

ANALYZING THE EFFECT OF VALUE STREAM MAPPING VIA SIMULATION IN GARMENT PRODUCTION LINE: A CASE STUDY

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Received 23/10/2018, Peer-reviewed 9/11/2018, Accepted for publication 24/12/2018

ABSTRACT

It cannot be denied that Lean Manufacturing (LM) is a useful technique which helps to enhance the product quality and quantity, eliminate waste from the organization and reduce the production cost. Therefore, more and more companies in Viet Nam have applied LM to increase their competitiveness and meet better the demand of customer. Garment industry is a key economic sector contributing to the industrial growth in Viet Nam, especially shirt items are one of the most popular exporting products. In this study, we will present Value Stream Mapping (VSM) which is one of LM tools. This study attempts to develop VSM in a long sleeve shirt production line at Tay Do Garment Joint-Stock Company. The goal of VSM is to identify and show Value Added (VA) and Non Value Added (NVA) in the process, then, waste in terms of non-value added processes will be eliminated. Current State Map (CSM) is drawn to give details about the current state and analyze the problems which are happening in the process. Future State Map (FSM) is drawn to show the proposed changes as well as proposed benefits. As a result, there are significant improvements for lead time, VA, Work in process (WIP) and Process Cycle Effectiveness (PCE). In addition, the simulation model will be developed based on VSM by using ARENA software. Moreover, the results are discussed elaborately.

Keywords: Lean Manufacturing; Value Stream Mapping (VSM); Value Added (VA); Non Value Added (NVA); Garment Industry.

1. INTRODUCTION

Lean manufacturing is one of an initiative to be used for streamlining production system, eliminating waste in organizations and increasing the business performance. It has been studied and utilized in Japan, the Republic of Korea and countries in EU. Furthermore, after the occurrence of World War II, lean was firstly applied in Toyota Company's production lines[1]. Facing shortage of material, money, and human resources in Japan after World War II, these conditions had led to the birth of the lean manufacturing concept [2]. The lean technique is a set of tools such as 5S, Kaizen, VSM, Takt Time that allow the process to take place smoothly, products are produced in a continuous flow, at a

formulated rate, while negative factors such as non-adding-value time, queue time and other delays are eradicated. Lean is a process-oriented system method to help organizations minimize waste and cost as well as maximize the competitiveness in the global market. The characteristic of lean manufacturing is the reduction or elimination of wasted types such as time, people and equipment, materials and defects of the product in the production process. In order to identify and evaluate these types of waste in a clear and specific way, developing a VSM is considered appropriate. VSM is one of the most popular lean tools to be used to present visually the whole process or system in a picture. Thanks to VSM, the value added, non-value added, WIP at stages, the cycle time of each stage... can be

made out clearly. Moreover, VSM is also possible to evaluate the current stage of the process, identify and analyze the root causes of waste as well as provide proposed changes to improve the current state. Recently, more and more studies about VSM have been carried out in Vietnam. All of them show that VSM is really a strong tool to be used for determining the root causes of waste such as the difference between the actual outputs and the target outputs, WIP at each stage in the process, the inappropriate layout. For instance, N.N. Phong et al. have been carried out a research application VSM for Clipsal Vietnam Co which shows various benefits of VSM for improving process opportunities [3]. Despite numerous benefits of VSM, not so many studies about garment have been conducted in the garment. Therefore, this study is performed to enhance a long sleeve shirt production line.

2. LITERATURE REVIEW

Nowadays, there are lots of studies which have been carried out to improve the manufacturing system. A report presented how to use lean thinking concept in product development process faster while maintaining quality and efficiency. VSM was chosen to identify waste and NVA steps in a process. The expected result showed that lead time might be reduced by 50% with removing all the wastes [4]. The goal of a case study for complex production environments is to prove how VSM application can be implemented successfully in these environments. This study provided useful insights and guidance to practice lean in an engineer to order and high-mix low-volume production environments [5]. In other paper, the authors said that with the support of value stream mapping such waste activities as waiting, redoing and batching might be recognized without modeling them [6]. A framework for lean improvement evaluating the feasibility of the lean principles by VSM to the blasting and coating industry is offered, and resulting in considerable increase in product delivery rates with lean

application [7]. In a case study in pulley industry, the cost benefits were analyzed, and the results pointed out that VSM is a good choice to reduce waste and save money for manufacturing system [8].

