

Optimization of Spare Part Inventory for Mask Production Machines at PT. XYZ to Enhance Productivity

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ABSTRAK

Penelitian ini berfokus pada optimalisasi persediaan suku cadang untuk mesin produksi masker di PT. XYZ dengan tujuan untuk meningkatkan produktivitas dan mengurangi biaya operasional. Penelitian ini mengidentifikasi titik-titik kegagalan utama pada mesin masker, termasuk masalah pada sistem konveyor, tarikan katrol, dan penyegel ultrasonik, yang merupakan kontributor utama terhadap waktu henti produksi. Penelitian ini mengadopsi pendekatan penelitian kuantitatif, dengan fokus pada pengumpulan dan analisis data numerik secara sistematis untuk menarik kesimpulan dan memberikan wawasan objektif terhadap masalah yang sedang dipelajari. Dengan menerapkan konsep manajemen inventaris seperti stok pengaman, tingkat layanan, dan tinjauan berkala, penelitian ini menentukan tingkat inventaris suku cadang optimal yang diperlukan untuk memastikan ketersediaan komponen dan meminimalkan risiko kehabisan stok. Penerapan metode PDCA (Plan-Do-Check-Act) semakin meningkatkan proses perawatan mesin, yang mengarah pada peningkatan tingkat efektivitas mesin. Selain itu, manajemen inventaris yang efektif mengurangi pemborosan karena pembelian berlebih dan kesalahan pengelolaan suku cadang. Temuan tersebut menyoroiti bahwa dengan mengoptimalkan inventaris suku cadang dan meningkatkan perawatan mesin, PT. XYZ mampu mengurangi waktu henti, meminimalkan biaya operasional, dan meningkatkan produktivitas secara keseluruhan, yang berkontribusi pada efisiensi dan profitabilitas yang lebih besar.

Kata kunci: Persediaan Suku Cadang; Produksi Masker; Mesin; Produktivitas.

ABSTRACT

This study focuses on the optimization of spare part inventory for mask production machines at PT. XYZ with the aim of enhancing productivity and reducing operational costs. The research identifies key failure points in the mask machines, including issues with the conveyor system, pulley pulls, and ultrasonic sealers, which were the main contributors to production downtime. This study adopts a quantitative research approach, focusing on the systematic collection and analysis of numerical data to draw conclusions and provide objective insights into the issues being studied. By applying inventory management concepts such as safety stock, service levels, and periodic reviews, the study determines the optimal spare part inventory levels required to ensure component availability and minimize the risk of stockouts. The implementation of the PDCA (Plan-Do-Check-Act) method further improves machine maintenance processes, leading to an increase in machine effectiveness levels. Additionally, effective inventory management reduces waste due to over-purchasing and mismanagement of spare parts. The findings highlight that by optimizing spare part inventory and improving machine maintenance, PT. XYZ was able to reduce downtime, minimize operational costs, and enhance overall productivity, contributing to greater efficiency and profitability.

Keywords: Spare part Inventory; Mask Production; Machines; Productivity.

INTRODUCTION

The manufacturing industry has experienced rapid growth, with companies competing in both local and global markets to deliver high-quality products. The production of superior products is influenced by various factors, one of which is the smooth operation of production processes that adhere to established standards [1]. Machinery plays a critical role in the production process. A machine is considered efficient if it can achieve production targets without interruptions, operate at the designated speed, and produce high-quality outputs that meet the required standards. Therefore, proper maintenance is essential to ensure machinery remains in optimal condition and ready for use at any time [2]. Maintenance also extends the lifespan of the machines, enabling consistent performance over time [3].

PT. XYZ, an Indonesian pharmaceutical company based in Pandaan, East Java, was established in 2008. The company's primary vision is to foster Indonesia's independence in the healthcare sector, ensuring improved public health through the provision of high-quality, internationally standardized products. PT. XYZ's products cater to both domestic and international markets, including pharmaceuticals, medical devices, and household healthcare supplies. Its pharmaceutical portfolio spans categories such as antidotes and detoxifying agents, antiseptics, cardiovascular and hematopoietic drugs, dermatological treatments, herbal medicines, musculoskeletal remedies, vitamins, and minerals. The medical device range includes disposable devices, defibrillators, alcohol swabs, and ultrasound gel, among others. Additionally, its household healthcare supplies include hand sanitizers, underpads, medical plasters, and masks.

