Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Implementation of Maintenance Value Stream Mapping and Overall Equipment Effectivenes Methods to Increase the Effectiveness of Production Equipment in Andesite Mining Companies

Eka Irawanti*, Herry Agung Prabowo, Hasbullah
Industrial Engineering Department, Mercu Buana University, Jl. Meruya Selatan No. 1 Kembangan, West Jakarta 11650 Indonesia

ARTICLE INFORMATION

Article history:

Received: 24 December 2023
Revised: 21 October 2024
Accepted: 10 June 2025

Category: Research paper

Keywords:
Andesite
Mining
OEE
MVSM

DOI: 10.22441/ijiem.v6i3.24909

A B S T R A C T

The Andesite mining company experienced a 12.46% deviation between demand and actual delivery, primarily caused by reduced machinery effectiveness, which led to unmet production targets. This study aims to maximize production capacity and improve delivery performance through the application of the Overall Equipment Effectiveness (OEE) method. Furthermore, the Maintenance Value Stream Mapping (MVSM) approach was employed to evaluate and enhance the maintenance system by visualizing maintenance process flows and ensuring optimal facility functionality.The results showed that the initial OEE value of 39.72% increased significantly to 85.74% after the implementation of improvement strategies. This improvement was closely associated with the application of MVSM, which also enhanced the Value Added (VA) performance of several maintenance activities. For Conveyor gearbox maintenance, the VA value increased from 10.32% to 57.91%, while Motor Feeder maintenance improved from 18.04% to 61.04%. Screen sieve replacement for 1–2 increased from 17.04% to 32.50%, and Screen sieve replacement for 3–5 improved from 17.62% to 33.07%. Screen sieve replacement for 2–3 also showed an increase from 17.02% to 32.56%. Meanwhile, the VA values for small conveyor roller bearings maintenance remained constant at 62.39%, jaw setting maintenance at 20.78%, and large conveyor roller bearings maintenance at 41.78%. These findings indicate that the integration of OEE and MVSM methods effectively enhances maintenance performance and overall production efficiency, contributing to improved delivery reliability.

*Corresponding Author
Eka Irawanti
E-mail: ekairawanti8@gmail.com

1. INTRODUCTION

Andesite is a type of igneous rock with a soft texture and usually has a gray color. Almost in the entire Indonesian archipelago, andesite can be found, especially in locations with volcanic eruption traces. Kade lastly, this industry has undergone significant changes in technology and regulation (Yanuardian et al., 2020). Indonesia is one of the large andesite producing countries because it has the highest number of volcanoes in the world (Geologi Agency, 2021) by 33,478,000,000 tons in 2020. In 2021, data was significantly decreased due to data updates, which caused the volume of Andesite resources to reach 21,056,890,000 tons. The andesite mining industry has relatively abundant raw material volume reserves but still needs help in meeting consumer demand (Adiansyah et al., 2018). Based on the data, the second most significant factor is inadequate equipment at 20.60%. This can be confirmed based on internal data from one of the Andesite mining companies,which

