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Improving Process Efficiency in High Variant Industry Using Integrated Method of Value Stream Mapping and Overall Equipment Effectiveness

Cindy Kristiya Himawan[1)], Vanechka Manuel Sopater[2)]
[1)2)] Program Studi Teknik Industri – Institut Teknologi Harapan Bangsa, Jl Dipatiukur 80-84, Bandung, 40625, Indonesia

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ABSTRACT

Production efficiency remains a critical challenge where high product variability and equipment-intensive processes often lead to substantial downtime and inefficiencies. While VSM and OEE are widely used for performance improvement, they are commonly applied separately, limiting comprehensive evaluation of process waste and equipment losses. This study proposes an integrated VSM OEE framework to improve process efficiency in a cosmetic packaging production line, to identify value-added and non-value-added activities, and quantified equipment losses through availability, performance, and quality indicators. Improvement strategies were developed using the ECRS method and evaluated through a Future State VSM. Implementation of the proposed improvements reduces downtime by 85.5%, leading to PCE improvements to 76.88%, respectively. The findings demonstrate that integrating VSM and OEE provides a more comprehensive and analytically robust approach to diagnosing and improving production efficiency, contributing to the advancement of lean manufacturing practices.

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Corresponding Author:

Cindy Kristiya Himawan
Program Studi Teknik Industri, Institut Teknologi Harapan Bangsa,Jl Dipatiukur 80-84,Bandung,Indonesia
Email : cindy_himawan@ithb.ac.id

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INTRODUCTION

Manufacturing companies operate in an environment where efficiency determines their ability to remain profitable and competitive. When production processes fail to run efficiently, costs increase, delivery reliability declines, and the company risks losing its competitive position [1]. Understanding how a product moves through the entire production flow is therefore essential for identifying points where improvements can enhance overall efficiency. The firm will need to implement an efficient and responsive supply chain strategy [2]. In general, efficiency refers to the ability to use resources in a precise and responsible manner so that time, labor, and equipment are not wasted and output remains optimal [3].

Value Stream Mapping (VSM) is a lean manufacturing technique for analyzing, designing, and managing the flow of materials and information required to deliver a product to a customer by identifying value-added activities and non-value-added activities along the flow [4]. This method helps reveal waste such as excessive waiting time, unnecessary movement, and process delays. Previous studies have shown that VSM is an effective tool for measuring efficiency, identifying waste, and designing process improvements [5]. One of the most common forms of waste in manufacturing is downtime, which refers to periods when machines are unable to operate due to maintenance, technical issues, or repairs [6]. However, although VSM effectively reveals where inefficiencies occur, it provides limited insight into the equipment-related factors that contribute to such inefficiencies.

Overall Equipment Effectiveness (OEE) is widely used as a metric to evaluate how well manufacturing equipment performs [7]. It provides insight into three essential aspects of machine productivity, namely availability, performance, and quality. These three indicators help direct improvement efforts toward the most critical points in identifying improvement opportunities for injection molding machines [8]. Increasing the OEE score enables manufacturers to convert downtime and slow operating speeds into productive value-added time [9]. Nevertheless, OEE primarily focuses on machine performance and does not provide a comprehensive view of material flow, process interactions, and non-equipment-related waste within the production system.

Although both VSM and OEE have been extensively applied in manufacturing improvement initiatives, many studies employ these approaches independently, resulting in fragmented assessments of operational performance. Hence, the next step in this study is to determine the root causes of inefficiency. A fishbone diagram is used to group potential causes into the five main categories of manpower, machinery, method, material, and measurement [10]. The why-why analysis is also applied to ensure that each proposed improvement can be clearly linked to its underlying cause [11]. Once the root causes are identified, improvements are designed using the ECRS method, which consists of eliminating activities that do not add value, combining steps with similar functions, rearranging the sequence of activities, and simplifying processes to create a more efficient production flow [12].

PT TA is a cosmetic packaging manufacturer that operates in both national and international markets. The company currently supplies products to 38 customers, each with different models and specifications, with a total product variety of more than 100 products. This product variety adds complexity to the production process

and increases the likelihood of inefficiency. Recent data from the PT TA production report shows that downtime in the injection department reached 158 hours in January 2025 and 157 hours in February 2025. This condition indicates that the performance of production machines needs to be evaluated.

Therefore, this study proposes an integrated improvement framework that combines VSM and OEE to evaluate process efficiency in the CM-216 cosmetic packaging production line. Unlike studies that focus solely on either process flow or equipment performance, the proposed framework links waste identification through VSM, equipment-loss analysis through OEE, root-cause diagnosis using Fishbone Diagram and Why–Why Analysis, and improvement prioritization through ECRS within a single decision-making process.

The key contributions of this study are as follows:

1. To develop an integrated VSM–OEE framework for simultaneously identifying process waste and equipment-related losses in cosmetic packaging manufacturing.
2. To establish a systematic improvement pathway by linking VSM findings, OEE analysis, Fishbone Diagram, Why–Why Analysis, and ECRS-based improvement design.
3. To evaluate the effectiveness of the proposed improvements through Future State Mapping, Process Cycle Efficiency (PCE), and projected OEE performance.

RESEARCH METHOD

The research methodology consists of eight sequential stages, as illustrated in Figure 1.

Stage 1: Data Collection and Process Observations

Manufacturing systems encompass a series of integrated processes, from design to production execution, involving a combination of machines, people, material flow, and information [13]. Each type of process has its own unique characteristics, requiring a tailored management approach to achieve optimal efficiency and effectiveness. Therefore, the research methodology begins with identifying the problem by collecting data and observing the process that guides the overall investigation.

