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# Inventory Time Analysis Based on Value Stream Mapping: A Lean Manufacturing Processing Shrimp Case Study

Vo Tran Thi Bich Chau[1], Nguyen Nhut Tien[2]
[1]Department of Industrial Management, Can Tho University
[2]Department of Electrical Engineering, Can Tho University

***Abstract*—***One of the most important economic sectors contributing to the industrial growth in Vietnam is aquatic products processing industry, especially focusing on the seafood export as shrimp. More and more Vietnamese companies have applied Lean manufacturing to enhance the product quality and to reduce the production cost, which is called non-value activities for the system production. The aim of this paper is to implement Value Stream Mapping (VSM) in production line at Ocean Shine Company, a fundamental tool of Lean manufacturing that involves constructing an overview of the whole production system and identifying wastes. As a result, some suggestions supporting to reduce wastes and inventory time of the value stream production line will be applied in the short term. Focusing on the current and the future state value stream mapping was established. In addition, ARENA software has been used to build two simulation models based on two VSMs. The application results in the enterprise are also presented specifically.*

***Keywords*—** *Value Stream Mapping, Current State, Future State, Lean Manufacturing, Shrimp Production.*

## I. INTRODUCTION

Lean manufacturing is not a new technology because it has been studied and applied in a long time and in many countries such as Japan, the Republic of Korea, USA, and many European countries. Lean was introduced by engineer after the occurrence of World War II, and firstly designed for production lines of Toyota Company so Toyota Production System is another name [1]. Philosophy of this system is to eliminate wastes, empower human resources, reduce inventory, and importantly meet customer demands. Instead of storing required resources for future production, Toyota Company has built a good relationship with suppliers. In addition, by training multi-skill workers, the company could arrange them in flexible ways, so it could meet the unstable customers' demands better than competitors could. Lean methodologies are a compilation of many techniques that companies have used in the past and are familiar. The difference is the consolidation of these techniques into one set of powerful methodologies and their applications. Specifically, they are a series of techniques that allow being produced one unit at a time, at a formulated rate, while eliminating none adding-value wait time, queue time, or other delays. Lean technology is a systematic approach method to maximize the demand of customer demand at the highest level as well as minimize wastes. VSM is one of the tools that is a key tool to identify the cause of waste in the process and steps which might be taken to reduce or eliminate it [2]. This philosophy was first introduced by Daniel Jones who argued that eliminating waste was the biggest goal the system wanted to enhance [3].

In Vietnam, numerous studies have consistently found that VSM leads to improvement in aspect of Lean production system and the implementing VSM process. In order to find out the main causes of waste such as the difference between the outputs and the daily target, Work in Process (WIP) as many stages. In the future VSM, researchers had come up with several methods to eliminate wastes and improve the efficiency and effectiveness. Take for instance, a recent study by N.N. Phong et al. clearly showed various benefits of VSM providing opportunities for Clipsal Vietnam Co with improving productivity [4]. Besides, other studies have combined VSM and the principles of lean to enhance the production line. However, the VSM researches focused on the electronics or mechanics, having a few researches in the aquaculture. To put it another way, this paper will detail the steps of VSM implementation, and propose the shrimp processing improvement line to reduce the inventory time.

## II. LITERATURE REVIEW

Lean technology is a systematic approach method to maximize meeting the demand of customer demand at the highest level as well as minimize wastes. VSM is developed to overview the value processing of lean manufacturing systems. Researchers introduced an overview of the value stream mapping; the steps involved in making it and analysed the causes of waste in all processing [5]. Other reviewers presented a case study of the "Lean" approach, using the main tool of the value stream to draw a simulation model of the production line at a steel company [6]. This study gives the potential benefits of this tool, reducing the producing time and the inventory time. Specially, a report introduced a VSM at the status of industrial electricity in China [7]. This collaborative tool provided a flexible production and built a theoretical foundation with a new management concept for China's EMS to increase the productivity profits. During recent years, most manufacturing industries have tried to implement lean philosophy in the producing processes. Dinesh Seth has a case study in India that applied a value stream mapping to enhance the streamlined operations and minimize cycle time in the production process [2]. The report showed that VSM has proven effective in identifying and eliminating

wastes according to the basis producing processes, namely assembly facilities. VSM is used as an advanced tool to improve the supplier's productivity of the automation industry. A review presented the current data collection and the current value stream mapping that analysed the actual wastes, proposed the specific changes to the lean production model [8]. In addition, a systematic approach based on the technical value of the value stream mapping was developed to identify the current processes.

