Improving Curing Process Productivity in The Tire Industry Using OEE, TPM and FMEA Methods

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Abstract

The volume of car sales from time to time continues to increase (Gaikindo, 2020) so the need for supporting spare parts will also accompany it, both as an OEM (Original Equipment Manufacturer) supply in the car industry and to direct users as replacements. Tires are one of the important components, because the movement needs a rotating wheel as the means so that the tire manufacturing industry remains a profitable business. The curing process in the manufacture of tires is an obstacle to increasing the productivity of tire manufacturing, with an average OEE value of 75.86%, still far from the global company level target of 85% and the company's target of 89%. To increase the OEE value, start with the measurement of six big losses followed by a Pareto diagram to find the priority of the problem and the root of the problem using a fishbone diagram. The machine problem is fixed with the TPM program on the machine with the lowest OEE value until Autonomous Maintenance is running, then duplicating it. The FMEA method was used to solve the Rate of Quality problem so that an increase in the OEE value was 89.88% at the end of the study.

Keywords
TPM, OEE, Six Big Losses, FMEA

1. Introduction

In the current era, the progress of the times has made the industry in Indonesia now more complete, even in the same or similar industrial fields there are so many that competition can no longer be avoided. As a company that will be involved in the competition in the business world, they must be able to be superior when compared to other companies.

The automotive industry is one of them, each company innovates with each other and adds facilities and provides more comfort to its users according to consumer desires but still pays attention to safety and feasibility factors.

One of the automotive industries that continues to develop and innovate is the manufacture of cars, where manufacturers compete with each other to add facilities and accessories to provide users comfort and pleasure. Sales are very impressive from year to year even though they had decreased due to the Covid-19 pandemic in early 2020 until it got bitter in May, then gradually rose again (Figure 1).

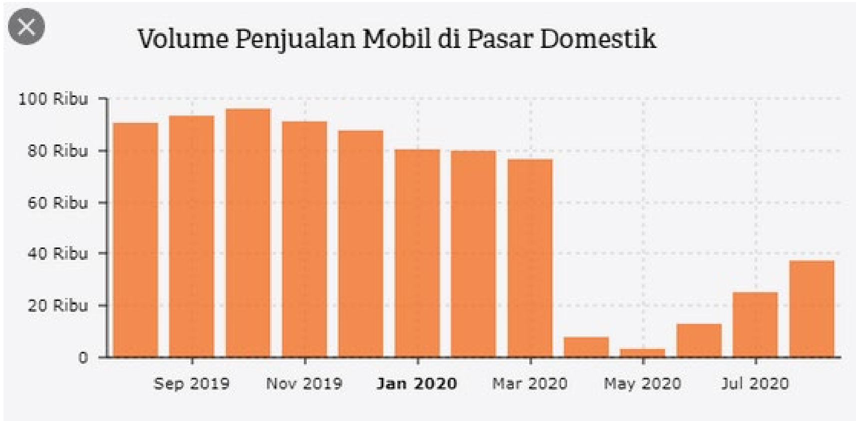

Figure 1. Car Sales Volume

Tires are one of the important components in the car world, because the movement needs a rotating wheel as a means. So that with the large number of use of cars, automatically the consumer's need for tires also continues to increase both as OEM (Original Equipment Manufacturer) orders in the car industry and to direct users as replacements. Reliable tires must be able to be used in all terrains and be safe and comfortable to use

The curing process as the chain link of making tires into a botle neck which hinders the increase in productivity of tire manufacturing, with an average OEE value of 75.86%, still far from the global corporate level target of 85% and the company's target of 89%. Improvement steps are needed to improve this condition.

