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Machine Reliability Analysis and Classification of The Critical Level of A Spare Part Using The Reliability-Centered Spares Method

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ABSTRACT

PT. X is a printing industry that applies a job shop production system. It produces various printed products such as textbooks, calendars, and tabloids with three production processes: the design, the printing, and the finishing process. The printing process using printing machines is the most important process to produce good printing products. However, the printing machines in PT. X often has an unexpected breakdown and make the production stopped to do maintenance or spare part replacement of the machine. This study aims to determine the reliability of the machine based on the Reliability Block Diagram and classify the critical components using the Reliability Centered Spares (RCS) method. RCS can determine which component or sub-components must be available. The results of this study, SM-52 printing machine has the highest critical level of 25% with 70 failures. The reliability value of the SM-52 machine is 0.669. There are 27 parts included in the critical sub-components, consist of the medium critical by 48% (13 parts) and low critical by 52% (14 parts). The study results give good recommendations to define the task and period of the maintenance of the printing machine in PT.X to increase the reliability and decrease the unexpected breakdown of the machine.

Key words: Reliability, Reliability block diagram, Reliability centered spares, Printing machine.

1. INTRODUCTION

Components relation analysis can determine the reliability of the complex machine system and the performance of the machine in operation [1], [2]. The relation of each component is very important for the sustainability of the production process. Therefore, to support the performance of machinery and equipment, spare parts should always available when component failure happens. The company should provide spare parts to cope with the machine failures, because the unavailability of the plant may lead to longer machine shutdowns and resulting in the production process and production targets not be achieved. Despite the availability of the spare parts, to reduce the breakdown of the machine, the reliability of the machine should have a minimum value of 70% to be able to run properly [3].

As the case study, PT X is a company engaged in the printing service to print various types of books, tabloids, magazines, calendars, and others, with the production system in the form of Job-shop. The production process consists of the design process, the process of printing and finishing processes. Consisting of 96 machines for production, the failures occurred 473 times from January to December 2018. There are 54% of the failures occurred in the printing machine which indicates that the printing machines most often fail. There are 4 types of printing machines used: XL-105, SM-102, CD-102, and SM-52. The failures occurred consist of 26% from XL-105, 26% from SM-102, 21% from CD-102, and the highest are from SM-52, which is 27%. Most of the failures are happened because of the need for spare part changes, but the company does not have a certain method for spare parts inventory control, that is why there is still overstocking and understocking of the spare parts in the warehouse.

In this study, we analyze the reliability of the SM-52 machine system based on the relationship of each part using Reliability Block Diagram and assigning a priority level of inventory or procurement of spare parts using Reliability Centered Spares to avoid overstocking and understocking in PT X.

2. METHOD

2.1 Research Methodology

In this study, the first step is to determine the type of data distribution time between failures of each component and then calculate the MTBF value to determine the reliability value of each component. After knowing the value of the reliability of each component, then counting machine reliability SM-52 is based on the RBD of machine SM-52. The final step of this research is classifying the level of criticality of the sub-components using the RCS method.

2.2 Data Collection

As the case study, PT X is a company engaged in the printing service to print various types of books, Tabloids, magazines, calendars, and others, with the production system in the form of job-shop. The production process consists of the design process, the process of printing and finishing processes. Consisting of 96 machines for production, the failures occurred 473 times from January to December 2018. There are 54% of the failures occurred in the printing machine the which indicates that the printing machines most Often fail. There are 4 types of printing machines used: XL-105, BC-102, CD 102, and SM-52. The failures occurred Consist of 26% from the XL-105, 26% from the SM-102, 21% from the CD-102, and the highest are from SM-52, which is 27%. Most of the failures are happened because of the need for spare parts changes,

The data used in this research is the maintenance tasks data and relationships between components in the SM-52 machine. Machine data used to calculate the time between failures of components, which are then used to determine the distribution of each component. After calculating the value of the reliability of components and reliability of SM-52 machine based on the Reliability Block Diagram (RBD), the grouping critical level of the sub-components using the method of RCS is analyzed.

