

Maintenance System of Universal Goss Printing Machine based on failure data using RCM and RCS method

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Abstract—Over time a machine will get experience a decrease in reliability, causing the engine to be damaged at the time of operation, thus disrupting the production line. To maintain a machine remains reliable then a good maintenance system is required. In this research, we will use Reliability Centered Maintenance (RCM) and Reliability Centered Spare (RCS) analysis on the critical system of Goss Universal printing machine based on engine failure data. The result of RCM analysis obtained the optimal preventive maintenance schedule and the type of treatment, while based on the RCS analysis obtained spare part needs following the maintenance schedule. With the result of this analysis, is expected where the machine will keep good and will continue to operate without a sudden breakdown under the production schedule's need. Based on RCM analysis for each critical subsystem obtained interval preventive maintenance for transfer roller 127.60 hours, Ink fountain roller 24.45 hours, ink form roller 29.23 hours respectively, and the wash-up device is no scheduled maintenance. For spare parts inventory strategies the result using RCS method are: transfer roller 104 units, ink fountain roller requires 32 units, ink form roller 36 units and are holding spare policy required, and a wash-up device no holding spare parts.

Keywords— Failure data, Maintenance System, RCM, RCS

I. INTRODUCTION

In a production line, the reliability of the machine is crucial because if the machine often damaged and runs not under what is expected, it will disrupt the production process which results in production targets are not achieved and losses of profit [1]. The performance of machine must be maintained well to ensure the availability, reliability, and maintainability during the production process. C. Horv [2] analysis the performance of machine by developing the maintenance organization system of printing offices information and management module focused on information and management relationships. One of maintenance policy to keep machines reliable as expected is by using the

Reliability Centered Maintenance (RCM) method. The output of RCM method optimizes the maintenance task and schedule of the machine by defining the proper maintenance activity based on the previous failure data. Nariska et al [3] analyzes maintenance policy for Solna D300B Printing Machine which is applied in Macanan Jaya Cemerlang company by using RCM II method, risk management method and reliability theory. To support a good maintenance system, especially for the optimum task and interval maintenance also required the availability of spare parts that meet this needs. The availability of spare parts is crucial to reduce downtime and keep the plant production machine running. The spare part problem can be solved and optimize using the Reliability Centre Spare (RCS) method. G. Lanza et al [4] presents a method which calculates the optimal time for preventive maintenance and spare part provision by a stochastic optimization algorithm based on a load-dependent reliability model. By implementing RCM and RCS method, the optimal maintenance task with specific interval schedule and spare part analysis can be achieved. The results of RCS method analysis will be highly valuable for inventory management, and with RCM-based procedures, it will minimize the shortage cost due to unavailability of spare parts during maintenance scheduling activity.

II. LITERATURE REVIEW

2.1 Reliability

Reliability is the probability that a component or equipment will perform a function where required within a specified period under certain operating conditions [5]. Reliability of a component can decrease in a row of time. To measure the reliability level used reliability functions which express:

$R(t)$ = Opportunity of a system can function well during (0, t)

$$R(t) = 1 - \int_0^t f(t)dt = \int_t^\infty f(t)dt \quad (II.1)$$

Where $f(t)$ is a probability density function that expresses the possibility of failure of a component/system for a given period.

2.2. Reliability Centered Maintenance

According to [6] RCM is the processes undertaken to determine the maintenance requirements of all physical assets in the context of its operations. Viewed from the RCM perspective, maintenance is to ensure that equipment will operate as expected. The outcome of the RCM analysis is to improve understanding of how an asset works, its potential failures and causes and lists the activities to be done to ensure an asset can continue to operate at the desired level of performance. The primary objective of RCM is creating the priorities of preventive maintenance activities, obtain useful information in improving the design of components reliability, and develop activities related to preventive maintenance to restore the reliability and security of the equipment or components at the proper level.

According to [7] in the RCM method, there are seven stages, namely system selection and information collection, system boundary definition, system description, function determination and functional failure, Failure Mode and Effect Analysis (FMEA), Logic Tree Analysis (LTA), Task Selection. Furthermore, to know the effective maintenance task performed two types of measurement, namely qualitative and quantitative measurement using Reliability Centered Maintenance method. Both of these measurements refer to the functional failure of the critical system. The first step in using RCM is to identify the functions of the system along with the desired standard performance in detail. Based on these standard functions will be obtained a functional failure of failure caused a system that cannot perform its functions by the standards.

The impact of such failure will lead to a consequence of failure. The implications of this failure will significantly affect the determination of the maintenance policy which will be selected. In this research will also be calculated the maintenance cost

that will be used according to with the preventive maintenance task and schedule.

