ISSN 2087-3336 (Print) | 2721-4729 (Online)
TEKNOSAINS: Jurnal Sains, Teknologi dan Informatika
Vol. 12, No. 2, 2025, page. 191-203
http://jurnal.sttmcileungsi.ac.id/index.php/tekno
https://doi.org/10.37373/tekno.v12i2

Reduction of changeover time and solvent cleaning cost in tank cleaning process in paint manufacturing industry in Indonesia

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Submitted: 31/01/2025 Revised: 06/03/2025 Accepted: 16/03/2025

ABSTRACT

In the era of globalization, competition in the manufacturing industry is increasing, especially regarding product quality and customer service. One of the paint manufacturing companies in Indonesia has experienced an increase in production volume in line with increasing market demand, as reflected in annual sales growth of 25-29%. As a market leader in the field of marine coatings and protective coatings with a market share of more than 29%. These challenges impact the tank cleaning process, which directly affects the duration of change over time with each product changeover. Based on company standards, the ideal changeover time is 30 minutes for each product changeover during tank cleaning. This research aims to reduce the duration of changes over time and reduce wasted costs in purchasing cleaning solvents (solvents) needed in the tank cleaning process at each batch change. The method of this research is a combination of A3 Problem Solving and Single-Minute Exchange of Dies (SMED), which is designed to compile documentation solutions in a consistent, clear, and structured manner. Research findings reveal that the duration of the initial change required reaches 95 minutes with a monthly solvent purchase cost of IDR 10,500,000. By converting several internal activities into external activities, the duration of the change to be completed was reduced to 30 minutes, and the completion cost was IDR 3,500,000 per month. Overall, this research shows an over-time change efficiency of 68% and operational cost savings of up to 66% in the tank cleaning process.

Keywords: A3 problem solving; cleaning tank; change over time; improvement, SMED

1. INTRODUCTION

In the current era of globalization, especially in the industrial world, competition between companies is increasingly fierce for all industrial sectors [1]. Product quality and customer service are common areas where companies compete, particularly when it comes to consumer pleasure [2]. In general, the faster a company can fulfill orders to consumers, the more satisfied consumers will feel [3]. This is because consumers can fulfill their needs more quickly, so the production process will not be hampered in its operations [4]. Companies may get many advantages from minimizing labor expenses, machine hours, power costs, and customer trust by rapidly and successfully delivering orders, etc, [5], [6]. This can be called repetitive work or any wasteful activity that will increase costs or unnecessary costs [7].

The way to achieve cost savings is to improve the production process continuously so that waste of material, costs, and time can be minimized [8]. The company provides targets in all production activities which have a close relationship with the manufacturing process [9]. Company targets in a manufacturing context are parameters used to measure the performance of a facility or production process [10]. This paint manufacturing industry has a standard change from time to time of 30 minutes for each product

change. High cleaning process times and the cost of using solvents to clean tanks are challenges during the batch replacement process. The cleaning process time for the cleaning matrix tank before repairs can be seen in Figure 1.

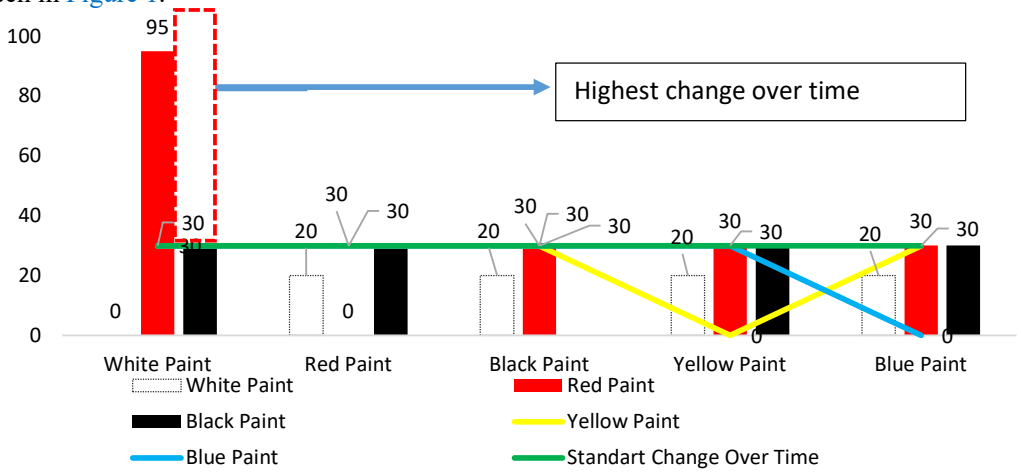

Figure 1. Cleaning matrix tank cleaning process time

Based on Figure 1, the peak change over time in product changes from red to white products is 95 minutes, this is a challenge for the paint manufacturing industry as a marine paint and protective coating industry in Indonesia to be able to move quickly to meet demand with high product variants. Quality is evident in every step of a production process, from raw materials to cleaning between batches [11]. No matter how good the product is, if there are many obstacles in the manufacturing process, then the product cannot be said to be good, it could even be said to be unsuitable for production because the time required is high and costs increase so that it is no longer competitive [12]. This research illustrates how batch changes are important in accelerating the production process so that product delivery to customers meets demand. Meanwhile, another problem is the high cost of solvent-cleaning materials that are imported. The costs of purchasing solvent cleaners can be seen in Table 1.

