Reducing Lean Wastes of the Leather Industry through the Application of Enhanced Value Stream Mapping

BY

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ABSTRACT

Numerous scholars have used classical value stream mapping to reduce waste of manufacturing sector in general and automotive company in particular. However, it provides low level of details for value streams. Additionally, it is applicable for linear production system. The aim of this research is therefore to address these research void and reduce waste of leather industry through the application of enhanced value stream mapping. The research is done in the case of leather industry. Besides extant literature, Gemba-walk, interview and company's report are used to collect relevant data from the case company. Product matrix is used to categorize the leather products into product families and select a product. The enhanced current state value stream mapping (ECSVSM) is developed by using data collected from the shop floor. The numerical results of the ECSVSM in terms of total production lead time (TPLT), value-added time (VA), non-value-added time (NVA), and VA ratio are 14.67days, 2198.244 seconds, 14.59 days, 0.54%, respectively. Using equivalent time, waiting and inventory wastes are found as major wastes of the shop floor. To reduce the identified waste, combining workstations, 5S, supermarket and layout modification are proposed. These proposed lean waste reduction techniques have been evaluated and approved by experts, including production manager, shift leaders, quality officers, of the company. A future state (FS) VSM is developed by incorporating the proposed solutions into the ECSVSM. Results of the research depict major waste reduction, including reductions in NVA by 41.95%, TPLT by 41.31%, alongside increase VA ratio by 29.63%.

KEYWORDS: Lean waste; Leather industry; Non-value-added time; Product matrix; Value stream mapping

1. INTRODUCTION

Recently, manufacturing industries have been influenced by stakeholder, including government agencies, NGOs, customers, suppliers, and regulatory bodies, to reduce waste and ensure their operational sustainability. Value stream mapping (VSM) is one of the prominent approaches employed to reduce waste in the manufacturing industries. According to Venkataraman et al. (2014), VSM is a lean manufacturing tool which uses symbols, metrics and arrows to show and improve the flow of inventory and information required to produce a product or service and identify sources of wastes and appropriate ways for improvement.

Numerous researchers (Lacerda et al., 2016; Saravanan et al., 2018; Patil et al., 2021; Singh & Sharma, 2009; Sophian et al.,2022; Suhardi et al.,2020; Venkataraman et al.,2014; Yuvamitra et al., 2017) have used classical VSM as a tool to identify and reduce wastes of manufacturing industries, and thereby ensure operational sustainability. However, this tool is not effective in reducing lean waste of manufacturing industries consisting of complex (multiple) production processes (Braglia et al., 2009; Gurumurthy & Kodali, 2011; Aziz et al., 2017). Moreover, the level of detail provided by this tool is limited (Braglia et al., 2009). Additionally, most of the abovementioned researchers have attempted to validate the application of classical VSM in manufacturing industries in general, and automotive industries in particular. Less attention has been paid for its application in the leather industry, and this problem is acute in the Ethiopian leather industry. Hence, to the best of the researchers' knowledge, none of the prior studies have attempted to reduce waste of leather industry through enhancing the level of details of classical VSM. Thus, the purpose of this research is to bridge this research gap and ensure the operational sustainability of the leather industry.

This research has significant contribution to the body of the state-of-the-art-literature. First, it enhances the classical VSM via three types of data (time, quality and energy). Most of the previous studies have attempted to enhance classical VSM using time data (Dinis-Carvalho et al.,2014; Lacerda et al.,2016; Suhardi et al. ,2020; Patil et al. ,2021; Braglia et al., 2009). Hence, we nomenclated the enhanced VSM as Time, Quality and Energy VSM. Second, it validates the application of enhanced VSM in the leather industry. Moreover, it has substantial benefit for the industry practitioners. It can create deep understanding for practitioners about the application of enhanced VSM to reduce waste in the leather sector. It can assist them to reduce production lead time, inventory levels, and waiting time, and increase value added time in the shop floor of the leather sector, thereby improve their customer satisfaction.

The remainder of this paper is organized as follows: Section 2 presents the literature review; Section 3 presents case company problems and research methodology; Section 4 deals with the results of the study; Section 5 presents the discussion; and the last section concludes the findings of the research, limitations and future research agendas.

2. RELATED STUDIES

In this section, we have presented related state – of – the - art literature related to this research topic.

2.1 Lean manufacturing

The idea of lean manufacturing (LM) was come to exist after the Second World War in the Toyota Production System. The LM concept originated from two Japanese Engineers, Taiichi Ohno and Shigeo Shingo, who competed with the mass production system of the USA (Kaswan et al., 2019). It refers to a manufacturing paradigm aims to differentiate value added and non-value added activities of manufacturing system with continuous improvement, and ultimately reduce and eliminate wastes and maximize productivity (Bait et al., 2020; Seth et al., 2017). shop floor activities that utilize resources without adding any value to a product, and thus, customers are unwilling to pay are defined as waste. Accordingly, over-production, transportation, inventory, waiting, motion, over-processing, defects, and unused creativity (skill) are categorized as lean manufacturing wastes (Gupta & Kundra, 2012).

According to (Gupta & Kundra, 2012), lean manufacturing wastes are categorized into eight different wastes.

I. Over-production: - Wastes come from making more products than customer's demand

II. Transportation: - Wastes due to unnecessary movement of products during production.

III. Inventory: - all raw materials, work-in-processes and finished products that are kept in the store are considered as wastes.

IV. Waiting: - When available resources are idle during production processes. When the machines, men, and material wait for next process, it is waste of these resources and it demoralizes the employees.

V. Motion: - Wastes due to unwanted movement of workers (equipment) from one workstation to another. It may also include excess physical motion such as reaching, lifting and bending.