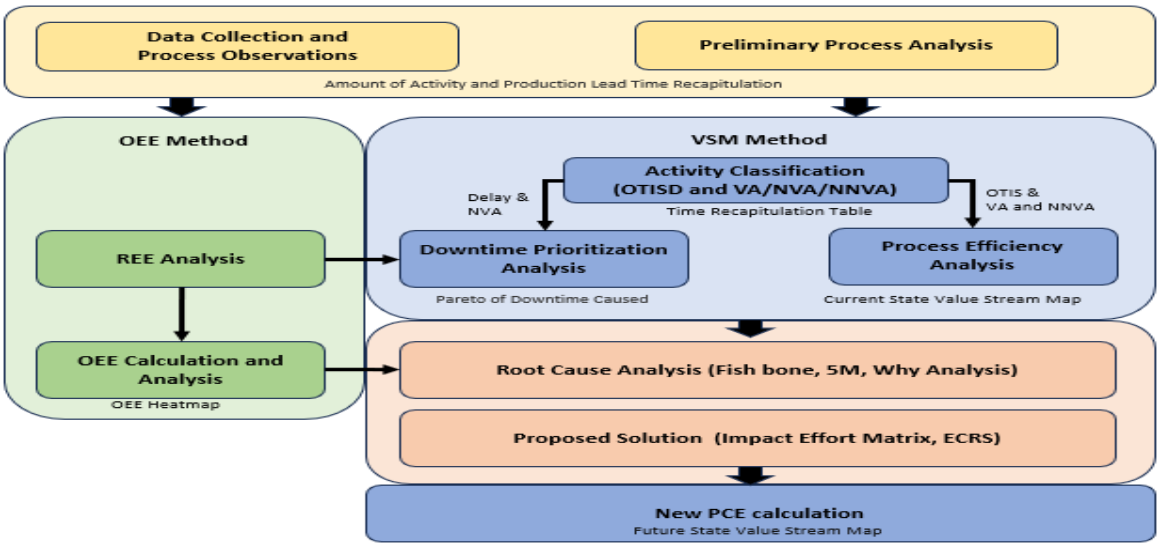


Figure 1. Research Workflow

In addition to direct process observations, production records, Realized Equipment Effectiveness (REE) reports, production lifetime data, and downtime records were collected to provide a comprehensive assessment of production performance. In this study, downtime refers to any period during which a machine or production line is unable to produce output, including both scheduled downtimes, such as preventive maintenance and planned component replacement, and unscheduled downtime resulting from machine failures, system disruptions, or material shortages, which have a greater impact on production losses [14]. To ensure a valid comparison between the current and future production states, the analysis assumes that product specifications, production volume, machine configuration, workforce allocation, and operating conditions remained relatively consistent throughout the observation period.

Stage 2: Preliminary Process Analysis

The collected production data were analysed to determine the number of activities in each department, the production lifetime of each process, and the frequency and duration of downtime activities. This preliminary analysis was used to identify departments with the highest operational complexity and downtime contribution prior to conducting detailed efficiency assessments. Figure 2 illustrates production data in a Pareto diagram. The CM-216 model was chosen as the focus of the analysis because it has the highest production value and the largest revenue contribution, namely 18.61% during January-March 2025. By focusing on this model, process waste and equipment effectiveness can be identified in depth to support efficiency improvements.

Stage 3: Activity Classification and Current State VSM

VSM is a visual tool used to map and analyze the flow of materials and information in the production process [15]. By depicting each step of the process, the VSM helps identify how value is added and where waste occurs. Activity categorization is then conducted using the OTISD (Operations, Transportation, Inspection, Storage and Delay) framework along with value-added (VA), non-value-added (NVA), and necessary non-value-added (NNVA) classification [16]. This step separates activities that create value from those that generate waste. The identified NVA activities are summarized and analyzed through a Pareto approach to highlight the most dominant sources of inefficiency.

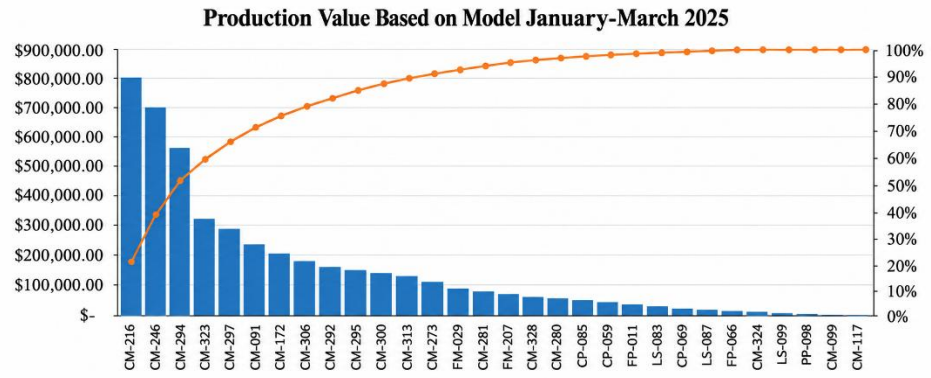


Figure 2. Pareto Diagram of Production Results

Stage 4: Process Efficiency Analysis

In this stage, VA and NVA activities are used to construct the current state map and to calculate the process cycle efficiency (PCE) for the CM 216 variants. PCE were calculated to quantify current process performance. The results indicate the proportion of total production time that directly contributes to customer value.

PCE was calculated as:

$$PCE = \frac{VA\ Time}{Total\ Lead\ Time} \times 100\% \quad (1)$$

Stage 5: Downtime Prioritization Analysis

Downtime prioritization was conducted to identify the most critical departments and downtime categories requiring improvement. Hence, this stage analysed the downtime frequency, average downtime duration, and total downtime contribution by department.

Stage 6: Overall Equipment Effectiveness (OEE) Analysis

OEE is a key indicator for assessing machine efficiency in production by comparing actual performance against its maximum potential [17]. Hence, in this stage, the OEE analysis was used to determine the equipment-related factors contributing to downtime identified in the VSM. OEE consists of three main components, one of which is availability, which measures effective operational time compared to planned production time and is affected by unexpected downtime such as machine failures. Availability (Av) can be calculated using the following formula:

$$Av\ (\%) = \frac{(Run\ Time)}{(PTI)} * 100\% \quad (2)$$

By definition, run time is the actual running time of equipment, while Planned Production Time (PTI) is the expected production time for the equipment. Furthermore, performance measures the actual production speed compared to the ideal or design speed, which can be calculated using the following formula:

$$Ideal\ Output = PTI * Ideal\ Cycle\ Time \quad (3)$$

$$Performance\ (\%) = \frac{Actual\ Output}{Ideal\ Output} * 100\% \quad (4)$$

Ideal Output is obtained by multiplying the Planned Production Time by the Ideal Cycle Time (CT), where Ideal Cycle Time is the ideal time to produce one product. Performance (%) is the result of dividing the actual output by the ideal output in the same time period, multiplied by 100%. Finally, there is quality, which indicates the percentage of products that meet quality standards without requiring further repair or being considered defective. Hence, a good product has successfully passed quality control and is deemed fit for further production, calculated by subtracting defects from actual output [18]. Quality is calculated by dividing the number of good products by the actual output, multiplied by 100% [19]. Quality (%) can be calculated using the following formula:

$$Good\ Output = Actual\ Output - Defect\ Product \quad (5)$$

$$Quality\ (\%) = \frac{Good\ Product}{Actual\ Output} * 100\% \quad (6)$$

To obtain the OEE value, multiply these three main components by the following formula:

$$OEE\ (\%) = Availability(\%) * Performance(\%) * Quality(\%) * 100 \quad (7)$$

Seiichi Nakajima led the introduction of TPM, OEE, and the Six Big Losses, whereby an OEE

value of 85% is considered a world-class standard[20].

Stage 7: Root Cause Analysis and Improvement Design

In this stage, the dominant inefficiencies from VSM and OEE were further investigated using a five M fishbone diagram and why-why analysis, ensuring that the underlying issues are addressed rather than only their symptoms. The improvement proposals are then evaluated using the ECRS method to determine which actions can eliminate, combine, rearrange, or simplify activities in the production flow.

Stage 8: Future State Mapping and Performance Evaluation

The proposed improvements are incorporated into the development of the future state map, whereby the NVA activities and lead times were recalculated and projected OEE performance was evaluated. The resulting Future State Map provides a representation of the expected process performance after implementation of the proposed improvements. VSM is first employed to identify process-level waste and efficiency losses across the entire value stream. Subsequently, OEE is used to analyze equipment-related losses contributing to the identified delays and downtime. The combined findings are then utilized as the basis for root-cause analysis and improvement prioritization.

RESULT AND DISCUSSION

Preliminary Process Analysis

Direct observations and interviews with production personnel were conducted to understand the production flow and collect operational data for the CM-216 product family as shown in Figure 3. The process begins with the sales department receiving a customer order, followed by the supply chain department creating a parent production order for injection, decoration, and assembly. The injection department creates a child production order for the material warehouse for resin checking and delivery. After receiving the resin, the operator installs the mold, fills the resin, and sets up the machine to begin the injection process. In the decoration department, the child production order is directed to the supporting warehouse to check the availability of foil and ink. The finished product is sent to the packing department before entering the finished goods warehouse.

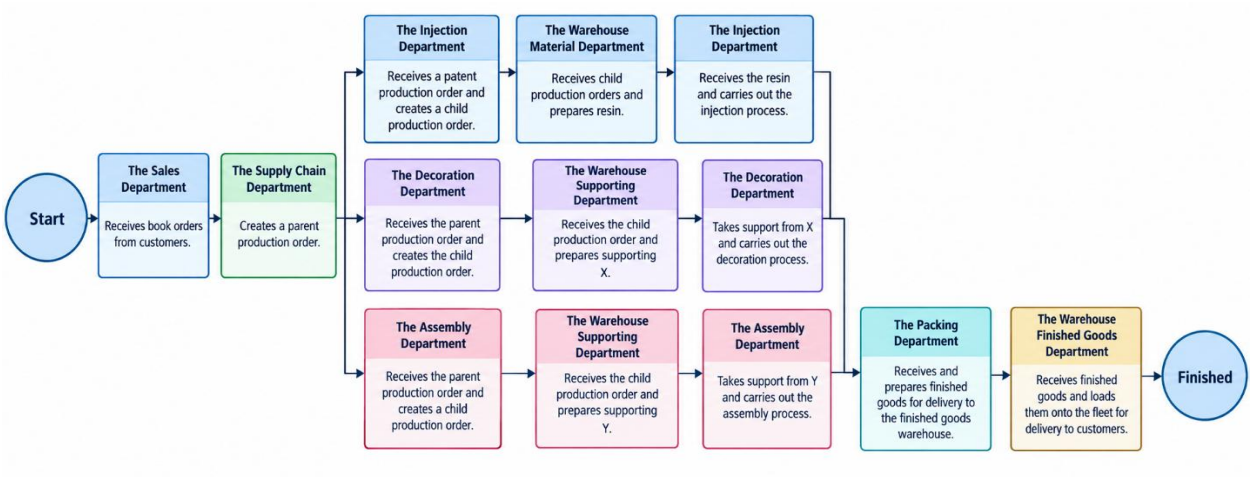


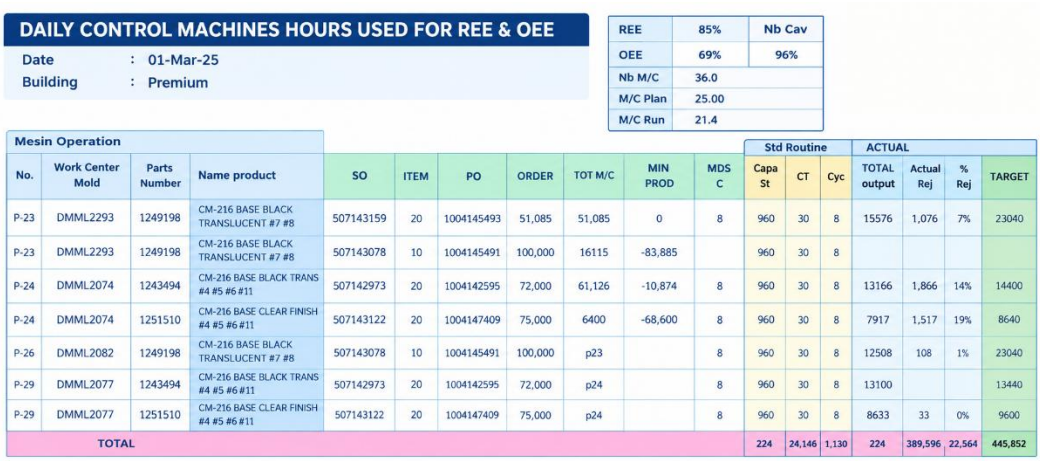
Figure 3. Production process and activity details

Table 1 summarizes the time from each production department as well as the number of activities in each department, according to the variants. The preliminary analysis revealed considerable variation in the number of activities and production lifetime across departments. Departments with a larger number of activities generally exhibited longer production lifetimes and a greater potential for process interruptions due to increased handoffs, material movements, inspections, and coordination requirements. This finding suggests that process complexity contributes significantly to operational inefficiencies and should be considered alongside equipment-related performance losses.

Table 1. Amount of Activity and Production Lead Time Recapitulation for Model CM-216
(NoA = Number of Activity; PL = Production Lifetime)

Dept.	Silver		Red	
	NoA	PL (day)	NoA	PL (day)
Warehouse Material	5	0.01	6	0.01
Warehouse Supporting	9	0.04	9	0.04
Injection	18	1.55	18	1.83
Decoration	21	2.45	10	1.31
Assembly	7	1.05	8	1.09
Packing	7	0.02	7	0.02
WH Finished Goods	3	0.01	3	0.02
Total	76	5.17	67	4.32

In parallel, downtime records extracted from the REE documents were analyzed to identify the frequency and duration of downtime activities. Figure 4 is an example of a screenshot of the REE document for department injection. Production lifetime analysis further indicated that injection and decoration processes accounted for the largest proportion of total production time. This observation was consistent with production reports shown in Table 2 and was confirmed by operator interviews, which identified these departments as the primary contributors to production delays. Therefore, these departments became the focus of subsequent VSM and OEE analyses.



DAILY CONTROL MACHINES HOURS USED FOR REE & OEE

Date : 01-Mar-25
Building : Premium

REE	85%	Nb Cav
OEE	69%	96%
Nb M/C	36.0	
M/C Plan	25.00	
M/C Run	21.4	

Mesin Operation

No.	Work Center Mold	Parts Number	Name product	SO	ITEM	PO	ORDER	TOT M/C	MIN PROD	MDS C	Std Routine			ACTUAL			TARGET
											Capa St	CT	Cyc	TOTAL output	Actual Rej	% Rej	
P-23	DMML2293	1249198	CM-216 BASE BLACK TRANSLUCENT #7 #8	507143159	20	1004145493	51,085	51,085	0	8	960	30	8	15576	1,076	7%	23040
P-23	DMML2293	1249198	CM-216 BASE BLACK TRANSLUCENT #7 #8	507143078	10	1004145491	100,000	16115	-83,885		960	30	8				
P-24	DMML2074	1243494	CM-216 BASE BLACK TRANS #4 #5 #6 #11	507142973	20	1004142595	72,000	61,126	-10,874	8	960	30	8	13166	1,866	14%	14400
P-24	DMML2074	1251510	CM-216 BASE CLEAR FINISH #4 #5 #6 #11	507143122	20	1004147409	75,000	6400	-68,600	8	960	30	8	7917	1,517	19%	8640
P-26	DMML2082	1249198	CM-216 BASE BLACK TRANSLUCENT #7 #8	507143078	10	1004145491	100,000	p23		8	960	30	8	12508	108	1%	23040
P-29	DMML2077	1243494	CM-216 BASE BLACK TRANS #4 #5 #6 #11	507142973	20	1004142595	72,000	p24		8	960	30	8	13100			13440
P-29	DMML2077	1251510	CM-216 BASE CLEAR FINISH #4 #5 #6 #11	507143122	20	1004147409	75,000	p24		8	960	30	8	8633	33	0%	9600
TOTAL											224	24,146	1,130	224	389,596	22,564	445,852

Figure 4. Screenshot of the REE Document for Injection

Table 2. Downtime Activity

No	Downtime Activity	Dept	Average Time (Hours)	
			Silver	Red
1	Operator unavailable	Injection	0.93	0.93
2	Sticky mold	Injection	1.18	1.18
3	Mold problem	Injection	0.36	0.36
4	Material changeover	Injection	0.65	0.19
5	Robot malfunction	Injection	0.19	2.85
6	Workpiece has not arrived yet	Decoration	0.19	2.06
7	Machine damaged by worn-out products	Decoration	0.29	5.72

Current State Value Stream Mapping Analysis

To evaluate process efficiency, all observed activities were classified according to the OTISD framework and subsequently categorized into Value Added (VA), Non-Value Added (NVA), and Necessary Non-Value Added (NNVA) activities. The results summarized in Table 3 indicate that operation activities account for the largest proportion of total processing time for both CM-216 variants. However, a substantial amount of time was also allocated to delay-related activities, indicating the existence of significant inefficiencies throughout the production flow.

For the CM-216 Silver variant, total operation time reached 302,961.22 seconds, while NVA activities accounted for 33,400.44 seconds. Similarly, the CM-216 Red variant recorded 281,019.38 seconds of operation time and 56,092.12 seconds of NVA activities. Although operation activities dominate the overall process time, the proportion of NVA activities remains sufficiently large to negatively affect production efficiency. These findings suggest that a considerable portion of the production lead time is consumed by waiting, transportation, and other activities that do not contribute directly to customer value.

Table 3. Time Recapitulation for OTISD dan VA/NVA/NNVA CM-216 *(in seconds)*

Department	Remarks							
	Operation	Transportation	Inspection	Storage	Delay	NNVA	NVA	VA
Warehouse Material	-	539.04	-	16.83	600	555.88	600	-
Warehouse Supporting	2,829.33	-	48.57	-	600	48.57	600	2,829.33
Injection	70,877.20	-	0.18	-	23,012.14	41.26	23,012.14	70,836.12
Decoration	52,926.48	32,622.48	912.33	-	26,810.07	61,597.53	26,810.07	24,863.76
Assembly	153,519.48	-	1,570.80	-	2,638.18	4,225.08	2,638.18	150,865.20
Packing	755.91	-	509.92	158.89	540	668.82	540.00	755.91
Total	281,019.38	33,161.52	3,041.80	175.73	56,092.12	67,137.13	56,092.12	250,261.30
Overall Process Cycle Efficiency: 67%								

Figure 5 visualizes the current state mapping of the CM-216 process flow. The CM-216 achieved a PCE of 67%, indicating that only approximately sixty percent of the total process time contributes directly to value creation. The remaining time consists of NVA and NNVA activities that represent opportunities for process improvement. The decoration department contributed the largest downtime accumulation, reaching 38.31 hours, while material warehouse activities contributed the least. These findings indicate that the major opportunity for efficiency improvement lies within the decoration process rather than material handling activities.

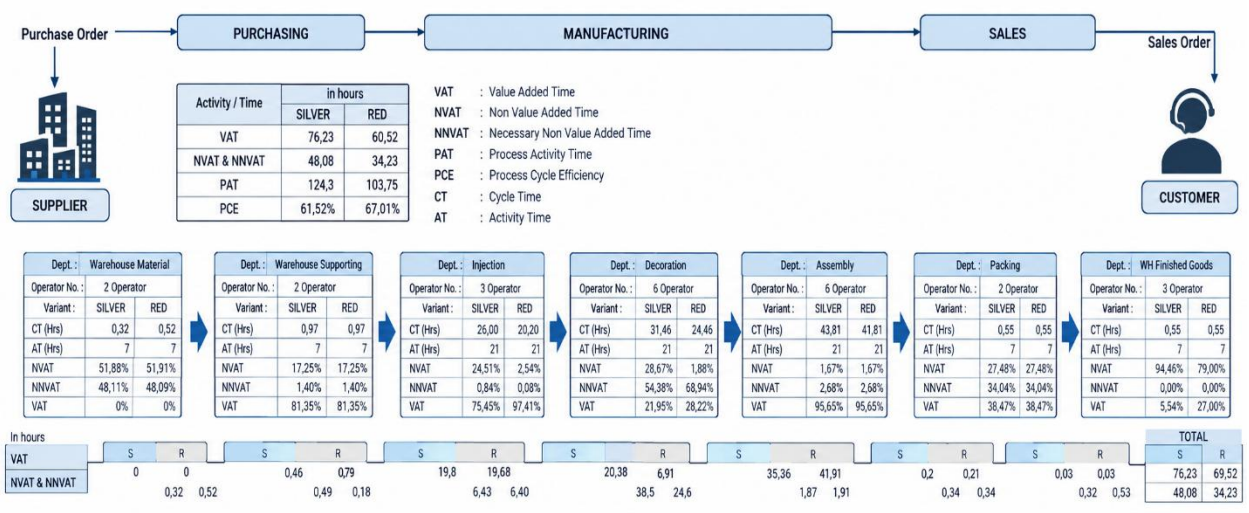


Figure 5. Current State Mapping CM-216

Downtime Prioritization Analysis

Following the VSM analysis, downtime activities were aggregated and analysed using Pareto analysis to identify the most critical contributors to process inefficiency, as shown in Figure 6. The objective of this stage was to establish a direct connection between process-level inefficiencies identified through VSM and equipment-related losses evaluated through OEE. The analysis revealed that the CM-216 Silver variant experienced a total downtime of 29,831.58 seconds (497.19 minutes). Approximately 80.14% of total downtime originated from only nine categories of downtime activities. This result confirms the Pareto principle, whereby a relatively small number of causes generate the majority of production losses. Among the identified causes, take-out robot malfunction, mold related defects, machine contamination, and operator unavailability were found to be the dominant contributors.

The concentration of downtime within a limited number of categories suggests that improvement initiatives should prioritize these issues to maximize efficiency gains. Rather than distributing resources across numerous minor issues, focusing on the few dominant causes offers greater potential for reducing production losses and improving overall process performance. This analysis also strengthens the relationship between VSM and OEE within the proposed framework. From the VSM perspective, downtime contributes directly to delay activities and increases NVA time. From the OEE perspective, the same downtime events reduce equipment availability and OEE. Therefore, downtime serves as a common performance indicator linking process efficiency and machine effectiveness.

Overall Equipment Effectiveness Analysis

The results of the OEE calculation, based on the process and product parts, are recorded in Table 4. The results indicate that the injection process consistently achieved the lowest OEE values among the evaluated departments for both CM-216 variants. This finding is consistent with the VSM results, which identified injection-related activities as major contributors to production delays and NVA time. The alignment between the two methods provides evidence that equipment-related losses significantly influence overall process efficiency.

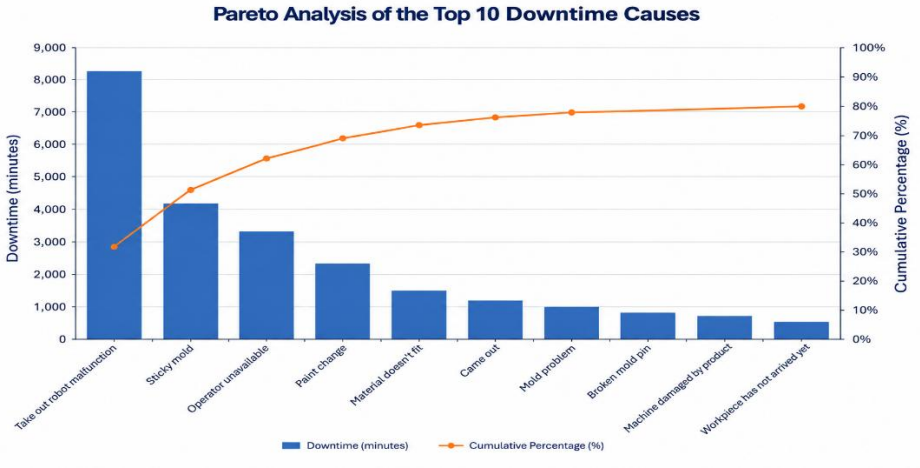


Figure 6. Pareto Diagram Downtime per activity

A detailed examination of the OEE components reveals that availability and performance losses are the primary contributors to the reduced OEE values. Frequent downtime events reduce machine operating time and consequently lower availability performance. Furthermore, several operational disruptions increase cycle times and reduce actual production speed, thereby affecting the performance component of OEE. In contrast, quality performance remained relatively stable throughout the observation period. Although quality losses were comparatively smaller than availability and performance losses, quality remains an essential component of OEE and contributes to the overall effectiveness calculation. Therefore, quality was not excluded from the analysis but was interpreted as a relatively strong performance dimension compared to the other OEE components. These findings suggest that productivity improvement efforts should primarily focus on reducing downtime and improving machine operating stability, as these factors have the greatest impact on both process efficiency and equipment effectiveness.

Table 4. Time Recapitulation for OTISD dan VA/NVA/NNVA CM-216 *(in seconds)*

Process	Injection			Printing			Stamping		
Part	Cover	Platform	Base	Cover	Platform	Base	Cover	Platform	Base
Availability	86.57%	89.32%	85.32%	-	99.52%	-	99.70%	98.25%	-
Performance	66.59%	89.09%	81.54%	-	170.13%	-	125.36%	121.45%	-
Quality	92.77%	97.61%	94.79%	-	99.20%	-	98.72%	98.84%	-
OEE	53.48%	77.68%	65.95%	-	167.96%	-	123.40%	117.94%	-

Root Cause Analysis

After identifying the dominant sources of downtime, Fishbone Diagram and Why–Why Analysis were employed to investigate the underlying causes. The analysis was structured according to the five manufacturing dimensions of manpower, machinery, material, method, and measurement. The results in Figure 7 indicate that machinery and material-related issues are the dominant contributors to downtime. Several recurring causes were identified, including take-out robot failures, mold contamination, mold pin damage, machine contamination by defective products, and delayed workpiece arrivals. These issues frequently interrupted production flow and generated prolonged waiting periods that contributed directly to NVA activities.

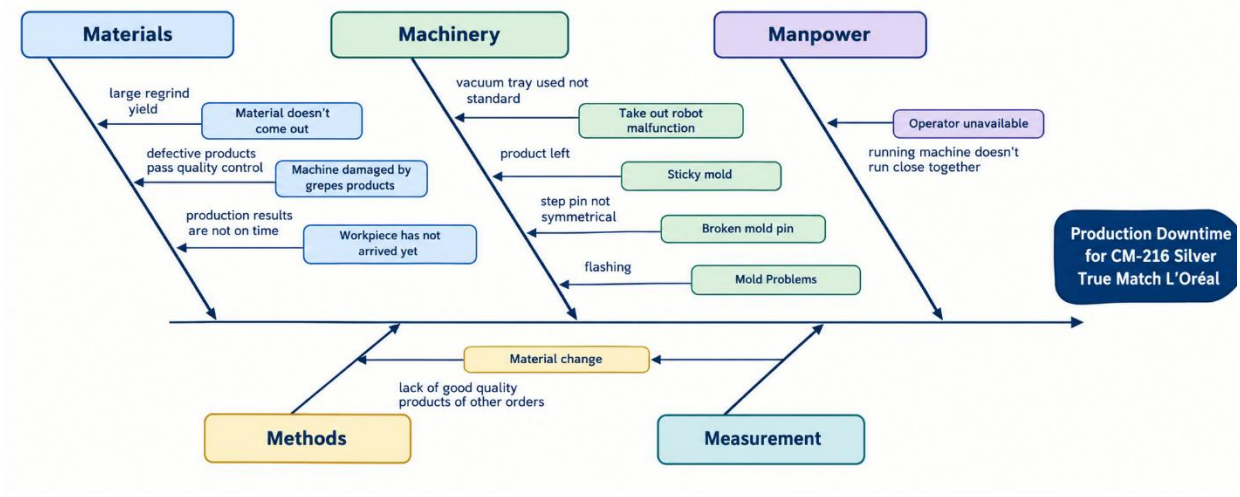
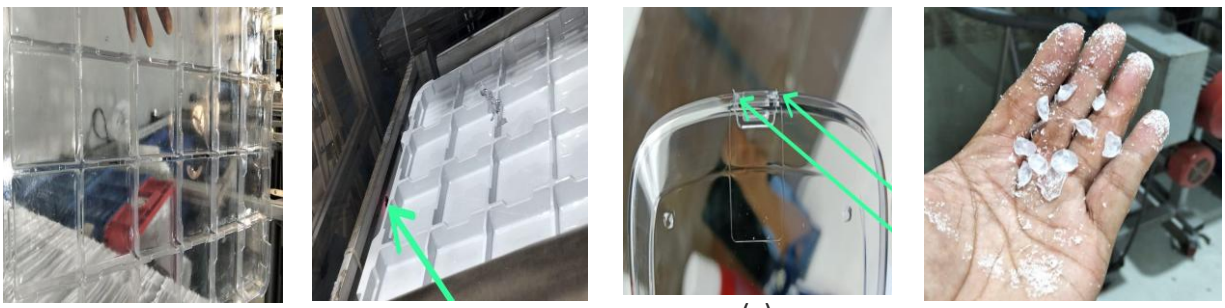


Figure 7. 5M Fishbone Diagram CM216

As illustrated in Figure 8, the machinery and material issues contribute to production downtime. For machinery factors, PET VTs and their sensor detection process can fail to identify defects, as shown in Figure 8a and 8b. Sticky mold occurs when residual resin remains in the cavity, while broken mold pins result from misaligned step pin guides. Mold flashing also causes interruptions by producing excess material along the parting line, as shown in Figure 8c. For material factors, the main issue is improper regrind size. Regrind that is too fine or too large, as shown in Figure 8d, can lead to screw starvation because the screw's first thread is not fully filled before entering the compression zone. These findings demonstrate that downtime is not solely an equipment problem but rather the result of interactions among machine conditions, operational procedures, material management, and production coordination. Consequently, effective improvement initiatives must address both technical and organizational factors simultaneously.



(a) (b) (c) (d)

Figure 8. (a) Vacuum Tray made of PET (b) Infrared Sensor that detects Vacuum Tray (c Flashing on a Product (d) Large Regrind Yield

Next, Table 5 is an example of the Why–Why Analysis that revealed many of these problems originated from insufficient standardization, inadequate preventive

maintenance practices, weak synchronization between departments, and inconsistent material handling procedures.

For example, delayed workpiece arrivals were associated with scheduling and coordination issues between upstream and downstream processes.

Table 5. Why – Why Analysis

Aspect	Why	Answer
Rearrangement of changeover (SMED)	Why does downtime occur when changing materials?	Because the changeover process takes a long time.
	Why does it take so long?	Because there are many internal activities to be done while the engine is stopped.
	Why can't it be done while the engine is running?	Because internal & external activities aren't separated.
	Why hasn't it been separated yet?	Due to the lack of SMED training and standard changeover procedures.
	Why hasn't the training been done yet?	Because it has not been made a priority in increasing setup efficiency.

Improvement Prioritization and Future State Analysis

Prioritizing the implementation of proposed solutions is necessary to determine which causes of downtime are prioritized for resolution. The impact variable is assessed based on the downtime that can be eliminated, while the effort variable is divided into four levels: very easy with a score of (1), meaning it can be done without additional costs and the addition of new SOPs. Easy with a score of (2), meaning it requires light coordination or short training. Difficult with a score of (3), meaning it involves several parties and costs 1-10 million rupiah, and very difficult with a score of (4), meaning it requires an investment of more than 10 million rupiah and major changes to procedures. Table 6 details the root cause of downtime and suggested solutions for each cause.

Table 6. Proposed Solution to Decrease Production Downtime for both CM-216 Models

No.	Root Cause	ECRS Component	Proposed Solution	Impact	Effort	Before	After
1	Operator Unavailable	Eliminate	Running machines in pairs	High	Low	1,1 H	0,5 H
2	Mold problem	Eliminate	Perform preventive maintenance for molds every 20,000 shots	High	Low	1,5 H	0,3 H
3	Material doesn't come out	Eliminate	Routine knife and filter crusher checking	Medium	Low	0,7 H	0,4 H
4	Machine breakdown	Eliminate	Tighten quality control before the stamping process	Low	Medium	1,2 H	0,6 H

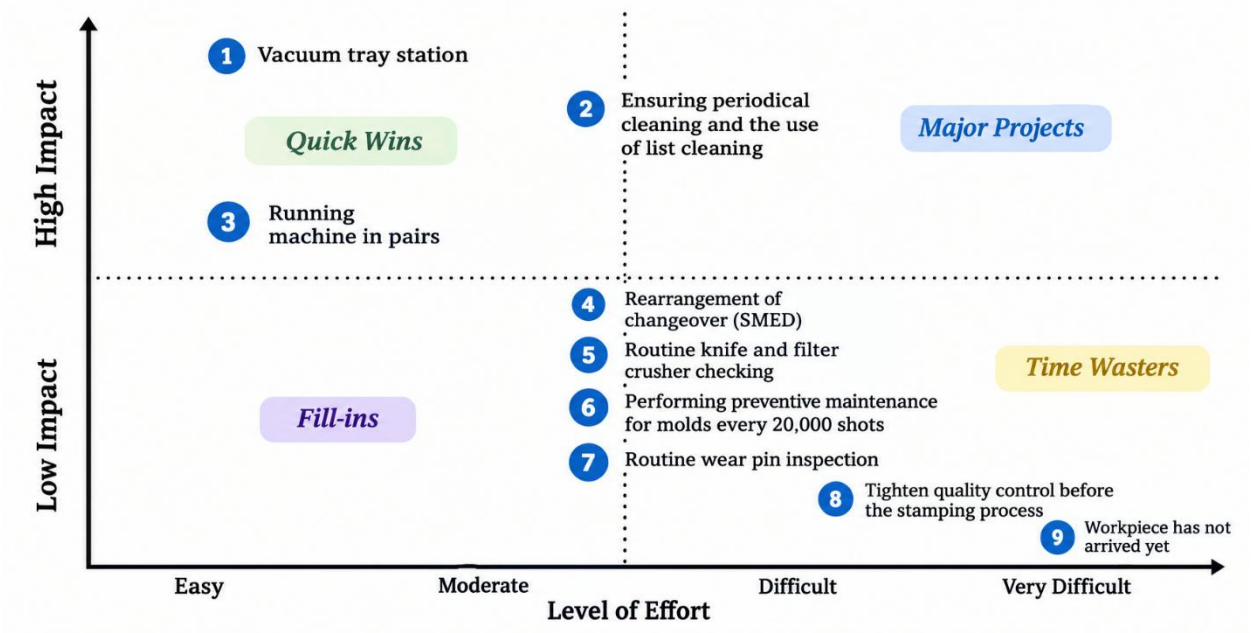
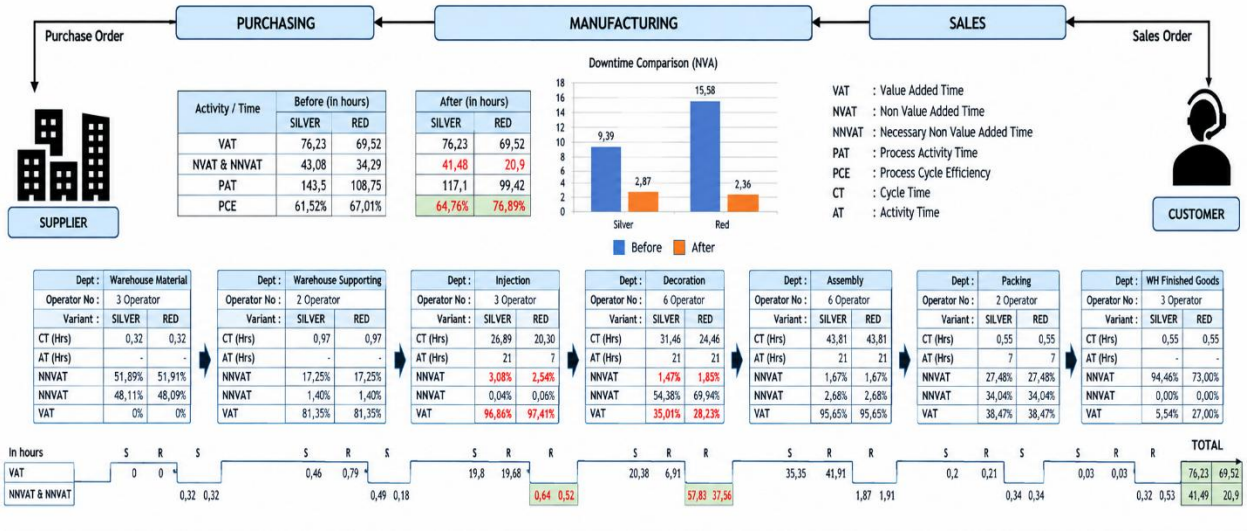


Figure 9. Impact-Effort Matrix for CM-216

As illustrated in Figure 9, proposed solutions one, two, and three fall into the Quick Wins quadrant because they require low effort while generating high impact. The downtime reduction achievable through these proposals exceeds the average downtime of 0.74 hours for the CM-216 Silver product. Proposals four through seven falls into the Fill-Ins quadrant because they require relatively low effort and no significant additional time or cost, but their potential impact is comparatively limited, with downtime reductions below 0.74 hours. In contrast, proposals eight and nine are categorized as Time Wasters because they require high effort while providing relatively low impact. Therefore, these proposals are not prioritized for immediate implementation.

The prioritization indicates that improvement efforts should initially focus on the Quick Wins, as these solutions offer the greatest potential for downtime reduction with relatively limited implementation requirements. The Fill-In solutions can subsequently be incorporated as supporting improvements, whereas the Time-Waster solutions require further evaluation before resources are allocated.

Figure 10 presents the Future State Map and the comparison of NVA activities before and after the proposed improvements. For CM-216 Silver, NVA time decreased from **9.19 hours to 2.97 hours**, while CM-216 Red decreased from **15.58 hours to 2.26 hours**. Consequently, PCE increased to **76.89% for CM-216 Silver** and **64.76% for CM-216 Red**, corresponding to reductions in NVA time of **6.22 hours and 13.32 hours**, respectively. These results indicate that prioritizing the proposed improvement actions can substantially reduce non-value-added activities and improve the proportion of production time that contributes to value creation.



Activity / Time	Before (in hours)		After (in hours)	
	SILVER	RED	SILVER	RED
VAT	76,23	69,52	76,23	69,52
NVAT & NNVAT	43,08	34,29	41,48	20,9
PAT	143,5	108,75	117,1	99,42
PCE	61,52%	67,01%	64,76%	76,89%

Dept :	Warehouse Material	
Operator No :	3 Operator	
Variant :	SILVER	RED
CT (Hrs)	0,32	0,32
AT (Hrs)	-	-
NNVAT	51,89%	51,91%
NNVAT	48,11%	48,09%
VAT	0%	0%

Dept :	Warehouse Supporting	
Operator No :	2 Operator	
Variant :	SILVER	RED
CT (Hrs)	0,97	0,97
AT (Hrs)	-	-
NNVAT	17,25%	17,25%
NNVAT	1,40%	1,40%
VAT	81,35%	81,35%

Dept :	Injection	
Operator No :	3 Operator	
Variant :	SILVER	RED
CT (Hrs)	26,89	20,30
AT (Hrs)	21	7
NNVAT	3,08%	2,54%
NNVAT	0,04%	0,06%
VAT	96,86%	97,41%

Dept :	Decoration	
Operator No :	6 Operator	
Variant :	SILVER	RED
CT (Hrs)	31,46	24,46
AT (Hrs)	21	21
NNVAT	1,47%	1,85%
NNVAT	54,38%	69,94%
VAT	35,01%	28,23%

Dept :	Assembly	
Operator No :	6 Operator	
Variant :	SILVER	RED
CT (Hrs)	43,81	43,81
AT (Hrs)	21	21
NNVAT	1,67%	1,67%
NNVAT	2,68%	2,68%
VAT	95,65%	95,65%

Dept :	Packing	
Operator No :	2 Operator	
Variant :	SILVER	RED
CT (Hrs)	0,55	0,55
AT (Hrs)	7	7
NNVAT	27,48%	27,48%
NNVAT	34,04%	34,04%
VAT	38,47%	38,47%

Dept :	WH Finished Goods	
Operator No :	3 Operator	
Variant :	SILVER	RED
CT (Hrs)	0,55	0,55
AT (Hrs)	-	-
NNVAT	94,46%	73,00%
NNVAT	0,00%	0,00%
VAT	5,54%	27,00%

In hours	S	R	S	S	R	S	S	R	R	S	R	R	S	R	S	S	R	R	S	R	S	TOTAL	
VAT	0	0		0,46	0,79		19,8	19,68		20,38	6,91		35,35	41,91		0,2	0,21		0,03	0,03		76,23	69,52
NNVAT & NNVAT			0,32	0,32		0,49	0,18		0,64	0,52		57,83	37,56		1,87	1,91		0,34	0,34		0,32	0,53	41,49	20,9

Figure 10. Future State Mapping with Downtime Comparison

CONCLUSION

Research on the production process of CM-216 cosmetic packaging at PT. TA using the VSM and OEE approaches successfully identified NVA activities and the root causes of production inefficiencies. VSM was used to map the process flow and categorize activities based on their added value, which was below the global standard of 85%, reinforcing the VSM finding that the greatest downtime occurred in the injection department. Data integration from VSM and OEE was used for root cause analysis using the 5M fishbone diagram, and solutions were developed using the ECRS approach. Three proposed improvements were categorized as quick wins because they offered high impact with relatively low implementation effort. Several additional proposals were classified as fill-in opportunities due to their low implementation difficulty but limited impact on downtime reduction. In contrast, certain proposals required substantial investment while offering only marginal benefits and were therefore assigned lower implementation priority. The improvement results indicate that the combined approach of VSM and OEE is effective in developing an efficiency improvement strategy, while also providing a strong foundation for continuous improvement in PT. TA's manufacturing system.

REFERENCES

[1] W. Murti, H., & Siregar, M. T. (2021). STUDI PERBANDINGAN KEBIJAKAN INDUSTRI 4.0 INDONESIA DENGAN TIGA NEGARA LEADING GROUP FUTURE OF PRODUCTION. *Jurnal Manajemen Industri Dan Logistik*, *5*(1), 62–74. https://doi.org/10.30988/jmil.v5i1.654

[2] Ahyat, M., Sahar, S., Afriwan, O., Saniah, E. Y., & Saputra, A. M. (2023). Digital Transformational Leadership A Village Head On Organizational Citizenship Behavior Through Work Climate And Job Satisfaction Village Officials In Lombok Island. *Jurnal Manajemen Industri Dan Logistik*, *6*(2), 242–255. https://doi.org/10.30988/jmil.v6i2.1047

[3] Kiswanto, E. (2021). PERILAKU EKSPOR DAN PRODUKTIVITAS PADA USAHA MANUFAKTUR MIKRO DAN KECIL DI INDONESIA: PENDEKATAN MODEL LIMITED DEPENDENT. *Jurnal Manajemen Industri Dan Logistik*, *5*(1), 42–52. https://doi.org/10.30988/jmil.v5i1.652

[4] S.N. Dinesh, M. Shalini, M. Vijay, R.C. Vijey Mohan, Rajasekaran Saminathan, Ram Subbiah, Improving the productivity in carton manufacturing industry using value stream mapping (VSM), Materials Today: Proceedings,Volume 66, Part 3, 2022, Pages 1221-1227, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.05.015.

[5] Khoeruddin, R. ., & Indrasti, D. (2023). Analisis Lean Manufacturing Produksi Saus Gulai dengan Metode Value Stream Mapping. *Jurnal Mutu Pangan : Indonesian Journal of Food Quality*, *10*(1), 15-23. https://doi.org/10.29244/jmpi.2023.10.1.15

[6] Abhilash Pathania, Raj Kumar, Kuldeep Rojhe, Bhaskar Goel, Sorabh Aggarwal, Dalgobind Mahto, Value stream mapping – Panacea for lead time reduction in ferrite core industry, Materials Today: Proceedings, Volume 46, Part 7-2021, Pages 2456-2461,ISSN 2214-7853. https://doi.org/10.1016/j.matpr.2021.01.362.

[7] Dorota Klimecka-Tatar, Manuela Ingaldi, Digitization of processes in manufacturing SMEs- value stream mapping and OEE analysis, Procedia Computer Science,Volume 200,2022,Pages 660-668,ISSN 1877-0509, https://doi.org/10.1016/j.procs.2022.01.264.

[8] DM, S. (2023). The Influence Of Logistic Management, Governance, And Social Responsibility On Competitiveness And Operational Performance Of Manufacturing Companies At Makassar Industrial Estate. Jurnal Manajemen Industri Dan Logistik, 7(1), 165–176. Https://doi.org/10.30988/jmil.v7i1.1180

[9] N. Corrales, L.d.C.; Lambán, M.P.; Hernandez Korner, M.E.; Royo, J. Overall Equipment Effectiveness: Systematic Literature Review and Overview of Different Approaches. Appl. Sci. 2020, 10, 6469. https://doi.org/10.3390/app10186469

[10] M. Coccia. (2017). The Fishbone diagram to identify, systematize and analyze the sources of general-purpose technologies. The Fishbone Diagram to Identify, Systematize and Analyze the Sources of General Purpose Technologies, 4(4), 291–303. https://doi.org/10.1453/jsas.v4i4.1518

[11] Pietsch, D.; Matthes, M.; Wieland, U.; Ihlenfeldt, S.; Munkelt, T. Root Cause Analysis in Industrial Manufacturing: A Scoping Review of Current Research, Challenges and the Promises of AI-Driven Approaches. J. Manuf. Mater. Process. 2024, 8, 277. https://doi.org/10.3390/jmmp8060277

[12] Kelendar, H., & Mohammed, A. M. (2020). Lean And The ECRS Principle: Developing A Framework To Minimise Waste In Healthcare Sectors. International Journal of Public Health and Clinical Sciences, September. https://doi.org/10.32827/ijphcs.7.3.98[11]

[13] Wardani, K., & Yudhistira , M. H. (2021). KONSENTRASI SPASIAL, AGLOMERASI DAN PRODUKTIVITAS PERUSAHAAN INDUSTRI MANUFAKTUR INDONESIA. Jurnal Manajemen Industri Dan Logistik, 4(2), 146–156. Https://doi.org/10.30988/jmil.v4i2.544

[14] Aripin, Norhana & Nawanir, Gusman & Mahmud, Fatimah & Fauzi, Muhammad & Hussain, Suhaidah & Lee, Khai Loon. (2023). Systematic Literature Review: Theory Perspective in Lean Manufacturing Performance. Management Systems in Production Engineering. 31. 230-241. 10.2478/mspe-2023-0025.

[15] S. Borris, Total Productive Maintenance, Mc Graw-Hill, 2006.

[16] Atikno, W., & Hardi Purba, H. (2021). Sistematika Tinjauan Literature Mengenai Overall Equipment Effectiveness (OEE) pada Industri Manufaktur dan Jasa. Journal of Industrial and Engineering System, 2(1), 29–39. https://doi.org/https://doi.org/10.31599/jies.v2i1.401

[17] N. Azizah, Fahriza & Rinaldi, Nurwinata. (2022). Effort to Improve Overall Equipment Effectiveness Performance with Six Big Losses Analysis in the Packaging Industry PT BMJ. IJIEM - Indonesian Journal of Industrial Engineering and Management. 3. 26-34. Https://doi.org/10.22441/ijiem.v3i1.13508.

[18] Hilman, H., Ali, G. A., & Gorondutse, A. H. (2020). The relationship between TQM and SMEs' performance. International Journal of Productivity and Performance Management, 69(1), 61–84. https://doi.org/10.1108/IJPPM-02- 2019-0059

[19] Setiawan, Indra & Tumanggor, Ojakma Sihar Panaili & Purba, Humiras. (2021). Value Stream Mapping: Literature Review and Implications for Service Industry. Jurnal Sistem Teknik Industri. 23. 2021. . https://doi.org/10.32734/jsti.v23i2.6038

[20] Nakajima, S. (1988), Introduction to Total Productive Maintenance, Productivity Press, Cambridge, MA.

BIOGRAPHIES OF AUTHORS

<table>
<tr><td colspan="2">Author 1 Contribution : Correspondence Author</td></tr>
<tr><td></td><td>Cindy Kristiya Himawan received the B.Sc. degree in Information Systems from Institut Teknologi Harapan Bangsa, Indonesia, in 2006 and the M.Sc. degree in Informatics from Institut Teknologi Bandung, Indonesia, in 2014. She is currently a Lecturer in the Supply Chain Management Program at Institut Teknologi Harapan Bangsa. Her research interests include lean manufacturing, supply chain management, production systems, enterprise resource planning (ERP), and business process improvement. She has participated in SAP and Odoo ERP implementation projects across 13 countries and is the co-author of two books on Odoo manufacturing and human resource management. She can be reached at cindy.himawan@gmail.com and youtube channel: Cindy Himawan

The Author Contribution is Conceptualization, Methodology, Validation, Formal Analysis, Writing – Review & Editing, Visualization, Supervision, Funding Acquisition</td></tr>
<tr><td colspan="2">Author 2</td></tr>
<tr><td></td><td>Vanechka Manuel Sopater received the bachelor degree in supply chain management from Institut Teknologi Harapan Bangsa Bandung in 2025. He held certification for logistic analysis from CILT. He joined the PT TA during his internship and after graduate, he is working in this company as Sales Engineer to continue this improvement done in the previous research. He can be contacted at email: vanechkamanuelso@gmail.com

The Author Contribution is Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation Resources, Data Curation, Writing – Original Draft</td></tr>
</table>