DESIGN MAINTENANCE OF STITCHING MACHINE MAINTENANCE BASED ON THE RELIABILITY CENTERED MAINTENANCE (RCM) METHOD

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ABSTRACT

Machine maintenance and repair are essential to maintain optimal machine performance. Downtime is a situation where damage occurs to a machine component or when the machine restarts after undergoing a repair or replacement process. CV Madyotomo is a printing company that experienced a total of 20,114 minutes of machine downtime, resulting in a financial loss of Rp 50,285,550. This study aims to design a maintenance system on the Müller Martini 321 stitching machine at CV Madyotomo using the Reliability Centered Maintenance (RCM) approach. The results of the Failure Mode and Effect Analysis (FMEA) analysis show four critical components, namely bearing (RPN 240), v-belt (RPN 189), shaft gear (RPN 175), and support gear (RPN 160). The critical components are bearing, v-belt, shaft gear, and support gear. The application of the RCM method and the integration of the 5R concept has been proven to minimize downtime, extend the life of critical components, and increase the efficiency of the production process.

KEYWORDS Preventive maintenance, Reliability Centered Maintenance (RCM), Stitching Machine, FMEA

INTRODUCTION

In the manufacturing industry, machine maintenance and repair are essential to maintain optimal machine performance. In the manufacturing industry, there is a term called downtime. Downtime is a situation where damage occurs to a machine component or when the machine restarts after undergoing a repair or replacement process. This process is usually marked by two indicators: the start of the repair and the end (Juwandono & Purnama, 2023). The impact of downtime in the manufacturing industry is the failure to achieve production targets, lost production time, increased repair costs, and decreased productivity. Downtime is an unavoidable condition in the manufacturing industry. Therefore, the primary goal of maintenance management is to minimize downtime. In this context, component replacement decisions are crucial. To ensure that the machine can operate normally for a specified period, support from a combination of reliability, maintenance, and maintainability is required (Akbar & Widyaningrum, 2023).

Downtime is common in the manufacturing industry, particularly in the printing industry. Printing is the process of transferring text or images onto paper or other objects using a printing press. In this era of globalization, systems and technology have advanced rapidly, across large, medium, and small businesses. Therefore, many printing companies have begun utilizing information systems and technology to support their business operations and achieve a competitive edge over existing competitors. (Rahmawati, Karmelia, & Survia, 2024).

One of the growing companies in the city of Surakarta is CV Madyotomo which is located on Jl. Watuburik, Geplukan, Wonorejo, Kec. Gondangrejo, Karanganyar Regency, Central Java 57188, CV Madyotomo is a printing company that specializes in serving book orders, especially in the production of student worksheet books (LKS). This company has three main divisions, namely the web, sheet, and finishing divisions. In one day, CV Madyotomo is able to produce between 40,000 to 50,000 LKS books. CV Madyotomo has 3 web machines, 2 sheet machines, and 1 stitching machine. One of the machines at CV Madyotomo is a stitching machine or wire sewing machine Müller Martini 321 Automatic Saddle Stitching Machine is a device capable of reaching speeds of up to 14,000 cycles per hour. Specifically designed to meet medium to high production needs, this machine is ideal for printing LKS books. The following is downtime data on stitching machines for 6 months between October 2024 and March 2025. Based on the data, the highest downtime of the stitching machine occurred in October at 5737.2 minutes, while the lowest downtime was recorded in February at 872.4 minutes and the total downtime of the first 6 months was 23082.66 minutes.

The Reliability Centered Maintenance (RCM) method aims to ensure that the maintenance practices implemented are appropriate to operational conditions and the potential impact of failure. When a system shutdown occurs due to a damaged component, downtime can be significantly minimized by providing all necessary spare parts to replace the affected component (Hermawan & Akmal, n.d. 2021). RCM as an approach requires different forms of maintenance according to the specific context (Sugiarto & Pudji, 2023). Reliability Centered Maintenance (RCM) is a methodical procedure that is crucial for ensuring physical infrastructure functions optimally, in accordance with the established design and operational requirements (Surya, Saputra, & Sirlyana, 2024). RCM in physical asset management serves as a primary strategy for establishing routine preventive maintenance practices.