Some important tools of lean have put forward for applying in the operational system, first using, namely the pull system instead of the used push system, changed to cellular layouts, and then using Kanban System to eliminate waste and improve the production processes. Simulation is one of the techniques having many applications in various practical fields and the better performance as the reality of the virtual work. By this, a simulation model was built to study the system operations in order to determine the impacts of solutions, simulated with the obtained results [9]. Today, simulation is run in the different industries and the different goals. The purpose of applying Arena simulation methods is to find the best strategy for product distribution network and to reduce the response time in the leather products [10]. According to Tayfur Altiok et al., Arena is a simulated environment consisting of modular modules, built around SIMAN language constructs and other facilities, and enhanced by the interface visual user [11]. In order to apply this software to simulate processes in production, Mohsen Kamrani et al. performed simulations in a practical study [12]. The initial results show that there is a queue, suggesting improvements to time and building a future model, indicating an average waiting time of 67% and the average waiting time of queues across the entire system decreased by 53%. In addition to finding the causes of difficulties in the system, increasing production efficiency is a topic of great interest, especially from the point of application of lean production into the production system. Applied simulation research to support production planning is a platform to support the production system and reduce the bottleneck appearance. After using the tools in the Arena software to simulate the operation of parts related to production operations, testing the conformity of the simulation results to adjust the model according to the actual will be used to create future production plans [13]. Recently, Milson R. Nyemba et al. has simulated material flow of a multi-purpose furniture assembly plant to develop an efficient system to complete timely deliveries [14]. At a minimal cost, the general simulation models based on the two products were developed and built by using the Arena simulation software. As a result, average hourly throughput was significantly increased and additional space for storage of materials prior to processing at the workstations was observed. General models are compatible with the company's products and might make it easy for the company to plan production. A climax and an important growth for the technical performance and benefits have been performed by the simulation modelling of VSM. Integration VSM tools with a simulation model reduced the wastes, such as non-essential inventories, transportation and layouts [15]. There is evidence of integrated VSM tool and Arena to improve productivity with Pull modelling or with Kanban modelling [16, 17]. To address these shortcomings while preserving the intuitive set of symbols of VSM, we propose to use simulation as a documentation and implementation tool. Two ways of the simulation are shown in the paper.

## III. RESEARCH APPROACH

The methodology mentioned from the previous researchers above are summarized into main phases in Figure 1.

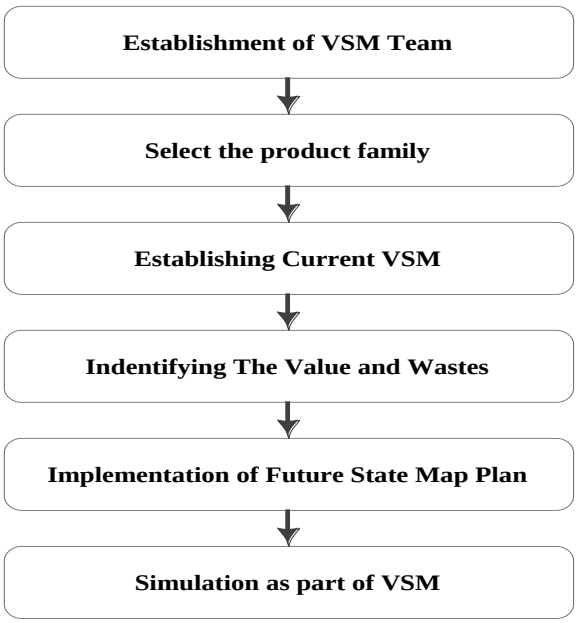


Fig. 1. Methodology of implementation research

### A. Establishment of VSM Team

The team has stablished members from various departments in this company. A leader is called "Value Stream Manager" who followed through on all shrimp processing, checking the daily and weekly materials and information flow mapped in the current state VSM. Thence, improvement proposals will be simulated in the future-status after identifying waste and suggest the advanced actions.

