

# Application of Value Stream Mapping in Manufacturing – A Case Study

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DOI: <https://doi.org/10.51244/IJRSI.2026.1309000093>

Received: 20 September 2026; Accepted: 25 September 2026; Published: 08 October 2026

## ABSTRACT

Cutting production costs is always the top concern of businesses to create a competitive advantage in the fierce market. According to lean perspective, cost reduction is based on the principle of eliminating wastes throughout the production and service provision process. Value Stream Mapping is a very powerful and useful lean tool to model the flow of materials, thereby evaluating the current situation in a visual way and giving ideas to eliminate waste and to give a look at the future system. In this study, it is applied in the production process of manufacturing wet wipes in tub in integration with other useful lean tools. As results, moving time reduced to 47.3%, labour head count reduction of 36.4%, and a 0.13% reduction in defects by broken tub appear when palletizing and transportation. Finally, total cost saving achieved was 26,978 USD in financial year 2023 and 33,723 USD in financial year 2024.

**Keywords:** Value stream mapping, Lean manufacturing, Kaizen, Just-In-Time, 5S, Cycle time.

## INTRODUCTION

In highly competitive manufacturing landscape, businesses are under constant pressure to enhance efficiency, reduce costs, and maintain high product quality. This drive for improvement has led many companies to adopt Lean Manufacturing principles, where Value Stream Mapping (VSM) has emerged as a pivotal tool. VSM allows organizations to visualize the flow of materials and information throughout the production process, identify inefficiencies, and develop strategies for eliminating waste.

This paper delves into the application of VSM within the context of manufacturing wet wipes in tubs, a product line that has recently gained market traction. By meticulously mapping the current state of the production process and proposing a refined future state, this study highlights the tangible benefits that can be achieved through strategic process improvements. The focus is on key performance metrics such as processing time, labor utilization, and defect rates. The ultimate objective is to provide a replicable model that can be adopted by similar manufacturing environments to drive substantial operational efficiencies.

By demonstrating the successful application of VSM, this research not only contributes to the body of knowledge on Lean Manufacturing but also offers practical insights for industry professionals seeking to optimize their production processes. The anticipated outcomes include significant reductions in processing times, labor costs, and error rates, which together underscore the effectiveness of VSM as a tool for enhancing manufacturing productivity.

## Background

The application of Value Stream Mapping (VSM) across various manufacturing settings highlights its effectiveness in enhancing operational efficiencies and reducing waste. Recent scholarly works contribute diverse perspectives and case studies.

VSM was explored in prefabrication shops, developing a systematic implementation procedure that underscores the method's adaptability in different manufacturing environments [1]. It was integrated with Kanban-based FIFO systems in the semiconductor industry, illustrating significant lead time reductions and increased throughput [2]. Extent of lean concepts integration with VSM, proposing enhanced approaches for more effective waste identification and elimination was examined [3]. VSM was combined with the theory of constraints for process improvement, providing a detailed case study on increasing efficiency and throughput [4]. Simulation alongside VSM in lean manufacturing settings was utilized, emphasizing the tool's role in optimizing production lines through detailed process analysis [5]. An empirical study on the implementation of lean principles, including VSM, in Indian manufacturing industries, highlighting significant improvements in process efficiency and waste reduction was conducted [6]. Mor et al. (2018) explored productivity gains through standardization of work using VSM in a manufacturing company, emphasizing its role in achieving consistent operational improvements [7]. Nallusamy and Saravanan (2016) investigated the enhancement of overall output in a small-scale industry through VSM, line balancing, and work standardization, demonstrating significant improvements in productivity and efficiency [8, 9].

These studies collectively illustrate the transformative potential of VSM in various industrial settings, from semiconductor manufacturing to prefabrication shops, showcasing its role in streamlining operations and enhancing productivity. Especially in small and medium enterprises, the proper application of VSM tools can create significant improvements, contributing to reducing production costs without affecting quality based on the waste elimination principle of lean tools [10].

## METHODOLOGY

This research employs a comprehensive Value Stream Mapping (VSM) approach integrated with Lean Manufacturing tools to enhance the productivity and efficiency of a manufacturing process. The methodology is structured as follows:

- a. *Data Collection:* Initial data collection through direct observation, time studies, and existing process documentation to understand the current state of manufacturing.

