Web-Based Application of Reliability Availability Maintainability and Cost of Unreliability Method to Analyze Performance of the Machine

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Abstract. Maintenance is important to do in order to maintain or improve the function of the equipment to work optimally. One factor that support the maintenance activities is machine reliability. Higher reliability can reduces process costs. Conversely, engine failure can reduce production output also the business benefits for the community. In business terms, the problem of controlling the Cost of Unreliability (COUR) of equipment and process failure is just a waste of money. Unreliable index costs are simple and practical reliability tools for converting failure data into costs. A long stage in manual calculation of COUR and RAM analysis with more than one applications used as work tool, therefore designed a web-based application with more complete features that can be used to analyze COUR and RAM. This application will simplify the calculation process, analysis, and results management, so it will helps maintenance analysts in doing their work. This application can determine the maintenance policy, predict the performance of machine's reliability, availability and maintenance capabilities. As well as calculating costs from reliability issues.

Keywords: Application, reliability, COUR, RAM

1. Introduction

Maintenance can be defined as a combination of various actions to maintain or repair an item to an acceptable condition. In Journal [1] One method described in determining the cost policy for maintenance is COUR. Research on determining preventive maintenance has been conducted by [2], [3], and [4] with Output Proposed Maintenance Policy in the Form of Maintenance Task and Industrial Application Based Maintenance. Reliability Availability Maintainability (RAM) is a method that can be used to predict and evaluate system performance. The purpose of this method is to increase the ability of the system to operate normally, for a long time, without any failure. Information obtained from the analysis helps management in improving system performance [5]. Therefore, a web-based application is designed to help determine maintenance policies. This application will facilitate the process of calculation, analysis, and storage of the calculated output output for companies that implement maintenance and also record the history of damage for each machine. Then to facilitate analysis using the COUR and RAM methods.
2. Methods

2.1. Maintenance Management
According to the journal [1], Maintenance Management is an activity that is carried out repeatedly with the aim that the equipment is in the same condition as the initial state. Maintenance activities also aim to maintain the equipment in conditions that are acceptable to its use.

2.2. Objective Maintenance
According to [6] the objectives of treatment are to extend the useful life of assets, to guarantee the optimum availability of equipment installed for production, to ensure operational readiness of the equipment needed in an emergency at all times, to ensure the safety of people who use these facilities.

2.3. Preventive Maintenance and Predictive Maintenance
Preventive Maintenance is a scheduled action that aims to maintain the system at a certain level by providing systematic review, detection, and or prevention of impending failure [3]. Corrective maintenance is an unscheduled maintenance caused from failures of component or system with the aims to return the performance back to the initial conditions [7]. Predictive maintenance is a maintenance strategy where the implementation is based on the condition of the machine itself [1].

2.4. Cost Of Unreliability (COUR)
According to [8], COUR means all costs that are caused from all reliability failures, costs associated with bad programs and poor maintenance. COUR gives the results of cost calculations arising from reliability problems, which will show the costs generated by each equipment or machine in the system [8]. Figure 1 explains the costs used in calculating the COUR according to [8].

![Figure 1. COUR Classification](image)

\[
\text{COUR} = \text{Direct Cost} + \text{Indirect Cost}
\]

2.5. Reliability Availability Maintainability (RAM)
RAM analysis is a method that can be used to predict the performance of reliability, availability maintainability of a system or component. The main performance indicator in RAM is availability which is part of the time when the system is fully functional. RAM analysis is used to identify critical and sensitive subsystems in production systems that can have a large effect on system performance. RAM analysis can also be used to assist in the selection of concepts, as well as being able to provide detailed decisions related to front end engineering systems [9].