2.3 Relationship of Components using Reliability Block Diagram (RBD)

Relationship of components comprising [4] :

A. Serial configuration

Configuration serial is probably the most commonly used and very easy to analyze. The serial connection of all components must operate in good condition if you want the system to function perfectly. For serial configuration, the function is :

$$\text{Reliability } (R) = (R1) \times (R2) \times (R3) \quad (1)$$

B. Parallel configuration

The parallel configuration is some of the same components in a parallel relationship and all components must be broken first to lead to total system failure. For parallel configuration, the function is:

$$\text{Reliability } (R) = [1 - (1 - R1)(1 - R2)] \quad (2)$$

C. Combined serial-parallel systems

Combination of Serial and Parallel Relations: Various levels of reliability can be achieved by applying a combination of serial and parallel configuration, which can be calculated serial or parallel first. For combined serial-parallel, the function is:

$$\text{Reliability } (R) = R1[1 - (1 - R1)(1 - R2)] \quad (3)$$

2.4 Mean Time Between Failure (MTBF)

MTBF is the average amount of time before there is a failure in the machine or component. MTBF calculations in accordance with the distribution selected based on the parameters of each component.

A. Exponential Distribution

The failure rate of the exponential distribution is constant .The parameters used in the exponential distribution is λ.

$$MTBF=1/\lambda \quad (4)$$

B. Normal Distribution

This distribution is known to shape like a bell (bell-shaped) that is symmetrical. The parameters used in the normal distribution is μ (mean) and σ (variance).

$$MTBF=\mu \quad (5)$$

C. Lognormal Distribution

A lognormal distribution is a probability distribution. This distribution has a variety of forms such as Weibull distribution. The parameters used in the lognormal distribution is t_{med} and s.

$$MTBF=t\_med\ e^\wedge(s^\wedge 2/2) \quad (6)$$

D. Weibull Distribution

Distribution Weibull an empirical distribution of the most widely used because it is well used in the distribution of the failure rate increases or decreases. The parameters used in Weibull distribution is β (shape) and θ (scale).

$$MTBF=\theta\Gamma(1+1/\beta) \quad (7)$$

2.5 Reliability

Reliability is the probability of a component or system will be able to operate in accordance with the desired function for a certain period when it is used under the specified operating conditions [5] :

A. Exponential Distribution

$$R(t)=e\ ^\wedge(-\lambda t) \quad (8)$$

B. Normal Distribution

$$R(t)=1-\Phi((t-\mu)/\sigma) \quad (9)$$

C. Lognormal Distribution

$$R(t)=1-\Phi(1/s \ln t/t\_med) \quad (10)$$

D. Weilbull Distribution

$$R(t)=e^{(-(t/\theta)^{\beta})} \quad (11)$$

2.6 Reliability Centered Spares

Reliability Centered Spares (RCS) is an approach to determine the level of inventory of spare parts based on through-life costing and equipment needs and maintenance operations. there are 5 basic questions on the method of Reliability Centered Spares (RCS) [6] : What are the maintenance requirement of the equipment?, What happens if no spare part is available?, Can the spares requirement be anticipated?, What the stock holding of the spares needed?, What if the maintenance requirements can not be met?

Table is a table Criticality Index to determine the levels in each factor [7]

Table 1: Criticality Index

Criticality	Criticality Index
High Criticality	A (4.0 0 5.0)
Medium Criticality	B (3.0 – 3.9)
Low Criticality	C (2.0 – 2.9)
Not Criticality	D (1.0 -1.9)

Index of criticality is used to classify the level criticality of spare parts procurement priority in the warehouse. To determine the criticality index for each sub-component is based on the interviews. Some applications for further reference can be extended and studied [8][9].

3. RESULTS AND DISCUSSION

3.1 Data collection results

The SM-52 machine consists of 9 main components, namely the feeder table, sucker, side lay, dampening rollers, ink rollers, plate cylinder, blanket cylinder, impression cylinder, and delivery. Figure 1 is a Reliability Block Diagram of the SM-52 machine.