Combination of VSM and other lean tools provides utility solutions for the manufacturing system. After drawing the current state map, researchers suggested 5S principles and Kanban method for the improvement. As a result, not only lead times but also value added times declined from 8.5 days to 6 days and from 68 minutes to 37 minutes, respectively [9]. The paper presented a study which has the main objective of developing VSM to enhance the productivity in SME by removing non-value added factors [10]. After drawing the current map, Single Minute Exchange of Die (SMED) has been applied to improve the process. According to this article, the input including VSM and Kaizen is used to improve the process continuously by applying SMED in SME which might decrease the manufacturing lead time. The research introduced about using VSM and Kanban might improve productivity. It has been observed that Kanban integrated VSM can be a great support to stream manufacturing system. Recently, a combination of VSM and simulation becomes more and more popular [11]. A research including VSM and simulation optimization in fishing net manufacturing has created a current map and used a simulation tool to optimize such five factors as production unit, pacemaker process, number of batches, production sequence, and supermarket size. As a result, the future state maps might rise the service by at least 29.41% while the WIP dropped by 33.92% [12]. Using simulation in conjunction with VSM has been attempted to solve all problems in a door and window manufacturing organization. There are still many other studies of integrated VSM tool and Arena such as improve productivity with Pull modeling or with Kanban modeling [13, 14].

3. RESEARCH METHODOLOGY

This study is carried out in the following six steps which shown in Figure 1.

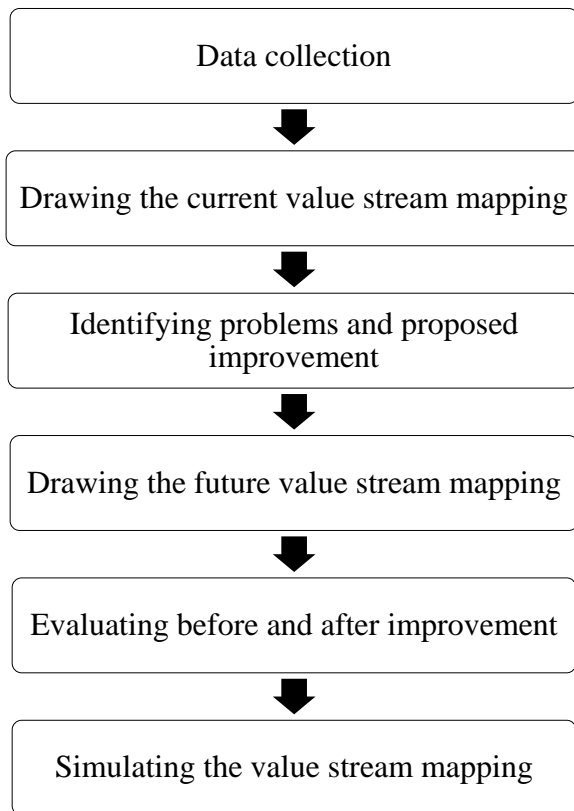


Figure 1. The methodology of implementation research

First, it is necessary to collect shifts per day, hours per shift, break minutes per shift, customer demand as well as cycle time, operators and WIP of each stage. Then, data has used to calculate Takt Time. Based on the data collected in the first step, a current state map is developed. The ineffectiveness of the process will be identified and analyzed. Thereafter, solutions will be offered for future improvement. Developing a new VSM based on the proposed improvements. Considering and making comments focused on the results of the improvements. Using Arena software simulates the VSM and demonstrates the results.

4. CASE STUDY

This study was implemented in Tay Do Company, specifically the producing line of long sleeve shirt, one of the family products.

The overall process is presented by SIPOC (Fig. 2).

Supplier	Input	Process	Output	Customer
Materials suppliers	- Raw materials - Operators - Machines	Producing Process	Long sleeve shirt	Distributors

