Analysis of Maintenance Quality 0f Mini Hydro Turbine Machines in the Service Phase for Electricity Production Process Hydroelectric Power Plant at Jatiluhur

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Abstract

Electrical energy is a fundamental necessity for society. As population growth continues, the demand for electricity also increases. To address the limitations of fossil fuel-based power generation, alternative energy sources such as mini hydro power plants have become essential. These systems rely on the continuous and efficient operation of turbines, which in turn require consistent maintenance. This research aims to evaluate the maintenance practices of mini hydro turbine machines at Perum Jasa Tirta II (PJT II), with a focus on identifying obstacles that affect maintenance quality and proposing improvements. This study employs a qualitative descriptive method using interviews and direct field observations at the Curug Purwakarta branch office of PJT II. The findings reveal that while routine maintenance is carried out in accordance with the established Standard Operating Procedures (SOP), several challenges persist. These include the lack of preparedness for long-term component damage, limited availability of essential spare parts, and frequent delays in the delivery of crucial lubricating oil. Such issues can hinder the efficiency and sustainability of electricity production. The study concludes that although PJT II's maintenance management aligns with operational guidelines, the company must enhance its long-term maintenance planning and logistics support to ensure the optimal functioning of its mini hydro systems.

Keywords: *maintenance, strategy, management, mini hydro*

Abstrak

Energi listrik merupakan kebutuhan dasar bagi masyarakat. Seiring dengan pertumbuhan penduduk, permintaan terhadap energi listrik juga terus meningkat. Untuk mengatasi keterbatasan pembangkit listrik berbasis bahan bakar fosil, sumber energi alternatif seperti pembangkit listrik tenaga mini hidro menjadi sangat penting. Sistem ini bergantung pada pengoperasian turbin yang berkelanjutan dan efisien, yang pada gilirannya memerlukan perawatan secara konsisten. Penelitian ini bertujuan untuk mengevaluasi praktik perawatan mesin turbin mini hidro di Perum Jasa Tirta II (PJT II), dengan fokus pada identifikasi hambatan yang memengaruhi kualitas perawatan serta upaya perbaikan yang dapat dilakukan. Penelitian ini menggunakan metode deskriptif kualitatif melalui wawancara dan observasi langsung di kantor cabang PJT II Curug Purwakarta. Hasil penelitian menunjukkan bahwa meskipun perawatan rutin telah dilakukan sesuai dengan Standar

Operasional Prosedur (SOP) yang berlaku, terdapat beberapa permasalahan yang masih dihadapi. Di antaranya adalah kurangnya kesiapan dalam menghadapi kerusakan komponen jangka panjang, terbatasnya ketersediaan suku cadang penting, serta seringnya terjadi keterlambatan dalam pengiriman oli pelumas yang dibutuhkan. Masalah-masalah ini dapat menghambat efisiensi dan keberlanjutan produksi listrik. Penelitian ini menyimpulkan bahwa meskipun manajemen perawatan di PJT II telah berjalan sesuai pedoman operasional, perusahaan perlu meningkatkan perencanaan perawatan jangka panjang dan dukungan logistik untuk menjamin kinerja optimal sistem mini hidro yang dimiliki.

Kata Kunci: pemeliharaan, strategi, manajemen, mini hydro

I. INTRODUCTION

Electricity is a crucial necessity for the general public. Every day, as people go about their activities, they rely on electrical power sources to meet their daily needs. With an increasing population, the demand for electricity is expected to rise. Alternative energy sources to replace fossil fuels are becoming more important. One such alternative is the use of mini hydro machines as power generators. "Micro-hydro Power Plants are small-scale power generators that use water as their driving force, utilizing irrigation channels, rivers, or natural waterfalls by harnessing the height and flow rate of water. The basic principle behind micro-hydro power generation is the transformation of potential energy from flowing water's height into mechanical and electrical energy. Micro-hydro power plants utilize the difference in elevation and water flow rate per second of the watercourse" (Panrita, 2023).

This research was conducted at the branch office of Perum Jasa Tirta II, located in Curug Purwakarta. The company's headquarters are located elsewhere, specifically in the Jatiluhur area. Since 1968, the company has been using mini hydro systems and has expanded with two additional units in 1999. These mini hydro machines have an approximate lifespan of 20 years. The company conducts maintenance in two different stages: service every 2,000 operating hours and overhaul every 20,000 operating hours. Maintenance is also conducted separately for each machine unit. When maintenance is performed on unit 1, unit 2 continues to operate.