VI. Over-processing: - It will increase machining time, material handling time and add more process steps.

VII. Defects: - During inspection processes, those products which don't produced as per customers' specification are identified as wastes.

VIII. Unused creativity (Skill): - wastes of human skill. This type of waste was not identified by Toyota Production System. This waste is developed when management not identify the skills of his/her workers in the organization. Employees are just following the boss order and do work as per the boss instructions.

2.2 LM tools

Several LM tools have been practiced in industries not only to reduce wastes but also eliminate them. According to numerous scholars (Gupta & Kundra, 2012; Oliveira et al., 2017; Solding & Gullander, 2009; Abdulmalek & Rajgopal, 2007; Kaswan et al., 2019; Karthy et al.,2017; Star & Sisay, 2019), the common LM tools mentioned in literature with goal of assisting industries to identify and eliminate wastes continuously are:

- *5S*: focuses on reducing waste and optimizing workplace efficiency by creating clean, uncluttered, safe, and well-organized working environment.

- *Just-in-time (JIT):* focus on producing the right product, right quantity and at right time.
- *Kanban*: Signal to track and manage production processes in just in time production system.
- *Poka–Yoke (error-proofing)*: Focuses on avoiding mistakes during production processes.
- *Value-Stream Mapping (VSM)*: Visualize the whole value streams of the production process to identify, reduce and eliminate wastes.
- *Heijunka (Production Smoothing)*: smoothing the workload in the production process.
- *Kaizen*: continuous improvement based on incremental change.
- *Single-Minute Exchange of Die (SMED)*: Focuses on reducing changeover time in production system.
- *Total Quality Management (TQM)*: Management philosophy focuses on empowering employee for continuous improvement of production processes.
- *Total Productive Maintenance (TPM)*: focus on proactive and preventative maintenance to maximize the lifespan and productivity of machines.

Thus, of the above LM tools, VSM was used in this research to identify and reduce the waste of the case company because of the following unique features:

- It provides insight into the flow of materials and information in the entire process (value streams) graphically. Thus, value - added and non-value - added activities are visualized , and improvements are triggered by highlighting waste (Seth et al., 2017).
- It integrates production planning and demand forecasting with production scheduling and shop floor control (Seth et al., 2017).
- Flexibility and adaptability for different application areas. It is applicable to any business venture, such as manufacturing, service ,and construction (Seth et al., 2017; Aziz et al.,2017).
- It provides relevant information related to the production time and inventory levels of the entire production process (Braglia et al., 2009).
- It provides a user-friendly language to discuss the waste, throughput rate, bottlenecks, cycle time and tack time of the entire production process.

2.3VSM

The concept of process mapping was established in 1980 by Japanese pioneers, Taiichi Ohno and Shigeo Shingo, at the Toyota Production System to visualize the flow of materials and information in the assembly plant, identify sources of waste, and finally to either reduce or eliminate waste. Ohno and Shingo, for the first time, named the mapping tool “Material and Information Flow Mapping”. This name has been changed to “Value Stream Mapping” after Mike Rother and John Shook published a book entitled “Learning to See”. The book was blue print for researchers and practitioners exploring the application of VSM to reduce and eliminate wastes and thereby maximize operational efficiency and product quality.

Rother and Shook (1999) defined VSM as VSM is a pencil and paper tool that is used to envisage the flow of material and information throughout the value stream, and to identify the source of waste and appropriate ways for improvement. VSM is composed of two basic states: current state VSM and future state VSM. Current state VSM provides graphical representation of flow of material and information in the value stream at the moment of review. It gives information about Work-in-process inventory (WIP), cycle time, process time and changeover time. Moreover, it assists to analyze and identify source of wastes. Future state VSM is constructed based on proposed improvement approaches which reduces wastes through lean tool (Andrade et al., 2016; Atieh et al., 2016).

Name of Measurement	Metrics	References	Percentage
Production (operational) efficiency	WIP	(Oliveira et al., 2017; Patil et al., 2021; Santosa & Sugarindra, 2018; Singh & Sharma, 2009; Suhardi et al., 2020; Venkataraman et al., 2014)	30.43%
	Changeover time	(Mohanraj et al., 2015; Oliveira et al., 2017; Patil et al., 2021; Salwin et al., 2021; Venkataraman et al., 2014; Yuvamitra et al., 2017)	30.43%
	Cycle time	(Lacerda et al., 2016; Mohanraj et al., 2015; Oliveira et al., 2017; Patil et al., 2021; Salwin et al., 2021; Santosa & Sugarindra, 2018; Singh & Sharma, 2009; Venkataraman et al., 2014; Yuvamitra et al., 2017)	43.5%
	Lead time	(Lacerda et al., 2016; Mohanraj et al., 2015; Oliveira et al., 2017; Patil et al., 2021; Salwin et al., 2021; Santosa & Sugarindra, 2018; Singh & Sharma, 2009; Suhardi et al., 2020; Venkataraman et al., 2014; Yuvamitra et al., 2017)	47.83%
	Waiting time	(Lacerda et al., 2016)	4.35%
	Non-value-added time	(Salwin et al., 2021)	4.35%
	Manpower	(Lacerda et al., 2016; Mohanraj et al., 2015; Salwin et al., 2021)	17.4%
	Processing time	(Lacerda et al., 2016; Patil et al., 2021; Salwin et al., 2021; Yuvamitra et al., 2017)	17.4%
	Transportation	(Oliveira et al., 2017)	4.35%
	Value-added time	(Lacerda et al., 2016; Salwin et al., 2021; Singh & Sharma, 2009; Suhardi et al., 2020; Venkataraman et al., 2014)	21.74%
Availability	Uptime	(Patil et al., 2021; Singh & Sharma, 2009; Venkataraman et al., 2014)	13.04%
	Overall equipment effectiveness (OEE)	(Oliveira et al., 2017)	4.35%
	Available working time	(Mohanraj et al., 2015)	4.35%
	Shift	(Singh & Sharma, 2009)	4.35%
Cost efficiency	Cost of the activity execution	(Salwin et al., 2021)	4.35%
Quality	Takt time	(Salwin et al., 2021)	4.35%

Several scholars have employed the classical VSM to reduce industrial waste. For instance, by employing this tool, Singh & Sharma (2009) reduced lead time,

Hence, this research used these lean metrics along with energy data to augment the classical VSM and provide sufficient level of details.

