ISSN No:-2456-2165

Analysis for Enhancing Quality and Productivity Using Overall Equipment Effectiveness and Statistical Process Control in Manufacturing Industry Case Study: Manufacturing Industry Sport Shoes in Tangerang Region

Wahyudin[1], Budi Irawan Saleh[1], Sawarni Hasibuan[2]
[1](Master of Industrial Engineering Student, Universitas Mercu Buana, Jakarta, Indonesia)
[2](Master of Industrial Engineering Program, Universitas Mercu Buana, Jakarta, Indonesia)

Abstract:- The main problem often faced by the manufacturing industry is the high level of loses time, which is illustrated by the low utilization rate of Total Productive Maintenance (TPM) time and the impact on the low level of effectiveness of the plant or equipment. This is often caused by breakdown losses, setup and adjustment losses, start-up losses, minor stoppage, idling, speed losses, and defect losses. This study aims to determine the time utilization of TPM and provide suggestions for improvements to improve Overall Equipment Effectiveness (OEE) time utilization and lead to savings in production costs. Case studies were carried out on manufacturing companies engaged in sport's shoes and are the largest supplier of world sports shoe brands. Products produced from this industry are the Upper (upper part of the shoe), Outsole (the bottom of the shoe), and Insole (the inside of the shoe) with the main raw materials being leather, foam, and rubber. From the results of data processing, it is obtained the effectiveness value of the manufacturing process, which is OEE, an average of 76.98% per month with a component availability of 94.87%, a performance rate of 41.42%, and a quality rate of 94.74%. The main causes of lost time are defect losses time of 4.74% per month of total productive time and breakdown losses of 2.17% per month of total productive time. Control process measurements are carried out to determine variations in the number of rework products and defects are still in the control limits of statistical control. To make improvements from the actual state, a new standard for product quality is set, from the number of 53 pairs of reworks and B'Grade (defective products sold at half the price of good products) 2 pairs to 47 pairs and 1 pair B'Grade. With the new work program and continuous improvement, it is the factory can reduce the number of rework products and B'Grade defects that can save up to IDR 56,586,860 per month.

Keywords:- *Total Productive Maintenance, Overall Equipment Effectiveness, Statistical Process Control, Shoe's Manufacturing Industry.*

I. INTRODUCTION

The stoppage of the process and ineffectiveness of the production system resulted in a decrease in production and also a decrease in the quality of the product produced. Efforts to make improvements sometimes become waste because it is done without knowing the root cause of the problem. Many organizations/companies end up going a long way to make improvements so that the repair system does not effectively touch directly into the problem.

In this research, where the subject is a manufacturing industry company engaged in sport's shoes and is the largest supplier of world sports shoe brands. Products that are being produced from this industry are the Upper (upper part of the shoe), Outsole (the bottom of the shoe) and Insole (the inside of the shoe) with the main raw materials being leather, foam, and rubber.

The shoe industry is a labor-intensive industry whose processes are still dominated by manual labor. Some of the problems often faced by the shoe manufacturing industry in Indonesia are low productivity. This is also reinforced by the results of research conducted by BAPPENAS and USAID in 2013 on the leather footwear industry that absorbs a lot of labor. From the results of the study, it was found that each shoe-making workforce in Indonesia was only able to produce 0.8% of pairs of shoes per day, while a Vietnamese worker was able to produce 1% of shoes each day (Aisiyah, 2016; Halim et al., 2019).

The low productivity in the shoe industry can also cause by, among others: (1) technology investment that is not carried out by companies, (2) long supply chains (3) Declining machine productivity in the company. Industrial competition in the fast shoe industry requires manufacturing companies in Indonesia to increase or improve productivity and efficiency, especially in facing global competition, with conditions where Indonesia has embraced the ASEAN Economic Community (AEC).

In an effort to increase and improve productivity, the company has implemented the TPM system. Although the company has implemented the program, but the company has never measured the effectiveness of the plant or its

ISSN No:-2456-2165

equipment or measured the performance of TPM time utilization, so the company cannot identified the factors that cause losses in operations which resulting in low plant or equipment effectiveness, including Breakdown, Setup and Adjustment, Idling, Reduced Speed, Quality Defect, and Startup, this is particularly are issues in the assembling of the sports shoe production system industry.