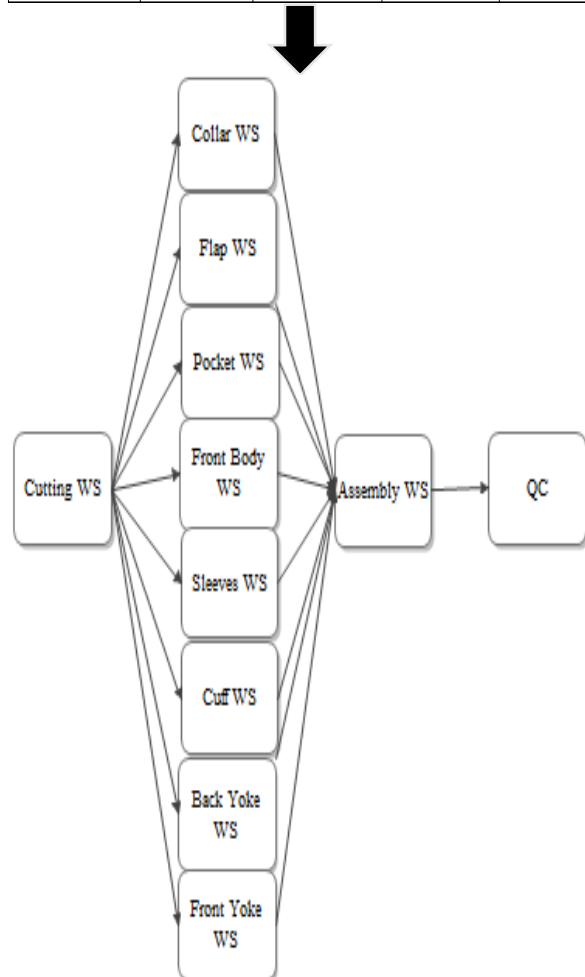


Figure 2. SIPOC of long sleeve shirt process

3.1 Data collection

Demand per day is 800 units. There is one shift per day, working 10 hours/shift. Workers have 60 minutes for lunch and 30 minutes for breaks time.

$$\text{APT (Available Production Time)} = \text{Number of shifts per day} \times (\text{Hours per shift} - \text{Breaks time per shift}) \quad (1)$$

$$\text{APT} = 1 \times (10 \times 60 - 80) \times 60 = 30300 \text{ seconds}$$

$$\text{Takt Time} = \frac{\text{Available Production Time}}{\text{Demand per day}} \quad (2)$$

$$\text{Takt Time} = 30300 / 800 = 38 \text{ seconds/unit.}$$

Cycle time (C/T), number of operators, WIP of each work station in producing process are collected and shown in Table 1.

Table 1. Processing data of each work station

Work station	C/T (seconds)	Operator Number	WIP
Collar	27	10	0
Flap	33	8	0
Pocket	34	8	0
Front body	31	6	0
Sleeves	33	15	0
Cuff	35	4	0
Back Yoke	37	2	0
Front Yoke	32	5	0
Assembly	45	12	2171
QC	43	2	0
Finished goods warehouse			673

4.2 Drawing the current value stream mapping

Based on data collection, the current state map in the whole process, as well as other details, are presented in Figure 3.

4.3 Identifying problems and proposed improvement

4.3.1 Identifying problems

The overall situation of the process is shown by the time parameters such as value added time, inventory time and lead time which are presented in the Table 2.

Table 2. Summary of the current state

Types of time	Time (seconds)
Value added time	350
WIP	83391
Inventory time of WIP	108783
Lead time	109080