Figure 1. Mini Hydro Machine at Jatiluhur Hydroelectric Power Plant

Source: Jatiluhur Hydroelectric Power Plant

In determining the maintenance schedule, employees do not need to hold a meeting beforehand. Instead, they should confirm with their supervisor several days in advance. Employees assigned to perform maintenance are divided into two specialized teams: the electrical team and the mechanical team. If during maintenance small parts of the machines are found damaged, the company simply purchases those parts from local manufacturers. However, if the damage involves major components, the company must procure them from the machine's original manufacturer. Regular maintenance of mini hydro turbines is critical to ensure optimal performance, extend the lifespan of the machinery, prevent unexpected failures, and maintain the safety of operations. The harsh environment, which includes continuous water exposure and potential debris in the water flow, can lead to wear and tear on various components. Without regular servicing and proper lubrication, the efficiency of electricity generation can significantly decline, and small issues may develop into major breakdowns that are costly and time-consuming to repair.

However, there are several critical issues that need attention in the maintenance of mini hydro turbine machines. Firstly, the availability of oil is crucial to ensure the smooth operation of the components. Oil functions as a rust preventer and reduces the risk of corrosion in the machine. If the oil is not applied to the machine as recommended, the processes of dirt filtration and electricity production can be disrupted. The issue here is that the supply of oil, which is crucial for the mini hydro machines, often experiences delays from the vendor, ranging from 4-5 days to over a week. This situation leads the researcher to assume that delayed oil delivery can affect the maintenance of the mini hydro machines. In addition, one of the challenges encountered during maintenance is the accumulation of debris that covers the water flow of the mini hydro machine. The buildup of debris in front of the filter obstructs the water flow, reducing the intake flow rate. This issue also affects the electricity production process, potentially lowering the power output. Moreover, when major components are damaged, the repair process is hampered due to the need to import original parts from the manufacturer, which often results in prolonged downtime. Furthermore, the lack of formal coordination, such as scheduled meetings prior to maintenance, might lead to miscommunication or inefficiencies between the electrical and mechanical teams.

Based on the mini research conducted, one of the challenges encountered during maintenance is the accumulation of debris that covers the water flow of the mini hydro machine. The buildup of debris in front of the filter obstructs the water flow, reducing the intake flow rate. This issue also affects the electricity production process. The research aims to understand the benefits of maintaining micro-hydro machines at PJT II, evaluate the maintenance of micro-hydro machines machines at PJT II, comprehend how the evaluation of micro-hydro machines machine maintenance at PJT II is conducted using O&M approach, and identify efforts to improve maintenance practices for micro-hydro machines machines at PJT.

II. LITERATURE REVIEW

Operational Management

Operational management is a system commonly utilized by organizations or companies responsible for planning, controlling, and coordinating functions. "Operational management is the activity of optimally managing resources in the process of transforming inputs into outputs" (Dwi Novitasari, 2022). Operational management is a part of an organization responsible for producing goods and/or services. Operational management executes all functions of management, including planning, organizing, staffing, leading, and controlling. The orientation of operational managers includes directing outputs or outcomes in terms of quantity, quality, price, time, and place according to consumer demand (Kurniawan, et al., 2024).

Maintenance Management

Maintenance management is an essential activity aimed at preserving the performance or quality of a machine to ensure it operates normally as intended. "Maintenance is a form of activity conducted to restore or maintain the condition of a machine so that it can always function. Maintenance is also a supporting activity that ensures the continuity of machines and equipment so that they can be used as expected when needed" (Ignatius Deradjad Pranowo, 2019). Integrated maintenance management systems play a crucial role in achieving a company's vision. Integrated maintenance systems consist of various elements such as facilities (machines), component replacement (materials), maintenance costs (money), maintenance activity planning (method), and maintenance operators (man), which are interconnected and interact in maintenance activities within the industry.

The maintenance process can be depicted as an input-output model. Maintenance activities influence the (availability) of production facilities, production rates, the quality of (end products), production costs, and operational safety. These factors, in turn, impact the (profitability) of the company. Not only that, maintenance management actually involves an inventory process to plan and control activities related to various operations in the factory. Maintenance management encompasses various aspects of competence and expertise fields, thus generally integrating labor and raw materials that are part of maintenance management in the storage warehouse (Kurniawan, et al., 2024).

