PROPOSED MAINTENANCE POLICY AND SPARE PART MANAGEMENT OF GOSS UNIVERSAL PRINTING MACHINE WITH RELIABILITY CENTERED MAINTENANCE, RELIABILITY CENTERED SPARES, AND PROBABILISTIC INVENTORY MODEL

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ABSTRACT

In maintenance activities, there are components that in case of damage cannot be repaired, but must be replaced. It's requires the replacement of spare parts. Reliability Centered Spares (RCS) and Probabilistic Inventory Model is one of the methods of analysis spare part management and Reliability Centered Maintenance (RCM) is method of maintenance decision making. Based on the results of measurements using Risk Priority Number (RPN), the critical system on a Goss Universal printing machine unit is inking system. Total value of RPN the inking system is 189. Based on RCM, the obtained maintenance policy for critical subsystems to the unit Goss Universal printing machine is scheduled on-condition. Maintenance interval for ink fountain roller is 25.19 hours, transfer roller is 96.42 hours, ink form roller is 27.16 hours, and wash-up device is 38.47 hours. For spare parts inventory strategies using RCS, obtained results are holding spare no strategy required for the ink fountain roller, hold parts for the transfer roller, ink form roller, and a wash-up device. Spare part requirements within one year are needed for transfer roller 104 units, 316 units for ink form roller, and 124 units for wash-up devices.

Key words: RPN, RCM, RCS, Probabilistic Inventory Model

1. INTRODUCTION

Newspapers are one of the print media that provide actual information, which contains information on various topics. The topic could be political events, crime, sports, editorials, and the weather. Newspapers usually also contains caricatures that are usually used as a laughingstock over the image with respect to certain issues, comics, crossword puzzles (TTS), short stories and other entertainment. Newspapers are generally printed on newsprint and printed in large numbers every day.

RCM is a process undertaken to determine what should be done to ensure all physical assets can do the things that users want to do in the context of the actual operation (Moubray, 1991). Reliability Centered

Spares (RCS) is one of the methods of spare part management by considering aspects such as maintenance needs what is required by the machine, what happens if spare parts are not available, anticipating the needs of spare parts, the amount of stock holding of spare parts required, and maintenance requirements what to do. The benefits gained from the RCS is able to determine the number of spare parts needed before making a purchase when required, this method can be applied long as the engine is still used, and this method can be applied selectively to focus on specific components.

2. THEORETICAL BACKGROUND

2.1. Reliability

Reliability is the probability that a component or equipment will function in a period of time when used in operating conditions (Ebeling, 1997). The value of the reliability of a component or system is generally expressed in terms of probability, with a value of R (Reliability) is between 0 to 1. Function used in the data distribution in this reliability is the function of the reliability and function of the rate of destruction. Reliability function is a function that shows the probability of a component or system to perform its function satisfactorily without failure condition in a specific time period. Meanwhile, the rate of failure function is a function that indicates the level of damage that occurs per unit time (Ebeling, 1997).

1. Exponential Distribution
   Reliability Function
   $$R(t) = e^{-\lambda t} \quad (1)$$
   Failure Rate Function
   $$h(t) = \lambda \quad (2)$$
2. Normal Distribution
   Reliability Function
   $$R(t) = \int_t^{\infty} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-\mu)^2}{2\sigma^2}} dt \quad (3)$$
   Failure Rate Fuction
   $$h(t) = \frac{\frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(t-\mu)^2}{2\sigma^2}}}{\int_t^{\infty} \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-\mu)^2}{2\sigma^2}} dt} \quad (4)$$
3. Weibull Distribution
   Reliability Function
   $$R(t) = e^{-\left(\frac{t}{\alpha}\right)^{\beta}} \quad (5)$$
   Failure Rate Function
   $$h(t) = \frac{\beta}{\alpha}\left(\frac{t}{\alpha}\right)^{\beta-1} \quad (6)$$

2.2. Spare Part Management

Spare Part are required to maintain the ability of the machine equipment in order to continue to be in good condition and can operate well (Kumar, 2004). When the machine is in need of repair or replacement at some part caused by breakdown (corrective maintenance), preventive maintenance and predictive maintenance, the availability of spare parts needed becomes an important thing. Spare parts are available to support the company's operational activities and services and to increase machine uptime.

2.3. Risk Priority Number

Risk Priority Number is a method for identifying critical components or criticality of the system. Identification of criticality is necessary because not all the equipment or machine has the same level of criticality. The impact of failure are also has different levels of risk. In addition to identifying the criticality of a component, company can define maintenance strategies will be selected. Risk Priority Number calculation is based on the value of severity, occurrence and detection, these factors are multiplied and will get the priority value with the greatest value component will require special attention due to have the highest criticality level.