The direct time study was used, where direct observation of a task using a stopwatch to record the time taken to accomplish a task. The analyst evaluates the worker's pace or performance rating factor (PR).

The equation (1) is used to determine number of observations required, which depends on the level of accuracy required and confidence level desired.

$$n \geq \left[ \left( \frac{z}{a} \right) \left( \frac{s}{\bar{x}} \right) \right]^2 \quad (1)$$

where:

n: number of observations of an element that are needed

z: the number of normal standard deviations needed for desired confidence

s: the standard deviation of the sample

a: desired accuracy or precision

x-bar: the mean of the sample observations

The standard deviation (s) of the sample is estimated as equation (2).

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad (2)$$

where:

s: sample standard deviation.

x: individual values of observed times collected during the study.

The observed time ( $T_{obs}$ ) of a work element is estimated from the the mean of the sample observations ( $\bar{x}$ ). The normal time ( $T_n$ ) is calculated as equation (3).

$$T_n = T_{obs}(PR) \quad (3)$$

The standard time is computed as equation (4), where  $A_{pfd}$  is known as allowance factor.

$$T_{std} = T_n(1 + A_{pfd}) \quad (4)$$

- Current State Mapping*: Development of a VSM for the current production process, identifying key areas of waste and inefficiencies.
- Analysis and Improvement Identification*: Utilizing tools like Pareto charts to prioritize problems and Kanban to manage workflow, identifying strategic improvements.
- Future State Design*: Based on the insights gained, a future state map is created, which proposes a redesigned workflow aimed at eliminating waste and optimizing process flows.
- Implementation and Evaluation*: Implementing the new process on a pilot basis followed by full-scale deployment if successful. Performance metrics are compared before and after implementation to assess the impact.
- Continuous Improvement*: On going monitoring and modification of the processes as needed, using VSM as an iterative tool for continuous improvement.

Illustrative Diagram as in Figure 1 shows that these symbols are utilized in the VSM diagrams within the paper, illustrating both the current and future states of the manufacturing process. Mention that these diagrams serve as a visual summary of the process analysis and the planned improvements. The use of symbols must be consistent throughout the research process to ensure consistency and to facilitate those who are not part of the project to understand the correct meaning and implement it correctly.

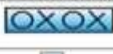
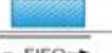
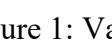
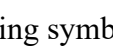
| VSM Symbol                                                                          | Description             | VSM Symbol                                                                          | Description             |
|-------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------|-------------------------|
|  | Customer or Supplier    |  | Load Leveling           |
|  | Process Operation       |  | Buffer Stock            |
|  | Shared Process          |  | Supermarket             |
|  | First In First Out flow |  | Time Line               |
|  | Push Arrow              |  | Truck Shipment          |
|  | Material Pull           |  | Kaizen Burst            |
|  | Kanban Post             |  | Inventory               |
|  | Kanban Signal           |  | Finished Good movement  |
|  | Kanban Production       |  | MRP/ERP                 |
|  | Kanban Withdrawal       |  | Electronic Flow         |
|  | Kanban Batches          |  | Manual Information flow |
|  | Gathering Information   |  | Operator                |

Figure 1: Value stream mapping symbols

This structured methodology is designed to ensure a thorough and systematic evaluation of the current manufacturing process, followed by the effective implementation of targeted process improvements. By focusing on the application of Value Stream Mapping (VSM), the approach allows for a detailed analysis of each step in the production of wet wipes in tubs, identifying key areas where efficiency can be enhanced. The aim is to significantly improve production metrics such as processing time, labor utilization, and error rates. Additionally, this methodology seeks to optimize overall operational efficiency, leading to a reduction in waste and costs. The study's outcomes are intended not only to demonstrate substantial improvements in these areas but also to provide a replicable model that can be adapted by other manufacturing environments facing similar challenges. This makes the findings and strategies developed through this approach highly valuable for broader application across the industry.

### Case Study

A real case study in this research is at KP company that specializes in manufacturing soft pack wet wipes product located in Binh Duong (Vietnam). The company has invested in automatic production lines to optimize production capacity to meet customer needs. The production process of a typical product goes through four stages including folding, cutting, wrapping and packing. The typical product and layout of the production line and are shown as on Figure 2 and Figure 3.



