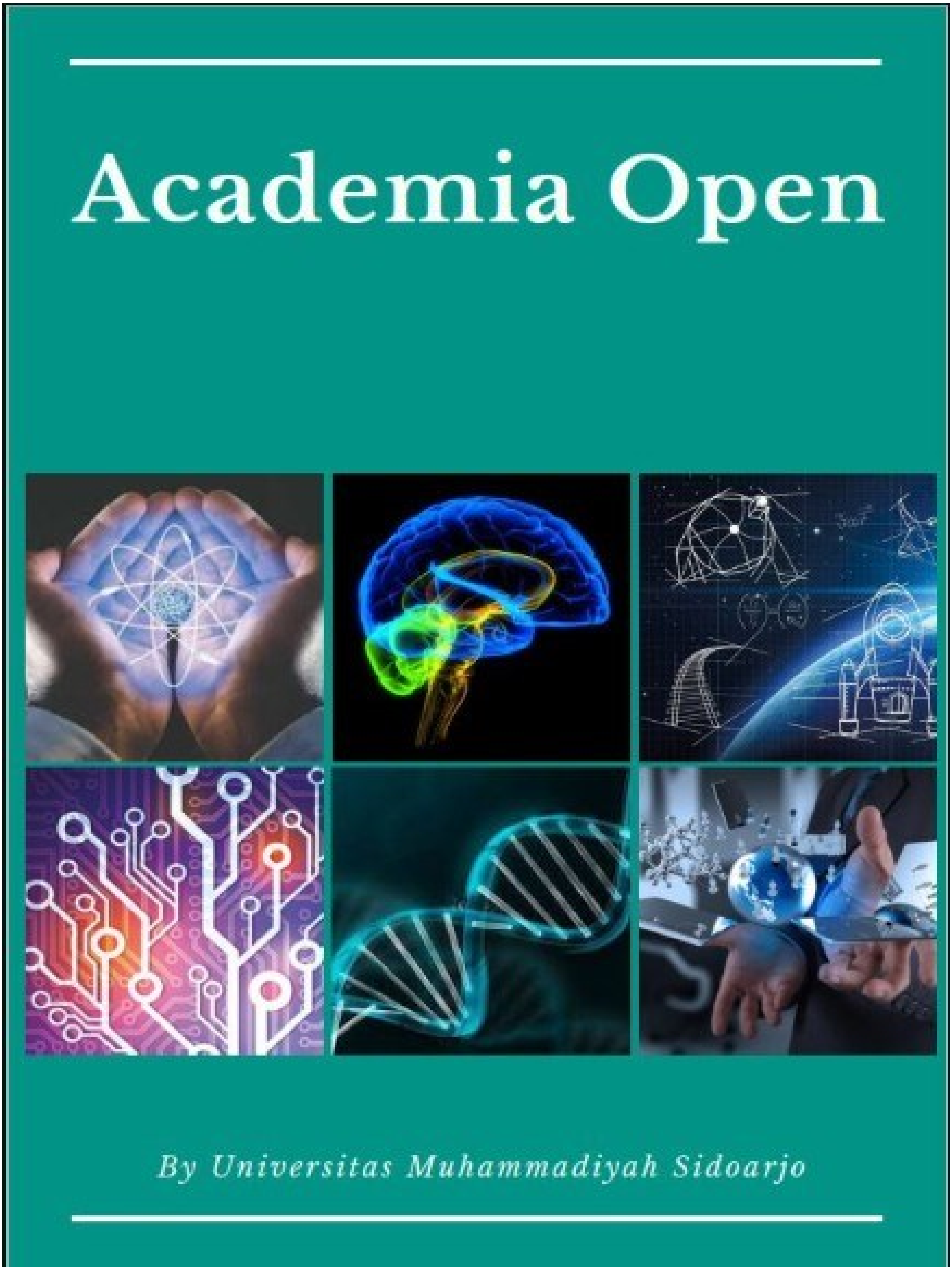
Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792



ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

Table Of Contents

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

Academia Open

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

EDITORIAL TEAM

Complete list of editorial team (link)

Complete list of indexing services for this journal (link)

How to submit to this journal (link)

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

Article information

Check this article update (crossmark)

Check this article impact (*)

Save this article to Mendeley

(*) Time for indexing process is various, depends on indexing database platform

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open

Vol. 11 No. 1 (2026): June

DOI: 10.21070/acopen.11.2026.13792

Impact of Lean Manufacturing and 5S In The Excavator Bucket Repair Process Waste Analysis

Kezia Grace Sudarman, 22032010105@student.upnjatim.ac.id (*)

Industrial Engineering Department, Universitas Pembangunan Nasional "Veteran" Jawa Timur , Indonesia

Rusindiyanto Rusindiyanto, rusindiyanto.ti@upnjatim.ac.id

Industrial Engineering Department, Universitas Pembangunan Nasional "Veteran" Jawa Timur , Indonesia

(*) Corresponding author

Abstract

General Background Repair process efficiency is essential in heavy equipment services because long lead time, rework, and disorganized work areas can reduce operational productivity. **Specific Background** Excavator bucket repair involves preparation, disassembly, machining, assembly, inspection, painting, and handover stages that may contain value-added and non-value-added activities. **Knowledge Gap** Previous Lean Manufacturing and 5S studies have mostly focused on production systems and small manufacturing enterprises, while their integrated use in heavy equipment repair services remains limited. **Aims** This study aims to identify waste, analyze its causes, and propose improvement initiatives in the excavator bucket repair process using Lean Manufacturing and 5S. **Results** Initial mapping showed a lead time of 5,543 minutes, consisting of 2,425 minutes of value-added activities, 2,810 minutes of non-value-added activities, and 308 minutes of necessary non-value-added activities. The dominant wastes were unnecessary motion, waiting, and defects. Process Activity Mapping was selected through VALSAT as the main analytical tool. Fishbone analysis showed that waste was caused by ineffective material layout, non-standardized inventory systems, disorganized tool storage, coordination delays, and material availability problems. After eliminating non-value-added activities and applying 5S-based recommendations, lead time decreased to 2,733 minutes and Process Cycle Efficiency increased from 43.75% to 88.73%. **Novelty** This study integrates VSM, VALSAT, PAM, fishbone analysis, and 5S for excavator bucket repair. **Implications** The findings provide practical guidance for reducing waste and streamlining heavy equipment repair operations.

