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THE EFFECT OF PREVENTIVE MAINTENANCE SCHEDULING ON RELIABILITY MACHINE IN PT INDONESIA TORAY SYNTHETICS (ITS)

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Abstract
The objection of this research is to analyze the influence factors of reliability machine and preventive maintenance scheduling on production process of staple fiber PT ITS. As for the method is used for this research is using six sigma approach with DMAIC (Define, Measure, Analyze, Improve, and Control) phases to analyze types of waste of staple fiber production and factors that causes the waste. Total Productive Maintenance (TPM) Method to analyze the effect of machine productivity and performance on waste of staple fiber production using calculation of Overall Equipment Effectiveness (OEE) and six big losses are using to analyze the losses that caused value of OEE. Failure Mode Effect Analysis (FMEA) is used to analyze the risks that probably occurs during spinning process on production line 28P which causes the high total time losses on idling and minor stoppages. One of the risk that has the highest probability is the amount of output caused by abnormality of gear pump machine. Based on the calculation of Time to Failure (TTF) and Time to Repair (TTR), the interval of gear pump machine replacement using age replacement model is 1300 hours and the interval of gear pump machine maintenance is 823,9277 hours as of the reliability of machine has increase after.

Index Terms -- DMAIC, Overall Equipment Effectiveness (OEE), Preventive Maintenance, Production Waste, Six Big Losses, Six Sigma, Staple Fiber, Total Productive Maintenance (TPM).

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INTRODUCTION

Competition between companies in the industrial world is getting tougher, every industry is required to be able to always meet customer demands on time and in accordance with the quality expected by the customer. Therefore, proper quality control is needed to monitor the entire series of production processes so the quality of the products produced remains under the supervision of the company. The waste production process is influenced by the level of efficiency, effectiveness, and productivity of its operational activities. In addition, the ineffectiveness of the use of machines also affects the quality of the products produced so this can also affect customer confidence in the company. Based on this, the problem we formulated is the factor that causes the high amount of waste in the production process of staple fiber, the effect of machine productivity on the amount of production waste, the type of failure that causes the low value of production machinery productivity and the scheduling of optimum preventive maintenance of the production machine. The purpose of this research is to analyze the factors causing production waste, the effect of machine productivity on waste and the factors that affect the productivity of production machines and make optimal preventive maintenance scheduling simulations so machines can work productively and the resulting waste is reduced.

RESEARCH METHOD

The methodology used in this research is the method of data collection conducted by interviewing operators and production managers, making direct observations to companies to obtain data such as the amount of waste production of staple fiber, production machine breakdown data, and the risks that may occur in the process production. The research method used is a six sigma approach with DMAIC (Define, Measure, Analyze, Improve, and Control) stages to analyze the causes of waste and Total Productive Maintenance (TPM) to analyze the effectiveness of production machines and scheduling preventive maintenance to improve the reliability of production machines.

RESULT AND DISCUSSION

A. Six Sigma Approach

In this research, the Six Sigma approach is used to determine the steps to control the waste of the staple fiber production process on PT ITS's 28P production line. The six sigma approach uses 5 stages known as DMAIC namely define, measure, analyze, improve and control [1].

B. Define Stages

Define phase is the initial stage in the six sigma approach. At this stage, the researchers identify the problems that occur in the company [1], in this case concerning the problem of the high amount of waste during the spinning process. The flow process of the 28P staple fiber production line can be seen in Fig. 1.

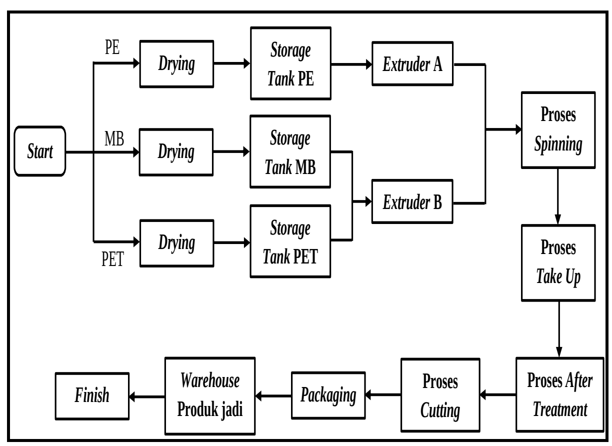

Figure 1. Production Process Flow of 28P Staple Fiber Production Line

Based on the agreement using the Critical to Quality (CTQ) tool, there are 8 types of waste during the 28P staple fiber production line production process which can be seen in Table I.