### B. Select the Product Family

For the purposes of this study, a product family is main products that follow a similar series of process steps. The shrimp products are one of the major products in this company.

### C. Building of the Current VSM

The current-status mapping is advantageous, presenting how production is actually occurring. Team should analyze directly a list of all properties in output, including the shift of one day, working time, Takt Time, cycle time, change-over time and operators at each station, that might be obtained by simulating the established VSM by iGrafx software.

### D. Identifying the Value and Wastes

Next, the cause and problem of the current system were been identified in VSM simulation. Based on relevant theory to develop a system improvement plan, the results of the

improvement options have reassessed the improved simulation model.

### E. Implementation of Future State Map Plan

The future state value stream mapping has established based on improved suggestions, being shown in three steps.

Step 1- Demand Management

In order to minimize inventory wastes, lean tools were used to improve and achieve the capacity of the processes. In the demand stage of this paper, 5S system and Quick Change-over (QCO) are applied commonly.

Step 2 - Continuous Flow

The improved actions for the design of a future-status map set up a continuous flow which experienced a smoother process, without returns, produced in the shortest lead time, highest quality, and lowest production cost. Using lean tools is to achieve continuous flow in this case, including Inventory Shelves, Kanban Systems and FIFO Flow.

Step 3- Production Coordination

This step is a systematic design in which information flow on the customer needs is seamlessly integrated with the stream of supplies of the value stream. Some Kanban systems are to control production lines such as Production Kanban, Kanban Signal, transportation Kanban.

### F. Simulation as Part of VSM

Simulation models of time distribution functions are determined in Arena software The processing time of all workstations and the inventory time are based on the processing time of the workshop.

## IV. Case Study

### A. Select the Product Family

In this study, focusing on the effectiveness of VSM was conducted in Ocean Shine Company, especially the producing line of PD Block Shrimp by SIPOC (Figure 2). The product was converted into one-unit block (1 Block = 1.98 kg) through the process.

### B. Establishment of VSM Team

VSM Team is shown in Table 1, associating with the authors to discuss steps by steps in this study.

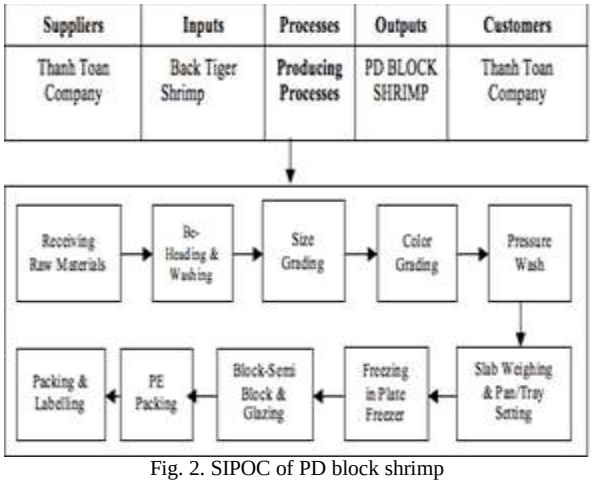


Fig. 2. SIPOC of PD block shrimp

TABLE 1. Establishment of VSM team

| S. No. | Full name | Position |
|---|---|---|
| 1 | Mr. Trieu Thanh Duoc | Deputy Production Director |
| 2 | Mr. Huynh Van Toan | Lean Leader |
| 3 | Mr. Huynh Van Can | Line Supervisor |

### C. Building of the Current State VSM

One day has two shifts, working 10 hours/shift. The output data is collected, namely Operator (OP), Cycle Time (CT), Change Over Time (CO). Then, data are calculated, such as:

Available Production Time:

APT = 10x60 = 600 (mins) (1)

Available Over Production:

AOP = APT – CO (2)

Up Time: UT (%) = AOP/APT x100% (3)

Measured parameters of all stages in this processing are shown in Table 2. The current state VSM is shown below in Figure 2 and interpreted in next step, about 1600kg each receiving order.