1.1 The research gap

We briefly presented the identified research gaps as follows:

- Difficult to generalize the application of VSM in all manufacturing industries. Most of studies exploring the application of VSM were done in the context of manufacturing industry in general and automotive industry, mass production system, in particular. Less attention is paid to study the application of enhanced VSM in the context of leather industry, and such problem is acute in the case of Ethiopian leather industry.
- Previous studies have developed process mapping models by considering either time or combine time with energy, but enriching VSM with time, energy, and quality attributes simultaneously is lacking.

2. RESEARCH METHODOLOGY

2.1 Case company problem

This research was conducted by considering Ethio-Leather Industrial PLC, Universal Leather Products Factory, as a case company. It is a leading leather products manufacturer located in Addis Ababa, Ethiopia. It produces a variety of leather goods including document cases, briefcases, ladies' handbags, luggage, school bags, leather jackets, and soccer balls across multiple production lines. Currently operating one daily shift of nine hours including breaks, Universal Leather Products company strives to meet local and international demand. However, production faces challenges including high work-in-process inventory, unnecessary processes, and long wait times and lead times. By undertaking lean interventions, this research aims to support the company in overcoming challenges and enhancing production performance.

2.2 Data Collection Methods

We reviewed the state-of-the-art-literature to understand the recent body of knowledge in the literature and identify research gaps. We use Gemba-walk, interviews and company reports were used to collect the relevant data from the case company. Gemba-walk, Japanese term which refers to observation, was employed to observe the actual work place in the shop floor and understand what is done, how it is done, and to fully understand the problems that affect the flow of material and information in the value streams. In addition, unstructured interview was held to systematically question about each activity of the product family at shop floor, methods of exchanging information among customers, production control and planning (PPC) department, suppliers and shop floor workers. This systematic questioning technique assisted to critically examine the shop floor activities and identify wastes and its improvement potentials. Moreover, company's daily, weekly. and monthly production, quality and maintenance reports were used to understand product demand, WIP, scarp products and quantity of order from both customers and PPC.

2.3 Data analysis methods

To conduct detailed analysis of the collected data and construct both the current state VSM and future (enhanced) VSM, we adapted The VSM procedures proposed procedures proposed by Rother & Shook (1999).

I. Selecting product family: After completing the critical observation of shop floor activities of the case company, we selected one product family based on customer demand data collected from the company's report. The product family having more customer demand over others was selected to develop VSM.
II. Identifying metrics required to enhance classical VSM: The most widely used metrics to extend classical VSM were identified from literature. As mentioned in Table 1, important metrics aimed to measure the value streams at shop floor in terms of operation efficiency, availability, quality and cost were clearly identified. Stop watch was used to record time related data for each operation/process/ of selected product family. Ten observation was collected for each observation. Besides, quality and energy data were collected from unstructured interview and company's report.
III. Constructing enhanced current state VSM: the whole process of the product family was mapped, using standard icons, to visualize the

flow of information and material throughout the value streams.

IV. Analyzing Enhanced VSM: Detail analysis of the developed current state map was done in details in term of identified performance measurement metrics, and potential area of improvements (waste) were identified.

After conducting detail analysis of the enhanced current VSM, we proposed improvement approaches aimed at reducing lean waste and ensure operational sustainability. Then, we constructed the future state VSM by incorporating the proposed improvement scenarios within the enhanced current state VSM.

3. RESULT AND DISCUSSION

3.1 Product Family Selection

To begin visualizing the value streams of the case company, it is necessary to select a product family. A product family refers to a group of products that common processing routes and machines throughout the value streams. Hence, the product matrix was used to categorize leather products into product families. The result of product matrix is illustrated in Table 2. The complexity and frequency of processes (processing routes shared by products), together with product demand, were used to select one family among the four product families categorized. Hence, using these criteria product family one was selected for this study. Of the products categorized under product family one, the school bag was selected for the value stream mapping process because it is the most demanded and frequently manufactured product, as confirmed during observation and review of company's monthly, weekly, and daily production reports, as compared to other products in the family.

3.2 Constructing enhanced VSM

The lean metrics used to enhance the classical VSM is presented in Table 1. Hence, we employed these metrics to construct the enhanced current state VSM, analyze it, thereby identify waste and potential improvement scenarios. We construct assembly process chart to show the chronological sequence of the assembly operations of the school bag, SB001 model. Similarly, the observation time for each assembly operation was recorded. The assembly process chart of the selected product family is shown in Figure 1.

According to company's report, the average daily demand for school bag (SB001 model) is 120 pcs. Using this data, takt time, the rate at which unit of product needed to meet customer's demand is manufactured, was computed by taking the ratio of net available working time per day (27,612 seconds) to average daily demand. Using this data, takt time, the rate at which unit of product needed to meet customer's demand is manufactured, was computed by taking the ratio of net available working time per day (27,612 seconds) to average daily demand. The company starts and completes operations at 8:00AM and 12:00PM respectively for the morning session, and resumes and completes operations at 1:00PM and 5:00PM respectively for the afternoon session. 20 minutes are allowed for tea break in the morning session only. Likewise, lunch break is allowed from 12 :00 PM to 1:00 PM. It has only 1 shift per day. Hence, the takt time is 230.1 seconds. This implies that in order to satisfy the daily demand one pc of product should be produced every 230.1 seconds. Moreover, the healthy production system is characterized as its total cycle time is less than the computed takt time; otherwise bottleneck processes (one sources of wastes) would happen in the production system. Thus, the total average cycle time (for the case company) required to assemble one pcs of school bag is 2198.244 seconds. This computed cycle time value is much greater than the takt time which depicts that there is potential floor for improvement.