According to Sigit and Machfud (2019), effective implementation of TPM to support increased factory productivity needs to be supported by efforts to improve 5S implementation, component replacement programs in planned maintenance and implementation of autonomous maintenance pillars. Research by Hadi and Choesnul (2018) states that FMEA can reduce the number of NG products from 2.86% to 0.98% where this value is smaller than the maximum limit set by the company, which is 1%. According to Darso and Aisyah (2019), the results of the six big losses analysis show that there are two major losses that have a dominant effect on the OEE value, namely damage losses and reduced speed losses, it is proven that the reduction in losses in the produced water injection process gives an increase in the OEE value. According to Hipny and Jimmy (2019) that the analysis of the causes of damage is carried out using the Ishikawa diagram or the fishbone concept then after the cause of the damage is known, a Failure Mode and Impact Analysis (FMEA) is carried out for centrifugal exhaust fans. Research by Bambang and Aris (2019) states that with a known OEE value of 85.83%, according to the Japan Institute of Plant Maintenance (JIPM) standards it can be concluded that investment in new machines is included in the "world-class production" category, and is an indicator of acceptance in good / decent category for new equipment

Based on the phenomenon of the development of the automotive industry which is tightly competing and the problem of increasing the productivity of the tire manufacturing process and the analysis of previous research, it has inspired this study that by combining the TPM and FMEA methods, the losses in the production process will be reduced and the machine can run more effectively and efficiently. In addition, companies will also be helped by reducing production processes that are deemed unimportant and can be reduced or even eliminated so that productivity will increase

2. Literature Review

Productivity is an attitude of mind, a mentality of progress and continuous improvement of what is. It is a certainty of being able to do better today than yesterday and continuously making constant adaptations of economic and social life to changing conditions. It is an ongoing effort to apply new techniques and methods as well as faith in progress. Greenberg (2005) defines productivity as the ratio between the total expenditure at a certain time divided by the total input during that period. Mali (1978) also argues that productivity is a combination of effectiveness and efficiency

Total Productive Maintenance (TPM) is a philosophy that originated and developed in Japan. Currently the concept of TPM is not only applied in Japan or by Japanese companies, TPM has also been implemented throughout the world. Companies from America, Europe, and other countries outside Japan also apply TPM for their factory operations. The implementation of TPM is proven to provide good changes in the company in the form of increased productivity, increased quality, cost control, accuracy of product delivery to consumers, maintaining safety and increasing enthusiasm in creating a conducive workplace for factory operations (Shukla and Upadhyaya, 2010)

Ambekar and Edlabadkar (2013) state that Failure Modes and Effect Analysis (FMEA) is a methodology in product development and operations management for analysis of potential failure modes in a system with a classification based on the severity and likelihood of failure Engineering department. Chikhale and Barik (2015) state that FMEA is a systematic method for identifying and preventing process and product problems before they occur. FMEA focuses on preventing breakdowns, increasing safety, and increasing customer satisfaction

3. Methodology

The focus of this research is on the curing process as a bottle neck, the tire manufacturing process, starting with the calculation of the OEE value and its three factors, namely Availability (AV), Performance Efficiency (PE) and Rate of Quality (RQ), then followed by calculating the value of six big losses. The priority of the problem is obtained by analyzing the Pareto diagram and fishbone diagram to get the root of the problem. Furthermore, the machine problem is fixed with the TPM program on the machine with the lowest OEE value until Autonomous Maintenance (AM) runs, then duplication is done on the other machine. The Failure Mode and Effect Analysis (FMEA) method is used to solve the Rate of Quality problem

4. Results and Discussions

From the data that has been collected daily and monthly reports of the production, maintenance and inspection sections from July to September 2020, the initial data is obtained for calculating the OEE value (Table 1)

Table 1. OEE values before repair

2020	Juli	Agustus	September
Total time	29,819,520	29,819,520	28,857,600
Planned Closing Time	6,883,199	7,031,751	5,840,258
Planned Production Time	**22,936,321**	**22,787,769**	**23,017,342**
Planned Down Time	48,903	34,379	60,569
Unplanned Down Time	4,464,107	4,754,045	4,514,081
Operating Time	**18,423,311**	**17,999,345**	**18,442,692**
Availability	**80.32%**	**78.99%**	**80.13%**
Speed Loss & Delay Production	587,802	334,665	552,596
Net Operating Time	**17,835,509**	**17,664,680**	**17,890,096**
Performance	**96.81%**	**98.14%**	**97.00%**
Quality Loss	435,575	403,995	402,423
Productive Time	**17,399,934**	**17,260,685**	**17,487,673**
Quality	**97.56%**	**97.71%**	**97.75%**
OEE	**75.86%**	**75.75%**	**75.98%**

Referring to the calculation of the OEE value from July to September 2020 (Table 1), the value of six big losses from July to September 2020 can be calculated (Table 2).

