Implementation of Total Productive Maintenance To Increase Productivity (Case Study: An Injection Manufacturing Company Located In Delta Silicon Industrial Area)

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Abstract. *In the world of industry, machinery is one of the main factors needed in production activities. The machine is always required to be in a prime state, especially when the company's sales conditions are good, but unfortunately along with usage, the machine will certainly experience a decrease in performance if there are no maintenance activities applied to the machine. The purpose of this research are (a) to find out the success rate of Total Productive Maintenance (TPM) implementation in a plastic manufacturing company located in Delta Silicon Industrial Area; (b) to find out the problems that arise during the implementation of TPM and (c) to find out how to solve the problem. The method used in this research is calculating the success value of TPM implementation by using Overall equipment Effectiveness (OEE) calculation, and then following by analyzing the problem using six big losses analysis and TPM implementation analysis.. The results showed that score of TPM achieve an average OEE rate of 93%. This rate is higher than minimum standard value of OEE itself which is determined at 85%. From the calculation of six big losses it is known that the highest problem is caused by downtime losses. It took 53% of the total losses incurred.*

Keywords: *Total Productive Maintenance, Productivity, Overall Equipment Effectiveness*

1. INTRODUCTION

In production activities, machines are requirement that must exist to support the production process in a company and cannot be replaced by other factor. To support company productivity, production machines are required to have optimal capabilities, especially when the company is in a good sales position. In this position, machine reliability is expected to meet production needs so that the demand for products from a company can be fulfilled. In fact, machines that are used continuously will experience a decrease in performance along with the routine usage. If this is ignored, the machine will be breakdown and certainly will cause a loss in production time (downtime). The loss in production time respectively will affect the achievement of production target. As a result, the company suffered losses and lost the profits that would have been possible to be achieved if there had been no breakdown. The company is required to carry out maintenance on its production machines in order to avoid damage that might occurs due to continuous use of these machines. By performing a continuous productive maintenance, it is expected that the potential damage can be detected early so that preventive actions can be taken. Apart from that, the aim of the maintenance of this machine is also aimed at creating a safe working environment, a longer service life of the machine and ensuring the readiness of the machine to meet productivity target.. The maintenance carried out by the company should not be the responsibility of the maintenance section only, but also become the responsibility of all employees, especially the operators of machines. Since they are have more knowledge about the character and condition of each machine.

The system or technique known as the TPM (Total Productive Maintenance) has the principle of carrying out thorough maintenance of production machines in order to increase engine performance and machine readiness so that it can support company productivity, Sethia et al. (2014). In practice, TPM uses the principle of preventive maintenance techniques as well as the involvement of all employees in carrying out maintenance or it can be called autonomous maintenance, meaning that by taking advantage of all employee involvement in maintaining this production machine, it is hoped that later it can create a sense of responsibility for themselves and creates a sense of belonging to these machines. Apart from this, this principle will also provide synergy between the machine operator employees and the maintenance department to ensure that the machine is in prime condition and ready to use at all times.

In TPM itself has several goals as the objective of implementing this system, namely zero breakdown and zero defect, if zero breakdown and zero defect can be achieved, of course it will support the company's profitability, Prinz et al. (2017). When the objective of implementing the TPM is achieved, it can almost be interpreted and ensured that the machine is in good efficiency and has a good productivity value, Wudhikarn et al. (2016). The productivity of this machine refers to the ability of the machine to produce goods according to the target set by the production planner. The successful level of TPM can be measured using the measurement of the efficiency value of the machine, Liao et al. (2018). It consist of three points of assessment, namely the value of availability, performance value and quality value, these values are referred to as the OEE value or Overall Equipment Effectiveness, Rasheed et al. (2016).

The company being studied is a manufacturing company engaged in the automotive sector. The products of this company are motorized vehicle parts made of plastic pellets, one of the product is a bumper cover for four-wheeled vehicles. Process to produce this part is called injection molding of plastic pellets. In this process, an injection machine is used, where this machine operates 24 hours non-stop. Besides producing bumpers this machine also produces another parts. Due to the tight working hours of this machine, the machine is automatically required to be in prime condition, especially if the company is in good sales condition. Unfortunately it is still far from expectations, injection machine studied often experiences unplanned downtime due to damage of the machine, Saleem, et al. (2017).

