JURNAL ECOTIPE
Electronic, Control, Telecommunication, Information, and Power Engineering
Volume 11, Issue 2, October 2024, pp. 170-176
ISSN 2355-5068 ; e-ISSN 2622-4852
DOI: 10.33019/jurnalecotipe.v11i2.4505

Reliability Analysis of Coal Feeder Instrumentation Using Failure Mode and Effect Analysis (FMEA) at PT. PLN Nusantara Power UP Tenayan

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ARTICLE INFO

Article historys:

Received : 25/07/2024
Revised : 18/08/2024
Accepted : 06/09/2024

Keywords:

Failure Mode and Effect Analysis; Instrumentation Components; Risk Priority Number

ABSTRACT

PT. PLN Nusantara Power UP Tenayan is a coal-fired power plant supplying electricity to the Riau region with a capacity of 2 x 110 MW. Operating 24/7, the plant faces frequent failures, particularly in the instrumentation components of the coal feeder. This research employs the Failure Mode and Effect Analysis (FMEA) method to identify and analyze these failures. The Risk Priority Number (RPN), calculated by multiplying severity, occurrence, and detection ratings, helps determine the failure level. Research stages include a preliminary study, problem identification, observations and interviews, data collection and processing, FMEA analysis, and conclusion drawing. The results indicate that the instrumentation components are generally reliable, with RPN values below the critical threshold of 200. The speed sensor, with the highest RPN value of 160, is still categorized as reliable. Failures in these components can lead to operational failures, suboptimal coal feeder performance, and monitoring difficulties. The study recommends preventive maintenance every six months to enhance reliability and minimize disruptions.

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1. INTRODUCTION

Electric energy is a renewable energy source that plays a very important role in the life and economy of a country. In several industries, including power plants, instrumentation systems have a crucial role in maintaining the performance and reliability of equipment. These instrumentation systems regulate critical parameters such as temperature, pressure, and vibration. Their function is to maintain the continuity of power plant operations by monitoring and controlling their conditions [1].

The Tenayan Steam Power Plant (PLTU Tenayan) is one of the main power plants that supply electricity needs in the Riau region and its surroundings. This company operates 24 hours a day by operating electricity with a capacity of 2 x 110 MW, organized by the government, and functions to distribute electricity needs in the Riau area [2].

PT. PLN Nusantara Power UP Tenayan operates through a complex process, utilizing various equipment and machinery. However, the production process does not always run smoothly due to frequent issues or failures in the machine components used. This results in disruptions in electricity production. Among the various machines used, one of the main components that experience failure is the coal feeder. As a coal-fired power plant, PLTU Tenayan has a Coal Feeder system that functions to

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deliver coal from the bunker to the boiler. The boiler is equipment that can supply the energy needs designed to meet the company's electricity requirements. The Coal Feeder is a critical component in the electricity generation process because a disruption in the coal feeder can cause interruptions in the coal supply to the boiler, leading to disruptions in the overall power generation process. Therefore, more intensive maintenance is required to maintain its performance to work as desired [3].

Based on direct observations and interviews with the instrumentation and control team leader at PT. PLN Nusantara Power UP Tenayan, it was explained that failures in instrumentation components can have wide-ranging impacts. Several problems that occur in the coal feeder instrumentation are prone to failures that can cause performance disruptions in the coal feeder. Coal feeder instrumentation failures can be caused by factors such as component damage, installation errors, extreme environmental conditions, and others.

One of the parameters that can be used to measure the performance reliability of the coal feeder instrumentation is by improving its reliability using the Failure Mode and Effect Analysis (FMEA) method. Failure Mode and Effect Analysis (FMEA) is a common approach used to analyze the risk of failure and to identify the causes of future failures [4]. Failure Mode and Effect Analysis (FMEA) qualitatively assesses the severity, occurrence, and detection of each activity for both the operational process and the equipment or components of a specific system. The three components that receive the highest Risk Priority Numbers (RPN) will be proposed for risk reduction strategies [5].

Previous research on reliability analysis was conducted by [6] with the title "Reliability Analysis of Instrumentation in the Central Mechanical Electrical Unit Using the Failure Mode and Effect Analysis (FMEA) Method." The method used in their research was the failure mode and effect analysis method by identifying failure modes from a cause of failure and the impact of each component's failure on a system. The analysis results showed that the devices in PT. Telkom Area Network Riau Daratan Pekanbaru are reliable, with an RPN percentage not exceeding 200 [7].