Despite its significant progress, PT. XYZ operates in an integrated and complex environment. Challenges occasionally arise in implementing systems on the ground, leading to discrepancies. For instance, in the production line for earloop masks, the high production costs result in narrow profit margins. Currently, the machines produce an average of 6,878 masks per shift. The total target for a single production batch is 250,000 masks, which requires 32 shifts to complete. With three shifts operating per day, it takes approximately 11 days to complete a single batch. This highlights the need for improvements in operational efficiency to optimize production and reduce costs [4], [5].

The initial stage involves the handover process by raw material warehouse personnel responsible for supplying materials, and production personnel responsible for counting and verifying whether the quantity and quality of raw materials meet the required standards. The second stage is the production process of masks. During the third stage, the packing and labeling processes occur simultaneously with production [6]. The final stage involves the handover of finished goods to the finished goods warehouse by production personnel and warehouse staff [7].

Observations indicate several issues during the mask production process, including production defects, breakdown losses, and setup and adjustment inefficiencies. Breakdown losses are primarily caused by machine failures, setup and adjustment times, and component replacement or repairs. In 2023, machine-related issues occurred an average of 2–3 times per month when production was limited to a single shift per day. However, since February 2024, with production operating on three shifts per day, machine issues have increased to an average of 15 occurrences per month, primarily due to problematic machine components. Data on these component issues will be used to calculate the Mean Time to Failure (MTTF), providing insights into the lifespan of

machine components. Understanding component lifespan is essential for preventing machine malfunctions and reducing breakdown time during production.

One of the key strategies to minimize breakdown time is the implementation of regular maintenance and timely replacement of machine components [8]. In this regard, the availability of machine components or spare parts plays a crucial role. A well-stocked inventory of spare parts ensures readiness when needed, thereby reducing breakdown time. This can be achieved through effective spare parts inventory management [9,10]. Efficient inventory management facilitates operational improvements by ensuring the availability of required spare parts within the designated time frame, while also avoiding wasteful over-purchasing or acquiring components that are unnecessary or unsuitable [11].

The study aims to address the issues described in the background by achieving several key objectives. First, it seeks to measure and evaluate the effectiveness of mask production machines. This involves analyzing their operational performance to determine their efficiency and reliability during the production process [12,13]. Second, the research focuses on identifying the types of failures that occur and uncovering the root causes of machine downtime, which is critical for minimizing disruptions and ensuring smooth operations. Lastly, the study aims to calculate the appropriate inventory levels for spare parts required for mask production machines. By determining the optimal stock levels, the research intends to support efficient inventory management, ensuring the availability of spare parts while avoiding overstocking or shortages.

METHOD

The research method refers to a series of strategies employed by the researcher to collect the necessary data to achieve the research objectives and address the identified problems. This study adopts a quantitative research approach, focusing on the systematic collection and analysis of numerical data to draw conclusions and provide objective insights into the issues being studied. The research steps undertaken are as follows:

1. Preliminary Phase: This phase involves determining the timeline and location of the research.
2. Identification Phase: formulating the problems identified during the research process.
3. Data Collection Phase: Gathering primary data, including production figures, machine downtime, rejection rates, and working hours. Secondary data collection includes an overview of the company and relevant documentation.
4. Data Processing Phase: Identifying machine problems, determining the causes of machine issues, analyzing the root causes of major problems using a fishbone diagram, implementing the PDCA method, and calculating productivity levels.
5. Conclusion Phase: The final stage involves drawing conclusions and providing recommendations based on the data analysis, aimed at addressing the research problems effectively.

RESULT AND DISCUSSION

Time Target

The time target is calculated by subtracting non-running time from the total working hours. This target corresponds to the productive working hours, which amount to 408 minutes per shift. This value serves as the basis for calculating the theoretical target.

