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The Role of Spare Parts Availability and Maintenance Data for Sustainability Maintenance at PT. Djarum Kudus

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Abstract

This research aims to develop a qualitative research model by identifying the implementation of maintenance at PT. Djarum and identifying the contribution of maintenance data and spare parts availability in selecting maintenance strategies. This research uses qualitative methods by conducting semi-structured interviews with representatives from PT. Djarum. The findings in this research are that maintenance data significantly influence the selection of machine maintenance strategies, and spare parts availability is not the primary factor in selecting machine maintenance strategies but contributes significantly. It is hoped that future research will be able to obtain more sources from other companies in the same sector as well as different sectors to compare the contributions of maintenance data and spare parts availability in their companies. Managerial implications for Machine Maintenance Service Companies in Improving Company Service Performance. This study explains the contribution of Maintenance Data and Spare Parts Availability to the performance of machine maintenance strategies in a company. This research model is used to determine the contribution of maintenance data and spare parts availability in improving the selection of machine maintenance strategies in the company.

Keywords

Maintenance, Maintenance Data, Spare Parts Availability, Maintenance Strategies

1. Introduction

Indonesia is one of the largest cigarette producers in the world (Tjandra et al., 2020). According to Ministry of Finance of the Republic of Indonesia, tobacco excise revenue (*Cukai Hasil Tembakau*) reached Rp 198.02 trillion in 2022, up 4.9% from the previous year. According to Kementerian Perindustrian Republik Indonesia, in 2019, the tobacco industry was able to employ up to 5.98 million people, consisting of 4.28 million in manufacturing and distribution sectors, and the remaining 1.7 million in the plantation sector. Generally, the tobacco industry in Indonesia produces cigarettes using two methods: manual labor, known as Sigaret Kretek Tangan (*Rokok Kretek Tangan / SKT*), and machine-made, known as Sigaret Kretek Mesin (SKM). The use of human labor in cigarette production can only be found in tobacco industries originating from Indonesia, as it is a local cultural heritage (Ozuem et al., 2023).

PT. Djarum is one of the largest cigarette producers in Indonesia. Currently, PT. Djarum ranks third nationally in producing cigarettes in Indonesia. The products produced include Sigaret Kretek Tangan (SKT), Sigaret Kretek Mesin (SKM), cigars, and shisha. The use of machines in producing Indonesia's cigarettes (kretek cigarettes) faces its own challenges for PT. Djarum. The mixture of cloves in cigarettes produces sticky residues that adhere to parts of the machinery during production. These sticky residues impair the optimal performance of the machines. The performance of machines in many companies or institutions, including PT. Djarum is commonly measured quantitatively using Overall Equipment Effectiveness (OEE). The issue faced by PT. Djarum in producing SKM is the suboptimal performance of the machines. Table 1 shows that the machine availability at PT. Djarum has the lowest value compared to the other two OEE factors, which are performance and quality. The low availability value is what leads to the low OEE at PT. Djarum.

Table 1. OEE Achievement at PT. Djarum for 2019-2021

Period	Av	Pe	RoQ	OEE
Semester I 2019	72.22%	91.47%	96.49%	64.00%
Semester II 2019	75.34%	92.69%	95.28%	66.51%
Semester I 2020	73.46%	92.67%	96.43%	65.84%
Semester II 2020	74.62%	93.27%	95.28%	66.41%
Semester I 2021	75.69%	93.09%	95.41%	67.28%
Semester II 2021	74.34%	92.86%	95.77%	66.21%

To restore the machine performance to optimal levels, maintenance is conducted by the relevant departments. Sidhu et al. (2012), machine maintenance is an essential activity that all organizations or industries, whether large-scale or SMEs, need to undertake. Generally, the maintenance strategy employed at PT. Djarum is divided into two categories: planned maintenance and unplanned maintenance. Unplanned maintenance (breakdown and corrective maintenance) still occurs frequently and contributes to the downtime experienced at PT. Djarum currently (Fani et al., 2024). With continuous downtime (Table 2), machine performance continues to decline, ultimately resulting in losses for the company as the machines are not ready to operate and cannot meet demand.

