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Increasing Overall Equipment Effectiveness on 650T Injection Machines with a Lean Manufacturing Approach

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Abstract

At the end of April 2024, national car sales for the domestic market were recorded to have decreased by 34.91% compared to the previous month. This negative trend, of course, disrupts company profits, including PT XYZ as a supplier of automotive components in Indonesia. This decline triggered the company to carry out cost reduction activities in the production area. However, in reality there is still a lot of waste during production, one of which is in the 650T injection molding process. The high cycle time of the injection process resulted in the Overall Equipment Effectiveness (OEE) target not being achieved. The lean manufacturing approach and DMAIC cycle as a research method aims to identify non-value added activities as well as make improvements by reducing the injection process cycle time from 86 to 57 seconds. These improvements made the OEE target for the 650T injection machine achieved because it increased from 67.9% to 76.3%.

Keywords: OEE, Injection Machine, Lean Manufacturing, DMAIC Cycle.

1. Introduction

Based on the report from the Association of Indonesian Automotive Industries (Gaikindo) in figure 1 below, car sales in April 2024 from factories to dealers (wholesales) in the Indonesian domestic market decreased by 34.91%. Sales in April decreased to 26.087 units, because previously they managed to sell 74.724 units, but in the following month they decreased to 48.637 units. This negative trend of course disrupts the cash flow or profits of automotive companies in Indonesia, including PT XYZ The decline in consumer enthusiasm for four-wheeled vehicles has increasingly made company owners look for various ways to reduce production costs in the company.

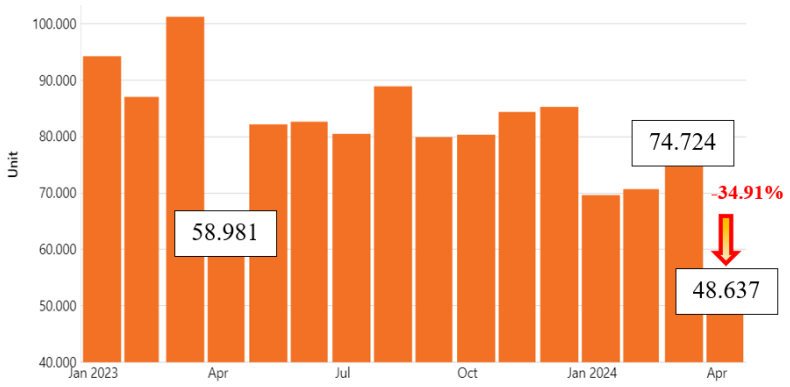

Figure 1. Domestic National Car Sales (2023-2024)

One concept to reduce manufacturing costs is to carry out cost reduction activities. The most fundamental method for carrying out cost reduction in the manufacturing industry is to eliminate any waste that occurs in every production line, including in the production process of the 650T injection machine at PT XYZ. Too much waste in the production process indicates that the process is still far from the lean manufacturing concept. Lean manufacturing is a structured method used by companies to recognize levels of waste with the aim of eliminating or eliminating activities that do not provide added value [1]. Lean manufacturing is an approach that can be applied to improve waste in a company, thereby reducing production waiting time [2]. The lean manufacturing

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approach includes a comprehensive understanding of business processes, including production processes, material flow, and information flow [3].
The method for minimizing waste is to apply the lean manufacturing concept [4]. Seeing the importance of the lean concept above, it requires PT XYZ to do the same thing. The lean concept is also called an efficiency concept that can be applied to manufacturing and service companies [5]. The lean manufacturing concept approach in this research aims to identify non-value added activities as well as determine the types of improvements that can be made so that the OEE value increases on the 650T injection machine at PT XYZ. OEE is an important efficiency indicator and is easy to apply to machines or equipment [6]. OEE discusses six major losses on machines that can be avoided such as breakdowns, setup time, waiting time, speed reduction, startup defects and rework [7]. The OEE calculation aims to determine the level of machine effectiveness [8]. OEE is defined as a tool for assessing equipment effectiveness with the aim of identifying production losses as well as indirect cost losses that contribute significantly to total production costs [9].