Figure 2: The typical soft pack product



Figure 3: A typical production line

Material flow of the typical production process is simply shown as in Figure 4. Typical products are processed serially in four main processes as mentioned previously.

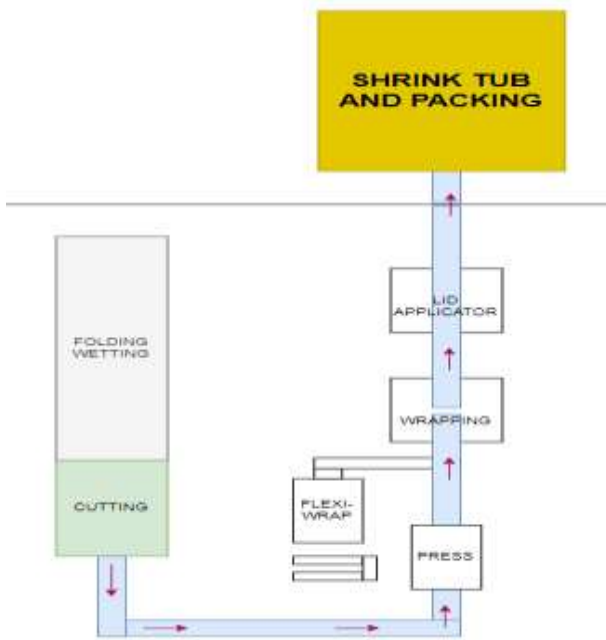


Figure 4: Simulation layout of typical production line

A new product type has been ordered by customers. The product is packaged in the Tub form. For the existing lines, it is possible for folding and cutting, but the wrapping process cannot be used because there are different kinds of materials for wrapping. To meet the new product demand from customers, two options were considered that is buying new line suitable for the new product or taking advantage current line for folding and cutting, then use manual work to pack wet block into the tub.

For the first option, the investment cost of a new production line is relatively high, about 2 million dollars. In addition, the space and related system requirements are also a difficult problem to solve if installing a new production line. Therefore, this option is not feasible.

With the second option, utilizing the existing production line with some minor changes seems more reasonable because it does not require too much cost and space as in the first option, although it requires a lot of manpower. Finally, the second option is chosen due to its simplicity in implementation when only needing to arrange the worker. The new tub product and layout is shown as on Figure 5 and Figure 6.



Figure 5: New ordered product in Tub form

In the suggested production line layout, workers 1 and 2 place the wet blocks into the Tub. Worker 3 transfers the Tubs from the machine's conveyor to the external conveyor. Workers 4 and 5 place the Tub covers on top of the Tub. Workers 6 and 7 close these covers tightly onto the Tub. Workers 8, 9, and 10 arrange the Tub on a pallet, with a quantity of about 600 Tubs per pallet. Finally, a forklift driver transports these pallets to the next step of shrink-wrapping, checking and packaging the finished products. Therefore, the entire process above requires a total of 11 workers (not including supporters).