2. LITERATURE REVIEW

2.1 Sub head (For example: Marketing Management or Intellectual Capital)

According to Sharma (2012), TPM is an amalgamation of total quality management with a strategic view of maintenance in terms of process design and equipment for preventive maintenance. Total productive maintenance includes the following: a) Good machine design, easy to operate and easy to maintain; b) Create a preventive maintenance plan, utilizing the best practices of the operator, maintenance department and service; c) Provide training to workers so they can operate and maintain their own machines.

TPM is productive maintenance which involves the entire participation of employees from top management to operators through activities carried out by small groups (Hooi et al., 2017). According to the name (Nakajima, 1988), TPM consists of three syllables, namely: (a). Total, This word identifies that TPM considers various aspects and involves all existing personnel, from the top level to the lower level. (b) Productive, emphasize all efforts to try to carry out maintenance with production conditions running and minimize problems that occur when maintenance is carried out. (c). Maintenance, means to maintain and maintain equipment in an attentive manner by production operators so that the condition of the equipment remains good and maintained by cleaning it, lubricating it and paying attention to it.

So that TPM itself can be interpreted as a close cooperation relationship between maintenance and the production organization as a whole aimed at improving production quality, reducing waste, reducing production costs, improving equipment capabilities and developing the entire maintenance system in manufacturing companies (Chong et al. 2016.). Meanwhile, Total Productive Maintenance (TPM) according to Tsarouhas, (2019) is not only focused on how to optimize the productivity of the equipment or materials supporting work activities, but also pay attention to how to increase the productivity of workers or operators who will later take control of the equipment and materials.

Singh, Singh et al. (2017), argues that the productivity of machines is the relationship between inputs and outputs in the production system. In theory this is often easily interpreted as the ratio of output to input Ngadiman et al. (2016). If an output with a greater number of the same input is produced, productivity increases. Likewise, if less is input for the same amount of output, productivity is also said to increase.

Smith and Wekley (2013) production is output that is produced in one unit of time for input. Other said that production, Foulloy et al. (2019) is a concept that shows a link between work results and the time unit needed to produce a product on a machine.

According to Sinungan (2010) productivity is associated with the relationship between real or physical results and actual input.

2.2 Overall Equipment Effectiveness

Overall Equipment Effectiveness hereinafter abbreviated as OEE is a tool used to measure how effective the utilization of a machine is both in terms of performance, time and quality of the product produced by the machine which refers to a reflection of how high the productivity of the machine's performance is in a company. Soltanali, et al. (2019). Whereas OEE, Paprocka et al. (2015), is a way to calculate and evaluate how effectively operational management can be carried out by a company. OEE measurement can also be used as a Key Performance Indicator (KPI) in a company. In implementing OEE has several variables, like; (a) availability; (b) Performance; (c) Quality. OEE can be measured by combining those three elements as a unity from the formula for finding the OEE value.

3. RESEARCH METHODS / METHODOLOGY

Steps analyzing method in this research are as follows: (a) data collection; (b) data processing; (c) six big losses analyses; (d) cause effect diagram analyses.

3.2 Data Colection

The data used in this study are divided into two types of data, namely primary data and secondary data. Primary data were obtained through direct interviews with TPM actors at an injection manufacturing located in Delta Silicon, while secondary data was obtained through archive reports and checksheets at the injection department.

3.2 Data processing

The data collected is processed using the Overall Equipment Effectiveness calculation method, which includes: (a) Calculation of Availability Rate; (b). Calculation of Performance Rate; (c). Calculation of Quality Rate; (d) Calculation of Overall Equipment Effectiveness

3.3 Six big losses analyses

The calculation of six big losses in this study was conducted to determine the largest factors that influence the low achievement of the OEE value.

3.4 Cause effect diagram

Causal diagram is a structured approach that allows a more detailed analysis to find the causes of a problem, discrepancies, and gaps that occur. (Nasution: 2005). The factors that will be analyzed using the causal diagram analysis method include; (a) man; (b) machine; (c) Method; (d) Material; (e) environment .