Moreover, we numerically quantified the value-added time (VA) and non-value-added time (NVA) of the entire value streams of the select product in the shop floor mapping process. Thus, the value streams of the school bag consist of 2198.244 seconds and 14.59 days of VA and NVA respectively. The NVA is wastes incorporated in the value streams, and it should be either eliminated or reduced for the sake of leveraging operational efficiency. Activities included under NVA are categorized either necessary non-value added (NNVA), unavoidable waste, or unnecessary non-value added (UNNVA), avoidable wastes, activities. Of 14.59 NVA days, 51.41% is NNVA (RM inspection, design and pattern making, and final inspection) time. Additionally, we computed the value-added ratio aimed to measure the efficiency of processes (value streams) by taking the ratio of VA to total production lead time (TPLT). The value of TPLT (14.67 days) is determined by summing up both VA and NVA. The number of days a unit (pc) wait until it gets processed by

Table 2 Product matrix

Products	Processes																														Product Family
	A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	A 11	A 12	A 13	A 14	A 15	A 16	A 17	A 18	A 19	A 20	A 21	A 22	A 23	A 24	A 25	A 26	A 27	A 28	A 29	A 30	A 31	
Document case	x	x				x					x			x						x			x			x					x	
Briefcase	x	x			x				x						x	x				x			x	x		x					x	
Ladies' hand bag	x	x			x										x	x					x			x		x					x	1
Luggage	x	x			x										x	x					x		x	x		x					x	
School Bag	x	x	x		x					x					x	x							x	x		x		x			x	
Leather jacket	x	x	x		x			x							x			x	x	x		x			x		x		x	x	x	2
Leather articles (Belt)	x	x		x			x					x																			x	3
Leather articles (wallet)	x	x				x					x			x																	x	
Soccer Ball	x	x		x									x				x														x	4

Where, A1: Design and Pattern Making; A2: Cutting; A3: Stitching Zipper pocket;A4: Punching;A5: Stitching front body; A6: Preparing Body;A7: Installing rivet and buckle;A8: Stitching front body with zipper;A9 :Stitching locks with front body;A10: Stitching front body with Zipper;A11: Stitching Inner Layers ; A12: Burnishing;A13: Stitching liner with surface leather;A14: Stitching layers with body;A15: Stitching Back body;A16: Stitching handler and strap;A17: Attaching inflator;A18: Stitching front and back bodies;A19: Stitching sleeves;A20: Stitching Zipper;A21: Stitching handler with front and back body;A22: Assembling sleeves with body; A23: Stitching back body with strap;A24: Stitching gusset/ side gusset; A25: Stitching Collar; A26: Assembling front and back bodies with gusset; A27: Stitching buttons;A28: Piping;A29: Stitching hem; A30: Ironing; A31: Trimming

the next process is included in determining the TPLT. Hence, the total work in-progress inventories in the value streams are converted into waiting days via dividing total pcs waiting to average daily demand; ex. 70 pcs are waiting for lining process, and thereby, its equivalent waiting days becomes 0.58 day (70 pcs/120 pcs/day). Thus, the value-added ratio becomes 0.54%. This result reveals that there is significant chance to enhance the efficiency of the value stream by either reducing or eliminating NVA activities. The summarized enhanced current state (ECS) VSM for the above-mentioned product is shown in Figure 2. In order to improve the quality of the figure for ECSVSM, cutting, dispatching, and preparation processes were categorized into lining process; making front body, making shoulder strap and making back body processes were categorized into making body; sub-assembly, gusset, and final assembly processes were categorized into assembly process; trimming and final inspection processes were categorized into the inspection process.

4.3 Waste identification

By visualizing the entire value streams and relying on the results of enhanced current state (ECS) VSM of the selected product, we identified the following waste:

I. Inventory waste: During visualization, we have obtained 187 pcs which are kept in buffer without adding value, across the value streams of the shop floor production processes. The inventory waste observed during the shop floor mapping process is depicted in Figure 3.

II. Waiting waste: We observed that the total WIP inventories observed in the shop floor processes are forced to wait 42,918 sec. Thus, this waiting time is NVA, and it should be either eliminated or reduced.

III. Over production waste: The production department of the case company dispatches daily schedule to each shop floor process based on average daily demand and allowance as safety stock level to absorb uncertain demand fluctuation. The average daily production capacity of the case company matches average daily demand. However, the daily demand might be either lower or higher than the daily production capacity. If the daily production capacity is higher than demand, over production will occur and it becomes waste to the company. On the other hand, 5% of the average daily demand is produced more when there is sales forecast showing increase in demand. Thus, in such period the production process produces 126 pcs (120 pcs normal demand and 6 pcs as safety stock) per day, and the safety stock will be kept in store until the new demand absorbs it. Keeping finished goods in store doesn’t add value rather it’s waste. As per report of the production department, increase in demand is usually observed in the first 10 days of a month. Besides, the daily WIP inventories produced in the production value streams are greater than the requirement, and it becomes over-production to the production process.

IV. Transportation waste: As can be seen in Figure 4, the operators are forced to travel approximately 36.25 meter in the shop floor starting from RM store to finished goods store. Traveling this distance every day to bring WIP from one station to another is waste to the operator as well as the company. Thus, this waste should be reduced, and thereby, operation efficiency will be enhanced.