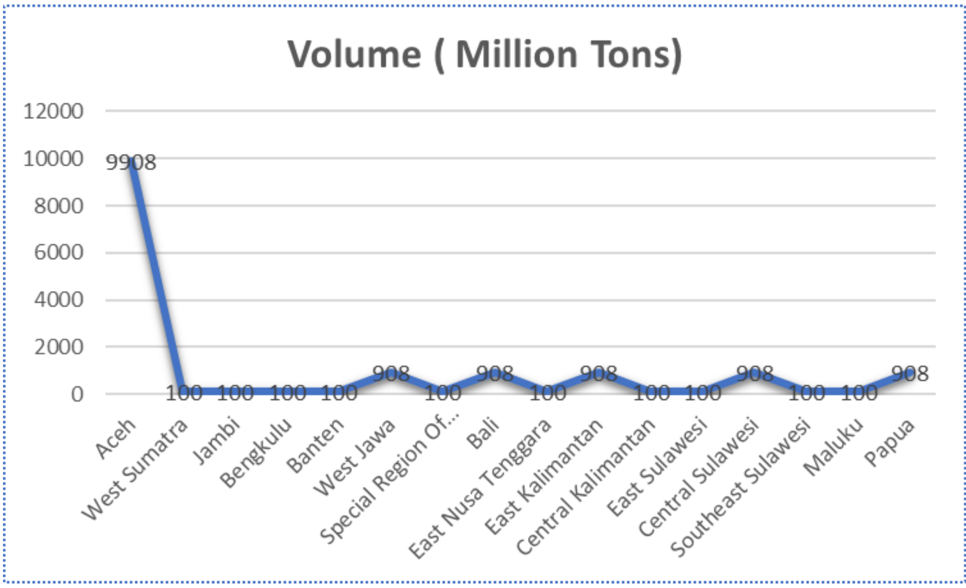

Figure 1. The distribution of andesite resources in Indonesia 2021

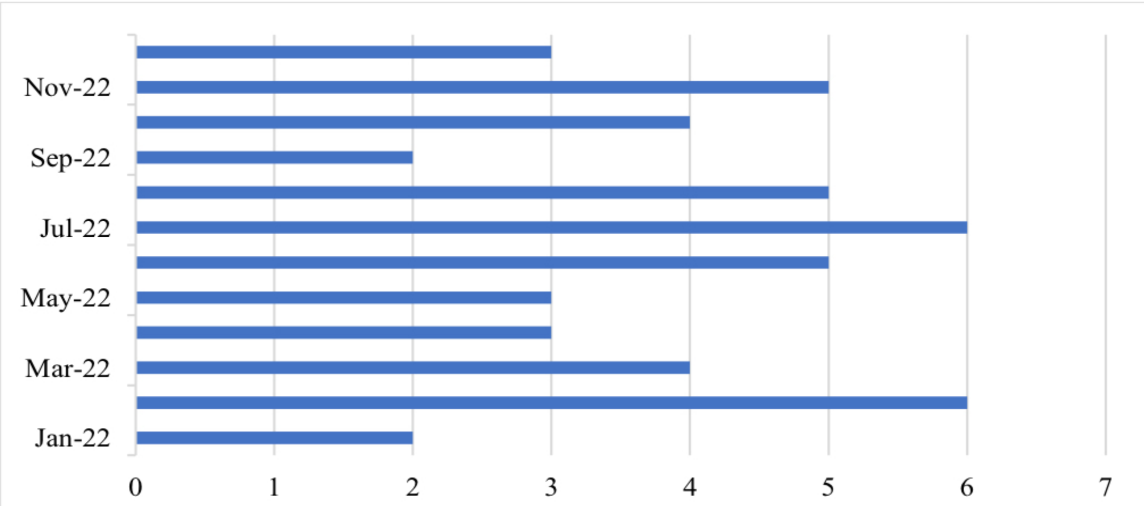

Figure 2. Breakdown of machine data in 2021

In Figure 1 can be seen the volume of Andesite resources 2017-2021, according to data from the Ministry of Energy and Mineral Resources for Andesite stone in 2017 amounted to 23,252,880,000 tons and continued to increase states the frequency of machine breakdowns for one year of as many as 48 events, with the lowest occurrence of 2 events and the highest of 6 events (Figure 2). This study aims to determine the effectiveness level based on the value of Overall Equipment Effectiveness (OEE) in the andesite mining industry to increase machine effectiveness after the application of the MVSM method in the andesite mining industry. To implement the solutions provided to maintain the effectiveness of machines in the andesite stone mining industry.

2. LITERATURE REVIEW

Total Productive Maintenance (TPM) is a philosophy that aims to maximize the effectiveness of facilities used in industry, which is not only maintenance but all aspects of the operation and installation of production facilities, including increasing the motivation of the people working in the company (Primary, 2019). Maintenance is a task that is as important as any other task, such as production. This is because using machinery and equipment as often as possible ensures the manufacturing process goes well. To ensure future usability of machinery or equipment and the ability to maintain production continuity (Nasution et al., 2021). OEE (Overall Equipment Effectiveness) measures the total efficiency of machinery and equipment management (Prabowo et al., 2018) OEE is calculated by multiplying machine availability, process performance efficiency, and product quality level by multiplying by the following formula (Ramadhani et al., 2022).

OEE = Availability x Performance x Quality Yield

where:

Availability level

Facility Performance

Product quality (Quality)

Fishbone diagrams show the relationship between cause and effect. In statistical process control, causality diagrams show the causal variables (causes) and quality attributes (impacts) caused by those causal factors. This cause-and-effect diagram is often called the "fishbone diagram" or Ishikawa diagram after it was developed in 1953 by Professor Kaoru Ishikawa of the University of Tokyo (Zulfatri et al., 2020)

MVSM is a visual tool that shows the flow of the machine maintenance process from start to finish. MVSM helps identify and eliminate waste in the maintenance process (Jhon shook, 2018).