Theoretical Target (Design Capacity)

The product target is determined by multiplying the machine speed with the time target. Machine speed refers to the number of products produced by the machine per minute, based on the design capacity of the Expert 9982 machine. The calculation is as follows:

$$\begin{aligned} \text{Theoretical Target} &= \text{Machine Speed} \times \text{Time Target} \\ &= 21 \text{ ppm} \times 408 \text{ minutes} \\ &= 8,568 \text{ pcs} \end{aligned}$$

Defective Product Percentage (%)

The percentage of defective products is calculated as the ratio of defective products to the total output. The calculation is illustrated below:

$$\begin{aligned} \text{Defective Product Percentage} &= \frac{\text{Defective Products}}{\text{Total Products}} \times 100 \\ \text{Defective Product Percentage} &= \frac{393}{6093} \times 100 = 6,4\% \end{aligned}$$

Average Actual Production Output



The average actual production output is calculated by dividing the total output by the number of shifts. The calculation is as follows:

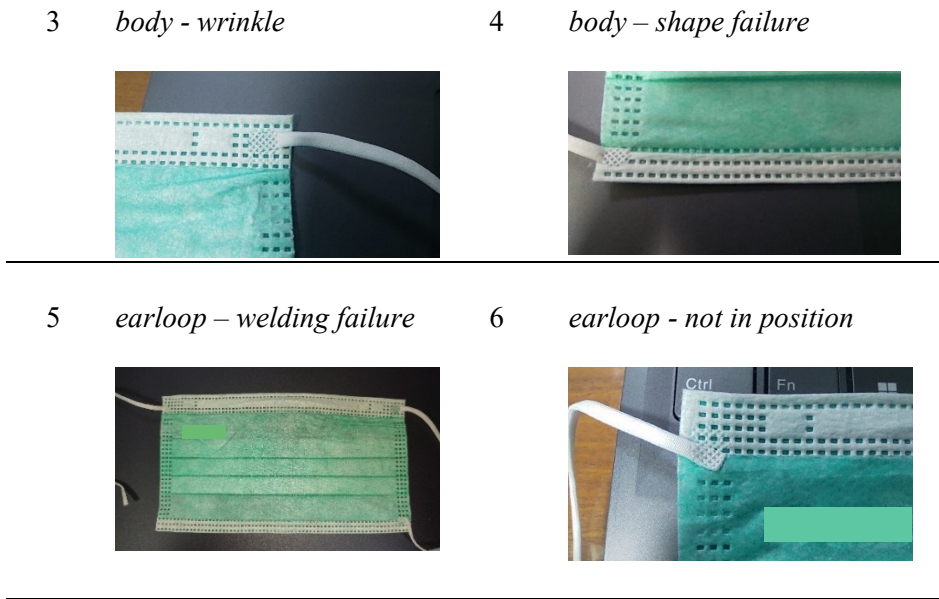
$$\begin{aligned} \text{Average Actual Production Output} &= \frac{\text{Total Output}}{\text{Total Shifts}} \\ \text{Average Actual Production Output} &= \frac{216,957}{32} = 6,779 \text{ pcs} \end{aligned}$$

Defective Products

The percentage of defective products per shift remains above 5%, exceeding the company’s acceptable threshold of 2%. Several types of defective products do not meet the company’s quality standards. These defective products are detailed in the table below.

Table 1. Defective Products

No	Defective Products	No	Defective Products
1	<i>double welding</i>	2	<i>body - folded</i>
			



Calculation of Estimated Loss Potential

One critical factor contributing to decreased productivity is machine downtime. Downtime, spanning from the onset of a problem to its resolution, potentially reduces revenue due to suboptimal production capacity. This calculation estimates the loss potential based on the production output that could have been achieved if the machine operated without interruption. Data provided: Total machine downtime (January 2023–March 2024): 17,674 minutes; Machine speed (standard): 21 ppm; Cost of Goods Sold (COGS): IDR 340 per unit.

$$\begin{aligned} \text{Estimated Loss} &= \text{Machine Speed} \times \text{Downtime} \times \text{COGS} \\ \text{Estimated Loss} &= 21 \text{ ppm} \times 17,674 \text{ minutes} \times \text{IDR } 340 \\ \text{Estimated Loss} &= \text{IDR } 126,192,360 \end{aligned}$$

Analysis of Machine Problem Causes

The following table summarizes the frequency of machine issues and their respective percentages of occurrence based on data from 2023 to March 2024.