According to Nakajima (1988), there are six equipment losses (six big losses) that cause ineffectiveness or low performance of production systems and equipment. The six losses are classified into three types, including time availability (consisting of damage and adjustments and adjustments), machine performance (which consists of pauses, loss of speed), product quality (consisting of production defects and loss of ratio).

This research objectives are (1) to measure time utilization of TPM for assembling line in the sports shoe industry and (2) provide suggestions for improvements that can be done so that the value of OEE can increase. Area of improvement is based on two defective product that are reworks product and B'grade product –product that defective but sold at half the price of good products.

Limitations in this research are: (1) the industry that produced sport's shoes and is the largest supplier of world sports shoe brands. Products produced from this industry are the upper part (the upper part of the shoe), the outsole (the bottom of the shoe) and the insole (the inside of the shoe) with the main raw materials are leather, foam, and rubber; (2) calculation of OEE values is carried out only in the assembly line of the sports shoe manufacturing industry; (3) the company is located in Indonesia and Java Island.

II. LITERATURE REVIEW

➢ *Total Productive Maintenance (TPM)*

TPM previously came from America, but then its application and development were carried out in many industries in Japan. Seichi Nakajima was first introduced in Japan in 1988 and subsequently developed rapidly in Japan. TPM is a PM that is attended by all employees (Total Productive Maintenance).

T of TPM has a total understanding which includes:

1. Total in the sense of "total efficiency",
2. Total in the sense of "the whole cycle of the production system", and
3. Total in the sense of "all sectors and all members participate".

Specifically, the definition of TPM are:

1. Form a company that strives to maximize the efficiency of the production system (total efficiency).
2. Building a loss prevention system using available goods, so that conditions can be achieved "without accidents, without defects, and without damage" as the goal of the entire production system cycle. Based on the principle of "preventing losses", then eliminating losses is a basic principle of TPM, while building a prevention system with available items is a feature of TPM.
3. Achievement "without loss", through small group activities

➢ *OEE (Overall Equipment Effectiveness)*

OEE is part of TPM which consists of three main parts, including availability (time of machine availability), performance (number of units produced) and quality (quality produced). The results of mathematical calculations from OEE are in the form of a percentage (%). OEE calculations are based on equation (1).

$$OEE = Availability \times Performance\ Rate \times Quality\ Rate \quad (1)$$

The following principles must be applied to increase or improve the effectiveness of the plant or equipment:

• Measure with detail and reasonable
• Collect or determine company priorities
• Clarify the purpose and direction

The factors that influence the amount of OEE value mentioned above are calculated using the following formula:

1. Availability

Loading Time is the availability of equipment's net time for a period, for example, a day, a week or a month as shown in equation (2).

$$Loading\ Time = Working\ Time - Planned\ Down\ Time \quad (2)$$

Operating Time is the loading time reduced by the downtime of the machine (breakdown, set up and adjustment) as shown in equation (3).

$$Operating\ Time = loading\ Time - Down\ Time \quad (3)$$

Availability is the ability of a machine or line or factory to operate according to a specified schedule or the availability of a plant to operate as shown in equation (4).

$$Availability = Calendar\ time - (Overhaul - Preventive\ Maintenance - Breakdown)/Calendar\ time * 100\% \quad (4)$$

2. Performance Rate

Net operating time is the time the equipment operates at a constant speed or operating time reduced by time loss due to minor stoppage (reduced stopping) and reduced speed (declining speed) as shown in equation (5).

$$Net\ Operating\ Time = (Output \times Actual\ cycle\ time)/(Loading - Downtime) \times 100\% \quad (5)$$

Operating speed rate is a comparison between ideal cycle time and actual cycle time, this is a picture of losses due to decreased speed.

$$Operating\ Speed\ Rate = (Ideal\ Cycle\ Time)/\ Actual\ Cycle\ Time \times 100\% \quad (6)$$

Performance rate is the performance of the machine or line or factory in producing products based on operating time-based on operating speed rate multiplication with net operating time, as in formula (7).

$$Performance\ Rate = (Ideal\ Cycle\ Time \times Processed\ Amount)/\ Operating\ Time \quad (7)$$

3. Quality Rate

Is the average level of products produced according to standards compared to products that not in accordance with the standards.