Table I. Important for Quality

Waste Type	Description
Spinning	
PA	This waste occurs because of a breakdown in the production machine so the spinning production process is stopped and the extruder machine still issues an output called waste PA or called a polymer block.
PB	Waste is in the form of a fine filament from a spinning block pack and is usually the result of changing component packs.
PC	Filament-shaped waste in the process of filament withdrawal from the godet roll to gear wheal or commonly called subtow takeup.
After Treatment	
PC	Waste that occurs during the replacement of creel components or commonly referred to as subtow creel.
PD	Filament-shaped waste that occurs due to material content that does not pass the qualification or also called tow material.
PE	Waste that occurs due to a problem in the crimper component or commonly called crimp tow crimper.
PF	Waste caused due to an error in the process of cutting the filament or commonly called crimp tow cutter
W/B	Waste caused by dirty filament and uncut filament.

C. Measure Stages

This measure phase is the next stage of the define stage, at this stage will be calculated the data that has been collected. The parameters used in this stage are the control chart and the calculation of Defect per Million Opportunities (DPMO) to determine the six sigma level in the spinning process.

D. Control Chart

A control chart is one of the parameters or tools in the measuring stage that the researchers uses to supervise and monitor the waste production process of staple fiber, especially the 28P production line [2]. Based on the results of data processing on the waste staple fiber production process on the 28P PT ITS production line using the p-chart, it can be seen that the entire staple fiber production process on the 28P production line during 2017 is outside the UCL (Upper Control Limit) value limit with value of 0.0691 and LCL (Lower Control Limit) value with a value of 0.0674. It can be said that the entire staple fiber production process on the 28P production line during the 2017 period is still beyond the control of PT ITS, resulting in a high total waste of the staple fiber production process. The control chart waste staple fiber production process graph can be seen in Fig. 2.

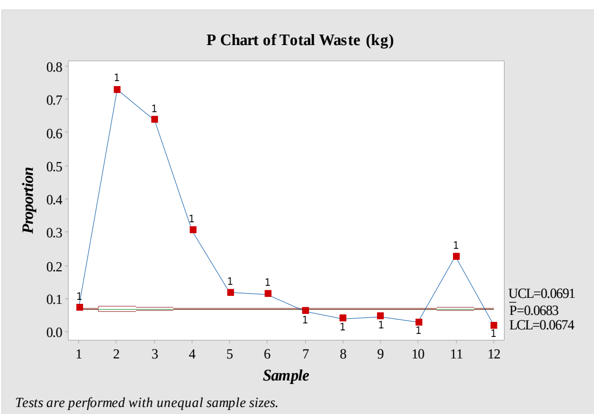

Figure 2. P-chart Graph of Staple Fiber Production Waste on the 28P Production Line

E. Defect per Million Opportunities (DPMO) and Six Sigma Levels

Furthermore, the researchers also use the Defect per million opportunities (DPMO) tool to determine the six sigma level at PT Indonesia Toray Synthetics which is used to analyze PT ITS waste control standards [3]. Based on the DPMO calculation and the six sigma level of the spinning process on the 28P production line in the January to December 2017 period, it can be seen that the overall DPMO value is 8,531.49 and the overall six sigma level is 3.89. PT ITS is a Japanese subsidiary, so in its production process, it uses Japanese industry average standards. This is because most of the customers owned by PT ITS are multinational companies, especially Japanese companies. Based on the achievement table of six sigma values, it can be said that the level of quality of PT ITS's staple fiber products is still below the average standard of the Japanese industry with a DPMO value of 233 and a six-sigma level of 5 [4]. Therefore, it is necessary to analyze to determine and determine the factors that cause the problem.