Maintenance Purpose

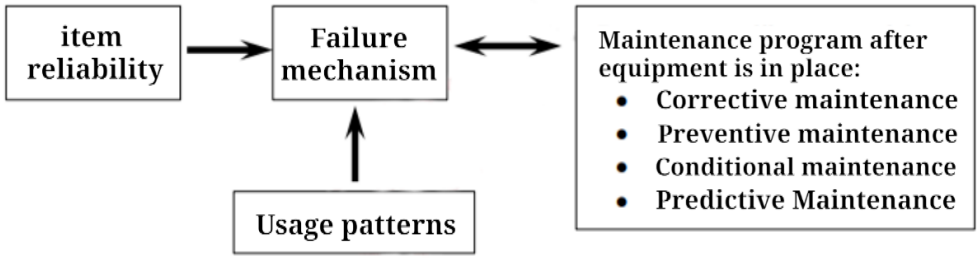
Performing maintenance within maintenance management is a critical aspect. Maintenance here can prevent equipment damage, ensure reliability and readiness, and minimize maintenance costs. The objectives of maintenance include: (Kurniawan, et al., 2024). Maintenance plays a crucial role in ensuring the smooth and efficient operation of production facilities. The primary goal is to extend the operational life of machinery and equipment, reducing the need for frequent replacements. By performing regular maintenance, production facilities can achieve optimal availability, minimizing downtime and

improving the overall efficiency of operations. Moreover, maintenance ensures that the equipment is always ready for operation, meeting the demands of production schedules without delays. Safety is another significant concern; maintenance activities help ensure that operators can work in a safe environment, while also guaranteeing the safety of the machinery and facilities. Additionally, effective maintenance enhances the capability of machines, ensuring that they meet their functional requirements and continue to perform at their best. Finally, the overall effectiveness of maintenance activities contributes to minimizing operational disruptions and maintenance costs, allowing for smoother, more reliable production processes.

Reliability and Faults

Reliability is defined as the probability that a component, equipment, machine, or system will continue to operate properly according to its expected function within a specific time interval and under certain conditions. Therefore, a good maintenance program requires information on (failure) mechanisms and (usage patterns).

Figure 2. Relationship Diagram Between (Reliability) and Maintenance



Source: Ignatius Deradjad Pranowo, 2019

The characteristics of equipment failures generally differ even when operated simultaneously; equipment with similar characteristics may experience failures at different intervals. The requirements that need to be fulfilled for the maintenance process to be carried out effectively and efficiently are:

1. The availability of data regarding the machines and equipment owned by the company is crucial. This data includes information such as the machine and equipment identifiers, types, ages, and manufacturing years. Based on this data, potential repair activities can be determined and planned.

2. The presence of maintenance planning and scheduling is crucial. Planning involves determining when long-term and short-term maintenance activities such as inspections, lubrications, cleanings, and repairs will be conducted. It also includes planning the allocation of maintenance personnel to ensure effectiveness and efficiency.
3. Availability of spare parts. Spare parts inventory must be readily available when needed, and the investment in spare parts inventory should be optimized to minimize.
4. There must be records. All maintenance activities must be well-documented, including progress updates and actions taken. This includes records of machine characteristics and inspection intervals for identifying failures.
5. Reporting, Monitoring, and Analysis (Report, Control, Analysis). Reports, monitoring, and analysis are essential for evaluating failures and making timely decisions for improvement measures.

Maintenance System

Maintenance can be defined as a series of activities conducted to keep equipment or systems in a stable condition or restore them to their designed functionality. Managing a maintenance system aims to ensure the operational reliability of production facilities and foster good interaction between humans and machines in the production process. An integrated maintenance system comprises elements such as facilities (machines), component replacements (materials), maintenance costs (money), maintenance activity planning (method), and maintenance operators (man), which are interconnected and interact within maintenance activities in industry.

O&M Maintenance Strategy

To implement and enhance maintenance practices ensuring machines operate effectively and meet quality standards, an efficient maintenance strategy is essential. Hydroelectric power plants must achieve high availability rates to generate profit. An effective operations and maintenance strategy ensures environmental and employee safety while maximizing the hydroelectric power plant's capabilities through operational and maintenance practices. O&M stands for Operational & Maintenance. For companies looking to enhance safety and performance, this strategy can begin with a comprehensive diagnosis of current performance. The results of the diagnosis are expected to identify aspects of O&M that need improvement, determining whether the company requires external assistance in operating its assets.

Operating a hydroelectric power plant is a continuous process that requires highly skilled staff and effective management to ensure that the plant functions as intended. It involves monitoring and managing various systems, ensuring they run smoothly, and addressing any operational challenges that may arise. The operation is guided by established procedures and requires regular assessments to maintain efficiency. On the other hand, maintenance of a hydroelectric power plant is equally crucial. It involves a series of activities

aimed at ensuring that the plant operates according to its set procedures, which allows the machinery to fulfill its designed functions and sustain its performance over time. Regular maintenance activities help identify potential issues before they become serious problems, ensuring the longevity of the equipment and preventing disruptions in power production. Both operations and maintenance are vital for the optimal performance and reliability of the hydroelectric power plant.

