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Combination of lean thinking and A3 problem-solving methods to reduce the cost of purchasing cleaning agents in a paint manufacturer in Indonesia

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Abstract
One of the manufacturing industries for making solvent-based and water-based paints is located in the Cikarang area, West Java. This paint company is experiencing an increase in production due to a large number of requests for various products. The company's level of cleanliness in maintaining quality and reducing waste of operational costs is the key to the company's success in becoming an international standard company. Every year the company incurs the cost of purchasing a cleaning agent imported from Norway because it is a basic requirement in material inventory to meet customer satisfaction. The purpose of this research is to reduce the wasted costs of purchasing cleaning agents originating from imports, maintaining 5S conditions, and fulfilling customer satisfaction. The method used in this study is a combination of the lean thinking method and the most effective A3 problem-solving method which can help create consistent, clear, and structured problem-solving documentation. This research found that there is a very large cost to buy a cleaning agent in 2021 of IDR 114,331,430 which must be spent by companies in using cleaning agents. The results of this study found that there was a reduction in the cost of purchasing a cleaning agent in 2022 to IDR 4,897,900. Therefore this paint company gets operational cost savings in purchasing cleaning agent materials of 97.71%.

Keywords:
A3 Problem-Solving;
Cleaning Agent;
Cost Reduction;
Lean Thinking;
Paint Industry;

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INTRODUCTION

One manufacturing industry in the Cikarang area, West Java, has produced high-quality solvent- and water-based paints. This paint company is experiencing an increase in production due to a large number of requests for various products. The company's cleanliness level in maintaining quality and reducing operational costs is the key to the company's success in becoming an international standard company [1]. A clean factory reflects a healthy work environment, clean equipment, and machines that can produce good output and extend the machine's life if properly cared for [2].

The high sales growth every year and the many product variants that must be made become a challenge during the process of cleaning the tank and maintaining the cleanliness of equipment and production floors every day [3]. To maintain the cleanliness of the production floor area, equipment, and machine cleanliness quickly, the company buys a cleaning agent imported from Norway. This is because cleaning agents from Norway have several very strong advantages in abrasive paint coatings. Another advantage is that it is

very strong in removing resin droplets that stick to the floor or on equipment, easy to apply, and quick to clean equipment so that 5S is maintained [4]. Every year the company pays for the purchase of a cleaning agent imported from Norway.

Every year the price of this imported cleaning agent always goes up because production output is always increasing so the demand for cleaning equipment and floors becomes quite frequent to maintain machine performance and keep equipment clean and floors clean to always keep it clean. This is a challenge for companies to be able to move quickly to make efficiencies in reducing the cost of purchasing imported cleaning agents that must be issued every year because the costs incurred always increase every year.

This research was conducted in the production department of the paint industry with a focus on the use of cleaning agents as materials for cleaning machines, equipment, and floors. Material cleaning agents are obtained from imported purchases, namely from Norway. The problem faced is the number of costs that must be incurred by the company in 2021 amounting to IDR 114,331,430.

The lean thinking method is the right method for reducing waste, consisting of 3 pillars reducing waste, focusing on improvement, and fulfilling customer satisfaction [5]. Lean has evolved from an operational tool to a complete management concept that incorporates softer aspects such as participation, learning, and leadership [6]. Lean Manufacturing (LM) is a method devoted to reducing waste by optimizing the utilization of resources so that the industry can respond to unstable and competitive business growth and increase productivity [7][8]. LM can significantly reduce waste but not eliminate it, and the benefits obtained do not always meet expectations [9][10]. The application of the SMED concept is carried out by changing several internal activities to become fewer and engineering gauge tool tools to reduce machine downtime [11].

Toyota uses A3 extensively to solve problems and cultivate competence by using the structure of A3 paper which contains problem-solving [12]. The A3 method is an improvement process that applies lean thinking to problem-solving and presents a comprehensive and organized report on one page. This improvement tool is considered helpful in the early stages of preparation for applying lean thinking to solving problems with the building blocks contained in the A3 report which are very simple and easy to understand [13].

The benefits of the A3 concept include facilitating the mapping of authority and responsibility of an organizational unit to eliminate waste in the workplace and increase productivity [14]. Thus, the building block elements in the A3 report can be adapted to the needs and conditions of each company. How does the A3 report structure follow a logical flow that makes it easy to understand the problem and find the right solution as shown in Figure 1?