Table2. Breakdown, Corrective, & Downtime at PT. Djarum 2019-2021

Year	Breakdown (x)	Corrective (x)	Downtime (in minute)
Semester I 2019	15	1.370	110.522
Semester II 2019	23	2.097	187.860
Semester I 2020	12	1.686	133.544
Semester II 2020	11	1.639	130.081
Semester I 2021	14	1.470	128.392
Semester II 2021	26	1.396	104.915

According to Mohideen & Ramachandran (2014), the attributes that cause damage leading to machine unavailability include component lifespan, inappropriate spare parts, lack of technician capabilities, improper planned maintenance, changes in the work environment, extreme natural conditions, workplace accidents, and unforeseen failures (Santos & Oliveira, 2019). In this study, spare parts availability will be the main focus in determining the maintenance strategy. When a breakdown occurs requiring spare part replacement, the spare parts must be available, and maintenance technicians should be able to immediately perform the replacement to promptly resolve the machine breakdown (Chemweno et al., 2015). The duration of machine breakdown handling is one measure of machine performance, namely availability. Table 3 shows the number of out-of-stock spare parts used for planned maintenance at PT. Djarum. As seen in the table, the out-of-stock inventory has been increasing over the years. This situation leads to postponed or neglected maintenance, which can result in damage when the machines are still operated.

Table 3. Out-of-stock Spare Parts for Planned Maintenance at PT. Djarum 2019-2021

Year	Out-of-stock (pcs)	Total of Spare part (pcs)	Percentage (%)
Semester I 2019	23	1998	1,15%
Semester II 2019	11	1390	0,79%
Semester I 2020	19	812	2,34%
Semester II 2020	30	860	3,49%
Semester I 2021	45	711	6,33%
Semester II 2021	78	1030	7,57%

When spare parts availability needs to be consistently met, accurate maintenance data is also required. Accurate maintenance data supports accurate spare parts procurement forecasting. Inaccurate spare parts procurement forecasting can result in excess or insufficient spare parts inventory or inventory that does not match actual field needs (Dong & Cooper, 2016). Retracing maintenance and its spare parts requirements cannot be accurately analyzed if the machine information and maintenance data generated in the field are not properly recorded (Van der Auweraer et al., 2018).

From various literature and previous research findings, researchers have conveyed that spare parts availability is one of the determining factors in the duration of equipment repair. Mohideen & Ramachandran (2014) stated that spare parts availability does indeed affect the speed of equipment repair, but it is not the primary factor because the selection of spare parts placement locations and the quality of spare parts when installed have a greater impact on the speed of equipment repair. Meanwhile, the research conducted by Chemweno et al. (2015) viewed spare parts availability as the primary factor in determining maintenance strategies. In previous research, there were differences in views regarding the influence of spare parts availability on maintenance strategies, indicating that spare parts availability needs to be further examined and analyzed (Wu et al., 2019).

Based on the background and actual field data explained above, this serves as the primary rationale for conducting this research. The research formulation in this case is that spare parts availability and accurate maintenance data can contribute to appropriate maintenance strategies. The objective of this research is to explore the role of accurate machine maintenance data in production machine maintenance strategies, with spare parts availability as an intervening variable. In this section, the research will focus on the production line of Sigaret Kretek Mesin at PT. Djarum.

2. Methods

The type of research used in this study is qualitative research. Qualitative research places research participants as subjects, rather than objects as in quantitative research. This study does not employ statistical analysis but instead aims to obtain subjective insights from research participants. The data sources used in this study are primary data and secondary data. Primary data are information obtained directly by the researcher from informants, while secondary data are information obtained from existing sources related to the research, including the company's vision and mission, qualifications of maintenance technicians, the number of maintenance technicians, facilities supporting maintenance activities, the number of assets maintained, and the quantity and size of storage warehouses. The data collection technique used in this study employs data triangulation. This technique is used for the validation process of qualitative data obtained. The data triangulation technique used in this study includes interviews, observation, literature review, and documentation. After the data is collected, it will be processed through stages of data categorization, data reduction, data presentation, and conclusion drawing.

Data processing in qualitative research can be carried out without waiting for all data to be collected. If it is deemed that there is insufficient data, additional data collection can be conducted as needed. To ensure internal validity of the research findings, the applied strategies include data triangulation, member checking, and a relatively short research duration to avoid changes due to time. For the characteristics of the research informants, two (2) levels of positions within the organization were selected, namely managerial and operational levels. At the managerial level, the research informants are Senior Managers who are involved in designing and decision-making in the implementation of maintenance activities. Meanwhile, at the operational level, the research informants are Supervisors who directly execute and oversee maintenance activities in the field. This research was conducted at PT. Djarum Kudus, located at Site SKM Gribig, which is addressed at Sukoharjo, Gribig Village, Gebog District, Kudus Regency, Central Java 59333, and Site SKM Oasis, which is addressed at Bacin, Gondangmanis Village, Bae District, Kudus Regency, Central Java 59325. The research period spanned from December 2023 to March 2024.