F. Analyze Stages

The analyze phase is the third stage in the six sigma approach. At this stage, the researchers analyze the root causes of the high amount of staple fiber production waste and the factors that influence the DPMO value and six sigma levels that are below the standard. The tools used are Pareto diagram, fishbone diagram analysis, Total Productive Maintenance (TPM) approach using Overall Equipment Effectiveness (OEE) calculation and six big losses, and Failure Mode Effect Analysis (FMEA) analysis. Based on the analysis using the Pareto diagram, it can be seen that 80% of the total waste is PA waste, namely raw material waste which is still in the form of polymer, this waste occurs because of a breakdown in the production machine so the spinning production process is stopped and the extruder machine still outputs an amount 57,403 kg or 30.01% of the total production waste [5]. Therefore, it is necessary to analyze using a fishbone diagram so it can be seen as the cause of the high PA waste which can be seen in Fig. 3.

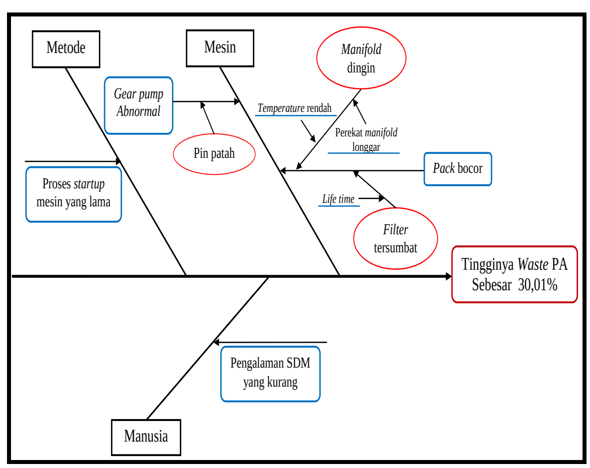

Figure 3. Fishbone Diagram

Based on analysis using a fishbone diagram, it can be seen that the most dominant factor is the engine [5]. Therefore, the researchers use the Total Productive Maintenance (TPM) approach with the calculation of Overall Equipment Effectiveness (OEE) to analyze the effect of machine effectiveness on the amount of staple fiber production waste [6]. Based on the diagram in Fig. 4, it can be seen that PT ITS OEE value is still below the world-class OEE value standard. Therefore we need an analysis of the calculation of six big losses to determine the failure factors that affect the effectiveness of the engine (OEE) [6]. Fig. 5 shows that the factors that cause low OEE values are the idling and minor stoppages with a total time loss of 5,664 hours or 82.95% of the total time losses.

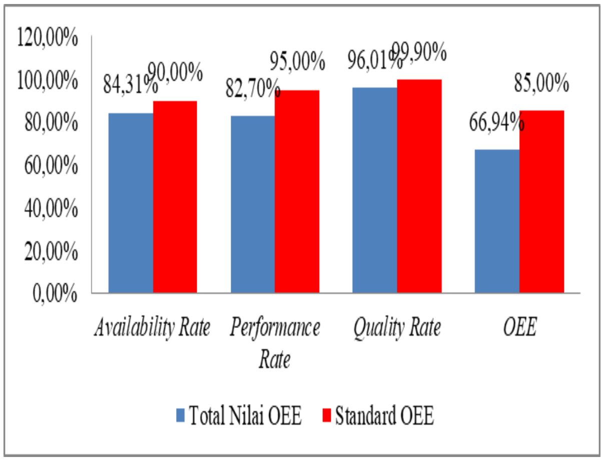

Figure 4. Comparison Diagram of OEE Value

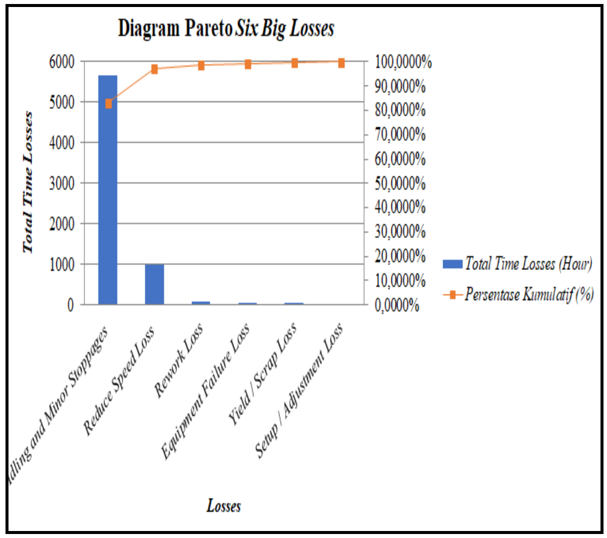

Figure 5. Pareto Six Big Losses Diagram

Based on FMEA analysis, there are 6 risks of causing idling and minor stoppages which can be seen in Table II [6]. After analyzing using the Pareto and scatter plot diagrams of the RPN and RSV values for each risk, it can be seen that the risk that has a high probability of occurrence is risk number 6 in Table II so mitigation analysis is carried out to overcome these risks by making a preventive maintenance scheduling simulation gear pump engine.