3. RESEARCH METHOD

This research belongs to the applied research and case studies. Tarapan research is research conducted to apply, test and evaluate the ability of a theory that is applied in solving practical problems. This means the results are expected to be used immediately for practical purposes (Trisliatanto, 2020).

The research design used in this study is an Exploratory Sequential Design, where researchers first explore a topic in-depth and detail with qualitative methods, then collect and analyze quantitative data. All employees of the maintenance division and cone crusher who are in one of the andesite mining companies in Cilegon as the population in this study.

The data that has been collected becomes the foundation for technical steps and data analysis processing, which is united with OEE (Overall Equipment Effectiveness) and MVSM (Maintenance Value Stream Mapping) techniques (Saifuddin et al., 2022). The sequence of the process is:

1. Finding Overall Equipment *Effectiveness*
   a. Calculate Availability
   b. Calculate Performance
   c. Calculating quality
   d. Calculating OEE
2. Make Maintenance Visual Stream Mapping. At this stage, several proposals will be made, including (Horsthofer et al., 2024):
   a. Create a framework
   The framework process incorporates signs and distribution of MTTR (Mean Time To Repair*), and MTTF (*Mean Time To Failure*) groups in each relevant activity.*
   b. Current State Mapping *Creation*
   in this process, making maps begins by collecting information about existing processes, tracking the flow of materials and information and identifying steps that create value and those that do not

(Rother & Shook, 2003). Furthermore, it describes the entire process visually, facilitating understanding and analysis. various causes of a problem. The concept describes the relation of a problem to all the elements that produce it (Michael Ballé, 2017)

3. Fishbone Diagram

   A fishbone diagram, also known as a slab and effect diagram, is a tool that can help identify, categorize, and illustrate the various causes of problems. The concept describes the relation of a problem to all the elements that produce it.

4. Making *of Future State Mapping*
   Future State Mapping in the Value Stream Mapping (VSM) context is a visualization of how the process will run after the desired improvements and changes re implemented (Andri & Sembiring, 2019). The goal is to create a more streamlined and efficient process. Provision of improvement proposals (Siagian et al., 2024)
5. Provision of improvement proposals
   In this phase, we will get maximum effectiveness and efficiency, identify and improve, and implement the ideal solution for the maintenance division (Khunaifi et al., 2022)

The research step is a series of procedures and steps aimed at obtaining systematically structured stages so that research can be carried out effectively and efficiently. The steps in this study are Figure 3.

