Analysis of Sludge Separator Using Failure Mode Effect Analysis (FMEA) and Reliability Block Diagram (RBD)

M Sabri¹, Bayu Ramadhan², Luthfi Ari Satya³, Ikhwansyah Isranuri⁴, Faris A M Sabri⁵
¹,²,³,⁴,⁵Computational & Experimental System Mechanics Research Centre
Mechanical Engineering Department
Universitas Sumatera Utara, Medan Indonesia
Email: m.sabri@usu.ac.id & sabrimesin@gmail.com

Abstract. The process of palm oil purification through Sludge separator serves to separate sludge and palm oil. This is an important process at the palm oil mill. The purpose of this research was to identify failure probabilities and reliability of sludge separator using failure mode and effect analysis (FMEA), and reliability block diagram (RBD). It was found that the sludge separator suffered severe damage and also frequent failure, the reliability before maintenance improvement is 17% and after applied some maintenance procedure correction achieved reliability 84.48%.

1. Introduction
Palm Oil Factory (POF) is a factory that process oil palm with certain methods and rules to produce Crude Palm Oil (CPO) and Palm Kernel Oil (PKO). In the processing process, the company always seeks to optimize the yield of CPO and PKO. One of the systems management applied to get the optimal amount of rendemen is to suppress the loss of oil (oil losses) on CPO and loss Kernel (PKO losses) during the process.

In the production process, seeks to optimize the yield and improve product quality. Thus, the POF can also ensure that the loss of oil (oil losses) occurs to a minimum. The loss of oil usually occurs at some point in the work stations on the production line. The average value of losses occurring in the period production is empty bunches of 2.43%, screw press is in 5.26% fiber, 0.78% nut and on final draft (final sludge) 0.8% [1].

From the location points of the oil losses occurrence, the company provides a default or maximum limit loss. In practice, the need for an analysis of the loss of CPO to determine whether the percentage loss of CPO is still on the standards set by the company and to determine the effectiveness of the tools contained in stations where the occurrence of oil losses so that in the end can suppress the loss of CPO.

2. Process of Palm Oil Clarification System
After passing the treatment of pressing then carried out the process of purification of palm oil. In this process the oil temperature is maintained from 85 - 90 °C [2]. The steps to be done at the clarification station from the sand trap tank to the tank can be seen in Figure 1 below.
3. Production Process and Types of failure Identification

Based on the observations regarding the process of oil palm refining, a description of the failure forms for each process - the process that can be seen in the table below:

| No | Process Functions            | Description                                                                                           |
|----|------------------------------|-------------------------------------------------------------------------------------------------------|
| 1  | Sand Trap Tank               | serves to trap sand and dirt contained in oil                                                          |
|    |                              | serves as a filter of dirt or solid objects (sand, shell, nut) and consists of several filtration rates of 30 and 40 mesh |
| 2  | Vibrating Screen             | serves as a reservoir of oil that has been filtered by vibrating screen before transferred to CST       |
| 3  | Crude Oil Tank               | serves to keep the flow of oil in order not to fluctuate before entering CST                             |
| 4  | Balance Tank                 | serves to separate the pure oil from crude oil that still contains water and solids follow the principle of gravity |
| 5  | Continuous Settling Tank     | serves to heat sludge for easy separation based on specific gravity                                    |
| 6  | Draft Tank                   | serves as a sludge flow regulator that will enter into the sludge separator                             |
| 7  | Brake Minor                  | serves to get oil that is still in sludge                                                              |
| 8  | Sludge Separator             | serves as a reservoir of oil before entering the oil purifier                                          |
| 9  | Decanting Basin              | serves as a reservoir of oil before entering the oil purifier                                          |
10 Oil Tank serves to separate the oil based on specific gravity, this tank is equipped with heating pipes to heat the oil

11 Oil Purifier serves to reduce levels of impurities and moisture content that is still in the oil

12 Vacuum Drier serves as an apparatus to reduce the maximum moisture content of CPO in the form of a cylindrical tube

13 Storage Tank serves as a final CPO storage

Based on table 1, then the data obtained type of failure that occurs in each process of oil purification, as for the types of failure can be seen in the table below:

| No | Process Functions          | Types of Failure                                      |
|----|----------------------------|-------------------------------------------------------|
| 1  | Sand Trap Tank             | Leak in the tank<br>Sand and dirt accumulate in the bottom of the tank |
| 2  | Vibrating Screen           | Screen damaged / torn<br>broken rubber screen         |
| 3  | Crude Oil Tank             | Leak in the tank<br>distribution pipes porous         |
| 4  | Balance Tank               | Leak in the tank<br>blockage of distribution pipes    |
| 5  | Continuous Settling Tank   | porous pipe distribution and elbow<br>Leak in the tank<br>damage of gate valve |
| 6  | Draft Tank                 | dirt in the tank                                      |
| 7  | Brake Minor                | damage of gate valve                                 |
| 8  | Sludge Separator           | bearing is damaged / broken<br>heavy spin and a rocking bowl<br>leakage on the seal ring<br>Nozzle broken and clogged |
| 9  | Decanting Basin            | bearing pump is broken<br>Leak in the tank            |
| 10 | Oil Tank                   | Leak in the tank                                      |
| 11 | Oil Purifier               | bearing is damaged / broken<br>leakage on the seal ring<br>Friction pad failure |
| 12 | Vacuum Drier               | dirt in the tank                                      |
| 13 | Storage Tank               | dirt in the tank                                      |

Trough Risk priority numbers (RPN) of FMEA process indicated there are 5 components have high concurrency and severity level namely bearing, seal ring, nozzle, bowl disc and worm gear.
4. Reliability Block Diagram (RBD)

To find the reliability value, we retrieved some maintenance data from the palm oil factory. The data identify any damage breakdown time. Four components with high failure occurrence are bearing, seal ring, nozzle, and bowl disc.

