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Analysis of Total Effective Equipment Performance SD5 Machine on *Krosok* Production Line, Primary Manufacturing Department. (Case Study: PT NT)

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ABSTRACT

PT NT is one of an International Tobacco Industries in Indonesia. The rapid development of the cigarette industry, as well as the increased demand, encourage many companies to evolve their production quality and capacity. One effort established by PT NT is controlling the effectiveness of production machines, including SD5 machine. In this study, an analysis of SD5 machine performance conducted using the Overall Equipment Effectiveness and Total Effective Equipment Performance. Based on the ten days of direct observation of machine performance, the study revealed that the OEE level was only a mere at 63.2%, under the world level, 85%. Further, the TEEP number was about 36.8%. Those low figures were mainly caused by the low level of machine utilization and availability. Thus, the fishbone diagram established to discover the main causal, reporting that four main aspects, human, methods, material and machine, played essential roles in the problem.

INTRODUCTION

A cigarette is one of the most demanded products by the public, especially among adults(Oztas et al., 2015). Indonesia included in one of the highest smoking rates as well as tobacco producers in the world. In 2017, approximately 322.1 billion cigarettes consumed in Indonesia(Hirschmann, 2020b). Even in 2019, an online survey with 2000 respondents conducted, discovering only 17% who smoked during social events and a mere 6% who did once a week. Meanwhile around 500 respondents consumed it once a day and almost half of them smoked three times within 24 hours which accounted for 49%(Hirschmann, 2020a). With the high amount of demand, therefore, many companies attempt to outperform others in term of quality and production capacity.

PT NT is a cigarette company established in 1932, which located in Kudus, Central Java. It is one of the largest company in Indonesia with numerous well-known brands, such as MD, CM, A, and NS. To maintain the productivity rate, PT NT should ensure every machine work properly, including the essential SD5 machine used to chop the tobacco leaf sheets to be subtle.

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In Fact, the SD5 machine usually hampered, resulting in the ineffectiveness of machine usage and increasing production time. Thus, PT NT monitored the effectiveness and found the potential problem and solution using the TEEP and Fishbone method.

Total Effective Equipment Performance (TEEP) is a percentage number representing the equipment performance which takes production rate and losses into consideration(Joseph & Jayamohan, 2017). TEEP also reflects how well the equipment run the production process and how optimal the equipment used by the company(Dal et al., 2000). Fishbone diagram, also called the Ishikawa diagram, is a technique to identify, sort and present the possible causes of a specific problem(Coccia, 2017). Causes are usually grouped to major categories, including people, methods, machines, materials, measurements and environment(Liliana, 2016). After discovering the main causal, the firm could focus on determining the solution to overcome the trouble.

This research aims to analyze the performance of SD5 machine using the Total Effective Equipment Performance and discovering the factors caused the problem using the fishbone diagram and six big losses analysis. Therefore, this research could indicate the essential part needed to analyze further to increase the effectiveness of the SD5 machine.

RESEARCH METHOD

The research is conducted based on the data collected from the production plant where the SD5 machine performed. The data then analyzed by the OEE and TEEP performance method. Further, after discovering the number and classified it to the world level, a fishbone diagram established to find out the possible causes of the problem.

Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a method used to measure the level of effectiveness of a machine or production equipment(De Ron & Rooda, 2006). The OEE Standard Value that widely used is determined by the Japan Institute of Plant Maintenance, including(Nakajima, 1986):

- 100% OEE, a production that runs perfectly, operates smoothly without any downtime, works with high performance and there are no defects or rework on production results.
- OEE 85%, indicates that the production machine is included in world-class. This score is a score that is suitable for long-term goals for the company.
- 60% OEE, it indicates that production is running sufficiently, but there is a great room for improvement
- OEE 40% indicates that production has a low score, suggesting that there are still rooms for improvement

OEE is calculated by calculating three essential elements(Hedman et al., 2016), the availability, the performance and the quality rate of SD5 machine(Lanza et al., 2013).

Availability Rate

Availability is an indicator that shows the level of machine availability to perform operations during working hours. Availability rate can be determined by equation 1.

$$\text{Planned Production Time} = \text{Loading Time} - \text{Planned Downtime} \tag{1}$$

$$\text{Run Time} = \text{Planned Production Time} - \text{Unplanned Downtime} \tag{2}$$

$$\text{AR} = \frac{Run\ Time}{Planned\ Production\ Time} \tag{3}$$

Equation 1 used to count the availability rate by considering several factors. Planned production Time is the total time that the machine is expected to perform operations. Run Time is the actual time the equipment can carry out the production process. Planned Downtime, the total time the equipment is in an off condition due to things that have been

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scheduled and Unplanned Downtime is the duration when the equipment is supposed to operate, but in an off condition due to unexpected things.

