ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Improving efficiency in green tea production time using lean manufacturing approach with value stream mapping: A case study at PT Candi Loka

[Perbaikan efisiensi waktu produksi teh hijau menggunakan pendekatan produksi ramping dengan value stream mapping: Studi kasus di PT Candi Loka]

Bambang Herry Purnomo[1], Ilham Aulia Rachman[1], dan Ida Bagus Suryaningrat[1]

[1] Agriculture Industrial Technology Study Program, Faculty of Agricultural Technology, Universitas Jember, East Java, Indonesia
* Correspondence email: bhp17@unej.ac.id

Submitted: 30 November 2023, Accepted: 18 April 2024, DOI: 10.23960/jtihp.v29i1.132-143

ABSTRACT

Green tea production activities at PT Candi Loka indicated a time-consuming, which caused process efficiency to be less than optimal. Process efficiency improvements must be made to increase company competitiveness and consumer satisfaction. This research aimed to analyze the efficiency of green tea production time at PT Candi Loka by identifying the processing time required in each production activity, including the time consumption and formulating recommendations for improvement using a lean manufacturing approach using the VSM (Value Stream Mapping) method. There were 30 activities in 6 processes consisting of receiving raw materials, withering, rolling, drying, and packaging. Identification of value streams using the PAM (Process Activity Mapping) tool produced 9 Value added (VA) activities, 19 Necessary but Non-Value Added (NNVA) activities, and 2 Non-Value Added (NVA) activities in the form of delays in the withering and drying processes. In the current state map analysis, the production lead time value was 315.286 seconds. Recommended improvements to eliminate delays in the withering process were to set up the rotary panner machine earlier and increase the number of supervisors, while to eliminate delays in the drying process were to implement a piece rate system. Increasing efficiency was also carried out by improving NNVA activities by adding weighbridge facilities and using a conveyor system. The future state map proposed by implementing recommended improvements resulted in an increase in production time efficiency to 222.356 seconds and an increase in the process cycle efficiency value from 58.95% to 84.85%

Keywords: green tea, lean manufacturing, time efficiency, value stream mapping

ABSTRAK

Aktivitas produksi teh hijau di PT Candi Loka mengindikasikan terjadinya pemborosan waktu yang dapat menyebabkan efisiensi proses menjadi tidak optimal. Perbaikan efisiensi proses perlu dilakukan untuk meningkatkan daya saing perusahaan dan kepuasan konsumen. Penelitian ini bertujuan menganalisis efisiensi waktu produksi teh hijau pada PT Candi Loka dengan mengidentifikasi waktu proses yang dibutuhkan dalam setiap aktivitas produksi termasuk pemborosan waktu yang terjadi dan merumuskan rekomendasi peningkatannya dengan menggunakan pendekatan lean manufacturing yaitu metode VSM (*Value Stream Mapping*). Terdapat 30 aktivitas dalam 6 proses yang terdiri dari penerimaan bahan baku, pelayuan, penggulungan, pengeringan 1, pengeringan 2, dan pengemasan. Identifikasi aliran nilai menggunakan tools PAM (*Process Activity Mapping)* menghasilkan 9 aktivitas *Value added* (VA), 19 aktivitas *Necessary but Non Value Added* (NNVA), dan 2 aktivitas *Non Value Added* (NVA) berupa *delay* di proses pelayuan dan pengeringan. Pada *current state map* nilai *lead time* waktu produksi sebesar 315,286 detik. Rekomendasi perbaikan untuk menghilangkan *delay* pada proses pelayuan adalah dengan melakukan *set up* mesin *rotary panner* lebih awal dan penambahan jumlah pengawas, sedangkan pada *delay* proses pengeringan adalah dengan menerapkan sistem upah borongan. Peningkatan efisiensi juga dilakukan dengan perbaikan aktivitas NNVA berupa penambahan fasilitas jembatan timbang dan penggunaan sistem konveyor. *Future state map* dengan menerapkan rekomendasi perbaikan menghasilkan peningkatan efisiensi waktu produksi menjadi 222,356 detik dan peningkatkan nilai *process cycle efficiency* dari 58,95 % menjadi 84,85 %.

Kata kunci: efisiensi waktu, *lean manufacturing*, teh hijau, *value stream mapping*

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Introduction

Tea is one of the primary plantation commodities in Indonesia. It is derived from the *Camellia sinensis* plant and enjoyed by the public as a drink made by steeping processed tea leaves in hot water. Tea is categorized into three types based on the production process (Fajar et al., 2018). One of them is green tea, which has the highest catechin content (Fadhilah et al., 2021) and provides numerous health benefits, including preventing heart disease, atherosclerosis, high cholesterol, diabetes, liver disease, weight loss, and reducing the growth of cancer cells in organs such as the lungs, intestines, and skin (Ratnani & Malik, 2022).

PT Candi Loka is a private company that produces green tea using raw materials (fresh tea leaves) from the Jamus plantation in Ngawi Regency, East Java. The green tea production process at PT Candi Loka consists of several stages, including receiving raw materials, withering using an oven, rolling, drying using an Endless Chain Pressure (ECP) machine and a ball tea machine, sorting and packaging. This process involves both manual and automatic activities. This company has a processing capacity of up to 10 tons per day, with a processing time of around three days. To ensure the efficiency of the production process, companies must optimize available operational time and save time, especially for activities that does not provide added value. Indications of time-consuming processes at PT Candi Loka can be seen from the slow process of withering and drying tea leaves and the relatively slow process of moving materials that still rely on human power. This inefficiency can cause additional costs, reduce productivity, and cause poor product quality, resulting in consumer dissatisfaction and reducing company competitiveness. Fauziah et al. (2022) explained that delay was one of the time-consuming activities in the production process. Delays can occur when the machine cannot reach its optimal capacity, causing the following process has to wait too long. PT Candi Loka often faces such situation, therefore the company's process efficiency still needs to be improved.