Based on Figure 1, usually, the A3 problem-solving method in each stage consists of historical, current status, proposal, time analysis and cost, possible implementation, and results. The lean thinking approach has been widely used in the manufacturing industry to reduce waste costs, including reducing the number of rejected products so that production costs are very high [13] and can reduce assembly rejects effectively and precisely by using the A3 method [14]. The new approach of this research is to analyze the high costs incurred in 2021 which is a challenge because companies spend a lot of money buying cleaning materials from Norway. Therefore, this research will discuss how companies can reduce wasteful purchasing costs by conducting trials using the A3 problem-solving method. Meanwhile, in the improvement process, there will be innovation in a new mixture of cleaning agent formulas called KC cleaner formulation from water-based (KC-04). This research aims to reduce wasted costs in purchasing imported cleaning materials, maintain 5S conditions, and meet customer satisfaction.

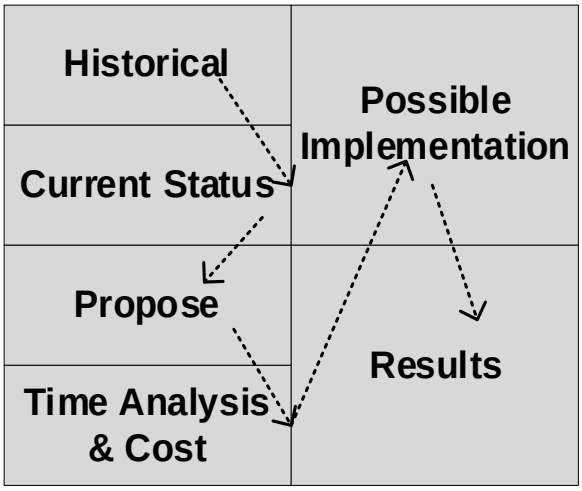


Figure 1. The logic flow of the A3 Report [15]

MATERIAL AND METHOD

In this section, we will discuss the materials used in this study, namely the use of cleaning agents, both imported and local materials. Then it will be discussed the steps of this research in the form of research stages.

Material

Cleaning agents are substances in the form of liquids, powders, sprays, and granules that are used to remove dust, stains, foul odors, and dirt on surfaces [16]. Cleaning agents are made for health and beauty, remove strong odors, and avoid spreading dirt on the surface of objects [3]. Some cleaning agents can also kill bacteria and clean them at the same time. While there are cleaning agents of the type degreasers containing organic solvents to help dissolve oil and grease. Cleaning agents also called detergents are used to differentiate between soaps and other chemical surfactants used for cleaning purposes [17]. The detergent molecule contains an oil-soluble hydrocarbon part and a water-soluble ionic part [18]. Detergent acts as an emulsifier by bridging the water and oil phases which can break down the oil into small droplets suspended in water so that the disruption of the oil layer allows dirt particles to become dissolved in water.

Methods

This research method includes a descriptive exploratory design where this research describes and explains the existence of problems, causes of problems, and finding solutions to improve in reducing the cost of purchasing cleaning agents. This type of research includes a mixed method of qualitative and quantitative, where qualitative is based on expert opinion and quantitative is in the form of mathematical calculations to reduce the cost of purchasing cleaning agents. This section will discuss the research steps from the beginning to the end of the research using the A3 problem-solving method in which there is a lean thinking method. The stages of implementing the A3 method can be seen in Figure 2.

Based on Figure 2, the first stage is to collect the data needed according to the A3 problem-solving report, including the background which will explain the background of the problems that occur in the company. At this stage, the company is thinking about how to reduce waste in purchasing cleaning materials over the last 5 years, because operational costs in purchasing materials increase every year. After all, the materials are imported from Norway. Therefore, for the company's sustainability in saving on material purchases, it is necessary to change materials from imported to local with internal product development which is expected to reduce operational costs for purchasing materials. The second stage is making 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 method, machine, material, and man.

The third stage of setting targets explains the targets to be achieved for solving problems in the A3 problem-solving theme. Then do a trial trip from start to finish to find a formula for changing cleaning agents.

