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Data-Based Maintenance Strategy Analysis Using Operational Excellence Approach in Engineering Asset Management

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Abstract: Traditionally, selecting maintenance strategy is based on reliability or cost. In this paper, a further discussion of redesigning the maintenance strategy is presented. The process of redesigning the maintenance strategy applies reliability centered maintenance approach and the result is analyzed further with the approach of operational excellence as presented in the structure of operational excellence. The output from the reliability centered analysis is three recommendations related to maintenance strategy. Then, the recommendations are aligned with the structure of operational excellence. The main conclusion of this study is the operational excellence approach is capable to assist the process to redesign the maintenance strategy by providing the decision maker with a guidance to improve productivity.

Keywords: Operational Excellence; Maintenance Strategy; Asset Management

1. Introduction

The purpose of implementing operation excellence in an organization is to continuously pursuit of improvement in all dimensions of management system [1]. One of the main dimensions of management system in an organization is maintenance system. Maintenance itself has evolved in the last decades, from being necessary evil in 1940's to corporate partnership in early 2000's and recently maintenance is integrated stages in asset management. So, it is argued that the appropriate implementation of maintenance system contributes to the perfection of operational excellence. According to [2], there are three pillars of operational excellence, one of them is the methods and philosophy pillar. The pillar includes maintenance as one of its elements as shown in Fig. 1. The three pillars are developed on the foundation of Quality Management System and Key Performance Indicators and used to support the process to achieve the goals of operational excellence (e.g. improved profitability, reduced waste and process variation, customer satisfaction). The successful implementation of operational excellence can be proved by its result: lower operation cost and risk, also creates value for customers and shareholders [3]. In the area of maintenance, lower risk and cost, and the value creation for the customers and shareholders can be achieved by implementing asset management. Asset management is coordinated activities to realise the value of asset in order to achieve the objective of organisations and the requirement and expectation of the stakeholders. It involves the balancing of cost and risk against the asset performance [4]. Thus, capital intensive organisations are encouraged to implement asset management system based on ISO 55000 and use operational excellence approach to create more competitive advantage. In other words, the organisations' operation excellence can be attained through asset management system.

In this paper, a process to redesign maintenance strategy is discussed. There are numerous researches in designing or redesigning maintenance and period of replacement as in [5-9]. However, research on redesigning maintenance strategy with operation excellence approach is very limited. This paper presents a case study on redesigning

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maintenance strategy with the asset management framework and the structure of operational excellence. The case study represents a maintenance strategy in a sugar mill manufacture in Yogyakarta Indonesia.

Fig. 1 - The Structure of Operational Excellence as in [2]

The company produces high quality of White Crystal Sugar. The daily capacity is approximately 250 tons of sugar or approximately 40,000 tons annually. It should be noted that the company only operates six months in a year, between May to October. In the process, several types of machine are used, such as: milling machines, refining machines, evaporation machines, and purification machines.

According to a preliminary study using risk management framework in [10], it is identified that the highest risk in the production process is machine failure. This risk has high level of likelihood and high level of severity. Referring to the previous information that the daily capacity of the factory is 250 tons and the factory runs for 24 hours daily and 7 days a week, every one-hour of machine failure generates loss as much as 10.41 tons of sugar or 173.61 kilogram every minute. To deal with this issue, the management should consider redesigning the maintenance activities to reduce the length of machine failure. One alternative suggested to re-design the maintenance activities is to apply reliability-centered maintenance (RCM). RCM is a systematic process used to determine what activities should be performed to ensure that the asset may fulfil its level of service [11]. One of RCM components is preventive maintenance. According to [12], the preventive maintenance is a scheduled maintenance, generally on a periodical basis, where a set of maintenance tasks such as inspection and repair, replacement, cleaning, lubrication, adjustment and equality are carried out.

To design the preventive maintenance task and schedule, a reliability analysis of component needs to be conducted. Reliability is defined as probability that a component or system will perform a required function for a given period of time when used under stated operating conditions [12]. Some organisations consider using CMMS (Computerised Maintenance Management System) in order to manage the maintenance task and schedule. The impact of application of CMMS in organisation has been observed by [13]. The result of the research indicates that the application of CMMS can support OPEX, however in some cases it is expensive and unaffordable.

2. Review of Literature

Operational excellence is a philosophy of organisation on continues improvement throughout the organisation in order to meet the customer expectation, empowering employees, and reach the optimum state of the existing process within the business process. The main idea of operational excellence is creating the operations lean all the way. In [3], operational excellence defined as "the execution of the business strategy more consistently and reliably than the competition". The definition leads to an interpretation that operational excellence focuses on the sustained and disciplined delivery of the processes that leads to excellence operations. Operational excellence can be applied in many levels of organization, from department level to top management. An example of implementation of operational in departmental level can be found in [14] while in corporate level can be found in [15].