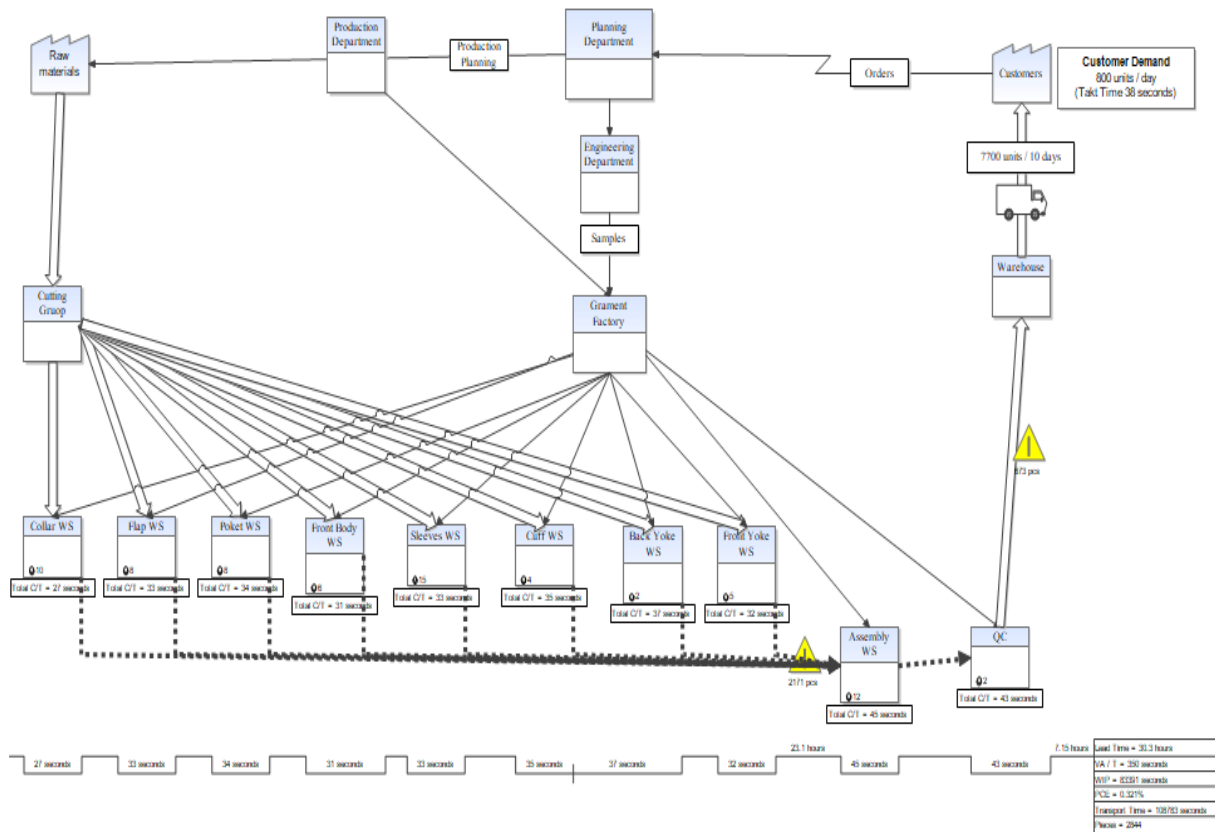


Figure 3. The current value stream mapping

The Process Cycle Effectiveness (PCE) has been calculated as follows:

$$PCE = (\text{Value added time} / \text{Lead time}) \times 100$$

$$= (350 / 109080) \times 100 = 0.32 \% \quad (3)$$

According to the current state, there are three wastes discovered such as waiting, inventory and defect. All of them will be analyzed in detail as follows:

4.3.1.1 Waiting waste

According to the current VSM (Figure 3) and chart of cycle time of each work stations (Figure 4), it has been observed that there is the difference in production capacity between work stations and the cause is determined by the unreasonable allocation of resources. On the other hand, cycle time of assembly WS is 45 seconds while Takt Time is 38 seconds. This leads to the bottleneck as the results, is that production line cannot meet the demand.

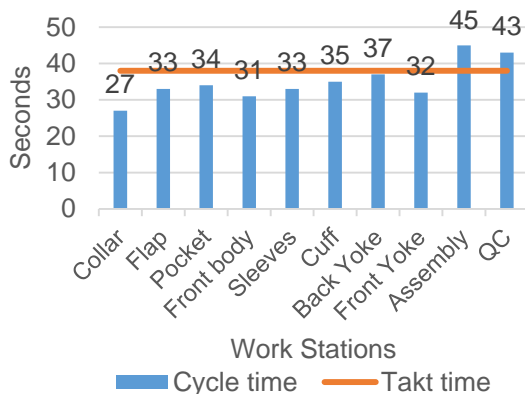


Figure 4. Cycle time of work stations

4.3.1.2 Inventory waste

Because of imbalanced line, it has a large of working in process (WIP). According to that, WIP of the assembly stage is 2844 pieces and inventory time is 23.2 hours. Moreover, it has been observed that the PCE ratio is very low because value-added time is much than lead time. It is essential that inventory time have to be reduced. The main reasons for WIP have been identified such as the yield difference between stations created the bottleneck on

the production line. In addition, due to push production system, the previous station has not produced on demand of the following station.

4.3.1.3 Defect waste

After reviewing and analyzing product quality data, it is confirmed that the rate of defects is 21.78%, defects are mainly caused by the sewing process (Figure 5). It takes a lot time to fix defects; therefore, it is necessary that quality assurance should be made before pushing the product from previous station to following one.