Based on the problems faced by CV Madyotomo and the existence of a compatible method, namely Reliability Centered Maintenance (RCM), this study has the objective of "Designing Maintenance of Stitching Machines Based on the Reliability Centered Maintenance (RCM) Method at CV Madyotomo".

RESEARCH METHOD

Table 1 presents previous research that will be used as a reference for this study. In detail, Table 1 lists previous research.

Table 1. List of Research

No	Method	Output	Objek	Author
1	Reliability Centered Maintenance (RCM)	Machine maintenance using the RCM method at CV. ABC. The cutting machine experienced 26 failures (MTTF 111.54 hours) and the drilling machine 24 failures (MTTF 120.83 hours). RCM effectively improves machine reliability by determining optimal maintenance intervals.	Cutting Machines	(Sastriawan, 2024)
2	Reliability Centered Maintenance (RCM)	RCM method on alumite machine at PT. XYZ. They found the loader component as the most critical component with RPN 144, and proposed scheduled on-condition maintenance actions to minimize maintenance costs, which were calculated at Rp11,961,496.	Aluminum Machines	(Hakim, Pratiwi, & Prasetyo, 2020)
3	Reliability Centered Maintenance (RCM)	Components with a high RPN (Risk Priority Number) are prioritized for maintenance. Maintenance recommendations focus on routine inspections, periodic component replacement, and implementing preventive maintenance strategies to extend machine life and reduce downtime.	Digital Screen Printing Machines	(Candra, 2022)
4	Reliability Centered Maintenance (RCM)	Reliability-Centered Maintenance (RCM) has demonstrated that this approach can improve machine reliability and operational efficiency. Through FMEA and FTA analyses, the study identified critical components, potential failures, and developed more effective maintenance strategies to reduce downtime and unexpected costs.	Paper Production Machines	(Azwir, Wicaksono, & Oemar, 2020)
5	Reliability Centered Maintenance (RCM)	Maintenance of the CZ6232A lathe at PT. TDE using the RCM method. The critical components found were the bearing (RPN 360), stator (RPN 288), and rotor (RPN 288). This study proposes maintenance strategies in the form of condition directed, failure finding, and time directed to reduce machine downtime.	Lathes	(Wibowo, Hidayatullah, & Nalhadi, 2021)
6	Reliability Centered Maintenance (RCM)	Maintenance of fuel conveyor unit with RCM at PT X. The critical components identified were electromotor, chain coupling, and gearbox. Preventive maintenance scheduling increased component reliability by 12–32% and saved maintenance costs of Rp37.7 million.	Fuel Conveyor Units	(Marimin & Zulna, 2022)
7	Reliability Centered Maintenance (RCM)	Reliability Centered Maintenance (RCM) to plan maintenance of standing pouch machines that frequently experience breakdowns. Three critical components—bearing, camp, and gripper—were identified as the main causes of downtime. The analysis results showed that the MTTF and MTTR of each component were: bearing (700.08 hours; 4.23 hours), camp (1359.84 hours; 5.37 hours), and gripper (1174.32 hours; 4.67 hours). RCM recommended failure-finding, condition-directed, and time-directed maintenance	Standing Pouch Machines	(Fatma, Ponda, & Saputra, 2022)

