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Article

Failure Analysis of Sludge Centrifuge Separator Machine Using Root Cause Analysis (RCA) at PT. X

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A B S T R A C T

The palm oil processing industry is expanding rapidly, as seen from the increasing land conversion for oil palm plantations. One critical machine in the production process is the sludge centrifuge separator, which functions to separate oil from sludge. At PT. X, a breakdown in this machine disrupted production and reduced the effectiveness of oil separation. This study aims to identify the causes of damage or failure in the sludge centrifuge separator machine. The research employs Root Cause Analysis (RCA) with a fishbone diagram as the analytical tool and proposes improvements using the 5W+1H approach.The results show that damage is caused by several factors. Human factors include operator negligence, lack of discipline, and inadequate supervision. Machine-related issues involve poor maintenance, leaks, insufficient inspections, bearing wear, and excessive friction. Material factors include the entry of metal pieces and small stones into the machine. Method-related problems stem from non-compliance with SOPs and insufficient training. Environmental factors include damp conditions, poor air circulation, oil spills, noise, and an unclean production floor.This research highlights the importance of regular maintenance, improved training, strict SOP implementation, and better workplace management to minimize machine failure and ensure optimal.

1. BACKGROUND

1.1 Introduction

Along with the development of the industrial sector, Indonesia has entered the Asian free trade area which creates competition between companies in the industry. Intense competition encourages each industry to manage its resources as optimally as possible. The goal is for the company to be able to produce high-quality products and services and always be available when needed. Thus, each industry is able to survive and compete with other industrial sectors. The company will make various efforts to satisfy consumers both at the price offered, the quality of the products and services owned, improve service to consumers, and fulfill demand with the accuracy and speed of delivery of goods. Fulfillment of product needs is very important for companies, because when needs are met it will affect consumer loyalty and increase company profits (Maharani & Sari, 2025). In increasing profits, the company will strive to optimize the production system implemented.

Indonesia is an agrarian country whose economy is largely dependent on the agricultural sector, because the majority of Indonesia's population works as farmers where the land is very suitable for farming activities. One agricultural sector that is growing quite rapidly is the palm oil industry. Indonesia is the world's largest producer of oil palm, because oil palm plants are an agricultural commodity that has a very high selling value (Rusba et al., 2023). The productive period produced by oil palm plants ranges approximately ± 25-30 years, after which oil palm plants will not produce Fresh Fruit Bunches (FFB) (Veronika et al., 2019). According to the Directorate General of Plantations in 2014, the area of oil palm plantations in Indonesia reached 11.4 million hectares with a production of 30.95 million tons of Crude Palm Oil (CPO). One of the provinces in Indonesia that has the most extensive oil palm plantation is Riau, with a land area of 2.3 Ha with annual production reaching 7.04 million tons of CPO (Veronika et al., 2019). Indonesia is one of the agricultural countries whose economy is largely dependent on the agricultural sector, because the majority of Indonesia's population works as farmers where the land is very suitable for farming activities. In this case, the palm oil processing industry is growing quite rapidly as evidenced by the large amount of land clearing for oil palm plantations.

Palm Oil Mill (PKS) is a place where fresh fruit bunches are produced on a large scale. Palm Oil Mill (PKS) has various processing capacities such as 30 tons/hour, 45 tons/hour, and 60 tons/hour. PT X is a company engaged in the palm oil processing industry.

The products produced are Crude Palm Oil (CPO) and Palm Kernel. In processing palm oil, the company has many major equipment to support its production process. One of the equipment that supports the smooth production process is the sludge centrifuge separator machine. The sludge centrifuge separator machine is one of the machines generally used to separate oil that still contains sludge. The sludge centrifuge separator machine is one of the most important components in palm oil processing, because if the machine experiences problems, the production process is disrupted, so that the oil separation process is not maximized.

PT X still often experiences breakdowns on the sludge centrifuge separator machine which hampers the production work process. Breakdowns on the machine have an impact on damage to spare parts on the machine in the production process, especially in the nozzle section which is caused by the entry of other particles such as stones and pieces of iron into the machine caused by a tear in the filter in the vibrating sludge so that the particles are not filtered and enter the filtering in the sludge centrifuge separator machine.

1.2 Research Purposes

The objective of this research is to determine the type of damage that occurs in the sludge centrifuge separator machine, and determine the factors that cause damage to the sludge centrifuge separator machine with Root Cause Analysis (RCA). In addition, this research will provide solutions to minimize the occurrence of damage to the machine.

2. LITERATURE RIVIEW

2.1 Sludge Centrifuce Separator

Sludge Centrifuce Separator is a machine that functions to collect oil that is still contained in the sludge centrifugally. The collected oil will be flowed back to the Crude Settling Tank (CST). Then, the remaining water will be discharged through the ditch while the sludge will be flowed to the waste disposal (sludge fit).