V. Defect waste: - As per our observation, we identified defective products in both RM inspection and final inspection stations. 29 pcs are found defective products in RM inspection station, whereas 24 pcs are found as defective products in final inspection station. These results reveal that waste of defective products is available in the shop floor value stream of the case company.

VI. Waste related to motion: - awkward motions of operators was observed during the mapping period. Unnecessary motion of operators in cutting station was visualized. The operators in this station bend their body to the direction of WIP inventory, pick it and again change their position to the cutting station and unload it. Besides, the operators in this station perform cutting

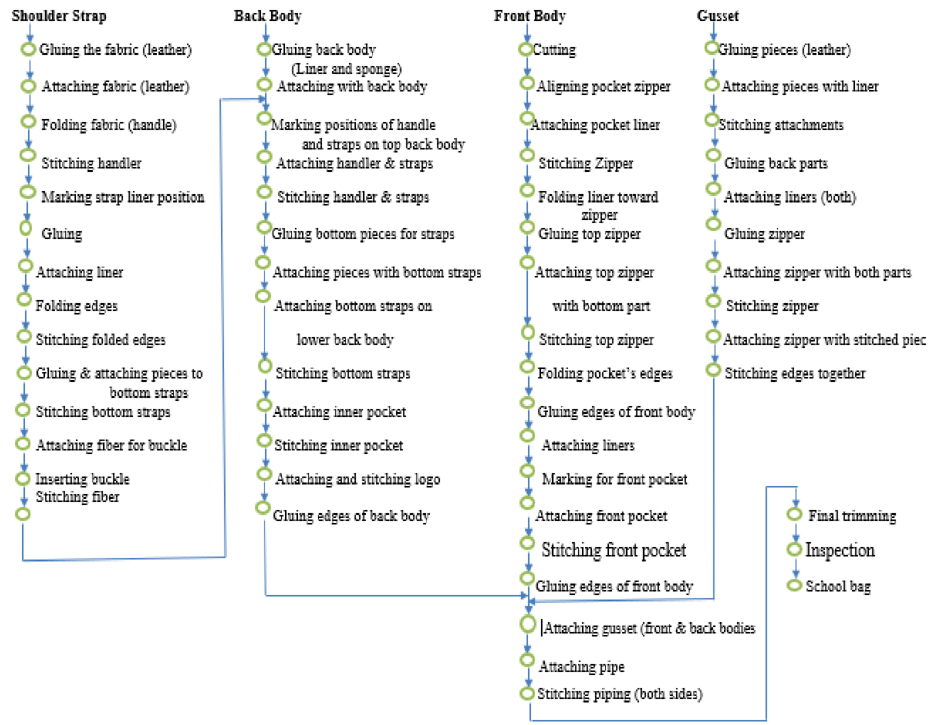

Figure 1 Assembly process chart

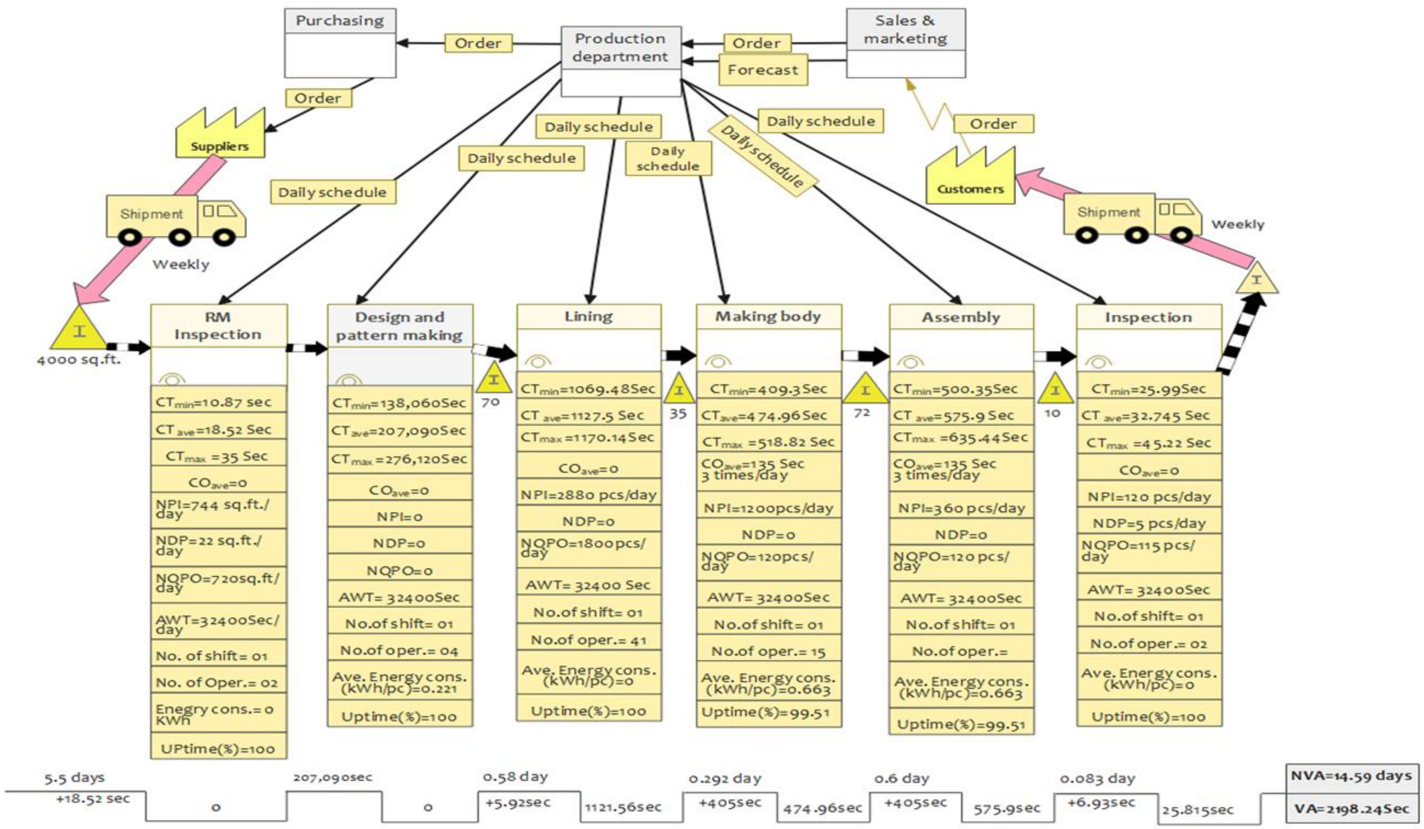

Figure 2 Enhanced current state VSM

FIGURE 2 ENHANCED CURRENT STATE VSM

Figure 3 WIP inventory waste

operations in standing position. Thus, the awkward motion together with the standing position have great chance to concentrate fatigue to the operators. As a result, their performance will be reduced. Performance reduction of operators is waste to the company, and it should be either reduced or eliminated.

We employed Pareto diagram to prioritize the identified waste in the shop floor. To provide similar unit, we converted the respective value of abovementioned waste into time unit. In this context, the equivalent time value of inventory waste is 43,028.7 seconds ((Total WIP during visualization)/ (average daily demand) * net- working hour per day*3600 sec.) = ((187/120) *7.67*3600) = 43,028.7 s). A similar method was used for the remaining waste. The equivalent time value results for each identified waste are summarized in Table 3.

Table 3 Equivalent time value of identified wastes

S.N.	Name of identified wastes	Equivalent time value (sec.)
1	Waiting	43028.7
2	Inventory	43028.7
3	Over-production	28992.6
4	Transportation	1010.5
5	Motion	1960.5
6	Defect	12195.3

Figure 4 Overview of transport distance in shop floor value streams

From Table 3, we noticed that waiting waste and inventory waste are the two major waste of the shop floor. Thus, these two major wastes received special attention in this research because addressing these wastes would have a significant impact, unlike other identified wastes, in reducing NVA activities observed in the shop floor value streams.

2.4 Proposed solutions

Based on the results of the ECSVSM and identified waste, we proposed the following strategies to reduce the identified lean waste.

I. Combining operations: We observed that operations, including dispatching and cutting, were done in separate work stations. We also observed that operators assigned in both operations are idle compared to other operations like preparation. Thus, we combined these two operations as in a single work station. We communicated this strategy to production manager, shift leader and quality officers. The managers were convinced to this strategy, they implemented it by shifting a few operators to preparation work station.

II. Line balancing: We noticed that shoulder strap, back body, and front body stations have different workload, which implies that these stations are not balanced. We contended to shift a few operators from both front body and shoulder strap stations into back body station, as the former stations are too idle relative to the latter station. We convinced the production manager, shift leader and quality officers about this change, and they were motivated to implement it.