Table II. FMEA for the Causes of Idling and Minor Stoppages

No	Failure	S	O	D	RPN	RSV
1	Raw materials which cannot be continued to the spinning process.	5	2	3	30	10
2	Raw material composition is not according to specifications.	7	1	3	21	7
3	Wet raw material.	7	1	5	35	7
4	Raw material in the form of polymer is clogged in the pipe after the extruder machine.	10	1	1	10	10
5	Supply of raw material to the spinning process is hampered.	8	1	1	8	8
6	The amount of spinning process output decreases.	8	3	3	72	24

G. Improve Phase

In the improve phase, improvements are made based on the analysis that has been done, namely by making a simulation of preventive maintenance scheduling. The initial step is to determine the appropriate distribution to calculate the MTTF and MTTR values using the index of fit test by looking at the largest r value and the goodness of fit test by looking at the smallest AD value and the largest P that can be seen in Table III [7]. Based on Table III, it is known that the appropriate distribution to calculate the MTTF and MTTR values is the lognormal distribution so the MTTF and MTTR values are obtained as shown in Table III.

Table III. MTTF and MTTR Values

Distribution	TTF			MTTF	TTR			MTTR
	Index of Fit	Goodness of Fit			Index of Fit	Goodness of Fit		
		AD	P			AD	P	
Weibull	0,994	0,263	> 0,250	2.123,99	0,959	0,337	> 0,250	1,179
Log normal	1	0,19	0,627		0,973	0,24	0,536	
Exponential	0,998	0,769	0,147		0,974	1,523	0,017	
Normal	0,993	0,206	0,56		0,968	0,255	0,502	

The next step is to determine the optimal time interval for the replacement of the gear pump engine using the age replacement model by looking at the smallest downtime values [8]. Based on the graph in Fig. 6, it can be seen that the smallest downtime is at a time interval of 1300 hours.

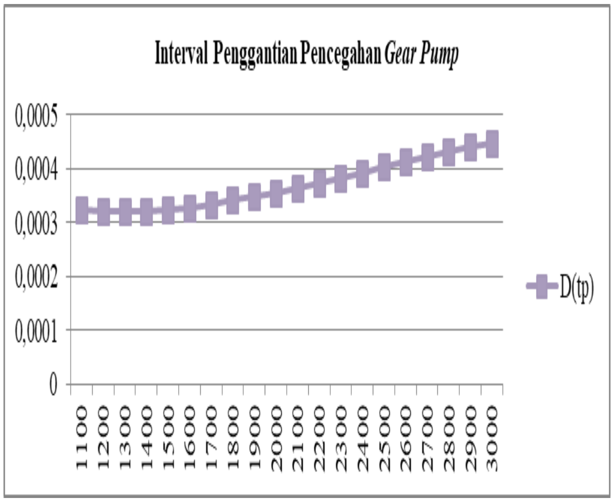

Figure 6. Downtime Graph on Gear Pump Engine Replacement Intervals

The final step is to determine the optimal time interval of the gear pump engine inspection using the calculation formula below [8]:
Average hours = 730 hours per month
Total damage for 1 year = 4 damage
Average damage per month =

Average repair time (μ)

$$\frac{1}{\mu} = \frac{\text{MTTR}}{\text{Rata-rata jam kerja per bulan}}$$

$$\mu = \frac{1}{0{,}00162} = 618{,}644$$

Average examination time (i)

$$\frac{1}{i} = \frac{\text{Rata-rata 1 kali pemeriksaan}}{\text{Rata-rata jam kerja per bulan}}$$

