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Productivity Analysis to Increase Overall Equipment Effectiveness (OEE) by Implementing Total Productive Maintenance

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Abstract:– Productivity was one of important thing that company should be focus on. In process of producing goods and service to fulfil customer's needs, the company expected to concern on process of continuous improvement. It aims to minimize the losses incurred, increase revenue and efficiency of production operating costs. One of effort that company can do was detailed the measurement of availability rate, performance and quality rate. The problem analysis carried out by the Overall Equipment method concluded that the company must focus on improvement by increasing production scheduling and equipment / machine production performance and reducing the quality issue before production and when the production process is running.

Keywords:- *Overall Equipment Effectiveness, Total Productive Maintenance.*

I. INTRODUCTION

Generally a company was built to produce goods and service based on customer's need, it aims for customer's satisfaction. If the customer's satisfaction could be fulfilled properly, so it would directly increase the company's profit because of customer's demand growth. In order to be able to compete with the competitors, company should be developed their business. The background of this study was in pharmaceutical company that there has not been a detailed measurement for effectiveness of machine that used in production process. Today, the calculation of the machine's effectiveness was only calculate after all the products are finished, it caused we could not knew the detail about the availability rate, performance rate and quality rate of the production process that has been running. Beside that the impact of downtime and rejects in production caused a large amount of lost costs due to loss output and overtime for the repaired production process and product reworked process. So that these problems required detailed measurement to determined the performance of the availability rate, performance and quality rate of the production process that runs in the pharmaceutical company so that in the future a focus for continuous improvement can be made on the losses that have occurred.

II. LITERATURE REVIEW

A. Total Productive Maintenance

Total Productive Maintenance was the idea of Nakajima, S (1988) which emphasizes the utilization and involvement of human resources and Preventive Maintenance systems to maximized the effectiveness of equipment by involving all departments and functional organizations. Total Productive Maintenance (TPM) is a combination of the implementation of maintenance in the United States with quality control in Japan involving labor elements where the results of developing the system in the company include increased effectiveness, reduced engine damage, and operator awareness in engine maintenance and products day by day. In addition, TPM is a close collaboration between maintenance and product organization as a whole that aims to improve product quality, reduce waste, reduce production costs, improve equipment capabilities and the development of the entire system of care in manufacturing companies. The benefits of implementing TPM systematically in a long-term work plan for the company in particular include the following factors:

- Increasing productivity by using TPM principles will minimize losses to the company.
- Improve quality with TPM by minimizing machine / equipment damage and machine downtime with a focused method.
- Delivery / delivery time to consumers can be fulfilled because uninterrupted production will be easier to implement.
- Low production costs because losses from non-value-added work can be reduced.
- Health and safety of the work environment for the better.
- Increase the motivation of the workforce because the rights and responsibilities are delegated to everyone.

Overall, the definition of Total Productive Maintenance according to Nakajima includes five elements as follows:

- TPM aims to create a preventive maintenance (PM) system to extend the life of machine / equipment use.
- TPM aims to maximize the effectiveness of the machine / equipment as a whole (overall effectiveness).

- TPM can be applied to various departments (such as Engineering, production parts, and maintenance parts).
- TPM involves everyone from the highest management level to employees / operators on the production floor.
- TPM is a development of a maintenance system based on PM through management motivation: autonomous small group activities.

B. Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) was a calculation used to determine the effectiveness of the equipment. With this method TPM seeks to maximize output by maintaining ideal operating conditions and equipment / machinery running effectively. A device that experiences a breakdown, a decrease in speed, or a lack of precision and produces defective products, the equipment / machine does not operate effectively. To achieve Overall Equipment Effectiveness, TPM works to eliminate Six Big Losses (Six Big Losses) which are heavy obstacles.