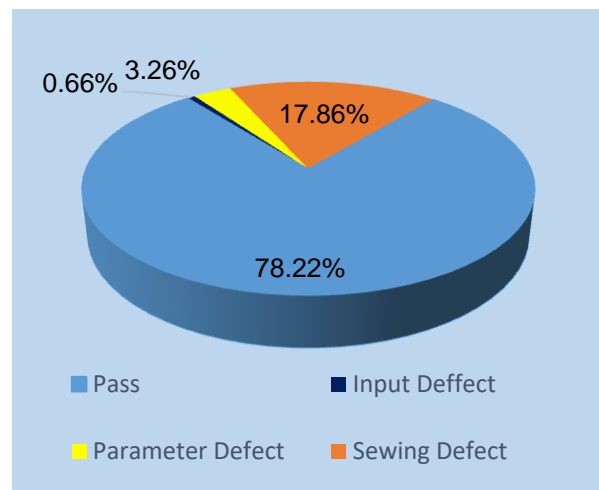


Figure 5. Percentage of Defects

4.3.2 Proposed improvement

4.3.2.1 Line balancing

As discussed above, the unreasonable allocation of resources is the main cause of the difference in production capacity between stations. Therefore, line balancing is a great idea for that issue. The results of the line balancing application are shown in Table 3.

Table 3. Results of line balancing application

Work station	C/T (seconds)	Operator Number
Collar	37	7
Flap	37	7
Pocket	37	7
Front body	31	6

Work station	C/T (seconds)	Operator Number
Sleeves	33	15
Cuff	35	4
Back Yoke	37	2
Front Yoke	32	5
Assembly	33	15
QC	22	4
Total		72

Considering the chart of cycle time of each work stations (Figure 6), it has been observed that the difference between stations was narrowed and there is no station that exceeds the Takt Time. As a result, assembly and QC stations have eliminated the bottleneck and no longer WIP anymore.

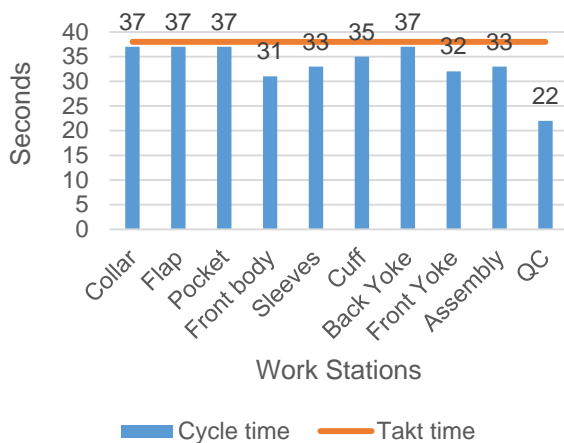


Figure 6. Cycle time of workstations after improvement

4.3.2.2 Kanban system

Defects which focus on sewing stations have caused most of the waste in the production line. Therefore, Kanban system is going to be developed to ensure the quality of the output of the previous station before moving to the following station as well as remove overproduction state. The Kanban system is planned and implemented in the following steps:

- Assembly station will fill out the demand of input into a Kanban card. Detailed information of demand includes name and number of WIP need to be provided from sewing stations. A card sample is shown in Figure 7.

Input Information		Signature and note	
Work station			
Name of WIP			
Quantity required			
Transport worker			
Output Information			
	Yes	No	
Meet the quality			
Meet the quantity			

Figure 7. Kanban card

- After filling out enough information, the card will be put into a WIP box. Then, a worker brings the box to sewing stations.

- Sewing stations will receive the box which has Kanban card inside and starts producing to provide exactly quantity required. When the process has completed, it is necessary that the card was signed by all stations to ensure quality output. Then, the Kanban card is put into the box again when there is enough quantity required. Finally, a worker will bring the Kanban box back with an exact number of input required for the assembly station.

4.4 Drawing the future value stream mapping

Based on step 3, the future value stream mapping (FVMS) is drawn to give out details to propose suggestions and results for improvement in the current position of the production line. FVMS is shown in Figure 8.