PT Candi Loka needs to increase its competitiveness by increasing the efficiency of its production process, which can be achieved by implementing lean manufacturing that involves continuous improvement by minimizing various time-consuming processes. The time-consuming processes include waiting time, long processing time, product defect, excess inventory, and operational costs (Satria & Yuliawati, 2018). Value Stream Mapping (VSM) is one of the lean manufacturing methods used to visually represent the current state of the process through a detailed process flow map. VSM is necessary to help identify and measure process inputs and outputs and to develop future state maps for better process alternatives (Khoeruddin & Indrasti, 2023). VSM has been widely used to solve time-wasting problems in many companies to gain a competitive advantage in the global market. Research on the application of VSM in footwear companies was reported by Liu & Yang (2017) with impressive results, namely success in shortening the footwear manufacturing process time from 8.5 days to 2.5 days. Furthermore, Khoeruddin & Indrasti (2023) also conducted research at a curry sauce company and found that the processing time was reduced by 2.35%. Meanwhile, Ma'sum & Setiafindari (2022) reported that implementing VSM in bag manufacturing factories reduced process time by 6%. According to Gebeyehu et al. (2022), reducing this time could be done by reducing time for activities that did not provide added value, such as queuing for materials, material transportation routes, and material movement.

PT Candi Loka requires a Value Stream Mapping (VSM) to evaluate the efficiency of its current processes. Indicators such as time-consuming processes and slow material movement suggest that the tea production process needs to adhere to lean manufacturing principles. Sundar et al. (2014) stated that eliminating wasted processing time and speeding up material movement were vital for realizing lean production. This research analyzed the efficiency of green tea production time at PT Candi Loka by identifying the processing time required in each production activity, including the time consumption, and formulating recommendations for improvement using the VSM method.

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Materials and methods

Materials and tools

The research required primary data (information flow, process flow, and process time) obtained through observation and secondary data from references and company documents. Tools used in this research included a stopwatch for time measurement during data collection and software such as Microsoft Visio and Microsoft Word to describe the mapping process.

Research methods

Identification of production activities at PT Candi Loka was conducted using the Process Activity Mapping (PAM) method (Ulfah et al., 2023). This method required data in the form of types of activities and the length of time of such activities, which had previously been collected through observation. The production activities observed were then grouped into five types of activities: operation (O), transportation (T), inspection (I), storage (S), and delay (D). Next, these types of activities were determined according to their usefulness into three groups: added-value activities (VA), non-added-value activities (NVA), and activities that were needed but do not provide added-value (NNVA) (Misbah et al., 2015). The added-value activities were determined through observation and interviews with experts from the companies being studied. The added-value activities could change the characteristics of the material being processed, whether physical, chemical, or physiological. These changes increased the value and benefits of the material or final product. The added-value activities were the core activities in the production process, while non-added-value activities were supporting or ancillary activities that accompany the core process, which included activities such as process preparation, rhythm and body movements, material flow, delays, worker supervision, and so on. If carried out excessively and inefficiently, these activities might become a source of lost time and money (Salwin et al., 2021).

Process flow analysis utilised a current state map that included information on material flow and process time data grouped by activity type, facilitating easy identification of areas where waste occurs (Ma'sum & Setiafindari, 2022). By using the 5 Whys method, the causes of the lost could be identified and then eliminated (Novitasari & Iftadi, 2020). Recommendations for improvement were developed in the form of a future state map. This map explained the elimination of NVA activities, processing time, and lead time (Dhika et al., 2023). The increase in process efficiency was expressed by the Process Cycle Efficiency parameter, determined using the following equation (Anggraini et al., 2020) :

$$Process\ Cycle\ Efficiency\ (PCE) = \frac{Value\ added\ time}{Process\ lead\ time} \times 100\%$$

Research implementation

The research began with field and literature studies to identify problems and determine research objectives. The primary data collection stage involved field observations, interviews, and time data measurement to identify activities at each process stage at PT Candi Loka. The identification results were then coded. Process time measurements were carried out by repeating each batch's activities three times. Primary and secondary data collection activities took place in June 2023. The data processing stages included analyzing added value using the PAM method, preparing a current state map, analyzing problems using the five Whys method, providing recommendations for improvements, and preparing a future state map. A comparative analysis between the current and future state maps was conducted to determine the increase in time efficiency after implementing the recommendations for improvement. The final stage involved comparing the two conditions' Process Cycle Efficiency parameter values to determine the achievable improvement results.

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Research parameters

The research parameter was Process Cycle Efficiency (PCE), which was the ratio between value-added time and total production process time (lead time) (Anggraini et al., 2020). Karabay & Kansul (2019) stated that higher PCE values indicated a more efficient process.