Highlights:

- Unnecessary motion ranked highest, followed by waiting and defects.
- Lead time dropped from 5,543 minutes to 2,733 minutes.
- PCE rose from 43.75% to 88.73% after workflow redesign.

Keywords: 5S, Excavator Bucket Repair, Lean Manufacturing, Waste

Published date: 2026-06-12

Introduction

The construction sector is a major part of Indonesia's economy, significantly contributing to national infrastructure development. It accounted for 9.84% of the Gross Domestic Product (GDP) in the first quarter of 2025 [1] and recording a 7.02% year-on-year growth in 2024 [2]. This growth highlights the increasing demand for both skilled labor and heavy equipment to enhance project efficiency. The excavator bucket, which is crucial for excavation and material handling, is a key component that can be damaged under heavy use. Heavy equipment, like excavators, is used in construction projects to increase efficiency and speed up task completion [3]. Excavators itself serving as hydraulic-powered machines capable of performing excavation, demolition, and material handling tasks with 360-degree rotation capability [4]. As a primary component, the bucket interacts directly with hard materials such as soil mixed with rocks, sand, and metal, increasing the risk of wear and damage [5]. Thus, repair activities are needed to restore its functionality by doing breakdown maintenance, which can be defined as reactive maintenance conducted after equipment failure through repair or component replacement [6]. Breakdown maintenance involves repair actions aimed at restoring damaged equipment to its original operating condition [7].

Given their critical function, repair is essential to maintain excavator reliability. PT XYZ who provides repair service upon heavy equipments, has completed numerous excavator bucket repair projects with each repair taking time of an average of 10–15 days prioritized based on urgency and customer contracts using a First In First Out (FIFO) system. Each repair is adjusted according to the bucket type and level of damage. Considering the complexity of the process, potential of waste was found and requiring further analysis to improve the repair process efficiency. The company provides a warranty period of up to 30 days after repair completion and administrative clearance. No warranty claims or reorders due to recurring failures were recorded in the past year.

Through field observations, interviews with company representatives, and questionnaires distributions then revealed that repair lead time remains relatively long due to the presence of non-value added activities. Lean Manufacturing offers a solution which focuses on improving productivity by eliminating non-value added processes [8]. Lean Manufacturing is a systematic approach derived from the Toyota Production System that focuses on eliminating waste without compromising productivity, quality, or efficiency through continuous improvement processes [9]. This approach emphasizes removal upon non-value added (NVA) activities to improve quality, reducing costs, and shortening process time through effective layout design, visual control, and appropriate equipment support [10]. Key performance indicators in Lean analysis include Process Cycle Efficiency (PCE) which compares value-added time to total lead time [11]. Lead time is the total duration required to complete production activities from the start until the end [12]. Activities then being classified into value added (VA), non-value added (NVA), and necessary non value added (NNVA) to identify and manage inefficiencies within production processes [13]. NVA activities should be minimized or eliminated to increase operational efficiency and enhance value creation [14]. Lean further categorizes waste into seven types which contribute to inefficiencies in manufacturing operations and require systematic identification and reduction to improve process performance. Those are overproduction, waiting, unnecessary transportation, overprocessing, excess inventory, unnecessary motion, and defects [15].

After further observation and interview identified three dominant types of waste, which are unnecessary motion, waiting, and defects. The unnecessary motion waste occurs when workers move between stations to retrieve tools and looking for materials. Waiting waste occurs when workers must delay tasks due to replacement of equipments. Defects result from rework caused by inaccuracies in previous stages. Workshop conditions further indicate that the implementation of 5S principles remains suboptimal; however, the 5S methodology can improve workplace organization and standardization to create a more efficient working environment [16]. The 5S method, which comprising Seiri (Sort), Seiton (Straighten), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain) is an effective approach for reducing waste in the excavator bucket repair process by improving workplace organization and standardization. As an initial step toward enhancing the work environment, the implementation of 5S aims to minimize inefficiencies related to materials, time, equipment, space, labor, and operational costs through systematic sorting, arrangement, cleaning, standardization, and discipline [17]. Consistent application of 5S has been shown to reduce non-value-added activities, minimize human error and workplace accidents, improve tool accessibility, optimize workspace utilization, and enhance overall productivity and work quality [18].Therefore, this study integrates Lean Manufacturing and 5S to reduce waste, streamline repair flow, and enhance operational efficiency in heavy equipment repair services.

Based on these findings, this study aim to analyze waste in the excavator bucket repair process using a Lean Manufacturing approach and proposing improvements based on 5S at PT XYZ. The objectives of this study are to identify types of waste in each repair stage, analyze the causes of waste and process effectiveness using Lean Manufacturing and 5S principles, and propose improvement to minimize waste and enhance repair efficiency and productivity. Although previous studies have applied Lean Manufacturing and 5S in manufacturing systems, most studies focus on production environments or SMEs. However, the application of these methods in heavy equipment repair services has received limited research attention. Especially in excavator bucket repair processes that involve irregular workflows and varying repair activities. This study then addresses this gap by applying an integrated Lean Manufacturing and 5S approach in the excavator bucket repair process to identify waste, analyze its causes, and improve process efficiency and contributes through the use of VSM, VALSAT, and PAM to increase Process Cycle Efficiency.