2.6. Related Paper
Based on research [10] the RAM and COUR methods were used to evaluate the M251 Weaving machine at Buana Intan Gemilang Company. The data that used in the calculation including, system breakdown structure, determining critical subsystems, Reliability Block Diagram (RBD) modeling, determining the representative distribution and distribution plotting (TTF, TTR and DT) data. From the result can be
concluded that the company needs to improve operational conditions. In addition, the lack of lagging indicator value of the company's target is recommended to increase the efficiency of the machine. On [7] research used statistical analysis of damage data to estimate RAM on an automated croissant production line with purpose to determine the critical point on the automated croissant production line that needs improvement through effective maintenance strategies. The methodology used is based on the analysis of damage and repair data with statistical techniques. By using data trend test and serial correlation to determine whether the data is independent and distributed or not. Based on research [11] analyze RAM in wine packaging production lines. In this study, RAM analysis is useful for determining maintenance intervals, planning and organizing adequate maintenance strategies. This study uses the Failure Mode and Effect Analysis (FMEA) method. Based on FMEA analysis the most common factors in wine packaging production lines include low availability of spare parts due to lack of planning and time-consuming delivery. Based on research [9] on cheese production lines over a 17 month period. It is known that the company applies corrective maintenance, ie maintenance when the engine is damaged. Data collection such as TTF and TTR is done when the machine breaks down and begins repairing. The results of the study note the availability value is greater than the actual availability which means the availability of the machine is large enough to be used. Based on research [12] determine the reliability and availability assessment of seabed storage tanks using fault tree analysis. There are four steps in the procedure including determining the system boundary, collecting reliability data, creating a fault tree and estimating the reliability value. The company suggested to do preventive maintenance so that the storage tank remained safe. Based on research [8] oil & gas companies are required to implement long-term strategies to reducing risk in the future. This paper focuses on the economic sustainability aspects, showing how the process must be carried out through the economy with COUR method. The purpose of this paper is to help make the right decisions of RAM improvement. On [1] research discuss about reliability of printing machine. Engine failure can disrupt production target so the company will incur financial losses. The purpose of this method is to calculate the total cost incurred because the printing press cannot be relied on during active repair and downtime. Based on research [5] Efficiency and effectiveness of a maintenance is important for the success and continuity of the organization. Some financial performance indicators for maintenance are presented in the literature but on the contrary, most indicators deal only with direct or preventive maintenance costs as added value and all costs for corrective maintenance as waste. Based on research [5] discusses the influence of the two-dimensional warranty policy to predict the cost of unreliability. This modeling procedure takes into account the observed reduction in the number of warranty claims, making it a more realistic evaluation of the product. On [5] research discusses failures related to the production system, which can result an enormous environmental, health and financial losses. Removing process of critical failures at the design stage results much lower costs than removing the manufacturing stage. The designer must know in advance about the real costs that can not be relied upon, so that it is faster to complete an unsuitable design solution related to the value of a very large loss of failure.

2.7. System Design

2.7.1. Use Case Diagram. Use case functions to identify the user and function of a system. Use cases explain the function of the system from the user's perspective and are still within the scope of user understanding [9]. Use cases represent the purpose of a system and explain the sequence of user activities can be seen in Figure 2:
2.7.2. Interface

On this page, there is a subsystem information in the form of the asset number and name, the name of the subsystem contained in the asset, failure function, failure mode of the asset. Users enter data in the form of failure causes and effects for each failure mode. Then, the user asks the system to do a COUR analysis with the output of the COUR Corrective & Downtime calculation results. Next, the user enters data assets to calculate RAM. After all data is defined the system can calculate RAM for subsystems.
2.7.3. **Database Design.** The picture below is a database design of the application that has been designed. One of the functions of a database is to store the output of the application.

![Database Design Diagram](image1)

**Figure 4. Application Database Design**

3. **Result and Discussion**

3.1. **Application Display**

This page displays a list of companies, assets, subsystems, and user accounts that have been stored in the database. The DT, TTF and TTR data page views of the designed application are shown in the following figure. This page displays DT, TTF and TTR data and graphics from each subsystem.

![Dashboard Page View](image2)

**Figure 5. Dashboard Page View**
3.2. Comparison of Manual and Application Calculation Results
After doing calculations manually and using the application of the case study given, the level of accuracy of the application can be seen in Table 1.