Table 1. Solvent cleaning costs April - June 2024 (before improvement)

2024	Cost solvent disposal
April	Rp 10.500.000,00
May	Rp 10.700.000,00
June	Rp 10.300.000,00
Average	Rp 10.500.000,00

Source: Production Data of PT. XYZ (2024)

Table 1 explains the high costs incurred in 1 month for purchasing solvent cleaning, amounting to IDR 10,500,0000. Currently, companies are required to always improve their performance and productivity. The way to achieve this is by improving the production process continuously and sustainably so that waste of material, costs, and time can be minimized. Lessening the need for solvent cleaning and slowing down the rate of change, it is possible to combine A3 and SMED troubleshooting methods. The A3 report method and SMED method can be used in the improvement process comprehensively and analyzing every activity that becomes an obstacle in the production process [13], [14].

As a tool and a method for developing organized approaches to tackling problems, A3 problem-solving is useful. Lean thinking is used for problem-solving in A3 problem-solving, an improvement approach [15]. An orderly and thorough report may be presented on a single page using this method. As a first step in learning how to apply lean thinking to problems, this tool is helpful [16]. The SMED method is a lean manufacturing improvement method used to speed up the time required to organize a change from producing the remainder of one type of product to another product model [17]. This process

involves supervision, testing, monitoring, analysis, and corrective action necessary to ensure that the resulting product or service meets or exceeds customer expectations and applicable standards [18]. Changes over time are of course an important concern because they have a direct effect on the time it takes to switch products [11]. The company has a standard change over time of 30 minutes for each product change, so this research is motivated to choose the topic of A3 problem solving and the SMED method to reduce changes over time and solvent cleaning costs in the tank cleaning process in the paint manufacturing industry.

To solve issues and encourage competence, Toyota makes heavy use of the A3 paper structure, which includes problem-solving [13]. Applying lean thinking to issue solutions, the A3 technique offers a thorough and structured report on one page. It is an improvement process. With the A3 report's straightforward and easy-to-understand building blocks as a starting point, this improvement tool helps prepare to use lean thinking to address issues [19]. In cases when ideas should be brought to light more prominently, A3 reports are also suggested. Further, it needs to be used in cases when there exists a disparity in persons' levels of knowledge [20]. Figure 2 shows the A3 report's logical flow, which aids in understanding the issue and finding the correct answer.

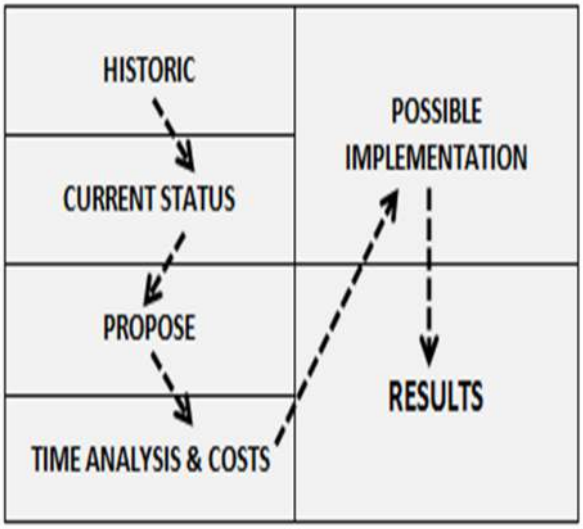

Figure 2. The logic flow of the report [21]

Quickening the process of managing changes from creating one product model to another is the goal of the SMED technique, a lean manufacturing improvement strategy. Since it does not benefit consumers and leads to inefficient procedures, replacement setup time is a kind of waste that the lean concept seeks to eradicate [22], [23]. Lost time in production series modifications due to running setup may be better understood and addressed using SMED, a technique for that. A tool change on a production line was originally defined as something that should take no more than 10 minutes to do. It deals with a set of techniques to minimize setup time, contribute to reduced equipment downtime, and increase production throughput. Additionally, product diversity and increasing volumes of small orders are making organizations optimize their equipment setup processes to produce a wide range of products. Streamlining the management of product changeovers is a primary goal of SMED, a lean manufacturing improvement strategy [24]. The word one minute does not mean that the setup time only takes one minute, but it takes less than 10 minutes, or in other words, it can be called single-digit minutes [25]. Change over time is defined as the time of change or the time to stop before the next product is launched. So in changes from time to time, there are organizational times such as cleaning machines or tanks, preparing setup equipment, and starting up. The problem phenomenon during the change over time can be seen in Figure 3.

Based on Figure 3, a completion time that is slower than the specified time will disrupt the company's smooth operations. Timely completion of the job depends on knowing which tasks are next and when they will be finished. Work completion delays will lead to higher time and cost estimates. There are two types of activities: internal and external. Internal time refers to the time needed to manage

the machine while it is not functioning or working. On the other hand, the time needed to carry out regulatory-related tasks before and after the regulatory period is known as external time [26].

This step is intended to convert internal activities into external activities. The Kaizen activities using the Single Minute Exchange of Die (SMED) method are very effective in supporting process improvements during product changes [27]. Greater adaptability and enhanced product flow in the production area are two outcomes of implementing SMED [26]. The novelty of this research is the use of the A3 report method to make conceptual and structured improvements. Meanwhile, the SMED method can speed up the time needed to arrange the replacement of paint items.