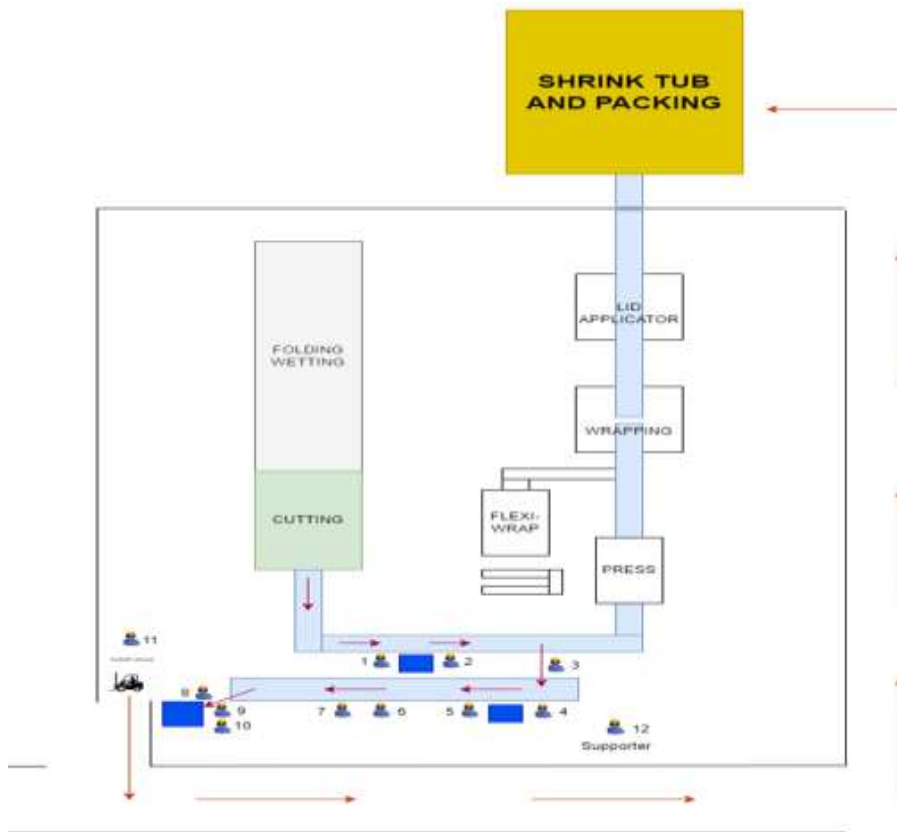


Figure 6: Layout of new tub product manufacturing

The flowchart of the new product manufacturing process is shown as on Figure 7.

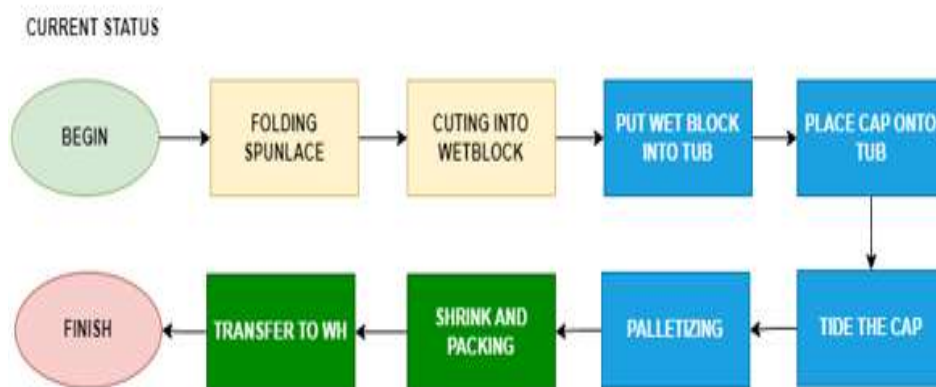


Figure 7: Flowchart of new tub product manufacturing

In the production process, the folding and cutting stages are completely automated by machines, so there is no problem. The last two stages of shrinking and warehousing will not be mentioned in this study. Looking at the current layout, it can be clearly seen that there is a lot of waste in human resources, equipment and time, especially at the palletizing and forklift transportation to the next process. These are a lot of activities that do not create any value but consume a lot of manpower, time and other resources. Therefore, the question is how to eliminate unnecessary waste, improve production capacity and efficiency.

The primary approach for improvement is to apply the Value Stream Mapping (VSM) tool to analyze and evaluate the flow of materials from input to output in the current process. Processing time, moving time, manpower, WIP and defect caused by palletizing. From there, we come up with ideas and solutions to improve processes, eliminate non-value-added activities and help reduce costs.

## A. Data Collection

The first step in the VSM tool is data collection. By directly punching time at the production site at each stage, data on defect rates are collected based on daily defect reports for each order, the actual number of personnel deployed. A table of actual data is shown as below:

Table 1: The data of current state of process

| Step  | Description                           | Processing (VA) | Moving (NVA) | Manpower | WIP  | Defect by broken tub (%) |
|-------|---------------------------------------|-----------------|--------------|----------|------|--------------------------|
| 1     | Put wet block into the Tub            | 1,67            | 0,83         | 2        | 2    | 0                        |
| 2     | Transfer Tub to external conveyor     |                 | 0,83         | 1        | 2    | 0                        |
| 3     | Place the cap onto the Tub            | 1,67            | 0,83         | 2        | 2    | 0                        |
| 4     | Tide the cap to the Tub               | 1,67            | 0,83         | 2        | 2    | 0                        |
| 5     | Palletizing                           |                 | 2,49         | 3        | 600  | 0,13                     |
| 6     | Tranfer to next process (by forklift) |                 | 0,5          | 1        | 600  | 0,13                     |
| TOTAL |                                       | 5,00            | 6,32         | 11       | 1208 | 0,13                     |

From the data table, the processing time is 5 seconds, the moving time is 6.32 seconds for each product, the total manpower required is 11 workers (not including supporter), the number of WIP products is 1208 products, and the tub broken occurring during palletizing and transportation is 0.13%. Other types of defect in other processes will not be mentioned in this research because there is no change before and after applying the improvement tool.