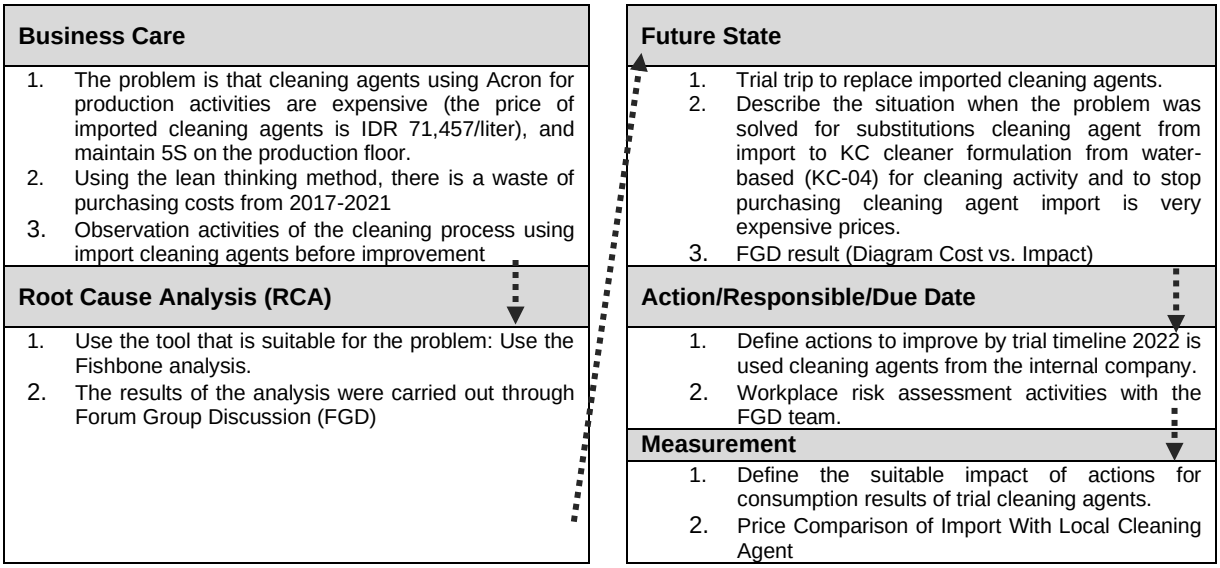


Figure 2. Research Stages

After that, an analysis was carried out through FGD with a cost versus impact diagram. The fourth stage is making an activity schedule explaining the stages of implementing activities according to the A3 report that has been made. Then carry out a risk assessment of raw materials that have been made locally through FGD. The fifth stage is taking measurements, namely explaining the stages of measuring the results of the success of the A3 problem-solving method that has been analyzed and the actions to be taken [19]. The next step is to carry out a profit comparison analysis before the improvement and after the improvement.

RESULTS AND DISCUSSION

In this section, we will discuss the results of the research based on the method used. In the previous section, it was explained that this study uses a research step in the form of the A3 problem-solving method in which there is lean thinking to reduce wasteful costs for purchasing cleaning agents.

Business Care

The result of the first step is that the company investigated to collect data on the cost of purchasing cleaning agents from 2017-2021 or for 5 years. The cost of purchasing imported materials from Norway in more detail can be seen in Figure 3.

Figure 3 shows that there is an annual increase in the purchase price of cleaning agents by 10% per year. The results of data collection in 2021 for the purchase of imported cleaning agents from Norway reached IDR 114,331,430. Researchers thought hard about how to reduce this wastage of costs by using the lean thinking method combined with the A3 problem-solving method. The implementation of lean thinking can be used in the A3 problem-solving method in the plastic injection industry [13]. While this research is in the paint industry on cleaning agents obtained from imports, the specifications are shown in Figure 4.

Figure 4 shows that the first action was to observe the cleaning of machines, work equipment, and floors. Furthermore, the use of imported cleaning agents can also be used to clean floors or maintain 5S conditions in production areas [4]. This observation is carried out to obtain a measure of the problem that can be assessed so that it is possible to create indicators that monitor the stages of improvement [15].

