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Analysis of Overall Equipment Effectiveness (OEE) Enhancement With Total Productive Maintenance Improvements in Rubber Company

Tania Alda[*1], Hiskia Bastanta Silalahi[1], Sukaria Sinulingga[1]
[1]*Department of Industrial Engineering, Faculty of Engineering, Universitas Sumatera Utara, Padang Bulan, Medan, 20155, Indonesia*
[*]Corresponding Author: taniaalda@usu.ac.id

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ABSTRACT

This research was conducted at a company engaged in rubber processing. This company plants, maintains, and processes rubber to produce Crumb Rubber. Based on observations during the study, it is known that there are defective products with an average of 400 kg per month. The type of defect found in the product is a white spot. Defects in these products are caused by failures in the performance of machines that experience thirst or collection, causing white spots in the products produced. This study aims to improve the company's performance by reducing defective products by analyzing the factors that cause a decrease in company performance, measuring the overall equipment effectiveness (OEE) value, and providing an improvement design to improve machine performance so that defective products can be minimized. The research found that two dominant factors cause high machine breakdowns: maintenance schedules and raw material quality. Based on the calculation results, the average overall equipment effectiveness value is 46%. Machine performance is not according to OEE standards due to the average value of the availability rate being 80%, the performance rate being 93%, and the quality rate being 57%. Based on this, the improvement design for the low OEE value is to improve the suggestion system, improve the quality control group, and implement the company's PDCA (Plan, Do, Check, Act) cycle.

Keyword: *Overall Equipment Effectiveness, Rubber, Total Productive Maintenance, Machine, Performance.*

ABSTRAK

Penelitian ini dilaksanakan pada perusahaan yang bergerak dalam pengolahan karet. Perusahaan ini menanam, memelihara dan mengolah karet untuk menghasilkan *Crumb Rubber*. Berdasarkan pengamatan selama penelitian diketahui bahwa terdapat produk cacat dengan rata-rata 400 kg per bulan. Jenis cacat yang terdapat pada produk adalah *white spot*. Cacat pada produk tersebut disebabkan oleh kegagalan pada *performance* mesin yang mengalami haus atau penumpulan sehingga menyebabkan *white spot* pada produk yang dihasilkan. Tujuan dari penelitian ini yaitu untuk meningkatkan kinerja perusahaan agar mengurangi produk cacat dengan melakukan analisis faktor-faktor yang menyebabkan penurunan kinerja perusahaan, melakukan pengukuran nilai *Overall Equipment Effectiveness* (OEE) dan memberikan rancangan perbaikan untuk meningkatkan performance mesin agar produk cacat dapat diminimalisir. Dari hasil penelitian diperoleh hasil bahwa terdapat dua faktor dominan yang menyebabkan tingginya *breakdown* mesin yaitu jadwal perawatan mesin dan kualitas bahan baku. Berdasarkan hasil perhitungan, rata-rata nilai *Overall Equipment Effectiveness* adalah 46%. Kinerja mesin belum sesuai dengan standar OEE dikarenakan rata-rata nilai *Availability Rate* 80%, *Performance Rate* 93%, dan *Quality Rate* 57%. Berdasarkan hal tersebut, maka rancangan perbaikan terhadap rendahnya nilai OEE adalah melakukan perbaikan sistem saran, perbaikan gugus kendali mutu dan melaksanakan siklus PDCA (*Plan, Do, Check, Act*) pada perusahaan.

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Keyword: Efektivitas Peralatan Total, Karet, Pemeliharaan Produktif Total, Mesin, Kinerja

1. Introduction

In an increasingly developing industrial era, companies compete to meet consumer needs and increase company profits. Companies use various methods to meet the needs of consumers. Consumer needs vary greatly, so companies must be able to act wisely when making decisions. Companies that can control the quality of their products well can survive in a competitive environment [1]. By producing quality products, the company has satisfied consumers [2]. If consumer satisfaction increases, customer loyalty to the Company's products will increase [3]. The availability of industrial facilities is essential for the Company to be productive and deliver quality products. The role of facility maintenance is needed to support the Company's performance.

This research was conducted at a company engaged in rubber processing. This Company is directly involved in planting, maintaining, and processing rubber to produce Crumb Rubber. The production process in this company generally starts with taking rubber tree sap from the company's plantations and smallholder plantations around the company. The sap is collected as raw materials and enters the pre-cleaning section. It is then stored in BIN storage, Factory Line, warehouse, and the Shipping section.