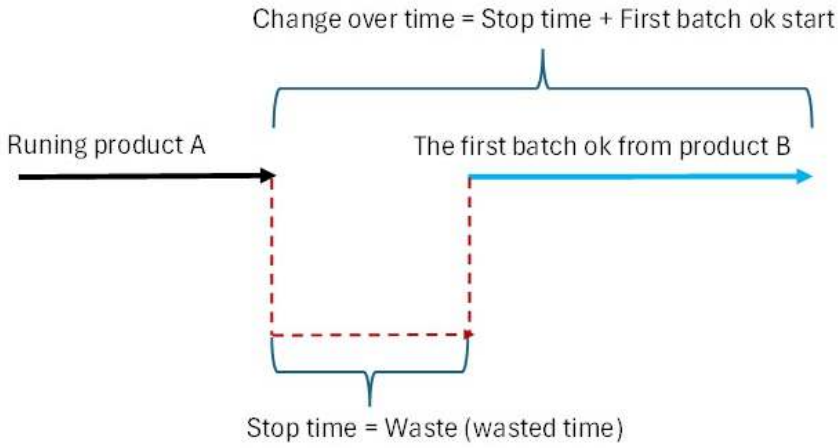

Figure 3. Definition of change over time

The combination of the two methods can reduce the changeover time for paint production items and save on cleaning material when used as a tank cleaning material. This research aims to reduce the duration of change over time and reduce wasted costs in purchasing cleaning solvents needed in the tank cleaning process at each batch change.

2. METHOD

For each product modification, this study used a descriptive exploratory approach to identify and explain issues, their causes, and potential remedies via the gradual reduction of changes in the tank cleaning procedure. The quantitative part of this study relies on mathematical calculations to limit changes over time and the expense of buying cleaning solvents, while the qualitative part relies on expert judgment. Here, we'll go over the whole research process from start to finish using the A3 problem-solving approach, which encompasses the SMED method. The A3 report is a method for improving processes by addressing problems using lean principles. An orderly and thorough report may be presented on a single page using this method. This tool is helpful when getting ready to use lean thinking to address problems. This seems to be because an A3 report's building pieces are straightforward to grasp. The following are some possible uses for A3 sheets: context/business case, present state/root cause analysis, objectives/targets, activities, and metrics. As a result, any business may modify the A3 report's foundational components to fit its unique circumstances. Table 2 shows the steps to implement the A3 technique.

The first stage, as shown in Table 2, is to gather the necessary data following the A3 problem-solving report. This data should include background information that would explain the problem's occurrence in the firm. At this stage, the company is thinking about how to reduce change over time and reduce purchasing solvent cleaning in 1 week because of the high change over time and operational costs in purchasing solvent cleaning. in the change-over-time process in the tank cleaning process, every product change always increases. Therefore, for the sake of the company's sustainability in saving on purchasing changes over time and purchasing materials, improvements need to be made, which are expected to reduce changes over time and operational costs for purchasing materials. The second stage

is to create a Fishbone analysis, explaining the root causes of the problems that occur based on several existing aspects. Analysis of the causes of this problem was carried out by conducting a Focus Group Discussion (FGD) on 4 related aspects, namely methods, machines, materials, and people. FGD members can be filled with an odd number of experts who are experienced in their respective fields [28]. The third stage of goal setting describes the targets to be achieved to solve problems in problem-solving theme A3. Then, do a trial run from start to finish to test pipe changes by adding air injection. The fourth stage is to create an activity schedule that explains the stages of implementing activities following the A3 report that has been created. Then, a risk assessment of repairing wind injection at the bottom of the T-valve through FGD. The fifth stage is to carry out measurements, namely explaining the stages of measuring the results of the success of the A3 problem-solving method that has been explained and the actions that must be taken. The next step is to conduct a comparative analysis of changes over time and the purchasing costs of solvent cleaning before and after improvements.

Table 2. Research stages

Business Case	Future State
1. The high change over time in the tank cleaning process from red paint products to white paint products, the time required is 95 minutes 2. The cost of solvent cleaning which is incurred every week is IDR 10,500,000	1. The Company's target change over time is 30 minutes. 2. Reduction of solvent cleaning costs
Root Cause Analysis (RCA) 1. Use the right tool for your problem, for example, a. Fishbone Analysis b. SMED	Action/Responsible/Due Date 1. Define actions to improve by trial timeline 2022 using cleaning agents from the internal company. 2. Workplace risk assessment activities with the FGD team.
	Measurement 1. The result of Change over time after improvement. 2. Cost of solvent cleaning consumption after improvement.

3. RESULT AND DISCUSSION

In this section, we will discuss the research results based on the methods used. In the previous section, it was explained that this research uses research steps in the form of the A3 problem-solving method where there is SMED to reduce changes over time and the cost of purchasing solvent cleaners in the cleaning process tank for each product change.

Business case

The result of the first step is that the company investigates to collect research data on the product change cleaning process when cleaning the tank from red product to white product. To achieve the results of reducing changes over time using A3 and SMED problem-solving methods. Carrying out observation activities during the tank-cleaning process is one of the corrective actions needed to support improvements.

The first action carried out is observation, and in this way, the size of the problem is assessed, making it possible to create indicators that monitor improvements. Observation activities are carried out in the tank cleaning process during product change from 16-27 Sept 2024. Based on data collection results, calculate the normal times for each data replacement time. Observation activities are carried out in the process of cleaning product replacement in the cleaning tank, which describes the internal and

external processes. The following is an observation of the product replacement process during tank cleaning in Table 3.