2. Research Methods

Overall Equipment Effectiveness is a hierarchical matrix discovered by Seiichi Nakajima in 1960, this matrix can evaluate and indicate how effective a machine or equipment is. In this case, what is said to be effective is a process that only produces good output in the shortest possible time without any downtime. OEE has become a tool for measuring and evaluating productivity. Overall Equipment Effectiveness includes three main components, namely Availability, Performance, and Quality [10].

Availability

Availability is the actual comparison of operating time with loading time. Availability is the capacity of an item to carry out the desired function every time it is needed [11].

$$\text{Availability} = \frac{\text{Operation time}}{\text{Loading time}} \text{ x } 100\% \quad (1)$$

Performance

Performance is the ratio of the quantity of product produced multiplied by the ideal cycle time to the available time (operating time). Performance is the productivity that can be achieved by superior or standard products in each hour compared to the designed productivity [12]. The product quantity ratio in question is the sum of products that are feasible or meet quality standards and products that have undergone rework and NG (No Good) products. Below is the formula for finding the performance value.

$$\text{Performance} = \frac{(\text{OK} + \text{Rework} + \text{NG}) \text{ x ideal CT}}{\text{Operating time}} \text{ x } 100\% \quad (2)$$

Quality

Quality is the ability of a machine to produce products to meet production targets. Quality is the result of a comparison between the number of OK products or according to the criteria of Quality Control (QC) with the actual total press. Total actual press is the sum of viable products, products that have undergone rework and NG (No Good) products. The data used in this Quality calculation includes actual production results, the number of products that meet specifications (good products), as well as the total of products that are delayed and rejected [13]. Mathematically it can be formulated as follows:

$$\text{Quality} = \frac{\text{Produk OK}}{\text{OK} + \text{Rework} + \text{NG}} \text{ x } 100\% \quad (3)$$

Meanwhile, Overall Equipment Effectiveness (OEE) is the product of the Availability, Performance and Quality values of a machine or production equipment. Equipment effectiveness is the actual output compared to the reference output [14]. The calculation formula is as follows:

OEE = Availability x Performance x Quality (4)

This research uses the DMAIC (Define, Measure, Analyze, Improve, Control) cycle. The flow chart for this research is listed as in Figure 2 below.

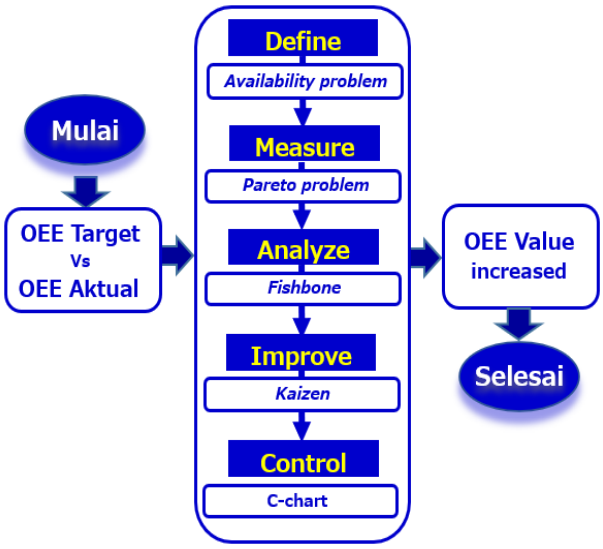


Figure 2. Research flow chart

The research flow starts from the Define phase, namely defining the OEE (Overall Equipment Effectiveness) factors consisting of (Availability, Performance and Quality) which most dominantly influence low OEE values. The second phase is Measure, namely measuring the downtime that occurs and creating a Pareto problem diagram. The data was then analyzed using a fishbone diagram to get the real root cause which caused the decrease in the OEE value of the 650T injection machine. This process is carried out in the Analyze phase, and the root cause of the problem is corrected by creating kaizen ideas in the Improve phase. The final phase is Control, namely controlling the OEE value that has been improved so that it continues to achieve the company's KPI (Key Performance Indicator) target and approaches the World Class Manufacturing target.

Injection Molding

Injection Molding Machine is a machine that is used to produce molded plastic parts by inserting melted plastic material into the mold cavity at very high pressure. A plastic injection machine is a device that produces products from various types of plastic materials (resins) which are heated and processed through various stages [15]. Plastic molds in the injection molding process need to pay attention to a number of parameters that can affect the quality of the final product so that defects do not occur. These parameters include injection temperature, pressure and injection time [16].

