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Implementation and analysis of Overall Equipment Effectiveness (OEE) methodology in Tube Welding Machine Productivity at PT Denso Indonesia

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ABSTRACT

An automotive manufacturer is known PT Denso Indonesia. Due to the various losses that occurred in the Tube Welding Radiator Machine, PT Denso Indonesia saw a decline in the volume of production while creating its products. Evaluating the efficiency of the Tube Welding Radiator Machine production process is vital in order to identify and reduce any losses that may arise. This study's objectives are to assess the Tube Welding Machine's efficiency using the Overall Equipment Efficientness (OEE) method, compute the cost of six major losses, pinpoint their causes using Fishbone Analysis, offer suggestions for improvement, and then put those suggestions into practice to raise the Tube Welding Machine's efficiency. The average value of the measurement findings for the Tube Welding Radiator machine's Overall Equipment Efectiveness (OEE) value is 83.16 percent. Reduced speed losses resulting from the time lost during the production process account for the largest loss time when the six major losses are measured. Making jig centering material and converting regular water to RO water allowed for advancements. Additionally, businesses must quickly replace any parts on the tube welding radiator machine that are already irregular..

Key Words: Total Productive Maintenance (TPM), Performance Rate, Six Big Losses, Overall Equipment Effectiveness (OEE)

1. INTRODUCTION

One of the variables that reduces a machine's effectiveness is the amount of time lost on the machine. Downtime caused by machine failure is referred to as loss time.

PT Denso Indonesia (DNIA) is a company engaged in the automotive sector, namely motor vehicle spare parts. In producing a product, PT Denso Indonesia (DNIA) always prioritizes quality and customer satisfaction in each of its products. To achieve this, one of the efforts is by keeping every facility or production machine running smoothly through continuous maintenance. Based on the latest data in 2019, PT Denso Indonesia experienced many losses, including many machine breakdowns in almost all production lines, namely 1791 incidents. The line that suffered the most engine damage was the radiator line on the tube welding machine.

Based on the total production capacity in 2019, tube welding machines experienced a decrease in production capacity and did not reach the target. This shows that the performance of the machine is not optimal which causes the production target not to be achieved. In addition, the service life of this machine has reached 15 years. In Japan 7 years, in Thailand 5 years and in Indonesia only 3 years. And the age factor is also one of the causes of not achieving production capacity, due to the large amount of loss time that occurs in the machine and frequent machine breakdowns. Therefore, it is necessary to make improvements in terms of the machine so that it can operate better.

From the background above, the identification of the problems that will be discussed are as follows: How is the effectiveness level of the tube welding machine at PT Denso Indonesia at this time? How to increase the effectiveness of the tube welding machine at PT Denso Indonesia?

Based on this, the goal of this research is to calculate the Overall Equipment Effectiveness (OEE) value of the tube welding machine at PT Denso Indonesia and make recommendations to improve the machine's effectiveness.

In this study, the author set a problem limit so that the research does not expand and focuses directly on the problem. The limitations of the problem are as follows: this research only focuses on tube welding machines, data collection is carried out in the period January ~ December 2021.

2. LITERATURE SURVEY

2.1 Total Productive Maintenance (TPM)

TPM is a method of increasing the efficiency of a corporate facility. It is not only concerned with maintenance, but also with all areas of the facility's operation and installation, and it has the potential to motivate employees [1]. TPM is an innovative approach to maintenance that maximizes machine effectiveness, eliminates malfunctions, and allows machine operators to undertake self-maintenance[1], [2]. The goal is to boost output while also improving employee morale and job satisfaction (Nakajima, 1988). The main goal of TPM is zero breakdown and zero defects. If the damage can be eliminated, it can increase the operating level of the equipment, reduce costs, increase labor productivity, and reduce inventory. The implementation of this TPM can save considerable costs by increasing the productivity of the machine or equipment [3]. When in one production line there is one equipment/machine that has a breakdown, it will have an impact on the whole process. Machines always experience a breakdown from time to time and one of the goals of TPM is to eliminate breakdowns. [4]