III. RESEARCH METHODOLOGY

This study utilizes a qualitative research method, as defined by Sugiono (2014:2), who explains that a research method is essentially a scientific way to obtain data for specific purposes. The focus of this research is to analyze the quality of maintenance for mini hydro turbine machines during the service phase at the Jatiluhur Hydroelectric Power Plant. The data for this study is collected from both primary and secondary sources. Primary data refers to information obtained firsthand, through methods such as interviews, surveys, and direct observations. For this research, primary data is gathered from field research, including interviews with relevant personnel at the Jatiluhur Hydroelectric Power Plant. Specifically, the researcher plans to interview Mr. Mulyadi, the Head of Maintenance Staff, to gather detailed insights on maintenance practices. Secondary data, on the other hand, is obtained from documents, records, books, and previous studies, providing additional context to the research.

To enhance the validity and reliability of the findings, triangulation testing is employed. Triangulation, a method used to validate data by comparing and cross-checking findings from multiple sources, is applied in this study. The researcher uses data triangulation, which involves collecting data from a variety of sources, including interviews with key informants such as maintenance staff and plant management, direct observations of maintenance processes, and secondary data sources such as maintenance logs and operational reports. This method ensures that the findings are accurate, reliable, and comprehensive by comparing data from different perspectives, which helps to reduce potential biases and increase the credibility of the research. Data analysis in this study follows a structured process. Data reduction involves selecting and focusing on relevant information aligned with the research objectives. This process includes categorizing the data from field observations and interviews to identify significant themes related to maintenance practices. Data display is used to organize and present the findings in a way that facilitates understanding and interpretation. Finally, the researcher draws conclusions based on the data analysis and applies verification techniques to confirm that the conclusions are supported by the collected data. This triangulation and thorough analysis ensure the robustness of the study's results.

IV. RESEARCH FINDINGS AND DISCUSSION

Research Results

In the research analysis, the researcher investigated the operational management process in electricity production at Hydroelectric Power Plant Jatiluhur by querying how informants explained the operational management flow at Hydroelectric Power Plant, which involves following company-established Standard Operating Procedures (SOP), such as a weekly machine checklist. Before conducting these tasks, employees typically hold a meeting with the relevant authorities, such as the Natural Resources Department. During this meeting, targets for water discharge levels are set to meet operational needs. Should the water levels fail to meet these targets, it falls upon maintenance personnel to take responsibility for addressing the issue. In addition to that, the research also inquired about the maintenance system implemented by the company to facilitate electricity production at Hydroelectric Power Plant Jatiluhur. The company's maintenance system involves conducting routine weekly checklist inspections, performed daily to maintain the condition of each unit. This includes monitoring the operating hours of the machines to determine when maintenance should be conducted. Ideally, maintenance is scheduled every 2000 operating hours, involving lubrication checks and machine cleaning. This is crucial for overall maintenance (overhaul) inspections.

The researcher also inquired about the reliability practices implemented by the company, where reliability is ensured through weekly checklists and quick-response unit servicing during operational hours and in case of disruptions. Regular reports are provided on the production outcomes from the Hydroelectric Power Plant units. When discussing reliability, the researcher also queried how the company handles breakdowns, to which informants responded that immediate maintenance actions are taken by mini hydro maintenance personnel to prevent prolonged or severe damage. Temporary spare parts are used to mitigate extended machine downtime since the company does not stock these parts in their warehouse, requiring orders to be placed in advance. In addition, the researcher also inquired about the strategies employed for maintaining mini hydro machines to ensure smooth electricity production at Hydroelectric Power Plant Jatiluhur. The respondents indicated that the strategy revolves around preventive maintenance, focusing on weekly maintenance to preempt any machine disruptions. The inspection process begins with a weekly checklist covering components such as the turbine runner hydraulic servo motor, turbine gear box generator bearings discharge, and generator bearing cooling. Lastly, the researcher queried whether Hydroelectric Power Plant Jatiluhur has standardized machine repair procedures aligned with given data standards. The response indicated there are no specific standard specifications provided for machine repairs. Instead, the company adheres to its own standards for the brand or type of machine lubricants used.