Overall Equipment Effectiveness (OEE) is a comprehensive measure that indicates the level of machine / equipment productivity and its performance in theory. This measurement is very important to find out which areas need to be increased in productivity or the efficiency of the machine / equipment and also can show the bottleneck area found on the production line. OEE is also a measuring tool for evaluating and providing appropriate ways to ensure increased productivity in the use of machinery / equipment.

The operating conditions of the machine / production equipment will not be accurately shown if only based on the calculation of one factor, for example performance efficiency. Six factors in the new six big losses are minor stoppages that are calculated on the performance efficiency of the machine / equipment. Other losses have not been calculated. The six factors in the six big losses must be included in the OEE calculation, then the actual conditions of the machine / equipment can be seen accurately.

➢ *Availability (AV)*

It is the ratio of the operation time to the timeline loading time so that values can be calculated from the machine:

- Operation Time (Operation Time)
- Preparation Time (Loading Time)
- Downtime

For availability values can be calculated using the following formula:

$$Availability = \frac{Operation\ time}{Loading\ time} \ x\ 100\ \%$$

Loading time was available time (availability time) per day or per month minus planned downtime.

Loading Time = Total Availability Time – Planned Downtime

- *Operation Time = Loading Time – Downtime*
- *Downtime = Breakdown + Set up*

$$Operation\ Speed\ Rate = \frac{Ideal\ cycle\ time}{Actual\ cycle\ time} \ x\ 100\ \%$$

For planned downtime is the amount of time planned in the production plan including scheduled maintenance or other management activities. Whereas Operation time is the result of a reduction of loaded time with engine operation time (non-operation time) in other words operation time is the time available (available time) after the engine downtime is removed from the total available time planned. Machine downtime is the processing time that should be used by the engine but due to interference with the machine / equipment (equipment failures) resulting in no output being produced.

➢ *Performance Efficiency / Proficiency (PE)*

It is the result of multiplying the operating speed rate and net operating speed or the ratio of the product quantity produced multiplied by the ideal cycle time to the time available for the operation time.

Operating speed rate is a comparison between the actual engine's ideal speed (theoretical / ideal cycle time) and the actual engine speed (actual cycle time). The mathematical equation can be shown as follows:

$$Net\ Operation\ Rate = \frac{Actual\ processing\ time}{Operation\ time} \ x\ 100\ \%$$

$$= \frac{Processed\ amount\ x\ actual\ cycle\ time}{Operating\ time} \ x\ \frac{Ideal\ cycle\ time}{Actual\ cycle\ time}$$

The net operating time is the ratio between the number of products processed (processed amount) multiplied by the actual cycle time with operation time. Net operating time is useful for calculating losses caused by minor stoppages and decreasing production speed (reduced speed). Three important factors are needed to calculate the Performance Efficiency:

- Ideal Cycle Time (ideal cycle time / standard time)
- Processed Amount (number of products processed)
- Operation Time (engine operation time)

Performance Efficiency can be calculated as follows:
Performance Efficiency = Net Operating Time x Operating Speed Rate

$$Performance\ efficiency = \frac{Processed\ amount\ x\ ideal\ cycle\ time}{Operating\ time}\ x\ 100\ \%$$

➢ *Product Quality Ratio / Rate of Quality Products (RQP)*

It is a good ratio of the number of products to the total amount of products processed. So the Rate of quality products is the result of a calculation using the following two factors:

- Processed amount (number of products processed)
- Defect amount (number of defective products)

The rate of quality products can be calculated as follows:

$$Rate\ of\ Quality\ Product = \frac{Processed\ Amount - Defect\ Amount}{Processed\ Amount}\ x\ 100\ \%$$

TPM reduces the loss of machinery / equipment by increasing availability, performance efficiency, and rate of quality products. In line with the increase in the three factors contained in the OEE, the capability of the company also increased.