Table 3. Data activities of the tank cleaning process at the time of product changeover

Dept.	Production	Change over the cleaning tank when changing red to white products.		
Activity no	Description of activity (cleaning tank)	Time		Type
		Min	Sec	
1	Thinner intake	5	0	Internal
2	Rinse thinner on dirty tanks	5	0	Internal
3	Scrub the tank using a long brush	10	0	Internal
4	flushing the tank using a thinner	5	0	Internal
5	Carry waste thinner in the drum	5	0	Internal
6	Disassembling the Bottom Valve for Cleaning the Inside of the Valve	30	0	Internal
7	Cleaning the bottom valve that has been dismantled	5	0	Internal
8	Reinstall the bottom valve	30	0	Internal
		Total Time		
		Internal		External
		95		0

Based on Table 3, the results of observations show that the problems faced are high changes over time, namely 95 minutes during tank cleaning, and all activity processes are included in internal activities. High changes over time can affect the total completion time of a product and the amount of product produced, so this research aims to increase the tank cleaning process time using the SMED method.

Root Cause Analysis

Using some preexisting factors, this section describes the repair outcomes obtained via the use of the Fishbone Analysis repair tool. Root cause analysis in a combination of the A3 problem-solving and SMED methods aims to identify the main causes of problems that hinder the efficiency of the machine setup or replacement process. This analysis technique helps understand the root of the problem and ensures that the solutions implemented are effective and sustainable. Four factors methods, machines, materials, and humans were identified as causative in the Fishbone diagram. In each aspect, the root of the problem will be traced in detail using cause and effect analysis for each causal factor. Fishbone diagrams are used to conduct root cause analysis with ideas outlined using fishbone diagrams [29]. Next, the root cause of the problem and the solution identified for each common cause for corrective action can be seen in Figure 4.

The findings of the investigation are shown in Figure 4 using a fishbone diagram. Several departments, including manufacturing, maintenance, HSEQ, buying, and finance, were represented in the FGDs that carried out the study. Considering the findings from the examinations, the change from time to time required for the process of changing a product from a red product to a white product is 95 minutes so all activities enter internal activities. Below is the lower valve cleaned before repair (before using A3 and SMED troubleshooting methods).

Future state

The A3 methodology took a key role in this project, allowing monitoring of the effectiveness of the various remedial measures put in place to ensure their transferability to future enhancement initiatives [13]. The paint manufacturing industry has a standard change from time to time of 30 minutes. Based on the results of the observations above of the total change over time of 95 minutes, it is known that the cause of the change over time in the tank cleaning process is the valve installation and dismantling process which takes 60 minutes. Changes to processes in the workplace raise serious concerns about potential hazards. So, to make sure that process adjustments are always safe, risk assessments are done

again. Risk assessment activities in the workplace with FGD teams involved starting from production, maintenance, HSEQ, and finance. This can be seen in Table 4.

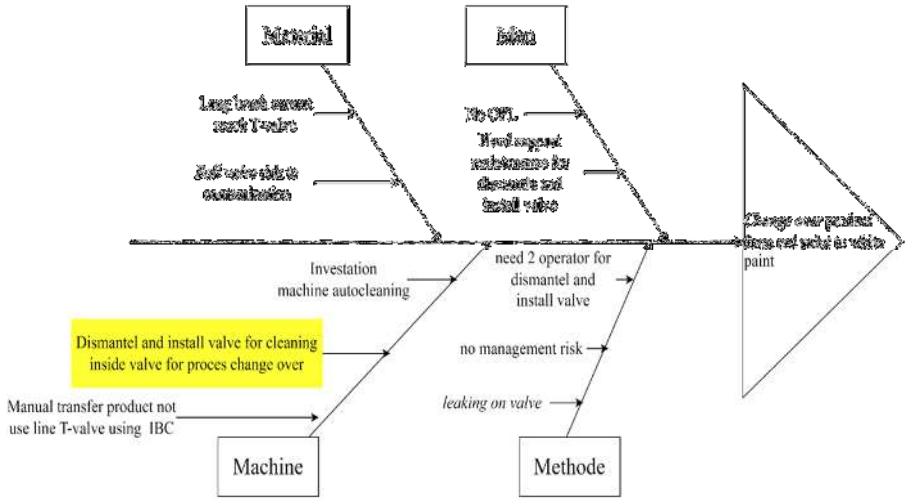

Figure 4. Fishbone diagrams

Table 4. Workplace risk assessment activities after improvement

Area/Scope:	FGD Participants				
SB Area – Change over cleaning tank when changing red to white products	1. Production 2. Maintenance 3. Finance 4. HSEQ 5. PPIC			Date: September 23, 2024	
Description of task/Area	Hazard Description	Existing Control Measures	Current Risk	Planned Improvement Actions	Residual Risk
Air injection trial	Splash	Using PPE	1D		1D
RCA and Gemba	No hazard		1A		1A
Forgetting to open and close the injection valve	contaminate	OPL & PPE	2D	Training	1D
Eyes exposed to paint splashes.	Irritant	OPL & PPE	2D	Training	1D
Cleaning is not clean	contaminate	OPL & PPE	2D	Training	1D

Action

Here, the activity schedule details the steps to take after reviewing the researcher's A3 report to put the plan into motion and bring the A3 problem-solving technique process under control. Enhancing and managing the quality of output calls for an innovative method of management known as Total Quality Management (TQM) that emphasizes the importance of both human and mechanical components in the pursuit of excellence [30]. When done well, a project timeline panel may be a strong tool for encouraging fruitful discussion and mutual learning thanks to its cross-functional design [31]. The corrective action schedule or action timeline can be seen in Table 5.