Method

This study was conducted at PT XYZ, located in Komplek Pergudangan Tiara Jabon, Sidoarjo, East Java, from September 2025 until the required observational data were obtained. The research began with problem identification in the excavator

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

bucket repair process, followed by literature and field studies to understand operational conditions and potential waste. The study focused on the bucket repair process using routine repair and involving both primary and secondary sources. Primary data were obtained through observation, interviews with supervisors, technicians, and operators, and questionnaires to assess the impact of seven waste on repair process efficiency. The questionnaire then being distributed to eight respondents consisting of administrative staff, field leaders, and operators whose directly involved in the repair process. Secondary data includes company documents such as standard operating procedures, repair records, workshop layout, and order reports.

To support waste identification, several analytical tools were used such as Value Stream Mapping (VSM) to visualize the repair process and identify value-added and non-value added activities. Value Stream Analysis Tools (VALSAT) were then applied to determine the most suitable mapping tools to identify waste characteristics through the answers of the questionnaires. Process Activity Mapping (PAM) then classify activities into value-added, necessary non-value-added, and non-value-added categories. To identify root causes of dominant waste, fishbone diagram was used. The 5S approach was applied to formulate improvement recommendations to PT XYZ.

Result and Discussion

A. Data Gathering

PT XYZ is a heavy equipment repair and maintenance service company located in Tambak Sawah, Waru District, Sidoarjo, with excavator bucket repair representing one of the most frequently requested small-scale services and serving as the primary focus of this study. The repair process begins with the arrival and initial inspection of the bucket to identify damage and determine repair requirements, followed by material preparation, component disassembly, machining processes such as welding, turning, and cutting, reassembly, quality control inspection, painting, and final reinstallation prior to delivery to the customer with a 30-day warranty. This repair workflow, which shown by Figure 1, was subsequently mapped using Value Stream Mapping (VSM) to represent the actual process conditions.

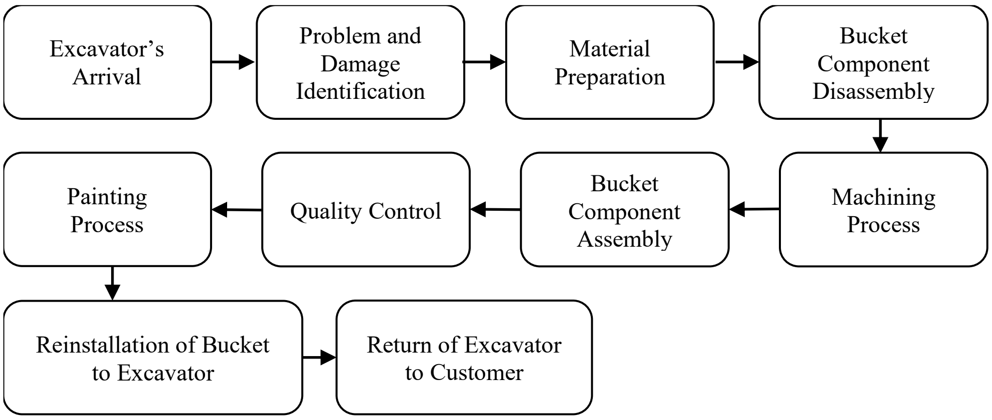


Figure 1. Excavator Bucket Repair Process Flow at PT XYZ

To support waste identification, a waste weighting questionnaire was distributed to eight staff members, supervisors, and operators directly involved in the repair process to assess the impact and frequency of the seven types of waste using a Likert scale. The results were then used as analytical input for selecting the appropriate VALSAT tools to minimize process inefficiencies. Further observation revealed that the most dominant types of waste were unnecessary motion, waiting, and defects, primarily caused by suboptimal placement of machinery, large bucket components, and supporting equipment that restrict workspace and disrupt workflow efficiency. Therefore, the untidy workshop across all areas indicates that 5S implementation at PT XYZ has not yet been optimally carried out.

B. Data Processing

Activities was then being categorized based on the overall repair workflow to determine the lead time of the excavator bucket repair process. These actions were examined in three bucket repair categories which are minor, moderate, and major repairs. Regardless of the extent of the damage, this classification was designed to identify the types of waste causing extended processing times and to capture the essential tasks involved in the entire repair process. The cycle time presented reflects the worst-case scenario in the excavator bucket repair process. In order to fully depict the overall repair operations at PT XYZ, the compiled table was a summary of the three repair categories by the longest duration for each activity.

1. *Questionnaire's Scoring*

After the questionnaires were distributed and the response data were obtained from the respondents, the next step was to compile the collected responses. The data were then analyzed by calculating the score for each respondent's answer to identify the types of waste occurring in the excavator bucket repair process. Based on the calculated scores, a ranking process was conducted for each identified type of waste. The results of the data compilation, score calculation, and waste ranking in the excavator bucket repair process at PT XYZ are presented as follows in Table 1:

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

Table 1. Recapitulation of Waste Weighting Questionnaire Scores

Type of Waste	Number of Scores Given by Respondents					Weight	Rank
	1	2	3	4	5		
Overproduction	2	4	2	0	0	0.099	6
Waiting	0	2	4	2	0	0.198	2
Transportation	5	2	1	0	0	0.049	7
Overprocessing	1	4	2	1	0	0.136	5
Inventory	1	3	3	1	0	0.148	4
Unnecessary Motion	1	2	1	3	1	0.21	1
Defect	3	1	2	0	2	0.16	3