2.2 Overall Equipment Effectiveness (OEE)

OEE is a metric expressed as a ratio of the actual output divided by the maximum output of the equipment employed under optimal performance conditions[1, 5]. Calculating OEE reveals that there are three significant components that influence machine effectiveness: machine availability, performance rate or production efficiency, and quality rate or engine output quality. Each factor has a separate global standard. The world standard for each variable is as follows: OEE > 80 % , Availability > 90 % , Performance rate > 95 % , Quality rate > 99 %[6, 7]

As per Nakajima (1988), OEE is defined as the ratio of actual output divided by the maximum output of the equipment under optimal performance conditions. The goal of OEE is to assess the efficiency of a maintenance system. This method can determine the availability of machines/equipment (availability), production efficiency (performance), and output quality of machines/equipment [8]. As a result, the relationship between the three productivity elements may be shown in the formula below.

$$\textbf{OEE} = \text{Avalability} \times \text{Performance} \times \text{Quality} \qquad (1)$$

Availability is the ratio between the amount of time a machine or piece of equipment is in use and the amount of time it takes to load. Then, here's how to figure out the availability:

$$\textbf{Availability} = \frac{\text{Operation Time}}{\text{Loading Time}} \times 100\% \qquad (2)$$

Performance is a way to measure how well a machine does its job in the production process. Ideal cycle time (standard time), processed amount (number of products processed), and operation time are all important parts of figuring out performance rate (machine processing time). Then, here's how to figure out how well it did:

$$\textbf{Performance Rate} = \frac{\text{Cycle Time} \times \text{Processed Amount}}{\text{Operation Time}} \times 100\% \qquad (3)$$

The quality rate is the proportion of processed products that are of high quality. Consequently, quality is the result of calculations involving processed quantity and defect quantity factors. This formula is extremely useful for identifying production process quality issues.

$$\textbf{Quality Rate} = \frac{\text{Process Amount} - \text{Defect Amount}}{\text{Processed Amount}} \times 100\% \qquad (4)$$

Six Big Losess, The production process has losses that affect its success; Nakajima (1988) grouped these losses into six major Downtime Losses[9]. If production output is zero and the system produces nothing, the unproductive time period is referred to as downtime losses. Losses due to downtime consist of:

1. Breakdown losses are incurred when equipment is damaged, cannot be used, and must be repaired or replaced. This loss is calculated based on how long it takes for the damage to be repaired.

$$\textbf{Equipment Failure Losses} = \frac{\text{Downtime}}{\text{Loading Time}} \times 100\% \qquad (5)$$

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2. Set-up and adjustment time, caused by changes in operating conditions such as the start of production or the start of different shifts, product changes, and changes in operating conditions. Equipment changes, mold changes, and jig changes are a few examples.

$$\textbf{Set Up and Adjustment Losses} = \frac{\text{Set Up Time}}{\text{Loading Time}} \times 100\% \qquad (6)$$

3. Idling and minor stoppages losses, are losses caused by equipment stopping due to temporary problems, such as engine halting, jamming, and engine idling.

$$\textbf{Idling and Minor Stoppages Losses} = \frac{\text{Non Productive Time}}{\text{Loading Time}} \times 100\% \quad (7)$$

4. Reduce speed losses, namely reducing the speed of production from the design speed of the equipment. Measurement of this loss by comparing the ideal capacity with the actual workload.

$$\textbf{Reduce Speed Losses} = \frac{\text{Operating Time} - (\text{Ideal Cycle Time} \times \text{Total Production})}{\text{Loading Time}} \times 100\% \qquad (8)$$

5. Rework and quality defects, these losses occur due to product defects during production. Products that do not meet specifications need to be reworked or scrapped. It takes manpower to carry out the rework process and the material converted into scrap is also a loss for the company.

$$\textbf{Defect Losses} = \frac{\text{Ideal Cycle Time} \times \text{Total Defect}}{\text{Loading Time}} \times 100\% \qquad (9)$$

6. Yield and scrap losses happen when raw materials are wasted. This loss is made up of two parts: raw material losses caused by how the product is designed and made, and adjustment losses caused by quality problems with the product at the start of production and when it is replaced.