Table 2. Analysis of Machine Problem Causes

No	Problem Cause	Frequency (2023)	Frequency (February -March 2024)	Total Incidents	Percentage (%)
1	Roll brake worn	1	4	5	9,6
2	Pneumatic misalignment	8	6	14	26,9
3	Encoder zero-point shift	-	2	2	3,8
4	Guide roll detachment	-	2	2	3,8

5	Sensor roll bolt damage	-	1	1	1,9
6	Nose wire platform misalignment	2	3	5	9,6
7	Mask frequently pinched	-	1	1	1,9
8	Ultrasonic error	3	2	5	9,6
9	Sensor roll misalignment	2	2	4	7,7
10	Motor failure	1	-	1	1,9
11	Mould misalignment	3	-	3	5,8
12	Pneumatic failure	1	-	1	1,9
13	Conveyor detachment	1	-	1	1,9
14	Gripper bolt damage	1	-	1	1,9
15	Bolt housing damage	1	-	1	1,9
16	HMI failure	1	-	1	1,9
17	Pull roll damage	1	-	1	1,9
18	Ultrasonic unit damage	2	-	2	3,8
19	Clamp damage	1	-	1	1,9
Total		29	23	52	100,00

The five main causes (below the 80% threshold) of the majority of issues are primarily due to shear pneumatic pull, worn roll brakes, misalignment of the nose wire support, ultrasonic errors, and misaligned roll sensors, while the remaining causes are considered minor. According to the Pareto principle (80/20 rule), the issues contributing to 80% of the problems are the primary causes, while the remaining 20% are minor issues that can either be addressed later or disregarded. In addition to the five machine-related issues that are prioritized for resolution, the availability of spare parts also becomes a key priority to address. Therefore, a summary of the overall problems can be seen in the cause-and-effect diagram presented in Figure 1.

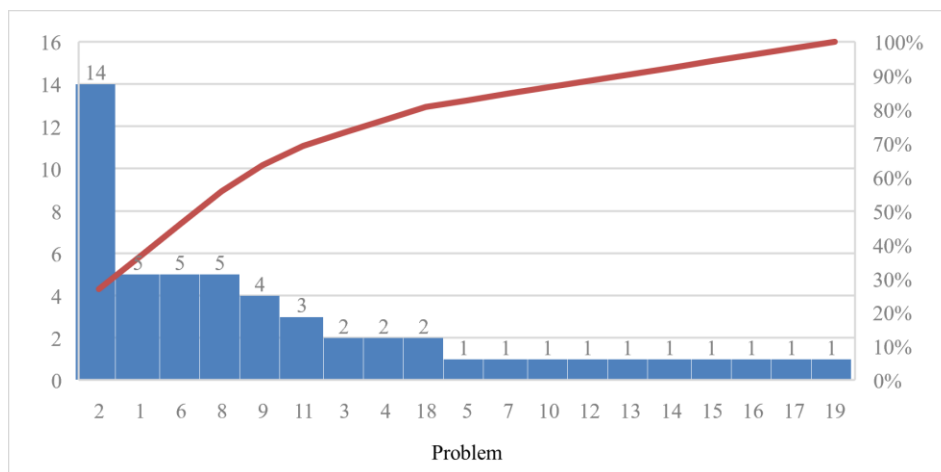


Figure 1. Diagram pareto

Safety Stock Calculation

The purpose of additional inventory is to account for uncertainties in demand and lead time. The calculation is as follows:

$$\sigma D \times \text{safety factor}$$

where:

σD = standard deviation

Standard Deviation Calculation:

The safety factor for a desired service level of 95% is 1.65 (refer to the attached Table of Safety Factors for Normal Distribution). The spare part usage data: 5, 1, 1, 1, 1, 1, 1, 2, 1

$$\text{Average} = \frac{\sum Xi}{n} = \frac{5+1+1+1+1+1+1+2+1}{9} = \frac{14}{9} = 1,56 \text{ units}$$

$$\text{Standard Deviation} = \sqrt{\frac{\sum (Xi - \mu)^2}{n}} = \sqrt{\frac{(5 - 2)^2 + (1 - 2)^2 + (1 - 2)^2}{9}} = 1,33 \text{ units}$$

$$\sigma D \times \text{safety factor} = 1,56 \times 1,33 = 2,07 \text{ units} = 3 \text{ units}$$

Analysis of Reduced Potential Losses

The implementation of inventory management, such as the ordering calculation using the periodic review formula, can assist companies in consistently ensuring the availability of spare parts. More structured inventory management can significantly reduce machine breakdown time, as it enables quicker handling when machinery issues arise, thus lowering the potential for losses. Furthermore, other loss impacts, such as emergency costs to compensate for production shortfalls, can be eliminated or minimized. On the other hand, the application of the periodic review method also reduces the risk of losses due to excess stock. By ordering items based on actual needs and more accurate demand forecasts, the company can avoid waste from stockpile accumulation, whether due to expired items or increased storage costs. Below is a comparison of the production process before and after implementing machine maintenance and inventory management:

Table 3. Reduction of Potential Losses in a Single Production Batch

Periode	Time Target	Time Achieved	Breakdown Time	Machine Effectiveness	Estimated Loss
February – Marc 2024	13.056	11.605	1.451	88,89%	Rp 10.360.140
September – October 2024	13.056	12.361	695	94,67%	Rp 4.962.300

Analysis of PDCA Implementation

1. Analysis of the Plan Stage (Planning)
The main issues have been clearly identified, including machine optimization, breakdown time, and insufficient operator training. The root causes of machine problems have been outlined, such as the lack of regular maintenance, insufficient or out-of-stock spare parts, and operator errors in handling the machines. The proposed solutions regular machine maintenance, spare parts availability, and operator training demonstrate a comprehensive approach to addressing these root causes.
2. Analysis of the Do Stage (Implementation)
The proposed solutions have been implemented, including performing maintenance during non-operational hours, training operators to enhance their skills, and ensuring adequate spare parts are stocked in the warehouse. The execution of these actions involved the Production and Engineering Departments.
3. Analysis of the Check Stage (Inspection)
An inspection is conducted by monitoring machine performance during operation and comparing effectiveness before and after maintenance. Data from this monitoring process are used to evaluate the success of the implemented solutions. Continuous monitoring is essential, as it serves as a foundation for further corrective actions.
4. Analysis of the Act Stage (Follow-up)
The Engineering Department ensures consistency in follow-up actions, focusing on maintaining routine machine maintenance and conducting repairs promptly when machine performance deviates from the standard, without waiting for the next scheduled maintenance. Meanwhile, the Spare Parts Warehouse consistently monitors the availability of machine parts and evaluates the need to adjust the minimum stock levels, thus supporting smooth machine operation.

CONCLUSION

Based on the research conducted on the optimization of spare part inventory for mask machines at PT. XYZ, the following conclusions can be drawn:

1. Identification of Masking Machine Failures: The study successfully identified the types of failures in the mask machines, such as disruptions in the conveyor, pulley pulls, and ultrasonic sealers, which were the primary causes of downtime during the production process.
2. Optimal Inventory Levels: By applying the concepts of safety stock, service level, and periodic review, this research determined the optimal quantity of spare parts required to maintain component availability when needed. This strategy effectively reduces the risk of stockouts, which can lead to production downtimes.
3. Effectiveness of Masking Machine Operations: The implementation of the PDCA (Plan-Do-Check-Act) method in production and inventory management significantly improved the machines' Overall Equipment Effectiveness (OEE), which in turn supported the company's productivity.
4. Impact of Effective Inventory Management: Effective inventory management not only helped reduce downtime but also minimized cost waste due to over-purchasing or improper

use of spare parts. This holistic approach to managing inventory proved to be a key factor in optimizing operational efficiency and reducing unnecessary expenses.

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