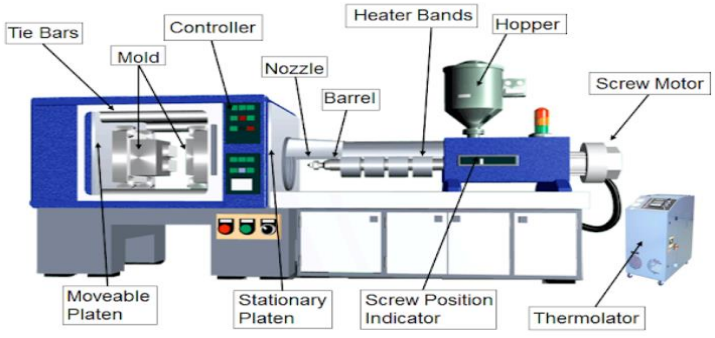


Figure 3. Injection molding machine components

3. Results and Discussion

3.1. Define

This define phase begins by identifying initial data on the OEE value of the 650T injection machine and comparing it with the company's target. The output of this phase is that the gap between the current OEE factor achievements, namely Availability, Performance and Quality, and the company's targets can be defined. The OEE gap factor then becomes the main focus in carrying out the improvement process. Based on production data

for the 650T injection machine for the period September to November 2023, you can see each factor's OEE value as in table 1 below.

Table 1. Value and comparison of OEE factors (before improvement)

Factors	OEE (Before improvement)	OEE Company Target	OEE World Class Manufacturing
Availability	85.20%	85%	90%
Performance	**81.20%**	90%	95%
Quality	98.10%	98%	99%
OEE	67.90%	75%	85%

By looking at the comparison in table 1 above, it can be defined that performance is a priority factor for improvement for PT XYZ. By increasing the performance value, the Overall Equipment Effectiveness (OEE) target will be achieved, as well as the productivity of the 650T injection machine will increase.

3.2. Measure

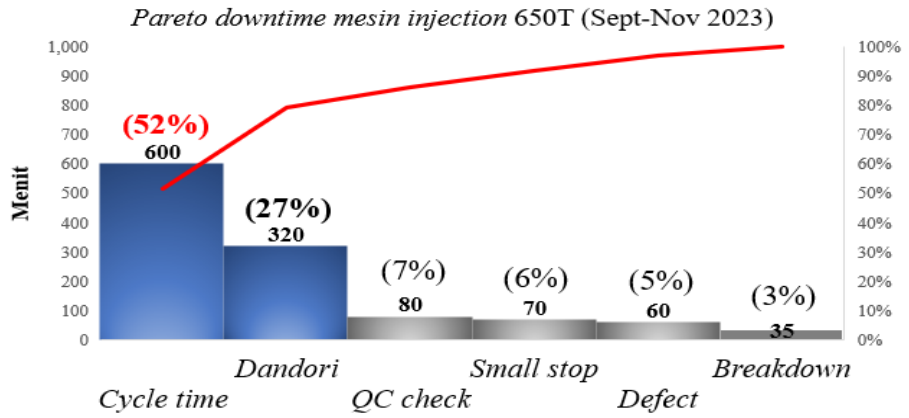


Figure 4. Pareto diagram of 650T injection machine downtime

Based on the Pareto diagram above, it can be concluded that the highest downtime of this 650T injection machine is cycle time with a percentage of 52%. The next phase is to carry out analysis of the very high downtime cycle time data, so that the root cause can be clearly identified.