Results and discussion

Value-added stream identification results

The green tea production processes at PT Candi Loka include receiving raw materials, withering, rolling, primary drying (using an ECP machine), secondary drying (using a ball tea machine), and packaging. The length of time for such activities falling into the categories of VA, NVA, and NNVA was identified based on previously explained rules, which involved measuring the duration of each activity (Karabay & Kansul, 2019; Shou et al., 2020). For VA, which was a core process, measurements were carried out from the beginning to the end. NNVA was a supporting activity separate from the core process but must be eliminated. The length of time was measured carefully just before or after the VA took place. Meanwhile, NVA was an activity outside of VA and NNVA that occured during production and contributed to lead time (Gebeyehu et al., 2022). The analysis revealed 30 activities distributed across six stages of the green tea production process, which included 3 activities in the raw material receiving process stage, 6 in the withering stage, 4 in the rolling stage, 5 in the drying stage 1, 7 in the drying stage 2, and 5 in the packaging stage. The results of activity identification and time measurements are input into Table 1.

Table 1. Process activity mapping for identifying VA, NVA, and NNVA activity types

No.	Activities	Code	Machine/ tools	Time (s)	Standard deviation (s)	Distance (m)	Worker	Category*					Type of activity
								O	T	I	D	S	
1.	Unloading raw materials from the truck	A1	-	1,467	115.47	-	2		×				NNVA
2.	Weighing and loading raw materials into trolleys	A2	Digital sitting scale (1 unit)	1,801	178.06	-	3	×					VA
3.	Delivery to the withering process	A3	Trolley (1 unit)	1,391	146.74	6.6			×				NNVA
4.	Set up the rotary panning machine	B1	-	1,221	68.71	-	1			×			NNVA
5.	Exposure to tea leaves	B2	-	6,905	643.1	-	4	×					VA
6.	Delay	B3	-	1,224	31.75	-	-				×		NVA
7.	Input and process withering	B4	Rotary panner (1 unit)	34,959	2,177.21	-	2	×					VA
8.	Putting the process results into the barrow	B5	-	11,298	1181.69	-	2		×				NNVA
9.	Delivery for the rolling process	B6	Barrow (1 unit)	1,459	154.02	9			×				NNVA
10.	Raw material input	C1	-	15,556	1,553.47	-			×				NNVA
11.	Rolling process	C2	Roller (2 units)	45,151	4,143.91	-	-	×					VA

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

No.	Activities	Code	Machine/ tools	Time (s)	Standard deviation (s)	Distance (m)	Worker	Category*					Type of activity
								O	T	I	D	S	
12.	Load the process results into the trolleys	C3	-	5,231	529.33	-	2		×				NNVA
13.	Delivery for the drying process 1st	C4	Barrow (2 units)	1,790	178.28	5			×				NNVA
14.	Set up	D1	-	2,577	268.37	-	1			×			NNVA
15.	Raw material input	D2	-	5,231	529.33	-	2		×				NNVA
16.	Drying process 1st	D3	Endless Chain Pressure (ECP) (1 unit)	33,835	3,171.46	-	-	×					VA
17.	Putting the process results into the barrow	D4	-	7,640	799.56	-	2		×				NNVA
18.	Delivery for the drying process 2nd	D5	Barrow (2 units)	1,360	135.28	15	1		×				NNVA
19.	Raw material input	E1	-	3,920	399.5	-	1		×				NNVA
20.	Drying process 2nd	E2	Ball tea (3 units)	57,200	4,812.48	-	-	×					VA
21.	Cooling	E3	-	1,651	133.06	-	-	×					VA
22.	Putting the process results into the bags	E4	-	5,036	130.33	-	1		×				NNVA
23.	Delay to warehouse	E5	-	60,000	3,747.00	-	-				×		NVA
24.	Loading bags into trolleys	E6	-	742	59.47	-	1		×				NNVA
25.	Delivery to warehouse	E7	Trolley (3 units)	472	27.79	40	1		×				NNVA
26.	Weighing	F1	Digital sitting scale (1 unit)	2,742	155.00	-	1	×					VA
27.	Bag sewing	F2	Sewing machine (1 unit)	1,626	73.32	-	1	×					VA
28.	Loading bags onto the trolleys	F3	-	644	55.43	-	1		×				NNVA
29.	Delivery to a storage warehouse	F4	Trolley (1 unit)	851	48.75	26	1		×				NNVA
30.	Arrange the bags in the warehouse	F5	-	306	27.71	-	1					×	NNVA
	Total			315,286	25,675.58	101.6	31	9	16	2	2	1	VA : 9 NNVA : 19 NVA : 2

*Note: O = operation, T = transportation, I = inspection, D = delay, S = storage

According to the Table 1, two non-value-added (NVA) activities are causing a delay in the withering process (B3), which lasts 1,224 seconds, and in the drying process 2 (ball tea) (E5), which lasts 60,000 seconds. Additionally, 19 non-value-added but necessary (NNVA) activities were identified, including 16 transportation activities, two inspection activities, and one storage activity. The findings from the analysis are illustrated in the current state mapping shown in Figure 1.

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Current state map development

The current state map in Figure 1 illustrates the flow of information, material/process flow, and time data for each process. The diagram depicts a flow of information involving the customer, marketing, PPIC (Production Planning and Inventory Control) division, plantation division, and production division. Each process includes data on the number of workers, inputs/outputs, length of VA time, NNVA time, and NVA time (Shou et al., 2020; Salwin et al., 2021). The lead time for green tea production in batch units for ± 5 tons of raw materials of was 315.286 seconds. The activity time that provides added-value (VA time) was 18.5870 seconds. The Process Cycle Efficiency value of the green tea production process in the current state map was 58.95%. The method for calculating lead time in batch units in the downstream production of tea drinks was also used by Satria dan Yuliwati (2018) by adding up all types of processing time, both VA, NVA, and NNVA.