3. Results and Discussion

The maintenance carried out at PT. Djarum is currently divided into 2 main methods, namely time-based maintenance and prediction-based maintenance (Al-Muhaisen & Santarisi, 2002). The first method is time-based maintenance, which is based on the duration of machine operation or the calendar. Time-based maintenance is further divided into several activities based on when this maintenance will be conducted. Starting with the daily maintenance carried out every day by Operators directly or Technicians is in line with the concept of Autonomous Maintenance in the Total Productive Maintenance (TPM) theory (Algabroun et al., 2022). The next maintenance is weekly maintenance, which is performed every week. Usually, this maintenance is done at the beginning and end of machine operation. The last maintenance in the time-based maintenance method is monthly maintenance. This maintenance is carried out within a one-month period and usually occurs very rarely. The monthly maintenance currently performed is Technical Cleaning, which is a thorough cleaning of the machine components, conducted by operators collaborating with technicians (Scholten et al., 2023).

The second maintenance method is based on prediction, commonly known as predictive maintenance. This maintenance can be performed based on smart sensors or the expected lifespan of a certain part or component failure. The advantage of this maintenance model is the ability to maximize the lifespan of a machine part or component because repair or replacement is done when the part or component is truly on the brink of failure. However, the disadvantage of this maintenance is the initial investment cost, which can be quite expensive for installing the required smart sensors (Anvari & Edwards, 2011). Meanwhile, predictive maintenance based on the expected lifespan of a specific part or component of the machine is carried out according to the machine vendor's recommendations beforehand. Currently, maintenance based on lifespan starts from the shortest interval at 1,500 hours, followed by 3,000 hours, 4,500 hours, 6,000 hours, 9,000 hours, and up to the longest interval of 12,000 hours. So, when the machine has operated for the specified hours, any predicted failures must be addressed with replacements. This maintenance is easy to supervise, and machines tend to operate safely because repairs are done at predetermined times. However, the disadvantage of this maintenance is the potential waste of lifespan if certain parts or components of the machine are still in good condition and can operate normally (Bhat, 2000).

The maintenance activities of the machines will generate machine maintenance data. Machine maintenance data itself encompasses all conditions or states of the machine resulting from human usage and maintenance that can be captured and provide information for further treatment (Ehrenthal & Stölzle, 2013). This maintenance data can offer information and guidance for users to take further actions to ensure the continuity of machine operation and production. Currently, maintenance data is obtained from sensors installed on the machines, as well as manually inputted by relevant technicians. The collected maintenance data will be organized and compiled into a system called CMMS (Computerized Maintenance Management System) (Firdaus et al., 2023). This system integrates all accumulated maintenance data and makes it easier for users to retrieve and process the data. The maintenance activities of the machines also generate the need for spare parts replacement. Machine spare parts themselves encompass everything prepared and become part of the machine to be replaced for the smooth and proper operation of the machine. Currently, machine spare parts at PT. Djarum are categorized into 4 (four) different categories. These categories are differentiated by their usage method and intensity (Garza-Reyes, 2015). The categories are consumable, maintenance, critical, and security parts, commonly abbreviated as CMCS.

Consumable parts are spare parts that are consumed over time. This can be likened to fuel (gasoline or diesel) used by vehicles. Maintenance parts are spare parts used for Preventive Maintenance (PM) activities. This activity involves planned maintenance based on the operational lifespan of a machine. Meanwhile, critical parts are provided to address issues beyond control and require spare parts replacement. Typically, these parts are prone to failure and are critical components of a machine. Security parts are similar to critical parts. These spare parts are used in cases of unforeseen machine issues requiring spare part replacement. However, security parts do not require constant stock availability in the warehouse. When an issue arises and such spare parts are needed, Operators or Technicians will inform the logistics department, and the logistics department will then provide them as requested.

Currently, the determination of spare parts availability is facilitated by a system. The system used at present is called Spare part Forecasting. This system integrates all the requirements and conditions of CMCS spare parts so that they can be consolidated and provided simultaneously for a specific period. However, procurement with the assistance of such a system does not solely rely on system calculations. Human intervention and analysis are still needed to support the accuracy and precision of spare parts provisioning (Jonsson & Mattsson, 2006). Based on the interview results, all respondents stated that machine maintenance data and spare parts availability are closely related. These two variables are interdependent (Talluri et al., 2004). Machine maintenance data will influence users' decisions to stock spare parts, while spare parts availability will, in turn, affect machine maintenance data used as the basis for spare parts provisioning. As explained earlier, spare parts are differentiated according to their usage and obtained using various pieces of information (Karim et al., 2018). The determination of the quantity and timing of consumable part purchases will be heavily influenced by production forecast data for the upcoming year. Meanwhile, maintenance parts will be influenced by the scheduled preventive maintenance issued by the Maintenance Planner. Critical and security parts, on the other hand, heavily rely on machine maintenance history data entered by Operators or Technicians after performing maintenance (Silva et al., 2024).