In the research conducted by [8], the RPN values were calculated for the temperature sensor, steam flowmeter, control valve, white liquor flowmeter, gamma ray level, pressure transmitter, and kappa number, with all instrumentation exceeding the standard RPN limit of 200. Therefore, actions need to be taken on these instruments by recommending preventive maintenance, which is safe and reliable to use. In the research conducted by [3], the results significantly contributed to the implementation of water level and temperature data processing technology through RPN value calculation simulation using the FMEA method implemented in MPSA. The medium-risk values obtained from the RPN calculation ranged from 4 to 23.

Research conducted by [9] based on the FMEA results identified components with a Risk Priority Number (RPN) > 300, namely the Dise Knife and bolt nuts. If the operator detects symptoms indicating problematic components, they fill out a damage form and send it to the mechanical department, which then performs a series of maintenance procedures to repair the components.

By conducting Failure Mode and Effect Analysis (FMEA) on the coal feeder instrumentation at PLTU Tenayan, it is expected to obtain comprehensive information regarding potential failure modes, causes, and impacts, as well as recommendations for actions needed to improve system reliability. The results of this analysis can be used as a basis for making improvements and optimizations to the coal feeder instrumentation system, thereby enhancing the reliability and performance of the coal feeder and ultimately supporting a more efficient and reliable electricity generation process at PLTU Tenayan [10].

This study aims to analyze the reliability of coal feeder instrumentation using the Failure Mode and Effect Analysis (FMEA) method at PT PLN Nusantara Power UP Tenayan. By identifying potential failures and their impacts, as well as formulating appropriate preventive actions, it is expected that the reliability of the coal feeder system can be improved, ensuring a sustainable coal supply and reducing the risk of disruptions or failures in the electricity production process.

2. RESEARCH METHOD

Failure Mode and Effects Analysis (FMEA) is a systematic method for identifying and preventing potential problems in a product or process before they occur. This research was conducted at PT. PLN Nusantara Power UP Tenayan, Pekanbaru. In the context of analyzing the reliability of coal feeder

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instrumentation, the FMEA method can be used to analyze potential failure modes in the coal feeder instrumentation components, as well as the effects of these failures.

2.1. Research Design

To facilitate the research process, the researcher created a flowchart to clearly outline each stage. The flowchart of the research process can be seen in Figure 1 as follows.

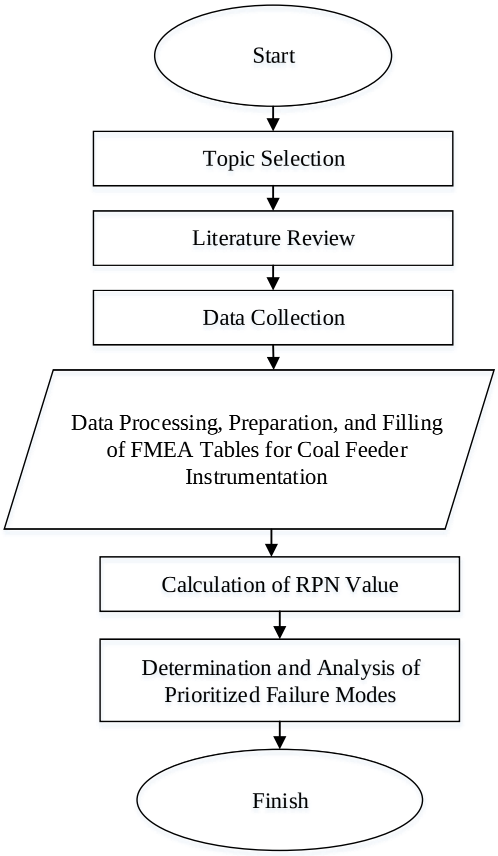

Figure 1. Research Flowchart

2.2. FMEA Analysis

The initial step in conducting research is called a preliminary study. This preliminary study involves gathering initial reviews through written sources such as journals, articles, and books. After conducting the preliminary study, the researcher collects data by identifying issues through interviews and field observations. Through interviews and observations, data is gathered regarding the failures of instrumentation components, their causes, and the effects of these failures using the FMEA method.

Failure Mode and Effect Analysis (FMEA) is a method implemented to determine the failure levels at a specific system level and to reduce a system to minimize the likelihood of critical issues in system components [11]. FMEA is a cyclical risk analysis technique used to identify the consequences arising from a failed piece of equipment, facility, or system [12].

The main objective of FMEA is to determine the level of failure based on the Risk Priority Number (RPN). The RPN value is obtained from the multiplication of severity, occurrence, and detection, and can be written using the following formula:

$$\text{RPN} = Severity \times Occurence \times Detection \tag{1}$$

Description:

RPN	: Risk Priority Number
Severity (Sev)	: Severity Level
Occurrence (OCC)	: Frequency of Failure
Detection (Det)	: Detection of Failure Causes

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Severity represents the severity or effects inflicted on the entire machine by a failure mode. Occurrence refers to the frequency of failure or damage. Detection is the control system used to detect the causes or modes of failure [13]. A higher RPN value indicates a higher level of criticality or problem within the system. Conversely, a lower RPN value indicates a lower level of criticality [14].