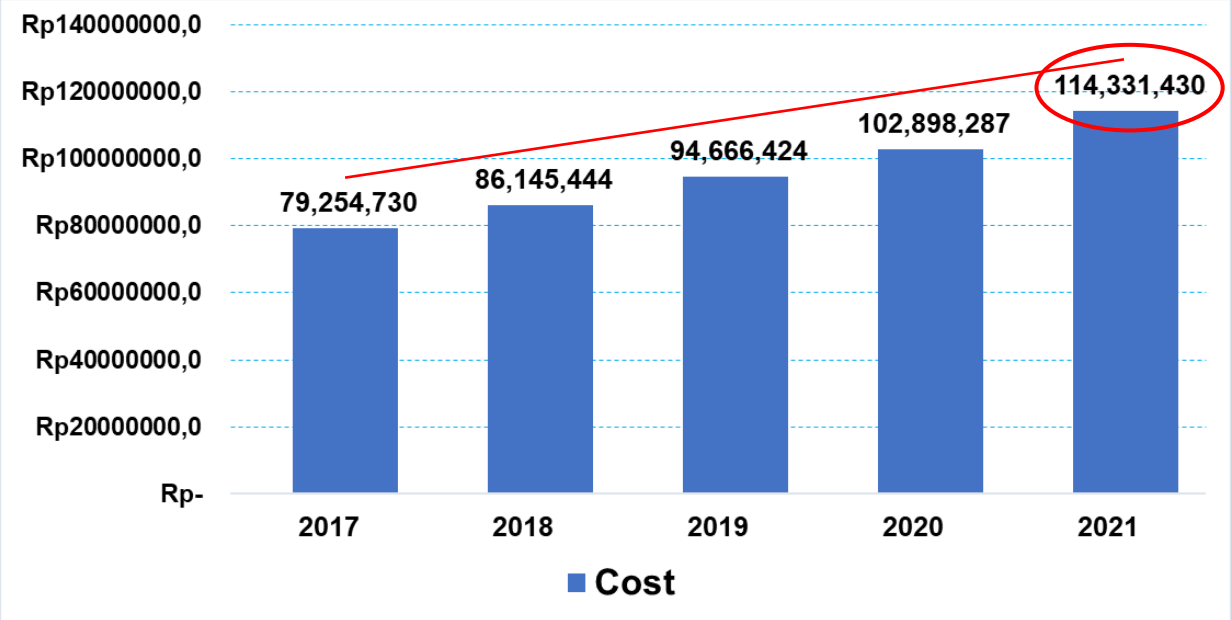


Figure 3. Cost of Purchasing Import Cleaning Agent per Year

Observation Activities of the Cleaning Process Using Import Cleaning Agents Before Improvement	
	• All cleaning floors use Arcon cleaner • After cleaning needs flushing with water • Arcon imports from Norway • Arcon price is more expensive • Too strong to the abrasive paint film • The use of cleaning agents for 5S, especially other cleaning, is quite extensive • Detergent cannot be used on the SB floor • The detergent is too weak to scrape resin drops

Figure 4. Observation of Cleaning Process Effects Using Cleaning Agent Import Before Improvement

Root Cause Analysis (RCA)

In this section there are results of improvements with the Fishbone Analysis repair tool, explaining the root causes of the problems that occur based on several existing aspects. The results of the Fishbone analysis found that 4 aspects were related to the causal factors, namely method, machine, material, and man. In each aspect, the root of the problem will be traced. The fishbone diagram is used to carry out root cause analysis with the ideas outlined by using a fishbone diagram. Next, the root cause of the problem and its remedies are identified for each common cause for corrective action [20][21].

Major problems are usually resolved through activities that are detected and controlled by management. The way this company can improve performance is through leverage and focus. Lean Production System (LPS) imposes basic problem-solving on all employees [22]. Based on the above observations, the cost of purchasing imported cleaning agents is the main focus. For this reason, an analysis process is carried out of why the cost of purchasing imported cleaning agents is expensive. Figure 4 is the result of the analysis using a fishbone diagram [23]. The results of the analysis were carried out through FGD (Forum Group Discussion) consisting of representatives from several departments such as production, maintenance, HSEQ, purchasing, and finance [24]. For more details, the Fishbone diagram can be seen in Figure 5.

Based on Figure 5, the main problem is the high price of cleaning agents, especially Acron material from Norway. Therefore, it is necessary to replace the use of imported materials with local materials with several trials and product development stages, all of which come from local materials.