Similarly, with the selection of maintenance strategies, all respondents agree that maintenance data is closely linked to the selection of maintenance strategies. The collected maintenance data (machine issues and repair efforts) will serve as the basis for decision-makers to decide which maintenance strategy to implement when faced with a problem or challenge (Kumar & Meade, 2002). Not all machine maintenance data can be directly applied to the same problem, but past machine maintenance data serves as a reference or guide to solve the same or similar issues or challenges. By conducting simple maintenance activities, such as inspections at the beginning and end of production processes, daily, or weekly, actual and controlled maintenance data will be obtained. These data will be collected, evaluated, and analyzed by decision-makers to determine the next tactical activities. This allows decision-makers more time to analyze and determine the appropriate repairs for their machines. Thus, comprehensive and accurate maintenance data will greatly contribute to the decisions regarding maintenance strategy that will be made (Mohan et al., 2023).

All respondents stated that the availability of spare parts significantly contributes to the selection of maintenance strategies. However, this spare parts availability is not the primary factor influencing decision-makers to choose which maintenance strategy to implement. In certain conditions, many other considerations may lead to the modification, postponement, or cancellation of a maintenance strategy (Özbayrak et al., 2004). This could be related to safety and health, for example. From field observations, there are maintenance strategies that cannot be implemented without the availability of spare parts. It can be said that these maintenance strategies heavily rely on and make spare parts availability their primary factor. For example, planned preventive maintenance strategies involve entirely replacing machine spare parts. Therefore, if even one spare part is unavailable, the implementation of this strategy can be postponed or even cancelled. If spare parts are truly unavailable but maintenance strategies still need to be carried out, efforts will still be made to implement these maintenance strategies. If the unavailable spare parts are mechanical, efforts can be made for in-house repairs at the company's refurbishment workshop (Patil et al., 2022).

Additionally, ordering from the company's centralized spare parts workshop can also be attempted. It would be different if damage occurs to spare parts with electronic components (Wijesinghe & Illankoon, 2024). Currently, the company does not have a repair and manufacturing workshop for spare parts with electronic circuits. The last resort, if spare parts are indeed unavailable, is to borrow spare parts that are still in good condition from other machines. This activity is commonly known as Limited Time Part Time Loan or *Peminjaman Part Waktu Terbatas* or PPWT. This means there are donor machines that lend spare parts to the machines that need maintenance strategies implemented. Donor machines are selected if they have been idle (not in operation) for more than 2 (two) weeks or if there is no production load on them (Wänström & Jonsson, 2006). This activity is highly controlled and meticulously recorded using specific forms to track the history of spare part usage, thus becoming part of the subsequent maintenance data. Spare parts may not be the primary factor in determining machine maintenance strategies, but spare parts are closely related and greatly support the implementation of a maintenance strategy. Therefore, spare parts availability becomes crucial and must always be ensured according to their functions and types.

4. Conclusion

The conclusion of this research focuses on three main variables: maintenance data, spare parts availability, and maintenance strategies. Maintenance data obtained from machines and the field play a crucial role in determining the availability of spare parts. The determination of the quantity and timing of spare parts needed is based on existing maintenance data. Additionally, maintenance data obtained from machines and the field are also crucial in the selection of maintenance strategies. Decision-makers will examine past maintenance data to guide them in determining the maintenance strategies to be implemented in order to restore the machine's performance to its original state. The availability of spare parts plays an important role in the selection of maintenance strategies but is not the primary factor in choosing them. Although not the primary factor in selecting maintenance strategies, spare parts availability still needs to be managed well and accurately because there are several maintenance strategies that cannot be implemented at all without the availability of spare parts. This research was only conducted at one company in the tobacco processing industry, so the findings of this study represent typical maintenance activities in that particular company. For future research, comparative studies can be conducted at other companies in the same industry, namely the tobacco processing industry. Additionally, since this research was only conducted in one type of industry, namely the tobacco processing industry, the findings may not be applicable to or comparable with other types of industries. For future research, studies can be conducted in various industries other than the tobacco processing industry, such as the consumer goods industry or the resin industry, both of which also utilize machines at high frequencies to produce products. In this research, only one factor in the selection of machine maintenance strategies was examined, namely the availability of spare parts, so the contributions and relationships of other factors are not yet known. For future research, other factors related to the selection of machine maintenance strategies can be added. This can be used to compare with previous research results involving other determining factors.

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