$$\textbf{Scrap Losses} = \frac{\text{Ideal Cycle Time} \times \text{Scrap}}{\text{Loading Time}} \times 100\% \qquad (10)$$

3. OBJECTIVE OF THE STUDY

Based on the background and problem formulation discussed previously, the main objective of this study was to quantify the amount of time needed to carry out an automatic model changeover that was accompanied by a jig changeover and a machine reset and required enough time to produce a number of product units. The factors affecting the productivity of the XZ product production process can be determined by calculating the time needed for the change. The company anticipated more suggestions and solutions to boost productivity consistently and significantly because it understood the factors that affect it.

4. RESEARCH METHODOLOGY

The research method starts from the company survey, problem formulation, research objectives and then continues with data collection and processing. Ends with analysis, implementing improvement ideas, conclusions and suggestions. The data taken are primary data and secondary data. Primary data is obtained from a direct survey on the machine to be studied and interviews with production and maintenance staff. While secondary data obtained from the record of damage and history of the machine. The following is a flow chart of the research steps.

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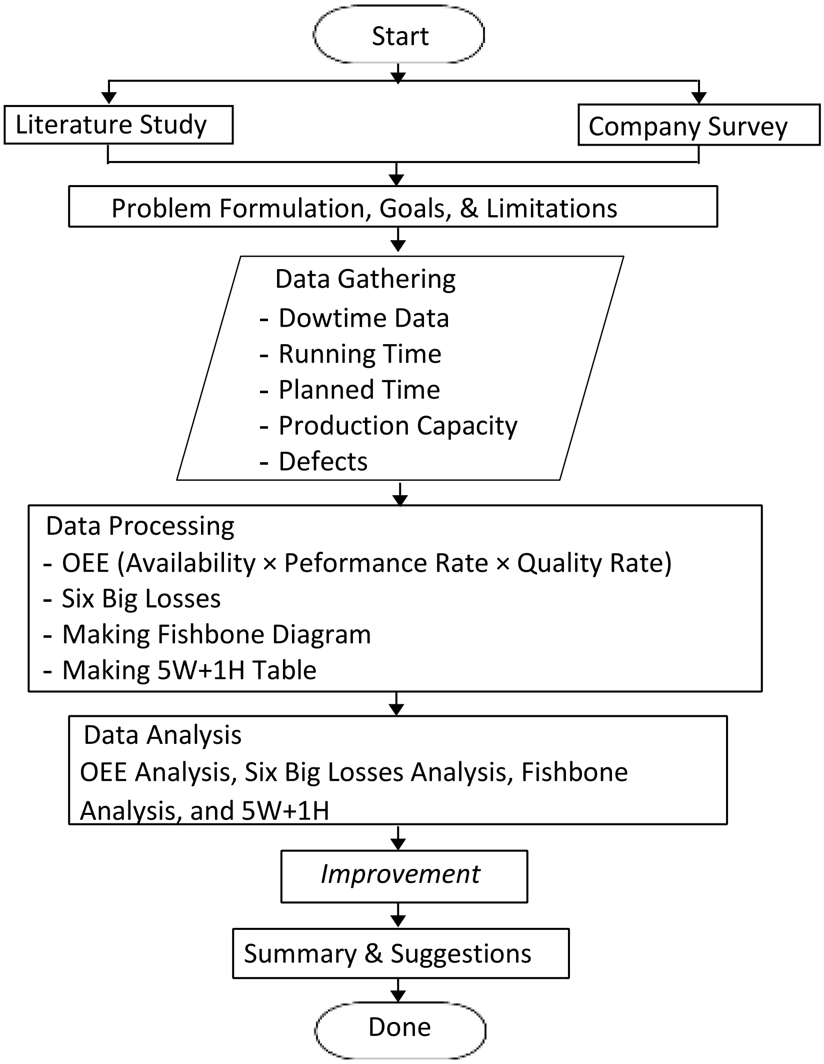

Figure 1 Research Stages

5. RESULT AND DISCUSSION

5.1 Availability Rate Calculation

Based on the formula to calculate the availability value, supporting data such as loading time and operation time values are required. The following is the data loading time and operation time of the tube welding machine.