Table 5. Timeline action April 2024 – December 2024

No	Activities	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	PIC	Status
1	Observation data change over time										Spv	Done

No	Activities	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	PIC	Status
2	Air injection installation on the bottom T-valve										MTC	Done
3	Monitoring of the results of air injection improvement during T-valve cleaning										Spv	Done

Measurement

Determine whether or not the A3 problem-solving approach under consideration was successful, it is necessary to follow the steps outlined in the measurement section. The issue of team members' views and background Many of the participating teams consider this to be one of the most significant challenges to effective problem-solving. Without the right background information (such as the components involved), problem solvers often struggle to describe a specific issue [32]. The activities of the tank cleaning process during product changeover after improvement can be seen in Table 6.

Table 6. Activities of the tank cleaning process during product changeover after improvement

Dept	Production	Machine no	001.KBJ			Improvement			
Activity no	Description of activity		Time Min	Time Sec	Type	Change/activity	Time Min	Time Sec	Type
1	Thinner intake		5	0	Internal	no change	5	0	Internal
2	Rinse thinner on dirty tanks		5	0	Internal	no change	5	0	Internal
3	Scrub the tank using a long brush		10	0	Internal	no change	10	0	Internal
4	flushing the tank using a thinner		5	0	Internal	no change	5	0	Internal
5	Carry waste thinner in the drum		5	0	Internal	Open the Bubbling Thinner valve, then place the bubbling results in the drum	5	0	External
6	Bottom Valve Bump for Cleaning the Inside of the Valve		30	0	Internal				
7	Cleaning the bottom valve that has been dismantled		5	0	Internal				
8	Reinstall the bottom valve		30	0	Internal				
Total Time Before Improvement			95		min: sec	Total Time After Improvement	30		min: sec

Based on Table 6, the results of the data analysis that have been carried out, researchers obtained quite significant results in changes over time after repairs by changing the internal activities of the valve assembly and disassembly process into external activities by adding air injection to the T-valve cleaning process. The improvements in the transfer of internal and external activities can be seen in Table 7.

Based on Table 7, after improvements using a combination of A3 and SMED problem-solving methods, the company obtained change results over time according to company standards, namely 30 minutes. The research was carried out on the most difficult and time-consuming tank cleaning process in the process of changing from red paint to a white product and had quite an impact.

Table 7. Data on improvement results from the transfer of internal and external activities

	Time changes			
	Internal	External	Changeover time	
Time before	95	0	Old	New
Time after	30	5		
Saved time	65	-5	95	30

Improvements Report on the actions that have been carried out and the findings after evaluating the production department against production objectives and procedures. Verify once again whether it has been executed or not, and whether it has followed existing standards. Changing internal activities into external activities by discussing with operators, maintenance, HSEQ, and finance. After these changes have been made, the next step is observation to monitor the results of the improvisation. Evaluation of the results of each corrective action is necessary to ensure that each action is following the corrective plan [33]. The results of changes over observations after improvements to other matrix cleaning products can be seen in Figure 5.

Based on Figure 5, after improvements were made by adding air injection to the T-valve cleaning process, the tank cleaning process during the change over time from red paint products to white paint products became according to the Company's standard, namely 30 minutes. Meanwhile, the matrix cleaning results from increasing the addition of air injection during the cleaning process can be seen in Figure 6.

Based on Figure 6, the movement of solvent used for cleaning tends to decrease after improving the combination of solving the A3 problem and the SMED method by adding air injection during the tank cleaning process. Figure 6, you can see the movement before and after the repair, this result has a positive impact on the company, before the repair the company spent IDR 10,500,000 for solvent cleaning every week. With this increase, the company spends IDR 3,500,000 every week. The A3 idea, when applied to improvements, may foster strong cross-departmental collaboration. If the A3 principle is followed, the path of progress will be just where it needs to be. Because the whole procedure is laid out on only one page of the paper, A3 reports are simple to comprehend. Then this A3 report can also maintain these results and improve the results that have been achieved better than before. The A3 report usually ends with the creation of a standard in the form of an OPL which is socialized to all employees [34]. One way is to create an OPL to standardize all cleaning processes agreed upon by the FGD as shown in Figure 7.