Figure 1. Sludge Centrifuce Separator Machine

2.2 Root Cause Analysis (RCA)

Root Cause Analysis (RCA) is a structured study that aims to find the underlying reason for a disturbance and find its root cause (Ito et al., 2022). Root Cause Analysis (RCA) also aims to identify a preventive measure needed to address the root cause (Ito et al., 2022). Recurring supply disruptions can only be avoided once the root cause is eliminated (Mahto & Kumar, 2008). The Root Cause Analysis (RCA) method helps solve business problems by identifying the root cause of a problem and proposing several corrective actions to reduce the intensity of the root cause of the problem (Varma & Lal, 2020). The analytical tool used by this research is using a fishbone diagram.

Fishbone diagram is a causal diagram used to show the relationship between the problem at hand and its possible causes, which generally helps identify the reasons behind defects, variations, or failures in a process (Gartlehner et al., 2017). This fishbone diagram provides a structured, qualitative approach to problem solving. Fishbone diagrams can help categorize the root causes of problems (Tantri et al., 2024). The next step, this research uses the 5W + 1H method as a proposed improvement. The 5W+1H method is an analytical approach to understand and describe a problem comprehensively. This method involves six questions to identify problems and provide general solution development (Putra & Nusraningrum., 2024).

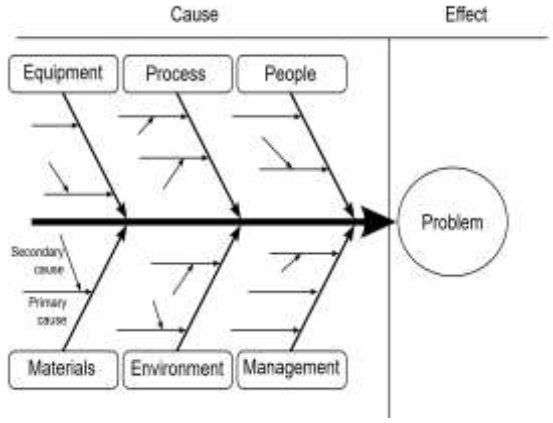

Figure 2. Fishbone Diagram (Gartlehner et al., 2017)

3. METHODOLOGY

The object of this research was carried out at the refining station. This research uses primary data and secondary data. Primary data in this research is data from PT X through field observations and interviews directly with the company. Secondary data refers to a literature review that provides information on the use of the Root Cause Analysis (RCA) method.

This research method uses Root Cause Analysis (RCA). The analytical tool used in this research is a fishbone diagram. Fishbone diagram is used to determine the root cause of damage to the sludge centrifuce separator machine.

The next step is to analyze using (5W+1H). This method consists of several questions to be answered: what, who, when, where, why, and how (Ismail, 2024).

4. RESULTS AND DISCUSSION

The causes of damage based on the fishbone diagram used in this research are humans (labor), machines, materials, work methods, and the surrounding environment.

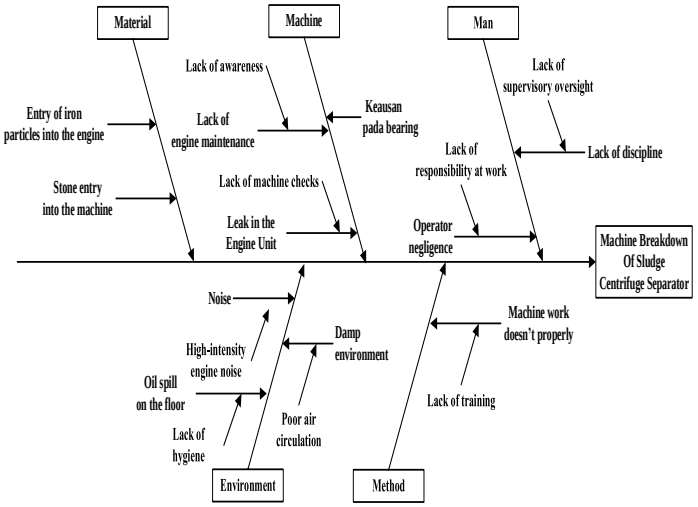

Figure 3. Fishbone Diagram
Machine Breakdown of Sludge Centrifuge Separator

1. Human Factors

Operator negligence can cause machine damage due to lack of responsibility and awareness at work. This is caused by a lack of supervision and motivation from superiors or managers. This lack of responsibility and awareness can be interpreted because the operator is not fit in a physical and psychological state such as the operator is tired, tired, or sick which can cause awareness in working to decrease and cannot work as much as possible. Psychological conditions that are not good such as operators having internal problems that are brought into the scope of the company so that the operator cannot concentrate on the work being done or the operator is not too suitable for the environment in the company. Then there are still operators who lack discipline and do not understand the standards according to the SOP so that it triggers damage to the machine.