4. RESULTS AND DISCUSSION

4.1 Result

Calculation of Availability Rate, Performance rate, Quality Rate and OEE rate can be obtain using the formula of each rate and the result is shown as in table 1 below:

Table 1 Calculation Results Availability Rate

No	Month	Availability Rate	Performance Rate	Quality Rate	OEE Rate
1	June 2019	94.05	98.42	96.59	89.40
2	July	92.75	99.02	98.63	90.59
3	August	95.27	99.01	97.46	91.92
4	September	95.04	98.96	98.65	92.78
5	October	92.75	99.02	98.28	90.27
6	November	96.03	98.97	98.78	93.88
7	December	96.03	98.80	98.91	94.33
8	Jan.2020	96.53	99.03	99.01	95.26
9	February	97.16	98.86	98.15	88.95
10	March	95.27	99.01	99.05	93.42
11	April	95.04	98.96	98.53	92.67
12	May	93.06	98.51	98.29	90.10

Source: Data obtained through manual calculation

Six Big Losses Calculation

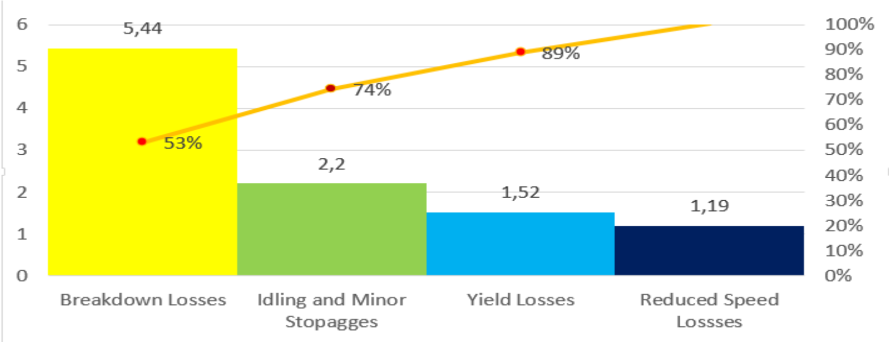
As we can see in the table, OEE calculation values (table 4.8) has decreased significantly to 89%, this means that there is a decrease in productivity within the scope of production of injection manufacturing, although the achievement rate was still above the minimum international standard for OEE achievement, this should be evaluated so that it will not be reoccur in the next period. The analysis performed by calculation of six big losses that consist of; (a) breakdown Losses; (b) set up and adjustment losses; (c) idling and minor stoppages losses; (d) reduced speed losses; (e) defect losses; (f) yield losses. The results of the calculation of six big losses are presented in table 2 bellow and illustrated in the Pareto diagram in Figure 1.

Tabel 2 Six big losess

Type Of Losses	Average	Percentage	% Cummulative
Breakdown Losses	5,44%	53%	53%
Idling and Minor Stoppage Losses	2,20%	21%	74%
Yield Losses	1,52%	15%	89%
Reduce Speed Losses	1,19%	11%	100%
	10,35%	100%	100%

After the largest sequence of losses that occur is figure out, then next step is to create a paretto diagram as shown in the following diagram.

Figure 1 Pareto Diagram



From the Parreto diagram above, it can be seen that the biggest losses are caused by breakdown losses. So if it linked back to the OEE achievement listed in table 1, the cause of the low or decreased OEE in the period of February 2020 at 88% is due to the high number of breakdown losses, this breakdown loss is caused by the high wasted production time.

4.2 Discussion

Availability Rate Value

The achievement of availability rate is already according to the world class OEE standards. Even so, if there is no downtime, the achievement of availability should be managed to be 100%. The highest score for availability rates were in January 2020 about 96,53% and February 2020 about 97,15%. Meanwhile, the lowest score was in July 2019 with a value of 92,75%.

Value of Performance Rate

Performance rate is a value referring to the reduced engine speed in production, where the engine speed slows down compare to the standard. The international standard of performance rate itself is 95%. It can be proven that the implementation of TPM, at an injection manufacturing in Delta Silicon Area, played a very important role in achieving the performance rate value, where the entire period from June'19 to Mei'20 were more than 95%.