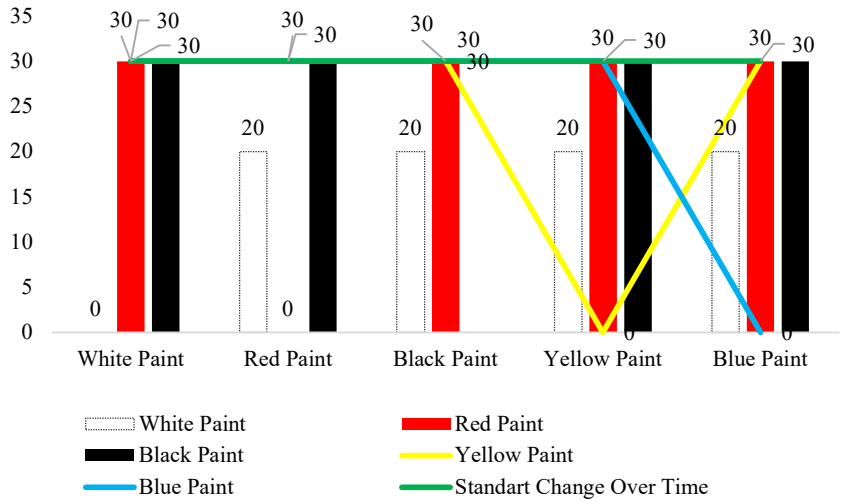

Figure 5. Cleaning matrix after improvement

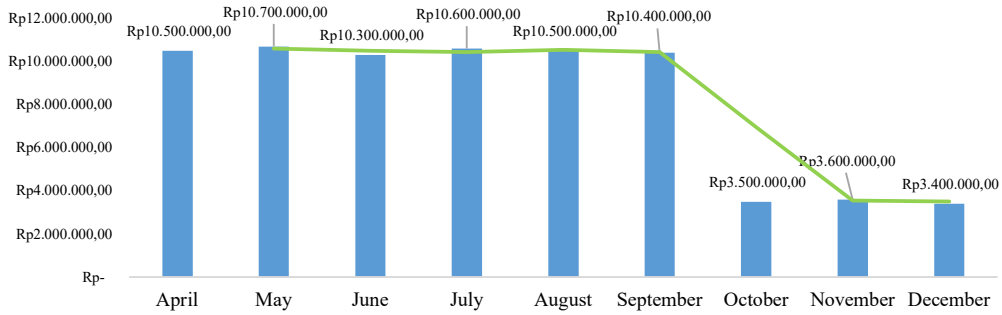

Figure 6. Cost solvent cleaning 2024

Line/Area: Charging & Filling Sb Topic: Tank Cleanliness After Filling	Issued by Supervisor	Approved by Manager

Solvent Base Cleaning Process: After the filling process is completed, the tank must be cleaned which is divided into production and filling areas

Steps 1-6 are the production area (internal activity)

1. Take a clean thinner using a pail.

2. Flush the tank using thinner.

3. Scrap the tank using scrapper.

4. Re-scrap the tank using a long brush.

5. Flush the tank using dirty thinner.

6. Rinse the tank using a clean thinner.

Steps 7-9 area external activity

7. Open the thinner bubbling valve for the T-valve cleaning process.

8. Open the thinner bubbling valve for the T-valve cleaning process.

9. Accommodate the paint scale in a special drum of paint scale, lower it according to the label

Figure 7. One point lesson (OPL) standardizes all tank cleaning processes

4. CONCLUSION

In this section, it can be concluded that the data processing that has been carried out using a combination of A3 and SMED problem-solving methods, it is concluded that there is a very large cost

to buy solvent cleaning every month of Rp 10,500,000 must be spent by the company in using solvent cleaning and the time required by the company for each tank cleaning as much as 95 minutes. The application of the combination of the A3 problem-solving method and SMED has been able to run successfully in reducing the waste of time and cost of solvent cleaning. Furthermore, the researchers suggest that this combination of methods can be applied in other industries, of course, looking at the extent of its influence on the manufacturing industry. After doing analysis and processing data utilizing a mix of A3 and SMED problem-solving methodologies, it is concluded that there is a very large cost to buy solvent cleaning every month, amounting to Rp. 10,500,000, which must be spent by the company in using solvent cleaning and the time required by the company. Company for every tank cleaning of 95 minutes. However, after improvements, the cost of purchasing solvent cleaning decreased to IDR 3,500,000 per month, and the time required by the company for each tank cleaning became 30 minutes. Therefore, the paint company has achieved savings of 66% in operational costs and 63% changeover time in each tank-cleaning process. The factor that causes changes in height over time is due to the process of installing and dismantling the t-valve, which cannot be cleaned using a long brush. After improvements from the results of the FGD team discussion, with the addition of air injection from the t-valve, the process of dismantling the t-valve for cleaning was no longer needed.

REFERENCE

[1] M. Ulfah, "Mitigasi risiko rantai pasok industri furniture dengan menggunakan metode house of risk di IKM Sinar Muda," *J. Ind. Serv.*, vol. 7, no. 1, p. 93, 2021, doi: 10.36055/jiss.v7i1.12745. https://doi.org/10.36055/jiss.v7i1.12745

[2] H. Kurnia, H. Manurung, S. Suhendra, and K. B. Juliantoro, "Implementation of Lean Service Approaches to Improve Customer Satisfaction and Sustainability of Health Equipment Procurement Process at Hospitals," *Qual. Innov. Prosper.*, vol. 15, no. 3, pp. 1–17, 2023, doi: 10.12776/QIP.V27I3.1875. https://doi.org/10.12776/qip.v27i3.1875

[3] T. N. Wiyatno, H. Kurnia, I. Miharti, M. Putri, and R. Nugraha, "The combination of the kaizen approach with the Design of Experiment (DoE) method for improving quality of the bread and donut products in SMEs," *J. Optimasi Sist. Ind.*, vol. 17, no. 1, pp. 12–26, 2024, doi: 10.31315/opsi.v17i1.11108. https://doi.org/10.31315/opsi.v17i1.11108

[4] C. Jaqin, H. Kurnia, H. H. Purba, T. D. Molle, and S. Aisyah, "Lean Concept to Reduce Waste of Process Time in the Plastic Injection Industry in Indonesia," *Niger. J. Technol. Dev.*, vol. 20, no. 2, pp. 73–82, 2023, doi: 10.4314/noted.v18i4.1396. https://doi.org/10.4314/njtd.v20i2.1396

[5] D. Sjarifudin, H. Kurnia, H. H. Purba, and C. Jaqin, "Implementation of the Six Sigma approach for increasing the quality of formal men's jackets in the garment industry," *J. Sist. Dan Manaj. Ind.*, vol. 6, no. 1, pp. 33–44, 2022, doi: 10.30656/jsmi.v6i1.4359. https://doi.org/10.30656/jsmi.v6i1.4359

