Application of Value Stream Mapping for Improvement the Manufacturing Process in Miniature Furniture: The Case Study of MW Crafts Firm

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Abstract

This research has applied Value Stream Mapping (VSM) for waste analysis in Logistics and Supply Chain of MW craft firm's miniature table product in China. Firstly, an in-depth interview has been employed to obtain the data from the staffs of the MW craft firm. Secondly, VSM is applied to draw the current production process. Finally, the analysis of the waste in the manufacturing process has been found. The whole non-value-added time of this miniature table product is 1,072.1 minutes. There are many non-value-added activities. The largest proportion among these non-value-added processes is the glue dry time of the assembling process, which is 44.78%. Since each product must go through more than eight hours of glue dry time. On the other hand, the largest proportion of the total value-added time is the cutting process, which is equal to 57.67%.

Keywords: Lean Production, Value Stream Mapping, Production Process, Miniature Toy

Introduction

According to statistics from the General Administration of Customs of China, China's toy exports in July 2020 amounted to US$3541.7 million, a year-on-year increase of 21.1%. This shows that in recent years, China has a strong comprehensive competitiveness in the field of toy manufacturing. But China's small-scale toy manufacturing enterprises, often encounter is that the company's low production efficiency results in the inability to deliver on time. The MW crafts firm is Chinese firm that is located in Guangdong province, China. This firm produces miniature toys. It includes wood products (miniature furniture), plastic (miniature daily necessities), and other materials. In this article, a production line of the miniature table in the MW firm has been selected as the research object. According to the data of the firm's sales department, the product selected for study is the best-selling product in woodware. This product has the problem of delayed delivery of goods. This firm's on-time delivery rate in 2019 was only 57%. The main reason for delayed delivery is low efficiency in the manufacturing process of the products. In order to understand what is happening on the

manufacturing process, Value stream Mapping (VSM) will be expected to explain the current production process of the products. Moreover, improvement of production process should be made for reducing the waste in the production process. In this article, an effective approach is expected to identify problems and eliminate waste through continuous repair.

Lean Production (LP) has always been a basic tool commonly used by many scholars and experts in improving production processes. Many large manufacturing factories in Asia have been trying to adopt lean production methods to reduce costs by eliminating non-value-added activities. (Rahani & al-Ashraf, 2012) Therefore, when companies need to improve production efficiency, LP is a good choice. Value Stream Mapping (VSM) is one of the key lean tools used to identify the opportunities for various lean techniques. (Rahani & al-Ashraf, 2012) Suhardi, Sahadewo, and Laksono (2015) used VSM in lean production to identify wastes in the production workshop, and then used other LP tools to improve the productivity of the factory. Because the majority of lean production experts choose VSM as a tool to find the wastes, VSM was chosen as the research tool for this article.

The aim of this article is to use the current state VSM method to find wastes in MW firm's manufacturing process. The current state VSM will collect detailed data of the miniature table's manufacturing process, such as cycle time, changeover time, uptime. The remainder of this article is organized as follows. Related works are shown in the section of literature review that consist of Lean Production and Value Stream Mapping. The current value stream mapping of the miniature table will be created in the section of results and discussion. Finally, conclusion will be provided to summarize whole of contents in this article.

Literature Review

The Company Overview

This article is from MW crafts firm, an emerging small craft manufacturer specializing in the production and processing of miniatures. The firm is founded in 2013, located in Guangdong province, China, specializing in the production and sales of miniature toys. It includes wood products (miniature furniture), plastic (miniature daily necessities), and other materials. The products are mainly sold to mainland China and other parts of the world through Alibaba, WISH, amazon, LAZADA, EBAY, and other network channels.

In this article, a production line of the miniature table in the MW firm was selected as the research object in Figure 2. With a size of 153 mm x 70 mm x 60 mm (width x height x depth).

Figure 1 The Miniature Table of MW Crafts firm

The whole production of this mini table involves cutting, tenoning and slotting, polishing, assembling, which needs to be produced in the woodworking workshop. Based on the production of material flow, information flow, and production field research and observation, some unreasonable problems and resources waste phenomenon reduce the production efficiency, such as the overlong operating path for workers caused by unreasonable production line layout. Therefore, it is urgent to study and to analyze the problems in the production department of the company and develop a systematic improvement plan to solve these problems.