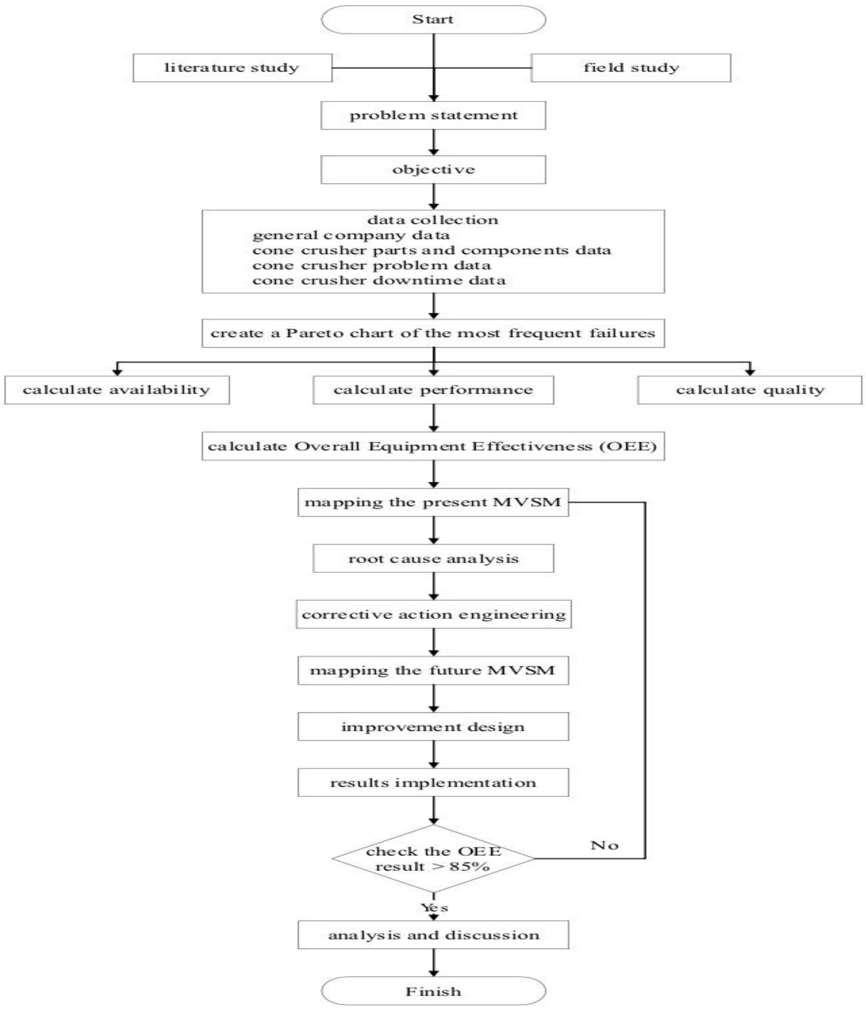

Figure 3. Flowchart of research steps

4. RESULT AND DISCUSSION

Based on the data analysis conducted, it was revealed that the OEE value before the improvement was 39.72%. This value is formed from OEE components such as availability, with a value of 79.88%, Performance of 54.20%, and Quality, which reaches 91.73% Based on the results of data processing, it can be seen that the repairs that are the maintenance burden are motor gearbox maintenance conveyors, motor maintenance feeders, sieve change screens (1-2), small roll bearing change conveyors, sieve change screens (3-5), sieve change screens (2-3), per jaw settings, and large roll bearing change conveyors can be seen in the following Figure 4.

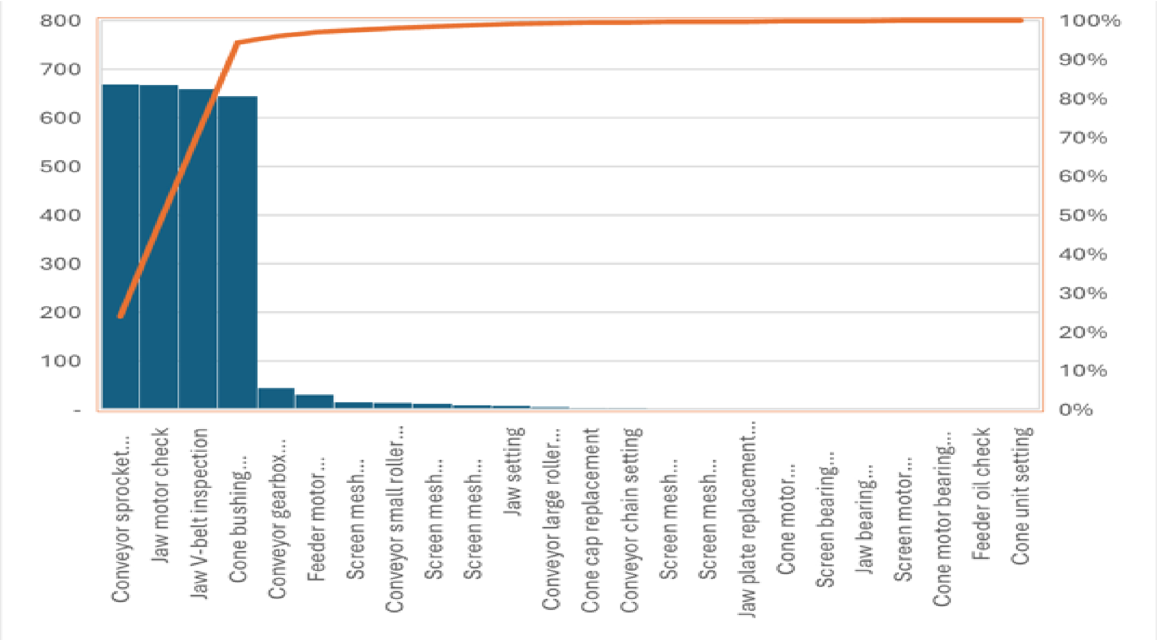

Figure 4. Types of improvements Pareto

The advanced process of making Current State Mapping is carried out by entering the average data (mean) in each process using the help of the Distribution analysis Tools in Minitab 19. Certain types, including MTTO, MTTR, and MTTY categorize all data processes listed. Here is one of the calculation method for Conveyor - Maintenance Gearbox Motor. Rest of result calculation can be seen on Table 1.

