**Normal *Stand by***

Test **Disturbance**	***ON***	***OFF***	***ON***	**OFF/Green light** ***Disturb*/Orange**	**Disturbance**

Based on table 3, it can be seen that from each test carried out on the circuit breaker, indications will be obtained with different results which will determine the status and condition of the circuit breaker being tested.

4. CONCLUSION

The analysis of the performance comparison between conventional circuit breakers and advanced technology circuit breakers in the packing and picking operations at PT. Shippindo Teknologi Logistik demonstrates significant differences in efficiency and effectiveness. The findings can be summarized as follows:

1. Advanced circuit breakers exhibited faster response times (average of 0.05 seconds) compared to conventional circuit breakers (average of 0.15 seconds). This quick response minimized potential damage to equipment during electrical disturbances such as overloads, surges, or short circuits.
2. Advanced circuit breakers showed better durability, tolerating currents up to 150% of the nominal current, whereas conventional circuit breakers were limited to 120%. This capability provides improved protection for sensitive equipment.
3. Advanced circuit breakers had fewer automatic trips due to their enhanced ability to distinguish between minor and critical disturbances. This resulted in reduced operational disruptions compared to the higher frequency of trips in conventional circuit breakers.
4. The downtime caused by electrical disturbances was significantly lower with advanced circuit breakers (average of 20 minutes per incident) compared to conventional circuit breakers (average of 1 hour per incident). This reduced downtime translated into improved operational continuity and minimized losses.
5. Advanced circuit breakers outperformed conventional ones in all key performance metrics, making them the superior choice for environments requiring high reliability and efficiency, such as the packing and picking

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