The implementation of operational excellence philosophy in maintenance management and maintenance strategy is relatively new as in [16]. To deal with this matter, the framework used to select the maintenance strategy is reliability centered maintenance (RCM) as presented in [17]. There are three phases of RCM:

1. Identification of maintenance significance items (MSI),
2. Assigning Preventive Maintenance according to MSI, and
3. Implementation and renewing the Preventive Maintenance Tasks.

In [17], those three phases can be presented in a framework of Reliability and Risk Centered Maintenance (RRCM) as shown in Fig. 2.

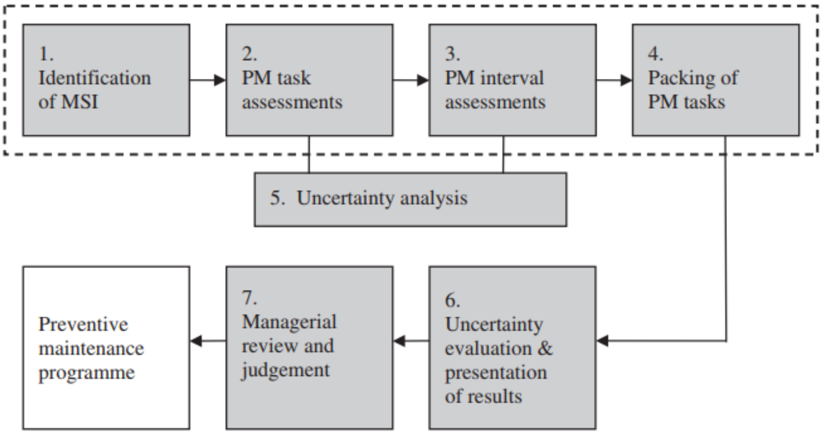

Fig. 2 -RRCM Framework in [17]

In the Fig. 2, boxes number one to four represent the process in phase 1 and 2. The rest of the boxes in Fig. 1 describe the process in phase 3. The process in phase 3 includes uncertainty analysis that might happen during the RRCM analysis. The result of the uncertainty analysis should be consulted to the management to design a preventive maintenance program.

3. Research Method

The object of this study is scrapper component in the rolling machines of the sugar milling manufacturer company in Yogyakarta, Indonesia. The main reason of selecting this component is because based on a preliminary study, the rolling machines contributes approximately 65% of the total number of machines downtime in 2017 production season. One of the critical components in the rolling machines is scrapper with 65 time of failure. In this research, six main steps to determine the optimum maintenance strategy are set. The steps are:

a. Failure Data Collection and Analysis

This step includes the activities of collecting failure data of the machines and its components. Then, the data is filtered and sorted as necessary. From this step, the critical component and machine can be determined.

b. Trend Analysis

Then, the data from step a is plotted into graphs. There are two kind of data plotting used: trend plotting and scatter plotting. The cumulative time between failure data and cumulative number of failure data are used in trend plotting to determine a specific trend occurs on the data. The scatter plotting uses time between failure data to find a possible trend on the time between failure. If the trend is found, a Non-homogenous Poisson Process Test is required.

c. Fit the Distribution and Goodness of Fit Analysis

If there are no trend found from step b, a statistical analysis is performed to find the distribution of the data. The goodness of fit analysis is employed to determine the distribution of the failure data.

d. Mean Time to Failure and Reliability Calculation

After the distribution is determined, the mean time to failure and reliability of the component calculated based on the selected distribution.

e. Determining Optimum Maintenance Interval

A simple model is developed to find whether the suggested maintenance strategy can improve the reliability of the component.

After the result from the Reliability Centered Maintenance is obtained. Several recommendations are proposed based on this result combined with the approach of operational excellence presented in Fig. 1. The recommendations could be related to the KPI, methods, culture, or tools in the maintenance to support the process of achieving the goal of operational excellence.

4. Result and Discussion

The first stage of the data collection in this research is to find out what is the critical component that contributes to the highest frequency of downtime. The downtime data from the company is collected and presented in a pareto chart as shown in Fig. 3.