2.4. Poisson Process

According to Fukuda (2008), the calculation of the number of component parts that is non-repairable, equal to the number of spare part requirements.

$$P \leq \sum_{x=0}^{n} \frac{(\lambda t)^x e^{-\lambda t}}{x!} = e^{-\lambda t}\left[1 + \lambda t + \cdots + \frac{(\lambda t)^n}{n!}\right] \quad (7)$$

T = operating time

$$\lambda t = \frac{1}{MTBF} t = \frac{AxNxMxT}{MTBF} \quad (8)$$

3. RESEARCH METHOD

First, system breakdown structure of Goss Universal printing machine that will created to determine the division based on the functions of the machine. Then, statistical analysis performed based on the TTF and TTR were obtained from the failure history to determine the distribution of the data, parameters, MTTR, MTTF of each component. After that criticality analysis system will be done using the risk priority number based on the severity, detection, and the occurrence of the failure history to know the system belonging to the critical category.

Furthermore, the criticality analysis at the level of critical components in the system by using the RCS analysis worksheet to know which components included in the category of critical components. Each component that is included in the critical components would be classified to 2 types, repairable or nonrepairable. Then the calculation needs of spare parts based on the type of components in order to know the number of spare part requirements within a certain period based on spare parts inventory strategy and data distribution with

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the number of engine, the number of components, confidence level.

Furthermore, to determine the effective maintenance tasks performed two types of measurements, qualitative and quantitative measurements using Reliability Centered Maintenance method will be used. Both of these measurements refer to functional failure of critical systems.

The initial step in using RCM is to identify the functions of the system along with the desired standards of performance in detail. Based on the functions of the standard will have obtained a functional failure is failure caused a system cannot perform its functions in accordance with the required standards. Obtained from the functional failure that causes failure model that allows the functional failure itself. Failure model may be the weather, natural disasters, or the occurrence of defects in components in the system. The failure of the model will bring an impact or effect of failure. Effect of failure are all possibilities that would occur if the failure model has emerged. The impact of failure is divided into three categories: local, system, and enterprise. The impact of such failure would pose a consequence of failure. The consequences of failure would be devastating to the maintenance policy determination to be selected. In this study also will be calculated cost of maintenance that will be used by the maintenance tasks and data Time to Failure and Time to Repair in the calculation of maintenance intervals, so we get an effective maintenance policy.

4. RESULT AND DISCUSSION

Failure history data for this research is taken from August 2015 to March 2016. The determination of the distribution of the data Time to Repair is done by using the Anderson Darling test. By using these tests will be known distribution of the most representative for data Time to Repair for each subsystem. AD value is a value that indicates whether a distribution may represent the spread of data. This is indicated by the smaller the value, the more the AD representing the distribution of the spread of the data. Value P-Value is used to determine a hypothesis is rejected or accepted with the provision Ho is rejected if the P-Value < α. After TTF and TTR obtained, then distribution plotting will be performed to determine the value of the reliability parameters. In Table 1 shows the distribution of each TTF and TTR.

Table 1. TTF and TTR Distribution

Subsystem	TTF	TTR
Ink Fountain Roller	WEI	WEI
Transfer Roller	NOR	WEI
Ink Form Roller	NOR	WEI
Wash-Up Device	WEI	WEI

After getting TTF and TTR distribution, Table 2 and Table 3 shows parameter value determination based on the reliability of the distribution that represents.

Table 2. Parameter TTF & MTTF

Subsystem	Parameter		MTTF
Ink Fountain Roller	η	0,730848	50,372
	β	41,3896	
Transfer Roller	μ	192,849	192,849
Ink Form Roller	μ	54,32	54,32
Wash-Up Device	η	0,772	76,94304
	β	66,0092	

Table 3. Parameter TTR & MTTR

Subsystem	Parameter		MTTR
Ink Fountain Roller	η	1,80865	3,381674
	β	3,80355	
Transfer Roller	η	1,84562	2,075907
	β	2,33695	
Ink Form Roller	η	1,902	2,147419
	β	2,426	
Wash-Up Device	η	1,9463	2,147419
	β	4,0616	

4.1. Preventive Task

Preventive maintenance task is an action taken before failure occurs, hoping to prevent equipment failure led to the worse condition. In the RCM, preventive maintenance is divided into three groups:

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the scheduled on-condition tasks, scheduled restoration tasks, and scheduled discard tasks. In determining the preventive maintenance actions will be based on the RCM decision diagrams.

