Analyzing the Value Stream Mapping to Achieve Lean Manufacturing via Line Balancing

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Abstract

Value stream mapping (VSM) visually depicts the flow of materials and information as a product passes through the manufacturing process; this information enables companies to meet customer demand by getting these materials and information for improvement at the right place and at the right time. This paper reviews the existing literature on VSM, describes the concepts and techniques of line balancing, and demonstrates through empirical study how the concepts and techniques of line balancing can help optimize VSM implementation to enhance business performance.

Introduction

Many papers about value stream mapping (VSM) and many others about line balancing (LB) have been published already, but these concepts have rarely been considered together. This research provides new insights into value stream mapping by combining its processes with line balancing (LB) improvements. The paper begins from an academic perspective with a literature review, and then gives an overview of how LB can be used to improve VSM by reducing process times.

1. Review of the literatures on VSM and LB

1.1 Value stream mapping

VSM is a powerful tool that not only highlights process inefficiencies and transactional and communication mismatches but also guides their improvement(8). VSM is one of the many tools, working methods and concepts used to create what is called a lean management(2)(6). Several reports that VSM walks through a manufacturing system and shows management facts such as cycle times, buffer sizes (inventory) and personnel requirements. A VSM generally consists of three components(3)(7).

1.1.1 Material flow

VSM enables a high-level perspective on the flow of material throughout the entire production process. Each process time and bottleneck of working station is identified, and inventory levels are generally also presented.

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2.1.2 Information flow

All information flows throughout the entire process are shown in the information flow part of the VSM. The information that triggers a business process can start, for example, with a customer order, followed by a production order message sent to the supplier and manufacturing department.

2.1.3 Time-line

The timeline takes the form of a square wave at the bottom of the VSM. This functions as an indicator of lead time (LT) and processing time (PT).

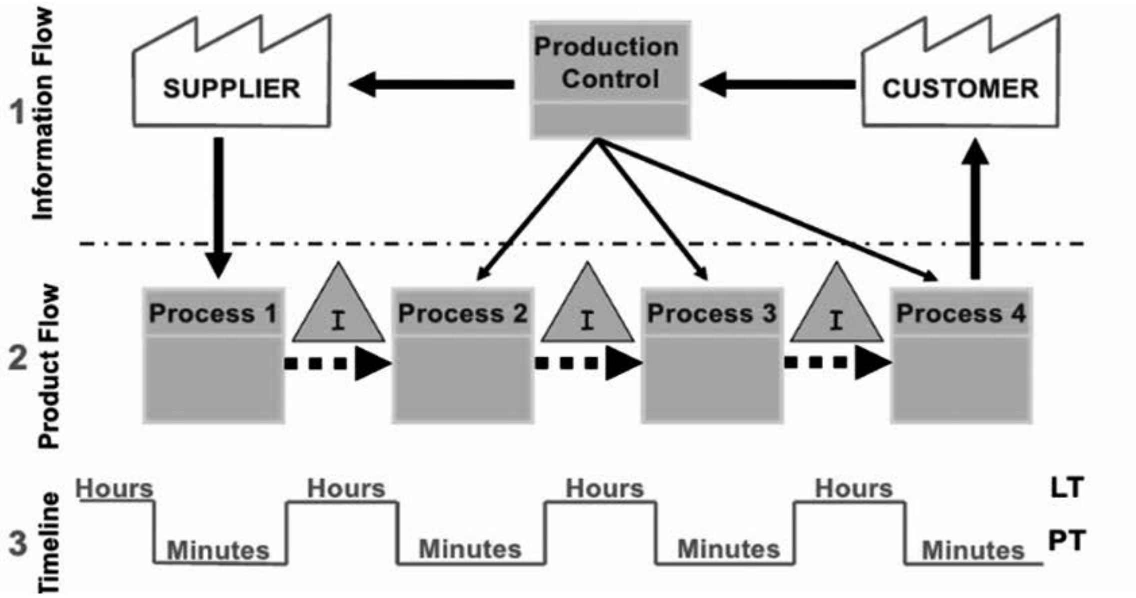


Figure 1. Typical manufacturing VSM components

1.2 Line balancing

Continuous improvement is required to create more value for customers while reducing the resources required processing value. The transformation of a traditional assembly line into a lean production one is a good means of improving efficiency, productivity and profitability(4). Line balancing (LB) is a technique that minimizes the imbalance between/among the working time of workers and workloads in order to achieve the required run rate(1). An important measure of LB performance for a production line is the system throughput, such as the average number of jobs produced per hour. The efficiency of a process is the ratio of the current productivity level to the best-practice productivity level. Best-practice is defined as the highest achievable productivity(5).