### D. Identifying The value and Wastes

The current state VSM is interpreted in Table 3, about 1600kg each receiving order. Inventory time is occurred all three days, with 80.9 hours. After analyzing the current VSM and identifying the realistic wastes at the processing, the solutions have been proposed to address the problem shown in Table 4.

TABLE 2. Processing data of the PD block shrimp

| S. No. | Work Station | OP *(person)* | CT *(second)* | CO *(minute)* | APT *(minute)* | AOP *(minute)* | UT *(%)* | Inventory *(Block)* | Inventory Time *(hour)* |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Receiving Raw Materials | 4 | 10 | 10 | 600 | 590 | 98.3 | 246 | 4.25 |
| 2 | Be-Heading & Washing | 1 | 1840 | 10 | 600 | 590 | 98.3 | 394 | 13.5 |
| 3 | Size Grading | 1 | 30 | 5 | 600 | 595 | 99.2 | 0 | 0 |
| 4 | Color Grading | 1 | 30 | 5 | 600 | 595 | 99.2 | 0 | 0 |
| 5 | Pressure Wash | 2 | 30 | 10 | 600 | 590 | 98.3 | 394 | 1 |
| 6 | Slab Weighing & Pan/Tray Setting | 4 | 150 | 30 | 600 | 570 | 95 | 0 | 0 |
| 7 | Freezing in Plate Freezer | 4 | 12600 | 30 | 600 | 570 | 95 | 427 | 14.17 |
| 8 | Block-Semi Block & Glazing | 2 | 7 | 30 | 600 | 570 | 95 | 0 | 0 |
| 9 | PE Packing | 1 | 7 | 10 | 600 | 590 | 98.3 | 0 | 0 |
| 10 | Packing & Labelling | 1 | 6 | 10 | 600 | 590 | 98.3 | 7 | 48 |

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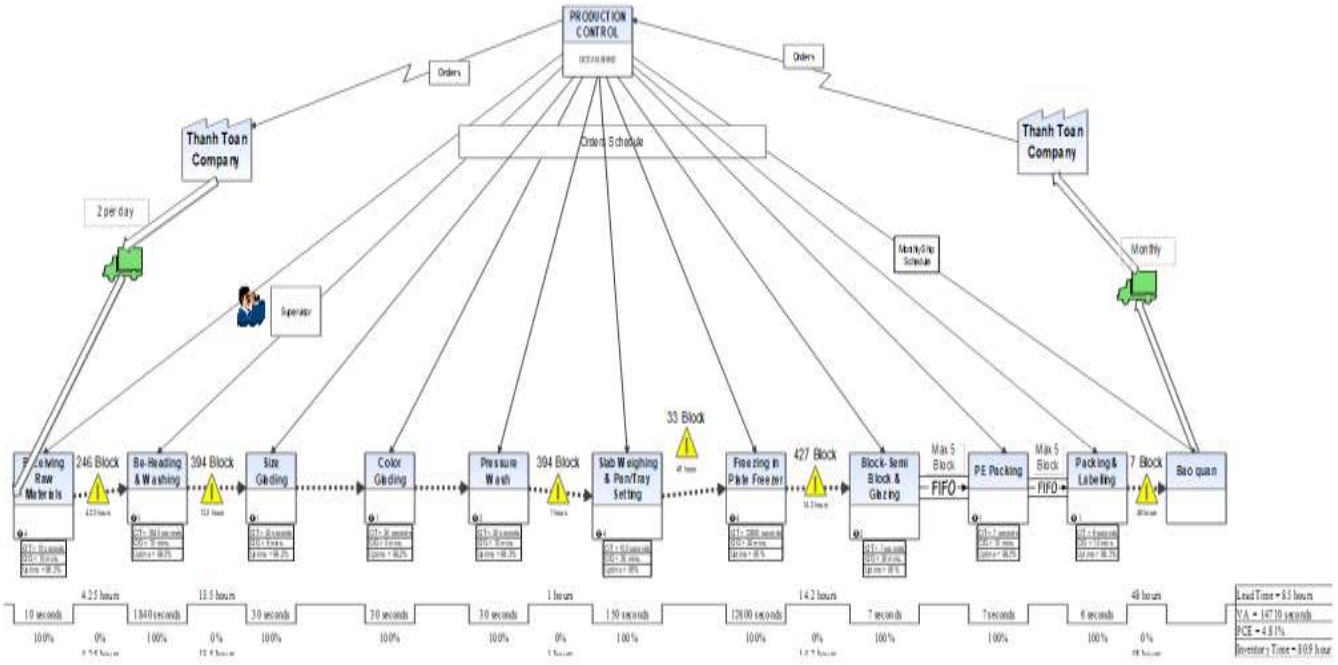