The PCE in FVMS has been calculated as follows:

$$\begin{aligned} \text{PCE} &= (\text{Value added time} / \text{Lead time}) \times 100 \\ &= (334 / 31289) \times 100 = 1.06\% \end{aligned}$$

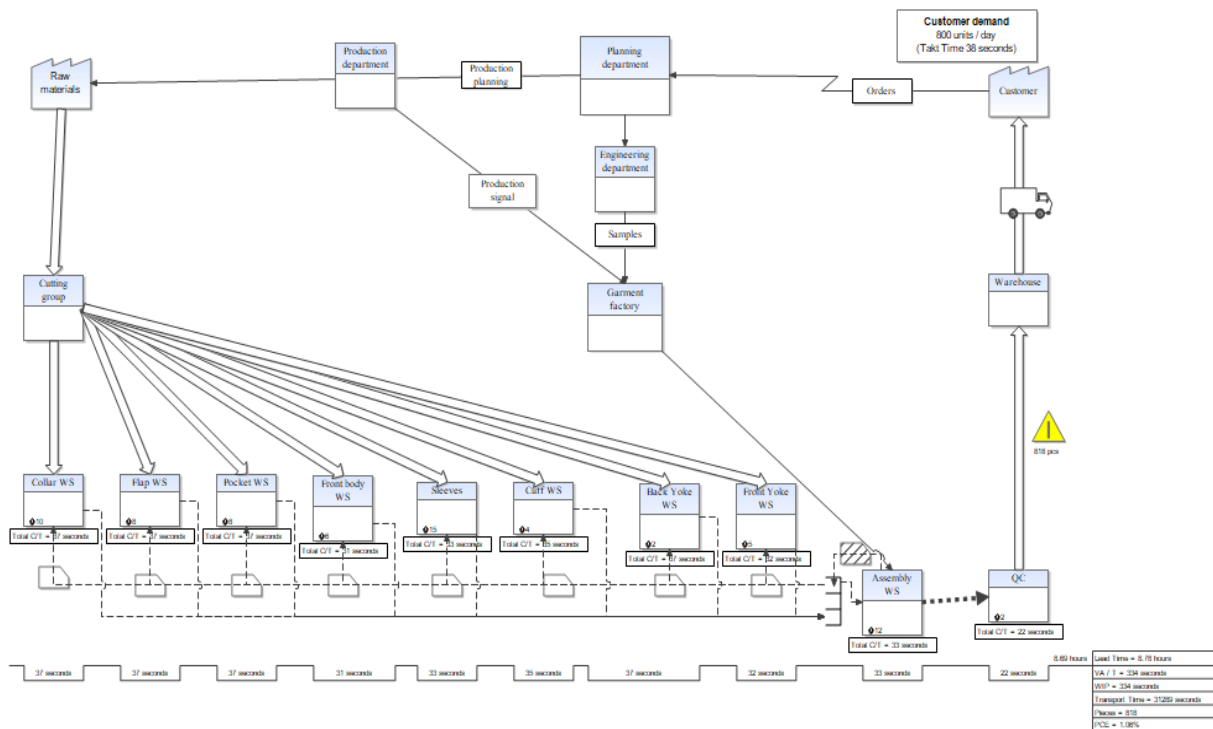


Figure 8. The future value stream mapping

4.5 Evaluating before and after improvement

Post-improvement efficiency will be evaluated and analyzed through comparison of process parameters such as lead time, VA/T, inventory time and amount of WIP and PCE (Fig. 3 and Fig. 8) which are shown in Table 4.

Table 4. Parameters before and after improvement

	Before	After
Lead time (hours)	30.3	8.78
Value added time (seconds)	350	334
WIP (seconds)	83391	334
Inventory time of WIP (seconds)	108783	31289
Amount of WIP (pieces)	2844	818
PCE (%)	0.32	1.06

Value stream mapping has been developed to assist the waste identification in producing the process as well as recommend solutions to remove waste. It has observed

that there are some improvements as the following:

- Lead time is reduced from 30.3 hours to 8.78 hours.
- Waste of WIP also is eliminate after improvement. Specifically, time inventory and amount have been decreased to 21.53 hours and 2026 pieces, respectively.
- The PCE ratio is improved from 0.32% to 1.06%.

In addition, applications of line balancing and Kanban system have provided some benefits such as improved quality, more appropriate allocation of resources and incomplete clause.

4.6 Simulating the value stream mapping

Time distribution functions for simulation models are confirmed by Input Analyzer tool of Arena software and presented in Table 5.

4.6.1 Assumption

- Cutters always provide enough material for each workstation at the same time.

- The process is operated continuously without sudden stops caused by machinery faults or unavailable workers.

- The simulation time for each iteration of a process is set up 24 days.

- The condition for ceasing the simulation (Entities Out) is specified by 1 (Entity 1).