[6] I. Zulkarnaen, H. Kurnia, B. Saing, and A. Nuryono, "Reduced painting defects in the 4-wheeled vehicle industry on product type H-1 using the lean six sigma-DMAIC approach," *J. Sist. Dan Manaj. Ind.*, vol. 7, no. 2, pp. 179–192, 2023, doi: 10.30656/jsmi.v7i2.7512. https://doi.org/10.30656/jsmi.v7i2.7512

[7] E. Febianti, S. K. Anggraeni, A. R. Zhen, N. Wahyuni, and R. Ekawati, "Evaluating service performance at a community health center: Promethee and Lean Service methodologies," *J. Ind. Serv.*, vol. 9, no. 2, p. 269, 2023, doi: 10.36055/jiss.v9i2.21889. https://doi.org/10.36055/jiss.v9i2.21889

[8] D. Sjarifudin and H. Kurnia, "The PDCA Approach with Seven Quality Tools for Quality Improvement Men's Formal Jackets in Indonesia Garment Industry," *J. Sist. Tek. Ind.*, vol. 24, no. 2, pp. 159–176, 2022, doi: 10.32734/jsti.v24i2.7711. https://doi.org/10.32734/jsti.v24i2.7711

[9] M. M. Uddin, "Improving Product Quality and Production Yield in Wood Flooring Manufacturing Using Basic Quality Tools," *Int. J. Qual. Res.*, vol. 15, no. 1, pp. 155–170, 2021, doi: 10.24874/IJQR15.01-09. https://doi.org/10.24874/IJQR15.01-09

[10] A. G. Prahara and C. B. Nawangpalupi, "Integrasi Manajemen Perubahan pada Proyek Lean Six Sigma dalam Peningkatan Mutu dan Kinerja Perusahaan," *J. Rekayasa Sist. Ind.*, vol. 10, no. 2, pp. 113–120, 2021, doi: 10.26593/jrsi.v10i2.4064.113-120. https://doi.org/10.26593/jrsi.v10i2.4064.113-120

[11] D. Agung and H. Hasbullah, "Reducing the Product Changeover Time Using Smed & 5S Methods in the Injection Molding Industry," *Sinergi*, vol. 23, no. 3, pp. 199–212, 2019, doi: 10.22441/sinergi.2019.3.004. https://doi.org/10.22441/sinergi.2019.3.004

[12] T. N. Wiyatno and H. Kurnia, "Increasing Overall Equipment Effectiveness in the Computer Numerical Control Lathe Machines Using the Total Productive Maintenance Approach," *J. Optimasi Sist. Ind.*, vol. 15, no. 2, pp. 284–292, 2022, doi: 10.31315/opsi.v15i1.7284. https://doi.org/10.31315/opsi.v15i1.7284

[13] G. M. Santos Filho and L. E. Simão, "A3 methodology: going beyond process improvement," *Rev. Gest.*, vol. 15, no. 4, pp. 1–15, 2022, doi: 10.1108/REGE-03-2021-0047. https://doi.org/10.1108/REGE-03-2021-0047

[14] R. Sundar, A. N. Balaji, and R. M. Satheesh Kumar, "A review on lean manufacturing implementation techniques," *Procedia Eng.*, vol. 97, pp. 1875–1885, 2014, doi: 10.1016/j.proeng.2014.12.341. https://doi.org/10.1016/j.proeng.2014.12.341

[15] S. Rini, "Implementation of lean thinking through A3 report in plastic injection company," *Int. J. Ind. Optim.*, vol. 2, no. 1, pp. 63–68, 2021, doi: 10.12928/Fiji.v2i1.3055. https://doi.org/10.12928/ijio.v2i1.3055

[16] H. Kurnia, K. Budi, and A. T. Zy, "Combination of Lean Thinking and A3 Problem-Solving Methods to Reduce the Cost of Purchasing Cleaning Agents in the Paint Industry in Indonesia," *Sinergi*, vol. 5, no. July, pp. 1–12, 2023, doi: 10.22441/sinergi.2024.1.011. https://doi.org/10.22441/sinergi.2024.1.011

[17] L. Setiawan and S. Hasibuan, "Improve Ramp-Up Performance on the Sewing Process in a Sports Shoe Factory Using 8-Disciplines and Lean Manufacturing," *Qual. Innov. Prosper.*, vol. 25, no. 2, pp. 19–36, 2021, doi: 10.12776/qip.v25i2.1516. https://doi.org/10.12776/qip.v25i2.1516

[18] J. K. Musyoki, P. N. Muchiri, and J. N. Keraita, "Improvement of Ring Frame Spindle Utilization in Cotton Short Staple Spinning: A Case Study of a Cotton Spinning Mill," *IOSR J. Mech. Civ. Eng. e-ISSN*, vol. 16, no. 1, pp. 58–65, 2019, doi: 10.9790/1684-1601035865.