Quality Rate Value

Quality rate is a value obtained from comparing the number of products that are "OK" withe overall production. In this company products that are declared OK are called “straight pass” products, while products that are declared reject or “NG” will then be scraped. Because the product is a plastic injection, there is no repair treatment for products that are declared NG. The company itself has implemented a company target that the minimum quality value is 95%, while for the OEE standard itself the minimum Quality Rate value is 99%. Value of quality rate after implementation of TPM can be said to be good, with achievement above 95%, it is above the company's target. However, if it is related to the standard OEE value, the quality rate must be at 99%, several production periods have not met the standard, including in the boasting of June'19 and August'19 which each h, ad a value of 97%, and in October'19, February'20 and May'20 each have a score of 98%.

Overall Equipment Effectiveness Value

The calculation of Overall Equipment Effectiveness is aim to find out the effectiveness level of a machine or production line. Whether a production line or a machine is effective or not can be represented by its productivity rate. The more effective it means the more productive the results from production line or the machine. Based on the score, the average achievement is above 85%, where the 85% is the standard score of OEE according to the benchmarks set by JIPM. The highest score was in January 2020, where the value reached 95%, while the lowest score was in February 2020, with a score of 88%. In February 2020 the values of availability, performance and quality were respectively 92%, 99% and 98%, where the cause of the low OEE value in that month was the Availability value, this happens because that month is the trial month, a new model appears, where machines often lose time for set-up, machine settings and so on, besides that, in the situation of adjusting to new products, trouble with machines often occurs because they have to adjust to new parameters in accordance with the specifications of the new product..

Six Big Losses Analysis

Since the results of the OEE calculation has been found, it can be concluded that the value of the machine effectiveness is good because it is above 85%. But it should also be noted that there was a problem with the results in February 2020 the result is down from the previous period to 88%. This case certainly must be analyzed in order to find out the root cause of the problem so that corrective actions can be taken in order similar problem may not reoccur in the future.

The six big losses analysis was the tools to be used in analysis the cause of the decline in OEE value in February 2020. Based on the calculation of the six big losses, it is found that there were 4 factors that causing the decrease of OEE value in February 2020 id est.: (a) breakdown losses; (b) Idling and Minor Stoppages Losses; (c) Yield Losses and (d) Reduced Speed Losses

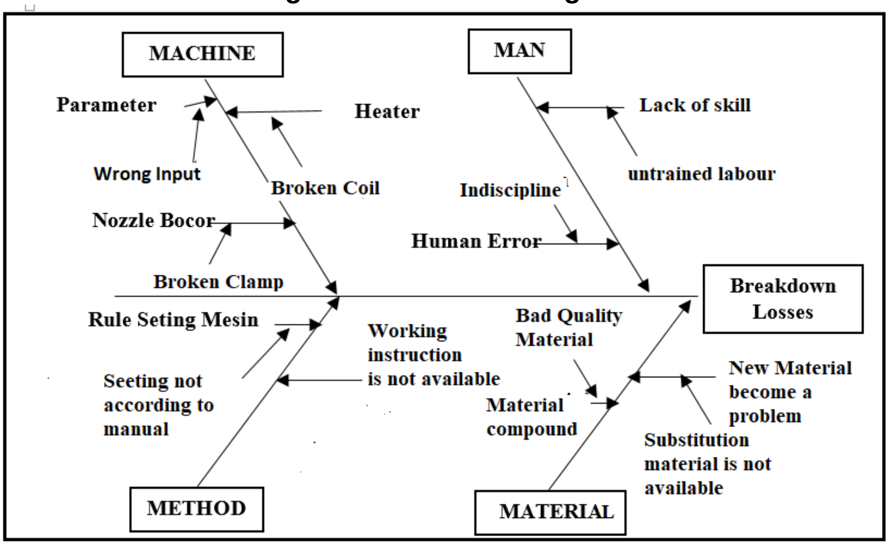
In this study, there is no calculation of the set-up and adjustment losses because the data obtained from the company regarding setup time losses have been equated to downtime or breakdown losses, and there is no defect losses calculation, because the production results from injection which are reject cannot be repaired and it is included in the scrap or yield losses category.

Based on the Pareto diagram in Figure 1, it is concluded that the cause of the low or decreased OEE value is due to breakdown losses by 53%.