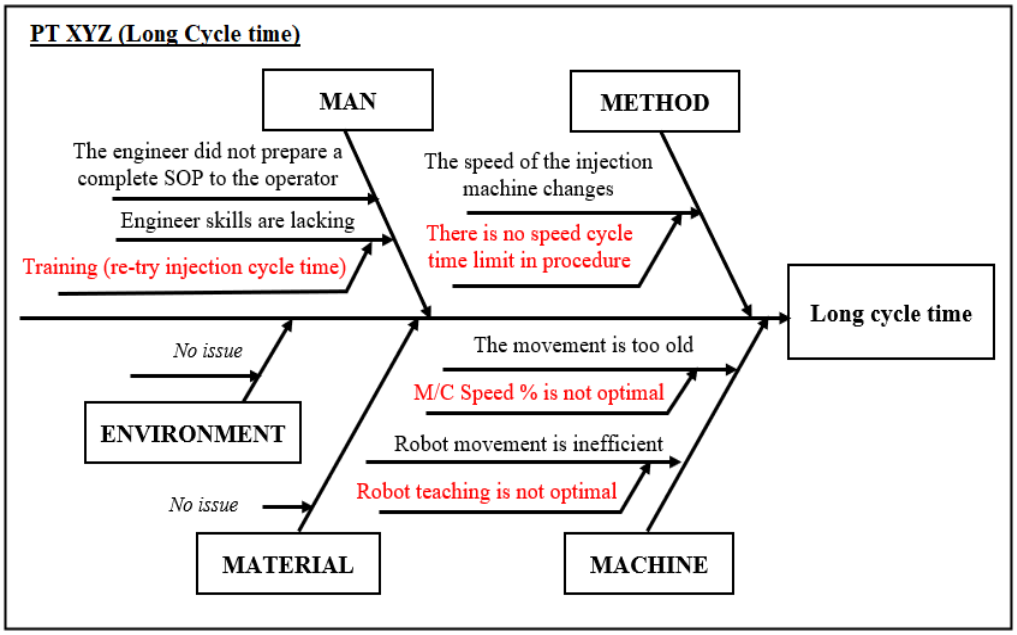


Figure 5. Fishbone diagram of long cycle time

3.3. Analyze

At this analysis stage, an FGD (Forum Group Discussion) is formed which will analyze, investigate, find the root cause, and make improvements (kaizen) so that productivity and OEE value increase. The steps in this analysis stage are as follows:

a. Carrying out a genba (on the spot study) to see directly the production process on the PT XYZ 650T injection machine.
b. Team discussions to obtain input and suggestions from the results of field studies.

At this stage, analysis is carried out using cause and effect diagrams. The purpose of making a cause and effect diagram is to find the root of the problem related to the OEE value [17]. Fishbone diagram analysis will be carried out by focusing machine problem variables into four categories, namely humans, machines, materials and methods [18]. The following are the results of the cause and effect diagram for the root cause of the long cycle time on the 650T injection machine at PT XYZ. Based on the fishbone diagram in Figure 5 above, what causes the long cycle time on the 650T injection machine at PT XYZ then from the machine side, currently the speed of the injection machine has not reached its optimal point, nor has the function of the robot on the machine. This means that there is still a fairly high chance that the machine's speed can be increased as optimally as possible. The current actual engine capacity must of course be proven directly through re-try injection cycle time activities with the PT XYZ engineering department.