2. Research methodology

The steps involved of research methodology in our research on VSM implementation are shown in Figure 2. The first step includes defining the problem and initiating the current mapping process, i.e., creating a current state map. The next step includes analyzing the current state map and creating a future state map, i.e., a depiction of the process “as it should be", which enables the design of a lean process flow through the elimination of non-value-added activities and other process improvements. The last step is analyzing the results and implementing the proposed changes, followed by the pursuit of continuous improvement. In addition, the team needs to develop an improvement action plan that outlines the action steps needed to support the proposed changes.

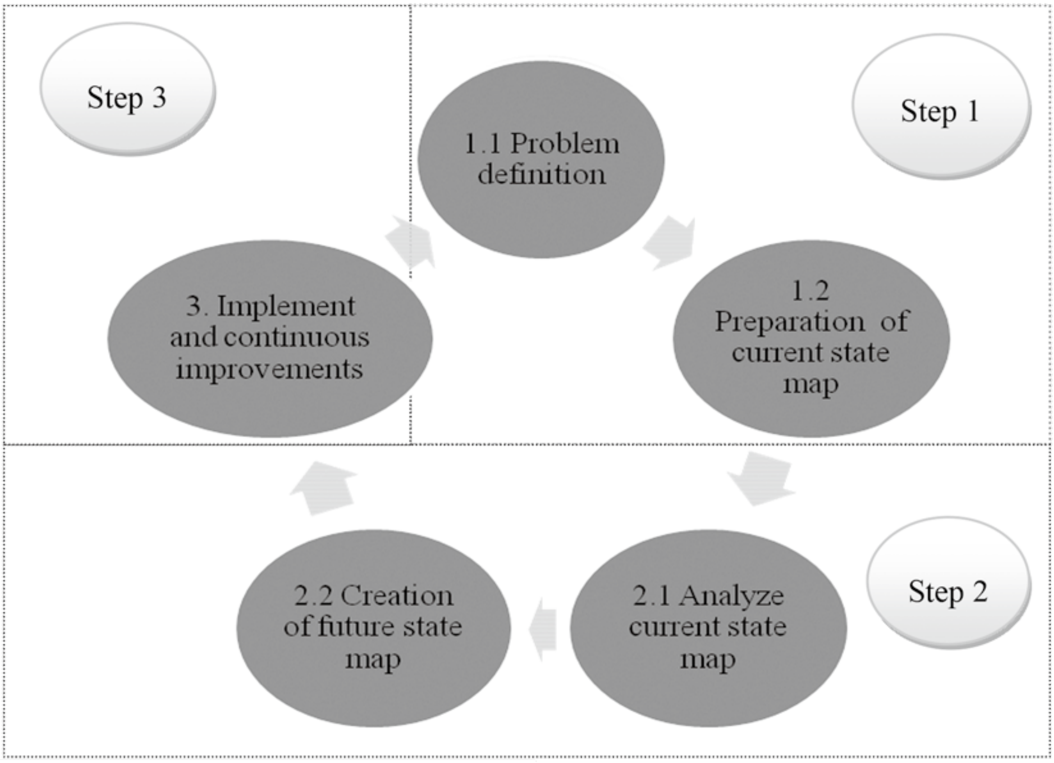


Figure 2. Steps in implementation of VSM

3. Empirical study on a process sector

3.1 Step1.1: Problem definition

The company used in our case study is headquartered in Los Angeles, California, while its production site is a plant in Ohio. The author interviewed members of the production and sales departments to obtain their opinions about sale & operation (S&OP) activities and performed a field study to explore problems in operations and production management.

3.1.1 Requirements from sales department

This company is typically consistent with regard to lead times but is running close to the fill rate of its purchase orders. This enables customers to predict and manage their business requirements when their orders will be fulfilled.

3.1.2 Challenges for Ohio plant

The big challenges regarding lead times are adversely affected by customer buying patterns and the wide range of products that this company produces and sells. These numerous diverse products are available for purchase in any quantity with any machining requirement, but how to balance the production capacity is a challenge for the Ohio plant.

3.2 Step1.2: Preparation of Current State Map

The current VSM, displayed in Figure 3, is based on the fiberglass door production process, which includes the molding and assembly departments. Some finished products are shipped directly to a warehouse whereas other products are sent elsewhere for advanced processed based on customer requirements.

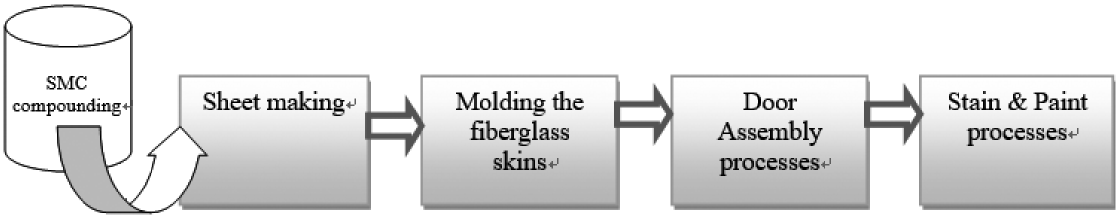


Figure 3. Basic process of fiberglass door product

3.2.1 Information flow

The sales department at the company's headquarters (HQ) draws up a baseline demand forecast (the quantity of products likely to be sold) without taking into account what the company can feasibly produce. The operation department team runs an ERP system which collects information about inventory strategies and the company's capacities. The Ohio plant team then are together to formulate production schedule for implementing the final plan.