In maintaining quality and increasing productivity, one of the critical factors that must be considered is the problem of machine maintenance of production facilities. The type of machine maintenance carried out by the Company today is the breakdown maintenance type. Breakdown maintenance is carried out after damage to the machine. The scope of the research is on the hammermill machine, which often experiences damage to the blade during the crumb rubber production process. If the blade is thirsty due to friction on the raw material, the Company will make repairs by lubricating the fluid to the machine. It causes the raw material not to be appropriately cut and results in the product experiencing white spots. Products that experience white spots become defective products. Breakdown Maintenance will impact the smooth production process [4].

The problem faced by the company is that many defective products are in production. Based on observations, it is known that an average of 400 kg of faulty products per month. The types of defects found in the product are white spots in the form of white spots on the product and defects in contamination by foreign materials. Contamination defects caused by foreign materials such as iron, sand, stones, and other substances affect production quality. Defects in these products are caused by failures in the performance of machines that experience thirst or collection, causing white spots in the products produced. Based on the above problems, it is necessary to analyze the overall equipment effectiveness (OEE) by measuring the OEE value to see the factors that cause the low overall equipment effectiveness value. Based on this description, it is necessary to find the causal factor so that the company can evaluate and follow up, and ultimately, the company's performance and productivity can increase [5]. Therefore, it is necessary to analyze and improve the company's overall equipment effectiveness (OEE).

2. Methods

This research was conducted at a company engaged in rubber processing. The object studied is the amount of production and the machine identified in productive maintenance activities, namely the hammermill machine. Data collection uses secondary information from company reports, such as the number of machine working hours, total production, total defective production, and machine downtime. The stages of data processing implementation are calculating the availability value, the performance rate value, the rate of quality value, and the OEE value, and making a fishbone diagram to determine the root of the problem and recommend improvement proposals for the company.

The availability, performance, and quality rate must be calculated before calculating the OEE value [6].

$$\text{OEE (\%)} = \text{availability (\%)} \times \text{performance (\%)} \times \text{quality rate (\%)} \quad (1)$$

Availability ratio is a ratio that describes the utilization of time available for machine or equipment operation.

$$\text{Availability Ratio}=\frac{\text{Operation Time}}{\text{Loading Time}}\text{X 100\%} \quad (2)$$

Performance is a ratio that describes the ability of a machine or equipment to produce an item or product.

$$\text{Performance}=\frac{\text{Production Quantity x Ideal Cycle Time}}{\text{Operation Time}}\text{ X 100\%} \quad (3)$$

Quality ratio is a ratio that describes the ability of machines and equipment to produce standardized products.

$$\text{Quality Ratio}=\frac{\text{Production Quantity- Defect}}{\text{Production Quantity}}\text{X100\%} \quad (4)$$

The World-Class Standard for Overall Equipment Effectiveness (OEE) value is an Availability Ratio of 90%, a Performance Ratio of 95%, a Quality Ratio of 99%, and an Overall Equipment Effectiveness (OEE) ratio of 85% [7]. After knowing the results of the OEE calculation, which consists of three factors: the analysis of the calculation of the Availability Ratio, Performance Ratio, and Quality Ratio, a fishbone diagram is used to find out the most dominant root cause [8].

3. Results and Discussion

3.1. Availability Ratio

The availability ratio describes the utilization of time available for machine or equipment operation. The data used in measuring the availability ratio are the values of machine working time, planned downtime, and downtime (Failure and repair and Setup and Adjustment).

Table 3.1 Availability Ratio

Month	Downtime (Minutes)	Operating Time (Minutes)	Failure & Repair (Minutes)	Set up % Adj (Minutes)	Availability Ratio (%)
Jan	32400	28632	807	2961	88.37
Feb	32400	28759	679	2962	88.76
Mar	32400	28926	543	2931	89.28
Apr	32400	28796	683	2921	88.88
May	32400	28699	757	2944	88.58
Jun	32400	29010	458	2932	90.00
Jul	32400	29061	536	2961	89.21
Aug	32400	27785	452	4163	85.76
Sep	32400	27504	532	4364	84.89
Oct	32400	27405	524	4471	84.58
Nov	32400	27871	356	4173	86.02
Dec	32400	27153	634	4613	83.81

From Table 3.1 above, the highest availability value occurred in June, reaching 90%, which meets the world-class standard of 90%. The lowest value was recorded in December, at 83.81%. The failure to meet the world-class standard was due to high downtime caused by damage to the blade component of the hammermill machine, resulting in an extended breakdown duration.