Lean Production

The new production management method of lean production was initiated by Toyota in Japan. Based on the theory, many scholars have conducted research on the application of lean production. Xie (2015) has researched lean management of Ningbo Cigarette Factory in terms of eliminating waste, reducing costs, improving processes, etc., and proposed improvements to the problems and deficiencies in practical applications. Zhou (2019) analyzed and optimized the value stream of HB company, arranged again under the guidance of lean production, reduced waste, and improved operational efficiency. Dmitriev and Barkova (2019) studied the application of lean production in the service industry and proposed a series of measures to apply lean to warehousing services, including optimization of warehouse space, improving the reliability of the collection of orders for shipment, reducing the number of warehouse operations and time to perform these operations.

Value Stream Mapping

Value Stream Mapping (VSM) uses lean manufacturing tools and technologies to help companies understand and streamline production processes. (Shuhua, Jianshu, & Wang., 2010) Harpreet Singh, Bahl, Kumar, and Mann (2018) selected a group of small enterprises to study with VSM, and the results showed that if the future state diagram of VSM could be implemented, it would have a significant effect on improving the productivity of these small-medium and micro enterprises. Roh, Kunz, and Wegener (2019) proposed an updated version of VSM -- information stream mapping. It is more suitable for the new method of information flow in production the environment. It analyzes and improves the information stream to make the information flow more structured. Tests were carried out in the workshop of a manufacturer of sanitary products, which successfully increased overall productivity.

Methodology

Data Collection

Based on the aim of the research is to use VSM to improve the manufacturing process, this article mainly needs the data of create VSM. In order to obtain research data, in-depth interviews with the firm's staffs have been employed.

The latest 1 month of production planning and manufacturing site data was collected from MW firm's staff as shown in Table 1-4.

Table 1 Customer demand information

Name	Quantity	Units
Quantity Demand	12	lot/month
Packing Quantity	40	pcs/lot
Frequency of Transportation	4	times/month

Table 2 Supplier information

Name	Quantity	Units
Frequency of purchase	1	week
Date of delivery	2	week

Table 3 Working time of employees

Name	Time	Units
Working days	22	days/month
Shift	2	shifts
Working Time	8	hours/Per shift
Mealtime	40	min/shift
Rest	30	min/shift

Table 4 Information of manufacturing station

Manufacturing Station	Content	Time (min)	Equipment Utilization Rate	The Number of Machines	The Number of Workers
Cutting	Debugging the CNC cutting machine; Put the wood board that has been cut to a fixed size on the CNC cutting machine	10.9	60%	2	1
Tenoning & Slotting	Put the cut parts on the tenoning machine; Manual Slotting by workers	3.1	75%	1	1
Polishing	Manual polishing by workers	1.3	/	/	1
Assemble	Apply glue by workers; Assemble all the parts	3.6	/	/	1

Value Stream Mapping creation

By using the data collected in the previous step, the current state diagram is drawn according to the standard steps of VSM. The drawing steps are as follows: (Zhang, 2013)

Step 1: Describe customer needs;

Step 2: Describe all processes, data boxes and inventory triangles;

Step 3: Describe the material flow of the process;

Step 4: describe the information flow and the driving arrow;

Step 5: Describe production time line and data completion status chart.

Performance analysis

This article verifies whether the implemented lean production improvement activities are suitable for the manufacturing of the MW firm's miniature table by comparing the process time data before and after the improvement. The performance data that needs to be calculated is Takt Time, Line Balance Rate (LBR), Value-Added Ratio (VAR). The formulas (1)-(3) are as follows: ("Takt Time: Formula & Calculation," 2016) (MarkRHamel, 2013) (Arora, 2015)