4.6.2 Simulation models with Arena

The current and future Simulation models are shown in Figure 9 and Figure 10.

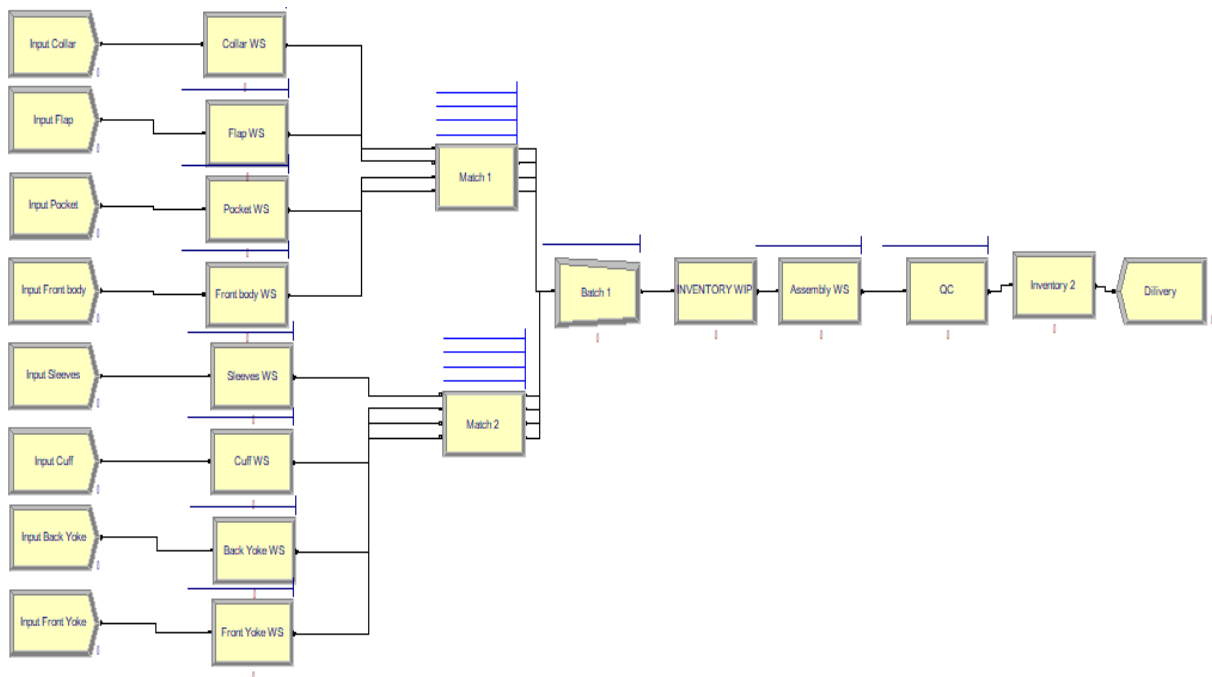


Figure 9. The current simulation model

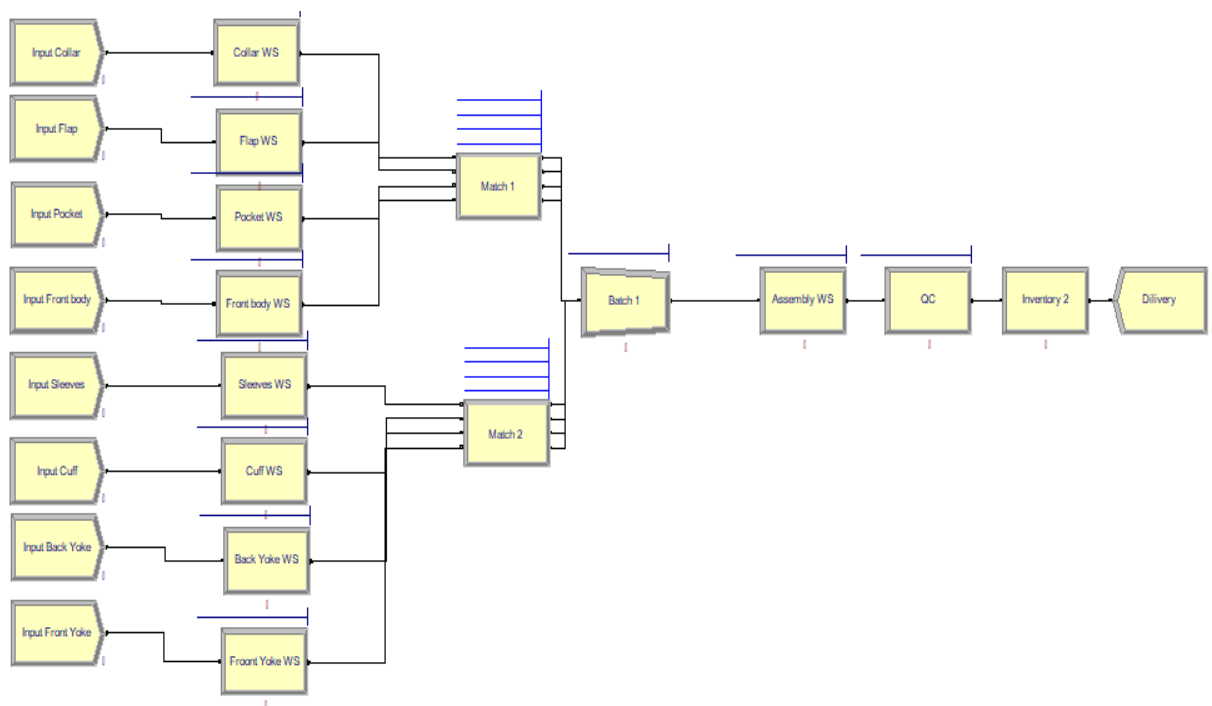


Figure 10. The future simulation model

4.6.3 Verification and Validation of Simulation Models

The processing time of all workstations, as well as the inventory time, are simulated according to the processing time of the workshop. As a result, the characteristics of the model are similar to the reality of the workshop.

4.6.4 Analysis of Simulation Results

After running the simulation models with Run Setup 10 hours per day for 24 days. The results are displayed in Figure 11.



Figure 11. Wait time before and after improvement (Unit: Seconds)

Examining the simulation results shows that Wait time decreased from 40s to 27s.

5. CONCLUSION AND DISCUSSION

In this study, the value stream mapping tool was used to find out the causes of waste in the production line. Besides, other lean tools such as line balancing and Kanban system have been applied for enhancing process and the results showed that Lead time decreased 30.3 hours to 8.78 hours, WIP inventory decreased from 2844 pieces to 818 pieces and PCE ratio initial 0.32% increased to 1.05%.