III. **5S :** This lean technique was proposed to be used in both combined cutting-dispatching and preparation processes. In both processes, variety of pieces in dis ordered manner are available. Thus, this technique aims to assist assigned operators to sort those cut pieces based on their respective pattern. Pieces with similar pattern will be sorted together. Unnecessarily pieces will be eliminated from the cutting process. Likewise, the operator will be informed to clean the workplace at the beginning, middle and finish time of every working day; it helps operators to arrange order of pieces required for next process. Moreover, it assists operators to make this technique as working culture (standard) and practice it continuously. The technique provides the abovementioned benefits to the preparation process as well. This technique assists to reduce time wasted for searching required parts/pieces in particular and TPLT in general. As a result, it enhances customer satisfaction level.

IV. Supermarket: This pull system was proposed for use in both RM storage and design and pattern-making areas. The sister companies deliver raw materials weekly. They are in Addis Ababa. However, the raw material will be kept for 5.5 days in stored until it is processed on the shop floor. The probability of suppliers' disturbance due to uncertainty for the case company is low compared to those suppliers located abroad, because both the case company and its suppliers are found in the same location. Thus, an average of 2000 sq.ft. of leather will be ordered and delivered to the case company twice a week, hence, the level of inventory kept in the store and its waiting days for the process will be reduced by half. Similarly, the company needs one to two weeks of operation to complete the design and pattern-making processes. Fortunately, as suggested by design team, the operation could be completed within four to seven days only if all assigned staff were engaged fully in the design operation. Thus, supermarket aims to order the design team to deliver the required products via these days. As a result, the NVA could be reduced significantly.

V. Layout modification**:** A total of 36.25m of distance is needed to travel from RM store to finished goods store. The modified layout has reduced the total travel distance from 36.25 meter to 19.3 meter. Moreover, the existing layout is disorganized which resulted unnecessary workplace usage. Thus, modification in existing layout has improved space utilization, thereby reduce the transportation and work place (space) waste visualized across the entire shop floor value streams. The existing and modified layout for value streams of the case company are demonstrated in Figures 5 and 6.

A future state VSM was constructed by incorporating the proposed solutions into the ECSVSM. As described above, the proposed waste reduction strategies were implemented in the case company, thereby the identified lean waste was reduced significantly. In this regard, the results of future state VSM (FSVSM) is illustrated in Figure 7. The results of the VA, NVA, TPLT, and VA ratio of the constructed FSVSM are 1675.1 Sec., 8.55 days, 8.61 days, and 0.7%, respectively. These imply that the VA, NVA and TPLT have been reduced by 23.78%, 41.95% and 41.31%, respectively. Moreover, the VA ratio have been increased by 29.63%. Furthermore, the transportation waste in the FSVSM was reduced by 46.76%. These results depict that the identified major lean waste has been reduced significantly, which assist the company in early product delivery important for enhancing customer satisfaction.

