Lean manufacturing with multilevel Value Stream Mapping

Y Prasetyawan\(^1\,2\), B A Ramadhan\(^1\,3\) and L Salsabila\(^1\,4\)

\(^1\)Departement of Industrial Engineering, Institut Teknologi Sepuluh Nopember, Kampus ITS Sukolilo – Surabaya 60111, Indonesia

Email: \(^2\)yudhaprase@gmail.com, \(^3\)abdurahmanbagas@gmail.com, \(^4\)bila.latifah@gmail.com

Abstract. The lean method is a process that helps the companies to produce more products by minimizing time of the process, capital, and other resources. VSM is a tool which is based on the lean manufacturing that used to identify the current scenario of the process in the company to solve the problems and fix the future scenario. As VSM identifies all the process steps, the value added, and non-value-added activities are analysed using this tool to help see the source of waste and the hidden waste. The existing VSM is limited to explain the production process in general and it is less detailed, so the improvements that made are limited to the level of the production line and not every production process. The purpose of this paper is to develop a dynamic mapping method to enable a more detailed analysis of lean problems by making value stream mapping into several levels (multilevel).

1. Introduction

The production process in manufacturing system requires cost reduction to maximize the profit. This time, it is one of the key problems that the companies must face. One of the ways to do the cost reduction is using lean method. The lean method is a process that helps the companies to produce more products by minimizing time of the process, capital, and other resources [1]. Lean is a systematic process that aims to fulfil demands and satisfy performance from the customer without reducing quality by using method that is efficient, optimize costs, and optimize delivery times for making the finish product [2] [3]. To achieve the goals, it is better to act based on the three sources of inefficiency, they are: waste, flexibility, and variability [3]. The measure of the lean level in the company can be seen using a tool called Value Stream Mapping (VSM), it is a method used to identify wastes and improve performance [4]. Not all problems can be easily identified using VSM because the analysis only considers the static aspect of the system and oversimplify problems that exist in manufacturing system, while manufacturing system is influenced by various dynamic problems of the production process and it includes high complexity [5]. Therefore, a method by considering the dynamic system must be applied. In this paper the authors want to develop VSM which considers static aspect to be dynamic based on Quality Function Deployment (QFD) framework with several levels, not based on the QFD matrix but from the dynamic aspects that shown in QFD.

VSM is a tool which is based on the lean manufacturing that used to identify the current scenario of the process in the company to solve the problems and fix the future scenario. VSM focused to reorganizing all of the manufacturing system with lean perspective. It described by information flow that includes all the process from customer order, manufacturing process, and delivers the product to the customer [6]. As VSM identifies all the process steps, the value added, and non-value-added activities are analysed using this tools to help see the source of waste and the hidden waste [7]. VSM can brings out the positive result on process ratio, takt time, process time and inventory level, total lead time, and reduced the labour power [8]. Not all of the problems can be easily solved by VSM, because it was able to display a static production flow and only suitable for representing production lines with one product or a product family [9]. It is difficult for applying VSM to complex product flow conditions. QFD is a method that translate customer requirements and manage it into the final product [10]. QFD discusses customer demand to improve product quality to match the voice of customer as a whole, which contains...
several multilevel matrices that are product planning matrix, product design matrix, process design matrix and process control matrix [11].

A publication presents QFD integrated with VSM that used for enabling identification of wastes and tools to eliminate them. The QFD framework has been used for identified scientific prioritization of wastes from the current VSM and techniques to eliminate them, then the result can be implemented for eliminating the wastes that visualized with future VSM [12]. Value stream mapping developed into a dynamic concept that taking both recent digitalization technologies and organization structures into account. The goals are developing static method into DVMM (Dynamic Value Stream Management) as a feedback to the changing status of challenges in the production line in manufacturing system. The concept of the DVMM framework is designed with two dimensions: technical infrastructure facing industry 4.0 and management approach that describe relevant day-a-day activities [13]. The use of value stream mapping with other methods for lean manufacturing has been done in research before, one of them is integration of value stream mapping with dynamic systems in modelling and analysing manufacturing lines [14]. The purpose of the method is to improve waste identification and eliminate it. The method has the main stages for identification waste, the first is creating a value stream mapping as in general, then making a value stream analysis, after which it is simulated using a scenario from a dynamic system analysis. The main purpose of value stream mapping and value stream analysis is to identify the problems and waste, while dynamic system analysis is make it possible to understand how the problem can affect the other system such as inventory levels that change in time and how that it can affect the amount of production and client satisfaction.

The purpose of this research is to develop a dynamic mapping method to enable a more detailed analysis of lean problems by making value stream mapping into several levels (multilevel). There are three levels of multilevel VSM namely previous VSM, current VSM, and future VSM which dynamically shows the improvement of the company’s production process.

2. Method

In order to be able to see the detail of wastes that exists in the production process, the authors develop VSM into several levels (multilevel). There are three level of the VSM: (1) level 1 is making detailed VSM for each process that occurs in the production line; (2) level 2 is making previous, current, and future scenarios of VSM for one production line (not each process) to see the improvement scenarios that have been made in a structured way by showing the impact of what would happen if a small change in production process was made; then (3) level 3 is a combination of level 1 and level 2 by combining the detailed process with each scenario (previous, current, future). To apply multilevel VSM, the authors takes an example of a case study in industrial and building paint company [6]. Below is the result of the multilevel VSM for the case study that has been modified by the authors.