Table 1. The data of NVA and VA

No.	Activity	MTTO *(minute)*	MTTR *(minute)*	MTTY *(minute)*	MMLT *(minute)*	NVA	VA
1	Conveyor – Motor gearbox maintenance	1556.36	183.5	37.72	1777.58	89.68%	10.32%
2	Feeder – Motor maintenance	911.495	208.78	37.13	1157.405	81.96%	18.04%
3	Screen – sieve replacement 1-2)	1543.88	325.03	38.13	1907.4	82.96%	17.04%
4	Conveyor – small rol Bearing replaced	57.14	156.9	37.46	251.5	37.61%	62.39%
5	Conveyor – sieve replacement screen (3-5)	1518.22	333.15	39.22	1890.59	82.38%	17.62%
6	Conveyor - sieve replacement screen (2-3)	1548.2	325.43	38.42	1912.5	82.98%	17.02%
7	Jaw - Setting	36.4	12.6	9.95	58.51	79.22%	20.78%
8	Conveyor - large Bearing Roll replacement	59.1	69	37,07	165.17	58.22%	41.78%

Mean Time To Organize (MTTO)
MTTO = 3.48 + 7.53 + 12.59+ 12.71 + 1520.71 = 1556,36 minutes

Mean Time To Repair (MTTR)
MTTR = 183.5 minutes
MTTR is the average time used in carrying out repair activities, which is 183.5 minutes.

Mean Time To Yield (MTTY)
MTTY = 24.78 + 12.94 = 37.72 minutes

Mean Maintenance Lead Time (MMLT)
MMLT = MTTOl + MTTR + MTTY
MMLT = 1556.35 + 183.5 + 37.72 = 1777.58 minutes

Based on the calculation results, it can be known that the time needed to run the maintenance process is 1777.58 minutes.
Indeks Value Added (VA) dan Non Value Added (NVA)
The calculation of the Value Added (VA) index is done using the equation below:
VA = MTTR/MMLT×100%
= 183.5/1777.58×100% = 10.32%
The calculation of the Non Value Added (NVA) index can be done as below:
NVA= (MTTO+MTTY)/MMLT×100%
= 1556.35+37.72)/1777.58×100%
=89.68%.
After knowing the NVA and VA values, proceed with the current MVSM mapping process. Based on these data, mapping is carried out using the Pareto Diagram so that it can be seen that the coordination process of preparing tools and spare parts, testing, delays, and making improvements is a priority to be completed using the Fishbone Diagram through FGD (Focus Group Discussion) activities (Figure 5)

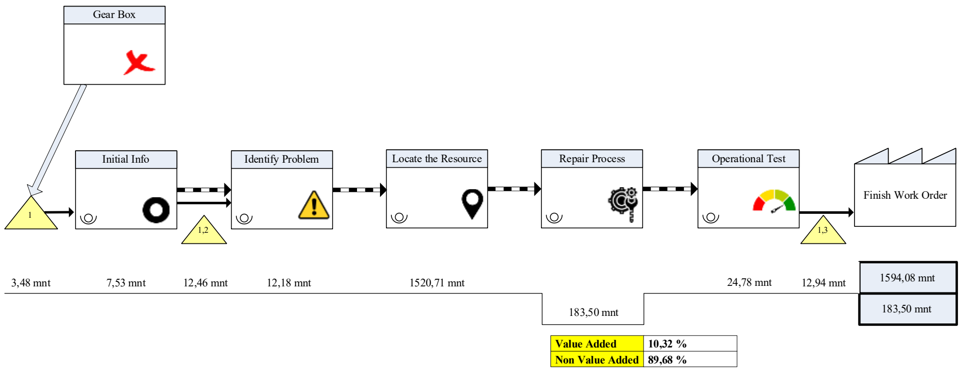

Figure 5. Conveyor Maintenance Gearbox Motor CSM

Based on fishbone analysis for coordinationactivities for tool preparation and spare parts, the human aspect is the leading cause due to inadequate worker skills, ineffective communication, and lack of team coordination. For methods, the causes a re no monitoring of worker performance, unclear SOPs, and poorly documented procedures. In terms of the environment that causes complex signals, noise interference, and high ambient temperatures. For parts that are the cause is limited parts availability, low part quality, and inadequate parts updates. Moreover, related tools are the cause due to tool damage, tools already used, and limited availability (Figure 6).