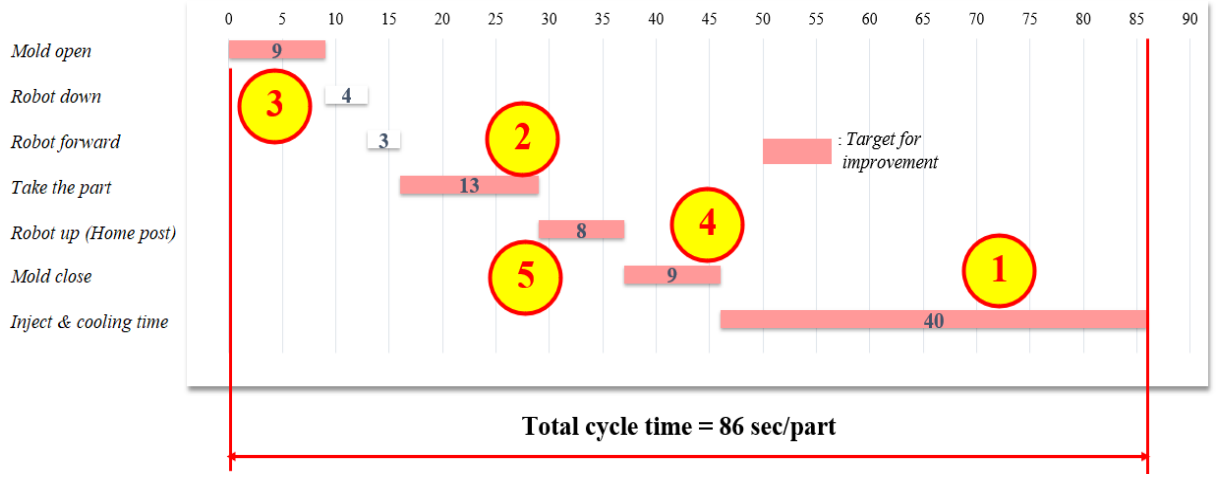


Figure 6. Breakdown cycle time of injection machine (before improvement)

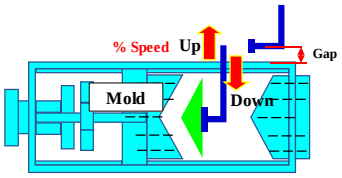
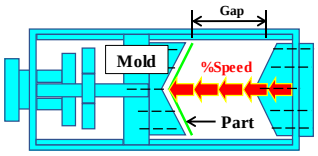
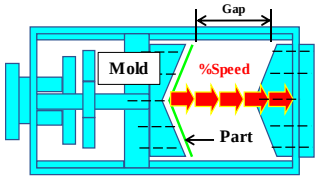
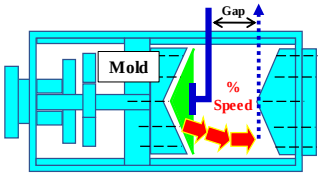
Based on the genba (on the spot study) of the 650T injection machine production line, there are still many cycle time movements for each process that can still be reduced. These include: during injection and cooling time, part pickup, mold open and close, and robot up (home post). The data in Figure 6 shows that the total cycle time is currently still high, namely above 86 seconds/part or 1 minute 26 seconds.

3.4. Improve

Furthermore, to increase the performance factor or in general the overall equipment effectiveness value of the 650T injection machine, an action plan is needed to improve it. Table 2 below is the result of discussions with the Forum Group Discussion (FGD) team regarding improvements that will be made to reduce the cycle time on the 650T injection machine. By making improvements to the 650T injection machine above, the injection process cycle time tends to be faster. The measurement results can be seen in Figure 7 below. After all kaizen is applied, the six big losses in the form of a cycle time which is quite long and is the root cause of not achieving the OEE target at PT XYZ can be resolved [19]. Apart from the problem of a fairly long cycle time, currently there are actually still losses in the form of high change over times (moving molds for the next product). Regarding mold change over, it can be completed using the SMED (Single Minute Exchange Dies) method. This SMED method has been proven to reduce changer over time in the automotive and non-automotive industries by up to 18% [20]. Furthermore, after all improvements have been applied to the 650T injection machine at PT XYZ, the overall equipment effectiveness (OEE) calculation of the 650T injection machine will be carried out

again. After carrying out calculations for each OEE factor, namely Availability, Quality and Performance, the results are obtained in table 3 below.

Table 2. List of improvements to increase the OEE value

No	Downtime	Cause	Illustration	Improvement
1	Inject and cooling time	Setting the cooling cycle time does not take into account the dimensions and plastic material		**Reduce cooling time 5~10%** (utilized software estimator & confirmed by actual try)
2	Picking up parts	The robot arm distance does not consider the mold width		**1. Reduce Gap arm robot and mesin** **2. Robot speed up 10~30%**
3	Open mold	The robot arm distance does not consider the mold width		**1. Reduce opening mold gap** **2. Open mold speed up 10~30%**
4	Close mold	The robot arm distance does not consider the mold width		**1. Reduce opening mold gap** **2. Close mold speed up 10~30%**
5	Robot up (home post)	The robot arm distance does not consider the mold height		**1. Reduce gap arm robot and mold** **2. Robot speed up 10~30%**

Based on the kaizen carried out above, the FGD team carried out cycle time measurements again. The following are the results of measuring the cycle time of the 650T injection machine at PTXYZ (after improvement).