2. *Current Value Stream Mapping*

Based on the information gathered above, the next step involves developing a process mapping in the form of a Current Value Stream Mapping (CVSM) to comprehensively illustrate the existing process flow, from material intake to the delivery of repaired products to customers. The CVSM depicts both the information flow and material flow within the excavator bucket repair process at PT XYZ. The material flow begins with ensuring the availability of raw materials and spare parts, followed by unit preparation, component disassembly, machining, assembly, quality inspection, painting, and final reassembly prior to customer handover. Based on the CVSM analysis, the total lead time of the repair process is 5,543 minutes, equivalent to 92 hours and 23 minutes, or approximately 13 working days assuming a 7-hour workday as presented in Figure 2:

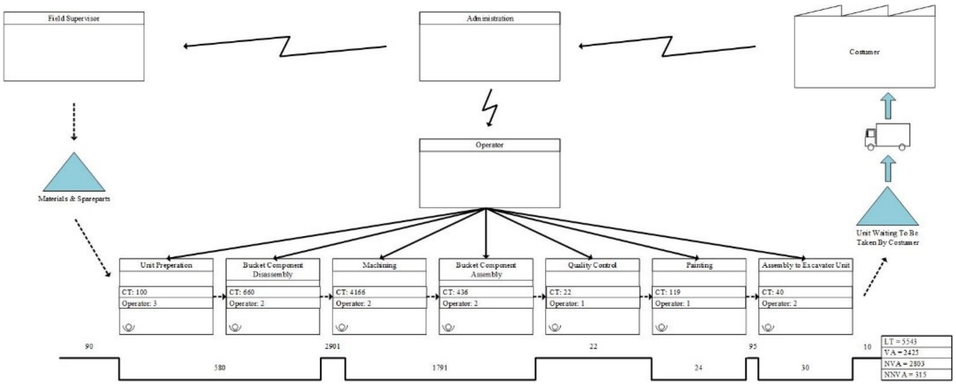


Figure 2. Current Value Stream Mapping

3. *Value Stream Mapping Analysis Tools (VALSAT)*

Following the calculation of weighted scores derived from the waste assessment questionnaire and the identification of process flow through the Current Value Stream Mapping (CVSM), the subsequent step involves determining the most appropriate analytical tool using the Value Stream Mapping Analysis Tools (VALSAT) approach. This selection process is facilitated through the VALSAT matrix, where the weight of each waste category is multiplied by the correlation score assigned to each VALSAT tool, with the objective of evaluating the effectiveness and relevance of each tool in analyzing and minimizing waste within the repair process. The recapitulation of VALSAT calculation results for the seven identified waste types is presented in Table 2 below:

Table 2. Recapitulation of VALSAT Calculation

Waste	Weight	Mapping Tools						
		PAM	SCRM	PVF	QFM	DAM	DPA	PS
Unnecessary Motion	0.210	1.889	0.210	0	1.889	0	0	0
Waiting	0.198	1.778	1.778	0	0.198	0	0.593	0.593
Defect	0.160	0.160	0	0	0	0	0	0
Inventory	0.148	0.444	1.333	0.444	0	1.333	0.444	0.148
Overprocessing	0.136	1.222	0	0.407	0.136	0	0	0.136
Overproduction	0.099	0.099	0.296	0	0.099	0.296	0.296	0
Transportation	0.049	0.444	0	0	0	0	0	0.049
Total		6,04	6.037	3.617	0.852	2.321	1.630	1.333
Rank		1	2	7	3	4	5	6

A higher score indicates a greater level of relevance and capability of the tool in representing the actual repair process conditions. Based on the VALSAT matrix analysis of the seven waste categories, the ranking of analytical tools was obtained. Process Activity Mapping (PAM) achieved the highest VALSAT score of 6.04, followed by Supply Chain Response Matrix (SCRM) with a score of 3.62, and Quality Filter Mapping (QFM) in third place with 2.32. Demand Amplification Mapping (DAM) ranked fourth with a score of 1.63, followed by Decision Point Analysis (DPA) at 1.33, Physical Structure (PS) at 0.93, and Production Variety Funnel (PVF) at 0.85. Based on these results, Process Activity Mapping (PAM) was selected for further analysis as it is considered the most representative tool for illustrating the excavator bucket repair process under investigation.

4. *Process Activity Mapping (PAM)*

Based on the VALSAT tool selection results, Process Activity Mapping (PAM) obtained the highest score of 6.04 and was therefore selected as the primary analytical tool to map all activities involved in the bucket repair process at PT XYZ. Through PAM, each activity was classified into value added (VA), non-value added (NVA), and necessary non-value added (NNVA) categories. The analysis results indicate that operation activities are the most dominant, as they directly contribute to restoring the bucket's function and are therefore categorized as VA. The details of Process Activity Mapping (PAM) can be seen in Table 3 below:

Table 3. Process Activity Mapping (PAM)