By including the six factors contained in the six big losses in the OEE meeting at first, companies generally only have an OEE level of around 50% to 60% in other words the factory only uses half of the potential capacity of the machine / equipment owned. Japan Institute of Plant Maintenance (JIPM) has set benchmark standards that have been widely practiced throughout the world. Here's the OEE Benchmark:

- If OEE = 100%, Production is considered perfect because it produces production without defects, works in fast performance and has no downtime.
- If OEE = 85%, Production is considered world class. For many companies, this score is a suitable score to be a long-term goal.
- If OEE = 60%, Production is considered reasonable but shows there is a large space for improvement.
- If OEE = 40%, Production is considered to have a low score but in most cases improvement can be easily done through direct measurement (for example by tracing downtime reasons and handling sources of causes of downtime one by one).

For the world class benchmark recommended by JIPM, which is OEE 85%, Figure 3 shows the scores that need to be achieved for each OEE factor.

C. Six Big Losses

The activities and actions taken in the TPM not only focus on preventing damage to machinery / equipment and minimizing machine / equipment downtime but many factors cause losses due to the low efficiency of the machine / equipment only. The low productivity of machinery / equipment that causes losses for the company is often caused by machine / equipment users who are not effective and efficient, there are six factors called big losses.

Efficiency is a measure that shows how best the resources used in the production process to produce output. Efficiency is a process characteristic of measuring actual performance of resources that are relative to the standards used and determined. While effectiveness is another characteristic of the process of measuring the degree of delivery of output from a production system where effectiveness is measured from the actual output ratio to the planned output. In the current era of free competition the measurement of production systems which only refers to the quality of output will be misleading because this measurement does not pay attention to the main characteristics of the process, namely: capacity efficiency and effectiveness.

In using the machine / equipment as efficiently as possible means that maximizing the function of the performance of the machine / production equipment appropriately to be able to increase the productivity of the machine / equipment used, it is necessary to analyze the productivity and efficiency of the machine / equipment on the six big losses. The six big losses are as follows:

➢ *Downtime*

For losses due to downtime consists of two categories, namely:

- *Equipment Failure / Breakdowns (Loss due to damage to equipment)*

To find the percentage of machine effectiveness lost due to breakdown losses factors can be calculated using the following formula:

$$EF = \frac{Total\ Breakdown\ Time}{loading\ time} \times 100\%$$

- *Set-up and Adjustment (Losses due to installation and adjustment)*

To find out the percentage of set-up and adjustment loss by the time set-up of the machine can be determined using the following formula:

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$$SA = \frac{total\ setup\ /adjustment}{loading\ \ time} \times 100\%$$

➢ *Speed Losses (Decreased Speed)*

For losses because speed losses consist of two categories, namely:

a. Idling and Minor Stoppages (Loss due to operating without load or stopping for a moment)

To be able to find out the magnitude of the factors of effectiveness lost due to the occurrence of Idling and Minor Stoppages the following formula is used:

$$IMS = \frac{Non\ Productive\ \ Time}{Loading\ \ Time} \times 100\%$$

For Non-Productive Time = Operation Time - Total Actual Hours

- *Reduces Speed (Loss due to production speed)*

To find out the percentage of reduce speed losses, the following formula is used:

$$RS = \frac{operation\ \ time\ -(Ideal\ Cycle\ Time\ x\ Result\ Processed\ )}{Loading\ \ Time} \times 100\%$$

➢ *Defects*

For losses because Defects consist of two categories, namely:

- *Process Defect (Losses due to defective products or because the product is reprocessed)*

$$Rework = \frac{Ideal\ \ Cycle\ \ time\ \ x\ Rework}{Loading\ \ time}\ x\ 100\%$$

To find out the percentage of defect loss, the formula is used as follows:

- *Reduced Yield Losses (Losses at the beginning of production time to reach a stable production time)*

To find out the percentage of yield loss, the formula can be used as follows:

$$Yield/Scrap\ loss = \frac{Ideal\ \ cycle\ \ x\ Scrap}{Loading\ \ time}\ x\ 100\%$$

III. RESEARCH MODEL AND RESEARCH HYPOTHESIS

Research methodology is needed to provide a systematic overview used in answering research problems. The research was conducted at a pharmaceutical company in Jakarta, primary data was taken by observing the field and asking directly to experts in their fields. Then secondary data can be obtained from all reported downtime data. The research method is shown in the following figure.