Table 4. Preventive Task

Subsystem	Preventive Maintenance Category	Suggested Task
Ink Fountain Roller	Scheduled On-Condition	visual control, setting, recovery
Transfer Roller	Scheduled On-Condition	rubber roll check
Ink Form Roller	Scheduled On-Condition	rubber roll check
Wash-Up Device	Scheduled On-Condition	visual control

4.2. Scheduled On-Condition Interval

In determining the time interval scheduled on-condition, we use Mean Time to Failure (MTTF). MTTF is the average time between failures of the subsystem. MTTF parameters used as reference to set a scheduled time interval due to an on-condition preventive maintenance and should be smaller than its MTTF value in order to reduce the chances of damage from these components.

Table 5. *Scheduled On-Condition Interval*

Component	MTTF (hour)	Maintenance Interval (hour)
Ink Fountain Roller	50,37	25,19
Transfer Roller	192.85	96,42
Ink Form Roller	54,32	27,16
Wash-Up Device	76,94	38,47

4.3. Subsystem Classification Analysis

The classification was made to all subsystems are included in the critical subsystems. The subsystem will be classified based on the type of repair that is repairable and non-repairable. The classification is done because at this stage of the calculation of the required amount of spare for each type has a different calculation stages. Repairable subsystem is a subsystem that in case of damage will be repaired. Non-repairable subsystem is a subsystem that will be replaced if damaged.

Table 6. Subsystem Classification Analysis

Subsystem	Classifiction
Ink Fountain Roller	Repairable
Transfer Roller	Non-Repairable
Ink Form Roller	Non-Repairable
Wash-Up Device	Non-Repairable

4.4. Spare Part Procurement Strategy

Determining strategies inventory of spare parts for every critical component is based on the question in the diagram decisions, including as a result of the failure, hidden or evident potential failure that occurs, it can be accepted or whether the risk of stock outs and can be received or whether the storage of spare parts in the warehouse and its risks.

Table 7. Spare Part Procurement Strategy

Subsystem	Spare Stategy
Ink Fountain Roller	No Spare Holding Required
Transfer Roller	Hold Parts
Ink Form Roller	Hold Parts
Wash-Up Device	Hold Parts

4.5. Spare Requirement Analysis

In the calculation of the required amount of spare parts, spare calculation for preventive maintenance activities being proposed along with the breakdown that may occur. For a number of requirements resulting from breakdown of components were calculated using Poisson process. So operational and maintenance activities will not be disturbed because of the number of critical requirements for each component are known. The level of service levels specified in this calculation are determined in accordance with company policy that is equal to 95%.

Table 8. Spare Requirement Analysis

Subsystem	Spare Part Required (unit/year)
Ink Fountain Roller	-
Transfer Roller	104
Ink Form Roller	316
Wash-Up Device	124

Based on Table 8, ink fountain roller has a total requirement of 0 units because no spare inventory holding strategies required. Ink form roller is a subsystem with the highest number of needs in the amount of 316 spares. While the wash-up device and transfer roller is a component with the least number of requirements are respectively 124 and 104 spares.

5. CONCLUSION

Based on the results of measurements using the Risk Priority Number (RPN), the system becomes a critical system on a Goss Universal printing machine unit is inking system with 7 severity grades (high), occurrence 9 (high), and detection 7 (high). The total value of the Risk Priority Number of inking system is 189.

Based on the results of measurements using Reliability Centered Maintenance (RCM) obtained maintenance policy for critical subsystems to the unit Goss Universal printing machine is scheduled on-condition. The subsystems are included in the maintenance policy is the ink fountain roller, transfer roller, ink form roller, and a wash-up device.

Based on the results of quantitative measurements obtained maintenance interval of each critical subsystem. Ink fountain roller for its maintenance interval is 25.19 hours, transfer roller its maintenance interval is 96.42 hours, ink form roller its maintenance interval is 27.16 hours, and wash-up device its maintenance interval is 38.47 hours.

Based on the analysis of spare parts inventory strategies using RCS to obtain subsystem spare part inventory strategies for the ink fountain roller is no spare holding required, the transfer roller is hold parts, ink form roller is hold parts, ink form roller is hold parts, and wash- up device is hold parts.

Based on the results of the calculation method poisson process for a period of one year to the next based on the service level set by the company, an ink form roller is a subsystem with the highest number of needs in the amount of 316 spare parts. While the wash-up device and transfer roller is a component with a number of needs, each for 124 and 104 spare parts.

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