		strategies to reduce breakdowns and increase effectiveness.		
8	Reliability Centered Maintenance (RCM)	Bearing components (RPN 120) and seals (RPN 105.6) underwent a combination of maintenance actions, such as no task and redesign. Cooling Fan components (RPN 24) and Stator Coil & Rotor (RPN 40) required corrective maintenance actions under operator supervision until failure occurred. In addition, Motor Housing components (RPN 30) and Housing Bearing (RPN 22.4) received scheduled replacement actions based on their usage time limits. The RCM approach has proven effective in identifying maintenance priorities, improving system efficiency, and reducing the risk of future damage. This study provides relevant solutions to improve the maintenance system at PT Kiat Kuda Prima.	Generators	(Juniadi & Sujatmiko, 2024)
9	Reliability Centered Maintenance (RCM)	The 550T injection machine with the RCM method and found Clamping Toggle (downtime frequency 1,215 minutes), Nozzle (60 minutes), and Piston Injection (55 minutes) as critical components. The highest RPN value is Clamping Toggle (196), followed by Nozzle (180) and Piston Injection (175). Recommended maintenance strategies include Condition Directed (12.5%), Time Directed (50%), and Finding Failure (37.5%) to reduce downtime.	Imjection Machines	(Alsakina & Momon, 2023)
10	Reliability Centered Maintenance (RCM)	Machine building maintenance at PT. Bridgestone uses the RCM method, focusing on the hose and seal components that most frequently fail. As a result, with scheduled preventive maintenance, hose maintenance costs decreased by 55.13% and seal maintenance costs by 25.45%, and maintenance intervals were set at 280.81 hours and 134.08 hours, respectively.	Building Machines	(Muhazir, Sinaga, & Septiadi, 2024)
11	Reliability Centered Maintenance (RCM)	Maintenance of the First Press Expeller P03 machine at PT. Multi Nabati Sulawesi using the RCM method, determines the 32310 bearing and worm shaft as critical components with replacement intervals of 2500 and 1000 hours respectively, and recommends CD, FF, and RTF actions to minimize downtime and maintain machine reliability.	First Press Expeller P03 Machines	(Rasyid, Mokodompit, & Aprilia, 2020)
12	Reliability Centered Maintenance (RCM)	The Reliability Centered Maintenance (RCM) method reduces high downtime. As a result, three critical components—the unwinder, cylinder roll, and rewinder—are recommended to be replaced periodically at 808.5 hours, 693 hours, and 924 hours of operation, respectively, reducing the failure frequency by 58%, 50%, and 66%, respectively.	Slitting Machines	(Rizal, Yudhanegara, & Putri, 2023)
13	Reliability Centered	Reliability Centered Maintenance (RCM) optimizes expedition truck maintenance. Analysis was conducted on five key truck	Truck Engines	(Fathurohman & Triyono, 2020)

Maintenance (RCM)	systems: electrical, power steering, cooling, clutch, and brakes. The resulting 16 components were divided into five Time Directed (TD), six Condition Directed (CD), three Failure Finding (FF), and two Run To Failure (RTF) components to improve maintenance performance and efficiency.

Stage 1: Determination of Critical Components

The first stage is to identify the machine components that have the greatest influence on performance, safety and operational costs if a failure occurs.

Stage 2: Failure mode and effects analysis (FMEA) and RPN values determine Priority

In the second stage, namely Failure Mode and Effect Analysis (FMEA) and RPN values determine Priority. The steps and formulas (FMEA) and RPN are as follows:

a. Determine the failure mode of each component
b. Determine the effects of failure
c. Fill in the Severity (S), Occurrence (O), and Detection (D) values
d. Calculating the Risk Priority Number (RPN)

$$RPN = S \ x \ O \ X \ D \quad (1)$$

Stage 3: MTTF and MTTR Calculation

The third stage is the calculation of MTTF and MTTR. The MTTF and MTTR calculation formulas are as follows:

a. *Mean Time To Failure* (MTTF)

$$MTTR = \frac{Total\ Maintenance\ Time}{Number\ of\ Repairs} \quad (2)$$

b. *Mean Time To Repair* (MTTR)

$$MTTF = \frac{Total\ Hours\ of\ Operation}{Total\ Number\ of\ Repairs} \quad (3)$$

RESULT AND DISCUSSION

Critical Component Identification, The determination of critical elements in this study was conducted using a direct approach and analysis using a Failure Mode and Effect Analysis (FMEA) table. The first step was to identify each component of the stitching machine. This process began with interviews with machine operators and technical assistants to obtain detailed information. The interviews and FMEA analysis conducted at CV Madyotomo yielded data on the components considered most critical on the stitching machine. The interviews determined that the critical components of the stitching machine were the main gear, supporting gear, cutter blade, trimming knife, bearing, V-belt, gear fastening butt, knife holder, spring, and gear shaft.