2. Machine Factors

The cause of damage to the machine is the lack of maintenance on the sludge centrifuge separator machine. Generally, each machine has a maximum usage limit for its operation, the older the engine age, the more the engine performance will decrease. With the older the age of use of the machine, it is necessary to carry out maintenance on the machine regularly. Then, bearing wear often occurs. Bearings are components that function to support the shaft so that when rotating it does not experience excessive friction. Bearings must be strong enough so that the shaft and other engine components can work optimally.

In this case, the long bearing usage period results in the erosion of the ring due to lack of lubricant. Sometimes, frequent leaks in the engine unit make the engine performance not optimal and hamper the palm oil processing process. This is due to the lack of regular checking of the centrifuge sludge separator machine.

3. Material Factors

The main cause of material factors is that there are often pieces of iron or stones that enter the machine. This results in the screening process in vibrating sludge often torn on the filter so that the remaining pieces of iron and stones enter the sludge centrifuge separator machine which will ultimately interfere with the production process. Thus, operators need to check regularly for component particles that enter the machine.

4. Method Factor

The main cause of the material factor is that the machine performance is not carried out in accordance with the Standard Operating Procedure (SOP). The SOP contains good and correct work procedures in accordance with the applicable provisions in the company. The use of machines that are run continuously will result in a decrease in the performance of the machine, so that the machine will be damaged faster because it works beyond the limits of the machine's capabilities. One of the main causes of the use of machines that exceed their usage limits is due to the lack of training to operators about the procedures and maximum use of the sludge centrifuge separator machine.

5. Environmental Factors

The environment is also very influential in the durability and damage of machines such as a humid environment due to the many water pipes that leak and hit the sludge centrifuge separator machine. Leaking pipes if continuously not handled, will make the machine corrode and result in reduced engine life resistance. A humid environment is also caused by poor air circulation, such as a lack of air ventilation so that the room becomes stuffy and uncomfortable to work in. This, of course, will have an impact on various problems with worker health and can reduce worker productivity. In addition, there are often oil spills on the floor which cause the floor to become slippery. This can result in work accidents, such as employees easily slipping or falling. Another cause of environmental factors is noise. Noise caused by machinery can cause discomfort for workers.

6. Proposed Improvements using 5W+1H

This stage analyzes improvements to damage or failure of the sludge centrifuge separator machine using the 5W+1H method. The use of 5W+1H can generally analyze what happened (what), why it happened (why), where to start repairs (where), when to be repaired (when), who repairs (who) and how the repair steps (how) (Ismail, 2024).

Table 1. Improvements 5W+1H sing 5W+1H

Indicator	What	Why	Where	When	Who	How
Man	• Operator lack of discipline • Operator negligence	• Lack of supervision from superiors • Lack of responsibility at work	The improvement plan was carried out on the process floor at the refining station	Conduct briefings and counseling every morning before work	Process Assistant	The process assistant supervises the operators and conducts briefings every morning and ensures the work is done properly according to the SOP.
Machine	• Lack of engine maintenance • Leakage in the engine unit • Bearing wear	• Lack of awareness of the importance of machine maintenance • Lack of machine checking • Excessive bearing friction occurs	The improvement plan was carried out on the process floor at the refining station	When the engine performance starts to decline or is not good when operated	Maintenance Assistant	The company must carry out routine maintenance, at least twice a week, and check the machine regularly for each day.
Material	• Entry of iron components into the machine • Entry of stones into the machine	• Lack of checks on materials	The improvement plan was carried out on the process floor at the refining station	During palm oil processing	Maintenance Operator	Operators should always perform regular checks during the production process.
Method	• Machine work doesn't properly	• Lack of training provided by the company	The improvement plan was carried out on the process floor at the refining station	During palm oil processing	Maintenance Assistant	The company needs to provide training once every 3 months to improve the operator's ability and experience in using the machine.
Environment	• Damp environment • Oil spills on the floor • Noise	• Poor air circulation • Room cleanliness is not maintained • The sound generated from the use of the machine is high frequency and high intensity sound	The improvement plan was carried out on the process floor at the refining station	During palm oil processing	Maintenance Operator	• The company needs to increase air ventilation. • Keep the production floor clean. • Provide ear muffs to minimize noise.

5. CONCLUSION

The conclusions that can be drawn by researchers from the results of research conducted based on the cause and effect diagram (fishbone diagram) of the factors causing damage to the sludge centrifuge separator are Man (human), which consists of operator negligence caused by lack of responsibility at work, operator lack of discipline caused by lack of supervision of superiors. Machine, which consists of lack of machine maintenance, leaks in the engine unit caused by lack of machine checking, wear on bearings caused by excessive use of friction on bearings. Material, which consists of the entry of iron components and small stones into the machine. Method, which consists of the performance of the machine not according to the SOP caused by the lack of training provided by the company. Environment, which consists of a humid environment caused by poor air circulation, oil spills caused by lack of cleanliness of the production floor, noise caused by machine noise with high frequency and high intensity.

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