## B. Current Value Stream Mapping (CVSM)

The second step of the VSM tool is to create a VSM diagram for the current state based on the data collected in the first step and the flowchart of the production process. This diagram shows the current flow of materials from the beginning to the end of the process. It also shows non-value adding activities and wastes related to travel time, manpower and other resources. This is an important factor in generating improvement ideas in the next step. The Current Value Stream Mapping (CVSM) as below:

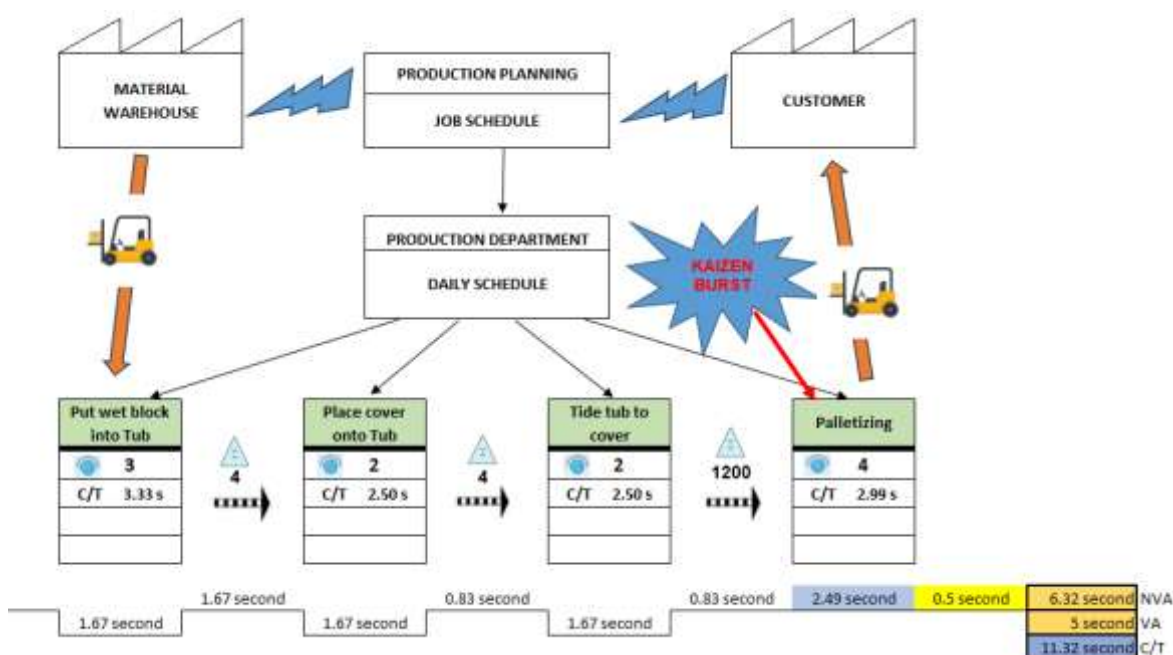


Figure 8: Current Value Stream Mapping (CVSM)

### C. Analysis and Improvement Identification

After analyzing the product characteristics as well as the layout of the production line, the team realized two things: first, the size of this new Tub product is completely similar to the typical product that the line is producing, so it can fully utilize the main conveyor of the existing line to transfer the product to the packing process without having palletizing and transport by forklift on a separate route. Second, the space along the main conveyor of the line is clear enough to install an external conveyor and arrange the jobs on that conveyor. Finally, the idea of improvement was to install an external conveyor belt along the main conveyor of the machine, arranging the jobs on this conveyor. At the end of the belt, a worker will transfer the Tubs after tight cover onto the main conveyor between the wrapping machine and the lid applicator. The palletizing would be completely eliminated and there would be no need for forklifts. The new layout of the improved production line is suggested as in Figure 9.