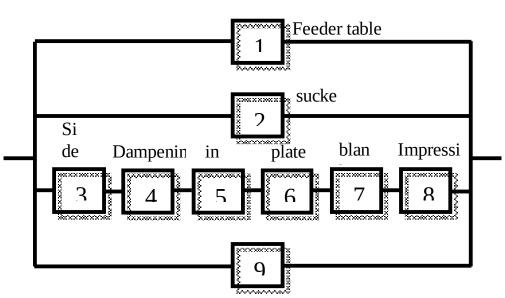

Figure 1: Reliability Block Diagram of SM-52

3.2 Data Analysis

A. Mean Time Between Failure (MTBF)

After knowing the type of distribution and parameters used, then calculate the value Mean Time Between Failure (MTBF). Table 2 is a table of MTBF for each component.

Based on MTBF, the maintenance time can be divided into four categories : at 600 hours of operation for the component feeder table and dampening rollers, at 400 hours of operation for the components of the ink roller, plate cylinder, blanket cylinder and impression cylinder, at 200 hours of operation for the component sucker and delivery, and at 100 hours of operation on the component side lay.

Table 2: Criticality MTBF each components

No.	Component	MTBF (minute)	MTBF (hour)	Maintenance Time Category
1	Feeder table	38.281.81	638	<_ 600 hour
2	Dampening Roller	37.847,66	631	
3	Ink Roller	29.218,76	487	<_ 400 hour
4	Blanket Cylinder	27.667,47	461	
5	Impression Cylinder	27.274,64	455	
6	Plate Cylinder	26.635,50	444	
7	Sucker	14.277,50	238	<_ 200 hour
8	Delivery	14.224,47	236	
9	Side lay	10.839,22	181	<_ 100 hour

B. Maintenance Time

Based on Table 2, Maintenance time of feeder table should be done at 300 hours of operation, so that the reliability value increased to 0.675, sucker should be done at 100 hours of operation, so that the reliability value increased to 0.516, side lay should be done in 50 hours of operation, so that the reliability value increased to 0.716, dampening roller should be done at 300 hours of operation, so that the reliability value increased to 0.552, ink roller should be done at 200 hours of operation, so that the reliability value increased to 0,467, plate cylinder should be done at 200 hours of operation, so that the reliability value increased to 0.345, blanket cylinder should be done at 200 hours of operation, so that the reliability value increased to 0.834, impression cylinder should be done at 200 hours of operation, so that the reliability value increased to 0.576, delivery should be done at 100 hours of operation, so that the reliability value increased to 0,462.

Maintenance time of sucker and delivery can be performed simultaneously because it has the same maintenance time. Maintenance time of feeder table and dampening roller can be performed simultaneously because it has similar maintenance, Maintenance time of ink roller, plate cylinder, blanket cylinder, and impression cylinder components that can be performed simultaneously because it has the same treatment time.

C. Reliability

After knowing the MTBF value for each component then calculate the reliability function (R(t)) in accordance with the distribution patterns for each component, by entering the MTBF value as the value of time (t).

D. Reliability System of SM-52 Machine

Based on Table 3. the reliability of SM-52 machine is obtained based on the relationship of components. There is a serial configuration between side lay, dampening rollers, ink rollers, plate cylinder, blanket cylinder, impression cylinder and the parallel configuration between the six components are arranged in serial with the component feeder table, sucker, and delivery. The serial configuration reliability value is 6,6 x 10-4 and the value of the parallel configuration reliability is equal to 0.669 or 66.9% (by using the formula in equation 1 and 2), this result shows that the reliability of the machine SM-52 can function properly because of the level of reliability is close to 70% [3].