Performance Rate

Performance Rate is an indicator that represents the level of a machine's ability to carry out the production process at its standard speed.Performance rate can be obtained using equation 4.

$$PR = \frac{Total\ Production}{Cycle\ Time \times Run\ Time} \quad (4)$$

Within equation 2, cycle time refers to the machine capabilities to produce goods in some amount of time. The total production represents how many goods successfully produced by the equipment. Run time means how long the machine performed.

Quality Rate

Quality rate is an indicator that shows how many defective or rework items appear during the production process. The quality rate can be measured by Equation 5.

$$QR = \frac{Good\ Products}{Total\ Production\ Number} \quad (5)$$

Overall Equipment Effectiveness (OEE)

OEE measured by considering three main elements, including availability rate, performancerate and quality rate and calculated using equation 6(Sayuti et al., 2019).

$$OEE = AR \times PR \times QR \quad (6)$$

Total Effective Equipment Performance (TEEP)

Total Effective Equipment Performance (TEEP) is a percentage value that describes the portion of the production of a good-quality product compared to the total time available. This formula includes equipment utilization and OEE value. TEEP can be measured using equation 8.

$$\text{machine utilization} = \frac{Run\ Time}{Loading\ Time} \quad (7)$$

$$TEEP = OEE \times \text{machine utilization} \quad (8)$$

Data collection was carried out directly within five days of observation, in the form of observing the work process of the SD5 machine. Several types of data collected by the researcher, including loading time, planned and unplanned downtime and the running duration that all used to evaluate the availability rate, shown in Table. 1.The number of the production process, batches product, machine capacity and its operation time used to determine the performance rate, shown in Table 2.While the number of rejects products and production number used to calculate the Quality rate shown in Table 3.

Table 1. Duration of Machine Usage

Period	Loading Time (second)	Planned Downtime (second)	Unplanned Downtime (Second)	Run Time (Second)
Day 1	32160	19770	2770	9620
Day 2	28800	7289	4641	16870
Day 3	28800	6360	10012	12428
Day 4	29820	0	7597	22223
Day 5	28800	4320	10370	14110
Day 6	28800	6580	3090	19130

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Day 7	28800	6580	4320	17900
Day 8	28800	4461	5366	18973
Day 9	28800	2881	7746	18173
Day 10	31680	7395	6485	17800

Table 2. Machine Capacity and Total Production

Period	Batch Product	Machine Capacity (kg/hours)	Actual Operation Time (second)	Total Production Number (kg)
Day 1	1	2601	4923	2579
	2	2651	4833	2543.8
Day 2	1	3104	4790	3373.6
	2	3009	2080	1708.9
	3	3087	3960	3356.9
Day 3	1	3011	4800	3771.1
	2	3046	4423	3415.8
	3	3051	4200	3051
Day 4	1	3056	4124	3422.2
	2	3107	4440	3733.1
	3	3093	4480	3710.9
	4	2362	5008	2553.8
	5	2348	4400	2288.1
Day 5	1	2403	4790	2552
	2	2473	4870	2570.2
	3	2415	4410	2635.5
Day 6	1	3041	4270	3453.4
	2	3032	4565	3434.2
	3	3047	4100	3411.9
Day 7	1	3141	4980	3838.4
	2	3107	3960	3243.1
	3	3100	4800	3169.7
	4	3086	2240	1730.3
Day 8	1	3114	4456	3469.1
	2	3107	4900	3415.1
	3	3087	4140	3430.3
	4	3113	4180	3439.1
	5	3093	4520	3446.1
Day 9	1	3017	4785	3769.8
	2	3022	4675	3765.8
	3	3021	4590	3730.7
	4	3110	4832	3386.1
	5	3119	4560	3471.1
Day 10	1	2714	3850	2349.2
	2	2734	4530	2572.7

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3	2720	4730	2594.9

Table 3. Number of Production and Rejects

Period	Batch Product	Total Products	Total Rejects
Day 1	1	2579	14,38
	2	2543.8	9,3
Day 2	1	3373.6	16.3
	2	1708.9	12.85
	3	3356.9	20.5
Day 3	1	3771.1	19
	2	3415.8	18.38
	3	3051	12.18
Day 4	1	3422.2	13.5
	2	3733.1	11.5
	3	3710.9	18.52
	4	2553.8	8.5
	5	2288.1	9.2
Day 5	1	2552	12.67
	2	2570.2	10
	3	2635.5	9.5
Day 6	1	3453.4	15.5
	2	3434.2	16
	3	3411.9	10.6
Day 7	1	3838.4	17.02
	2	3243.1	12.76
	3	3169.7	80
	4	1730.3	8
Day 8	1	3469.1	16.5
	2	3415.1	12.72
	3	3430.3	19.4
	4	3439.1	26
	5	3446.1	19.5
Day 9	1	3769.8	16.5
	2	3765.8	12.72
	3	3730.7	19.4
	4	3386.1	26
	5	3471.1	19.5
Day 10	1	2349.2	8.5
	2	2572.7	10.26
	3	2594.9	11.5
	4	2605.9	12.5

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RESULTS AND DISCUSSION/HASIL DAN PEMBAHASAN

From the data obtained during the observation, the measurement of OEE calculated using the equation, resulting in the data as follow.