Table 2. Value of six big losses before repair

2020	Juli	Agustus	September
Planned Production Time	**22,936,321**	**22,787,769**	**23,017,342**
Machine Breakdowns	4,223,170	4,561,637	4,305,286
Breakdowns Losses	**18.41%**	**20.02%**	**18.70%**
Set Up	240,937	192,408	208,795
Set Up Losses	**1.05%**	**0.84%**	**0.91%**
Speed Loss & Delay Production	587,802	334,665	552,596
Idle Losses	**2.56%**	**1.47%**	**2.40%**
Quality Loss	435,575	403,995	402,423
Yield Losses	**1.90%**	**1.77%**	**1.75%**

By analyzing the Pareto diagram, it is known the priority problems that must be corrected immediately for the four losses that arise (Figure 2) and the defects that arise (Figure 3).

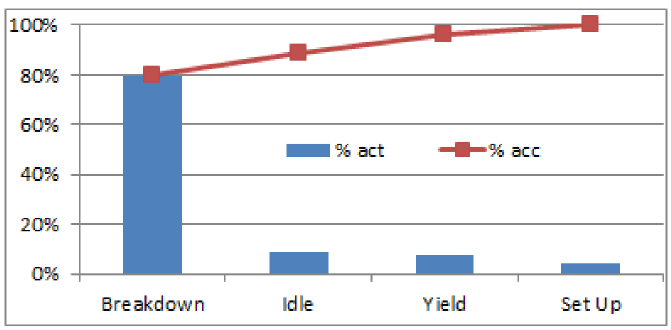

Figure 2. Pareto diagram of four losses that arises

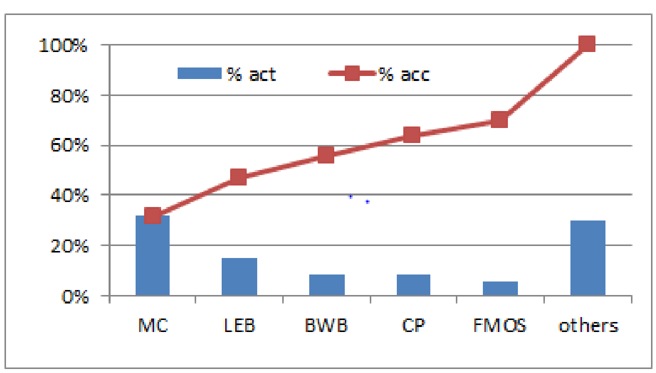

Figure 3. The Pareto diagram of defect that arises

From the two Pareto diagrams, it is clear that the correlation is that the engine factor is very dominant because the Miss Cure (MC) defect occurs when there is a process error in tire cooking, so it was agreed to make an engine model of the TPM program. The model machine was chosen the worst of the 334 curing machines, with an OEE value of 67.29% and breakdowns losses of 27.39%, the KTC-H27 machine was the right choice.

The program begins with the implementation of 5S and the initial marking of cleaning and tagging on each side and area of the machine, the results of collecting tags are important points that are the source of the breakdown losses problem, namely:

- Proximity (damaged, shake, improper position, dirty, etc.)
- Cylinder (leaking, mismatched speed, stuck, etc.)
- Encoder (damaged, improper position, unreadable PLC, etc.)
- Loader (tilted, not centered, finger upnormal, etc.)

