

Performance analysis of TPM implementation through Overall Equipment Effectiveness (OEE) and Six Big Losses

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Abstract. PT. TMI is a company engaged in the field of automotive that has implemented Total Productive Maintenance to improve efficiency and effectiveness of manufacturing companies as a whole. But it turns out that targets that are not achieved still often occur due to engine trouble. This study aims to determine the maintenance system of Press 2A machine that has a high rate of decline in speed. This study begins by measuring the achievement of Overall Equipment Effectiveness (OEE) value by first calculating the Availability, Performance Rate and Rate of Quality, then identifying the Six Big Losses that occur. The results showed that the average value of OEE on 2A Stamping machine is 70%, the effectiveness value is moderate and still below the standard of OEE value for world class company that is 85%. While the factor of Six Big Losses most influential on the low effectiveness of Press 2A machine is Reduced Speed Loss with total loss for a year of 56.411 minutes or 53% of all losses.

1. Introduction

Competition in the industrial world today is getting tighter and requires the company to focus more on customer satisfaction but still efficient in the production process. The company is challenged to be able to optimize all its resources to eliminate all forms of waste and prevent cessation of production due to engine failure. Lean Manufacturing (LM) method is a very popular and widely used method today to answer the challenge and one of the most important tools in successful application of LM method is Total Productive Maintenance (TPM). The effective integration of the maintenance of the amount of time, money and other useful resources in dealing with reliability, availability, maintainability and performance issues is what TPM (Moubray in [1])

PT. TMI is a manufacturing company engaged in the automotive industry. PT. TMI has produced various types of world-class cars and even have mastered the market share in Indonesia. To produce world-class products and guarantee high reliability of machinery / equipment, PT. TMM Indonesia has chosen the TPM method as the answer. However, there is still damage to the machine that causes disruption of the production process that ultimately causes the target is not achieved. Some studies have found that the success rate of TPM implementation varies widely, where the most accurate, and widely used method of measuring the success of TPM is through the method of Overall Equipment



Effectiveness (OEE) and Six Big Losses [2], [3]. OEE is a measure of the total effectiveness of TPM performance that represents the aspects of availability, performance and quality. While the six big losses are derived from OEE which consists of: breakdown losses, set-up / adjustment losses, idling and minor stop losses, reduced speed losses, rework losses and defect losses [4]. Several previous studies for example from [4] generate OEE value for motorcycle production line in PT. YMI is an average of 77.72% with the largest losses being set-up loss. From [5], the OEE value for the Lathe machine is 80% average while [6] get the DD07 Dual Filter OEE engine value is very low, only 26.22% with the biggest losses Idling and minor stoppages. Based on the above background, the purpose of the research is conducted is to analyze the implementation of Total Productive Maintenance (TPM) at PT. TMI especially for 2A Stamping machines measured through Overall Equipment Effectiveness (OEE) and Six Big Losses performance.

2. Literature review

2.1 Maintenance definition.

Understanding maintenance is the act of maintaining the machine and fix it up to acceptable conditions. Maintenance activities are different from Treatments. Maintenance activities are performed on machines that are still in 'healthy' condition and can operate normally, while Treatments activities are performed on machines that are 'sick', disrupted and unable to operate normally.

2.2. Maintenance activities classification

Broadly [1], [7] divides the type of maintenance according to the time of its implementation are as follows:

1. Unplanned Maintenance (Unplanned Maintenance). The oldest type of Maintenance was first introduced in the 1950s. There is only one kind of unplanned maintenance that is emergency maintenance or breakdown / emergency.
2. Preventive Maintenance of 1951. This method aims to prevent the occurrence of damage, and extend the life of the machine through maintenance activities on a regular basis.
3. Corrective Maintenance in the 1957 era. This maintenance is a work done to improve and improve the condition of facilities / equipment so as to achieve acceptable standards. The main objective is to improve the reliability, maintainability and safety of the engine.
4. Predictive Maintenance (Predictive Maintenance) in the era of 1965. Often referred to as Condition Based Maintenance. Maintenance of this type is characterized by the use of advanced techniques, sensors, including probability statistics to detect the appearance of signs of failure / decline in function. Predictive Maintenance is used only on systems that will cause serious problems in case of damage to the machine or to dangerous processes.
5. Productive Maintenance (1968). Maintenance method that aims to improve productivity through reduction of total equipment cost from start of design process, installation, operation and maintenance, and equipment losses. The key to this method is the reliability and maintainability of the machine.
6. Total Productive Maintenance (1971) TPM is an innovative maintenance approach aimed at
7. optimizing equipment effectiveness, eliminating breakdowns and running autonomous maint.by operators through daily activities and involving all employees [8].