Cause and Effect Analysis

Once it was known that the cause the fall in the OEE value in February 2020 is because it is caused by Breakdown Losses, which includes setup and adjustment losses, so the next will be analyzed using a causal diagram. An overview of the analysis of the five main factors is carried out using diagrams which are also referred to as fish bone diagrams, with this analysis it will immediately be known the cause of the problem of the high value of Breakdown Losses which caused the low and decreased OEE value in the period of February 2020. In this study, making a cause and effect diagram was done by interviewing and brainstorming with the injection department leader, apart from that the researchers also made independent observations, so that the search for the root of the problem as outlined in this causal analysis becomes easier and more objective because it is done together with the personal whom involve in the TPM implementation. Following are the results of fish bone diagrams analysis.

Figure 2 Fish Bone Diagram



From the description of the causal diagram above, there are 4 factors that are considered dominant that have been analyzed, while one factor, namely environmental factors, is not a dominant factor, because physical environmental factors like temperature, lighting, humidity, and etc. have no significant effect on the machine production. After it is known that the cause of the decline in OEE values in February 2020 was due to the high number of breakdown losses which also included losses caused by machine setup, then an analysis was carried out using a cause and effect analysis.

From the four dominant factors analyzed, namely human, machine, method, and material factors, all of which have been analyzed regarding the causes and consequences, the researcher wants to propose corrective actions that must be taken on these four factors so that the incidence of decreasing OEE value in February does not occur again in next period.

For human factors, according to the researcher's analysis, it is very important to prioritize the skills and discipline of a production operator, this can be done in accordance with one of the pillars of implementing TPM, namely Training and Skill Development, where this pillar aims to provide comprehensive training for all employees so that they have good skills in carrying out their responsibilities. Companies must regularly conduct skills-up training, especially when the company is about to get a new product project, this can increase the knowledge and abilities of all employees regarding the new products that will be produced before they actually enter the mass production stage. Training can also aim to improve employee discipline in respect of applicable work rules, such as work instructions, so as to minimize human errors which can refer to work accidents. If this is successfully done, of course the goal of implementing TPM, namely zero breakdown, zero defect and zero accident will be achieved.

Furthermore, regarding the machine factor, this is of course important to improve again regarding the implementation of the Autonomous Maintenance pillar and the Planned Maintenance pillar, so that machine damage that should have been detected beforehand will not occur when production is running. Regarding the method factor, it is also related to several pillars of implementing TPM which must be improved, one of which is Focus Improvement, where this pillar is related to other pillars, namely TPM in Administration, where people who work in the quality system fields must make patented improvements to work standards standard for production operators, then people in the middle and top management ranks must have one voice to enforce discipline on the implementation of the improved method that has been agreed upon, thus creating work discipline which leads to work efficiency.

The last is regarding the material factor, where the problem that is caused is the frequent occurrence of problems with new materials used, in response to this the researchers highlighted the pillars of TPM, namely Quality Maintenance which focuses on improving overall quality, both product and management. This means that the company must really pay attention to the use and selection of good materials for the creation of a good product, if the company thinks about its cost efficiency by using materials which is more affordable, of course this must also be in line with other TPM pillars, namely focused improvement, so that the replacement with cheaper materials will not affect product quality.

With the improvements in the application of TPM, it is hoped that events such as a decrease in the OEE value will not happen again, inversely proportional to this, the researchers' hope is that the OEE value can be increased by confirming the application of the existing TPM pillars, so that TPM can significantly increase machine productivity as well as the performance of the injection department.

CONCLUSION

Based on the research results that have been done, the following conclusions are obtained:

1. The implementation of TPM can be carried out properly because all data components needed to examine the implementation of TPM are available. If we look at the level of success, it can be concluded that the implementation of TPM in an injection manufacturing company which located in Delta Silicon Area is classified as good, because the OEE value achieved has exceeded the specified minimum standard by JIPM (Japan Institute of Plan Maintenance). Prior to the implementation of TPM at an injection manufacturing at Delta Silicon Industrial Area, the average achievement of the OEE score is only 66.40, this figure is of course still far below the predetermined standard. After TPM implemented, the calculation results for the June period 2019 to May 2020 the average is 91.96, this figure is in the good category as a manufacturing company.
2. Even though the calculation results are good, there was a period where the OEE rate below the average, namely in February 2020, this was due to several things, after doing the six big analysis losses, the biggest losses are caused by breakdown losses with a percentage up to 53% of the total Losses that occur.

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