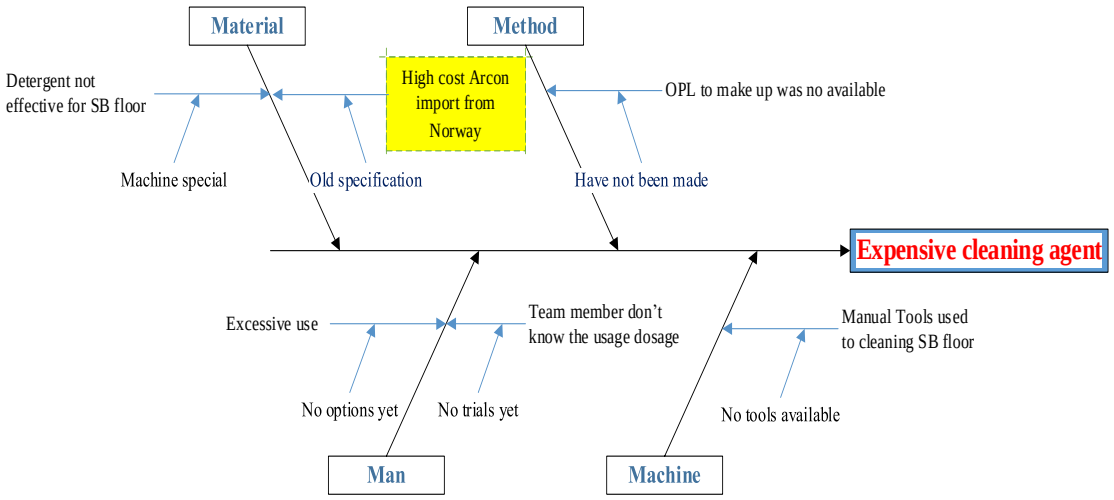


Figure 5. Diagram Fishbone

Future State

The A3 methodology assumes a key role in this project, enabling monitoring of the effectiveness of different corrective actions implemented so that it can be applied to other improvement projects [25]. Based on the results of the analysis above, it is known that the cause of the high cost of purchasing cleaning agents is because they are imported from Norway and dependency on purchasing imported cleaning agents. The trial trip to replace imported cleaning agents can be seen in Figure 6.

Figure 6 shows that the company conducted several trials of making cleaning agents during January 2022 and then obtained a cleaning agent formula made locally that is as effective as imported cleaning agents. This research has tried to react Sodium Lauryl Sulfate (SLS) 0.5% with Raw Material RM-06762 7.5% which contains benzyl alcohol content, then dissolved with water. The chemical material in the form of benzyl alcohol has been chosen as an alternative because benzyl alcohol is an aromatic alcohol with the formula C6H5CH2OH. The benzyl group is often abbreviated Bn (not to be confused with the "Bz" used for benzoyl), so benzyl alcohol is designated BnOH. Benzyl alcohol is a colorless liquid with a pleasant, mild aromatic odor. It is a useful solvent because of its polarity, low toxicity, and low vapor pressure. Benzyl alcohol is used as a common solvent for inks, waxes, lacquers, paints, varnishes, and epoxy resin coatings. As such it can be used in paint strippers, especially when combined with a compatible viscosity increaser to encourage the mixture to adhere to the painted surface.

The company has a target to stop buying imported cleaning agents and replace them with a local cleaning agent made internally by the company under the name KC-04. This study conducted a cost versus impact analysis before carrying out a strategic action plan to see a comparison between the resulting costs and impacts. However, the material change does not affect the condition of 5S which is maintained, and customer satisfaction with the product continues to increase. The cost versus impact diagram that the FGD team has carried out can be seen in Figure 7.