Fig. 3. The current state VSM of PD Block Shrimp

TABLE 3. Illustration of the current VSM time

| Date 1 | Date 2 | Date 3 |
|---|---|---|
| *Receiving Raw Materials*: 4 people<br>- First time: receiving 1000kg (≈ 246 Blocks), from 6h30 to 7h15.<br>- Second time: receiving 600kg (≈148 blocks), starting from 9h to 9h30.<br>Inventory time of 1000 kg ≈ 246 Blocks is 4.25 hours (from 7h15 to 11h30)<br>*Be-heading & Washing*: 49 people<br>- Processing time of 394 Blocks from 11h30 to 17h00.<br>**Inventory time** is 13.5 hours (from 17h to 6.30h the next day) | *Size Grading*: 8 people<br>*Color Grading*: 8 people<br>*Pressure Wash*: 2 people<br>- Three stages approximately equal working time of 1.33 hours, equivalently from 6h30 to 10h30.<br>- Inventory time: 1h (from 10h30 to 11h30)<br>*Slab Weighing & Pan/Tray Setting*: 4 people<br>- Preparing time: 30 minutes (from 11h30 to 12h)<br>- Processing time: 50 minutes (from 12h to 12h50)<br>*Freezing in Plate Freezer:* 4 people<br>- Products is put on a plate freezer, determined by 3.5 hours 3h30. This processing time is extremely high. In order to save the producing cost, the company only needs to perform this processing when the quantities of shrimp material reach 427 blocks. Therefore, 33 inventoried blocks will be reserved for this stage.<br>Total time: 4h (from 12h50 to 16h50) = working time + preparing time = 3.5h + 0.5h = 4h<br>**Inventory time:** 14.17 hours (from 16h50 to 6h30 the next day) | *Block, Semi-Block & Glazing*: 2 people<br>*PE Packing*: 2 people<br>*Packing Labelling*: 6 people<br>- Preparing time: 30 minutes (6:30-7:00).<br>-Three stages approximately equalled 50 minutes on machining time. However, these three steps follow the FIFO rule and perform the continuous flow.<br>**Total time**: 1.33 hours (from 6h30 to 7h50) = preparing time of the semi-block + processing time of three steps = 0.5 + 0.833 = 1.33 hours. |

TABLE 4. Main causes and improved tools in the PD Block Shrimp processing

| Wastes | Details | Tools |
|---|---|---|
| Information flow | - Be not synchronized all scheduling<br>- Depending on the Dept. of Quality Control<br>- Depending on receiving raw materials from customers | Kanban |
| Inventory | - Produced by Push System<br>- Fluctuating in demand<br>- Limited resources<br>- Unsuitable producing plan | Pull system<br>Building the inventory shelves<br>Kanban |
| Waiting | - Low productivity<br>- Depending on the raw material | |
| Defect | - Microbial infection<br>- Internal organs<br>- Incorrect required size | Building Standardized Worksheet<br>Applying 5S system |
| Movement | - Unreasonable position factory and layout<br>- Restrictions on people<br>- Distracted workers | Changing layout |

### *E. Building the Future State VSM*

Based on the basic knowledge of lean production as well as lean production tools, the authors have established the future value stream mapping with the improved suggestions, analyzing and presenting in Table 5 and Figure 4.