Directly identifying critical elements does not provide sufficient detailed information about the stitching machine. Therefore, an analysis is needed that can assess the severity of failure impact Severity (S), the frequency of failure Occurrence (O), and the ability to detect failure Detection (D). The method used was Failure Mode and Effect Analysis (FMEA).

Tabel 2. Critical Component Identification

No	Failure	Failure Mode	Failure Effect	S	O	D	RPN
1	Nanas Gear	Teeth wear and break	Rotation is not transmitted to other units and the machine won't run.	9	6	4	216
2	Shaft Gear	Shaft wears and wobbles	Imprecise gears and high vibrations, resulting in further damage.	7	5	5	175
3	Gear Buffer	Cracks and wear	Main gears are not supported stably and vibration/system damage occurs.	8	4	5	160
4	Gear Bolt	Loose and broken	Loose gears are misaligned and can cause breakage.	7	5	4	140
5	V-Belt	Broken and loose	Power is not transmitted and the shaft is not engaged.	9	7	3	189
6	Bearing	Wear and jam	Rotation is not smooth and the pulley is stuck, resulting in overheating.	8	6	5	240
7	Support Gear	Weak and broken Springs	The blade doesn't return to its original position.	6	4	4	96
8	Blade	Blunt and broken	Wire is not cut and results are not perfect.	7	5	4	140
9	Trimming Knife	Blunt and broken	Uneven and imprecise book cuts.	8	4	4	128
10	Knife Holder	Loose and cracked	Cutting position is slanted and results are not as expected.	7	3	5	105

The proposed improvements in this study were realized through the development of a machine maintenance schedule. The initial stage in this process was converting the results of the FMEA analysis, which consisted of failure data and their ranking based on the Risk Priority Number (RPN). The next stage after the conversion is carried out, it is included in the MTTF and MTTR calculations. Table 3 were calculation of *mean time to failure* (MTTF). Table 4 were calculation of *mean time to repair* (MTTR)

Table 3. Calculation of *Mean Time To Failure* (MTTF)

No	Component	Damage Distribution	Parameter	MTTF (h)
1	*Bearing*	*Weibull 3-P*	Beta = 2,28500 Eta (hr) = 94,4272 Gamma (hr)= 7,72182	91,50707
2	*V-Belt*	*Weibull 3-P*	Beta= 2,33823 Eta (hr) = 134,318 Gamma (hr) = -7,82355	127,0039
3	*Shaft Gear*	*Weibull 3-P*	Beta= 1,72099 Eta (hr) = 86,4025 Gamma (hr) = 38,6424	115,21229
4	*Support Gear*	*Weibull 3-P*	Beta = 0,566352 Eta (hr) = 131,256 Gamma (hr) = 6,41301	219,25905

Table 4. Calculation of *Mean Time To Repair* (MTTR)

No	Component	MTTR (m)
1	*Bearing*	224
2	*V-Belt*	200
3	*Shaft Gear*	145
4	*Support Gear*	86,7

CONCLUSION

To determine the critical components of the stitching machine, observations, interviews, and Failure Mode and Effect Analysis (FMEA) were used. The analysis revealed four critical components: the Bearing with an RPN of 240, the V-Belt with an RPN of 189, the Shaft Gear with an RPN of 175, and the Support Gear with an RPN of 160.

Based on the Mean Time to Repair (MTTR), Mean Time to Failure (MTTF), and maintenance time calculations, combined with the analysis results from Minitab 19 software, the stitching machine can operate optimally without any significant damage. Therefore, the critical components of the manuscript gathering section of the stitching machine are determined as follows: Bearing Component, V-Belt Component, Shaft Gear Component, and Support Gear Component.

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