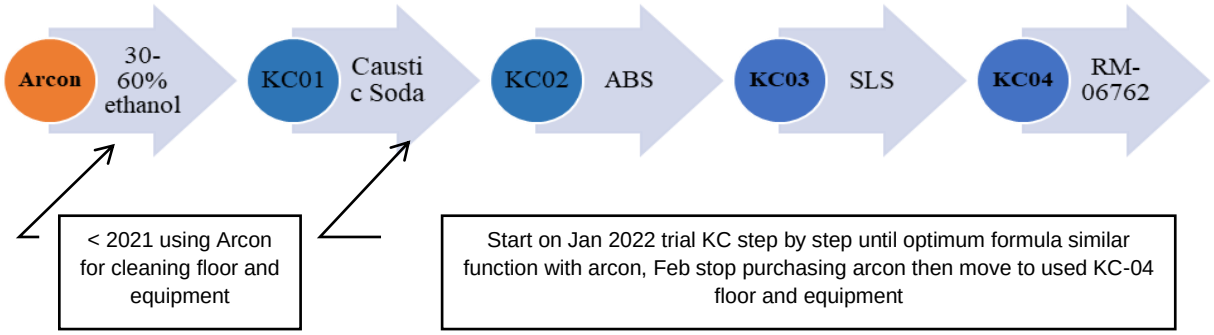


Figure 6. The Trial Trip for the Manufacture of Locally Made Cleaning Agents

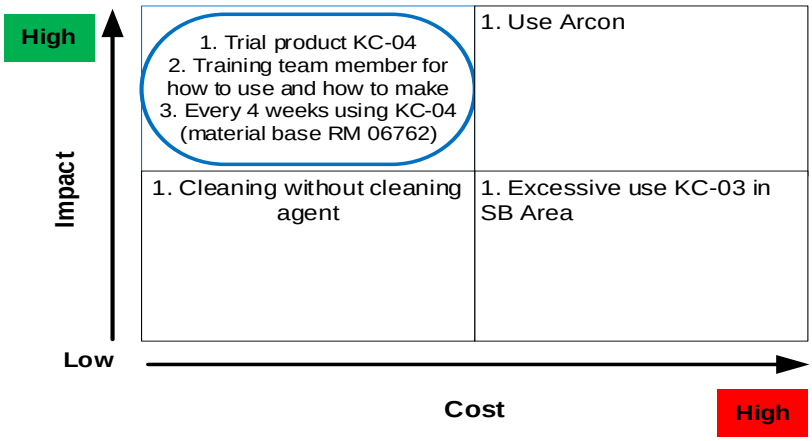


Figure 7. FGD Result (Diagram Cost vs. Impact)

Action

At this action stage, the activity schedule explains the stages of implementing activities according to the A3 report that has been made by the researcher carrying out an action plan so that the A3 problem-solving method process can be realized and controlled. Increasing and controlling production quality requires a commitment to improvement involving human factors (motivation) and machine factors as described in Total Quality Control (TQM) technology as a modern management approach [26]. Creating a project timeline panel is a very powerful tool when properly applied for productive dialogue and aids learning from one another, as it involves cross-functionality [27]. The timeline for 2022 can be seen in Table 1.

The safety aspect is an important point when there is a process change, then the workplace risk assessment activity is carried out again to ensure that the activity process changes are always carried out safely. The workplace risk assessment activities with the FGD team can be seen in Table 2.

Measurement

Measurement of measurement describes the stages of measuring the results of the success of the A3 problem-solving method that has been analyzed and the actions to be taken. The problem of ideas and context within a team is seen by many of the teams involved as one of the biggest obstacles to successful problem-solving. Problem-solvers often find it difficult to explain a particular problem without the appropriate context (e.g. specific components) in mind [28]. Improvements at this stage evaluate the production section against production targets and the production process and report what activities are carried out and the results, check again whether they have been carried out or not, and whether are they following existing standards [29]. An explanation of data on the use of local KC-04 cleaning agents in 2022 can be seen in Table 3.

Table 1. 2022 Time Line Activity

No	Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	PIC	Status
1	Stop purchasing arcon and trial KC-04													Spv	Done
2	Operator training on how to use and how to make KC-04													Spv	Done
3	Monitoring consume KC-04													Spv	Done

Table 2. Workplace Risk Assessment Activities After Improvement

AREA/SCOPE:	PARTICIPANTS:	DATE:
SB Area – Replacement of imported cleaning agent with local cleaning agent KC-04	1. Production team 2. Maintenance 3. Purchasing 4. Finance 5. HSE	January 30th 2022

Description of task/Area	Hazard Description	Existing Control Measures	Current Risk	Planned Improvement Actions	Residual Risk
Trial KC-04	Splash	Using PPE	1D		1D
RCA and Gemba	No hazard		1A		1A
Cleaning floor solvent base area	Irritant	OPL & PPE	2D	Training	1D
Made KC-04	Irritant	OPL & PPE	2D	Training	1D
Handling RM 06762	Irritant	OPL & PPE	2D	Training	1D