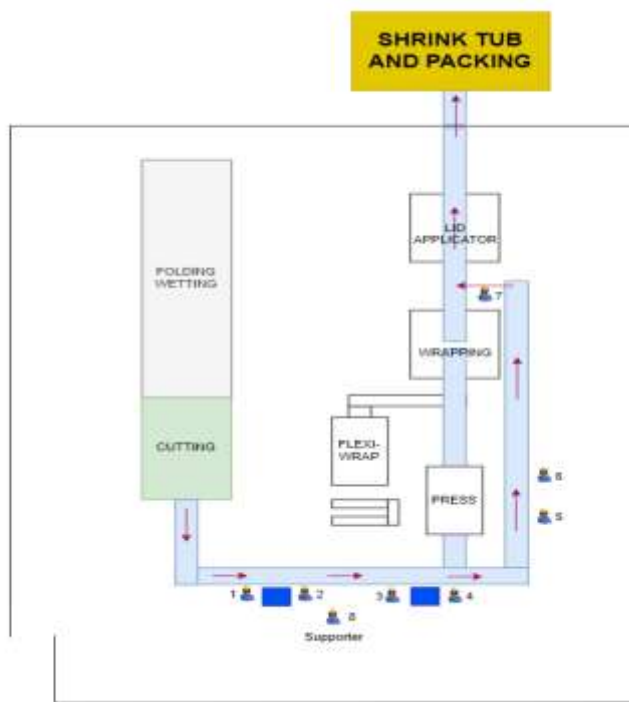


Figure 9: New layout for tub product manufacturing line

With the proposed layout, manpower is reduced 4 workers from 11 to 7 (except supporter). The flowchart of proposed idea is showed as below:

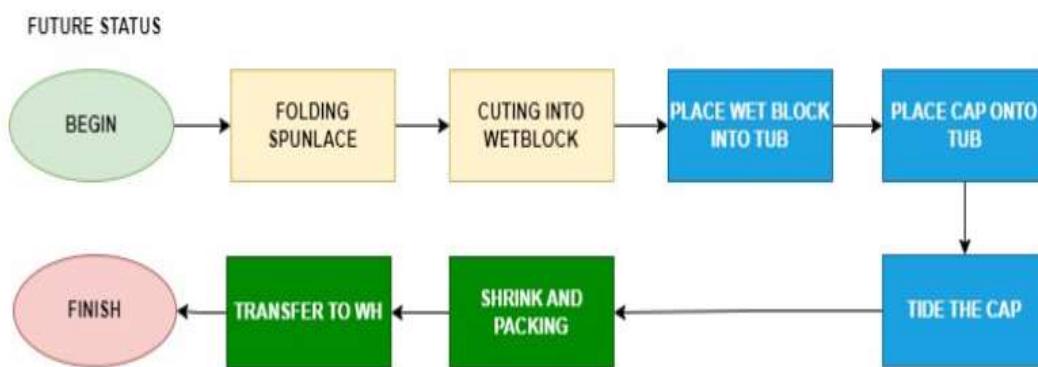


Figure 10: Flowchart of new tub product manufacturing line

## D. Future Value Stream Mapping (FVSM)

After the analysis and improvement ideas are generated, a future value stream mapping will be sketched. This model may not be the actual results achieved at the time of research, but it is the model we aim for in order to achieve the expected improvement results. The Future Value Stream Mapping is shown in the figure below:

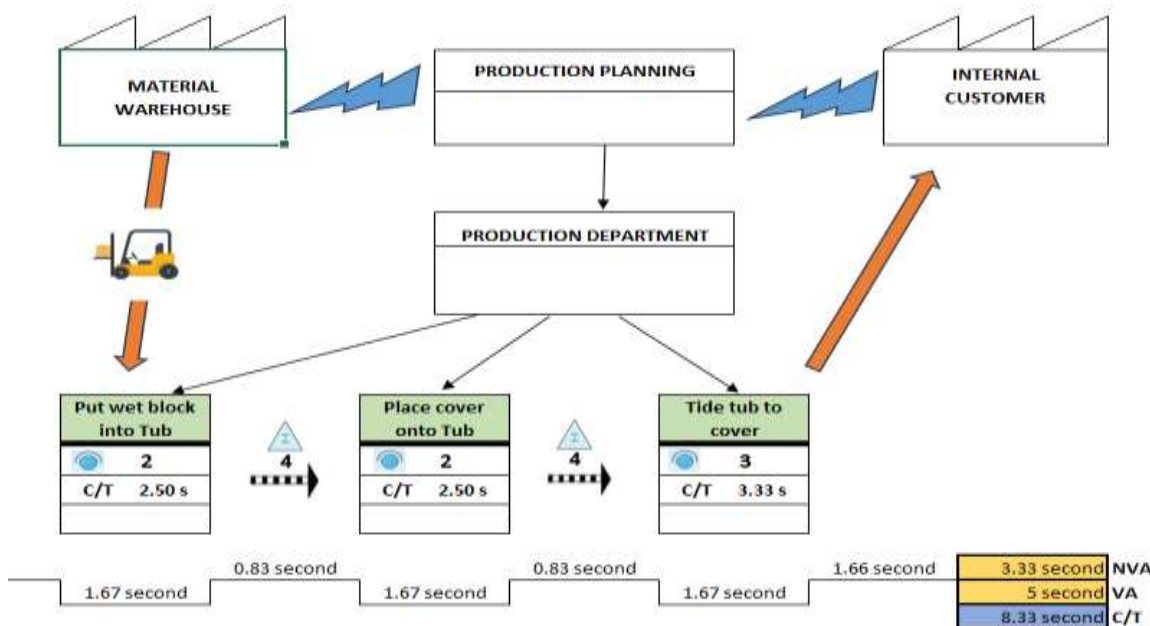


Figure 11: Future Value Stream Mapping (CVSM)

## E. Implementation and Evaluation

Before and after implementing change activities, evaluation is extremely important. Pre-implementation evaluation aims to convince the competent leaders in the enterprise to clearly see the potential and benefits of the improvement activities, thereby receiving support for the research. Post-implementation evaluation is the step to review the results of the improvement activities to see whether they are as expected, how positive the results are and whether they should be continued or not. This evaluation is based on many criteria as shown on Table 2.

Table 2: Data of Future State of the Process

| Step         | Description                            | Processing (VA) | Moving (NVA) | Manpower | WIP      | Defect by broken tub (%) |
|--------------|----------------------------------------|-----------------|--------------|----------|----------|--------------------------|
| 1            | Put wet block into the Tub             | 1.67            | 0.83         | 2        | 2        | 0                        |
| 2            | Transfer Tub to external conveyor      |                 |              | 1        | 2        | 0                        |
| 3            | Place the cap onto the Tub             | 1.67            | 0.83         | 2        | 2        | 0                        |
| 4            | Tide the cap to the Tub                | 1.67            | 1.67         | 2        | 2        | 0                        |
| 5            | Palletizing                            |                 |              |          |          | 0                        |
| 6            | Transfer to next process (by forklift) |                 |              |          |          | 0                        |
| <b>TOTAL</b> |                                        | <b>5.00</b>     | <b>3.33</b>  | <b>7</b> | <b>8</b> | <b>0</b>                 |

## F. Continuous Improvement

Normally, improvement activities have not given optimal results after each, it could only give better results. Sometimes even improvement activities give unsatisfactory results. Therefore, continuous improvement activities are extremely important to help the process become more and more perfect and effective.

In this study, after carrying out the improvement, at the position of transferring goods from the external conveyor to the main conveyor, workers are still needed at this workstation due to design and technology limitations. This is the point to continue researching and finding solutions in the future.

In addition, changing the process in this study would also change the way the related processes operate behind it, so continuous improvement should also be considered and applied to the related processes behind it to achieve even better results.

## RESULTS

The application of VSM tool to identify waste and thereby make changes to the layout has brought positive results. Table 3 shows a comparison of the status of the wet tissue production line before and after the improvement. The transportation time of the new layout has been significantly reduced, by 47.3% compared to the current one, reflecting improvements in transport efficiency and minimized waiting times. The amount of manpower on the line has been decreased from 11 to 7, a reduction of 36.4% indicating a more efficient process and reduced labour costs. In addition, because of the elimination of the palletizing step, the amount of WIP on the line has been reduced by 99.3%, and the WIP is only 8 for the future status. Finally, the defect rate of broken tub due to the transportation of goods has been eliminated.