Repair of damaged components is carried out by the maintenance department which is included in the PM program, while the production section carries out Autonomous Maintenance (AM) as routine minor maintenance (Table 3)

Table 3. AM for leaders and operators

AUTONOMOUS MAINTENANCE		ITEM	PIC	INTERVAL
CLEANING	1	BLOW KRAN PIPA TEMBAGA INTERNAL	OPERATOR	MINGGUAN
	2	CLEANING PHOTO SWITCH & REFLECTOR	OPERATOR	MINGGUAN
	3	CLEANING GREEN STAND	OPERATOR	MINGGUAN
	4	CLEANING LOADER	OPERATOR	MINGGUAN
	5	CLEANING COVER MOLD	OPERATOR	MINGGUAN
	5	AREA MESIN (SAMPING KIRI/KANAN MESIN)	OPERATOR	MINGGUAN
LUBRICATING	5	CHECK LEVEL OIL HYDRAULIC PUMP UNIT & COUPLE (KTC)	OPERATOR&LEADER	MINGGUAN
ADJUSTING	6	SET UP / SPEED LOADER & UNLOADER (IN-OUT)	OPERATOR&LEADER	MINGGUAN
INSPECTION	7	LAPORKAN KERUSAKAN SEDANG / BERAT	OPERATOR&LEADER	HARIAN
	8	LAPORKAN OIL KOSONG / KURANG (KTC)	OPERATOR&LEADER	HARIAN
	9	INFORMASIKAN KEBOCORAN / BERI TANDA	OPERATOR&LEADER	HARIAN
		(ANGIN, AIR, OIL, STEAM, N2)		
	10	CEK & LAPORKAN MESIN BUNYI / BERDERIK	OPERATOR&LEADER	HARIAN
REPAIR	11	PERBAIKAN KERUSAKAN KECIL (SELANG BOCOR) YANG BISA DITANGANI	OPERATOR&LEADER	HARIAN

For handling yield losses outside of machine problems such as Leaky Bladder (LEB) using the FMEA method, it appears that the RPN value is very high (above 100) because the severity value is 7 (product scrap) and detection 8 (visual check) so it is necessary to find the root of the problem with fishborne diagram

From the fishborne diagram, two ways of improvement can be maximized in reducing LEB defects, namely:

- Material: changed the bladder making compound so that it improved its quality and reached a lifetime of 450 x cure without leaks
- Method: reduce the lifetime to 300 x cure (LEB defects occur a lot at this number) with the risk of set up losses to increase

With the consideration of increasing the OEE value according to the mission of this research, a step was taken to reduce the lifetime because changing the spec compound takes a long time

At the end of the study breakdowns losses fell to 6.97%, set up losses rose to 1.34%, idle losses fell to 1.105, yield losses fell to 0.44% and OEE increased to 89.88%

5. Conclusions

With increasing age the engine will reduce the function and speed of the engine so that it can affect its performance, with a good and correct maintenance system it can maintain a stable performance condition. The application of TPM with AM and PM plars is an effective method to maintain this performance

Machine components that are not functioning properly can increase breakdowns losses and will automatically decrease productivity and the OEE value. By combining the TPM and FMEA methods is very effective in overcoming these problems so that productivity increases and will automatically increase company profits

Unresolved problems such as improving the quality of the bladder-making compound could be an opportunity for further research so that the OEE value can be increased again.

References

Ahmad Hipni, Jimmy Sabar HP Sitanggang, Erry Rimawan, Humiras Hardi Purba, Choesnul Jaqin. (2019). Analisys of the Centrifugal Exhaust Fan Damage on Line Painting. *International Journal of Innovative Science and Research Technology, 4(1)* : 410-415.

Ahmad Rozak, Choesnul Jaqin, Hasbullah, 2020. Increasing Overall Equipment Effectiveness in Automotive Company Using DMAIC and FMEA Method. *Journal Européen des Systèmes Automatisés, 53(1)* : 55-60

Ahmed, M., Ahmad, N. (2011). An application of pareto analysis and Cause-and-Effect Diagram (CED) for minimizing rejection of raw materials in lamp production process. *Management Science and Engineering, 5(3)*: 87–95.