Quality Rate = Processed Amount – (Reject + Rework)/ Processed Amount x 100%

(7)

➢ *Quality Control*

Quality control is the techniques and operational activities used to meet quality requirements. In quality control evaluation of the actual performance is carried out, comparing the actual with the target and then taking action on the difference between the actual and the target.

In conducting statistical quality control of existing problems, a method is used, one of which is Problem Solving or problem-solving methods which consist of steps - steps taken in solving quality problems, namely:

1. Determine the Theme, the tool used is the Pareto Diagram, the usefulness is:
• Shows the main issues.
• State the comparison of each issue to the whole.
• Shows the level of improvement after corrective actions in a limited area.
• Shows a comparison of each issue before and after improvement.
2. Understanding the problem and setting targets, the tool used is the control chart.
• A control chart is a tool that presents graphically a situation (day per day, a week per week, month per month) to oversee the process of producing quality products.
• The control chart is divided based on the type of data obtained. Control charts for variable data use control charts X and R. And control charts for attribute data use control maps P, np, C, and U.
• The np control chart shows the number of items that do not fit in the inspection group. The use of the np control map is based on:
• Data on the number of items that do not match is more useful and easy to interpret in making reports than proportion data
• The following formula used in creating the np control map is:

a) Calculation of the average value of the day or week of observation.

$$\overline{np} = \frac{\sum np}{n} \qquad (8)$$

b) Calculation of the standard deviation value.

$$\sigma_{np} = \sqrt{n\bar{p}(1-\bar{p})} \qquad (9)$$

c) Central Limit Calculation.

$$CL = n\bar{p} \qquad (10)$$

d) Calculation of upper control limit (UCL) and lower control limit (LCL).

$$UCL = n\bar{p} + 3\sigma_{np}$$

$$LCL = n\bar{p} - 3\sigma_{np} \qquad (11)$$

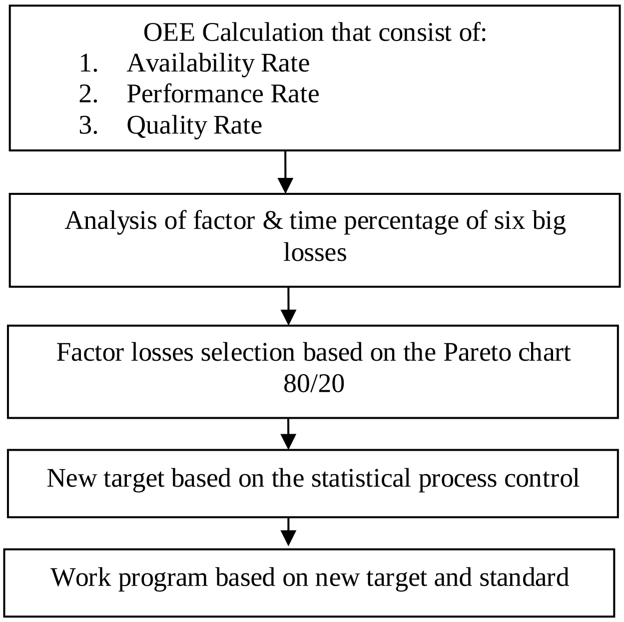
3. Arranging a work plan, the tools used are 5W + 1H, namely Why (cause), What (plan), Where (location), When (time), and How (how)
4. Perform analysis, tools that are used fishbone diagrams. Fishbone diagrams are causal diagrams that show the relationship between quality characteristics and their causal factors.
5. Implement and find solutions, the tool used is the fishbone diagram.
6. Seeing Effectiveness, the tools used are the histogram and the control chart. Comparison to see between before and after improvement.
7. Performing Standardization, the tools used are check sheets and control charts.

III. RESEARCH METHOD

➢ *Data Collection*

Data in this study include: (1) Data on working hours and machine down time within one (1) month, (2) Production data from assembly line 7 within one (1) month, and (3) Product data rework and B'grade and defects in assembly line 7 within a period of one (1) month.