Table 3: Result after Take Improvement

| No. | Description          | Current status | Future status | Comparison       |            |
|-----|----------------------|----------------|---------------|------------------|------------|
|     |                      |                |               | Future - Current | By percent |
| 1   | Processing time      | 5.00           | 5.00          | 0.00             | 0.0%       |
| 2   | Moving time          | 6.32           | 3.33          | 2.99             | 47.3%      |
| 3   | Total time           | 11.32          | 8.33          | 2.99             | 26.4%      |
| 4   | Manpower             | 11             | 7             | 4.00             | 36.4%      |
| 5   | WIP                  | 1208           | 8             | 1200             | 99.3%      |
| 6   | Defect by broken Tub | 0.13           | 0             | 0.13             | 100.0%     |

The calculation of the benefits of changing the premises was carried out by the author based on the actual demand for tub wet tissue products in 2023 and 2024. The cost savings results are shown in Table 4, Table 5, and Table 6.

Table 4: Cost Saving from Manpower Reduction

| FY        | Annual demand | Necessary time for demand (shifts) | Necessary manpower |               | Cost saving |        |
|-----------|---------------|------------------------------------|--------------------|---------------|-------------|--------|
|           |               |                                    | Current status     | Future status | Manpower    | USD    |
| 2023      | 518400        | 303.16                             | 3334.74            | 2122.11       | 1212.63     | 15,522 |
| 2024      | 6480000       | 378.95                             | 4168.42            | 2652.63       | 1515.79     | 19,402 |
| Cost rate |               |                                    | 320,000 vnd/day    |               |             |        |

Specifically, the labour cost of the line decreased by 15,522 USD in 2023 and decreased by 19,402 USD in 2024 (Table 4). Moreover, eliminating tub breakage due to palletizing and moving saves 11,457 USD in 2023 and 14,321 USD in 2024 (Table 5).

Table 5: Cost saving from defect reduction

| FY         | Annual demand | Defect reduction |            | Cost saving |
|------------|---------------|------------------|------------|-------------|
|            |               | Percent          | pcs        | USD         |
| 2023       | 5184000       | 0.13%            | 6739       | 11457       |
| 2024       | 6480000       | 0.13%            | 8424       | 14321       |
| Unit price |               |                  | 1.7USD/pcs |             |

The total savings are 26,978 USD and 33,723 USD in 2023 and 2024 if the production layout is improved based on the use of VSM (Table 6).

Table 6: Cost saving in total

| FY   | Annual demand | Cost saving in total (USD) |
|------|---------------|----------------------------|
| 2023 | 5184000       | 26978                      |
| 2024 | 6480000       | 33723                      |

In addition to these measurable benefits, the proposed solution also brings several other indirect benefits. No longer to use forklifts to transfer semi-product after palletizing to next process. So can save cost from using forklift. No need to use the pallet for this process which helps to save money from buying pallet. Workers do not need to move at the palletizing stage, making work simpler and reducing fatigue during work.

## CONCLUSION

Lean manufacturing has many tools and production management methods to eliminate waste and inefficiency in the production process to reduce production costs, shorten production time and increase output for the enterprise. Among the most basic tools of this production philosophy, VSM is one of the widely used tools to identify and visualize existing waste. VSM is a simple, easy to understand, easy to apply tool but can bring significant benefits to the organization.

A new line layout was proposed as a solution to eliminate this waste and the improved VSM diagram was built. With these improvements, the palletizing stage as well as the transportation of wet tissue boxes from the box-making line to the packaging line were eliminated. Moving time was reduced by 47.3%. The WIP of the previous improved line was 1208 with bottle neck as the palletizing step, which has been reduced to 8 with a reduction rate of 99.3%. The number of workers has been reduced by 36.4%, equivalent to savings of 15,552 USD in 2023 and 19,402 USD in 2024. In addition, with the complete elimination of shipping damage, 11,457 USD for 2023 and 14,321 USD for 2024 were saved.

However, because of this simplicity and ease of implementation, some lean practitioners may sometimes overlook the benefits that VSM can bring to the continuous improvement process. This article is a case study focusing on the use of VSM in integration with other lean tools in a wet wipes manufacturing enterprise. After the research, collection of necessary data and construction of the current VSM diagram, the palletizing step was identified as a non-value-added activity and could be improved more to achieve the perfect production system.

## ACKNOWLEDGEMENTS

We acknowledge Ho Chi Minh City University of Technology (HCMUT), VNU-HCM for supporting this study.

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