3.2.2 Product flow

The manufacturing process can be broken down into several major components. The first of these is (1) SMC compounding and sheet making. The production of SMC consists of two distinct steps: compounding of the resin and additives, and fabrication of the SMC sheet. The second is (2) molding the fiberglass skins. The fiberglass door skin molding process is a kind of SMC compression process. The "SMC Charge" is the material cut from the SMC roll, which has a pre-set length that is calculated based on weight/length conversion. The third component of the process is (3) the door assembly process. A complete fiberglass door is composed of two skins, two stiles, two rails, and one lock block. Finally, there is (4) staining and painting. To provide finished door products to the market, the company also offers a paint and stain finish line for its fiberglass door products.

3.2.3 Time-line

The bottom of the VSM (Figure 4) shows is display the timeline of the flow processes. The total value-adding time is 12.11 minutes (molding process = 2 min. + assembly process = 0.75 min. + door shop process = 4.34 min. + staining and painting process = 5.02 min.). The total lead time, an indicator need be some improved that includes value-adding and non-value-adding time, is 23 days (compounding process leading time = 2 days + Molding leading time = 15 days + Assembly leading time = 2 days + door shop leading time = 2 days + staining and painting leading time = 1 days)

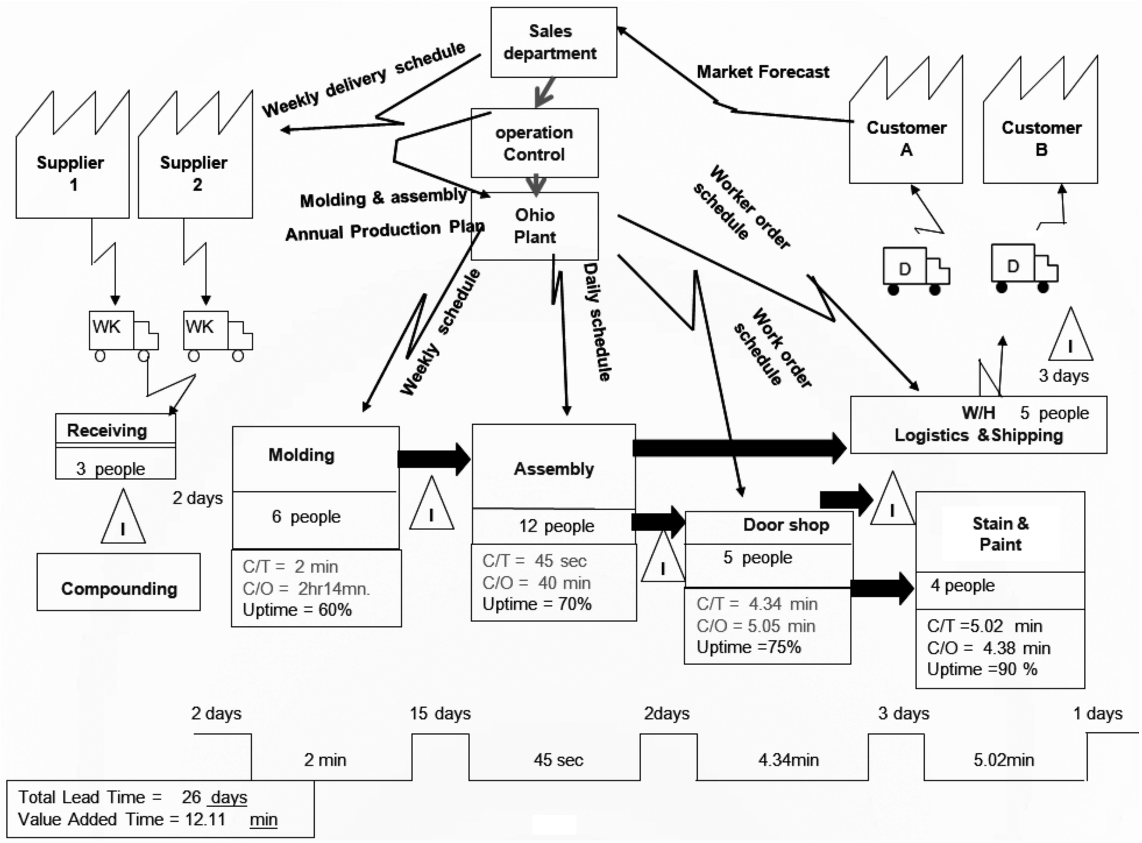


Figure 4. Current VSM

3.3 Step 2.1: Analysis of current state map

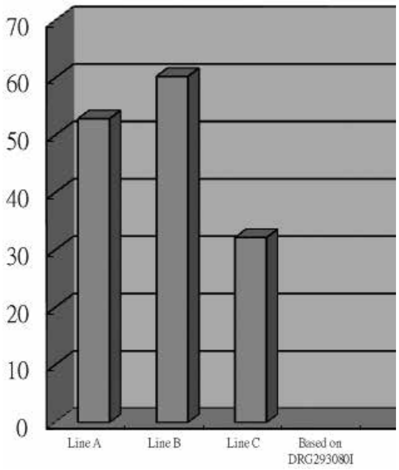
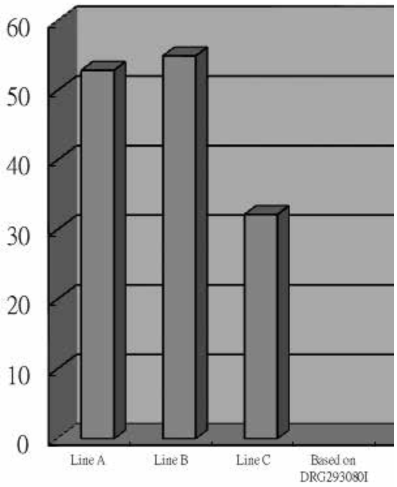
The total number of operators is 32(molding process = 6 operators + assembly operators = 12 operators + door shop operators = 5 operators. + staining and painting operators = 4 operators + logistics and shipping operators = 5 operators), the largest department is the assembly department, which employs 12 people. The major problem to be resolved is the excessive total lead time of 23 days. The bottleneck currently limiting this lead time is in the molding part of the process, which requires 15 days. To address this, we must explore possible improvement methodologies to reduce value-adding and non-value-adding time. The company in this case study balances its molding and assembly production capacity to reduce the work-in-process (WIP) inventory storage. The company also produces its own compounding materials as opposed to outsourcing its purchasing; this enables it to further control raw materials in the storage.

3.4 Step 2.2: Creation of future state map

The future state map was created based on the JIT (Just in Time) pull systems through which customer demand activates production of the service or items. A future state map has two production steps that are based on the production characteristics of the Ohio plant. The production schedules of the door shop and the staining and painting section are based on the work order schedule; these in turn drive the molding and assembly site production requirements. This means that customer demand activates production of the items.