- Using Kanban, Inventory Shelf

Because of the characteristics of the process of PD Block shrimp, Freezing in Plate Freezer has the longest processing time (3 hours and 30 minutes) and needs 427 blocks. It is said that this operation is the Pacemaker station in this processing. In the future value stream mapping, instead of ordering directly to the workshop as many times, the orders will be pooled to send a signal and controlled by Production Kanban with the pace of 4 hours and total WIPs are 427 blocks. Using the stored shelves (supermarket) at the stages such as Slab Weighing & Pan/Tray Setting, color Grading and Receiving Raw Materials sets up the pull demand or transports directly

the products to customers after this processing. Four inventory shelves are 427 blocks of maximum as follows:

1) S1 (Shelf No 1 – Material Shelf) is put in front of Receiving Raw Materials station, corresponding one day. When Kanban System is set up, this station truly produce with 427 blocks and a signal Kanban is used to issue the producing orders to Quality Control Department. At this time, Kanban card, corresponding to the number of materials, is put into the card box and sent to the production department, receiving daily materials from the supplier based on this Kanban.

2) S2 (Shelf No 2 – WIP Shelf) is set up between Size Grading station and Color Grading station. Production Kanban is used to issue additional WIP for S2, creating Pull System.

3) S3 (Shelf No 3 – WIP Shelf) is set up between Color Grading station and Pressure Wash. Production Kanban is used to issue the producing orders for S3, creating Pull System.

4) S4 (Shelf No 4 – WIP Shelf) is set up between Slab Weighing & Pan/Tray Setting station and Freezing in Plate Freezer. Signal Kanban is used to issue the producing orders for S4, creating Pull System.

WIP after the Pressure Wash station is pushed through FIFO flow to Slab Weighing & Pan/Tray Setting station, the maximum is 5 blocks.

- Using QCO tool (Quick Change – Over)

Applying QCO in the stations which have the highest prepared times is built such as Slab Weighing & Pan/Tray Setting, Freezing in Plate Freezer and Block-Semi Block & Glazing.

- Implementing 5S tool

In order to set up the future VSM, we suggested the long-term solution to improve the working environment that one of Lean tools is 5S. It splits out of 2 phases or implements 5S at the company:

Phase 1: Sort - Set in order – Shine

Phase 2: Standardize – Sustain

TABLE 5. Initial implementation of 5S tool

| Before | After |
|---|---|
|  |  |
|  |  |
|  |  |
|  |  |

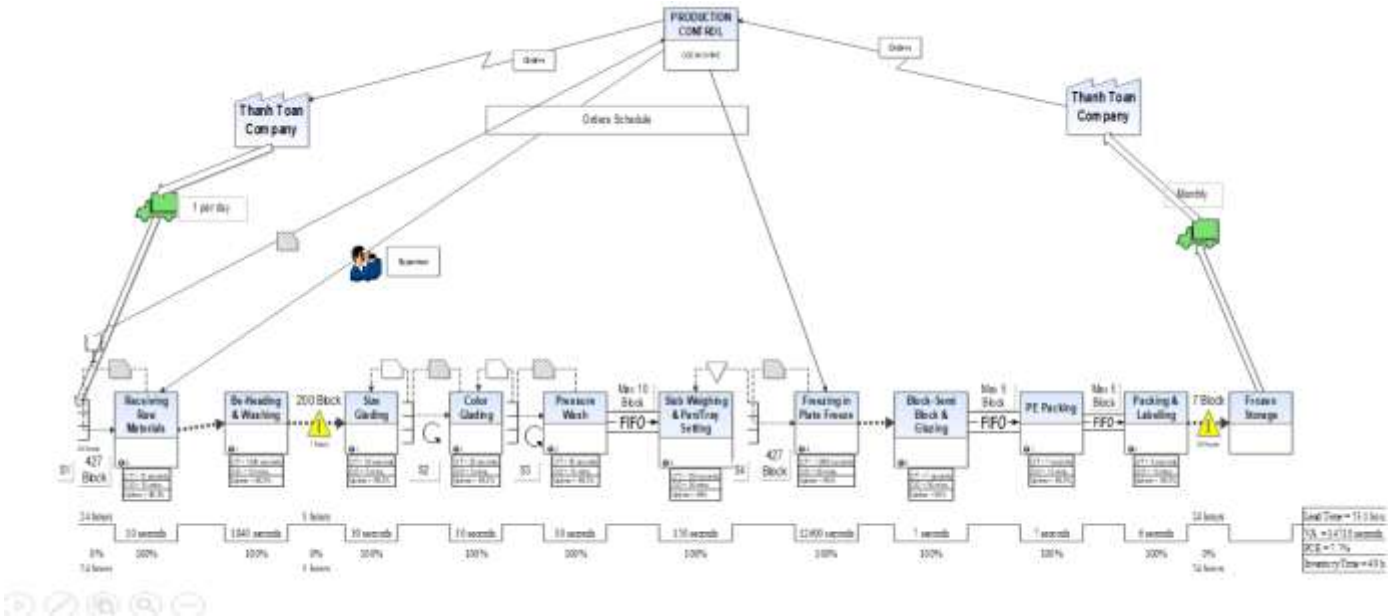


Fig. 4. The future VSM of PD Block Shrimp

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TABLE 6. Illustration of the current VSM time

| Shift 1 | Shift 2 |
|---|---|
| *Receiving Raw Materials*: 4 people<br>- Receiving 1.7 tons of raw materials (427 blocks), from 6.30 to 7.40.<br>*Be-heading & Washing*: 49 people<br>- Processing time of 200 blocks from 7h40 to 10h30.<br><br>**Inventory time** is 1 hour (from 10h00 to 11h30) | *Size Grading*: 8 people<br>*Color Grading*: 8 people<br>*Pressure Wash*: 8 people<br>*Pressure Wash*: 2 people<br>*Slab Weighing & Pan/Tray Setting*: 4 people<br>- Preliminary processing + Washing are processed with block number is 247 with a corresponding time is 2.17 hours.<br>- All 3 stages approximately equal work time of 1.33 hours.<br>- Processing time is 50 minutes.<br>Since in the future value chain map applies pull system for the production process, the steps from Pre-processing + Washing to the balance are one in parallel and consecutive in a continuous way to the shrimp Custom that might be provided for the next stage.<br>=> Total execution time = 1.33 hours + 50 minutes = 2.163 hours (from 11h30 to 13h40)<br>*Freezing in Plate Freezer*: 4 people<br>The freezing stage is carried out by a freezer exposed to the working time of 3h30 minutes. Time of execution: 3.5h (from 13h40 to 17h10)<br>*Block, Semi-Block & Glazing*: 2 people<br>*PE Packing*: 2 people<br>*Packing & Labelling*: 6 people<br>All three stages have approximately 50 minutes of machining time.<br>However, these three steps follow the FIFO rule (whichever product first comes first) and performed in parallel with each other in continuous flow. Time of implementation: 0.833 hours (from 17h10 to 18h) |

### *F. Simulation as Part of VSM*

Simulation models of time distribution functions are determined in Table 6, using Input Analyzer tool of Arena software.

- Assumption

The process is the continuous flow, not occurring the sudden stops, namely the broken machinery, absent workers.

Setting up the simulation time for the workshop in 24 days each iteration of a process.

Specifying Simulation Stop Condition is Entities Out (Entity 1) = 1.

- Simulation Models with Arena

The current and the future Simulation models are shown in Figure 5 and Figure 6.