Table 1. Manual Calculation and Application of the Tundish Car Subsystem

| Process Name | Manual Calculation | Application Calculation | Accuracy |
|--------------|--------------------|-------------------------|----------|
| **Calculation Parameter TTF** | | | |
| Conveyor | $\mu = 1271,85$ hour, $\eta = 1081,30$ hour, $\lambda = 0,00079$ hour | $\mu = 1271,85$ hour, $\eta = 1081,30$ hour, $\lambda = 0,00079$ hour | 100% |
| Capper | $\mu = 3587$ hour, $\eta = 3777,25$ hour, $\lambda = 0,0003$ hour | $\mu = 3587$ hour, $\eta = 3777,25$ hour, $\lambda = 0,0003$ hour | 100% |
| **Calculation Parameter TTR** | | | |
| Conveyor | $\mu = 4,27$ hour, $\eta = 2,65$ hour, $\lambda = 0,234$ hour | $\mu = 4,27$ hour, $\eta = 2,65$ hour, $\lambda = 0,234$ hour | 100% |
| Capper | $\mu = 2,54$ hour, $\eta = 2,77$ hour, $\lambda = 0,393$ hour | $\mu = 2,54$ hour, $\eta = 2,77$ hour, $\lambda = 0,393$ hour | 100% |
| **Distribution Test TTF** | | | |
| Conveyor | Dmax: Normal = 0,327, Eksponential = 0,246, Weibull = 0,148 | Dmax: Normal = 0,327, Eksponential = 0,246, Weibull = 0,148 | 100% |
| Capper | Dmax: Normal = 0,2496, Eksponential = 0,1167, Weibull = 0,1294 | Dmax: Normal = 0,2496, Eksponential = 0,1167, Weibull = 0,1294 | 100% |
| **Distribution Test TTR** | | | |
| Conveyor | Dmax: Normal = 0,4419, Eksponential = 0,4685, Weibull = 0,3002 | Dmax: Normal = 0,4419, Eksponential = 0,4685, Weibull = 0,3002 | 100% |
| Capper | Dmax: Normal = 0,2781, Eksponential = 0,1792, Weibull = 0,2334 | Dmax: Normal = 0,2781, Eksponential = 0,1792, Weibull = 0,2334 | 100% |
Table 1. Continued

| Process Name       | Manual Result | Application Result | Accuracy |
|--------------------|---------------|--------------------|----------|
| **Calculation MTTF** |               |                    |          |
| Conveyor           | MTTF = 2037.50 hour | MTTF = 2037.50 hour | 100%     |
| Capper             | MTTF = 3587.00 hour | MTTF = 3587.00 hour | 100%     |
| **Calculation MTTR** |               |                    |          |
| Conveyor           | MTTR = 2.94 hour  | MTTR = 2.94 hour   | 100%     |
| Capper             | MTTR = 2.54 hour  | MTTR = 2.54 hour   | 100%     |
| **Time Lost**      |               |                    |          |
| Conveyor           | Failure Rate = 0.000491  | Failure Rate = 0.000491 | 100%     |
| Capper             | Corrective Lost Time = 50.0291 hour | Corrective Lost Time = 50.0291 hour | 100%     |
|                    | Downtime Lost Time = 129.51 hour | Downtime Lost Time = 129.51 hour |          |
| **Money Lost**     |               |                    |          |
| Conveyor           | Corrective Cour = Rp. 1.652.569.612.27 | Corrective Cour = Rp. 1.652.569.612.27 | 100%     |
| Capper             | Downtime Cour = Rp. 9.041.364.517.85 | Downtime Cour = Rp. 9.041.364.517.85 |          |

4. Conclusion

Based on the test results and analysis discussed in the previous chapter, the following conclusions can be concluded.

1. Applications that have been designed can automatically determine distribution. Calculate and determine the results of MDT, MTTR, and MTTF accurately.
2. Applications that have been designed can accurately calculate and determine COUR maintenance policies.
3. Applications that have been designed can calculate and determine RAM maintenance policies accurately.
4. Applications that have been designed can accurately determine the performance verification indicators of the technical and operational availability of the machine.
5. The application that has been designed has been verified because it has an output with an accuracy level above 95%.

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