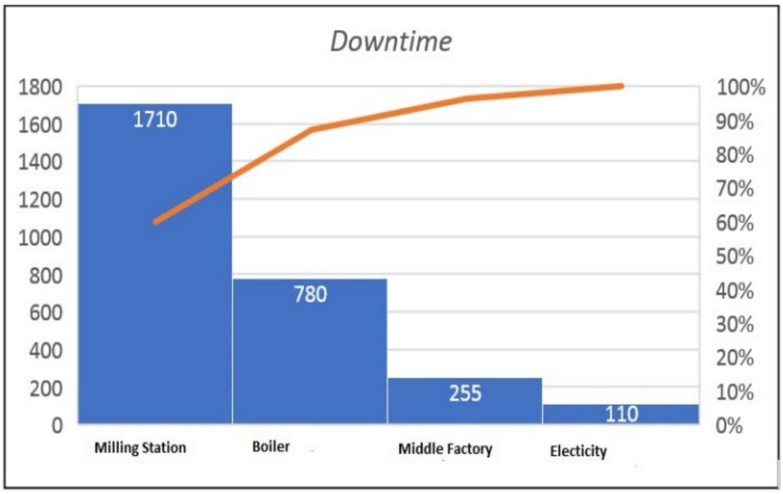

Fig. 3 - Pareto Chart for Downtime

From the Fig. 3, the highest number of downtimes is from the milling station. It contributes approximately 65% of all machine downtime in the factory. Then, the study is focused on the critical component in the milling station and it is found that the critical component in the milling station is the scrapper. The scrapper failed 63 times during the operational period of the plant and is the highest frequency of failure among other components in the milling station. Hence, this component is determined as the critical component and will be observed further. Based on the steps mentioned in research method, after the data is collected then the data is plotted into a trend plotting and scatter graph as shown in Fig. 4 and Fig. 5 accordingly.

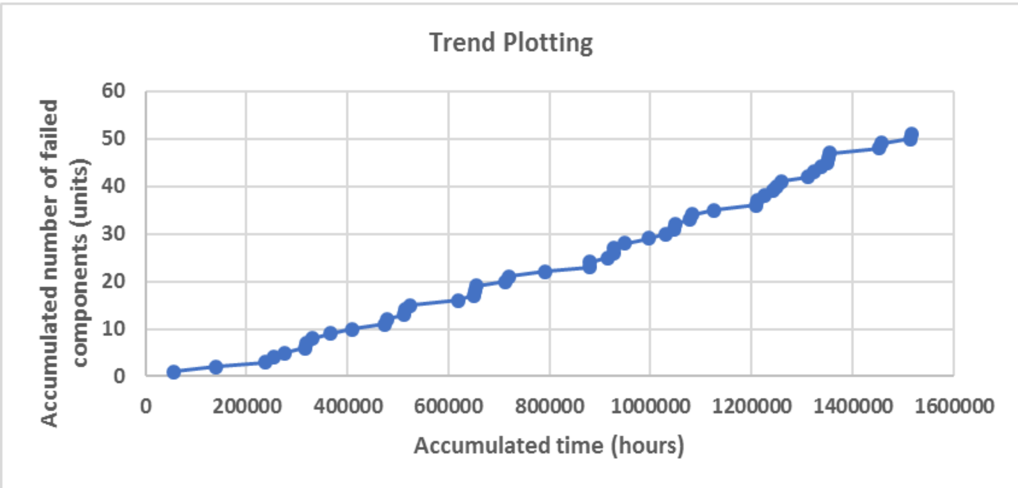

Fig. 4 - Trend Plotting

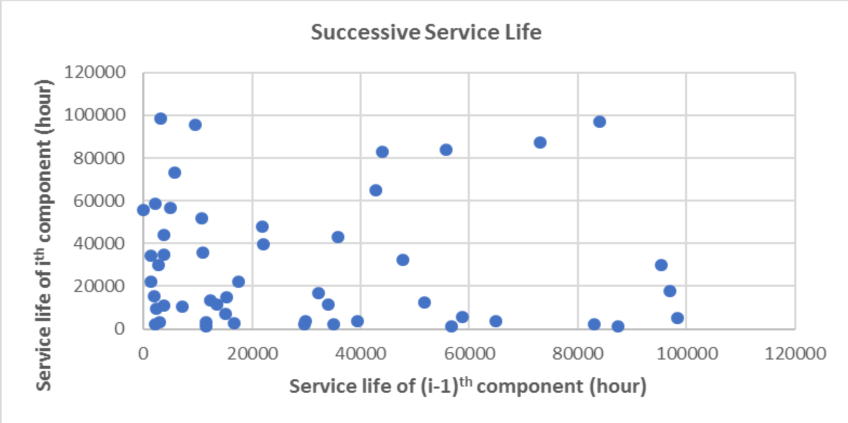

Fig. 5 - Scatter Plotting

The trend plotting is the plotting of the cumulative time between failure against the cumulative number of failures. According to [18], the data is considered as has no trend if the result of trend plotting is a linear line or nearly straight line. If so, the Non- homogenous Poisson Process Test is unnecessary, and the goodness of fit process might be undertaken. Fig. 5 shows the result of scatter plotting or successive service life plot for scrapper. It can be analyses from the figure that the data is not randomly scattered but tend to develop a group. If the data tends to developed a group, it is considered that there are no trend on the data [18]. The analysis result from trend plotting and scatter plotting leads to a conclusion that there is no trend on the data and the goodness of fit test can be undertaken. The result of goodness of fit shows that the distribution of the data fits to exponential distribution.