➢ *Data calculation and analysis*



ISSN No:-2456-2165

IV. RESULT AND DISCUSSION

OEE calculation results, availability, performance rate, and quality rate are as follows:

No	Month	OEE (%) Target > 85%	Availability (%) Target > 95%	Performance Rate (%) Target 95%	Quality Rate (%) Target 99.9%
1	Jan-17	62,05%	94,87%	69,04%	94,74%
2	Feb-17	68,69%	98,36%	72,81%	95,92%
3	Mar-17	67,90%	98,40%	72,02%	95,82%
4	Apr-17	65,12%	97,81%	69,12%	96,32%
5	May-17	60,06%	93,57%	66,72%	96,20%
6	Jun-17	60,94%	98,53%	64,19%	96,36%
7	Jul-17	56,27%	96,98%	6175,00%	93,96%
8	Aug-17	72,24%	98,02%	78,97%	93,33%
9	Sep-17	72,40%	97,45%	79,78%	93,12%
10	Oct-17	67,25%	98,30%	73,14%	93,54%
11	Nov-17	75,79%	97,36%	82,95%	93,85%
12	Dec-17	76,41%	98,88%	81,97%	94,28%
13	Jan-18	77,30%	97,22%	82,97%	95,82%
14	Feb-18	73,51%	95,88%	78,90%	97,18%
15	Mar-18	65,91%	97,02%	69,99%	97.06%

Table 1:- Result of Calculation of OEE, Availability, Performance Rate, Quality Rate

The influencing factors are as follows:

Factors	OEE	Availability	Performance Rate	Quality Rate
Breakdown Loses	V	V	-	-
Setup & Adjustment Loses	V	V	-	-
Startup Loses	V	V	-	-
Minor Stoppage & Idling	V	-	V	-
Speed Loses	V	-	V	-
Defect Loses	V	-	-	V
Reworks	-	-	-	V

Table 2:- Factor that influencing % of OEE, Availability, Performance Rate, Quality Rate

Calculation results of six big loses time are as follows:

No	Type of Losses	Losses Time (Hours)	Cumulative (Hours)	Losses Time (%)	Cumulative (%)
1	Defect Losses	116.2	116.02	55.01	55.01
2	Breakdown Losses	53.17	169.18	25.21	82.21
3	Setup & Adjustment	26.08	195.27	12.37	92.58
4	Startup Losses	15.65	210.92	7.42	100

Table 3:- Calculation results and percentage of six big loses time

Using Pareto Chart 80/20 to see the most influencing factor for six big losses:

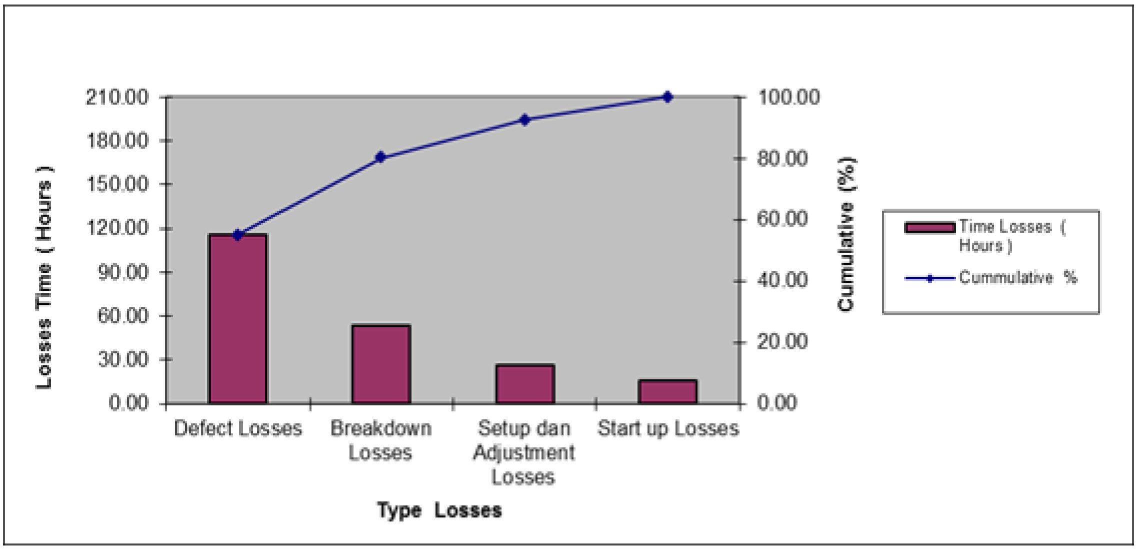


Chart 1:- Pareto Chart 80/20 for six big losses

Based on the Pareto chart above it is known that losses which cause the greatest loss of production time are Defect Losses. Therefore, problem solving in an effort to improve the performance of Total Productive Maintenance time utilization focus on Defect Losses.