Table 1. Tube Welding Machine Data Loading Time

No.	Month	Total Days	Running Time (minutes)	Planned Downtime (minutes)	Loading Time (minutes)
1	January	22	21120	3740	17380
2	February	20	19200	3400	15800
3	March	21	20160	3570	16590
4	April	21	20160	3570	16590
5	May	21	20160	3570	16590

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6	June	12	11520	2040	9480
7	July	22	21120	3740	17380
8	August	19	18240	3230	15010
9	September	22	21120	3740	17380
10	October	21	20160	3570	16590
11	November	21	20160	3570	16590
12	December	21	20160	3570	16590

Table 2. Tube Welding Machine Operation Time Data

No.	Month	Total Days	Loading Time (minutes)	Downtime (minutes)	Operation Time (minutes)
1	January	22	17380	745	16635
2	February	20	15800	524	15276
3	March	21	16590	671	15919
4	April	21	16590	590	16000
5	May	21	16590	620	15970
6	June	12	9480	389	9091
7	July	22	17380	564	16816
8	August	19	15010	335	14675
9	September	22	17380	576	16804
10	October	21	16590	589	16001
11	November	21	16590	605	15985
12	December	21	16590	567	16023

After the loading time and operation time values are obtained, then the next step is to calculate the availability rate value . For the calculation of the availability rate value will be presented in the following table:

Table 3. Availability Rate Value

No.	Month	Total Days	Operation Time (minutes)	Loading Time (minutes)	Availability Rate
1	January	22	16635	17380	95,71%
2	February	20	15276	15800	96,68%
3	March	21	15919	16590	95,96%
4	April	21	16000	16590	96,44%
5	May	21	15970	16590	96,26%
6	June	12	9091	9480	95,90%
7	July	22	16816	17380	96,75%
8	August	19	14675	15010	97,77%
9	September	22	16804	17380	96,69%
10	October	21	16001	16590	96,45%
11	November	21	15985	16590	96,35%
12	December	21	16023	16590	96,58%

5.2 Performance Rate Calculation

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Based on the previous formula to calculate the performance rate value, supporting data are needed such as production capacity, cycle time per one product in minutes, and operation time.

For the calculation of the performance rate value will be presented in the following table:

Table 4. Performance Rate Value

No.	Month	Total Days	Production Capacity (×100.000)	Operation Time (minutes)	Performance Rate
1	January	22	324	16635	97,39%
2	February	20	317	15276	103,76%
3	March	21	237	15919	74,44%
4	April	21	301	16000	94,06%
5	May	21	298	15970	93,30%
6	June	12	169	9091	92,95%
7	July	22	330	16816	98,12%
8	August	19	260	14675	88,59%
9	September	22	220	16804	65,46%
10	October	21	267	16001	83,43%
11	November	21	271	15985	84,77%
12	December	21	260	16023	81,13%

5.3 QUALITY RATE CALCULATION

The data used to calculate the value of the quality rate are data on the total amount of production per month and data on defective products. The calculation of the quality rate value will be presented in the following table:

Table 5. Quality Rate Value

No.	Month	Total Production (×100.000)	Defect (×100.000)	Production Capacity (×100.000)	Quality Rate
1	January	336	12	324	96,43%
2	February	319	2	317	99,37%
3	March	241	4	237	98,34%
4	April	316	15	301	95,25%
5	May	309	11	298	96,44%
6	June	172	3	169	98,26%
7	July	333	3	330	99,10%
8	August	266	6	260	97,74%
9	September	223	3	220	98,65%
10	October	271	4	267	98,52%
11	November	274	3	271	98,91%
12	December	267	7	260	97,38%

5.4 OVERALL EQUIPMENT EFFECTIVENESS (OEE) CALCULATION

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After calculating the data availability rate, performance rate, and quality rate, then calculate the value of Overall Equipment Effectiveness (OEE) will be presented in the table as follows:

Table 6. Overall Equipment Efectiveness Value

No.	Month	Availability Rate	Performance Rate	Quality Rate	OEE
1	January	95,71%	97,39%	96,43%	89,88%
2	February	96,68%	103,76%	99,37%	99,69%
3	March	95,96%	74,44%	98,34%	70,24%
4	April	96,44%	94,06%	95,25%	86,41%
5	May	96,26%	93,30%	96,44%	86,62%
6	June	95,90%	92,95%	98,26%	87,58%
7	July	96,75%	98,12%	99,10%	94,08%
8	August	97,77%	88,59%	97,74%	84,66%
9	September	96,69%	65,46%	98,65%	62,44%
10	October	96,45%	83,43%	98,52%	79,28%
11	November	96,35%	84,77%	98,91%	80,78%
12	December	96,58%	81,13%	97,38%	76,31%
				Average	83,16%

The standard OEE value that can be used as a target is 85%. In February, the highest OEE value was 99.69%. What causes high OEE values? If we look at the performance rate in February, it exceeded the predetermined target of 103.76%. This shows that in February the performance of the tube welding machine has exceeded the predetermined target and the loss time is less than in other months. This is because in the last week of January, preventive maintenance was carried out on the tube welding machine by the maintenance department. So that there is less downtime and less engine damage.

However, in other months, they still found a low OEE value, namely in September with a value of 62.44%. What caused the low OEE value in September? When viewed, the value of the performance rate in September was lower than other months, namely 65.46%. And judging from the loss time that occurred in September as many as 5804 minutes or 33.39%. This shows that the amount of loss time that occurs affects the OEE value in September.

Based on the monthly average, the OEE value of the tube welding machine is 83.16%. Thus, this value has not yet reached the target of 85%. Therefore, it is necessary to make improvements to increase the effectiveness of the tube welding machine in order to achieve the target. One way is to reduce the loss time that occurs on the machine.

5.5 SIX BIG LOSSES CALCULATION

There are 5 losses that occur in the tube welding machine. The losses are:

1. Equipment Failure Losses
2. Set Up and Adjusment Losses
3. Reduced Speed Losses
4. Iddling and Minor Stopages Losses, and
5. Quality Defect/ Scrap.

There are no rework losses because all defective products will be scrapped immediately and cannot be repaired. The following are the results of the calculation of the six big losses that have been carried out:

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Table 7. Six Big Losses Calculation

Losses	Total Loss Time (minutes)	Percentage	Cumulative
Reduced Speed Losses	22495	65%	65%
Equipment Failure Losess	6775	20%	85%
Quality Defect (Scrap)	3650	10%	95%
Set Up and Adjusment Losses	1215	4%	99%
Iddling and Minor Stoppages Losses	209	1%	100%