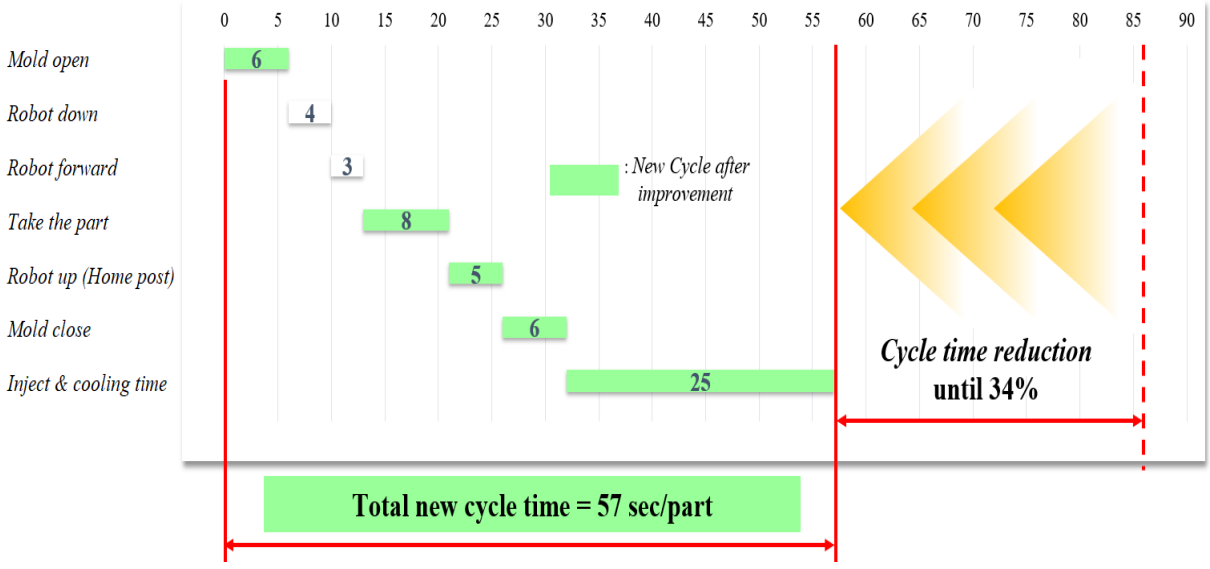


Figure 7. Breakdown cycle time of injection machine (after improvement)

Table 3. Value and comparison of OEE factors (before improvement)

Factors	OEE (After improvement)	OEE Company Target	OEE World Class Manufacturing
Availability	85.50%	85%	90%
Performance	**91.00%**	90%	95%
Quality	98.10%	98%	99%
OEE	76.30%	75%	85%

By looking at table 3 above, and comparing it with the data before improvement (table 1), it can be concluded that the OEE value increased from 67.9% to 76.3%. The high OEE value was due to the increase in performance value from previously 81.2% to 91.0%. By increasing the Overall Equipment Effectiveness (OEE) value, it will also increase the productivity of the 650T injection machine at PT XYZ.