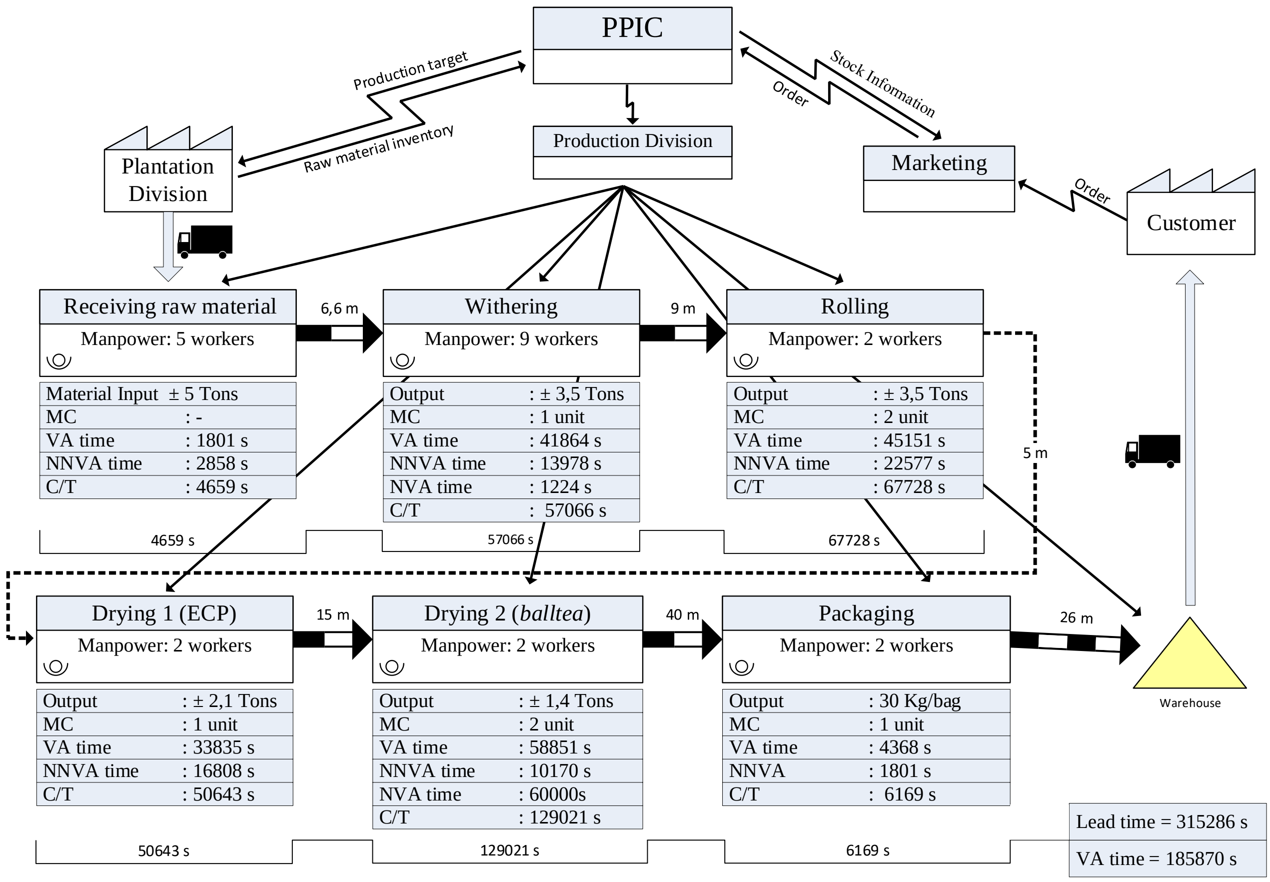

Figure 1. Current state map of the green tea production process at PT Candi Loka

Problem analysis and recommendations for improvement

The time lost in the tea production process at PT Candi Loka was due to non-value-added activities, either excessive NVA or NNVA, which included 2 NVA activities and 19 NNVA activities. Delay activity was considered NVA activity, so repairs must be done immediately (Shou et al., 2020; Fauziah et al., 2022). According to Saravanan et al. (2018), Improving production time efficiency was carried out by eliminating NVA activities with recommendations for improvements provided. The very large number of NNVA activities meant that tea production needs to be improved, including mechanisms and equipment types, therefore processing times become more efficient.

(1) NVA activities before the withering process (B3)

The causes of delays before withering activities (B3) were determined using the 5 Whys method and the results are presented in Table 2. Two factors contribute to delays: human resources and machinery.

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Table 2. Analysis of 5 Whys activity delay (B3)

Problem: There was a delay in the withering process (B3)		
Factors	Why	The answer
Human resources	Why 1	Since the supervisor has not given any instructions
	Why 2	The supervisor has not checked
	Why 3	Supervisors are still checking other processes
	Why 4	There are not enough supervisors available
	Why 5	The company has not adjusted the number of supervisors
Machine	Why 1	The machine is not ready
	Why 2	The engine temperature is still not at the appropriate level
	Why 3	The setup only begins when the raw materials arrive

Based on the results of the 5-why analysis listed in Table 2, it was found that one of the causes of delays at the withering stagewas the human resource factor. The withering stage commences after the machine-checking supervisor instructed workers to start the activity. However, there was a delay in checking because the factory relied only on one supervisor to check all production activities. Furthermore, delays in machine operation readiness caused delays in the withering process. The machine was not ready to operate when the raw materials arrived at the withering area, as the new machine setup process was carried out shortly after completing the raw material receiving process in the previous stage. The machine required time to reach the specified process temperature. Delays in the withering process represented a form of time lost, commonly occurring in factories that needed to be improved in providing skilled worker resources. This resulted in excessive workers' dependence on supervisors and inaccuracies in arranging material and process flow (Omogbai & Salonitis, 2016; Marques et al., 2021; Poswa et al., 2022).

To avoid delays caused by slow-starting workers, increasing the number of supervisors from one to two is recommended. With two supervisors, the workload can be expedited. One supervisor will oversee the process of receiving raw materials, withering, and rolling. At the same time, the other will supervise the drying process on the ECP machine and ball tea machine, as well as packaging. By adding supervisors, inspecting on the rotary panner machine can be carried out earlier, allowing the withering process to begin immediately. The ball tea machine, which has a drying chamber in the form of a rotating cylinder with a heat source from a heating element, requires setup to reach the expected drying temperature (125–150°C), so this must be done from the start (Lestari et al., 2022). According to Delbridge & Lowe (1997); Nucci (2017); and Habib et al. (2023), increasing the number of supervisors increased production costs, however the time efficiency that could be achieved was essential for increasing company productivity. Meanwhile, efforts to reduce delays can be made by setting up the rotary panner machine at the same time as raw material coming. For example, suppose the process of obtaining raw materials starts at 12.30, the machine setup process is also carried out at 12.30 so that when the material has entered the withering process, the machine is ready for processing.

(2) NVA activity after drying process 2 (E5) to the packaging warehouse

An analysis was conducted to identify the causes of delay (E5) after the drying process 2 (ball tea) to the packaging warehouse using the 5 Whys method (Table 3). It was found that the absence of workers caused the delays. The drying process was completed in the afternoon (after 14:00) when the workers had already left the warehouse. The warehouse working hours were from 07:00 to 14:00. As a result, the delivery process to the packaging warehouse had to be resumed the next day during the warehouse working hours.

To eliminate NVA activities such as delays after the drying process 2, switching from a daily wage system to a piece rate system for workers in the packaging process is recommended. Working in the packaging warehouse does not require special skills and does not affect the value or quality of production results. Piecework wages were paid based on the completion of specific types of work (Srihastuti et al., 2023). A piece rate system is based on the amount of material produced rather than the time spent. This system

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

offered advantages such as time efficiency, flexibility, and more straightforward cost prediction for the packaging process (Guiteras & Jack, 2018). Appropriate wages provided worker satisfaction and motivation to increase productivity, providing optimal results for the company (Prayudo et al., 2020).

Table 3. Analysis of 5 Whys activity delays (E5)

Problem: There was a delay in the drying process 2 (ball tea) (E5)	
Why	The answer
Why 1	There are no workers in the subsequent process
Why 2	Since it is outside of working hours
Why 3	The company has not scheduled any extra working hours

(3) NNVA activities in the process of receiving raw materials

Improvements in time efficiency were also carried out at the raw material receiving process stage by adding weighbridge facilities. A weighbridge was a set of tools that determine a vehicle's weight and cargo (Foyer & Schulz, 2021). By using a weighbridge, the raw material weighing activity, which was initially carried out one by one, could be carried out simultaneously as receiving raw materials for each delivery truck (Chimezi et al., 2023). Companies can form planning teams for additional weighbridge facilities so that additional facilities can be carried out by conditions that benefit the company. The addition of weighbridge facilities can replace three workers previously tasked with manual weighing. An overview of changes in activities after implementing improvements to the raw material receiving process can be seen in Table 4.

Table 4. Description of changes in the raw material receiving process activities

Activity description	Estimated time (seconds)	Explanation
Weighing (2 trucks for a 5-ton batch of raw materials)	162	81 s/truck *
Unloading raw materials from the truck	1,467	-
Delivery to the withering process	857	30 s/ trolley
Total	2,486	-

*) Nugraha et al. (2017)

(4) NNVA activity in the withering to the rolling process

Production time efficiency can be improved by speeding up material movement from the withering to the rolling stage using a conveyor belt. Conveyors were mechanical devices widely used in industry, and they move goods in large quantities and continuously (Hanafie et al., 2020). Conveyor systems speeded up operator work and increased production efficiency (Mendes et al., 2023; Zhang et al., 2024). Companies can form planning teams so that conveyor system installation is appropriate and benefits the company. Material transportation by conveyor can replace three workers and change several activities. An overview of changes in activity after improvements in the withering and rolling processes can be seen in Table 5.

Table 5. Description of activity changes in the withering and rolling process

Process stage	Activity	Estimated time (seconds)
Withering	Exposure to tea leaves	6,906
	Input and process withering	34,959
Rolling	Rolling process	45,151
	Putting the process results into the barrow	5,231
	Delivery for the drying process 1st	1,790

Future state map development

Increasing time efficiency in green tea production was achieved by improving activities that caused time wastage (NVA and NNVA) in the current state map (Satria & Yuliawati, 2018). The improved activities

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

have considered operational possibilities in terms of costs and other resources based on expert meetings with company management. This improvement produces a new process flow picture called the future state map, as shown in Figure 2. This picture shows that there are four improvements, namely a) the use of a weighbridge in the process of receiving raw materials; b) increasing the number of supervisors and arranging the setup time for the withering machine before the withering process; c) the use of conveyors to speed up the process of transferring materials from the withering process to the rolling process; and d) using a piece rate system in the packaging process.

The proposed future state map can reduce green tea production lead time by 29.47% from 315,286 seconds to 222,356 seconds, as shown in Table 6. The Process Cycle Efficiency value also increases significantly from 58.95% to 84.85%. These results indicate that the application of the future state, apart from generating the production process more efficient, also results in green tea production at PT Candi Loka leaner in terms of processing time. This is in line with research conducted by Wurjaningrum & Shafak (2022) and Groneberg et al. (2022), which stated that process improvement recommendations must be able to reduce activity time significantly in NVA and NNVA activities so that it has an impact on reducing lead time.

Table 6. A comparison of green tea production time between the current state and future state

Type of activity	Current state		Future state	
	seconds	hours	seconds	hours
VA	185,870	51,63	184,232	51,17
NNVA	68,192	18,94	38,124	10,59
NVA	61,224	17,00	0	0
Lead time	315,286	87,57	222,356	61,766
Process cycle efficiency	58.95%		82.85%	

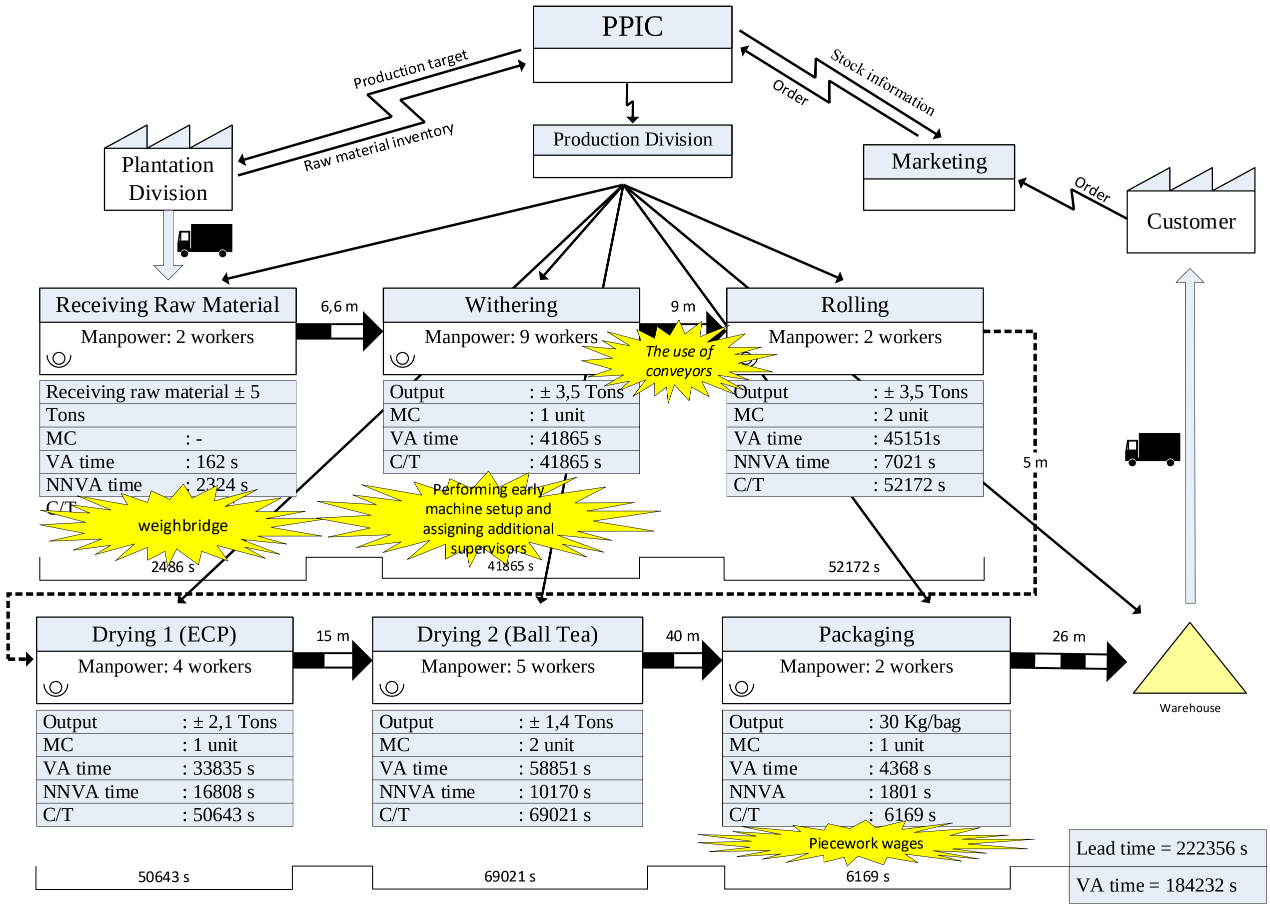

Figure 2. Future state map of the green tea production process at PT Candi Loka

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Conclusion

The current green tea production process at PT Candi Loka still indicates that there is a time lost in several activities, such as weighing raw materials, delays before the withering process, transferring materials from the withering process to the rolling process, and delays in transferring materials to the packaging warehouse. The results of the VSM analysis for current conditions (current future map) show that the lead time is still relatively long, about 315,286 seconds for every 5 tons of raw material, with a process time efficiency level of only around 58.95%. Improvements are made to activities that cause time lost. The improvements' results, represented in the form of a future state map, provide more efficient results, the lead time decreases to 222,356 seconds and the process cycle efficiency value increases to 82.85%.

References

Anggraini, W., Kusumanto, I., Permata, E. G., & Yola, M. (2020). Pendekatan lean services untuk perbaikan pelayanan administrasi akademik perguruan tinggi. *Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri*, *6*(1), 21. https://doi.org/10.24014/jti.v6i1.5246

Chimezie, O.S., Isaac,O.E, & Nkoi, B. (2023). Determination of boiler maintenance effectiveness on productivity in a palm oil producing company: A case study. *International Journal of Engineering and Modern Technology* (IJEMT), 8(1). https://doi: 10.56201/ijemt.v9.no1.2023.pg33.41

Delbridge, R., & Lowe, J. (1997). Manufacturing control: supervisory systems on the `new' shop floor. *Sociology*, *31*(3), 409–426. https://doi.org/10.1177/0038038597031003003

Dhika, D. A., Witonohadi, A., & Akbari, A. D. (2023). The proposed warehouse improvement using lean approach to eliminate waste at the main warehouse of PT. XYZ. *Opsi*, *16*(1), 94. https://doi.org/10.31315/opsi.v16i1.7310

Fadhilah, Z. H., Perdana, F., & Syamsudin, R. A. M. R. (2021). Review: telaah kandungan senyawa katekin dan epigalokatekin galat (EGCG) sebagai antioksidan pada berbagai jenis teh. *Jurnal Pharmascience*, *8*(1), 31–44. https://doi.org/10.20527/jps.v8i1.9122

Fajar, R. I., Wrasiati, L. P., & Suhendra, L. (2018). Kandungan senyawa flavonoid dan aktivitas antioksidan ekstrak teh hijau pada perlakuan suhu awal dan lama penyeduhan. *Jurnal Rekayasa dan Manajemen Agroindustri*, *6*(3), 196. https://doi.org/10.24843/jrma.2018.v06.i03.p02

Fauziah, Y., Wijaya, E. O., Setiawan, I., & Nugroho, B. H. (2022). Improving the efficiency of material transfer system using Value Stream Mapping (VSM): A case study in the shoe industry. *Journal Industrial Servicess*, *8*(2), 181–186. https://doi.org/10.36055/jiss.v8i2.15908

Foyer, G., & Schulz, K. (2021). Overview study of the use of several weighing instruments for static determination of vehicle mass in Germany. *Measurement: Sensors*, *18*, 100114. https://doi.org/10.1016/j.measen.2021.100114

Gebeyehu, S. G., Abebe, M., & Gochel, A. (2022). Production lead time improvement through lean manufacturing. *Cogent Engineering*, *9*(1). https://doi.org/10.1080/23311916.2022.2034255

Groneberg, H., Horstkotte, R., Pruemmer, M., Bergs, T., & Döpper, F. (2022). Concept for the reduction of non-value-adding operations in Laser Powder Bed Fusion (L-PBF). *Procedia CIRP*, *107*, 344–349. https://doi.org/10.1016/j.procir.2022.04.056

Guiteras, R. P., & Jack, B. K. (2018). Productivity in piece-rate labor markets: Evidence from rural Malawi. *Journal of Development Economics*, *131*, 42–61. https://doi.org/10.1016/j.jdeveco.2017.11.002

Habib, M. A., Rizvan, R., & Ahmed, S. (2023). Implementing lean manufacturing for improvement of operational performance in a labeling and packaging plant: A case study in Bangladesh. *Results in Engineering*, *17*, 100818. https://doi.org/10.1016/j.rineng.2022.100818

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Hanafie, A., Darty Akhsa, A. C., Alam, N., & Sandy, A. (2020). Rancang bangun sistem konveyor penghitung telur otomatis. *ILTEK : Jurnal Teknologi*, *15*(01), 1–4. https://doi.org/10.47398/iltek.v15i01.1

Karabay, G., & Kansul, D. S. (2019). Increasing the process cycle efficiency of a men trousers assembly line. *Tekstil ve Konfeksiyon*, *29*(3), 253–261. https://doi.org/10.32710/tekstilvekonfeksiyon.498921

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

Lestari, P. W., Harianto, S., Prawira-Atmaja, M. I., Andriyani, M., Shabri, S., Maulana, H., & Putri, S. H. (2022). Identifikasi sifat fisik produk samping dari mesin ball tea pada pengolahan teh hijau. *Jurnal Teknotan*, *16*(2), 85. https://doi.org/10.24198/jt.vol16n2.4

Liu, Q., & Yang, H. (2017). Lean implementation through value stream mapping: A case study of a footwear manufacturer. *2017 29th Chinese Control And Decision Conference (CCDC)*, 3390–3395. https://doi.org/10.1109/CCDC.2017.7979092

Marques, J. P., Sá, J. C., Silva, F. J. G., Pereira, T., Ferreira, L. P., & Santos, G. (2021). Safety efficiency value stream mapping (SEVSM) - A new tool to support the implementation of Lean Safety. *IOP Conference Series: Materials Science and Engineering*, *1193*(1), 012124. https://doi.org/10.1088/1757-899X/1193/1/012124