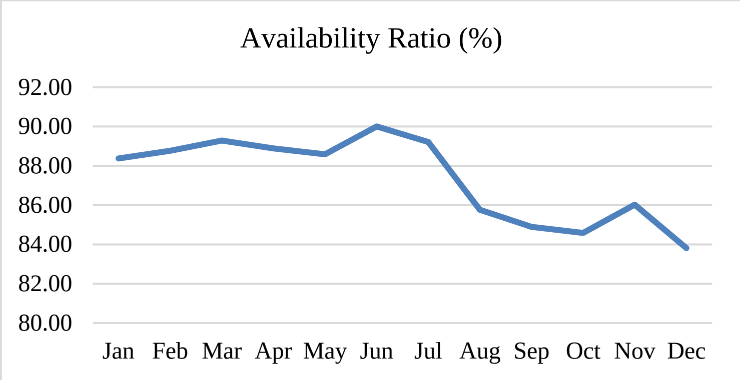

Figure 3.1 Availability Ratio

3.2. Performance Ratio

Performance is a ratio that describes a machine's or equipment's ability to produce an item or product. The data used to measure the performance ratio are Output, Cycle Time Actual, Operating Time (Loading time, Failure and repair, and Setup Adjustment).

Table 3.2 Performance Ratio

Month	Operating Time (Minutes)	Output (Kg)	Ideal Cycle Time (Minutes)	Performance Ratio (%)
Jan	28632	1285	22	98
Feb	28759	1190	24	99
Mar	28926	1244	22	94
Apr	28796	1311	21	95
May	28699	1339	19	88
Jun	29010	1423	19	93
Jul	29061	1365	21	98
Aug	27785	1239	22	98
Sep	27504	1381	18	90
Oct	27405	1051	22	84
Nov	27871	1131	20	81
Dec	27153	1442	18	95

Based on Table 3.2 above, the highest Performance value occurred in February, reaching 98%, which exceeds the world-class standard of 95%. The lowest value was recorded in November at 81%. The failure to meet the world-class standard during March, May, June, September, and November was due to low production volumes. Additionally, the available operating time was reduced because of high downtime.

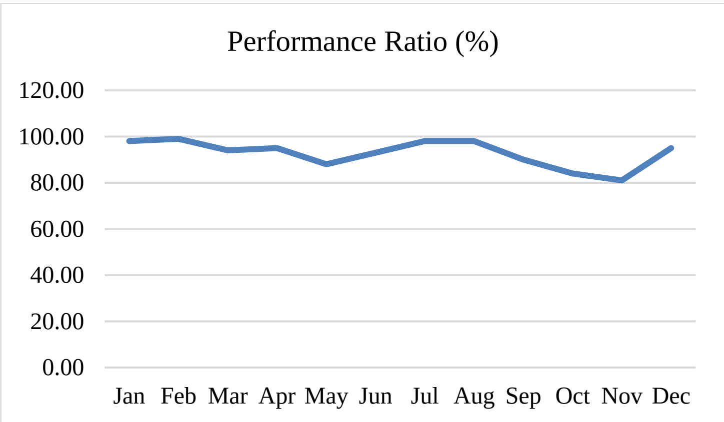

Figure 3.2 Performance Ratio

3.3. Quality Ratio

Quality ratio is a ratio that describes the ability of machines and equipment to produce standardized products.

Table 3.3 Quality Ratio

Month	Output (kg)	Number of Defects (kg)	Quality Ratio (%)
Jan	1285	454	45
Feb	1190	509	50
Mar	1244	563	56
Apr	1311	530	53
May	1339	568	56
Jun	1423	495	49
Jul	1365	532	53
Aug	1239	548	54
Sep	1381	610	61
Oct	1051	739	73
Nov	1131	730	73
Dec	1442	649	64

Based on Table 3.3 above, the highest quality value occurred in November at 73%. However, this value needs to meet the world-class standard of 99%. The lowest value was recorded in January, with a quality value of 45%. The failure to achieve world-class standards in production can be attributed to inconsistencies in the raw material chopping process, which did not align with the company's standards. Consequently, the raw materials were not cooked thoroughly in the oven during the cooking process. This issue was also exacerbated by the suboptimal performance of the chopping machine, leading to a high number of rejected products in the company.