From the time between failure data, the mean time to failure of the scrapper is 495.489 hours. From this result, it is proposed that a preventive maintenance with the interval of 480 hours could be performed to maintain the component's reliability. However, a further study is required to confirm this estimation. Then, an empirical model is developed to study the effect of the proposed interval of preventive maintenance. The output of the developed model is presented in Fig. 6. As shown in the output of the model presented in Fig. 6, there is no difference on the reliability of the component without the preventive maintenance (R(t)) and the reliability of the component with 480 hours interval of preventive maintenance (Rm(t)). It leads to a suggestion that implementation of 480 hours interval of preventive maintenance is not significantly improve the component's reliability so that this preventive maintenance recommendation can be ignored to avoid unnecessary cost.

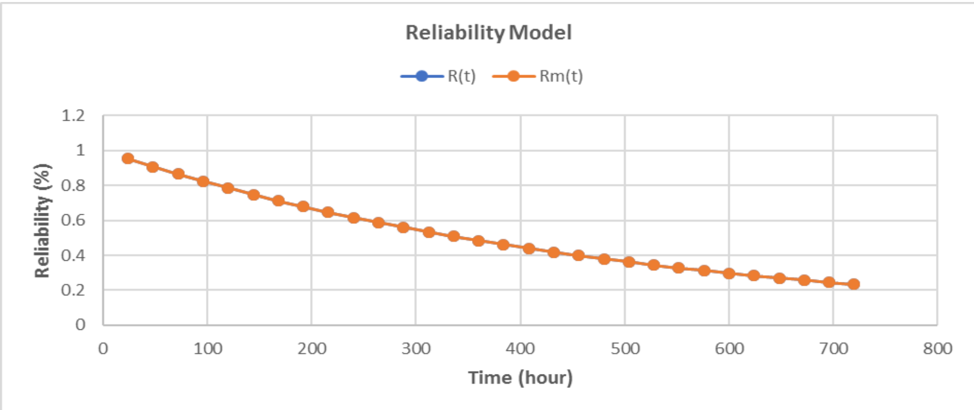

Fig. 6 - Component Reliability Based on 480 hours PM interval.

This result is also supported by [19] who mentioned that component with constant failure rate or with the failure rate is exponentially distributed, a preventive maintenance treatment will not significantly affect to the failure rate or improving reliability. Thus, the recommendations proposed to the management are:

1. Selecting breakdown maintenance strategy for this component,
2. Providing enough spares for this component, and
3. Designing a method to reduce the replacement time of this component.

These recommendations are then aligned with the structure of operational excellence shown in Fig. 1. Based on Fig. 1, a reliability-related KPI can be proposed. A minimum time to failure can be set 480 hours as an KPI. In order to achieve this KPI, the total predictive maintenance can be applied and combined with the process of reducing waste and process variation in the process of component replacement. By minimizing waste and the process variation, the required time to replace the component can be reduced. It may lead to a cost reduction and improve the profit which is one of the goals of operational excellence. Another recommendation that can be highlighted is providing enough spare components. However, this study does not further discuss a method or approach to determine an optimal level of spare part should be provided as it has been discussed in [20]. It should be noted that excessive number of spare parts may generate a high inventory cost. Conversely, insufficient number of spare parts may lead to a high maintenance cost or opportunity lost.

5. Conclusion and Recommendation

In this paper, an operational excellence approach is proposed to assist the process of redesigning the maintenance strategy instead of using reliability or cost as the main parameter in the traditional approach of redesigning the maintenance strategy. This approach is capable to assist the redesign process. By using the reliability centered maintenance, a maintenance strategy is determined, and three recommendations related to the redesign of maintenance strategy is proposed. Then, this result is aligned with the structure of operational excellence to dig deeper other opportunity arises from this recommendation. For the future study, the research continues on analysing other components in the milling station to develop or redesign an integrated maintenance strategy for the milling station. An analysis of setting optimum inventory level for the observed component to reduce the cost is also necessary along with analysis for other maintenance resources provisioning system.

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