Ma'sum, A., & Setiafindari, W. (2022). Analisis pemborosan pada proses produksi dengan Metode Value Stream Mapping di PT Mandiri Jogja Internasional. *Jurnal Cakrawala Ilmiah*, *1*(10), 2517–2526. https://doi.org/10.53625/jcijurnalcakrawalailmiah.v1i10.2582

Mendes, D. S. F. T., Navas, H. V. G., & Charrua-Santos, F. M. B. (2023). Improving the performance of a conveyor belt through lean philosophy and Industry 4.0. *Journal of Quality in Maintenance Engineering*, *29*(4), 842–862. https://doi.org/10.1108/JQME-09-2022-0055

Misbah, A., Pratikto, P., & Widhiyanuriyawan, D. (2015). Upaya meminimalkan non value added activities produk mebel dengan penerapan metode lean manufacturing. *Journal of Engineering and Management Industrial System*, *3*(1). https://doi.org/10.21776/ub.jemis.2015.003.01.8

Novitasari, R., & Iftadi, I. (2020). Analisis lean manufacturing untuk minimasi waste pada proses door PU. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *6*(1), 65–74. https://doi.org/10.30656/intech.v6i1.2045

Nucci, F. (2017). Machines set up the reduction in lean manufacturing environment. *DEStech Transactions on Engineering and Technology Research*. https://doi.org/10.12783/dtetr/icamm2016/7406

Nugraha, G. D. Y., Prayogo, R. C., Syafitri, A. K. N., Berlian, I. N., Pratama, R. J. A., & Widianto, E. D. (2017). Sistem identifikasi beban angkutan barang yang terintegrasi pada jembatan timbang menggunakan kartu RFID. *Jurnal Fakultas Teknik*, *18*(2). https://doi.org/10.30595/techno.v18i2.1958

Omogbai, O., & Salonitis, K. (2016). Manufacturing system lean improvement design using discrete event simulation. *Procedia CIRP*, *57*, 195–200. https://doi.org/10.1016/j.procir.2016.11.034

Poswa, F., Adenuga, O. T., & Mpofu, K. (2022). Productivity improvement using simulated value stream mapping: A case study of the truck manufacturing industry. *Processes*, *10*(9), 1884. https://doi.org/10.3390/pr10091884

Prayudo, A. N., Fathorrahman, F., & Karnawati, T. A. (2020). Analisis Pengaruh masa kerja, upah dan usia terhadap produktivitas tenaga kerja buruh borongan linting rokok di SKT Gebog, PT. Djarum Kudus. *Jurnal Ekonomi Manajemen dan Bisnis*, *1*(1), 1–10. https://doi.org/10.32815/jubis.v1i1.311

Ratnani, S., & Malik, S. (2022). Therapeutic properties of green tea: A review. *Journal of Multidisciplinary Applied Natural Science*, *2*(2), 90–102. https://doi.org/10.47352/jmans.2774-3047.117

Salwin, M., Jacyna-Gołda, I., Bańka, M., Varanchuk, D., & Gavina, A. (2021). Using Value Stream Mapping to eliminate waste: A case study of a steel pipe manufacturer. *Energies*, *14*(12), 3527. https://doi.org/10.3390/en14123527

ISSN (electronic): 2302-4399 http://jurnal.fp.unila.ac.id/index.php/jthp/index

Satria, T., & Yuliawati, E. (2018). Perancangan lean manufacturing dengan menggunakan Waste Assessment Model (WAM) dan VALSAT untuk meminimumkan waste (Studi Kasus: PT. XYZ). *Jurnal Rekayasa Sistem Industri*, *7*(1), 55. https://doi.org/10.26593/jrsi.v7i1.2828.55-63

Shou, W., Wang, J., Wu, P., & Wang, X. (2020). Value adding and non-value adding activities in turnaround maintenance process: classification, validation, and benefits. *Production Planning & Control*, *31*(1), 60–77. https://doi.org/10.1080/09537287.2019.1629038

Srihastuti, E., Agustin, B. H., & Suntoro, R. C. (2023). Analisis perhitungan pajak penghasilan orang pribadi atas wajib pajak penerima upah harian dan upah borongan sesuai dengan ketentuan Undang – Undang Harmonisasi Peraturan Perpajakan (HPP). *JURA : Jurnal Riset Akutansi*, *1*(4), 80–87. https://doi.org/10.54066/jura-itb.v1i4.840

Ulfah, M., Trenggonowati, D. L., Lean, P., & Sigma, S. I. X. (2023). Minimizing seven wastes in the inner lid production process using the lean six sigma approach. *Jurnal Teknologi Industri Pertanian*, *33*(2), 117–129. https://doi.org/10.24961/j.tek.ind.pert.2023.33.2.117

Wurjaningrum, F., Shafak, C.A., 2022. How does the value stream mapping method identify waste and improve the coffee bean production process of a café?. J*ournal Of Theoretical And Applied Management,* 15 (3),362 – 375 https://doi.org/10.20473/jmtt.v15i3.40440

Yang, M. M., Yang, F., Cui, T., & Cheng, Y.-C. (2019). Analysing the dynamics of mental models using causal loop diagrams. *Australian Journal of Management*, *44*(3), 495–512. https://doi.org/10.1177/0312896218823831

Zhang, X., Zhu, X., & Wang, R. (2024). Simulation and identification of multiscale falling morphology of fresh tea leaves at different transport speeds based on discrete element method. *HortScience*, *59*(2), 167–172. https://doi.org/10.21273/HORTSCI17548-23