Discussion

In this discussion, the theory used by the researcher will be linked. It turns out that according to Ignatius Derajad Pranowo (2019), the requirement that must be fulfilled for maintenance to be carried out effectively is the availability of data on the company's machines and equipment. This has also been implemented by the Hydroelectric Power Plant to conduct maintenance on the mini hydro in Jatiluhur when carrying out the maintenance process flow. Planning and scheduling maintenance here is also a very important aspect when planning for long-term and short-term maintenance, including inspections, lubrication, cleaning, and repairing damage. Planning regarding the number of maintenance activities to be effective and efficient. In the research results here, it is in accordance with what is determined by the theory that to carry out a maintenance system here they have a schedule and later they must hold a meeting beforehand to see the machine check list set.

Availability of spare parts, which in this case was found to be less reactive during the study. For instance, when a spare part is needed due to damage, the company does not keep machine parts in stock at the warehouse. Instead, they need to be ordered in advance if a malfunction occurs. It's actually something that needs to be considered for the long term, as the company should think more about how to handle potential breakdowns. If not thought about critically, it could disrupt maintenance during the electricity production process at the Jatiluhur Hydropower Plant. In both activities and reports, it turns out that the company itself conducts them to provide progress on how they maintain mini hydro machines to support the smooth process of electricity production at the Jatiluhur Hydroelectric Power Plant

Maintenance O&M Strategy

In the context of O&M strategies, operational activities here are continuous and require qualified staff and management to ensure that the power plant operates according to its intended functions. This is already in line with what is done by the Jatiluhur Hydroelectric Power Plant before conducting maintenance procedures, which involves the operational management flow at the hydroelectric power plant by implementing company-established Standard Operating Procedures (SOP) in the form of a weekly machine checklist. Furthermore, the O&M strategy here involves maintenance. Maintenance is an activity carried out to ensure that operations comply with procedures so that machines can achieve the intended goals and sustain required performance. This is already consistent with what the informant mentioned about maintenance being carried out according to schedule.

Subsequently, there will be a meeting with other parties who will conduct a weekly machine inspection to implement operational management at the hydroelectric power plant in accordance with SOP. However, regarding the issue of "match" here, it actually relates to the presence of damaged spare parts. The company should ideally have one or two spare parts as backups. However, it turns out that this is not being done by the company. In fact, with maintenance here, the company aims to prevent damage to the mini hydro machines. Nevertheless, the company cannot guarantee that the mini hydro machines will not break down if operated continuously. Despite frequent maintenance, it is essential for the company

to ensure the availability of spare parts for the machines and the appropriate oil for lubrication to maintain the mini hydro plant.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study aimed to analyze the maintenance quality of mini hydro turbine machines at the Jatiluhur Hydroelectric Power Plant, focusing on the maintenance process, reliability, and operational management strategies. The research revealed that the maintenance practices at the plant are generally in line with industry standards. The company follows a preventive maintenance approach, which includes regular weekly machine checklists, scheduled inspections, and maintenance every 2000 operating hours. This structured maintenance process is designed to ensure the smooth operation of the plant and reduce the risk of machine breakdowns.

However, despite these proactive measures, the study identified a significant issue regarding the availability of spare parts. The company does not maintain an adequate stock of essential spare parts, leading to delays in repairs when machines break down. This delay affects the overall reliability of the plant's operations and increases the risk of extended downtime, which can disrupt electricity production. Therefore, while the maintenance strategy is generally effective, the lack of immediate access to spare parts represents a critical problem that could undermine the maintenance quality and reliability of the power plant.

Recomendations

Based on the findings of this study, several recommendations are proposed to improve the maintenance quality and reliability at the Jatiluhur Hydroelectric Power Plant. First, it is crucial for the company to prioritize stocking essential spare parts for the mini hydro turbines. Currently, the lack of readily available spare parts leads to delays in repairs, which can significantly disrupt operations. By maintaining an adequate inventory of critical components, the plant can ensure quick and efficient repairs, minimizing downtime and improving overall system reliability. Additionally, the procurement process for spare parts should be optimized to reduce waiting times. Establishing partnerships with reliable suppliers and creating a faster supply chain could help address delays and ensure that the necessary parts are available when needed. Furthermore, regular reviews and updates to the maintenance procedures should be conducted to ensure that they remain effective and aligned with industry best practices. This includes adapting maintenance schedules based on machine performance and operational demands, ensuring that machines are maintained in optimal condition throughout their service life. Finally, investing in ongoing training for maintenance personnel is essential to keep the team well-prepared for handling complex repairs efficiently. By implementing these recommendations, the Jatiluhur Hydroelectric Power Plant can significantly improve the quality and reliability of its maintenance practices, ensuring a smoother and more efficient electricity production process.

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