Table 4. Availability Rate SD5 Machine

Period	AR
Day 1	77,6%
Day 2	78,4%
Day 3	55,4%
Day 4	74,5%
Day 5	57,6%
Day 6	86,1%
Day 7	80,6%
Day 8	78,0%
Day 9	70,1%
Day 10	73,3%

Table 5. Performance and Quality Rate SD5 Machine

Period	Batch Produk	Performance Rate		Quality Rate	
Day 1	1	72,5%	72,0%	99,4%	99,5%
	2	71,5%		99,6%	
Day 2	1	81,7%	92,9%	99,5%	99,4%
	2	98,3%		99,2%	
	3	98,9%		99,4%	
Day 3	1	93,9%	90,3%	99,5%	99,5%
	2	91,3%		99,5%	
	3	85,7%		99,6%	
Day 4	1	97,8%	89,8%	99,6%	99,6%
	2	97,4%		99,7%	
	3	96,4%		99,5%	
	4	77,7%		99,7%	
	5	79,7%		99,6%	
Day 5	1	79,8%	81,9%	99,5%	99,6%
	2	76,8%		99,6%	
	3	89,1%		99,6%	
Day 6	1	95,7%	94,5%	99,6%	99,6%
	2	89,3%		99,5%	
	3	98,3%		99,7%	
Day 7	1	88,3%	87,5%	99,6%	99,0%
	2	94,9%		99,6%	
	3	76,7%		97,5%	
	4	90,1%		99,5%	
Day 8	1	90,0%	90,3%	99,5%	99,5%
	2	80,8%		99,6%	

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Period	Batch Produk	Performance Rate		Quality Rate	
	3	96,6%		99,4%	
	4	95,1%		99,2%	
	5	88,7%		99,4%	
Day 9	1	94,0%	91,2%	99,6%	99,5%
	2	96,0%		99,7%	
	3	96,9%		99,5%	
	4	81,1%		99,2%	
	5	87,9%		99,4%	
Day 10	1	80,9%	77,2%	99,6%	99,6%
	2	74,8%		99,6%	
	3	72,6%		99,6%	
	4	80,4%		99,5%	

Referring to the number of availability, performance and quality rate, as shown in Table 4 and Table 5, the number of OEE can be calculated using equation 6. The OEE figure of SD 5 machine is shown in Table 6.

Table 6. OEE of SD5 Machine

Period	AR	PR	QR	OEE
Day 1	72,0%	77,6%	99,5%	55,6%
Day 2	92,9%	78,4%	99,4%	72,4%
Day 3	90,3%	55,4%	99,5%	49,8%
Day 4	89,8%	74,5%	99,6%	66,7%
Day 5	81,9%	57,6%	99,6%	47,0%
Day 6	94,5%	86,1%	99,6%	81,0%
Day 7	87,5%	80,6%	99,0%	69,8%
Day 8	90,3%	78,0%	99,5%	70,0%
Day 9	91,2%	70,1%	99,5%	63,6%
Day 10	77,2%	73,3%	99,6%	56,3%
Overall	86,8%	73,2%	99,5%	**63,2%**

Based on the overall calculations executed, SD5 machine's OEE value is 63.6%. For the availability aspect, an average number of 73.2% obtained. The performance aspect was about 87.1%, while the average number 99.5% performed by the quality aspect.Refers to the global standard number of OEE, Score of 63.6% is classified to sufficient performance with the big room available for improvement.This number is still far under the OEE world standard, which is 85%. The 85% OEE value is obtained from the availability value with 90%, 95% performance and 99% quality, thus the SD5 machine OEE number must be improved, especially on availability and performance.

Further, a measurement of Total Effective Equipment Performance conducted before establish the fishbone diagram analysis. Using equation 7, the number of TEEP can be obtained, as shown in Table 7.

