agriTECH, 44 (1) 2024, 80-89

Productivity Improvement Based on Lean and Green Productivity in Herbal Tea Production Line CV. DM

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Submitted: January 5, 2022; Revised: April 6, 2023, May 4, 2023; Accepted: June 19, 2023

ABSTRACT

Herbal tea is a functional beverage with significant health benefits, produced from processed plants, namely Chinese teak (*Cassia angustifolia Vahl*) and soursop leaves (*Annona muricata L*). However, herbal industry faces a productivity problem due to the production process time caused by human factors, machines, and raw materials. Productivity can also be affected by non-value-adding activities in the production processes, such as unnecessary inventory and overproduction. Fossil energy used by industry to generate electricity contributes to the production of solid waste, posing a long-term environmental risk. To address this problem, Objective Matrix (OMAX) is needed to measure the industry production rate, where all non-value-adding activities are reduced in lean and green productivity. The concept of lean and green productivity facilitates the identification of all activities to determine the locus of the highest waste, material, or energy usage. Therefore, this research aimed to propose alternative improvements for enhanced productivity by assessing production rates and identifying generated waste, energy consumption, and emissions. The results show that herbal industry had low productivity, 0.4, on a scale of 1. To improve efficiency, recommendations for lean aspect were based on forecast demand and workload. This improvement was projected to raise Process Cycle Efficiency (PCE) ore from 7.97% to 9.05% and reduce solid waste by maintaining and repairing filling machines. Green aspect could be improved by turning off idle facilities and machines, thereby minimizing electricity energy usage to 43.37%.

Keywords: Herbal tea; lean and green; objective matrix; productivity

INTRODUCTION

Herbal tea is a functional beverage with several health benefits, produced from herbs, fruits, flowers, and spices. This product is specifically different compared to traditional tea leaves derived from the Camellia sinensis plant, such as leaves, stalks, roots, and petals. In Indonesia, CV. DM industry is one of the producers of herbal tea, producing five variants of tea bags, namely Chinese teak (*Cassia angustifolia Vahl*), soursop leaves (*Annona muricata L*), mangosteen peel (*Garcinia mangostana L*), anthill (*Myrmecodia pendensi*) and rosella (*Hibiscus sabdariffa*).

CV. DM industry strives to improve production performance for customer satisfaction but challenges are often encountered in the fulfillment of product orders, leading to potential delays. In cases where new orders are received with a certain deadline that cannot be met, the industry is compelled to decline, resulting in missed opportunities. According to Duranik et al. (2011), the

DOI: http://doi.org/10.22146/agritech.71901
ISSN 0216-0455 (Print), ISSN 2527-3825 (Online)

success of the industry is based on product quality and accuracy in delivering products to customers. Delays in order fulfillment due to a limited supply of resources and sub-optimal can also inhibit productivity. Several factors have been identified to inhibit production process, including the absence of workers and machine downtime. Consequently, production activities must be observed to identify factors inhibiting the smooth flow of productivity. During production process, inattentiveness to energy consumption and solid waste generation can have an impact on the environment. Supartono et al. (2016) stated that the industry should optimize energy use, reduce emissions, and solid waste generated to improve industrial performance in reducing production costs. In herbal tea industry, solid waste is produced in the form of leaves, powder, and tea bags, with energy consumption including both electrical and gasoline to power facilities and production machinery.

Productivity in CV. DM is measured using Objective Matrix (OMAX), serving as a valuable reference tool throughout the project. This matrix allows the team to track progress against each objective and make essential adjustments. Furthermore, it communicates progress and ensures the project is in line with the industry strategy and goals (Hamidah et al., 2013). The method offers several advantages by allowing the management to easily identify the criteria measuring productivity, as reported by Leonard and Wahyu (2010) in Hamidah et al. (2013). All activities in CV. DM had been identified using lean and green productivity concepts. Lean manufacturing was used to eliminate non-value-adding activities based on seven wastes, namely overproduction, inventory, defects, transportation, motion, waiting time, and over-processing. (Firozabadi, 2015). Meanwhile, the green concept focuses on waste and energy elimination by considering the use of resources.

The lean concept is carried out using several tools such as Kaizen, Kanban, and 5S, which is a workplace organization method that involves creating and maintaining a clean and organized work environment. Furthermore, 5S is based on five principles, namely Sort, Set in order, Shine, Standardize, and Sustain, which aims to create a safe and efficient workspace by eliminating clutter, optimizing workflows, and standardizing processes), Just In Time Value Stream Mapping (VSM). However, the VSM method provides a better illustration of the problems that exist in the industry by identifying waste and causing a significant reduction (Mayatra et al, 2016). The VSM method has several weaknesses, such as the inability to consider the flow of material, economic aspects, and size of the material handling area (Firozabadi, 2015).

The application of green concept is a part of achieving green productivity. According to Hines (2012), the categories of waste based on green productivity are greenhouse gases, eutrophication, excessive resource, water, and power usage, including pollution, rubbish, and poor health as well as safety. Therefore, this research aimed to propose alternative improvements for enhanced productivity by measuring the production rate and identifying waste generated, energy consumption, and emissions.

METHODS

This research was conducted at CV. DM Bantul, Yogyakarta, focusing on herbal tea bags production obtained from five variants, namely Chinese teak, rosella, soursop leaves, mangosteen skin, and ant nest, using the Zero-one method. Production activities commenced from ordering raw materials until products were ready to be distributed to consumers. Primary data were collected through observation and in-depth interviews, including production process and quantity, product demand and delivery, number and distance between work stations, workers, cycle time, working hours, number of work in process, lead time for delivery of raw materials and products, job descriptions, factory layout, gasoline needs, and electricity usage. Secondary data included the industry profiles, determining Objective Matrix (OMAX) criteria, ordering raw materials, product requests, and deliveries, employee absences, and machine working hours.

Data analysis and processing, uniformity, and data adequacy tests were carried out at a 95% confidence level and 10% degree of accuracy in advance for cycle time, amount of raw material, scrap, and defects. Lean analysis was carried out by making a current state map of the occurrence of waste, followed by calculating takt time, Value Added Time (VAT), Non-Value Added Time (NVAT), and Lead Time (LT). Meanwhile, green analysis used mass balance to identify inputs, outputs, waste, and scrap during production. Productivity analysis was conducted to determine performance indicators, calculate performance ratios, standards, final targets, and matrices, followed by estimation of time standards using setting normal time, performance rankings, and employee benefits factors. The waste analysis on lean aspects used Value Stream Analysis Tools (VALSAT), while green aspect applied pareto diagrams, five whys, and Ishikawa diagrams. VALSAT tool is just a modification of Quality Function Deployment (QFD) whereby the WHATs represent the improvements required based on customer needs, and the HOWs represent possible techniques to achieve these improvements (Buxton and MacCarthy, 2005). Regarding electrical energy use, a comparative analysis was conducted for each workstation, with an emphasis on minimizing consumption. For fuel energy, the resulting emissions were analyzed compared to the boundary fence.

The zero-one method was used for product selections by establishing criteria through a process of, comparison, determining the level of importance, and weighting of each criterion, followed by adding the calculation results. Criteria were determined using interview method with in-depth interviews. The purpose of weighting referred to Ulrich and Eppinger (2000) by allocating a value of 100% on predetermined criteria, determined subjectively by the consensus team. Subjective weighting was determined based on thoroughly understanding the object under study (Ulrich and Eppinger, 2000).

Measurement of productivity using the OMAX method referred to by Nasution (2006) in Hamidah et al. (2013). The steps taken included the determination of criteria, calculation of performance ratio, standard achievement (score 3), highest achievement (score 10), worst achievement (score 0), score determination, weight, and Index Performance (IP) (Equation 1).

$$IP = \frac{\text{(The value of the current period) - (The value of the previous period)}}{\text{(The value of the previous period)}} \times 100\,\% \quad (1)$$

Non-value-added activities were identified using VSM by creating a current state map. Subsequently, it was analyzed using VALSAT. The formula used to create a current state map is expressed using Equation 2, 3, 4, 5, and 6.

$$\text{Take time} = \frac{\text{(Working time per day - rest time per day)}}{\text{(Number of requests per day)}} \quad (2)$$

$$\text{Lead time inventory} = \frac{\text{(Inventory)}}{\text{(Production rate)}} \quad (3)$$

$$\text{Process lead time} = VAT + NVAT + LT - \quad (4)$$

$$PCE = \frac{\text{value added time}}{\text{Process lead time}} \times 100\,\% \quad (5)$$

Description: PCE = Process Cycle Efficiency, VAT = Value-added time, NVA = non-value-added time, LT = Lead Time.

Solid waste was measured by collecting waste generated on the floor and the production machine was weighed. Subsequently, mass balance was created to determine the amount of material entering and leaving the system. Measurements of electrical and gasoline fuel energy were carried out using the Equation 6 and 7.

Energy (MJ) = Mass (kg) x heating value (MJ/kg) (6)

Electrical energy (J)= Power (W) x time (s) (7)

Description: The measured emissions and NOx will be compared with the SO2 threshold of 4.037 g/kg. 3.309 g/kg (EPA, 2008).

RESULTS AND DISCUSSION

CV. DM, established in 2008, is the industry engaged in the production of herbal tea. The industry has seven workers in production processes such as sorting, grinding, filling tea powder with a filling machine, and packing. First packaging is carried out by filling tea in filter paper bags with tea tags. This is followed by the second packaging using aluminum foil and box, while the third packaging entails the insertion of boxes into the cardboard.

The research commenced with the identification of the object using the zero-one method. The selected criteria were the production volume, demand volume, availability of raw materials, and price, which were determined by in-depth interview with an expert in the production manager and industrial owner field. Lowe and Taylor (2013) stated that in-depth interview provide a direct insight into the perspective of respondents, focusing on a single topic based on the intended purpose. The zero-one method shows that teak tea and soursop leaves are superior in every criterion and can be used as the research object.

The advantages of possessing tea bags are based on the profit factor for the industry and properties, specifically for the treatment. Chinese teak has anti-rein compounds with stimulant laxative properties (Werner and Merz, 2007). According to Motoyuki (2000) in Hermawan and Hendrawan (2013), in soursop leaves, there are acetogenic compounds capable of attacking cancer cells with excess adenosine triphosphate (ATP).

Productivity Measurement

Productivity was measured using Objective Matrix (OMAX), with the work attendance criterion (production volume criterion/A) selected based on absenteeism data, identifying workers who were often absent. The working hour criterion (volume demand criterion/B) was selected because there were still workers who did not work for 7 hours. Additionally, the criterion for using machine hours (availability of raw materials Criterion/C) was selected because the engine experienced downtime.

Criterion B has the highest weight as there were still workers who did not meet the required 7 working hours. This criterion was significant as the majority of work in the industry was manual, making workers input an essential factor in productivity. Machine usage

Table 1. Preparation of OMAX in January 2017

Matrix Objective Matrix (OMAX) January 2017					
Criterion	Attendance of workers (days)	Use of worker hours (hours)	Use of the machine (jam)	Score	Information
Actual value	0,7976	0,7494	0,6488		
Target	0,8800	0,8500	0,8500	10	Very good
	0,8610	0,8346	0,7874	9	Good
	0,8420	0,8192	0,7247	8	
	0,8229	0,8038	0,6621	7	
	0,8039	0,7884	0,5994	6	
	0,7849	0,7730	0,5368	5	
	0,7659	0,7576	0,4741	4	
	0,7468	0,7422	0,4115	3	Medium
	0,7379	0,6848	0,3677	2	Bad
	0,7289	0,6274	0,3238	1	
	0,7200	0,5700	0,2800	0	Very bad
Score actual	5	3	6		
Weigt	35	40	25		
Productivity value	175	120	150		
Informatian	Good	Medium	Good		
Final value	445				
Performance index	Currently (445)	Month before (360)	Index (23,61)		

criterion had the lowest weight compared to others, as machine hours depended on the number of workers present and batches of tea bags to be produced. This was because increased batches and more frequent workers attendance contributed to enhanced machine efficiency. Subsequently, the preparation of the OMAX table is shown in Table 1.

The performance index from November 2016 to March 2017 was plotted on the graph in Figure 1.

Hamidah (2013) observed that fluctuations in the value of the performance index indicated sub-optimal level of productivity, requiring improvement. An efficient strategy to explore the causes and formulate improvements is to analyze with five whys, referring to Chen et al. (2010). In this research, analysis results with five whys showed that the largest productivity increase in January 2017 was due to low worker absenteeism. The highest production output was 1949 packs, and defective tea bags produced the lowest, averaging 68 tea bags per day. Meanwhile, the lowest decrease in

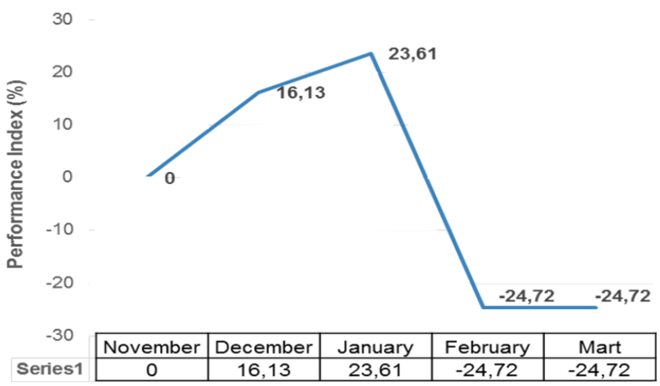

Figure 1. Performance index of productivity from November 2016 to March 2017

productivity was in February 2017 due to a decrease in production output of 1434 packs. During this period, the industry recorded the largest defect in tea bags with average of 117 teebags per day, followed highest

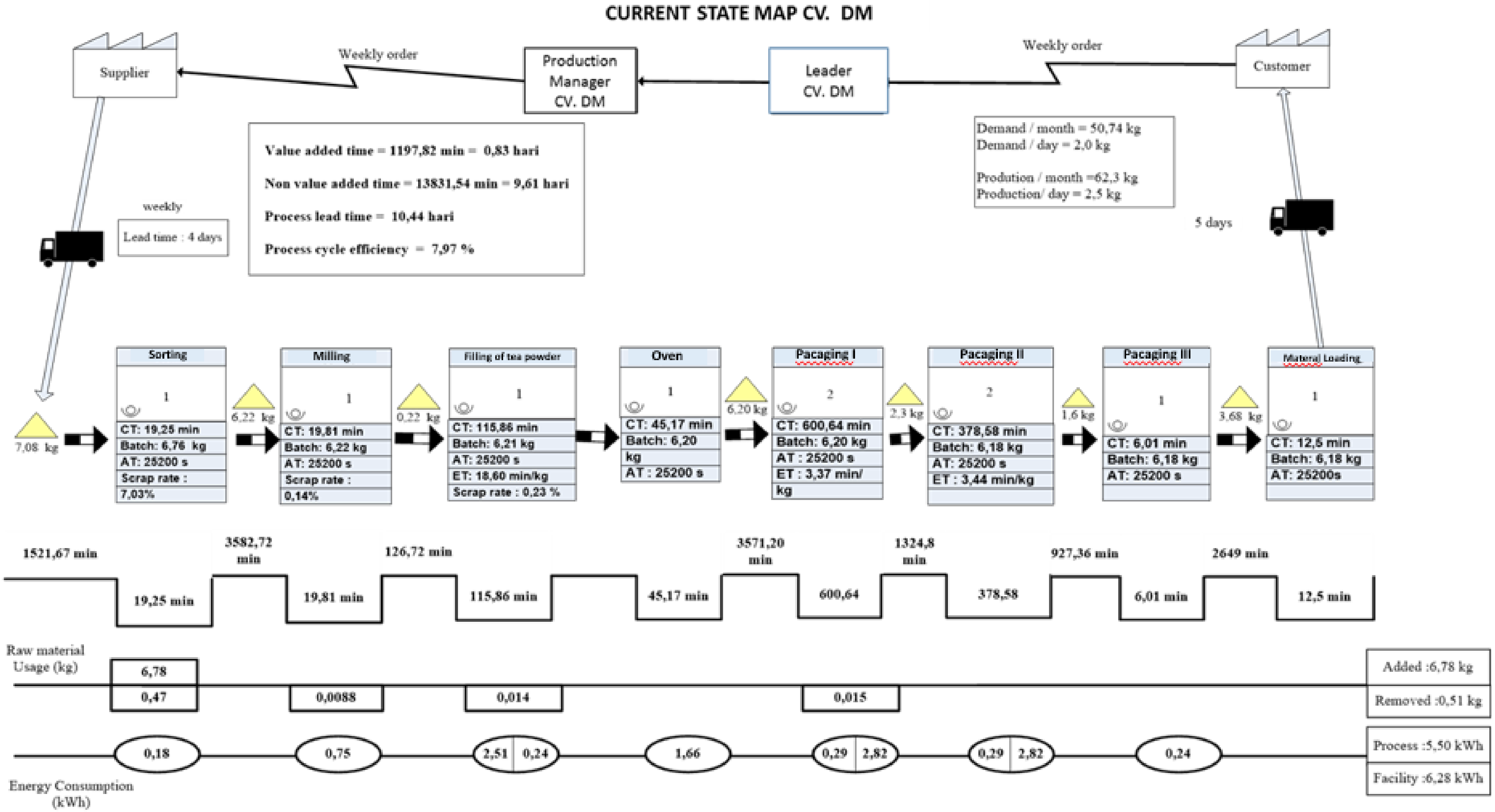

Figure 2. Current state map of CV DM

number of workers absenteeism. Workers at the Working Station (SK) Mill were present for 12.5 days, and SK Package I was obtained in 11.5 days among 24 working days.

The low number of worker attendance was due to the lack of discipline, motivation, and allowance factor, which led to boredom with repetitive job desks. Meanwhile, on the engine factor, there was damage to the inner spare part of the machine causing defects in the tea bags.

Based on the results of productivity measurement from November 2016 until March 2017, the final value of 400 among 1000 was recorded. This indicated that low productivity level of 0.4 was achieved for CV. DM, showing a significant short of the ideal value of 1, as presented in Table 1.

Identification of Waste

Waste identification in the production process was carried out using lean manufacturing concept with the Value Stream Mapping (VSM) tool. Vinodh et al. (2016) stated that conventional VSMs can only assess Value Added Activities (VA) and Non-Value-Added Activities (NVA). This has led to the recent development of conventional VSMs to not only describe VA and NVA but also assess the environmental and energy performance of the industry issued by the Environmental Protection Agency (EPA) Year 2007. This tool facilitates the identification and elimination of waste by visualizing the use of energy, water, and materials together with VA and NVA in matrix form. The initial step of the VSM method was to create the current state map, as shown in Figure 2.

The current state map results in Figure 2 were analyzed using Value Stream Analysis Tools (VALSAT). The highest score on VALSAT determined the selection of tools, followed by an assessment or scoring with the production manager. Based on the results of analysis using VALSAT, Process Activity Mapping (PAM) obtained the highest score of 71, showing its suitability for analyzing the current state map. The results of the PAM analysis are shown in Table 2.

Table 2 shows that storage has the largest percentage among other activities due to storage time of raw materials, semi-finished materials (WIP), and finished products. Storage of raw materials occurred because the industry ordered from suppliers located outside Yogyakarta. Storage of finished products was caused by overproduction due to the lack of amount to be produced. Meanwhile, WIP occurred because of differences in workload on each SK.

Process Cycle Efficiency (PCE) is a measure to determine the extent of time efficiency of the flow of value in the industry (Nugroho et al., 2015). In this

Table 2. Percentage of production activities

Activities	Amount of time (minute)	Percentage (%)
Delay	116,75	0,77
Operation and inspection	1197,82	7,96
Storage	13703,47	91,17
Transportation	11,32	0,075
Total	15029,36	100

research, PCE value of 7.97% was obtained due to the long duration of process lead time. According to Gasperz (2007), when the PCE value is less than 30%, the process is considered un-lean (not lean). Hossain and Uddin (2015) also added that PCE value of more than 25% is included in a competitive industry, indicating the inclusion of CV. DM in un-lean (not lean) category.

Solid Waste

Based on the current state map in Figure 2, the causes of solid waste are proposed with a Pareto Diagram. Prashar (2014) uses Pareto analysis to prioritize the solution in Figure 3.

Figure 3 shows that leaf-spilt solid waste has the highest percentage of 62.75%. The availability of raw materials is an aspect that cannot be controlled directly due to the direct supply from outside Yogyakarta, facilitating the improvement of tea bags waste. Based on the analysis of five whys, tea bags defects were obtained from filling machines due to humans, machines, and methods. Additionally, leaves-spilled solid waste was obtained from sorting, milling, and packaging I, including tea bags and powder.

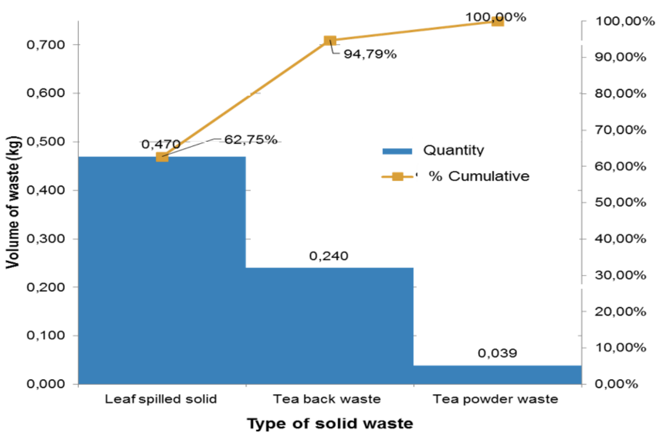

Figure 3. Pareto solid waste diagram of CV DM

Energy Utilization

Based on Figure 2, electrical energy used for the production machine was 5.50 kWh, the production facilities were 6.28 kWh, and electricity cost was Rp. 18,488/kWh Moreover, production facilities require greater energy because air conditioning demands more power.

The fuel used was gasoline to power the milling machine. The use of gasoline was multiplied by the heating value, which was 44.75 MJ/kg (International Energy Agency, 2005), resulting in energy consumption of 0.401 MJ/kg. Energy use will produce emissions that contain components such as CO2, SO2, and NOx. Moreover, emissions were determined by multiplying the energy used by the fuel emission factor, as presented in Table 3.

The results of emissions expenditures in Table 3 were compared with the threshold referring to environmental quality standards by EPA 2008 with SO2 and NOx emissions. The SO2 emissions threshold is 2.65 x 10-5, and NOx is 1.69 x 10-5, thereby emissions issued by the industry are still within the threshold of environmental quality standards.

Alternative Improvement Preparation

Production based on demand forecasting

The production of tea bags was based on a push system, where the industry produced goods using estimated demand to avoid stock out and lost opportunity. However, the industry cannot implement a pull system due to the lack of daily orders from consumers. According to previous investigations, it was reported that push systems are suitable for the industry with non-daily order frequencies (Houti et al., 2016). Forecasting for the production of tea bags uses historical sales data for 2014-2017 through WINQSB software and the decomposition method. Moreover, the decomposition method selected the smallest Mean Absolute Error (MAE), with the results shown in Table 4.

Table 3. Emissions produced per 1 kg of product

Gasoline emission factor (mg/kg)		Energy use per kg	Emission (g)
CO_2	0,0225[1)]	0,401	$9,022 \times 10^{-6}$
O_2	0,0661[1)]	0,401	$2,650 \times 10^{-5}$
NO_x	0,0423[1)]	0,401	$1,696 \times 10^{-5}$
Total			$5,249 \times 10^{-5}$

Source: 1) BUWAL 250 in Supartono (2002)

Table 4. Forecasting tea bags in 2017

Month	Forecasting tea bags in 2017 (Unit)				
	Chinese Teak	Soursop leaf	Mangosteen petals	Anthill	Rosella
May	626	439	270	472	155
June	571	529	351	378	355
July	509	479	639	245	241
August	603	716	529	392	252
September	518	406	296	423	320
October	438	521	364	399	438
November	708	631	452	360	484
December	553	504	266	273	356

Balancing the workload

Determination of workload was carried out using Workload Analysis (WLA) to assess the need for the amount of labor at a certain time. The results showed that improvement reduced workload, namely SK Sortation from 0.14 to 0.08, SK Milling from 0.14 to 0.08, and SK Filling from 1.71 to 0.95. Furthermore, workload on oven was reduced from 0.67 to 0.28, Packaging I SK from 8.87 to 4.92, Packaging II SK from 5.57 to 3.09, and Packaging III SK from 0.03 to 0.0005. The improvement decreased the delay in production activities, as shown in Table 2. Allocation of workers is required, as there are some with low workload that can help others. Based on the results, it was discovered that allocation was carried out for SK workers who do not require special skills, as shown in Table 5.

Reducing the use of electricity

Reduction of electricity usage, as stated by Ball (2015), included turning off facilities or tools that are not used, causing a 43.37% reduction, from 11.78 kWh to 6.67 kWh per batch. Although there was a decrease in electricity usage, high energy (kWh) released per kg was observed, from 2.10 kWh/kg to 2.69 kWh/kg. The energy consumption increased due to the effectiveness of machine as the energy loss decreased. However, the industry still benefited due to a reduction in waste through over-production and excessive inventory. Reducing the electricity for each batch also reduced the initial cost of Rp18488 to Rp10472.83.

Solid waste reduction

Improvement alternatives to reduce the amount of solid waste by considering the problem of maintenance of production machinery and checking the components

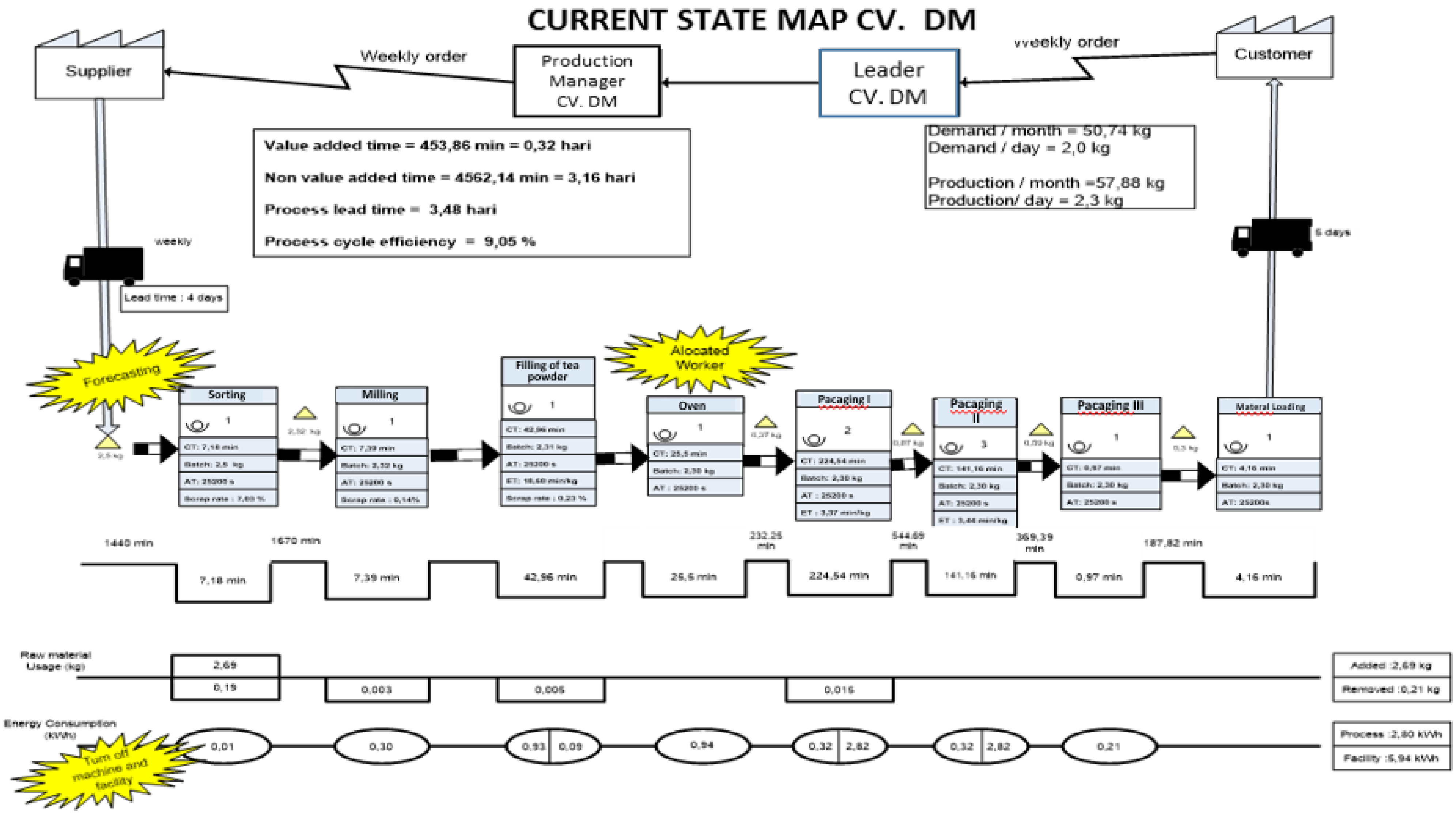

Figure 4. Future state map of CV DM

Table 5. Allocation of workers before (a) and after repair (b)

Workers	Work station,	Workload
A	Sorting, milling	0,28
B	Filling tea powder, oven	2,38
C, D	Packaging I	8,87
E, F	Packaging II	5,57
F	Packaging III	0,03

(a)

Workers	Work Station,	Workload
A	Sorting, milling, packaging III	0,15
B	Filling tea powder, oven	1,22
A, C, D	Packaging I	4,92
E, F	Packaging II	3,09

(b)

in the filling machine before the commencement (Pujotomo and Rama, 2007). This process aims to avoid sudden damage to the engine by installing the blower on the filling machine close to the sealer to remove the powder attached, facilitating adjustment in the mounting strength of the screw to the gear. Consequently, the operation reduced the amount of scrap powder that was processed. Alternative improvements in demand forecasting, workload, shutting down machinery, and production facilities are simulated in the future state map presented in Figure 4.

The results showed a decrease in the use of raw materials by 4.58 kg or 67.51%, which positively impacted savings such as time, inventory, excess production, and work in process. This showed that energy use was reduced by 5.17 kWh or 43.37%, while PCE increased by 9.05%. However, the values were still below expectations of 30%.

CONCLUSION

In conclusion, this research showed that CV. DM has a low productivity of 0.4 on a scale of 1. The dominant sources of waste in the production process were overproduction and excessive inventory, accounting for 13703.47 minutes or 91.17% of the total production time. Solid waste generated included 0.47 kg (62.75%) of leaves spillage, 0.24 kg (32.04%) of tea bags, and tea powder 0.024 kg (5.21%). The fuel emission of the milling machine was 2.65 x 10-5 g/kg for SO_2 and 1.69 x 10-5 g/kg for NO_x. These values were within the threshold of environmental quality standards (4,037 g/kg for SO_2 and 3,309 g / kg for NOx). The use of electrical energy was 11.78 kWh/batch or 2.10 kWh/kg of production. Improvements in forecasting and allocation of workers increased the PCE value by 1.08% to 9.05%. For the green aspect, electricity usage was reduced by 43.3% through the maintenance and repair of the filling machine, as well as shutting down production facilities that were not used.

ACKNOWLEDGMENT

The authors are grateful to CV DM as the research location and the 5th International Conference of Agroindustry (5th ICoA) who have reviewed and accepted the presentation of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the publication of this research.

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