Source: Company production data

Table 3. Use of KC-04 and Cost of Manufacturing KC-04 in 2022

No	Manufacture Date	RM-06762 (kg)	IDR Cost RM-06762 (25,000/kg)	SLS (kg)	IDR Cost SLS (30,000/kg)	Cost Man Power 1 hour for making KC-04 (IDR)	Total (IDR)
1	14.01.2022	20	500,000	1	30,000	28,900	558,900
2	05.03.2022	15	375,000	1	30,000	28,900	433,900
3	27.03.2022	15	375,000	1	30,000	28,900	433,900
4	10.04.2022	15	375,000	1	30,000	28,900	433,900
5	27.05.2022	15	375,000	1	30,000	28,900	433,900
6	05.06.2022	15	375,000	1	30,000	28,900	433,900
7	15.07.2022	15	375,000	1	30,000	28,900	433,900
8	24.08.2022	15	375,000	1	30,000	28,900	433,900
9	10.09.2022	15	375,000	1	30,000	28,900	433,900
10	5.10.2022	15	375,000	1	30,000	28,900	433,900
11	24.11.2022	15	375,000	1	30,000	289,00	433,900
				Grand Total			4,897,900

Source: Company production data

Table 4. Price Comparison of Import Versus Local Cleaning Agent

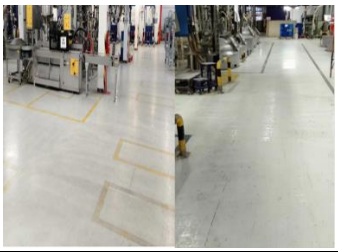
Source	Norway ARCON < 2021 Before Improvement)	Local KC04 Jan 2022 (After Improvement)
Content	30 – 60% ethanol	Sodium Lauryl Sulfate (SLS) + RM-06762
Price	IDR 14,291,428 / 200L	IDR 530,000/ 200L
Usage 2019	8 drums/year (diluted 1:5)	2 drums/month and 24 drums/year
Cost/year	IDR 114,331,430	IDR 4,897,900 saving 97.71%
Strength	1. All cleaning floors use Arcon cleaner 2. After cleaning needs flushing with water 3. Arcon imports from Norway 4. Arcon price is more expensive 5. Too strong to the abrasive paint film 6. Used to clean floors or maintain 5S conditions in production areas, but using cleaning agents is too wasteful. 7. Purchase lead time is quite long not ready stock 8. Indent 3 months for order	1. Strong power 2. Water-based solutions → environment friendly 3. No extra process (no need for water rinsing) 4. Applicable for SB floor cleaning 5. Applicable for cleaning tank WB 6. It can still be used to clean floors or maintain 5S conditions in production areas economically and efficiently 7. Applicable and another metal surface in WB, 8. Made by Internal
Weakness	1. Damaging the floor 2. The extra process to rinse with water 3. Sticky, Import from Norway	-
Picture		

Table 3 shows that there are expenses for purchasing materials and manufacturing cleaning agents locally for 1 year, namely 2022, amounting to IDR 4,897,900. A comparison between before repairs using imported cleaning materials and after repairs using local cleaning materials and the advantages of using locally made cleaning materials during 2022 compared to using imported cleaning materials in 2021 can be seen in Table 4.

Table 4 shows that there is a comparison of the cost of purchasing an imported cleaning agent and a local cleaning agent made internally by a company named KC-04. Replacing the use of imported materials with local materials results in differences in content, price, and usage requirements each year. So replacing this material is very useful or profitable in terms of cost down, the cleanliness of the production floor is maintained and product quality remains consistent.

The results of the research before carrying out repairs using the A3 problem-solving method, the cost needed to buy a cleaning agent in 2021

is IDR 114,331,430. After applying the A3 problem-solving method, the cost of purchasing a cleaning agent in 2022 will be IDR 4,897,900, which means that the company has saved the cost of purchasing a cleaning agent by 97.71%. Apart from the benefits of reducing costs, this material change also has an impact on the condition of the floor which is maintained by 5S, customer satisfaction with the product is maintained consistently and the delivery of variations of paint products to various countries has had no complaints about delays.

Discussion with Previous Research

The implementation of the A3 problem-solving method to reduce the purchase of cleaning agents is the right method because the production area is the area with the most space to carry out the Lean Manufacturing concept in the plastic injection industry [13]. The process of making A3 problem-solving requires teams from various departments to get precise and effective results for making decisions at every step of the process of making A3 problem-solving in increasing laboratory productivity [12].