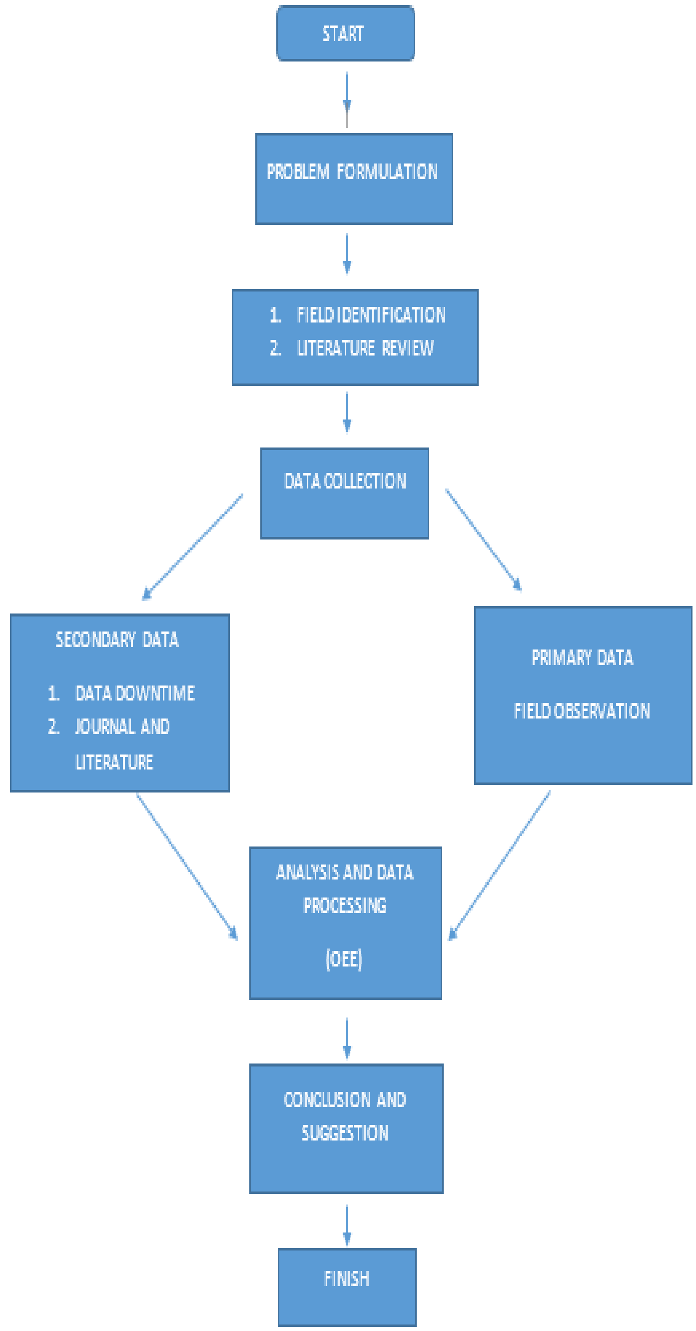

Fig 1:- *Flowchart* Penelitian

IV. METHODOLOGY

PT XYZ evaluates production every month. From the data and logbook recording downtime that occurs in the production line can be known the cause of loss output. There are 7 related departments in the production process, as follows:

No	BPO PO		Target
1	Produksi		2,0%
	1.1	Granulisasi	
	1.2	Core	
	1.3	Coating	
	1.4	Change Over	
	1.5	Blistering	
	1.6	Change Over	
2	Packing		1,0%
	2.1	Labeling	
	2.2	Cartoning	
	2.3	Change Over	
3	Engineering		0,7%
	3.1	Machine Downtime	
	3.2	Machine Availabillity	
	3.3	Electicity	
4	PPIC		0,5%
	4.1	BPO	
	4.2	PO	
	4.3	RFID	
5	Quality Control		0,6%
	5.1	Quality Downtime	
	5.2	Quality issue Raw Material	
	5.3	Quality issue Pack Material	
	5.4	Quality Granulisasi	
	5.5	Quality Core	
	5.6	Quality Coating	
	5.7	Quality Mikrobiologi	
	5.8	In Process Control	
6	Development		0,1%
	6.1	Product Readiness	
	6.2	Standar Readiness	
	6.3	Produvt Design	
7	Costing		0,1%
	7.1	Yield Issue	
Total Batch Produksi			5%

Table 1:- Production Process

From the table it is concluded that the total production downtime target of 7 related departments is a maximum of 5.0% where the production department has a target that is greater than other departments, namely a maximum of 2.0%. For the calculation of Overall Equipment Effectiveness (OEE) Production Downtime data will be taken in September 2018.

- OEE calculation in September 2018
- Summary of Production Downtime Sept 2018

No	Batch Produksi		Target	Based On Loss Output		
				Total Target	Total Loss Output	% Downtime
1	Produksi		2,0%	99990	118	11,80%
	1.1	Granulisasi		99990	0	0,00%
	1.2	Core		99990	8	0,80%
	1.3	Coating		99990	6	0,60%
	1.4	Change Over		99990	12	1,20%
	1.5	Blistering		99990	78	7,80%
	1.6	Change Over		99990	14	1,40%
2	Packing		1,0%	99990	26	2,60%
	2.1	Labeling		99990	0	0,00%
	2.2	Cartoning		99990	15	1,50%
	2.3	Change Over		99990	11	1,10%
3	Engineering		0,7%	99990	26	2,60%
	3.1	Machine Downtime		99990	26	2,60%
	3.2	Machine Availabillity		99990	0	0,00%
	3.3	Electicity		99990	0	0,00%
4	PPIC		0,5%	99990	1	0,10%
	4.1	BPO		99990	0	0,00%
	4.2	PO		99990	0	0,00%
	4.3	RFID		99990	1	0,10%
5	Quality Control		0,6%	99990	20	2,00%
	5.1	Quality Downtime		99990	14	1,40%
	5.2	Quality issue Raw Material		99990	0	0,00%
	5.3	Quality issue Pack Material		99990	0	0,00%
	5.4	Quality Granulisasi		99990	0	0,00%
	5.5	Quality Core		99990	0	0,00%
	5.6	Quality Coating		99990	0	0,00%
	5.7	Quality Mikrobiologi		99990	0	0,00%
	5.8	In Process Control		99990	6	0,60%
6	Development		0,1%	99990	9	0,90%
	6.1	Product Readiness		99990	0	0,00%
	6.2	Standar Readiness		99990	0	0,00%
	6.3	Produvt Design		99990	9	0,90%
7	Costing		0,1%	99990	0	0,00%
	7.1	Yield Issue		99990	0	0,00%
Total Batch Produksi			5%	99990	200	20,00%

Table 2:- Summary Production Downtime

From table 2 the summary production downtime data above can be seen that the percentage of production downtime in September 2018 is 20.00%, which means that it does not reach the predetermined target because it has exceeded the maximum target set by the company by 5%. For calculation of summary production downtime, namely:
Total Production Downtime = (Total Loss Output / Total Target Output) x 100%

From the table it can also be concluded that the biggest cause of production downtime in September was caused by blistering and change over or due to changes in production schedules due to problems that could not work in accordance with PO ODS (Bulk Product Order and Packaging Order).

a. Overall Equipment Effectiveness Calculation (OEE)

To find out the effectiveness of the equipment and the effectiveness of the manufacturing process that is carried out, it can use the Overall Equipment Maintenance (OEE) method which has 3 measurement variables to be used.