[19] R. Soesilo, "Implementasi Konsep A3 Untuk Mengurangi Reject Proses Assembly," *J. Tek. Ind.*, vol. 18, no. 1, pp. 68–73, 2017, doi: 10.22219/jtiumm.vol18.no1.68-73. https://doi.org/10.22219/JTIUMM.Vol18.No1.68-73

[20] L. Guimarães and R. Lima, "Changes in teaching and learning practice in an undergraduate logistics and transportation course using problem-based learning," *J. Univ. Teach. Learn. Pract. Vol.*, vol. 18, no. 3, pp. 1–29, 2021, doi: 10.53761/1.18.3.12. https://doi.org/10.53761/1.18.3.12

[21] K. YörükoĞlu, E. Özer, B. Alptekin, and C. Öcal, "Improving histopathology laboratory productivity: Process consultancy and A3 problem solving," *Turk Patoloji Derg.*, vol. 33, no. 1, pp. 47–57, 2017, doi: 10.5146/tjpath.2016.01375. https://doi.org/10.5146/tjpath.2016.01375

[22] S. F. Fam, N. Ismail, H. Yanto, D. D. Prastyo, and B. P. Lau, "Lean manufacturing and overall equipment efficiency (OEE) in paper manufacturing and paper products industry," *J. Adv. Manuf. Technol.*, vol. 12, no. 1 Special Issue 2, pp. 461–474, 2018.

[23] H. Kurnia, I. Setiawan, and Hernadewita, "Integration of Lean and Green Manufacturing to reduce Process Waste and Employee Recruitment Paper Waste in the Manufacturing Industry in Indonesia," *J. Rekayasa Sist. Ind.*, vol. 11, no. 2, pp. 145–156, 2022, doi: https://doi.org/10.26593/jrsi.v11i2.5608. https://doi.org/10.26593/jrsi.v11i2.5608.145-156

[24] A. Mulyana and S. Hasibuan, "Implementasi Single Minute Exchange of Dies (Smed) Untuk Optimasi Waktu Changeover Model Pada Produksi Panel Telekomunikasi," *Sinergi*, vol. 21, no. 2, pp. 107–114, 2017, doi: 10.22441/sinergi.2017.2.005. https://doi.org/10.22441/sinergi.2017.2.005

[25] S. Kukhan and B. Kumar, "Implementation of lean tools and techniques in an automotive industry," *J. Sist. Dan Manaj. Ind.*, vol. 12, no. 10, pp. 1032–1037, 2012, doi: 10.30656/jsmi.v5i2.3611. https://doi.org/10.30656/jsmi.v5i2.3611

[26] H. Kurnia, O. S. P. Tumanggor, and C. Jaqin, "Lean Six Sigma: Literature Review and Implementation for Textile and Textile Product (TTP) Industries," *3rd Mercu Buana Conf. Ind. Eng. 2021*, pp. 1–11, 2021.

[27] I. Leksic, N. Stefanic, and I. Veza, "The impact of using different lean manufacturing tools on

waste reduction," *Adv. Prod. Eng. Manag.*, vol. 15, no. 1, pp. 81–92, 2020, doi: 10.14743/APEM2020.1.351. https://doi.org/10.14743/apem2020.1.351

[28] D. I. Sukma, H. A. Prabowo, I. Setiawan, H. Kurnia, and I. Maulana, "Implementation of Total Productive Maintenance to Improve Overall Equipment Effectiveness of Linear Accelerator Synergy Platform Cancer Therapy," *Int. J. Eng. Trans. A-Basics*, vol. 35, no. 7, pp. 1246–1256, 2022, doi: 10.5829/ije.2022.35.07a.04. https://doi.org/10.5829/IJE.2022.35.07A.04

[29] A. Nuryono, H. Kurnia, and I. Zulkarnaen, "Spare parts warehouse re-layout design with kaizen 5S implementation to reduce wasted time searching for machine parts," *Oper. Excell. J. Appl. Ind. Eng.*, vol. 15, no. 3, pp. 293–305, 2024, doi: 10.22441/oe.2023.v15.i3.095. https://doi.org/10.22441/oe.2023.v15.i3.095

[30] T. N. Wiyatno, H. Kurnia, I. Zulkarnaen, and A. Nuryono, "How Influenced Management Behavior is on the Implementation of Total Quality Management (TQM) and Company Operational Performance," *Int. J. Ind. Eng. Manag.*, vol. 15, no. 3, pp. 225–237, 2024, doi: 10.24867/IJIEM-2024-3-359. https://doi.org/10.24867/IJIEM-2024-3-359

[31] H. Kurnia, A. A. Sulaiman, and V. S. Pasha, "Integration of lean and green manufacturing to speed up the automotive parts production process for sustainability orders from customers," *J. Sist. Dan Manaj. Ind.*, vol. 8, no. 2, pp. 89–106, 2024, doi: 10.30656/jsmi.v8i2.8831. https://doi.org/10.30656/jsmi.v8i2.8831

[32] Y. Fauziah, E. O. Wijaya, and I. Setiawan, "Improving the efficiency of material transfer system using Value Stream Mapping (VSM): A case study in the shoe industry," *J. Ind. Serv.*, vol. 8, no. 2, pp. 181–186, 2022, doi: 10.36055/jiss.v8i2.15908. https://doi.org/10.36055/jiss.v8i2.15908

[33] H. Kurnia, Setiawan, and M. Hamsal, "Implementation of statistical process control for quality control cycle in the various industry in Indonesia : Literature review," *Oper. Excell. J. Appl. Ind. Eng.*, vol. 13, no. 2, pp. 194–206, 2021, doi: 10.22441/oe.2021.v13.i2.018. https://doi.org/10.22441/oe.2021.v13.i2.018

[34] H. Kurnia, C. Jaqin, H. H. Purba, and I. Setiawan, "Implementation of Six Sigma in the DMAIC Approach for Quality Improvement in the Knitting Socks Industry," *tekstilvemuhendis*, vol. 28, no. 124, pp. 269–278, 2021, doi: 10.7216/1300759920212812403. https://doi.org/10.7216/1300759920212812403