



Original Paper

Lean Manufacturing Implementation in Indonesian Coffee Processor

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Abstract—The rapid competition between business and sustainability policy has encouraged the coffee industry in Indonesia to make their business more environmentally friendly. However, this initiative has yet to be fully underway. Several inefficiencies still prevail in Arabica coffee production sites, such as product defects in inventory, the inefficiency of production machine performance, and dependence on manpower that can increase the production and inventory costs. Therefore, the Arabica coffee agroindustry needs to improve its performance by addressing these issues in production activity using the lean manufacturing approach. Several tools proven influential to reduce waste in the agroindustry are Value Stream Mapping (VSM) and VALSAT. VSM could document the entire mapping of material and information management, but cannot classify the time required to complete the whole process. VALSAT has several derivative tools, but polyacrylamide (PAM) and Supply Chain Response Matrix (SCRM) are mostly used in agroindustry to classify value-added time of processes and illustrate the supply chain cumulative inventory of a company. The result of this study shows that the Indonesian Arabica coffee industry could reduce its cycle time by 57%, lead time by 63%, and changeover time by 50%. In addition, the recommendations result in the involvement of only 2 people during the drying process and eliminate the non-value-added time, while improving the overall production efficiency and capacity.

Keywords— Coffee industry; Lean Manufacturing; Value Stream Mapping; Process Activity Mapping; Supply Chain Response Matrix.

I. INTRODUCTION

Arabica Coffee is one of the superior commodities in Indonesia which has a high degree of global competitiveness. The concept of sustainability has been stressed to build an environmentally friendly industry. The lean manufacturing approach is a concept that can support a company to improve its production performance by eliminating its waste. There are seven types of waste mostly recognized as a form of production inefficiencies, such as defect, overproduction, waiting time, transportation, inventory, motion, and excess processing [1]. For the past two years, the company has suffered from product defects in inventory as it incurs an inventory cost of approximately \$2000 per year, and the production machine inefficiency extends the lead time by two to three times a day

and therefore affects the service level received by customers. If those inefficiencies remain unsolved, then the company will face business failure.

In coffee company, there are several steps of production ranging from sorting, washing, pulping, fermentation, drying, hulling, to packaging [27]. The tool with the lean manufacturing concept can be used to detect waste by illustrating the process called Value Stream Mapping (VSM) [2][3]. Several studies have discovered the benefit of VSM in reducing production lead time, cycle time, work line, and the necessity for manpower [4] [5].

However, VSM cannot classify the time based on a product's value proposition. Therefore, it has to be supported by process activity tools, as the basis to supply chain response matrix and inform inventory cumulative to involved actors throughout the supply chain [6].

This paper aims to eliminate waste in the coffee agroindustry to elevate customer satisfaction by improving the efficiency of coffee production using VSM, Process Activity Mapping (PAM), and Supply Chain Response Matrix (SCRM) approaches.

II. LITERATURE REVIEW

A. Lean Manufacturing Concept and Tools

Lean manufacturing is a concept of waste elimination in the industrial sector. It aims at improving business performance while increasing customer satisfaction. By maintaining business effectiveness and efficiency as well as environmental consideration, the company will earn higher profit, prevent risks, and maintain its continuity [7,28]. Only a few companies are taking this step because this approach depends on the leadership's commitment to ensuring quality management [8].

Generally, there are several lean manufacturing tools known as managing transport, inventory, motion, waiting time, over-processing, overproduction, and defects waste such as 5S, VSM Total Productive Maintenance (TPM), Kaizen Blitz Events, Kanban, Just in Time, Setup Reduction, Poka Yoke and Value Stream Analysis Tools (VALSAT) [9] [10].

B. Value Stream Mapping

The VSM is a popular tool in lean manufacturing approach. It is used to determine business streams (information, and material), activity, lead time, resources, manpower use, takt time, and uptime of a business [11]. These strategies are mostly used to visualize the business process and identify waste through inefficient time through the current state mapping of VSM. Current state mapping will serve as the basis of company evaluation, and then the company will create a strategy to improve its performance which will be represented in future/proposed state mapping of VSM.

Several steps should be done to implement these tools [12]: (1) The first step is to identify the targeted products or services and determine the third party (supplier and distributor) related to the coffee company; (2) The next step is drawing the current mapping which shows the current process, delays, and required information concerning how the coffee is delivered to the customer (including the production process from raw material until finish product); (3) Third, it is imperative to analyze and evaluate the current state mapping in terms of waste selection and the strategy for eliminating the waste; (4) The fourth step is to draw the future map of VSM as it represents implemented recommendation on business process; (5) Eventually, it is important to maintain the continuous improvement through process efficiency.

C. Value Stream Analysis Tools

Other than VSM, VALSAT has arisen as a decent complementary strategy to draw and identify industrial waste. However, VALSAT shows stronger detail in classifying the stages into value-added, non-value-added, and non-value-added activities classification [1]. Before the whole process is accomplished, those stages will be divided into several types of activity such as operation (O), delay (D), transportation (\Rightarrow), storage (∇), and inspection (\square). One of the VALSAT tools is called PAM (Table I).

TABLE I. PROCESS ACTIVITY MAPPING

Activities	Type of Activity				
	O	D	\Rightarrow	∇	\square
Activities 1
Activities 2
Activities 3

After listing the process stage and classifying the activity, the next stage is accumulating the inventories of all related supply chain actors using another tool of VALSAT called Supply Chain Response Matrix (SCRM). SCRM is mostly used in manufacturing to figure the longest leading time taken by supply chain actors and reduce the lead time as well which will affect the service received by customers. Some companies use these tools combination to support their lean concept [6] [13].

At the outset of the research activity, the observation of the coffee industry products and organizational backgrounds was conducted. The observation focused on evaluating the tangible

waste of the coffee industry. After that, literature review was carried out to find to eliminate the waste and improve business performance through efficiency improvement. There were some stages after accomplishing the literature review, such as collecting data on the waste and proposing recommendations.

To identify the waste, an interview with the coffee company was carried out to observe some tangible waste deemed impactful to the business. The next step was identifying the coffee industry processing in how the raw material (coffee seed) turned into the green bean and then recording the time required in every stage to create the current state mapping using VSM. After that, the waste was identified using the time classification of Process Activity Mapping and Supply Chain Response Matrix as the basis to develop the inventory waste.

D. Value Stream Mapping

There are several types of the time visualized in VSM, such as cycle time, changeover time, uptime, available time, takt time, and lead time. The definition of each time is hereby presented [4] [14]:

- Cycle time is the time needed to work in one lap process.
- Changeover time is the time between the first run of a production of a product to the second one.
- Available time is the amount of time needed by a company to complete the whole process in a day.
- Lead time is the accumulation of the whole activity time for all processes.
- Takt time is the operation time used in every unit of product.
- Uptime is the percentage ratio of the processing time against available time, as expressed in (1).

$$Uptime = \frac{\text{Available time} - \text{Change over time}}{\text{Available time}} \quad (1)$$

E. Waste Analysis

VSM aided in observing the waste. The next step is waste analysis to determine how to manage it properly. Moreover, it is important to think about effective and efficient recommendations for future practice and eliminating waste to make the future VSM more efficient.

F. Recommendations for Future VSM

The coffee company needs to ponder future VSM. This can help the company to realize how efficiently the process works.

G. Cost Analysis

Lastly, there is an accumulation of budgeting to find out how much a coffee company needs to invest on the recommendation to gain more benefits for his company.

III. RESULTS AND DISCUSSION

This research project aimed to analyze waste in the current condition and determine ways to mitigate waste in the future. Therefore, it starts with VSM current mapping and ends up with the projection of future VSM which will visualize the efficiency of business operations.

12% moisture. This rate could prolong the shelf life and ease the hulling process of beans.

Lastly, the hulling process taking 22.7 minutes was done to remove the coffee parchment from the beans. The coffee beans were then packaged using plastic bags in a small amounts and using plastic sacks in a big amounts to safely keep the beans from any physical, chemical, and biological defects. In the end, coffee beans were shipped within 3 days to the consumer, as illustrated in Table II.

TABLE II. CURRENT VSM

Component	Resources required
Total lead time	24,990 minutes
Manpower	6 workers
Total cycle time	14,108 minutes
Non-value-added time	0.3%

Table II describes a higher amount of lead time compared to its cycle time. The analysis identified 10,882 minutes of unprocessed time. It happened because the drying process was difficult to predict due to the volatile climates. Moreover, the unused machine and the dependence on manpower reduced the efficiency and thus extended the cycle time. Hereunder are the data displaying changeover time of the entire green beans processing.

TABLE III. CURRENT CHANGEOVER TIME

Production Stage	Time (Minutes)
Sorting	0.7
Soaking	0
Pulping	0
Fermentation	15
Washing	5
Drying	10
Hulling	5
Packaging	0.1
Total Changeover Time	35.8

Table III illustrates the changeover time of all processes. In total, the production required 35.8 minutes to accomplish a changeover from all processes. The biggest changeover time is identified in fermentation which is necessary to manage coffee quality. The other time is the washing process because it needs to fill out the other vessel to wash fermented beans. Afterward, drying takes 10 minutes to move all of the washed beans into the drying basket. Such detailed analysis clearly shows how important it is for the company to ensure efficient processing efficiency through activity mapping.

B. Process Activity Mapping

Process activity mapping is mostly used to describe and classify every activity whether a certain process is valuable or not. PAM will divide the time by activity type. There are 29 activities in coffee industry as shown in Table IV.

TABLE IV. ACTIVITY MAPPING

Code	Activity	Duration	O	D	T	S	I	Category
1	Harvesting preparation	00:30:00		✓				NVA
2	Harvesting departure	00:19:42			✓			NNVA
3	Harvesting 1	03:32:05	✓					VA
4	Resting time	00:22:01		✓				NVA
5	Harvesting 2	03:06:03	✓					VA
6	Weighing	00:06:14					✓	NNVA
7	Departing back	00:22:12			✓			NNVA
8	Coffee fruit transfers	00:04:10			✓			NNVA
9	Vessel soaking filling	00:08:22		✓				NVA

Drying	0
Hulling	2
Packaging	0,1
Total changeover time	17,8

Subsequently, the changeover time in future VSM illustrates the accumulation of changeover time in every production station where the reduction time occurs in the washing, drying, and hulling process (Table VII). The use of a washing machine and drying machine will make the changeover time more efficient. This is because the maximum production capacity has been achieved by the use of machines. The hulling process will take only 2 minutes because of the shorter distance taken to transport the green bean to the hulling station.

F. Cost Analysis

The cost analysis determines the required cost to apply the recommendations which are geared to the same purposes. These involve preventing waste and bottlenecks during production, preventing transportation problems from the harvesting point to the processing point, and fastening the drying process regardless of weather conditions. The cost analysis is displayed in Table VIII, which also describes the necessary investments.

TABLE VIII. COST ANALYSIS

No.	Recommendation	Cost
1	Machine maintenance/year	200,000 IDR (13.80 USD)
2	Transportation maintenance/year	300,000 IDR (20.70 USD)
3	Drying machine investment	20,000,000 IDR (1,379 USD)
	Total Cost	20,500,000 IDR (1,413.50 USD)

1 USD = 14.500,- IDR

The table above shows that the biggest cost lies in the drying machine investment, reaching 1,379 USD. This investment will nullify the need to wait for 7 to 10 days to dry out the fermented coffee. Instead, the drying machine will require only 3 hours to reach the same drying quality, meaning a shorter production process. By implication, this reduces the dependence on manpower while allowing the company to elevate production efficiency and capacity. In total, the recommendation will cost 1,413.50 USD (Table VIII).

CONCLUSION

The results of lean analysis using VSM and VALSAT have concluded that recommended strategies will improve the overall production efficiency. This is indicative of reduced manufacturing lead time by 63%, cycle time by 57%, and changeover time by 50.2%. In addition, the recommendations result in the involvement of only 2 people during the drying process and eliminate the non-value-added time. These

recommended strategies cost the small-medium coffee industry 1,413.50 USD.

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REFERENCES

- [1] Hines, Peter and Rich, N. The Seven Value Stream Mapping Tools, *International Journal of Operation and Production Management*, Vol. 17 No. 1, 1997, pp. 46-64.
- [2] Goriwondo, Mhlanga, and Marecha, Use of Stream Mapping Tool for Waste Reduction in Manufacturing Case Study for Bread Manufacturing in Zimbabwe, *International Conference on Industrial Engineering and Operations Management*, 2011, pp. 236-241.
- [3] Prasetyo and Wicaksono, Desain Perbaikan untuk Meningkatkan Nilai Efisiensi Manufaktur Keberlanjutan menggunakan Sustainable Value Stream Mapping (Studi Kasus: CV Mugiharjo), 2019, *Industrial Engineering Online Journal*, Vol. 7 No. 4, pp. 1-7.
- [4] Ahmad, F and Aditya, D., Minimizing Waste with a Value Stream Mapping Approach, *Journal of Industrial Systems Optimization*, Vol. 18 No. 2, 2019, pp. 107-115.
- [5] Tarapituxwong, Tantranon, dan Duangpatra, Production Process Improvement Using Value Stream Mapping: A Case Study of Organic Coffee Firms in Thailand, *Journal FEU Academic Review*, Vol. 8 No. 2, 2015, pp 128-143.
- [6] Rimawan, Molle, and Putra, Lean Production Design with Waste and Method Analysis of VALSAT for Assembly Process of Four Wheel Vehicle Components, *International Journal of Innovative Science and Research Technology*, Vol. 11 No. 3, 2018, pp. 449-455.
- [7] Mor, Singh, and Bhardwaj, Learning on Lean Production: A Review of Opinion and Research within Environmental Constraints, *Operations and Supply Chain Management*, Vol. 9 No. 1, 2016, pp. 61-72.
- [8] Nordin, Deros, and Wahab, Lean Manufacturing Implementation in Malaysian Automotive Industry: An Exploratory Study, *Operations and Supply Chain Management*, Vol. 4 No. 1, 2011, pp. 21-30.
- [9] Lute and Charkha, Review of Lean Manufacturing Implementation: Case of Junction Box Post Processing Phase, *International Journal of Civil, Mechanical and Energy Science*, Special Issue 1, 2017, pp. 22-27.
- [10] Satria and Yuliawati, Perancangan Lean Manufacturing menggunakan Waste Assessment Model dan VALSAT untuk Meminimumkan Waste, *Jurnal Rekayasa Sistem Industri*, Vol. 7 No. 1, 2018, pp. 55-63.
- [11] Bhoose, Pooja, Sulanke, and Hermant, Value Stream Mapping: Case Study on Residential Construction Sector, *International Journal of Engineering Sciences Research Technology*, 2015, pp. 353-360.
- [12] Kengar, Kadam, Pandit, and Vingale, Manufacturing System Performance Improvement by Value Stream Mapping a Literature Review, *IJRSET*, Vol. 2 Issue 9, 2013, pp. 12709-12716.
- [13] Auliandri and Alfiani, Lean Manufacturing Approach to Reduce Wastefulness During Production of Train Car-Body Using VALSAT Method, *Knowledge E*, 2018, pp. 1256-1269.
- [14] Hidayat, Tama, and Efranto, Lean Manufacturing Approach with VSM and FMEA Methods to Reduce Waste in Plywood Products, *Journal of Industrial Systems Engineering and Management*, Vol. 2 No. 5, 2014, pp. 1032-1043.
- [15] Schwan, Silva, and Batista, *Handbook of Plant-Based Fermented Food and Beverage Technology*, Brazil: CRC Press, 2012.
- [16] Jackels SC, Jackels CF, Characterization of The Coffee Mucilage Fermentation Process Using Chemical Indicators: A Field Study in Nicaragua, *J Food Sci*, Vol. 70, 2005, pp. 321-325.
- [17] Alysouf, Imad, The Role of Maintenance in Improving Companies Productivity and Profitability, *International Journal Production Economics*, Vol. 105, 2007, pp. 70-78.

- [18] Sary, Ratna, Kaji Eksperimental Pengerinan Biji Kopi dengan Menggunakan Sistem Konveksi Paksa, *Jurnal Polimesin*, Vol. 14 No. 2, 2016, pp. 13-18.
- [19] Kamaruddin, Syariazulfa, Mohammad, and Mahbub, Barrier and Impact of Mechanisation and Automation in Construction to Achieve Better Quality Products, *Social and Behavioral Sciences*, Vol. 222, 2015, pp. 111-120.
- [20] Syahri, Heryanto, Wibowo, and Hatmoko, Waste Analysis with Value Stream Mapping in Multi-storey Building Column Work, *Journal of Civil Engineering Works*, Vol. 6 No. 4, 2017, pp. 192-200.
- [21] Mushavhanamadi, Khathutshelo and Selowa, Tumiso Brian, The Impact of Plant Maintenance on Quality Productivity in Gauteng Breweries, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2018, pp. 1743-1753.
- [22] Lipinska, Tomaszewska, and Krajewska, Identifying Factors Associated with Food Losses during Transportation: Potentials for Social Purposes, *Sustainability*, 2019, pp. 1-15.
- [23] Villarreal, Garcia, Rosas, Eliminating Transportation Waste in Food Distribution: A Case Study. *Transportation Journal* Vol. 48 No. 2, 2009, pp. 72-77.
- [24] Esa, Rahman, and Jamaludin, Reducing High Setup Time in Assembly Line: A Case Study of Automotive Manufacturing Company in Malaysia, *Procedia Social and Behavioral Sciences*, Vol. 211, 2015, pp. 215-220.
- [25] Sanderson, M. Penelope, The Human Planning and Scheduling Role in Advanced Manufacturing Systems: An Emerging Human Factors Domain, *Human Factors*, Vol. 31 No. 6, 1989, pp. 635-666.
- [26] Mata, Quesada, and Mata-Marin, Can E-Commerce Provide a Solution to the Coffee Paradox, *IFIP World Information Technology Forum (WITFOR)*, 2016, pp. 181-194.
- [27] Endar Hidayat, Asmak Afriliana, Gusmini Gusmini, Masuda Taizo, Hiroyuki Harada. 2020. Evaluate of Coffee Husk Compost. *International Journal of Food, Agriculture, and Natural Resources*. Vol 1 (1):37-43. <https://doi.org/10.46676/ij-fanres.v1i1.8>
- [28] Giuliano Marodin, Alejandro Germán Frank, Guilherme Luz Tortorella, Torbjørn Netland. 2018. Lean product development and lean manufacturing: Testing moderation effects. *International Journal of Production Economics*. Vol 203. <https://doi.org/10.1016/j.ijpe.2018.07.009>.