Optimal inspection frequency (n)

$$n = \sqrt{\frac{k \times i}{\mu}} = \sqrt{\frac{0{,}333 \times 1.460}{618{,}644}} = 0{,}886$$

Inspection time interval (ti)

$$ti = \frac{\text{Rata-rata jam kerja per bulan}}{n} = \frac{730}{0{,}886} = 823{,}9277 \text{ jam}$$

H. Control Stages

The last step in the six sigma approach with the DMAIC method is the control stage, where at this stage a monitoring simulation or supervision of proposed improvements or improvements has been made to ensure that an increase in the reliability value of the machine used during the spinning process on the 28P PT ITS production line can be seen in Fig. 7 [9]. Based on the gear pump engine reliability value chart above, it can be seen that there is a significant increase in the value of the gear pump engine reliability before and after doing preventive maintenance. The calculation results in table 4.20 can be seen that the value of reliability before doing preventive maintenance at an interval of 1350 hours is 0.8133 or 81.33% and the value of reliability after doing preventive maintenance at the same time interval is at 0.8365 or 83.65 %. Based on the simulation improve and control that has been done, it can be said that the simulation improve is optimal.

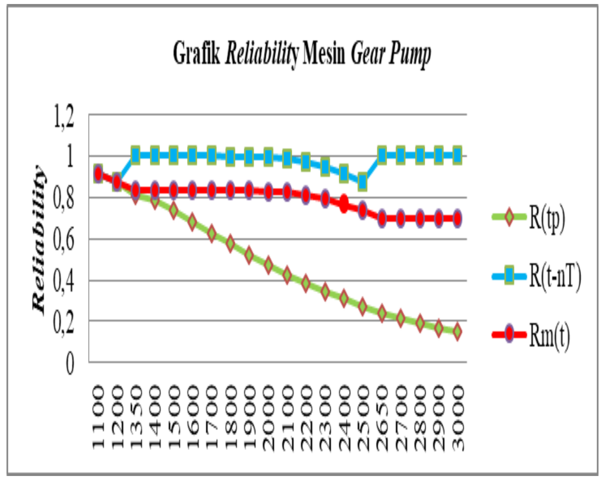

Figure 7. Graphs of Gear Pump Engine Reliability Values Before and After Preventive Maintenance

CONCLUSION AND SUGGESTION

A. Conclusions

Based on the analysis that has been done regarding the effect of machine productivity on the waste of the staple fiber production process, it can be concluded as follows:

Based on Pareto diagram analysis, the most common type of waste is PA waste with a percentage of 30.01% of the total staple fiber production waste on the 28P production line. Waste PA is caused by 3 main factors namely humans, machines, and methods used in the production process. Engine factor is the most dominant factor resulting in a high amount of PA waste as in the leak component pack and broken gear pump coupling from the driving motor. Machine productivity affects the production waste that occurs. This can be seen from the low OEE value of the production machine at 66.9% which consists of an availability rate of 84.3%, a performance rate of 82.7%, a quality rate of 96% and a high amount of waste that occurred in the same period. Based on the analysis of the calculation of six big losses using a Pareto diagram, the low OEE value of the production machine is caused by 2 dominant factors of the six big losses, namely the idling and minor stoppages factor with a percentage of 76.72% and the reduced speed loss factor with a percentage of 19.95%. One of the most dominant factors that cause idling and minor stoppages is the abnormality of the gear pump engine so it is necessary to carry out preventive maintenance on an optimal schedule. Based on the mitigation of risk in FMEA, to improve engine reliability it is necessary to schedule optimum preventive maintenance using the age replacement model so the optimum gear pump preventive engine replacement interval is obtained during an interval of 1300 hours and the gear pump engine inspection interval is during the interval 823.9277 hours.

B. Suggestion

Based on the conclusions above, the suggestions that can be obtained for PT Indonesia Toray Synthetics (ITS) are:

Companies can use the Six Sigma approach with DMAIC stages to analyze the production waste that occurs and the factors causing waste. Companies can implement Total Productive Maintenance (TPM) with OEE calculations and six big losses analysis to ensure machine productivity is within normal limits and can analyze the factors that cause the low value of OEE production machine so as to reduce the amount of waste generated. Companies need to make preventive maintenance to monitor the condition of the production machine so the machine can work normally and the resulting waste decreases.

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