To reduce product rework and or defects, a new target or standard needs to be made as a reference for subsequent process control. Determination of the target is done by using data that has a value below the average value in the initial calculation (present). Then from the data the upper control limit (UCL) and the new control limit (LCL) are determined. The following is the calculation of the target number of reworks and defects for the next production:

A. Calculation of the average value of the number of rework products from 30 days of rework observation :

Rework Product:

$$\overline{np} = \frac{\sum np}{n} = \frac{704}{15} = 46.93$$

B'Grade Product :

$$\overline{np} = \frac{\sum np}{n} = \frac{17}{22} = 0.77$$

B. Calculation of the standard deviation

Rework Product:

B'Grade Product :

C. Calculation for Central Limit:

$$CL = n\overline{p} = 46.93$$
$$\sigma_{np} = \sqrt{n\overline{p}(1-\overline{p})} = \sqrt{(1809)(0.026)(1-0.026)} = 6.761$$

Rework Product :

$$CL = n\overline{p} = 0.77$$
$$\sigma_{np} = \sqrt{n\overline{p}(1-\overline{p})} = \sqrt{(1809)(0.0004)(1-0.0004)} = 0.879$$

B'Grade Product :

D. Calculation of upper control limit (UCL) and lower

$$UCL = n\overline{p} + 3\sigma_{np} = 46.93 + 20.28 = 67.217$$
$$LCL = n\overline{p} - 3\sigma_{np} = 46.93 - 20.28 = 26.649$$

control limit (LCL)

Rework Product :
B'Grade Product :

$$LCL = n\overline{p} - 3\sigma_{np} = 0.77 - 2.637 = -1.864 = 0$$
$$UCL = n\overline{p} + 3\sigma_{np} = 0.77 + 2.637 = 3.409$$

To reduce product rework and or defects, a new target or standard needs to be made as a reference for subsequent process control. Determination of the target is done by using data that has a value below the average value in the initial calculation (present). Then from the data the upper control limit (UCL) and the new control limit (LCL) are determined. The following is the calculation of the target number of reworks and defects for the next production:

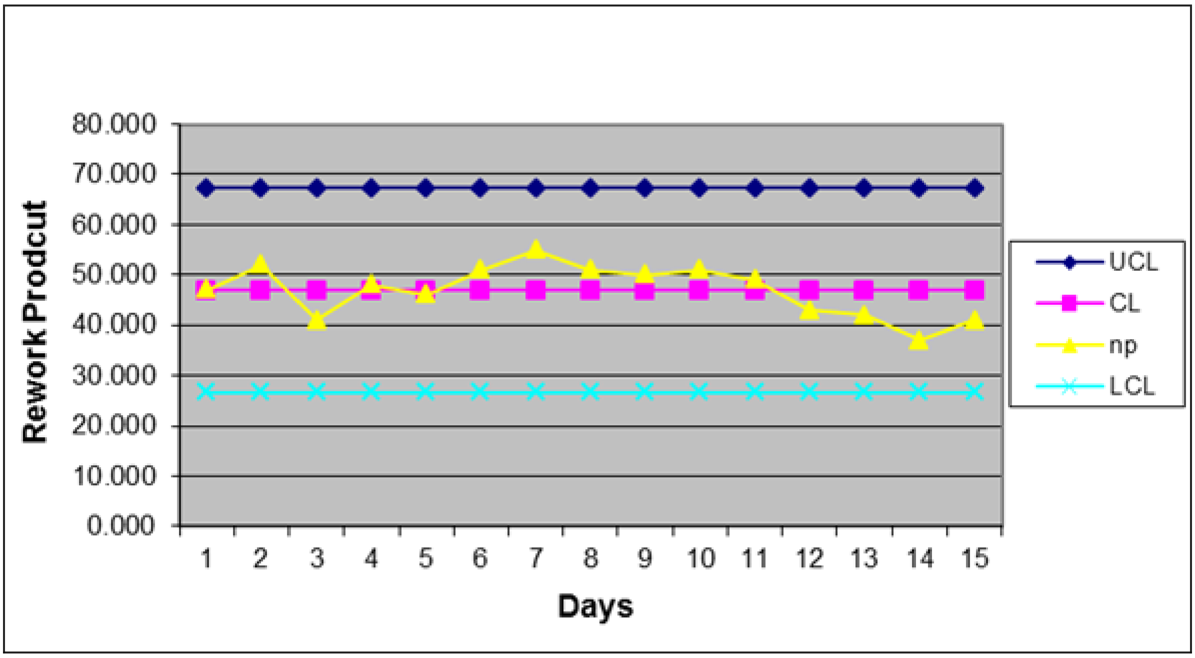


Chart 2:- Chart Control Target for reworks product

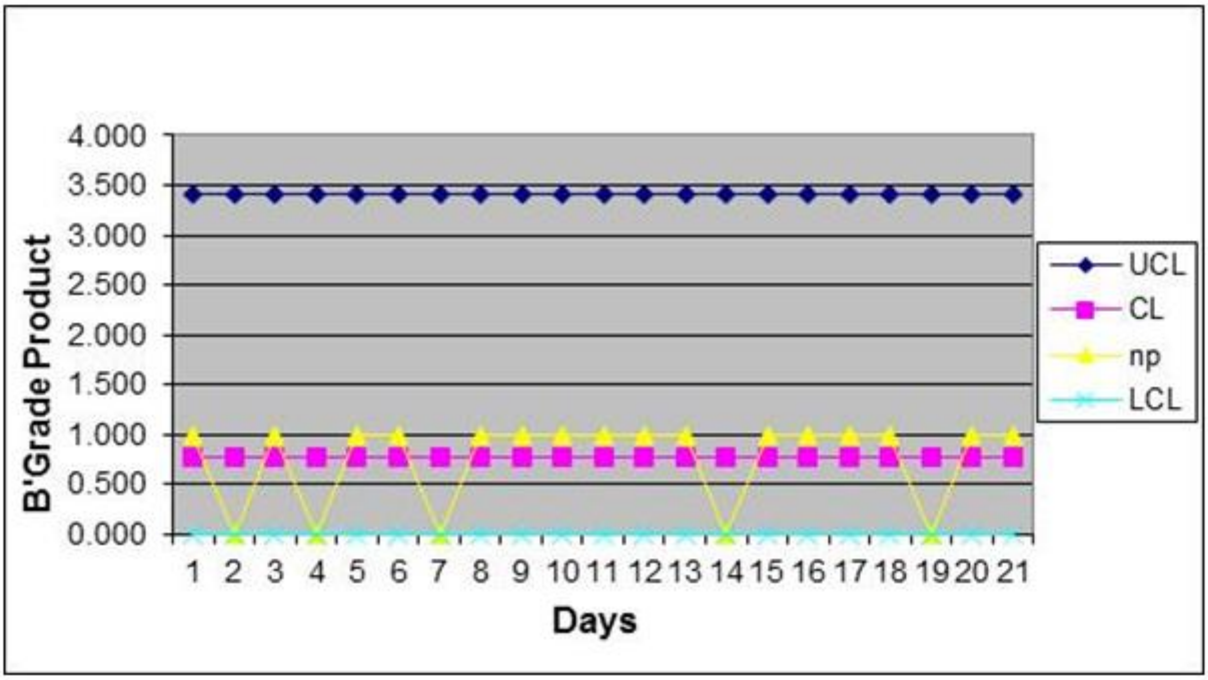


Chart 3:- Chart Control Target for B'grade Product

V. CONCLUSION AND SUGESTION

Based on the result from the calculation, conclusions can be put forward as follows:

➢ *Conclusion*

1. OEE showing increase in average from 2017-2018 (2017 average OEE : 61.37%, 2018 average OEE : 72.24%). Follow with performance rate % (Year 2017 : 72,71; year 2018: 77.29%) and Quality rate % (Year 2017 : 94.78% ; Year 2018 : 96,69%). Those increase due to the factory can reduce the reject product to 0 pairs in 2018
2. Main losses identified in 2017-March 2018 as: defect losses with total loss time for 116.2 hours and breakdown losses with total loss time for 53.17 hours.
3. From the new target stated based on the control chart target for decreasing the number of rework products is 2.6% or 46.93 pairs per day and B'Grade is 0.04% or 0.77 (rounded up 1) pairs per day.
4. By implementing the work program that has been prepared and achieving the targets. The factory can save costs by IDR. 56,586,860 per month, thereby increasing profits for the company.