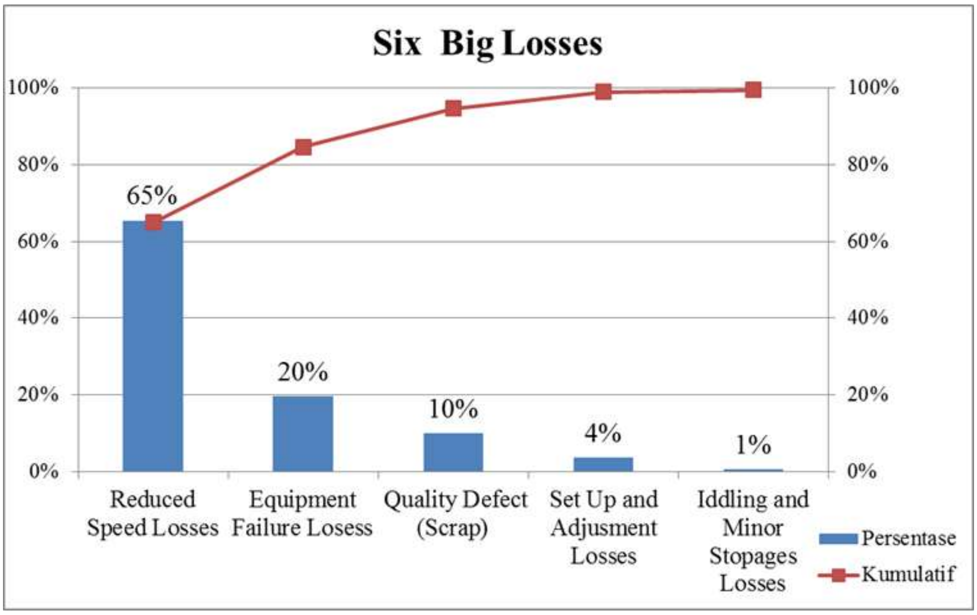

Figure 2. Cumulative Six Big Losses Calculation

Based on the data above, the highest losses are Reduced Speed Losses and Equipment Failure Loses. Where this loss has the most amount of time if it is accumulated for one year, respectively as much as 22495 minutes or 60% and 6775 minutes or 20%. This loss is the loss that has the most impact on the performance of the tube welding machine which makes the production target not achieved and makes the OEE value low.

5.6 Fishbone Diagram Analysis

In the calculation of the six big losses, the very high and most impactful loss that causes the low OEE value is reduced speed losses. To find out the cause of this problem, it is necessary to do further analysis using the fishbone diagram method. The fishbone diagram method identifies problems in 6 categories, namely man (human), machine, material, method, measurement (inspection), and environment. After the analysis, there are 4 categories that affect the high loss that occurs, namely the category of machines, materials, methods and the environment. The following is a fishbone diagram for the problem of high loss, which the author has made together with production members and maintenance members.

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Fig 3. Fishbone Diagram

Based on the picture above, it shows that the factors that affect the high loss that occur are:

1. Machine, there is often a breakdown machine (BM) on tube welding machines due to the large number of worn parts that must be replaced immediately, such as rollers, shafts, bearings, etc. Therefore, it is necessary to change parts and check accuracy periodically on tube welding machines.
2. Method, the length of the material joining process is due to the absence of a jig to straighten the material so that it can be spliced properly. The length of the splicing process is also due to the difficulty of straightening the material before being spliced. Therefore, it is necessary to have a jig to straighten the material to be joined.
3. Material, the amount of NG loss that occurs is due to the large number of burries or remaining pieces in the row material. This causes the material formation process to be imperfect during the welding process and the product becomes NG and is scraped.
4. Environment, what causes the high loss is the length of the cleaning roller process due to the large amount of dirt attached to the roller. If the roller is not clean it will produce defective products, so the cleaning process must be carried out properly. With the roller cooling water quality that is not good, it causes the roller to get dirty quickly, so it is necessary to clean the roller every time. What causes the quality of the roller cooling water is not good because there is no filtering process to reduce the content of substances mixed with the roller cooling water. Therefore, it is necessary to have a filtering process to remove substances contained in the roller cooling water.

5.7 Six Big Loss Analysis Using 5W+1H

After analyzing based on the fishbone diagram, from the factors that cause the high loss that occurs, the author will try to analyze the problems that occur using the 5W + 1H method. It is hoped that the results of this analysis can reduce the loss and also increase the OEE value. Here is a six big loss analysis using 5W+1H:

Table 8. Six Big Loss analysis using 5W+1H

Factor	***Root Cause***	***Why*** Why is it necessary to be repaired?	***What*** What is the repair plan?	***Where*** Where is the repair done?	***When*** When is the repair going to be done?	***Who*** Who is the repair PIC?	***How*** How to repair?
Material	Uneven material cutting process	Material formation is not perfect during the welding process	Discussion with suppliers for fix the burry arise in raw material	Maker	Apr-19	Production Engineering (PE)	Supplier checks cutting machine and changes cutter regularly