For 3 measurement variables used in the OEE method include:

1. Availability

Noted that :

The number of working days in Sepetember 2018 is 22 working days, so for operational time calculation is based on the total target output multiplied by the production cycle time per blister with the calculation as follows: 99,990 x 2 minutes = 199,980 minutes.
For downtime loss the following calculation is obtained: 200 x 2 minutes = 400 minutes.
Then Availability for August 2018:
(199980-400) / 199980 x 100%
= 99.8%

2. Perfomance Rate

Noted that :
Running time = operational time - downtime loss = 199980 - 400 = 199580 minutes.
Cycle time per pair = average output per hour / 60 minutes = 80 pairs / 60 minutes = 1.3 minutes
The number of products processed *or the actual production output = 110,000*
Then the Perfomance Rate for August 2018:
(1.3 x 110000) / 199580 x 100%
= 71.65%

3. Quality Rate

Noted that :
The number of products processed or the actual production output is 110000 blisters
Total quality loss of 15451
Then the Quality Rate for August 2018:
(110000-15451) / 110000 x 100%
= 86%.

After obtaining the results of availability, performance rate, and quality rate, the achievement of OEE production for September 2018= 99.8% x 71.65% x 86% = 61.5%.

Produksi	Six Big Loss		No	OEE	Nilai
Operation Time	Downtime Losses	1. Breakdown Loss	1.A	Waktu Operasional	99.999
		2. Set Up dan Adjustment Loss	1.B	Dwontime Loss	200
			1.C	Availability	99,80%
Net Operating Time	Speed Losses	3. Chokotei Loss	2.A	Waktu Running	199.580
			2.B	Cycle Time	1,3
		4. Cycle Time Loss	2.C	Jumlah Produk Diproses	110.000
			2.D	Performance Rate	71,65%
Quality Losses	Quality Losses	5. Defect Loss	3.A	Jumlah Produk Di proses	110.000
		6. Starup Loss	3.B	Quality Loss	15.451
			3.C	Quality Rate	86%
			4.A	OEE	**61,50%**

Table 3:- OEE Calculating Result

Based on the OEE calculation in September 2018, it can be seen that OEE of 61.5% gives a description of each room for improvement to a score of 85% or more. To focus on improvement, it was shown to improve performance scheduling in production because based on the previous table, the causes of production downtime were caused by change over and blistering so that production did not run according to ODS BPO schedule and improved equipment performance in production. loss output and focus of improvement to reduce the quality issue before walking and reject production that occurs during the production process.

V. RESULTS

A. Conclusion

Based on the results of problem analysis carried out with the Overall Equipment Effectiveness (OEE) and Fishbone Diagram methods, the following conclusions are obtained:

- Achievement of September 2018 production downtime data of 20.0% so as not to reach the standard set by the company a maximum of 5%.
- The biggest downtime in September 2018 is caused by Blistering of 7.8% change over by 2.5%
- Overall Equipment Effectiveness (OEE) data in September 2018 amounting to 61.5% consisted of Availability of 99.8%, Performance Rate of 71.65%, and Quality Rate of 86%.

Based on the OEE data, it was concluded that companies must focus on improvement

- By increasing production performance scheduling and equipment / machine production performance and reducing the quality issue before production and when the production process is running.
- Based on the discussion above it can be concluded that the cause of blistering and change over is too high because the heater machine is not perfectly hot (the spare part is not functioning) and packaging material (Aluhard foil) is too thin so it is easy to tear considering the tablet almost fills the blister gap.

B. Suggestion

Based on the results of problem analysis carried out with the Overall Equipment Effectiveness (OEE) method, the following recommendations are obtained:

- It is proposed for the Packaging Development department to redesign the foil packaging in the blistering process by paying attention to the average weight of the tablet.
- Both new machine operators and old employees must be given retraining on how to maintain the machine and if you need to give 1 PIC name to be more responsible for engine maintenance.
- There needs to be active management involvement in evaluating and carrying out continuous improvement for performance production downtime.

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