In trial activities, the human aspect is the leading cause due to unskilled operators, poor communication, and low employee discipline. Then, if unclear SOPs cause the method, the method is not tested periodically, and the procedure is not by actual conditions. Tools that are the cause are already used and damaged, and the number of tools is minimal. Parts related are caused by parts life, availability, and storage. The environment that is the cause is an environment that is too noisy and dusty, has high ambient temperature, and has an adequate control system. The one of sample fishbone diagram can be seen on Figure 6.

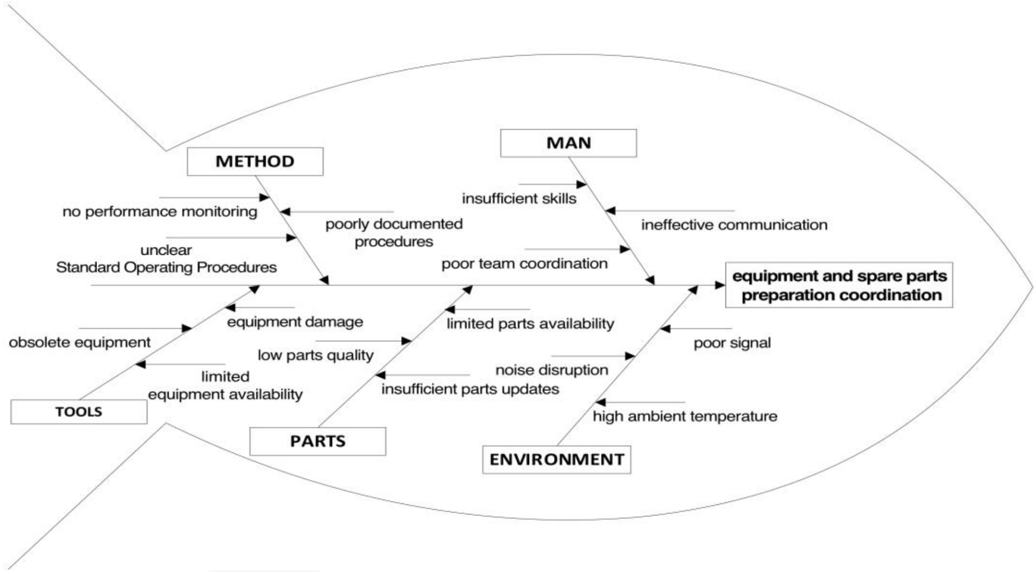

Figure 6. Fishbone diagram of coordination for equipment and spare parts preparation

In delay activities, humans as the central aspect are caused by coordination between departments, low awareness of employees, and lack of supervision in implementation. In the context of the method caused by unavailable reports, incomplete SOPs, and undocumented results. Then, the environment that causes delays is high ambient temperatures, location access, and dusty locations. For parts that are the cause is an inappropriate maintenance schedule, parts stock records, and replacement of parts without notice. Untreated tools, tool storage, and obsolete tools cause related tools.

Improving the human aspect is the leading cause due to lack of training, lack of supervision and control of processes, and lack of communication between workers. Then, in the method aspect caused by methods that do not pay attention to environmental factors, incomplete SOPs and the methods used are still lagging or not up-to-date. Limited tool stock, obsolete tools, and storage processes cause the tools aspect. Related parts that are the cause are limited stock, quality of parts, and stock of parts. And related to environmental aspects due to signal conditions, dusty locations, and access to repair locations.

Based on the results of the application of the experiment above, this study showed a significant increase in the value of Overall Equipment Effectiveness (OEE) from 39.72% to 85.74%. This represents a substantial improvement in key aspects such as Availability, Performance, and Quality (Figure 7). This increase was driven by improvements in the management and prioritization of maintenance work, emphasizing the importance of identifying and addressing work with the most significant contribution to inefficiencies. Implementing the MVSM (Maintenance Value Stream Mapping) method decreased work time for the repair of the motor box degree maintenance conveyor, with a total time needed to do a job of 1460.71 minutes decreased by 316.87 minutes. Motor maintenance feeders with a total time required to perform a job of minutes decreased by 342.04 minutes. The repair form of sieve change screens (1-2) with a total time required to perform a job of 1000.24 minutes decreased by 906.8 minutes, demonstrating the effectiveness of this approach in reducing non-value-added (NVA) activities (Figure 8).