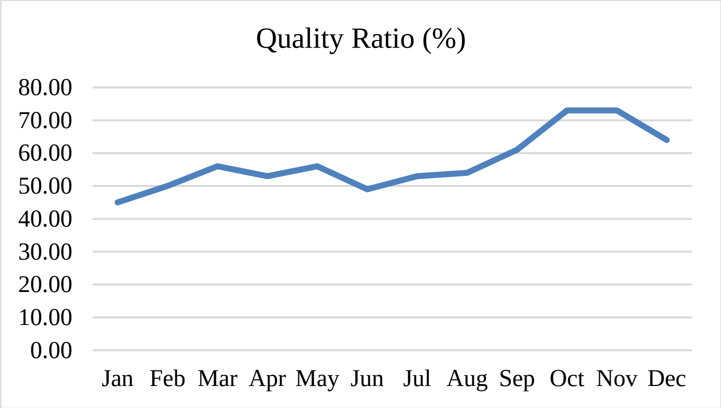

Figure 3.3 Quality Ratio

3.4. Overall Equipment Effectiveness (OEE)

After obtaining the Availability, Performance, and Quality ratio values, the next step is calculating the OEE value.

Table 3.4 Overall Equipment Effectiveness (OEE)

Month	Availability Ratio (%)	Performance Ratio (%)	Quality Ratio (%)	OEE (%)
Jan	88	98	45	39
Feb	88	99	50	44
Mar	89	94	56	47
Apr	88	95	53	45
May	88	88	56	44
Jun	89	93	49	41
Jul	89	98	53	46
Aug	85	98	54	46
Sep	84	90	61	46
Oct	84	84	73	52
Nov	86	81	73	50
Dec	83	95	64	51

Based on Table 3.4 above, the highest OEE value occurred in October at 52%, but this figure does not meet the world-class standard of 85%. The lowest value was recorded in January at 39%. The low-quality rate is attributed to the inability to achieve a world-class production standard. It can be concluded that the OEE value in this company remains below 60%. According to the benchmark set by JIPM, if the value does not meet the 60% standard, production is considered to have a low score and requires immediate improvement.

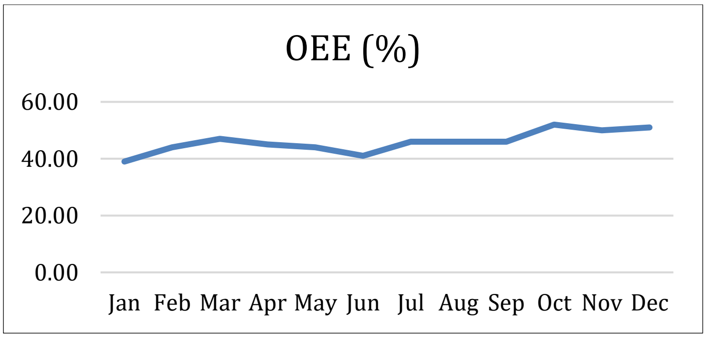

Figure 3.4 Overall Equipment Effectiveness (OEE)

Table 3.5 compares the company's OEE value with the World-Class Minimum Standard value.

Table 3.5 Comparison of Actual OEE Value Achievement With World-Class Standard Value

Month	World Class Standard (%)	Actual Value (%)
Jan	85	39
Feb	85	44
Mar	85	47
Apr	85	45
May	85	44
Jun	85	41
Jul	85	46
Aug	85	46
Sep	85	46
Oct	85	52
Nov	85	50
Dec	85	51

From the table above, it can be seen that the highest OEE value occurred in October at 52%. This value does not exceed the world-class standard value of 85%. The lowest value occurred in January, at 39%. Not achieving world-class standards in production is caused by the low-quality rate value. Based on the calculation, it is found that the achievement of the OEE value in this company is below 60%. According to The Japan Institute of Plant Maintenance (JIPM), if the value does not meet the 60% standard, the production will have a low score and require immediate improvement.

3.5. Fishbone Diagram

A fishbone diagram is one of the methods/tools for improving quality. This diagram shows an effect or consequence of a problem with various causes. The impact or consequence is written as a snout head, while causes fill the fishbone according to the problem approach. The following is a diagram of the cause and effect of the low OEE value in the company.