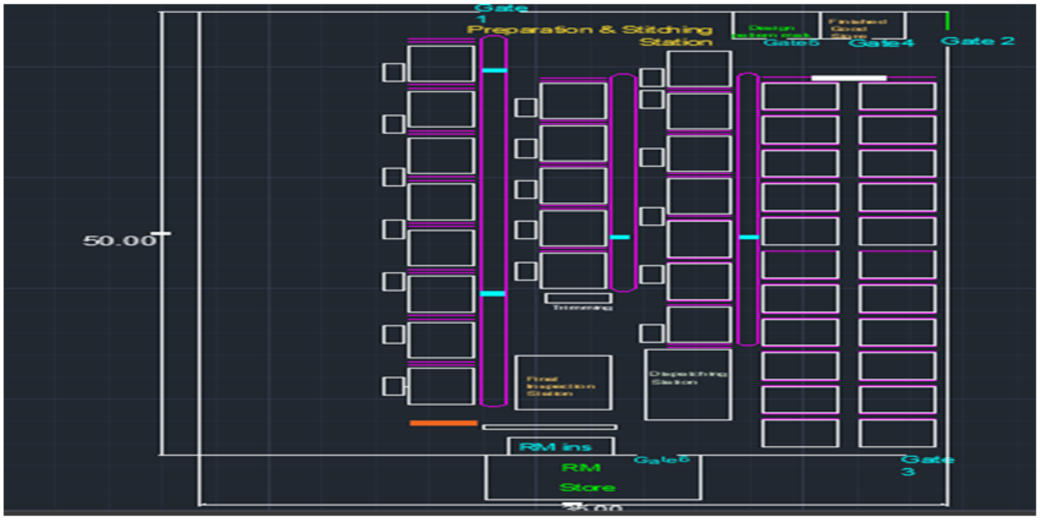

Figure 5 Existing shop floor layout of the case company

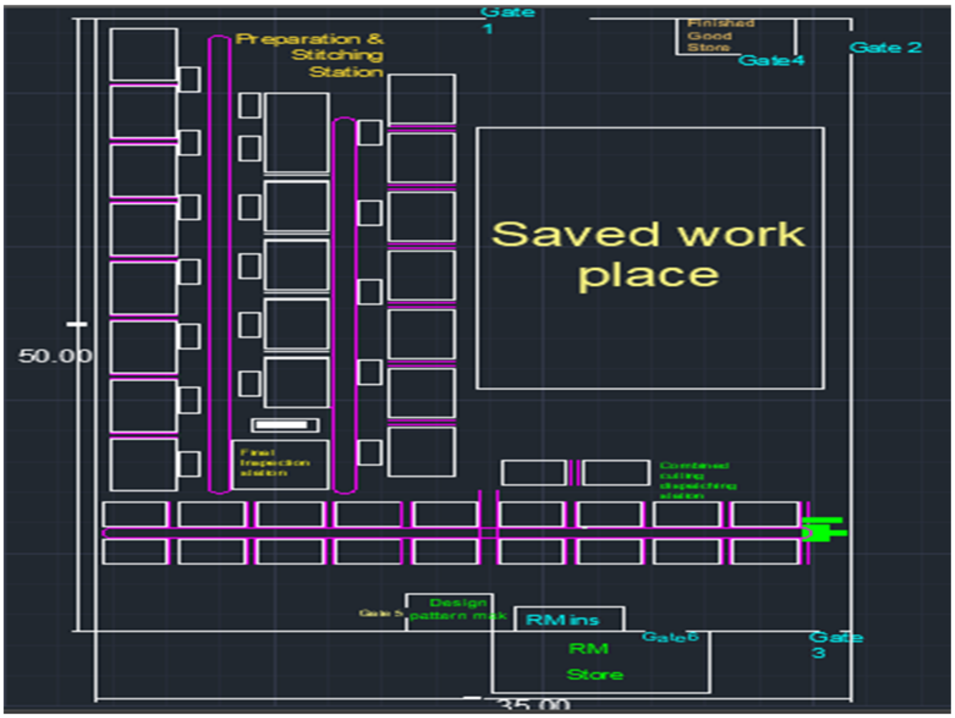

Figure 6 Modified shop floor layout for the case company

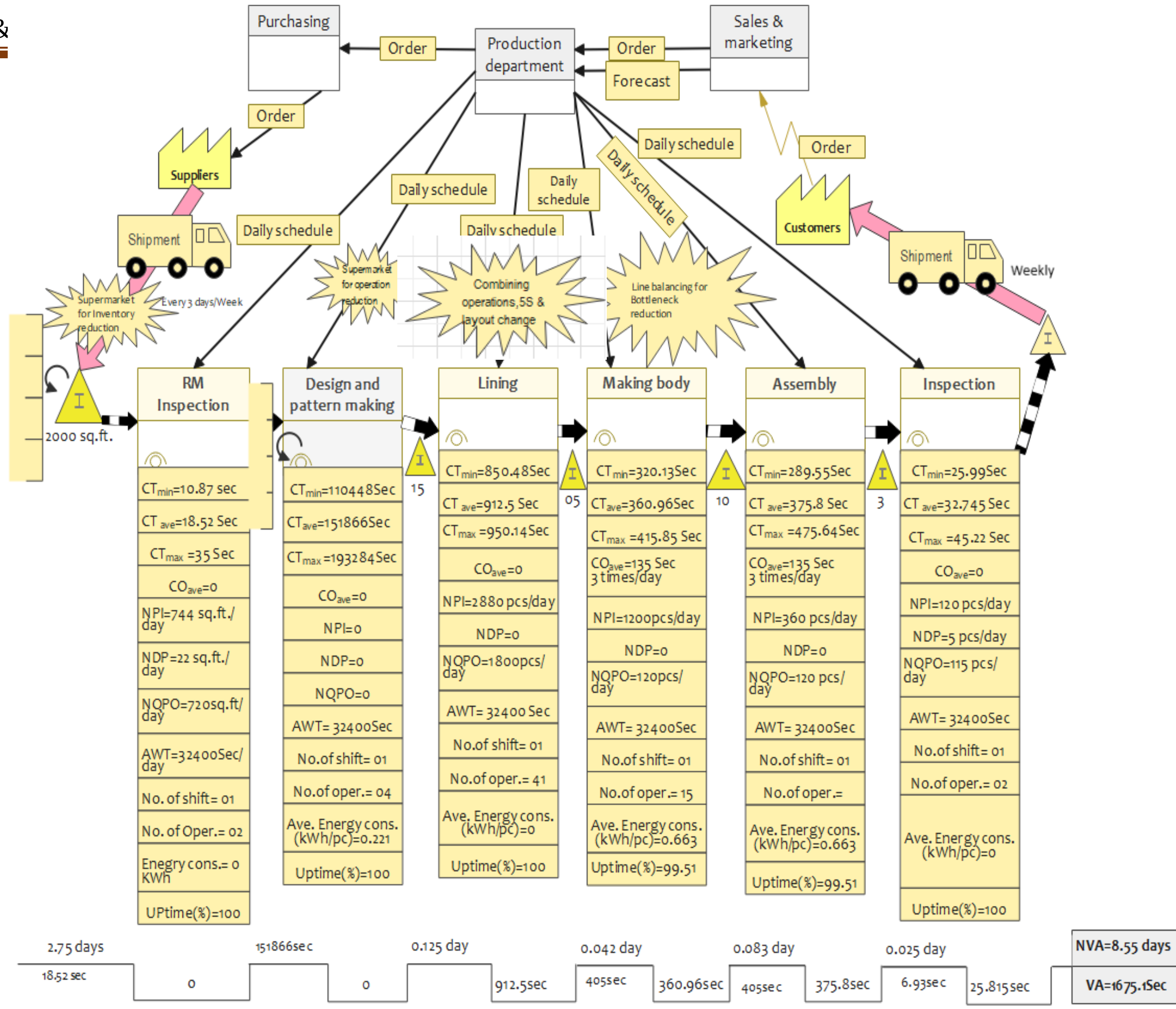

Figure 7 Developed FSV

3. CONCLUSION, RESEARCH LIMITATIONS AND FUTURE DIRECTIONS

Numerous studies have been conducted to reduce lean waste of manufacturing industries using classical VSM approach. However, the classical VSM provides limited details about the shop floor value streams. Additionally, little attention has been paid to validate the application of VSM in the leather sector. The aim, therefore, of this research was to fill these research gaps by enhancing the level of details provided by the classical VSM in the case of leather sector, thereby reduce lean waste significantly. This research was conducted in the case of Ethio-Leather Industrial PLC, Universal Leather Products Factory. Gemba-walk, interviews and company reports were used to collect the relevant data from the case company. Moreover, state -of- the -art literature review was conducted to identify the widely used lean metrics for extending the details of current VSM and potential research gaps. Hence, collection of data from the case company was started by selecting adequate product family. Product matrix was used to categorize the leather products into product families. Accordingly, school bag was selected to carry out this research. Furthermore, assembly process chart was constructed to visualize the chronological sequence of assembly operations of the selected product family. Besides, observation time for each assembly operation (process) was recorded properly.

Based on the collected data, ECVSM was constructed. The numerical results of ECSVSM in terms of VA, NVA, TPLT, and VA ratio are 1675.1 Sec., 8.55 days, 8.61 days, and 0.7%, respectively. Moreover, the analysis of the ECSVSM showed that waiting and inventory waste were the major wastes on the shop floor. To alleviate the challenges of the shop floor, relevant solutions were proposed. The FSVSM was developed by incorporating