2.3. Reliability Centered Spares (RCS)

According to [8] RCS is one of spare part management analysis method which is considering some aspect such as the inventory policy, the quantity of spare part, consequence if the spare part is not available, and anticipate sudden spare part requirement. RCS is an approach to determine the level of inventory spare parts based on through-life costing and equipment requirements and maintenance operations in support of inventory. R.Deckker [9] explain that the basic principles of RCS are to ensure that the maintenance needs of an asset are clear and understandable, determine spare part requirements, and provide that resources, procedures, and systems are inline. The direct advantage in the implementation of RCS method is to know the critical spare part component based on maintenance and operational requirements. The criticality analysis is was performed at the component level in the crucial system by analyzing the RCS worksheet to determine the components included in the critical component category. Each element included in the critical component will be classified into two types: repairable and non-repairable. Then calculate spare part requirement based on the component type to know the number of the extra part requirement in a particular period based on spare part inventory strategy and its data distribution with machine number parameter, component count, confidence level, operational time, repair time, and scrap rate. In a classic approach [10], to determine the number of spare parts in the stock, there is often a shortage of spare parts resulting in lack cost from the company. The difficulty of this approach is to estimate shortage costs or determine the minimum level of spare parts availability. To solve this problem, RCM analysis results are used to calculate shortage costs. Spare parts availability is essential for a company, as spare parts availability reduces machine downtime. If spare parts are not available, then it will increase the waiting time causing the production to disrupt. To avoid spare parts shortages and determine how much should be in stock then a proper spare parts management is

required to ensure that the availability of spare parts was maintained well.

Where:

λt = mean value (the amount of damage that occurs during time t)

To make changes when the component is damaged, it is very important to have one replacement spare part, so the calculation becomes as follows.

$$P = e^{-\lambda t} [1 + \lambda t + \dots + (\lambda t)^{n-1} / (n-1)!] \quad (II.3)$$

And the calculation of the need for non-repairable spare part components, the number of failures that occur

According [11] on repairable components, the existing spare parts inventory level that can be calculated by the formula:

$$\lambda t = (1 / MTBF) t = (A \times N \times M \times RT) / t \quad (II.2)$$

equally to the number of spare part needs. The total requirement of the spare part component is the minimum value of (n) with the following calculation.

$$P = e^{-\lambda t} [1 + \lambda t + \dots + (\lambda t)^n / n!] \quad (II.4)$$

III. RESEARCH METHODOLOGY

The data was obtained from the GOSS Universal printing machine. In this research, we used the failure data and the repair time of Goss Universal printing machine from January 2016 to June 2017.

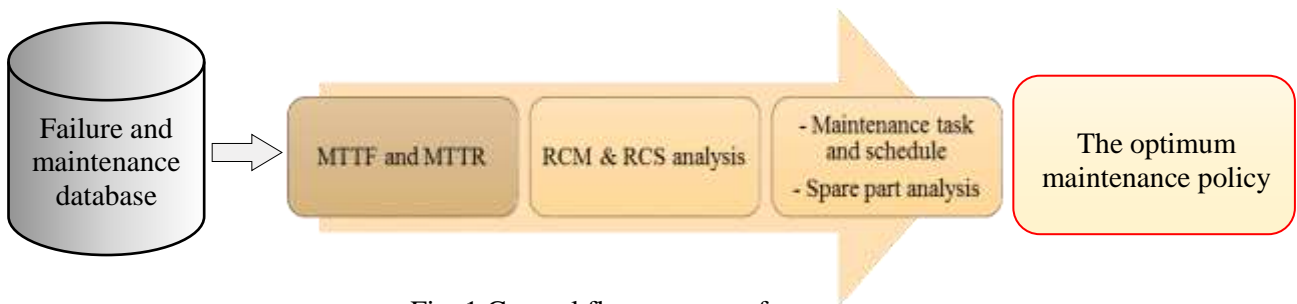


Fig. 1 General flow process of

From the Fig. 1, shows the failure and maintenance database is the main input for the analysis. The first step is to define the critical subsystem of the machine using Risk Priority Number (RPN) than the determination of the distribution of failure data Time To Failure (TTF) and data distribution Time To Repair (TTR) each subsystem. The Minitab 17.1 and AvSim+9.0 software are used to find the distribution of data and obtain the parameters of each distribution, and then performing the suitability test of each distribution to determine the Mean Time to Repair (MTTR) and the Mean Time to Failure (MTTF). The RCM analysis performed was to determine the optimum schedule and maintenance tasks, and then RCS analysis is conducted to calculate how much required spare parts and its policy. Finally, the maintenance policy based on schedule and spare part analysis can be proposed.

IV. RESULT AND DISCUSSION

Based on the RPN analysis, the critical subsystem is Wash-up Device, Ink Form Roller, Transfer Roller, and Ink Fountain Roller. The next analysis is finding the distribution data TTF and TTR of each subsystem which can be seen in Table 1.