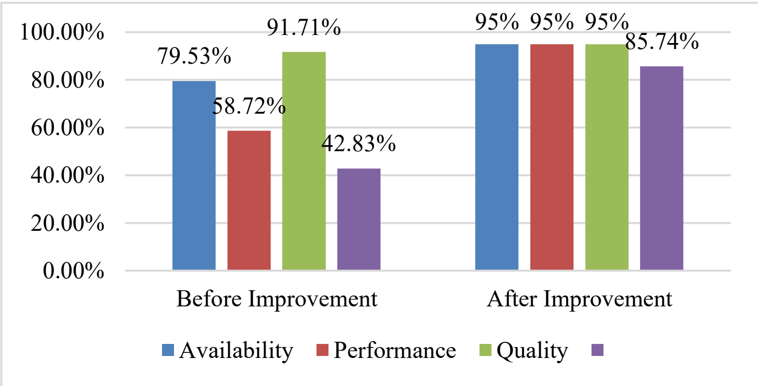

Figure 7. OEE before vs after improvement

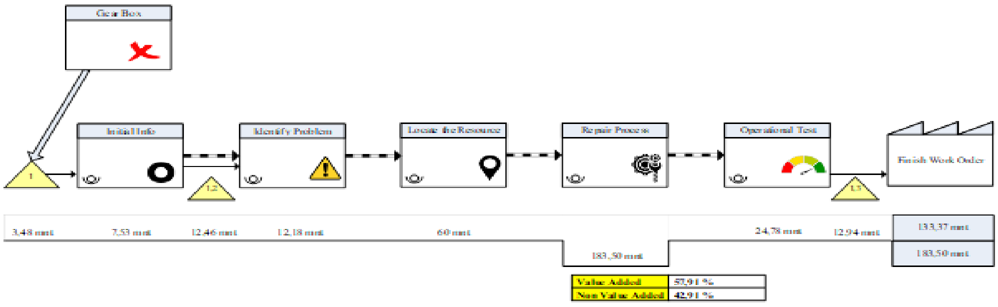

Figure 8. Conveyor maintenance gearbox motor FSM

5. CONCLUSION

The effectiveness rate based on the Overall Equipment effectiveness (OEE) value in the andesite stone mining industry before repair was 39.72%. The OEE value is caused by the Availability value, which is only 79.88%, Performance at 54.20%, and Quality at 91.73%, so improvements are needed to increase the OEE value. After the application of the MVSM method in the andesite stone mining industry, an increase in Value Added (VA) value and a decrease in Non-Value Added (NVA) value was obtained, namely for the type of repair of the motor box degree maintenance conveyor 57.91% and 42.09% with the total time needed to do a job of 1460.71 minutes, down by 316.87 minutes. Motor maintenance feeders 61.04% and 38.96% with a total time required to do a job of 815.365 minutes down by 342.04 minutes, and types of repairs Screen sieve changes (1-2) 32.50% and 67.50% with a total time needed to do a job of 1000.24 minutes down by 906.8 minutes. Solutions provided to maintain the effectiveness of machinery in the andesite stone mining industry, such as training workers, equipment and parts inventory management, tool maintenance, replacing tools that are starting to wear out and damaged, providing SOPs, and cleaning the repair environment. These improvements can increase machine maintenance efficiency and reduce non-value-added activities.

REFERENCES

Adiansyah, J. S., Payadi, K., Alpiana, & Rahmawati, D. (2018). Evaluation of loading and hauling technology for improving andesite mine performance. *IOP Conference Series: Materials Science and Engineering*, *403*(1). https://doi.org/10.1088/1757-899X/403/1/012048

Andri, A., & Sembiring, D. (2019). Penerapan Lean Manufacturing Dengan Metode VSM (Value Sream Mapping) untuk Mengurangi Waste Pada Proses Produksi Pt.XYZ. *Faktor Exacta*, *11*(4), 303. https://doi.org/10.30998/faktorexacta.v11i4.2888

Geologi Agency. (2021). *Potensi Sumber Daya Mineral Indonesia*. Jakarta.