the proposed solutions into the ECSVSM. Thus, NVA and TPLT in FSVSM were reduced by 41.95% and 41.31%, respectively. VA ratio resulted in FSVSM was increased by 29.63%. Moreover, transportation waste in FSVSM was reduced by 46.76%. These results demonstrated that the major wastes were reduced significantly in the FSVSM through the proposed solutions. These results confirmed the application of enhanced VSM to reduce lean waste in the leather sector.

Similar to other researches, this research has limitations. It was limited to a single leather company. The results may not generalize to other companies in the industry without further replications. It was limited to visualizing only one component of the supply chain (the manufacturing component). Moreover, the impacts of other LM tools, such as, JIT, Kanban, Poka–Yoke), Heijunka, SMED, TQM and TPM, on the reduction of lean waste in leather industry were not studied in this research. While Zahraee (2016) assessed these tools in Iranian manufacturing, the findings may not apply to other country contexts. In this regard we proposed the following topics to be explored in the future: (1) to increase generalizability of this study, further study needs to be conducted by considering the remaining supply chain components of leather industries with uncertainty using the technique applied in this research; (2) empirical study needs to be done to investigate and prioritize the effect of abovementioned lean tools on LM implementation in leather industries and generalize the findings of similar previous research; (3) transparency in information and material flows of value streams of a leather industry is essential to visualize entire value streams and identify areas of improvement. Hence, to improve information and material flows of value streams of leather industry, the simulation based VSM need to be supported by I4.0 technologies such as, internet of things (IoT). Anosike et al. (2021) argued the operational performance of manufacturing industries can be improved by integrating lean tools with IoT.

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