The LM concept originated with Toyota in the 1980s and this philosophy was developed to reduce waste and is defined as the goal of efficiency and effectiveness, due to the scarcity of material, human, and financial resources [30] and can be applied to the employee recruitment section [31][32]. The body of this research engineering includes product design and development due to the replacement of imported materials with local materials by creating a cleaning agent whose materials are all locally sourced so that it can reduce the cost of purchasing these materials but not reduce the quality of the materials, while maintaining 5S conditions in floor cleanliness and maintain consistent customer satisfaction.

The application of the A3 concept in LM process improvement can form good teamwork between departments. The A3 concept can direct the direction of improvement to be precise so that it is following the target. A3 Report is easy to understand because the whole process is described on just 1 sheet of paper, as can be seen in Figure 8.

Based on Figure 8, the combination of the lean thought approach and the A3 problem-solving method has resulted in a reduction in the cost of purchasing cleaning agent materials by 97.71%. Meanwhile, other research using the same method has resulted in a reduction in machine setup time of 70.4%, thereby eliminating the need to add a third production shift [22].

Business Care

The problem is that cleaning agents using Acron for production activity is expensive, and to maintain 5S on the production floor. Prices of cleaning agents import is 71,457 IDR/liter

Root Cause Analysis

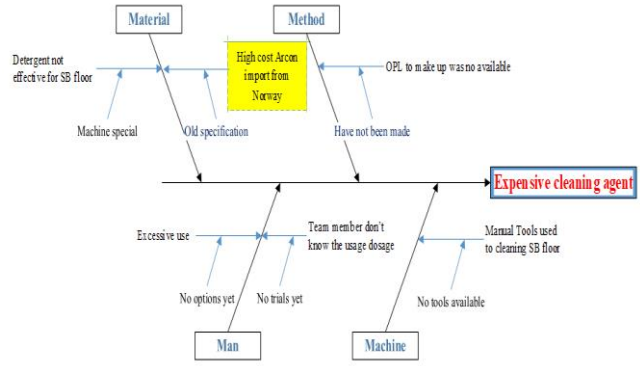


Figure 5. Diagram Fishbone

Future State

Substitutions cleaning agents from Norway to KC cleaner formulation from water-based (KC-04) for cleaning activity and to stop purchasing cleaning agent import is very expensive prices.

Action/Responsible&Due Date

No	Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	PIC	Status
1	Stop purchasing arcon and trial KC-04													Spv	Done
2	Operator training on how to use and how to make KC-04													Spv	Done
3	Monitoring consume KC-04													Spv	Done

Measurement

1. Consumption of KC-04 per month.
2. Cost of consumption RM-06762 for KC-04 per month.

Figure 8. Implementation of the A3 Problem-Solving Report Method

CONCLUSION

In this section, it can be concluded that a reduction in wasted costs for purchasing cleaning agents can be realized in 2022. The application of the lean thinking method and A3 problem-solving in combination can clearly describe the detailed steps of the improvement process. In addition, by applying the A3 problem-solving method in the process of changing purchases of cleaning agents, costs can be reduced by up to 97.71% or decreased from IDR 114,331,430 to IDR 4,897,900. This has a positive impact on the

cost of purchasing a cleaning agent every year. After implementing the A3 problem-solving method, the company stopped buying imported cleaning agents and switched to using KC-04, which has cheaper manufacturing costs and locally available raw materials. Furthermore, 5S still maintains its tidiness which can be proven in experiments. This can also affect increasing customer satisfaction because for 1 year the delivery of variations of paint products to various countries has had no complaints about delays.

The implications of this research theoretically provide additional references for other researchers in applying lean thinking and the A3 problem-solving method in the manufacturing industry. Meanwhile, the practical implications of this research with a combination of lean thinking and the A3 problem-solving method can produce a harmonious correlation in replacing imported materials with local materials in terms of reducing waste costs, maintaining 5S conditions, especially the production floor, and providing consistent customer satisfaction.

The application of LM has been able to run with success in reducing the waste of purchasing cleaning agents combined with the A3 problem-solving method. Furthermore, the researchers suggest that this locally made cleaning agent named KC-04 is already environmentally friendly in its application in the industry, of course seeing the extent of its effect on Green Manufacturing (GM) in the manufacturing industry, especially the paint industry.

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