Failure rate of four components are:

\[ \lambda_{\text{bearing}} = 0.003703, \lambda_{\text{seal ring}} = 0.001481, \lambda_{\text{nozzle}} = 0.001111, \lambda_{\text{bowl disc}} = 0.001851 \]

Then the value of reliability on Sludge separator is \( R_{sys} = 17\% \)

At the reliability value of each component on the sludge separator, it can be concluded that the sludge separator is unreliable and may jeopardize the production of the palm oil mill. The most failure components influenced by maintenance footprint. The Sludge Separator said reliable when the achievement optimally and minimize the failure.

Some corrections are used to improve the reliability of the sludge separator, ie.

- Using components under required operational conditions.
- Following Standard Operational Procedure (SOP) applies in the company.
- Using material that has been specified in the manual book.
- Using the failure detection tool
- Discipline of the operators on duty in the field
- Assertiveness of supervisors to operators
- To reduce the number of failures then used CBM (Condition Based Maintenance).

The value sought will be obtained based on some operational and maintenance data from the production line. The data collected is a record of the damage that has occurred, and the length of failure can be overcome. Then determined how long the machine works, the author assumes 2000 hours of work or 3 months of work. After that determine the components we will calculate reliability, the author takes five components namely bearing, seal ring, nozzle, bowl disc, and worm gear. The author takes the five components mentioned earlier because the component is often damaged and also the component is very critical.

The formula to calculate the value of such reliability is

\[ \text{MTBF} = \frac{\text{Operating Time}}{\text{Failure}} \]

MTBF (Mean Time between Failures) shows how reliable the equipment / machine operation is in generating the product, viewed from the average time the equipment / machine will function starting from one repair / damage to the next repair / damage. Operating Time is machine time works and failure is how many failures occur during the operating time.

To determine the failure rate on a component then it can be calculated as follows:

\[ \text{MTBF bearing} = \frac{2000 \text{ hours}}{12} = 166 \text{ hours}, \text{MTBF seal ring} = \frac{2000 \text{ hours}}{9} = 222 \text{ hours}, \]

\[ \text{MTBF nozzle} = \frac{2000 \text{ hours}}{6} = 333 \text{ hours}, \text{MTBF bowl disc} = \frac{2000 \text{ hours}}{1} = 2000 \text{ hours} \]

Counting Failure Rate (\( \lambda \) - lambda) used the following formula: \( \lambda = \frac{1}{\text{MTBF}} \)
Figure 2. Failure rate components

Based on 12 hours of operation, the reliability of each components can be calculated and shown in the following Reliability Block Diagram

![Reliability Block Diagram](image)

Figure 3. Reliability of each component

The Reliability of Sludge Separator is 84.48% based on 12 hours of operation.

5. Conclusion
The Reliability of Sludge Separator depend on proper planning and good practices of operational and maintenance implementation. Standard Operational Procedure designed by management will guide the optimal functions and improve machines life.

      The previous reliability of sludge separator only 17% and after modified some Operational Procedures and Maintenances the reliability achieved 84.48% based on 12 hours operation. It shows a strength correlation between Operational procedures and Maintenances and overall effectiveness of Sludge Separator functions. The study shows that the reliability before maintenance improvement is 17% and after applied some maintenance procedure correction achieved reliability 84.48%.

Acknowledgement:
The data presented and analyzed in this report were collected during research “Reliability Analysis Of Sludge Separator On Palm Oil Processing” the financial supported by TALENTA Universitas Sumatera Utara Research No. 2590/UN5.1.R/PPM/2017 date 16 March 2018.

References
[1] Vera Devani dan Marwiji, 2014, Analisis Kehilangan Minyak Pada Crude Palm Oil (Cpo) Dengan Menggunakan Metode Statistical Process Control, Jurnal Ilmiah Teknik Industri, Vol. 13, No. 1 Juni, ISSN 1412-6869.
[2] B.O. Abikoye, S.R Ogblechi, T.O Okoronkwo, A.O obande , E. Ataga, 2014, Comparative Studies of Palm Oil Separation Techniques For Improved Oil Recovery, International Journal of Agriculture and Crop Sciences. Available online at www.ijagcs.com, IJACS/2014/7-14/1447-1451, ISSN 2227-670X ©2014 IJACS Journal

[3] Wuttichai Seephueak, Wanwisa Ngampongsai and Pin Chanjula, 2011, Effects of palm oil sludge in concentrate on nutrient utilization and rumen ecology of thai native cattle fed with hay, Songklanakarin J. Sci. Technol. 33 (3), 271-280, May - Jun.

[4] Zawawi Daud, Ab. Aziz Abdul Latiff, Nur Adila Ab. Aziz, Halizah Awang, 2013, Treatment of Palm Oil Mill Effluent by Electrocoagulation with Aluminium Electrodes, Australian Journal of Basic and Applied Sciences, 7(2): 457-463, ISSN 1991-8178.

[5] Yahaya S. Madaki, Lau Seng, 2013, Pollution Control: How Feasible is Zero Discharge Concepts in Malaysia Palm Oil Mills, American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-10, pp-239-252 www.ajer.org.

[6] J.C. Igwe and C.C. Onyegbudo, 2007, A Review of Palm Oil Mill Effluent (Pome) Water Treatment, Global Journal of Environmental Research, 1 (2): 54-62, ISSN 1992-0075, © IDOSI Publications.

[7] Wong, P.W., Sulaiman, N.M., Nachiappan, M. and Varadaraj, B., 2002, Pre-treatment and membrane ultrafiltration using treated palm oil mill effluent (POME), Songklanakarin J. Sci. Technol., 24(Suppl.) : 891-898