Horsthofer, Rauch, Julia, Guesken, Sarah Ranjana, Weich, J., Rauch, A., Bittner, M., Schulz, J., & Zaeh, M. F. (2024). Sustainability-integrated value stream mapping with process mining. *Production & Manufacturing Research*, *12*(1). https://doi.org/10.1080/21693277.2024.2334294

Khunaifi, A., Primadasa, R., Sutono, S. B., & Teknik, F. (2022). Implementasi Lean Manufacturing untuk Meminimasi Pemborosan (Waste) Menggunakan Metode Value Stream Mapping di PT. Pura Barutama. *Jurnal Rekayasa Industri (JRI)*, *4*(2).

Michael Ballé. (2017). *Maintenance Value Stream Mapping: A Lean Approach to Maintenance Management* (Vol. 1).

Nasution, M., Bakhori, A., & Novarika, W. (2021). MANFAAT PERLUNYA MANAJEMEN PERAWATAN UNTUK BENGKEL MAUPUN INDUSTRI. In *Cetak) Buletin Utama Teknik* (Vol. 16, Number 3). Online.

Prabowo, H. A., Suprapto, Y. B., & Farida, F. (2018). The Evaluation Of Eight Pillars Total Productive Maintenance (Tpm) Implementation And Their Impact On Overall Equipment Effectiveness (OEE) and Waste. *SINERGI*, *22*(1), 13–18. https://doi.org/10.22441/sinergi.2018.1.003

Pratama, W. C. (2019). *Mesin Treatment Analysis And Tota Productive Maintenance (TPM) Absorption at Departemen Personal Wash PT. Megasurya Mas Di Soap Stamping Machine.* [Thesis]. Universitas Muhammadiyah Surabaya.

Ramadhani, A. G., Zahra Azizah, D., Nugraha, F., & Fauzi, M. (2022). Analisa Penerapan Tpm (Total Productive Maintenance) dan OEE (Overall Equipment Effectiveness) pada Mesin Auto Cutting di PT XYZ. . *Jurnal Ilmiah Teknik Dan Manajemen Industri*, *2*(1).

Riezebos, J., & Huisman, B. (2020). Value stream mapping in education: addressing work stress. *International Journal of Quality & Reliability Management*, *38*(4), 1044–1061. https://doi.org/10.1108/IJQRM-05-2019-0145

Rother, M., & Shook, J. (2003). *Learning to See: Value Stream Mapping to Add Value and Eliminate Muda* (1st ed.). The Lean Enterprise Institute.

Saifuddin, J. A., Nugraha, I., & Winursito, C. Y. (2022). Total Productive Maintenance Analysis Using OEE and FMEA Method at PT. XYZ Phosphoric Acid Factory. *Nusantara Science and Technology Proceedings*, 63–69. https://doi.org/10.11594/nstp.2022.2711

Siagian, Wiranty Tiara Wijaya, TEKMAPRO, & Joumil Aidil Saifudin. (2024). Analisis Penerapan Lean Manufacturing dengan Metode Vsm (Value Stream Mapping) Guna Mengurangi Waste dan Cycle Time pada Proses Produksi Keramik di PT XYZ. *Tekmapro*, *19*(2). https://doi.org/10.33005/tekmapro.v19i2.419

Trisliatanto, D. A. (2020). *Metodologi Penelitian Panduan Lengkap Penelitian dengan Mudah.* Tirta Buana Media.

Yanuardian, A. R., Hermawan, K., Martireni, A. P., & Tohari, A. (2020). The influence of discontinuities on rock mass quality and overall stability of andesite rock slope in West Java. *Rudarsko Geolosko Naftni Zbornik*, *35*(3), 67–76. https://doi.org/10.17794/rgn.2020.3.7

Zulfatri, M. M., Alhilman, J., & Atmaji, F. T. D. (2020). Pengukuran Efektivitas Mesin dengan Menggunakan Metode Overall Equipment Effectiveness (OEE) dan Overall Resource Effectiveness (ORE) pada Mesin PL1250 DI PT XZY. *JISI: Jurnal Integrasi Sistem Industri*, *7*(2), 123. https://doi.org/10.24853/jisi.7.2.123-131