2.3 Total productive maintenance

According to [1], [9] and [10], Total Productive Maintenance is the development of Preventive and Corrective Maintenance, Maintenance Prevention combined with Total Quality Control concept. This maintenance concept involves all workers aimed at achieving effectiveness throughout the production system through productive, proactive, and planned participation and activities.

2.4 Six Big Losses

In TPM the low productivity of machines or equipment that incur losses for the company is often caused by the use of inefficient and efficient machinery or equipment. According to [1], [9], [11] there are six loss factors called six big losses and are classified into three groups:

1. Downtime Losses
2. Speed Loss
3. Defect Loss

2.5 Overall Equipment Effectiveness (OEE)

The OEE method incorporates metrics of all machine and equipment conditions into a measurement system so as to help improve equipment performance and reduce ownership costs. The OEE values are derived from the calculation of the Availability engine level, the efficiency performance of the process and the rate of quality product (Dal et al in [1], [12] and [13]. The mathematical formula of overall equipment effectiveness (OEE) formulation according [1],[12], [13] and [9] is as follows:

$$\text{OEE} = \text{Availability Ratio} \times \text{Performance Efficiency} \times \text{Rate of Quality Product} \quad (1)$$

2.6. Cause effect diagram (fishbone diagram)

The causal diagram or fishbone diagram is a structured approach that allows more detailed analysis to find the causes of a problem, the inconsistencies and the gaps [4]. The causal diagram classifies 5 main factors causing a problem that is: 1. Manusia (man), that is related to lack of knowledge, lack of basic skills related to mental and physical, fatigue, stress, ignorance and others, 2. Method work method, which is related to no correct, unclear, unknown, non-standardized, unsuitable, and other work procedures and methods, 3. Machinery or other equipment (machine / equipment) there is no preventive maintenance system for production machines, including other facilities and equipment, not in accordance with task specifications, not calibrated and others, 4. raw materials, ie in the absence of quality specifications of raw materials and materials supporters are used, the absence of effective handling of raw materials and supporting materials and others, 5. Work environment (work environment) related to place and time of work that does not pay attention to aspects of hygiene, health, safety, lack of lighting, poor ventilation and others.

3. Research method

3.1 Subject dan research object

The research location is in production line using Stamping Machine 2A and Maintenance and Welding Division at PT. TMI. Research conducted from January - Dec 2015. Which is located in industrial area Karawang.

3.2 Research steps

1. Define topic and problem formulation through literature study and preliminary field study.
2. Determine the purpose and scope of the study.
3. Conducting the process of data collection: time and amount of production, reject, rework, data maintenance machine Press 2A, data breakdown time Press 2A machine.
4. Conducting data processing: calculation of operating time, Availability ratio calculation performance ratio, quality rate, OEE value, six big losses.
5. Analyze results: analysis of TPM implementation level through OEE value (comparison with OEE world class and other industry) Pareto diagram analysis for six big losses, fishbone diagram analysis to determine biggest losses and main cause.

4. Result and discussion

4.1 Availability ratio

To find the Availability value, the first value to look for is Loading Time, the calculation of the value of Loading Time for January is as follows:

$$\begin{aligned} \text{Loading Time} &= \text{Available Time} - \text{Planned Downtime} \\ &= 19200 - 0 \\ &= 19.200 \text{ minutes} \end{aligned} \quad (2)$$

To find the Availability value, the first value to look for is Loading Time, the calculation of the value of Loading Time for January is as follows:

$$\begin{aligned} \text{Downtime} &= \text{akdown} + \text{Setup Adjustment} \\ &= 135 + 3600 \\ &= 3.735 \text{ minutes} \end{aligned} \quad (3)$$

After Loading Time and Downtime have been obtained, the availability value can already be calculated, the calculation of availability value of Stamping machine 2A for January is as follows:

Table 4.1. Loading time calculations

Month	Available time (minutes)	Planned downtime (minutes)	Loading time (minutes)
Januari	19200	0	19200
Februari	19200	0	19200
Maret	22080	0	22080
April	20160	0	20160
Mei	18720	0	18720
Juni	20640	0	20640
Juli	15840	0	15840
Agustus	21120	0	21120
September	19680	0	19680
Oktober	14400	0	14400
November	20160	0	20160
Desember	17760	0	17760

Table.4.2. Availability ratio calculations

Month	Available time (minutes)	Downtime (minutes)	Operation time (minutes)	Availability (%)
January	19200	3735	15465	81%
February	19200	3766	15434	80%
March	22080	4331	17749	80%
April	20160	3883	16277	81%
May	18720	3713	15007	80%
June	20640	3824	16816	81%
July	15840	2986	12854	81%
August	21120	2884	18236	86%
September	19680	3549	16131	82%
October	14400	2022	12378	86%
November	20160	1969	18191	90%
December	17760	2199	15561	88%

4.2 Performance efficiency calculations

Calculating the Performance Efficiency value requires the total data of all processed products (Total Product Processed), Operation Speed Rate, and Operation Time.

Table 4.3. Performance efficiency calculations

Month	Total product processed (pcs)	Ideal cycle time (pcs/min)	Actual operation time (minutes)	Performance efficiency (%)
January	172686	12	14942	96%
February	167182	12	14853	94%
March	167188	11	15972	95%
April	168751	12	14593	96%
May	159646	12	13393	99%
June	185048	13	14871	96%
July	109178	11	11306	88%
August	186050	12	15912	97%
September	192546	14	14054	98%
October	190452	18	11145	95%
November	33991	5	17112	40%
December	75002	6	14396	91%

4.3 Rate of quality calculations

Rate of Quality is a ratio that describes the ability of equipment in producing products in accordance with standards that have been determined company. In searching the Rate of Quality value requires only processed product data (Total Product Processed) and Reject / Rework / Reduced Yield data.

With the same calculation obtained Quality Rate value from January 2015 until December 2015, the results can be seen in table.4.4.

4.4. Overall Equipment Effectiveness (OEE)

After calculating the value of Availability, Performance Efficiency and Rate of Quality on 2A press machine, then calculate the Overall Equipment Effectiveness (OEE) value to know the effectiveness of using 2A press machine at PT. TMI .

Table 4.4. The OEE calculations result

Month	Availability (%)	Performance efficiency (%)	Rate of quality (%)	OEE (%)
January	81%	96%	94%	73%
February	80%	94%	92%	69%
March	80%	95%	91%	69%
April	81%	96%	94%	73%
May	80%	99%	94%	75%
June	81%	96%	94%	73%
July	81%	88%	94%	67%
August	86%	97%	93%	79%
September	82%	98%	93%	75%
October	86%	95%	93%	76%
November	90%	40%	92%	33%
December	88%	91%	91%	73%

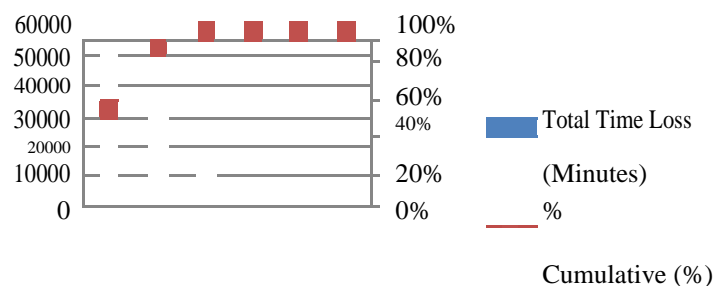
From Table 4.4 above, it appears that the average OEE value is 70%. This value is still far from the World Class OEE value of 85% [4] but still higher than the OEE value for the Dual Filters DD07 engine at PT Filtrona which is only 26.22% [6] but still below the OEE of the Lathe machine in the Engineering Division PT Barutama which is 80% [5].

4.5. Calculating the value of six big losses

The calculation of six big losses is useful for identifying losses, such as loss of equipment damage, loss of preparation or adjustment, loss of speed, or loss of product damage

Table 4.5. Six big losses cumulative value

No	Six big losses	Total time loss (minutes)	(%)	Cumulative (%)
1	Reduced speed loss	56411	53%	53%
2	Setup/adjustment loss	36472	35%	88%
3	Yield/scrap loss	10398	10%	98%
4	Equipment failures loss	2389	2%	100%
5	Idling and minor stoppage Loss	0	0%	100%
6	Rework loss	0	0%	100%
	Total	105670	100%	

**Figure 4.1.** Pareto diagram for six big losses

4.6 Cause-and-effect diagram (fishbone diagram)

By looking at the pareto diagram above, the factor that gives the biggest influence of the six big losses factor is Reduced Speed Loss is 56.411 minutes and with cumulative percentage below 80% that is equal to 53%. With this causal diagram it will show what are the secondary causes which then affect the main cause and result in Reduced Speed Loss.

5. Conclusion

Based on research results, PT. TMI has implemented the concept of Total Productive Maintenance (TPM) quite well / at the Medium level of implementation where the OEE value in 2015 is 70% average, with the lowest OEE 33% (one time only) and the highest 79%. Availability percentage results range from 80% - 90%, while Performance Efficiency percentage ranges from 40% - 99%, and the percentage Rate of Quality Product ranges between 91% - 94%. Six Big Losses analysis results obtained the largest percentage for losses is Reduced Speed Loss is equal to 53%, This factor is the most influential on the low value of OEE Stamping Machine2A.

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