Process Flow	Activity	Duration (minutes)	O	T	I	S	D	Activity Category
Unit Preparation	Arrival of the bucket / excavator at the company	–		T				NNVA
	Removal of the bucket from the excavator unit	30	O					NNVA
	Transfer of the bucket to the fabrication area	15		T				NNVA
	Repeated adjustment and repositioning of the bucket using a wall crane or forklift	30		T				NNVA
	Condition inspection and damage identification	15			I			NNVA
	Marking of damaged areas and cutting points	10	O					VA
Bucket Component Disassembly	Removal of main components (floor, side walls, tooth adapter)	470	O					VA
	Removal of old patches and protectors	100	O					VA
	Cleaning of the work area from cutting residue and slag	90	O					NNVA
Machining	Plate cutting (floor, walls, adapters, protectors)	300	O					VA
	Rolling process of the main floor plate (waiting for plate delivery from vendor)	60					D	NNVA
	Dimensional adjustment after rolling and additional cutting	145	O					NVA
	Fabrication of bushing and pin components	240	O					VA
	Fabrication of reinforcement components (drill nails, reinforce, side breaker)	113	O					VA
	Tack welding of bucket components	60	O					VA
	Fill welding of main components and reinforcements	360	O					VA
	Further welding and weld repair	146	O					NVA
	Waiting for operators, tools, materials, or other job priorities	2460					D	NVA
	Grinding of cutting and welding results	244	O					VA
	Simple heat treatment	38	O					VA
Bucket Component Assembly	Installation of the main floor and bucket walls	145	O					VA
	Installation of reinforcements, protectors, and ribs	146	O					VA
	Final adjustment of bucket shape and dimensions	145	O					VA
Quality Control	Dimensional and weld conformity inspection	15			I			NNVA
	Final inspection before painting	7			I			NVA
Painting	Preparation of paint and painting equipment	43	O					NNVA
	Base and finishing painting (multi-layer)	24	O					VA
	Paint drying waiting time	52					D	NVA
Assembly to Excavator Unit & Handover to Customer	Reinstallation of the bucket to the excavator unit	30	O					VA
	Transfer of the bucket for customer pickup	10		T				NNVA
	Work reporting and administrative processing	–	O					NNVA
Lead Time			21	4	3	0	3	VA = 15 NVA = 5 NNVA = 11

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

5. *Fishbone Diagram*

Based on the results of the Recapitulation of Waste Weighting Questionnaire Scores, the three dominant types of waste identified with the highest weights were unnecessary motion, waiting, and defect, therefore, a Fishbone Diagram analysis was conducted to determine the root causes of these inefficiencies in the excavator bucket repair process which can be seen by Figure 3 below:

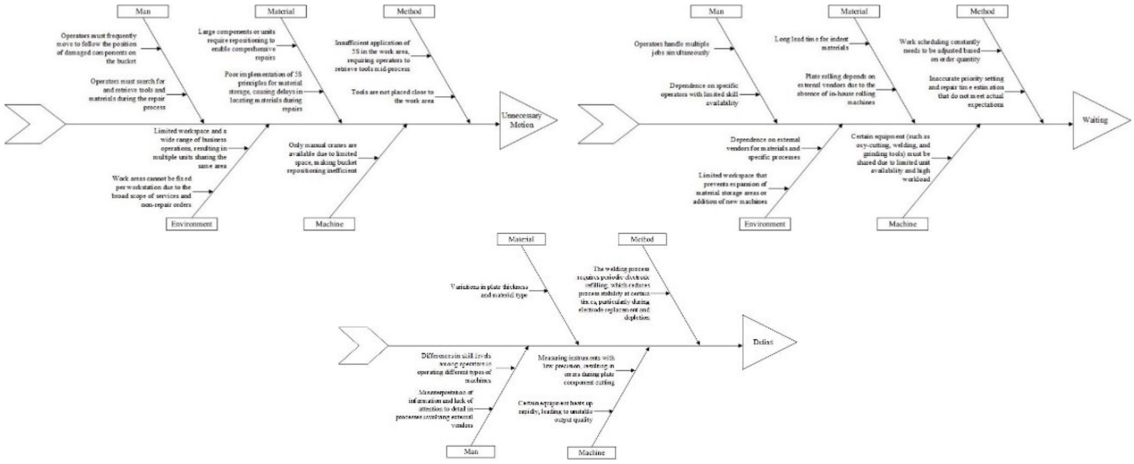


Figure 3. Process Activity Mapping (PAM)

The analysis indicates that defects are primarily caused by variations in operator skill levels, miscommunication in processes involving external vendors, differences in plate thickness and material types, unstable welding processes due to repeated electrode refilling, and the use of imprecise or overheated equipment that affects cutting accuracy and machining stability. Unnecessary motion is mainly attributed to operators frequently moving to follow damaged bucket components, retrieving tools and materials during repair activities due to inadequate workplace organization, limited workspace that prevents fixed workstations, repeated repositioning of large components, and reliance on manual cranes for bucket reorientation. Meanwhile, waiting waste is largely influenced by operators handling multiple jobs simultaneously, dependence on specific skilled personnel, delays in indent material delivery, outsourcing of plate rolling processes to external vendors, shared usage of critical equipment such as oxy-cutting, welding, and grinding tools, as well as non-standardized work scheduling and inaccurate repair time estimation. These findings highlight that inefficiencies are driven by interrelated factors involving manpower, machinery, methods, materials, and the working environment.

6. *Future Value Stream Mapping*

Non-value added (NVA) activities identified through the Process Activity Mapping (PAM) analysis were subsequently eliminated, leading to adjustments in the excavator bucket repair workflow, which are represented in the Future Value Stream Mapping which can be seen by Figure 4 below:

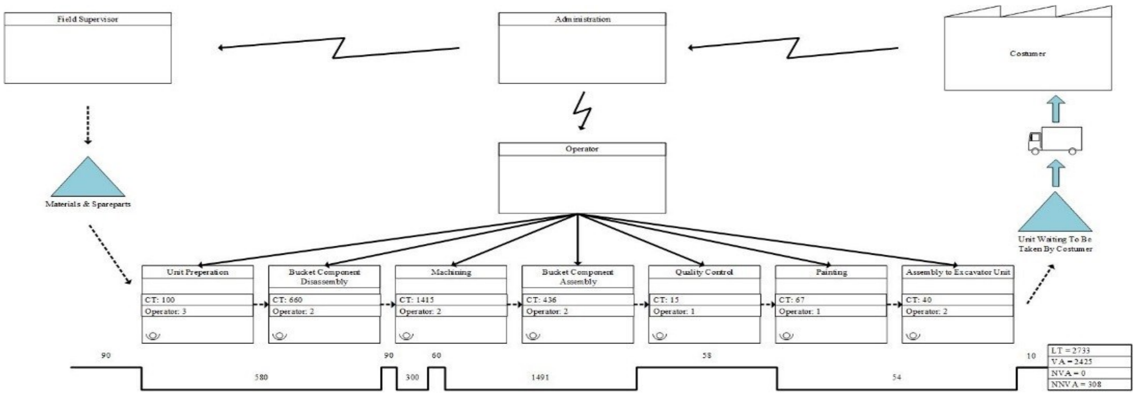


Figure 4. Future Value Stream Mapping

Activities such as dimensional adjustment after rolling and additional cutting, further welding and weld repair, and waiting for operators, tools, materials, or other job priorities were classified as NVA and therefore removed from the process. In addition, inspection activities were found to be conducted excessively (overprocessing), as comprehensive dimensional and machining checks had already been performed earlier; thus, redundant inspections were eliminated to improve repair efficiency. Similarly, paint drying waiting time was minimized through improved workflow arrangement and the application of more effective drying methods, thereby reducing overall lead time.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

7. *Improvement Recommendation by Implementing 5S*

Improvement recommendation based on the 5S approach can enhance repair efficiency at PT XYZ through the following implementations. Under the *Seiri* principle, material classification and sorting are conducted, along with the elimination of rarely used equipment to reduce accumulation and minimize unnecessary motion waste. For *Seiton*, improvements are proposed through material flow relayout, the implementation of kanban cards to support smoother inventory systems and reduce unnecessary motion, as well as better organization of tools and personal protective equipment (PPE) using racks and shadow boards which can be seen by Figure 5 and 6 below.

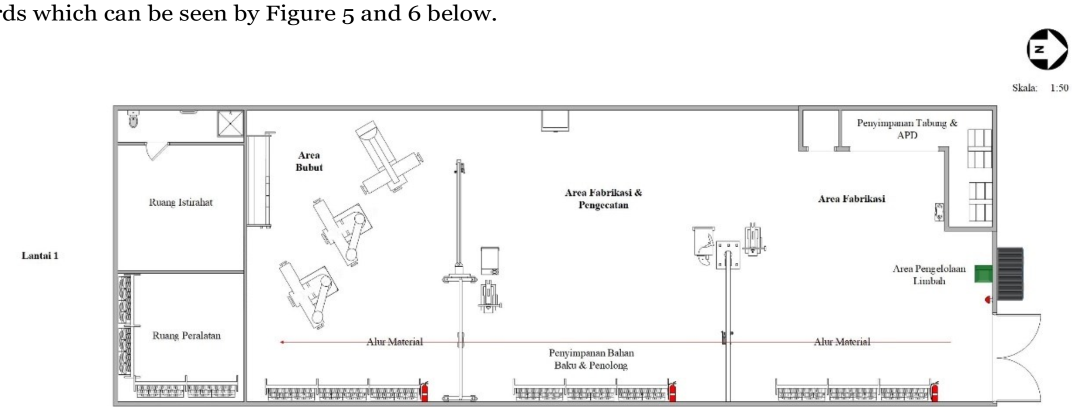


Figure 5. Proposed Seiton Implementation through Work Area Relayout Based on Material Flow