3. RESULTS AND DISCUSSION

3.1. Failure Mode and Effects Analysis

Failure Mode Effect and Analysis is used to identify the coal feeder instrumentation components that are most vulnerable to failure during the electricity production process. The FMEA worksheet aims to assess severity, occurrence, and detection based on the potential impact of failures, their causes, and the control actions taken, resulting in a Risk Priority Number (RPN). The FMEA table can be seen in Table 1 below:

Table 1. FMEA Worksheet for Coal Feeder Instrumentation at PT. PLN Nusantara Power UP Tenayan

Component	function	Potential Failure Mode	Potential Effect Failure	SEV	Potential of Failure	OCC	Current Control	DET	RPN	Recommended Action
Load Cell	Measures the weight of coal used	Load cell position is unbalanced	Cannot read the load normally	6	Uneven load cell mounting surface	4	Checking the voltage at the sensor cable connection terminals	4	96	Create a strong sensor support and perform maintenance every 6 months
Sensor Speed	Measures the speed of the coal feeder mechanism	Measured speed is erratic	Equipment operational failure	8	Sensor overheats and fails to stop	5	Speed readings per second on the display module are unstable	4	160	Perform sensor maintenance every 1 month
Pressure Transmitter	Measures air or gas pressure for coal flow to furnace	Discrepancy between local and DCS readings	Uncontrolled coal flow to the boiler	5	Corrosion at cable terminals	4	Readings in the CCR do not match those in the local area	5	80	Perform maintenance every 6 months
Belt Sway	Detects if the belt conveyor stays on track	Belt sway switch failure	Conveyor belt breakage	7	Corrosion at switch terminal due to coal dust	4	Belt sway sensor cannot cut off or stop the conveyor belt during jogging	4	112	Perform maintenance on sensor terminal connections every 6 months
Level Transmitter	Measures the coal level in the bunker	Sensor cannot accurately read coal level	Equipment cannot operate normally	8	Rusted cable terminals	4	Display on the DCS is not accurate	3	96	Perform zero calibration every 6 months
Flow transmitter	Measures the rate of coal flow into the furnace	Sensor fails to read coal flow	Inaccuracy in measuring coal flow	4	Rusted sensor	7	Visual inspection in the local area	4	112	Perform calibration every 6 months
Temperature Indicator	Reads local temperature	Temperature reading error	Operator cannot control effectively	5	Weak spring	5	Temperature readings are not accurate	3	75	Verify sensor every 6 months

The data on the instrumentation components of the coal feeder is as follows:

1. Load Cell

This component measures the weight or load of the coal to be used. The failure occurring is that the load cell position is unbalanced, preventing it from reading the load normally due to an uneven load cell mounting surface. This can be observed when checking the voltage at the sensor cable connection terminals. The team leader for instruments and control assigned a severity score of 6, an

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occurrence score of 4 due to the low likelihood of failure, and a detection score of 4 because the failure can be detected. Therefore, the RPN value for the component is 96.

2. Sensor Speed

This component measures the speed of the coal feeder mechanism. The failure observed is that the measured speed is erratic, leading to operational failures because the sensor overheats and fails to stop working. This can be seen from the unstable speed readings per second on the display module. The team leader for instruments and control assigned a severity score of 8, an occurrence score of 5, and a detection score of 4. Therefore, the RPN value for the speed sensor is 160.

3. Pressure Transmitter

This component measures the air or gas pressure used to convey coal to the furnace. There is a discrepancy between readings in the local area and those in the Distributed Control System (DCS), resulting in uncontrolled coal flow to the boiler due to corrosion at the cable terminals. This discrepancy can be observed from the readings in the Central Control Room (CCR) not matching those in the local area. The team leader for instruments and control assigned a severity score of 5, an occurrence score of 4 due to the very low likelihood of failure, and a detection score of 5. Therefore, the RPN value for the component is 80.

4. Belt Sway

This sensor is used to detect if the belt conveyor stays on its track. The failure occurring is that the switch on the belt sway sensor is broken, leading to a conveyor belt breakage due to corrosion at the switch terminal caused by frequent coal dust ingress. This can be observed when the belt sway sensor fails to stop or shut off during jogging of the conveyor belt. The team leader for instruments and control assigned a severity score of 7, an occurrence score of 4 due to the very low likelihood of failure, and a detection score of 4. Therefore, the RPN value for the component is 112.

5. Level Transmitter

This component measures the height or level of coal in the bunker. The failure occurring is that the sensor cannot accurately read the coal level, preventing normal operation of the equipment due to rusted cable terminals. This is evident from the display on the DCS not reflecting the actual level. The team leader for instruments and control assigned a severity score of 8, an occurrence score of 4 due to the very low likelihood of failure, and a detection score of 3. Therefore, the RPN value for the component is 96.

6. Flow Transmitter

This component measures the rate of coal flow into the furnace. The failure occurring is that the sensor fails to accurately read the flow, leading to inaccurate measurements of coal due to sensor rust. This is evident from visual inspections in the local area. The team leader for instruments and control assigned a severity score of 4, an occurrence score of 7 due to the sensor being corroded, and a detection score of 4. Therefore, the RPN value for the component is 112.

7. Temperature Indicator

This component is used to read the local temperature. The failure occurring is temperature reading errors, making it difficult for the operator to control effectively due to a weak spring. This can be observed from the temperature readings not being accurate. The team leader for instruments and control assigned a severity score of 5 because damage to the temperature indicator prevents the operator from controlling it effectively, an occurrence score of 5 due to the very low likelihood of failure, and a detection score of 5. Therefore, the RPN value for the component is 75.

Based on the Risk Priority Number (RPN) analysis using the Failure Mode and Effects Analysis (FMEA) method, it can be concluded that the instrumentation components of the coal feeder at PT. PLN Nusantara Power UP Tenayan exhibit very good performance. The RPN values for each component are below the standard threshold of 200. According to the literature, a high RPN value indicates a more urgent need for maintenance, while a low RPN value, below 200, suggests that the components are still in good condition and do not require immediate maintenance. [13].
There is a Pareto chart of the Risk Priority Number (RPN) values as follows:

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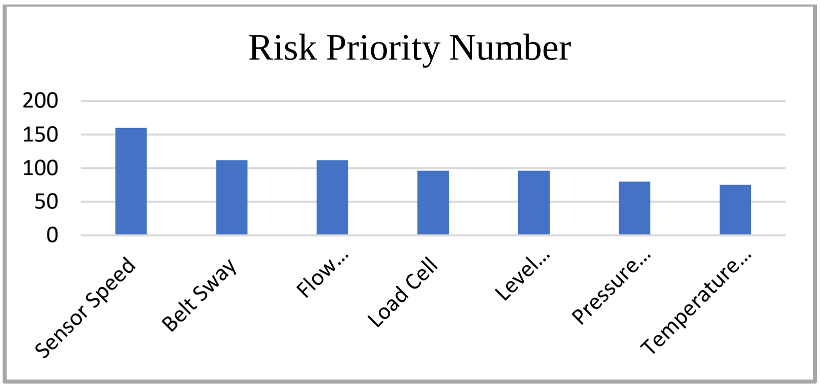

Figure 2. Pareto Diagram

From the Pareto diagram above, it is evident that the component with the highest RPN value is the speed sensor, which functions to measure the speed of the coal feeder mechanism. This component significantly impacts the continuity of electricity production, with an RPN of 160, indicating that this sensor frequently experiences failures, such as inaccuracies in speed measurement due to the sensor overheating. Conversely, the Temperature Indicator is a tool used to read local temperature and is the component with the least damage, having an RPN of 75. All these components are interdependent, so a failure in one component can cause the entire system to malfunction or trip until the damaged component is repaired and returns to normal operation. The Pareto chart is used to address major problems before minor ones and to identify failure points with significant contributions, allowing for optimal improvements by prioritizing resources for corrective actions [15].

4. CONCLUSION

From the reliability analysis of the coal feeder instrumentation at PT. PLN Nusantara Power Up Tenayan, Pekanbaru, using the Failure Mode and Effect Analysis (FMEA) method, several conclusions can be drawn. Firstly, the analysis identified various failure modes in the coal feeder, including discrepancies between local area and DCS readings, switch failures, and speed measurement issues caused by overheating sensors. Secondly, despite the high Risk Priority Number (RPN) of 160 for the sensor speed, it is still categorized as reliable because it does not exceed the standard RPN threshold of 200. Finally, the ranking of instrumentation components based on their RPN values, from highest to lowest, is as follows: Sensor Speed (160), Belt Sway (112), Flow Transmitter (112), Load Cell (96), Level Transmitter (96), Pressure Transmitter (80), and Temperature Indicator (75). The effects of these failures include operational disruptions, suboptimal performance of the coal feeder, and challenges in monitoring the system effectively.

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