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Machine	Abnormal parts	To reduce losses that occur due to engine breakdown due to abnormal parts	Replacing abnormal parts	Tube Welding Radiator Machine	Apr-19	Maintenance Dept.	Make schedule to change abnormal parts
Method	There's no jig to make material aligned	To make it easier for the operator when splicing material	Make jigs to help operator in the process of material splicing	Tube Welding Radiator Machine	Apr-19	Maintenance Dept.	Designing drawing for jig
Environment	There's no filter process	To reduce dirt that occurs on the roller caused by bad coolant water quality	Replacing mineral water with RO water	Tube Welding Radiator Machine	Apr-19	Maintenance Dept.	Replacing mineral water with water RO, by taking from the process in the company

From the analysis above, improvements to be made are on the method and environmental factors. Where on the method factor, improvements will be made in the form of making a parallel jig and on the environmental factor the improvements made are replacing ordinary water into RO water. Meanwhile, on the other factor, namely the material factor, the Production Engineering department will discuss with the material maker so that it can be better and on the engine factor it is necessary to wait for the parts that must be ordered first and then schedule the replacement of parts.

5.8 Discussion of Improvement Results

From the improvements that have been made, there are several advantages, namely:

1. The material splicing cycle time can be as much as 2 minutes (5 minutes – 3 minutes) due to the addition of the material alignment jig.
2. The cycle time of the cleaning roller is faster, which is 18 minutes (30 minutes – 12 minutes) due to the change of ordinary mineral water into RO water (pure water).

So the total time that can be reduced is:

18 minutes + 2 minutes = 20 minutes/shift
2 shifts × 20 minutes × 22 days = 880 minutes/month
880 minutes × 12 months = 10560 minutes/year
If it is simulated and calculated with loss time (reduced speed loss), then the loss time that occurs becomes:

Reduced Speed Loss = 22495 – 10560 = 11935 minutes

This shows that the improvement results can reduce loss time (reduced speed loss) as much as 53%. When depicted with a graph, the calculation of the improvement results will be as follows:

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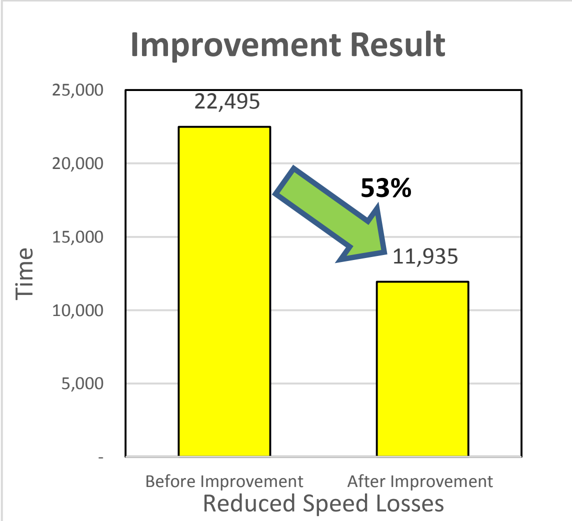

Fig 4. Simulation of Results Improvement Calculation

6. CONCLUSION

Overall Equipment Effectiveness (OEE) calculation results on tube welding machines have an average of 83.16%. This value has not reached the target of 85%, so it is necessary to make improvements in order to achieve the target. To increase the effectiveness of the tube welding machine, it must decrease the loss that occurs in the machine. Based on the calculation of the six big losses, the highest loss is reduced speed loss. To reduce this loss, improvements were made to the material joining process, namely by making parallel jigs to facilitate the material splicing process so that the splicing process time can be faster and replacing mineral water with RO water (pure water) so that the rollers are not easily dirty and reduce the cleaning roller process. From this improvement, it can reduce the loss on reduced speed loss by 53%.

From the results of the fishbone diagram analysis, in terms of machinery, there are many abnormal parts and must be replaced immediately, so that the performance of the tube welding machine can be maintained, accuracy checks must be carried out regularly and consistently to find out early damage that will occur and prevent engine damage occurs.

REFERENCES

[1] N. E. Triana and U. Amrina, "Menghitung Efektifitas Mesin Laser Cutting Menggunakan Metode Overall Equipment Effectiveness," *Jurnal Penelitian dan Aplikasi Sistem & Teknik Industri (PASTI)* , vol. XIII, no. 2, pp. 212–222, 2019, Accessed: Feb. 10, 2022. [Online]. Available: https://www.neliti.com/publications/328406/menghitung-efektifitas-mesin-laser-cutting-menggunakan-metode-overall-equipment

[2] H. A. Prabowo and M. Agustiani, "Evaluasi Penerapan Total Productive Maintenance (TPM) Melalui Pendekatan Overall Equipment Effectiveness (OEE) Untuk Meningkatkan Kinerja Mesin High Speed Wrapping di PT. TES," *Jurnal Penelitian dan Aplikasi Sistem & Teknik Industri (PASTI)* , vol. XII, no. 1, pp. 50–62, 2017, Accessed: Feb. 10, 2022. [Online]. Available: http://digilib.mercubuana.ac.id/manager/t!@file_artikel_abstrak/Isi_Artikel_433974277977.pdf

[3] T. Haddad, B. W. Shaheen, and I. Németh, "Improving Overall Equipment Effectiveness (OEE) of Extrusion Machine Using Lean Manufacturing Approach," *Manufacturing Technology*, vol. 21, no. 1, pp. 56–64, 2021, doi: 10.21062/mft.2021.006.

[4] H. A. Prabowo, Farida, and D. I. Rahmawan, "Improve The Work Effectiveness With Overall Equipment Effectiveness (OEE) As The Basis For Optimizing Production," *Jurnal Penelitian dan Aplikasi Sistem & Teknik Industri (PASTI)* , vol. IX, no. 3, pp. 286–299, 2015.

[5] A. Arifianto, "Penerapan Total Productive Maintenance (TPM) Dengan Menggunakan Metode Overall Equipment Effectiveness (OEE)," 2018. Accessed: Nov. 10, 2021. [Online]. Available: https://dspace.uii.ac.id/bitstream/handle/123456789/5496/Tugas%20Akhir_Asyrof%20Arifianto%2013522162.pdf?sequence=1&isAllowed=y

[6] E. Rimawan and A. Raif, "Analisis Pengukuran Nilai Overall Equipment Effectiveness (OEE) pada Proses Packaging di Line 2 (Studi Kasus PT. Multi Bintang Indonesia. Tbk)," *SINERGI*, vol. 20, no. 2, pp. 140–148, 2016, Accessed: Feb. 10,

DOI : 10.31695/IJERAT.2022.8.8.4

2022. [Online]. Available: https://sinergi.mercubuana.ac.id/publications/165544/analisis-pengukuran-nilai-overall-equipment-effectiveness-oee-pada-proses-packag

[7] A. Rahman and S. Perdana, “Analisis Produktivitas Mesin Percetakan Perfect Binding Dengan Metode OEE Dan FMEA,” *Jurnal Ilmiah Teknik Industri*, vol. 7, no. 1, pp. 34–42, 2019, Accessed: Feb. 10, 2022. [Online]. Available: http://journal.untar.ac.id/index.php/industri/article/view/5034

[8] D. S. Kuncahyo, “Pendekatan Penerapan Total Productive Maintenance (TPM) Di Stasiun Press Palm Oil Pada Mesin Digester Dan Mesin Press PT. Bangkitgiat Usaha Mandiri Dengan Menggunakan Indikator OEE Dan Metode FMECA (Failure Mode Effect And Critical Analysis),” *Jurnal Penelitian dan Aplikasi Sistem & Teknik Industri (PASTI)* , vol. VIII, no. 3, pp. 436–450, 2014.

[9] N. C. Dewi and D. I. Rinawati, “Analisis Penerapan Total Productive Maintenance (TPM) dengan Perhitungan Overall Equipment Efectiveness (OEE) dan Six Big Losses Mesin Cavitec PT Essentra Surabaya (Studi Kasus PT Essentra),” *Industrial Engineering Online Journal, E-Journal UNDIP*, vol. 4, no. 4, pp. 21–26, 2016, Accessed: Dec. 10, 2021. [Online]. Available: https://ejournal3.undip.ac.id/index.php/ieoj/article/view/9868

DOI : 10.31695/IJERAT.2022.8.8.4