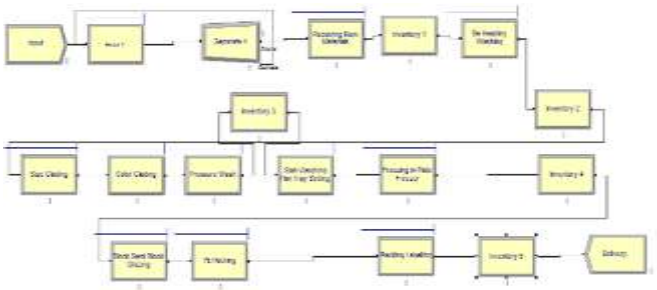

Fig. 5. The Current simulation model

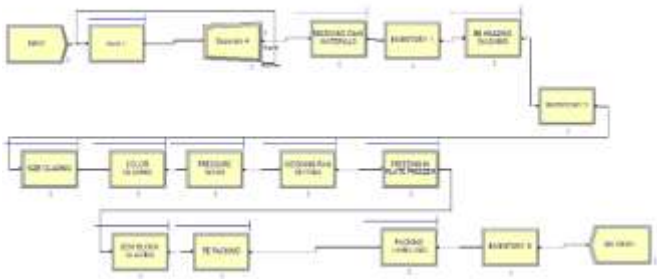

Fig. 6. Future simulation model

- Verification and Validation of Simulation Models

The processing time of all workstations and the inventory time are based on the processing time of the workshop. Therefore, the model is close to the reality of the workshop.

- Analysis of Simulation Results

After running the simulation model about 10 hours per day for 24 days, the results are displayed in Figure 7.

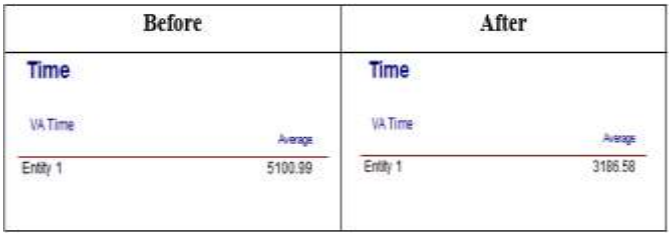


Fig. 7. Production time before and after improvement (Unit: minutes)

## V. RESULTS AND DISCUSSION

The research has achieved the following results, such as 1) Developing VSM of PD Block Shrimp in the company; 2) Figuring out the main stages of all operations; 3) Reducing and identifying wastes in the manufacturing process

The future value stream mapping which reduces lead time decreased inventory and inventory time at the workstations. Therefore, the company will be able to reduce costs and satisfy customers more in Table 8.

TABLE 7. Comparing the effectiveness of VSM before and after improvement

| Content | The current VSM | The future VSM |
|---|---|---|
| Lead time (Hours) | 85 | 53.1 |
| Value added time (Seconds) | 14710 | 14710 |
| PCE (%) | 4.81 | 7.7 % |
| Inventory Time (hours) | 80.9 | 49 |

After performing lean system, lead time is declined from 85 hours to 53.1 hours, the PCE ratio is improved from 4.81% to 7.7%. Waste of time reduced, satisfying the needs of customers significantly. This model simulates a shrimp block

through the processing. VA Time has 53.1 hours, decreased about 32 hours compared to the current modelling. Improving performances based on the future VSM has been getting revenues that are more feasible recently.

If we have enough time and resources, we will develop the research by:

- Declined improvements to the entire lines of company products.
- Performing line balancing to improve cycle time to achieve Takt Time.
- Making statistic and solving the quality problems of the product.

## VI. CONCLUSION

In generally, most companies do not realize the majority of production costs in non-value generating activities. This leads to a bias in the calculation and selection of improved solutions. Therefore, managers need to focus on losses and minimize or eliminate waste by redesigning the future VSM precisely according to condition of the company. This will help the company increase its competitiveness in many aspects such as prestige, price, productivity and quality. The results of the study are the basis for further research on the application of lean production tools to the production line and the extension of research to other lines in the company as well as other seafood companies.

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