2.1. VSM Level 1

The production process consists of first mixing process, big mixer process, testing, and packaging. There are some wastes for each process that is rarely known if we make direct VSM for one production line, therefore VSM can be made more detailed for each process or in this case referred as VSM level 1. The VSM has shown the details of processes that occur within a process, so detailed wastes can be identified. Below is the example of VSM level 1 in first mixing process and big mixer process. VSM we use as example is from [15].
2.2. VSM Level 2
This level illustrates previous, current, and future scenarios of VSM for one production line. By making VSM for each production process at level 1, it can be identified waste that occurs in each production process. The wastes can be reduced using several tools, for example: the use of Kanban, single minute exchange dies (SMED), and all available lean manufacturing tools. At level 2, the previous VSM is
shown before the improvement process is performed. After the company makes improvements by eliminating waste, current VSM is made to describe the company’s current condition. Then the company makes another improvement to become future VSM.

Figure 3. VSM level 2 (previous VSM).

Figure 4. VSM level 2 (current VSM).
2.3. VSM Level 3

VSM level 3 is a combination of level 1 and level 2 where the previous, current, and future VSM are described in detail for each process, so the VSM can be seen in detail what process that occur, and it wastes. Figure 6, Figure 7, and Figure 8 show VSM level 3 for previous, current, and future VSM.
By describing VSM up to level 3, the company can find out where the waste occurs in more detail so the elimination of the wastes can be right on target. It is not the same as the existing method of VSM that only explains the production process in general and it is less detailed, so the improvements that are made only at the level of the production line and not every production process.

3. Result and Discussion
After making the three levels of Value Stream Mapping, it can be performed an analysis of each operation that occurs in the production line to determine the amount of Value Added (VA), Non-Value Added (NVA), and Necessary but Non-Value Added (NNVA). Table 1 shows an analysis of total activity in previous VSM, current VSM, and future VSM.

It can be seen in Table 1 that if we use existing VSM in general, we can only know the total cycle time and total lead time, more detailed activities cannot be analysed in general VSM. But by using Multilevel VSM, it can be identified the activities that occur in each process in its production line in order to reduce the number of Non-Value Added activities. From Table 1 is known that from previous VSM to current VSM had reduced lead time from 10.7 days to 8.5 days and the cycle time from 78 minutes into, also current VSM to future VSM had reduced lead time from 8.5 days to 6 days and the cycle time had reduced from 58 minutes into 24 minutes. From that fact there has been an improvement in the system and the company can achieve the following benefits.

Figure 7. VSM level 3 (current VSM).

Figure 8. VSM level 3 (future VSM).
in current VSM and there has been improvement again in Future VSM, it can be seen that the most visible reduction is in non-value added, total cycle time, and lead time.

| Activity   | Qty  | Total Time | Activity | Qty  | Total Time | Activity | Qty  | Total Time |
|------------|------|------------|----------|------|------------|----------|------|------------|
| Operation  | 10   | 61.5       | Operation| 10   | 46.5       | Operation| 10   | 18         |
| Transportation | 3 | 1.5        | Transportation | 3 | 1.5         | Transportation | 3 | 1.5        |
| Inspection | 1    | 15         | Inspection | 1    | 10         | Inspection | 1    | 4.5        |
| Storage    | 5    | 10.7 days  | Storage   | 5    | 8.5 days   | Storage   | 3    | 6 days     |
| Delay      | 2    | 25         | Delay     | 2    | 25         | Delay     | 0    |            |
| VA         | 7    | 158.72     | VA        | 7    | 158.72     | VA        | 7    | 158.72     |
| NVA        | 6    | 11.5       | NVA       | 6    | 11.5       | NVA       | 3    | 11.5       |
| NNVA       | 8    | 36.51      | NNVA      | 8    | 36.51      | NNVA      | 7    | 36.51      |
| Total CT   |      | 78         | Total CT  |      | 58         | Total CT  |      | 24         |
| Total LT   |      | 10.7 days  | Total LT  |      | 8.5 days   | Total LT  |      | 6 days     |

4. Conclusion

VSM is a tool which is based on the lean manufacturing that used to identify the current scenario of the process in the company to solve the problems and fix the future scenario. Multilevel VSM is divided into three levels and multilevel VSM is developed to identify wastes for each process that occurs in the production line, so the waste elimination can be used on time especially for reducing non-value added activity. Level 1 is making detailed VSM for each process that occurs in the production line. Level 2 is making previous, current, and future scenarios of VSM. The previous VSM is shown before the improvement process is performed. After the company makes improvements by eliminating waste, current VSM is made to describe the company's current condition. Then the company makes another improvement to become future VSM. Then level 3 is a combination of level not as the same as existing and level 2 by combining the detailed process with each scenario (previous, current, future). It is not one method of VSM that only explains the production process in general and it is less detailed, so the improvements that are made only at the level of the production line and not every production process.

5. References

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