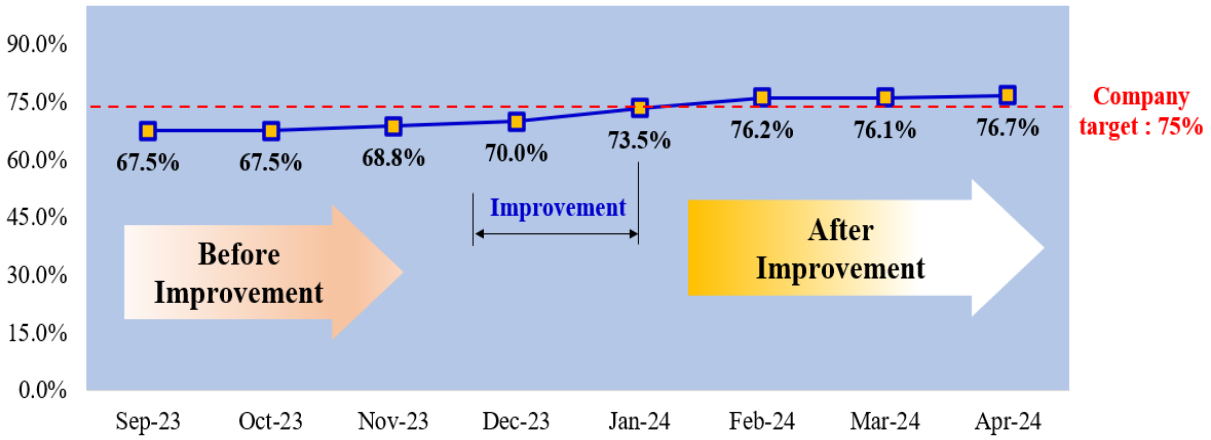


Figure 8. OEE control chart before and after improvement

3.5. Control

Determining the control plan and next improvement items is the goal of this phase. After improvement activities are carried out, waste in the production process on the 650T injection machine is reduced and approaches the concept of lean manufacturing. The next step is to maintain these results and strive to improve the results that have been achieved to be better than before. Figure 8 above is a control chart of OEE values carried out by PT XYZ. Even though currently the 650T injection machine at PT This, of course, can also be an opportunity to continue to increase the OEE value so that it is equivalent to an OEE value of 85% (World Class Manufacturing).

4. Conclusion

There are three factors that are the main cause of the low OEE value of the 650T injection machine at PT XYZ The data in Figure 6 shows that the total cycle time before repair is still high, namely above 86 seconds/part or 1 minute 26 seconds. The improvement process using the DMAIC cycle as a frame work has been proven to be able to increase the performance value and also the OEE value from an average of 67.9% to 76.3%.

References

[1] M. S. N. Afif and S. Sudarto, "Penerapan Konsep Lean untuk Meningkatkan Operasi Warehouse di Industri Manufaktur," *Oper. Excell. J. Appl. Ind. Eng.*, vol. 14, no. 1, p. 57, 2022, doi: 10.22441/oe.2022.v14.i1.043.

[2] H. H. Purba and E. Paulina, "Overall Equipment Effectiveness to Increase Productivity of Injection Molding Machine : A Case Study in Plastic Manufacturing Industry," vol. 12, no. June, pp. 53–64, 2021, doi: 10.21512/comtech.v12i1.6706.

[3] E. A. Mantiri, P. Kindangen, and M. M. Karuntu, "Pendekatan Lean Manufacturing Untuk Meningkatkan Efisiensi Dalam Proses Produksi Dengan Menggunakan Value Stream Mapping Pada CV. INDOSPICE," *1292 J. EMBA*, vol. 5, no. 2, pp. 1292–1303, 2017.