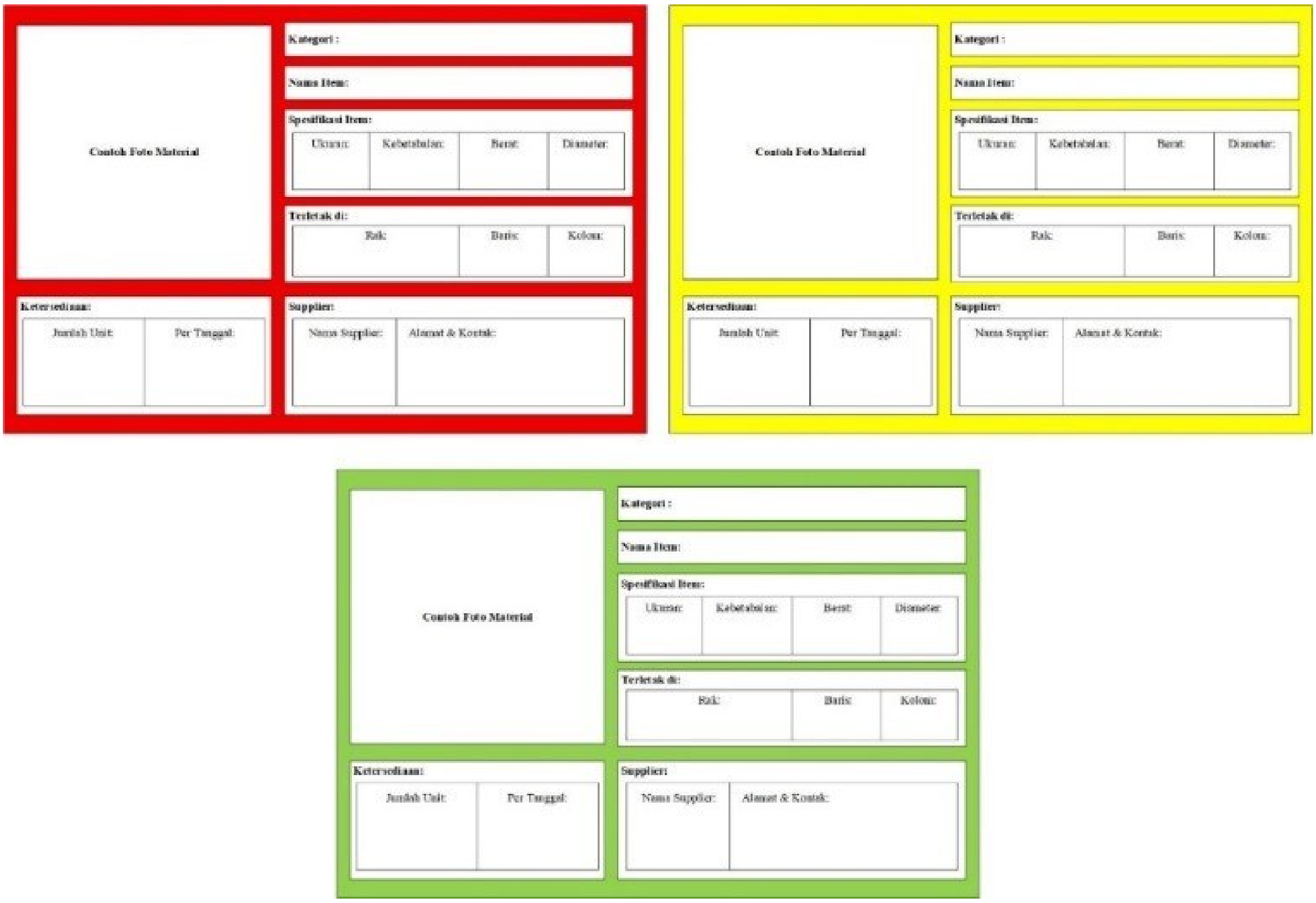


Figure 6. Example of Seiton Implementation through the Use of Kanban Cards in Material Control System

In terms of *Seiso*, thorough cleaning of oil residues and dirt is carried out alongside routine maintenance of machines and measuring instruments to maintain precision and reduce the risk of rework. Under *Seiketsu*, standardization of the inventory control system is implemented through the establishment of safety stock limits, an integrated inventory recording system, and the development of standard operating procedures (SOPs) for kanban card usage. Lastly, under *Shitsuke*, periodic 5S audits are proposed, along with the assignment of a Person in Charge (PIC) for each work area and the integration of 5S compliance indicators into the operator performance evaluation system.

C. Result and Discussion

Table 5 presents a comparison of repair process activities before and after the elimination of non-value added (NVA) activities, as identified through the Process Activity Mapping (PAM) analysis. Prior to improvement, the bucket repair process consisted of 31 activities with a total lead time of 5,543 minutes, where delay and unnecessary waiting activities contributed significantly to the overall duration, accounting for 2,572 minutes (46.40%) of the total process time. In contrast, value added (VA) activities accounted for only 2,425 minutes (43.75%), while NVA activities consumed the largest proportion of total duration at 2,810 minutes (50.69%), indicating substantial process inefficiencies primarily caused by waiting for material availability, operator readiness, equipment usage, and paint drying time which presented by Table 5 below:

Following the identification of waste sources using the Fishbone Diagram and the implementation of improvement strategies based on the 5S approach, NVA activities were successfully eliminated from the repair workflow. As a result, the total number of activities decreased from 31 to 26, and the total lead time was reduced to 2,733 minutes. Thereby increase the proportion of PCE from 43.75% to 88.73% of the total process duration. These improvements shows that the elimination of NVA activities impacting the process efficiency by reallocating time toward core operational activities that directly contribute to restoring the bucket's functional performance and is consistent with previous studies on maintenance and repair operations [19], where Lean Manufacturing tools have been shown to reduce process delays caused by waiting time, workspace limitations, and inefficient workflow organization. In addition, the implementation of 5S supports better workplace organization and smoother operational flow and improves maintenance process efficiency.

Conclusion

Based on the waste identification results in the excavator bucket repair process at PT XYZ, the most dominant waste types are unnecessary motion (0.21), followed by waiting (0.198) and defect (0.16). Process Activity Mapping (PAM) analysis shows that from the total lead time of 5,543 minutes, value-added (VA) activities account for 2,425 minutes (48.39%), non-value-added (NVA) activities for 2,810 minutes (16.13%), and necessary non-value added (NNVA) activities for 308 minutes (35.48%). According to the fishbone diagram analysis, the main causes of waste include ineffective material layout, non-standardized inventory systems, disorganized tool storage, and waiting times caused by coordination issues and material availability problems. Improvements based on the 5S principles are proposed, including material classification, workflow relayout with kanban-based inventory control, workplace cleaning, inventory standardization, and periodic audits. NVA activities elimination resulting the decreasing lead time to 2,733 minutes and Process Cycle Efficiency (PCE) increasing from 43.75% to 88.73%. By the improvements suggestions, waste are reduced significantly and improve repair efficiency. These findings provide practical insights for heavy equipment repair companies in implementing Lean-based improvements, while future research may extend this approach to other maintenance processes or integrate digital monitoring systems for real-time waste identification.