Ahuja, I. P. S., & Khamba, J. S. (2008). Total productive maintenance: Literature review and directions. *International Journal of Quality and Reliability Management*, *25*(7), 709–756. https://doi.org/10.1108/02656710810890890

Bambang Biantoro, Aris Trimarjoko, Choiri Purwanto, Erry Rimawan. (2019). Case Study : Acceptance Analysis for New Tire Building Machine Technology using Overall Equipment Effectiveness Methodology. *International Journal of Innovative Science and Research Technology 4(1)* : 351-354

Borris S. 2006. Total Productive Maintenance – proven strategies and techniques to keep equipment Running at Peak Efficiency. New York: McGrawHill

Choesnul Jaqin, Darso Alimudin, Humiras Hardi Purba, Siti Aisyah. (2019). Performance Improvement of Injection Pump Machines Based on Overall Equipment Effectiveness : Case Study in Oil Company. *Advances in Intelligent Systems Research, volume 173* : 103-110

Hari Abdul Hadi, Choesnul Jaqin. (2018). Analisis Penurunan Rasio Defect Compound di Industri Ban Mobil dengan Metode Failure Mode Effective Analysis (FMEA). *Prosiding Seminar Nasional Aplikasi Sains & Teknologi (SNAST) 2018* : 557-566.

Hartman. E. 1992. Successfully Installing TPM in a NonJapanese Plant. Pittsburgh, PA, TPM Press, Inc.

Law, S.-N., Chong, S.-H., Sim, H.-Y., Razalli, S., & Kamaruddin, S. (2014). Measurement of Overall Performance Effectiveness in Setup Improvement. *Journal of Industrial Engineering*, *2014*, 1–7. https://doi.org/10.1155/2014/264980

Mardono, U., Rohimah, A., & Rimawan, E. (2018). Six Big Losses Approach and Kaizen Philosophy Implementation to Improve Overall Equipment Effectivenes (OEE) (Case Study : PT . ABC , Areinforced Steel Manufacturer). *International Journal of Innovative Science and Research Technology. 3*(6), 165–171.

Musa, M. A., Kasim, N. I., Razali, A. R., Mahadzir, & Wan Saidin, W. A. N. (2015). Improvement of Overall Equipment Effectiveness (OEE) through Implementation of Autonomous Maintenance in Crankcase Line. *Applied Mechanics and Materials*, *761*, 165–169. https://doi.org/10.4028/www.scientific.net/amm.761.165

Nakajima S. 1988. introduction to tpM. Translator; Bodek N. Oregon: Productivity Press.

Nayak, D. M., Naidu, G. S., Shankar, V., Manager, A., & Manager, A. (2013). Evaluation Of OEE In A Continuous Process Industry On An Insulation Line In A Cable Manufacturing Unit. *International Journal of Innovative Research in Science, Engineering and Technology*, *2*(5), 1629–1634.

Nina Hairiyah, Raden Rizki Amalia, Rino Adi Wijaya, 2019. Analisis Total Productive Maintenace (TPM) pada Stasiun Kernel Crushing Plant (KCP) di PT. X. Jurnal Teknologi Pertanian Andalas, 23(1) : 103-110

Nurdin, M., Firdaus, M., & Rimawan, E. (2018). Analysis and Implementation of Total Productive Maintenance (TPM) using Overall Equipment Effectiveness (OEE) and Six Big Losses on Press Machine in PT . Asian Bearindo. *International Journal of Innovative Science and Research Technology. 3*(6), 172–176.

Rajput, H.S., and Jayaswal, P. 2012. A Total Productive Maintenance (TPM) Approach To Improve Overall Equipment Efficiency. *International Journal of Modern Engineering Research (IJMER). Volume (2)* : 4383-4386.

Shukla R, Upadhyaya A. (2010). TPM effectiveness : an operational study. Prestige International Journal of Management and research 3(4) : 35–40.

Singh, R., Gohil, A. M., Shah, D. B., & Desai, S. (2013). Total productive maintenance (TPM) implementation in a machine shop: A case study. *Procedia Engineering*, *51*(NUiCONE 2012), 592–599. https://doi.org/10.1016/j.proeng.2013.01.084

Sigit Priyono, Machfud, Agus Maulana. (2019). Penerapan Total Productive Maintenace (TPM) pada Pabrik Gula Rafinasi di Indonesia (Studi Kasus: PT. XYZ). *Jurnal Aplikasi Bisnis dan Manajemen (JABM), Vol. 5 No. 2, Mei 2019* : 265-277 http://journal.ipb.ac.id/index.php/jabm

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