[4] K. P. Sari, A. A. Yanuar, and M. Rendra, "Penerapan Lean Manufacturing Untuk Meminimasi Waste Waiting Time Pada Proses Produksi Spring Guide XXX Di CV. Gradient," *J. Rekayasa Sist. Ind.*, vol. 4, no. 02, p. 170, 2017, doi: 10.25124/jrsi.v4i01.218.
[5] A. R. Irwan Setiawan, "Penerapan Lean Manufacturing Untuk Meminimalkan Waste Dengan Menggunakan Metode VSM Dan WAM Pada PT XYZ," *Semin. Nas. Penelit. LPPM UMJ*, pp. 1–10, 2021.
[6] K. Krachangchan and N. Thawesaengskulthai, "Loss time reduction for improve Overall Equipment Effectiveness (OEE)," *2018 5th Int. Conf. Ind. Eng. Appl. ICIEA 2018*, no. Mc, pp. 396–400, 2018, doi: 10.1109/IEA.2018.8387132.
[7] D. P. T. Cwi, "Peningkatan Overall Equipment Effectiveness (OEE) Pada Mesin Molding Melalui Perbaikan Six Big Losses," vol. 7, no. April, pp. 100–108, 2021.
[8] A. Suherman and B. J. Cahyana, "Pengendalian Kualitas Dengan Metode Failure Mode Effect And Analysis (FMEA) Dan Pendekatan Kaizen untuk Mengurangi JumlahKecacatan dan Penyebabnya," *Semin. Nas. Sains dan Teknol.*, vol. 16, pp. 1–9, 2019.
[9] D. Lina Purnamasingrum, A. Fuad Afdhal, M. Ilmu Kefarmasian, F. Farmasi Universitas Pancasila, and J. Selatan, "Analysis Of Overall Equipment Effectiveness (Oee) In Determining Productivity In Semi Automatic Semi Solid Filling Machines At PT X. 1 under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0)," *J. eduhealth*, vol. 14, no. 01, p. 2023, 2023, [Online]. Available: http://ejournal.seaninstitute.or.id/index.php/healt
[10] R. I. D. Suyatmo, E. Melyna, H. Arina, and A. O. Shelia, "Sosialisasi Hasil Analisis Overall Equipment Effectiveness (OEE) dan Six Big Losses Dalam Implementasi Total Productive Maintenance (TPM) Di PT ABC," *J. Pengabdi. Masy. Bangsa*, vol. 1, no. 10, pp. 2507–2515, 2023, doi: 10.59837/jpmba.v1i10.542.
[11] B. Setiawan, F. Al Latif, and E. Rimawan, "Overall Equipment Effectiveness (OEE) Analysis: A Case Study in the PVC Compound Industry," *IJIEM - Indones. J. Ind. Eng. Manag.*, vol. 3, no. 1, p. 14, 2022, doi: 10.22441/ijiem.v3i1.12066.
[12] U. Mardono, A. Rohimah, and E. Rimawan, "Six Big Losses Approach and Kaizen Philosophy Implementation to Improve Overall Equipment Effectivenes (OEE) (Case Study : PT . ABC , Areinforced Steel Manufacturer)," *Int. J. Innov. Res. Sci. Eng. Technol.*, vol. 3, no. 6, pp. 165–171, 2018.
[13] J. Koip, "Peningkatan Nilai Overall Equipment Effectiveness (OEE) Mesin Injection Molding Di Perusahaan Beverage Packaging," *Oper. Excell.*, vol. 10, no. 2, pp. 152–163, 2018.
[14] L. D. Gabahne, M. M. Gupta, and D. Zanwar, "Overall Equipment Effectiveness Improvement: A Case of injection molding machine," *Int. J. Eng. Sci.*, vol. 3, no. 8, pp. 2319–1805, 2014.
[15] S. W. Putri, A. Momon, W. Wahyudin, and S. Fikri, "Analisis Efektivitas Mesin Injection 2500 Ton di Bagian Produksi PT.XYZ Menggunakan Metode Overall Equipment Effectiveness," *J. Serambi Eng.*, vol. 7, no. 4, pp. 4195–4200, 2022, doi: 10.32672/jse.v7i4.5105.
[16] N. D. Anggraeni, "Perancangan Cetakan Injection Molding Handpress Material Komposit Pphi Dan Serat Alam," *Mach. J. Tek. Mesin*, vol. 8, no. 2, pp. 12–16, 2022, doi: 10.33019/jm.v8i2.2554.
[17] M. Anrinda, M. E. Sianto, J. T. Industri, U. Katolik, and W. Mandala, "ANALISIS PERHITUNGAN OVERALL EQUIPMENT EFFECTIVENESS (OEE) PADA MESIN OFFSET CD6 DI INDUSTRI OFFSET PRINTING," pp. 1–8, 2021.
[18] A. Rivaldo, I. N. Gusniar, A. Santosa, and J. Sumarjo, "Evaluasi Optimasi Mesin Tonase 650 Ton Injection Molding Menggunakan Evaluasi Optimasi Mesin Tonase 650 Ton Injection Molding Menggunakan Metode Overall Equipment Effectiveness Studi Kasus PT . XYZ," vol. 5, no. October 2021, pp. 118–125, 2022.
[19] B. F. P. A. Marfinov and A. J. Pratama, "Overall Equipment Effectiveness (OEE) Analysis to Minimize Six Big Losses in Continuous Blanking Machine," *IJIEM - Indones. J. Ind. Eng. Manag.*, vol. 1, no. 1, p. 25, 2020, doi: 10.22441/ijiem.v1i1.8037.
[20] D. Agung and H. Hasbullah, "Reducing the Product Changeover Time Using Smed & 5S Methods in the Injection Molding Industry," *Sinergi*, vol. 23, no. 3, p. 199, 2019, doi: 10.22441/sinergi.2019.3.004.