Table 3: MTBF each components

No	Component	MTBF (hour)	Reliability
1	Feeder table	638	0.391
2	Sucker	238	0.248
3	Side lay	181	0.350
4	Dampening Roller	631	0.295
5	Ink Roller	487	0.276
6	Plate Cylinder	444	0.184
7	Blanket Cylinder	461	0.374
8	Impression Cylinder	455	0.337
9	Delivery	236	0.276

E. Reliability Centered Spares

On the machine SM-52, Reliability Centered Spares (RCS) applies to arranged parts. There are 4 factors that affect the weight of each component, the value of each weight has a level between 1 to 5. These factors, namely consequence, anticipation, effects, and costs with their respective weight by 35%, 30%, 25%, and 10%. There are 27 parts are arranged, the highest values are in part RCS filtering bag, as gear roll air, laker skf, baut L4, ring 14 and pen belah of 3.45, while the lowest RCS values are in part o-seal and paku rivet of 2,60. This weighting indicates the priority procurement of parts that must be provided to the warehouse, in the high criticality, the component is prioritized to be available in the warehouse.

Table 4 : Criticality index

No	Spare part	Criticality	Criticality Index
1	As gear roll air	Medium critical	3.45
2	Laker skf	Medium critical	3.45
3	Baut L4 (7mm)	Medium critical	3.45
4	Ring 14	Medium critical	3.45
5	Filtering bag 50/60 mm	Medium critical	3.45
6	Pen belah 5mm	Medium critical	3.45
7	Piston compressor	Medium critical	3.25
8	Carbon blade	Medium critical	3.25
9	Laker Nachi 6001 ZZE	Medium critical	3.20
10	Roll Teflon	Medium critical	3.15
11	Cam follower	Medium critical	3.05
12	Valve	Medium critical	3.05
13	Lifting sucker nossle	Medium critical	3.00
14	EPC 12-03	Low critical	2.85
15	EPU 12	Low critical	2.85
16	EPL 6-02	Low critical	2.85
17	Baut roll	Low critical	2.85
18	Baut setelan klem plat	Low critical	2.85
19	Paku rivet ukuran kecil	Low critical	2.85
20	EPL 6-02	Low critical	2.85
21	Van belt T5-68	Low critical	2.85
22	Rakel	Low critical	2.85
23	Motor register	Low critical	2.85
24	Bellows	Low critical	2.85
25	Baut klem	Low critical	2.85
26	Paku rivet ukuran sedang	Low critical	2.60
27	O-seal R60 x 3	Low critical	2.60

Reliability Centered Spares (RCS) is to know what part of the priority that should be available in the warehouse, so there is no overstocking or understocking of spare parts that can cause harm to the company. Based on the criticality analysis using RCS, part only classified into two groups, namely the critical medium and low critical. Part classified as medium critical is 48% composed of lifting sucker nozzle, carbon blade, laker nachi, filtering bag, as gear roll air, laker skf, baut L4, ring 14, piston kompresor besar, roll teflon, cam follower, valve, dan pen belah 5 mm, while the parts are relatively low critical is 52%, consisting of a motor register, bellows, o-seal R60, rakel, van belt, baut klem, paku rivet ukuran sedang, paku rivet ukuran kecil, EPL 6-02, baut roll, baut setelan klem plat, EPC 12-03, EPU 12, dan EPL 6-02.

4. CONCLUSION

The relationship between the machine components SM-52 consists of a serial configuration and in parallel, the value of machine reliability SM-52 based on the relationship between the components is at 66.9%, this shows that the reliability of the machine SM-52 can function properly because of the level of reliability of close to 70 %. On the machine SM-52, there are 9 major components consisting of 27 parts that belong to the sub-critical components. Based on the criticality analysis using RCS, parts are classified into two groups: medium critical by 48%, consisting of 13 parts (lifting sucker nozzle, carbon blade, laker nachi, filtering bag, as gear roll air, laker skf, baut L4, ring 14, piston kompresor besar, roll teflon, cam follower, valve, dan pen belah 5 mm) and low critical by 52%, consisting of 14 parts (motor register, bellows, o-seal R60, rakel, van belt, baut klem, paku rivet ukuran sedang, paku rivet ukuran kecil, EPL 6-02, baut roll, baut setelan klem plat, EPC 12-03, EPU 12, dan EPL 6-02).

Recommendation for the company should conduct the maintenance based on the duration of MTBF to have higher reliability and prevent machine failures. For further research, the independent component should be included in the analysis to have more specific reliability and RCS.

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