References

1. BPS, Indikator Konstruksi Triwulan I 2025. Jakarta, Indonesia: Badan Pusat Statistik, 2025. [Online]. Available: https://www.bps.go.id/id/publication/2025/06/30/bda0b92469ca6711d3a6bf57/indikator-konstruksi--triwulan-i-2025.html
2. PT Wijaya Karya Bangunan Gedung Tbk, Transformation Journey to Achieve Sustainable Growth: Annual Report 2024. Jakarta, Indonesia: PT Wijaya Karya Bangunan Gedung Tbk, 2024. [Online]. Available: https://investor.wikagedung.co.id/misc/media/downloads/annual-report-2024-1762373653.pdf
3. E. V. Y. Waney, S. Runtunuwu, D. Y. F. Mandang, and K. A. C. Lamia, "Analisis Produktivitas Alat Berat dan Harga Satuan pada Proyek Peningkatan Jalan Ruas Dalam Kota Airmadidi," Jurnal Ilmiah Media Engineering, vol. 13, no. 1, pp. 1–14, 2023. [Online]. Available: https://ejournal.unsrat.ac.id/v3/index.php/jime/article/view/49213
4. F. R. Sitinjak and F. T. R. Silalahi, "Analisis Strategi Pemeliharaan Preventive Maintenance Excavator Menggunakan Pendekatan Analytical Hierarchy Process (AHP) dan Analisis Sensitivitas," Journal of Integrated Systems, vol. 6, no. 2, pp. 226–242, 2023, doi: 10.28932/jis.v6i2.7633.
5. A. R. Asman and E. P. Widjajati, "Analisis Kebijakan Perawatan Mesin Secara Corrective dan Preventive dengan Metode Reliability Centered Maintenance (RCM) di CV XYZ," JUMINTEN: Jurnal Manajemen Industri dan Teknologi, vol. 2, no. 3, pp. 24–34, 2021, doi: 10.33005/juminten.v2i3.283.
6. A. W. Arohman, M. Agus, Solahhudin, and D. Agustin, "Analisis Preventive Maintenance pada Mesin Injection Molding dengan Metode Mean Time Between Failure dan Mean Time to Repair di PT XYZ," Jurnal Serambi Engineering, vol. 9, no. 1, pp. 7623–7630, 2024, doi: 10.32672/jse.v9i1.720.
7. L. Moldovan and M. Magyari, "Aspects Regarding the Repair of Electrical Equipment Designed for Use in Potentially Explosive Atmospheres," MATEC Web of Conferences, vol. 373, p. 00011, 2022, doi: 10.1051/matecconf/202237300011.
8. K. K. Demilza, A. A. Rachman, N. Anisa, A. H. N. Azizah, S. A. N. Nugroho, and K. A. Husyairi, "Pendekatan Konsep Lean untuk Mengurangi Lead Time dan Waste Transportasi: Studi Kasus pada PT Eteris Prima Wiyasa," Indonesian Research Journal of Education, vol. 4, no. 4, pp. 1953–1960, 2024, doi: 10.31004/irje.v4i4.1583.
9. H. A. Prabowo, F. Farida, and A. Husnur, "Pengenalan Konsep Lean untuk Meningkatkan Efisiensi Melalui Waste Elimination," ABDI MASSA: Jurnal Pengabdian Nasional, vol. 3, no. 3, pp. 12–22, 2023, doi: 10.69957/abdimass.v3i03.982.
10. B. N. J. Lawal, "Lean Manufacturing and Its Impact on Supply Chain Efficiency," American Journal of Humanities and Social Sciences Research, vol. 9, no. 4, pp. 88–98, 2025. [Online]. Available: https://www.ajhssr.com/wp-content/uploads/2025/04/J259048898.pdf
11. S. Suradi, D. Lantara, and A. Padhil, "Waste Analysis of Tapioca Unloading Process with Lean Supply Chain Approach in Makassar Port," Acta Logistica, vol. 10, no. 1, pp. 71–77, 2023, doi: 10.22306/al.v10i1.353.

Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13792

12. P. Moengin and N. Ayunda, “Lean Manufacturing untuk Meminimasi Lead Time dan Waste agar Tercapainya Target Produksi (Studi Kasus: PT Rollflex Manufacturing Indonesia),” Jurnal Teknik Industri, vol. 11, no. 1, pp. 77–92, 2021, doi: 10.25105/jti.v11i1.9699.
13. S. Nasution, A. Haq, and S. Karmilah, “The Application of Lean Supply Chain in the Process of Loading and Unloading Fish in UKM Camar Laut South Jakarta,” Jurnal Ilmiah Teknik, vol. 3, no. 1, pp. 81–89, 2023, doi: 10.56127/juit.v3i1.1170.
14. R. Ahmad, R. F. M. Amin, and S. A. Mustafa, “Value Stream Mapping with Lean Thinking Model for Effective Non-Value Added Identification, Evaluation and Solution Processes,” Operations Management Research, vol. 15, no. 3–4, pp. 1490–1509, 2022, doi: 10.1007/s12063-022-00265-9.
15. N. R. Nurwulan, A. A. Taghsya, E. D. Astuti, R. A. Fitri, and S. R. K. Nisa, “Pengurangan Lead Time dengan Lean Manufacturing: Kajian Literatur,” Jurnal Industri Manufaktur Engineering, vol. 5, no. 1, pp. 30–40, 2021, doi: 10.31289/jime.v5i1.3851.
16. P. Lamtiur, M. Hermanto, S. Aprilyanti, N. Alamsyah, and P. Togar, “Implementasi 5S (Seiri, Seiton, Seiso, Seiketsu, dan Shitsuke) pada Bagian Workshop di PT Agrotamex Sumindo Abadi,” Jurnal Desiminasi Teknologi, vol. 11, no. 2, pp. 122–127, 2023, doi: 10.52333/destek.v11i2.178.
17. T. Z. Fitri et al., “Implementasi 5S di Industri Manufaktur,” Journal of Engineering Science and Technology Management, vol. 4, no. 2, pp. 76–82, 2024, doi: 10.31004/jestm.v4i2.189.
18. A. Hafidz and D. Soediantono, “Benefits of 5S Implementation and Recommendations in the Defense Industry: A Literature Review,” International Journal of Social and Management Studies, vol. 3, no. 3, pp. 13–26, 2022, doi:10.5555/ijosmas.v3i3.139.
19. K. Radecka, “Improving Business Maintenance Processes Using Lean Manufacturing Tools: Case Study,” Zeszyty Naukowe Organizacja i Zarządzanie Politechniki Śląskiej, no. 156, pp. 395–405, 2022, doi: 10.29119/1641-3466.2022.156.27.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo