Determination of component categories using logic tree analysis

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Abstract. Sterilizer machine plays important role in crude palm oil. Component machine has an important function to determine a maintenance based on the failure. Component failure is used to determine a correct maintenance. The problem faced by the company today is the high downtime of the sterilizer making machine causes the sterilizer production process to be disrupted. Machine breakdown around 35.66 hours/month. Machine failure analysis using the Failure Mode and Effect Analysis (FMEA) method and the Logic Tree Analysis (LTA) method. The LTA method used to determine priority to each failure mode and to review functions and malfunctions produce categories A (evident), B (safety), C (Economic Problem) and D (Hidden Failure) with the largest percentage for category B. The FMEA method analyse the factors causing component failure and its effect on overall system function by giving a Risk Priority Number value (RPN) based on severity, occurrence, and detection. The FMEA method produces the highest RPN values for 5 components namely IGBT, Mosfet, Bearing Bushing, Rool Former, and V-Block. LTA method shows that B Category has the largest percentage of component category. The result of this research is to categorize component failure and determine the Risk Priority Number for sterilizer machine.

1. Introduction
At this moment, most companies tend to outsource part of their production process to other parties. For companies to do production for the other companies, the accuracy of lead time and quality assurance is important. This condition requires the company to ensure that all tools/production machines function optimally without disturbances, so that the target of production quantity and product quality meet the target [1]. The smooth process of production is influenced by several aspects such as human resources and the conditions of the production facilities owned, in this case the production machinery and other supporting tool/equipment. Production tool is always in good condition capable to provide optimum performance in supporting the smooth production process [2].

The rapid development of the industrial world increased the competition in the industrial world, so that companies compete to improve the quality and quantity of production. Machinery and production equipment are the most important elements in supporting the continuity of production in a manufacturing company. Scheduled maintenance is very necessary for production machines in the company, because production machines and equipment are experiencing the failure. Failure results in the hamper and causes production disturbance. The effort of a company in increasing the production quantity is by extending the operation of industrial facilities and reducing company expenses caused by failure to production facilities. One of them is machine failure [3]. Machining is accepted removal process used to manufacture components with complicated shapes and profiles [4]. Component is one of the machine part. The failure may obtained by manufacturing, assembly or operation that are not based on the design [5].

Companies that produce machinery and equipment in the oil palm industry often experience engineering prevents the smooth production process. For the continuity of the production process the
company is supported by a machine’s quantity and equipment interacts with each other to achieve optimal productivity. Pressing, digester and sterilizer are few machines often experiencing a damage/failure. CPO is obtained from the fruit of the palm oil mesocarp which has undergone several processes, namely sterilization, pressing and clarification [6]. Sterilizer machine plays important role to transform Fresh Fruit Bunches (FFB) to Crude Palm Oil. Currently, the problem in production often occurs in companies is the non-operation of production activities on the sterilizer production floor due to failure to the production machine. One approach to minimize failure is the Logic Tree Analysis (LTA) method. Failure category consequences determination usually caused by failure modes performed by LTA[7]. Logic Tree Analysis is carried out critically analysis of failure mode consequences has been set at the FMEA stage. It is resulted an analysis to provide four of consequence categories. Four categories are A, B, C, D obtained based on three basic questions of LTA, such as Evident, Safety and Outage. LTA result will become one of the variable input for RCM Decision Worksheet [8]. Four important things in LTA are evident, safety, outage and category. Evident indicates which the operator knows that under normal conditions a system interruption has occurred. Safety indicates which the failure mode is causing a safety problem. Outage indicates which the failure mode has caused all or part of the machine to stop. The category is categorization obtained after answering the questions raised [9]. Factors analysis using the FMEA method causing in component failure. The FMEA method is a tool suggestion. Documenting and risks impact must be a key part of the supply chain management and managers must have access to readily available risk information to make decisions. FMEA is a method used to collect such information. The FMEA method related to risk management decisions [10][11]. Three main variables which are, Severity, Probability, and Detection is the main factors in FMEA mode calculation. Severity, Probability, and Detection are then evaluated by FMEA. The multiplication of those three factors determines and affects the calculation of the Risk Priority Number (RPN) [12].

Research to overcome the problem of machine failure has been done before. The study was conducted by Jigar Doshi in an automobile industry company. The FMEA method was applied with the use of the Cross-Functional Team (CFT). CFT used to identify the potential failure modes and effects and impact on Continuous Quality Improvement in overall. The result of FMEA at four companies reveals that there is a scope of improvement in the manufacturing process. Implementation of FMEA method shows improvement and the definite signs of continuous improvement and give the effect in-process quality and product. The FMEA implementations had reduced the quality rejections around 3% to 4% in the company [13].

Studies presented a research using LTA method is to determine the probabilistic tsunami hazard analysis to the Japanese coasts. Logic Tree Analyses is applied to categorize causes of tsunami source zones, size and tsunami genic earthquakes frequency, fault models, and standard error of estimated tsunami heights. Numerical simulation was used to estimate the median tsunami heights. Interpretations determination using a questionnaire survey for tsunami and earthquake experts to present error of estimated value based on historical data. Result of tsunami hazard curves were illustrated for the coastal sites, and uncertainty in the tsunami hazard was displayed by 5-, 16-, 50-, 84- and 95-percentile and mean hazard curves [14]. Another study presented research using the LTA method is in the power plant industry. The LTA method is used to categorize Automatic Transfer Switch machine components. There are eleven components. Analysis using the LTA method obtained that preventive maintenance recommendation of time interval selection in preventive implementation. Preventive implementation includes periodic inspection (per two weeks) to Lightning Arrester, Condition Monitoring (per month) for upcoming Terminal, Incoming Genset Terminal, Outgoing MDP Terminal, Quarterly (per 3 weeks) for Crank Relay, Fuel Relay and alarm relay [15]. Based on some previous research, this paper will describe the use of Failure Mode and Effect Analysis with Logic Tree Analysis to classify the components category based on potential failure. This classification aims to facilitate decision making in implementing machine maintenance systems.
2. Methodology
There are various research methods such as experiment, case study and action research. In this study case study is used as a research method. The study was conducted in one of the palm oil industry in the Medan city which produces equipment and machinery. The objects examined in this study were the components of the sterilizer machine. The study stage began with observations to observe and to see the real industry condition. After observation stage, the next topic and research objectives are determined according to the conditions on the production floor. Then do the data collection needed to overcome machine failure occurs. Data collected in the form of machine components, failure mode, and failure cause. The data collected is then processed using the FMEA method. The FMEA method is carried out to determine the component failure factor and its effect on the overall system function based on the highest Risk Priority Number (RPN) value. The RPN formula can be obtained with the formula below:
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RPN = \text{Severity} \times \text{Occurrence} \times \text{Detection}
\]
Furthermore, each machine component is given a category based on 4 categories namely A (Safety Problem), B (Outage Problem), C (Economic Problem) and D (Hidden Failure) using the Logic Tree Analysis method. The preparation of the Logic Tree Analysis LTA has the aim to give priority to each failure mode and review and function, malfunction so that the failure mode status is not the same. Classification based on Logic Tree Analysis is done by brainstorming and questionnaires distribution based on purposive sampling.

3. Result and Discussion

3.1. FMEA analysis
Based on FMEA analysis on the company’s sterilizer production process, it will be known the causes of component failure and its effect on the overall system function so that effective machine component maintenance solution can be found. FMEA analysis also can be obtained the value of RPN (Risk Priority Number) for each component so that the maintenance can be focused on the main components that have the highest priority value in the production process system. RPN values for each component that have been sorted by priority can be seen in Table 1.

| No | Component           | RPN |
|----|---------------------|-----|
| 1  | IGBT                | 340 |
| 2  | Mosfet              | 260 |
| 3  | Bearing Bushing     | 260 |
| 4  | Tool Former         | 180 |
| 5  | V-Block             | 120 |
| 6  | Scriber             | 64  |
| 7  | Coil Feeding        | 64  |
| 8  | Solenoid Valve      | 64  |
| 9  | Swirl Baffle        | 48  |
| 10 | Fan                 | 48  |
| 11 | T-Bolt              | 42  |
| 12 | Nozzle              | 42  |
| 13 | Transformer Switching | 40    |
| 14 | Drill Chuck         | 40  |
| 15 | Shield Cup          | 32  |
| 16 | Solenoid Fuel       | 28  |
Based on the calculation of RPN, obtained 5 components with the highest RPN values, namely IGBT, Mosfet, Bearing Bushing, Tool Former, and V-Block.

3.2. Analysis of component categories based on LTA method
Based on LTA analysis, it can be obtained each failure category of each machine component. The categorization of components is based on several considerations, including:
1. A Category (*Safety problem*) components cause safety disturbances to the operator and the environment.
2. B Category (*Outage problem*) components cause failure in the whole or part of the system.
3. C Category (*Economic problem*) components cause failures in whole or in part of the system but cause losses to the company due to reduce component functions.
4. D Category (*Hidden failure*) the component which function failure is not recognized and is difficult for the operator to detect because it is hidden from the operator's vision.

The category at each components can be seen at Table 2.

**Table 2. RPN of machine component failure.**

| No | Component       | Category |
|----|----------------|----------|
| 1  | IGBT           | B        |
| 2  | Mosfet         | B        |
| 3  | Bearing Bushing| B        |
| 4  | Tool Former    | B        |
| 5  | V-Block        | B        |
| 6  | Scribe         | B        |
| 7  | Coil Feeding   | B        |
| 8  | Solenoid Valve | C        |
| 9  | Swirl Baffle   | B        |
| 10 | Fan            | B        |
| 11 | T-Bolt         | B/D      |
| 12 | Nozzle         | B        |
| 13 | Transformer Switching | C  |
| 14 | Drill Chuck    | B/D      |
| 15 | Shield Cup     | B        |
| 16 | Solenoid Fuel  | B        |

Based on the table above, it can be seen that Category B has the largest quantity. The percentage recapitulation of component failure categories obtained at the LTA stage can be seen in Table 3.

**Table 3. The percentage recapitulation of machine component categories.**

| Category | Component Quantity | Percentage (%) |
|----------|--------------------|----------------|
| A        | 0                  | 0              |
| B        | 12                 | 75             |
| C        | 2                  | 12.5           |
| D        | 0                  | 0              |
Based on the recapitulation of machine component categories, it can be seen that category B has the largest percentage. This means that 75 per cent of components can cause failure on the whole or part of the system.

4. Conclusion
This paper is expected to give the advantage for the company. The company suggested to do preventive maintenance of sterilizer machine at each component based on category determination. The paper focus on sterilizer components. This study in palm oil industry is useful to prevent components failure and gives the impact of income maximization in the future.

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