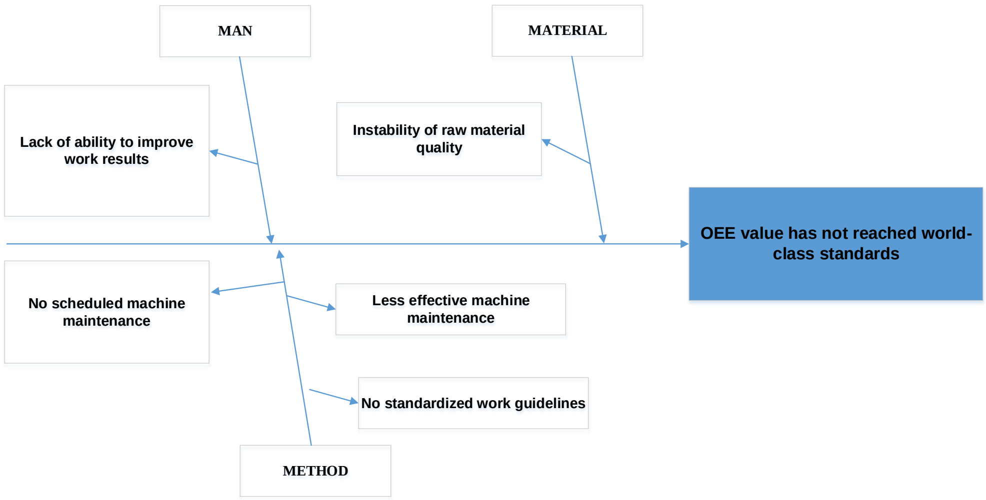

Figure 3.5 Fishbone Diagram

From the figure 3.5, it can be seen that there are three categories of causes of low OEE values in this rubber processing company. The first cause is the method factor. The method used to maintain machines is less effective because the tools used to help carry out maintenance are often problematic or damaged, so *engineering* staff use makeshift tools. It causes *downtime* to be more extended. In addition, only *maintenance* division staff are charged with repairing machine damage. Staff in the production division are less concerned about the machines around them, causing a lack of communication between workers if the machine is experiencing interference.

The second cause is the material factor. The company works with many *suppliers*, especially *from the* local community, who plant their rubber trees. The community's rubber sap results are used to meet production needs. It causes the quality of raw materials to change frequently and become inconsistent. Raw materials from community *suppliers* often contain foreign objects such as stones, sand, twigs, and high water content in rubber sap. It has an impact on machine performance and also the results obtained when processing raw materials. The third cause is the human factor, namely the lack of ability of workers to improve the quality of work, which impacts the quality of the workers' performance. It causes the quality of raw materials to affect the quality of the resulting product significantly. Human factors play a significant role in this study as they relate to the product's production process and the responsiveness in the maintenance and repair of machinery, ensuring that the machines can resume normal operations promptly.

Based on the root cause of the problem from the fishbone diagram, several recommendations for improvement are proposed; namely, the company must make changes to the improvement of the suggestion system. The suggestion system can be used as a means to empower employees to cultivate a kaizen mindset and quality improvement. Improvements made to the suggestion system are creating a schedule for evaluating suggestions and giving awards to every employee who offers suggestions. The company also needs to make improvements to the Quality Control Cluster. Implementing the Quality Control Cluster allows employees to provide creative ideas in solving problems and improving the workplace. These activities are the company's efforts to educate employees to create a quality culture. Improvements to the quality control group include forming a quality control group comprising all employees and creating standard work guidelines. The company should also start implementing the PDCA cycle. PDCA is a continuous feedback cycle in which the system carries out a planned process, is evaluated, gets feedback, makes improvements, and returns to planning in a cycle that continues to improve [9]. PDCA consists of plan (develop a plan), do (implement the plan), check (check the results achieved), and action (take adjustment action if necessary) [10].

4. Conclusion

Based on the research results, the performance of the *hammermill* machine is different from that of OEE standards. Based on calculations that have been carried out, the average *overall equipment effectiveness* value is 46%. This is because some values do not reach the standard three components of the OEE value calculation. In the performance of *the hammermill* machine, the average value of *the Availability Rate is* 80%, *the Performance Rate* is 93%, and *the Quality Rate* is 57%. Based on the approach model in this study, companies can use the *total productive maintenance* improvement method *to increase OEE value. Recommendations for* *improvements to the non-optimal* OEE value are to improve the suggestion system, improve the quality control group, and implement the PDCA cycle.

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