TABLE 1.
DISTRIBUTION DATA OF TTF AND TTR

Subsystem	Distribution (TTF)	Distribution(TTR)
Wash-up Device	Weibull	Weibull
Ink Form Roller	Normal	Weibull
Transfer Roller	Exponen	Exponent
Ink Fountain Roller	Weibull	Exponent

After obtaining the distribution representing next searched parameters and MTTF and MTTR for each distribution which results can be seen in Table 2 and 3.

Table 2. Reliability parameter TTF

Subsystem	Parameter		MTTF
	β	0.772	
<i>Ink Form Roller</i>	η	54.32	58.05
<i>Transfer Roller</i>	λ	0.004	255.20
	β	0.730848	

Table 3. Reliability parameter TTR

Subsystem	Parameter		MTTR
	β	1.95	
	β	1.9	

4.1. RCM Preventive Task

Based on the RCM decision diagram, the preventive maintenance strategy of each of subsystem is obtained.

Table 4. RCM analysis result

Subsystem	Failure Mode	Maintenance category	Proposed Maintenance task	Initial Interval (h)
Wash-Up Device	Wash Up Device failure	No Scheduled	Visual control detection	
Ink Form Roller	Ink Form Roller failure	Scheduled on-condition task	Rubber roll detection	29.03
Transfer Roller	Transfer Roller failure	Scheduled on-condition task	Rubber roll detection	127.60
Ink Fountain Roller	Inking System failure	Scheduled on-condition task	Visual control detection, setting, recovery	24.45

Table 4 shows the maintenance category and maintenance task for each of critical component or subsystem. For example the subsystem Ink form roller, maintenance category is scheduled on-condition task,

and the proposed detail task is rubber roll detection with interval every 29.03 hours. The maintenance cost of subsystem based on RCM analysis will be shown in Table 5.

Table 5. Maintenance cost analysis result

Subsystem	Failure Mode	Maintenance Task	Frequency	Maintenance Cost (IDR)
Wash Up Device	Wash Up Device failure	No Scheduled	-	-
Ink Form Roller	Ink Form Roller failure	Scheduled on-condition task	298	77.132.830.000
Transfer Roller	Transfer Roller failure	Scheduled on-condition task	68	16.374.740.000
Ink Fountain Roller	Inking System failure	Scheduled on-condition task	353	140.561.010.000
Total Cost				234.068.580.000

Table 5 shows the maintenance cost affected for each of critical component or subsystem. From this table, the frequency and maintenance cost each subsystem are calculated. The total cost for four subsystems is IDR 234.068.580.000. In the wash-device, there is no maintenance cost because the task is not defined yet (there is no specific schedule only visual control).

4.2. RCS Spare Part Analysis

Classification is performed on all subsystems belonging to the critical subsystem. Subsystems will be classified by the type of repair which is repairable and non-repairable. Each of them has a different type of calculation.

Based on the decision diagram that has been made to determine the spare part inventory strategy on each critical subsystem is considering several aspects, for example, the effect of failure, hidden, evident potential failure, stockout risk and storage of spare parts. The calculation of spare parts needs is analysis for one year ahead to minimize the stock out of critical spare part which can make the machine stop and disrupt the production process schedule. In the calculation of the number of spare parts needs, also considering the need for the spare for preventive maintenance activities due to the possibility of breakdown that may occur. The level of service level specified in this calculation is set following company policy that is equal to 95%. The result of the spare part policy is shown in Table 5.

Table 6. The spare part analysis result

Subsystem	Type	Strategy	Number of stock	Initial Period
Wash-up Device	Non-Repairable	Order parts before demand	131 pcs	12 months
Ink Form Roller	Non-Repairable	Order parts before demand	178 pcs	12 months
Transfer Roller	Non-Repairable	Order parts before demand	44pcs	12 months
Ink Fountain Roller	Non-Repairable	Order parts before demand	208 pcs	12 months

Based on the RPS calculation inventory strategy in Table 6, all the subsystems are must order the part before demand, which means that all components of the subsystem must be prepared in the warehouse.

V. CONCLUSION

This paper analyzes and propose the RCM and RCS maintenance system to obtain the optimum maintenance

policy in the manufacturing, especially in the printing industry. RCM method focus on identification of critical subsystem and optimum maintenance task meanwhile the RCS method focus to find the optimum spare parts policy which should be prepared and available for one year. Failure and repair time data from Goss Universal printing machine are used for this analysis. The result of RPN critical analysis shows that

Wash Up Device, Ink Form Roller, Transfer Roller, and Ink Fountain Roller was selected as a critical subsystem. Each of these critical subsystems than analyzes using RCM and RCS method resulting in the preventive maintenance schedule and spare part policy. Based on the RCM maintenance schedule, the maintenance interval and maintenance cost also can be predicted. For the future research, the more maintenance method can be applied to support the optimum maintenance policy for Goss Universal printing machine.

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