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Table 7. TEEP number of SD5 Machine

Period	Loading Time (second)	Run Time (Second)	Utilization	OEE	TEEP
Day 1	32160	9620	29,9%	55,6%	16,6%
Day 2	28800	16870	58,6%	72,4%	42,4%
Day 3	28800	12428	43,2%	49,8%	21,5%
Day 4	29820	22223	74,5%	66,7%	49,7%
Day 5	28800	14110	49,0%	47,0%	23,0%
Day 6	28800	19130	66,4%	81,0%	53,8%
Day 7	28800	17900	62,2%	69,8%	43,4%
Day 8	28800	18973	65,9%	70,0%	46,1%
Day 9	28800	18173	63,1%	63,6%	40,1%
Day 10	31680	17800	56,2%	56,3%	31,7%
		Overall			36,8%

Based on the calculations executed, the TEEP number of the SD5 machine is 36.8%, where the largest number is on Day 6 which is 53.8% while the lowestis at mere 16.6% on Day 1.The TEEP value is influenced by the utility of the production machine and the value of its OEE.The low average TEEP value indicates that the use of SD 5 machines is still not optimal, mainly because of the low usage of SD 5 machines.

Further, the fishbone diagram conducted to analyze the causes of low OEE number at SD5 machine. Therefore the researcher could discover the main factor which could be used in further research.

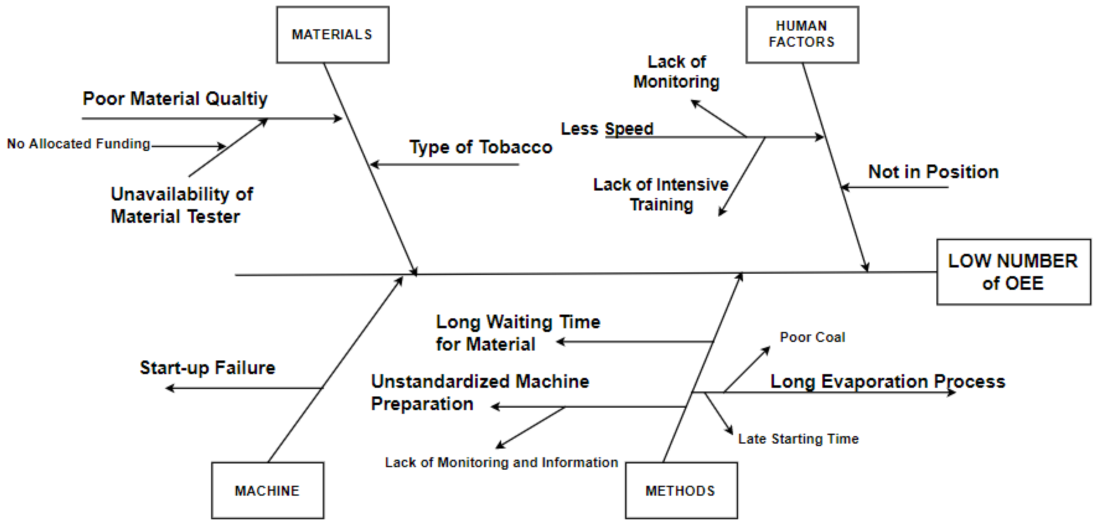

Figure 1. Fishbone Diagram

Based on the fishbone diagram, it is discovered that the low OEE and TEEP values are influenced by four factors, namely humans, methods, materials and machines.

Humans

Two main factors fall into this category, namely non-site workers and less-skilled workers. Workers are not on-site because of backups for other machines left by the original operator

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either for temporary (resting) or permanent (not working on that day). Workers are also less swift, in the sense that they do not understand the machines they run.

Methods

Three main factors included in this category, are preparation machines that do not comply with standards, long enough evaporation of coal due to bad coal materials and no arrived material leading to delay of work.

Materials

Two main factors fall into the material category. First is material with low density. This material has a large amount but with a small weight so that if it is processed in the SD5 machine, it does not match the original capacity.Second is coal quality that is not sufficient enough, which can inhibit the evaporation process. It is because there is no equipment available to check the quality of the ordered coal, which is quite expensive, so the company has not allocated money to purchase.

Machine

SD5 machine has a disadvantage which fails to cut tobacco properly at the beginning of the process. It is because of the inability of the cutting knife to reach the tobacco that enters the machine for the first time (engine startup failure).

CONCLUSIONS

This research was conducted to analyze the effectiveness and the utilization of SD5 machine performance at the cigarette industry, PT NT. The analysis was established using the Overall Equipment Performance, Total Effective Equipment Performance and Fishbone Diagram. The research discovered that the machine performance was far under the global standard, only a mere at 63.2% compared to 85% that would mean there are many rooms for improvement, especially in the availability rate of machine. Established using the fishbone diagram, the firm should focus on solving the main cause of low OEE and TEEP, including the low monitoring activities, lack of intensive training and more. It is necessary for the firm to have appropriate strategies to improve the utilization of machine which result in the higher effectiveness and performance of SD5 machine.

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