Furthermore, two simulation models were carried out to verify VSMs. The results of the study are the basis for the company to consider using VSM in improvement as well as eliminating waste. Finally, there are some suggestions for future research such as extending the scope of research for the whole production lines of the company; implement continuous improvement programs for Lean applications; statistic and solve the quality problems of the product.

Table 5. Time Distribution Function in the process

Workstations	The current		The future	
	Expression	P-Value (P>0.05)	Expression	P-Value (P>0.05)
Collar	$26 + 2 * \text{BETA}(0.831, 0.62)$	0.618	$36 + 2 * \text{BETA}(0.691, 0.795)$	0.354
Flap	$31 + 3 * \text{BETA}(1.41, 1.53)$	0.562	UNIF(36, 38)	0.62
Pocket	UNIF(33, 35)	0.378	$36 + 2 * \text{BETA}(0.866, 0.926)$	0.464
Front body	$29.6 + 2.78 * \text{BETA}(2.87, 3.58)$	0.439	$30 + 2 * \text{BETA}(0.645, 0.846)$	0.192
Sleeves	$32 + 2 * \text{BETA}(1.2, 1.12)$	0.59	$32 + 2 * \text{BETA}(0.872, 1.05)$	0.122
Cuff	$33 + 3 * \text{BETA}(0.931, 0.796)$	0.198	$34 + 2 * \text{BETA}(1.02, 1.35)$	0.0695
Back Yoke	$36 + 2 * \text{BETA}(0.819, 0.985)$	0.37	$36 + 2 * \text{BETA}(1.17, 0.914)$	0.143
Front Yoke	UNIF(31, 33)	0.435	UNIF(31, 33)	0.504
Assembly	$44 + 2 * \text{BETA}(0.878, 0.929)$	0.63	TRIA(32, 33.1, 33.8)	0.744
QC	$42 + 2 * \text{BETA}(0.993, 0.815)$	0.426	$21 + \text{WEIB}(1.06, 1.73)$	0.181

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