➢ *SUGESTION*

The structure of the Total Productive Maintenance time utilization when assembling the sports shoe industry is still below the standard. There are elements of time utilization that have not been documented so that they do not accurately and fairly describe the state of the field. These time elements include idle time, startup time, performance loss time, and the still unclear difference in overhaul time, preventive maintenance, and team breakdown.

The factory needs to discipline their documentation record for elements of time utilization for more time reduction can be saved.

REFERENCES

[1]. Aisiyah, G., 2016. Pengaruh Technical Skill dan Kompensasi Non Finansial Terhadap Kinerja Karyawan Pabrik Sepatu Garsel Cibaduyut Bandung. Universitas Pendidikan Indonesia.

[2]. Heng, Z., Aiping, L., Liyun, X., & Moroni, G. (2019). Automatic estimate of OEE considering uncertainty. *Procedia CIRP*, 81, 630-635. https://doi.org/10.1016/ j.procir.2019.03.167

[3]. Halim, K., Setyawan, A., Halawa, M., & Hasibuan, S., (2019), Analysis causing and improvement defect bonding on soccer products in PT. PDK use design of experiment, *International Journal of Scientific & Engineering Research*, 10(6): 787-794.

[4]. Hermanto. (2016). Pengukuran Nilai Overall Equipment Effectiveness pada Divisi Painting di PT. AIM. *Jurnal Metris*, 17, 97-106.

[5]. Koip, J., & Control, W. Q. (2018). Peningkatan Nilai Overall Equipment Effectiveness (OEE) Mesin Injection Molding di Perusahaan Beverage Packaging. Operations Excellence 10(2), 152-163.

[6]. Nakajima, S. (1988). Introduction to TPM (Total Productive Maintenance). Cambridge: Productivity Press, Inc.

[7]. Nursanti, I. (2014). Analisis Perhitungan Overall Equipment Effectiveness (OEE) Pada Mesin Packing Untuk Meningkatkan Nilai Availability Mesin. *Jurnal Ilmiah Teknik Industri*, 96–102.

[8]. Oechsner, R., Pfeffer, M., Pfitzner, L., Binder, H., Müller, E., & Vonderstrass, T. (2002). From overall equipment efficiency (OEE) to overall Fab effectiveness (OFE). *Materials Science in Semiconductor Processing*, 5(4-5 SPEC.), 333-339. https://doi.org/10.1016/S1369-8001(03)00011-8

[9]. Pascal, V., Toufik, A., Manuel, A., Florent, D., & Frédéric, K. (2019). Improvement indicators for Total Productive Maintenance policy. *Control Engineering Practice*, 82, 86-96. https://doi.org/10.1016/ j.conengprac.2018.09.019

[10]. Relkar, A. S., & Nandurkar, K. N. (2012). Optimizing & analysing overall equipment effectiveness (OEE) through design of experiments (DOE). *Procedia Engineering*, 38, 2973–2980. https://doi.org/10.1016/ j.proeng.2012.06.347

[11]. Suliantoro, H., Susanto, N., Prastawa, H., Sihombing, I., & Mustikasari, A. (2017). Penerapan Metode Overall Equipment Effectiveness (OEE) dan Fault Tree Analysis (FTA) Untuk Mengukur Efektifitas Mesin Reng. *J@ti Undip: Jurnal Teknik Industri*, 12(2), 105-118. https://doi.org/10.14710/jati.12.2

[12]. Triwardani, D., Rahman, A., & Tantrika, C. (2012). Analisis Overall Equipment Effectiveness (OEE) dalam Meminimalisi Six Big Losses Pada Mesin Produksi Dual Filters DD07 (Studi Kasus: PT. Filtrona Indonesia, Surabaya, Jawa Timur. Jurusan Teknik Industri Universitas Brawijaya, 07, 379–391. Retrieved from https://media.neliti.com/media/ publications/127943-ID-analisis-overall-equipment-effectiveness.pdf

[13]. Wang, T. Y., & Pan, H. C. (2011). Improving the OEE and UPH data quality by Automated Data Collection for the semiconductor assembly industry. *Expert Systems with Applications*, 38(5), 5764–5773. https://doi.org/10.1016/j.eswa.2010.10.056