One way to begin improving the current value-adding time is to use line balancing which based on standard time approaches to measure the current balancing efficiency, which in this case are 80.40% (See Table 1). An assembly line is a flow production system in which product units perform workstation operations while work pieces move from one station to the next. The assembly lines, which include lines A, B and C, are identified as improvement targets. In this case, Line B is the source of the bottleneck that needs to be improved to enhance operation efficiency. The recommended improvement methodology is a change from manual operation to sensor-based automated operation, which will reduce operation time and enhance LB efficiency.

Table 1. LB improvement based on product code DRG 239080I

Indicator	Before improvements	After improvements
Standard time (minutes)	Line A 52.9368 Line B 60.32 Line C 32.23	Line A 52.9368 Line B 55 Line C 32.23
LB figure		
LB efficiency	80.4%	84.95%
Performance	6 % (84.95%-80.4%/80.4%)	

3.5 Step 3: Implementation and continuous improvements

In the end, VSM is merely an analysis and improvement tool. If a company wants to implement successful VSM, it needs to integrate other performance roadmaps as well. The present company's improvement teams have implemented the PDCA (Plan-do-check-action) cycle to improve their business performance. The PDCA cycle not only supports the development and implementation of a VSM system but also drives results-based culture change throughout the organization.

4. Conclusions and Management implications

4.1 Conclusions

In conclusion, line balancing tools can be used to formulate an adjusted VSM with improvement strategies. LB techniques help companies reduce the lead times of their process chains to better fit the VSM structure. The experience of a single case study cannot be used to derive a standard VSM structure; rather, each VSM process should be custom built to fit the organization's structure and manufacturing flow.

4.2 Management implications

The combination of value stream mapping with line balancing has major implications for management: industrial engineering (IE) must undergo continuous improvements in connection to the VSM process.

Continuous improvements in IE are basically needed in order to minimize non-value-adding activities; this will improve efficiency and flow in connection to the VSM process. VSM improvements include removing wasteful activities and amplifying the perceived customer value. VSM analysis and the continuous IE improvement approach enable us to identify non-value-adding time, analyze the root causes of non-value-adding time, increase value-adding time by redesigning assembly lines, and finally decrease the total manpower requirement without hampering production efficiency or productivity.

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