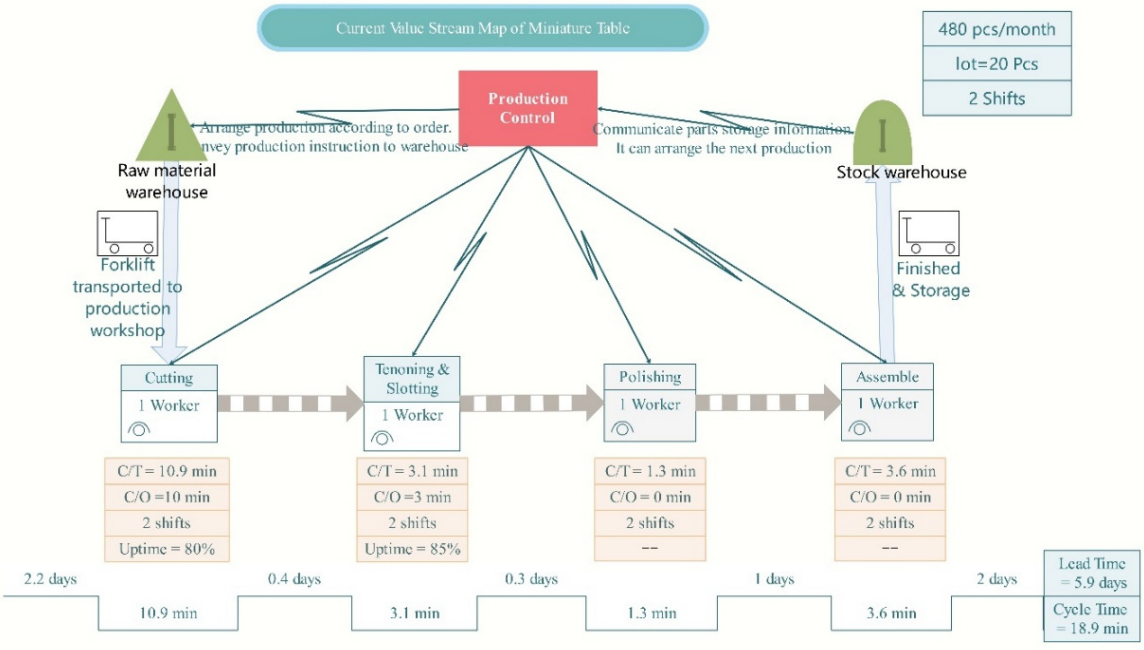
$$Takt\ Time = \frac{Available\ work\ time}{units\ of\ production\ demanded} \quad (1)$$

$$LBR = \frac{\sum Task\ Time}{Actual\ no\ of\ workstations \times Cycle\ Time} \times 100\% \quad (2)$$

$$VAR = \frac{Value\text{-}added\ time}{The\ total\ cycle\ time} \times 100\% \quad (3)$$

Results and Discussion

Value Stream Mapping



Picture1 : Current state value stream mappingof the miniature table

The current state value stream mapping of the miniature table is shown in Figure 1. It can be seen from the figure that the monthly demand for this miniature table is 480 pcs. Workers in this workshop work 2 shifts every workday. When production control issues the production order, the warehouse where the raw materials are stored will send the wooden boards to this production workshop through a forklift. This begins the production of the miniature furniture. Each production process has one staff to operate. The cycle time in the whole process is 18.9 min, while lead time is 5.9 days. The changeover time in cutting step and tenoning & slotting step are 10 min and 3 min respectively. And uptime in these two steps are 80% and 85%.

Performance analysis

Takt time refers to the time required to produce a finished product within the effective working time in order to meet the needs of customers. If takt time is longer than the whole process time, it will result in production waste. If the takt time is less than the process time, the customer's demand cannot be satisfied. It is known that the daily demand of customers is 22 pcs, with an average demand of 11 pcs per shift. Then according to the formula (1) (2), the takt time of this manufacturing process is 35.45 min, while the LBR is 43.35%.

1. Low value-added ratio

First, the Value-Added Ratio (VAR) is calculated based on formula (3). In this case, VAR is equal to 1.73%. The whole non-value-added time of this miniature table product is 1,072.1 min. There are a lot of non-value-added activities that waste time between processes. These consist of the loading and unloading time of each process and the time of adjusting the machine, the transportation time between each process, and the glue dry time of the assemble process. However, the most of each process is waiting time. In addition, these waiting times, the glue dry time of the assemble process accounts for the largest proportion, which is 44.78%. This is because each product has to go through more than eight hours of glue dry time. The cutting process takes up the largest proportion in processing time, accounting for 57.67% of the total value-added time.

2. Waste of defective products

Any non-value-added products and processes in lean production are waste. Waste of defective products is mainly caused by irregular operations. The improper operation of any process will lead to defective products and waste products. These substandard products will never be able to meet further production needs, and re-production that will disrupt the production plan. This not only delays the duration, but also increases costs. At the production site of the miniature table, there was such a problem: When sawing the board, due to the

pursuit of fast speed, at the last moment, the saw blade tends to take a corner of the board along with the wooden board. This leads to incomplete parts and needs re-cutting. And this not only consumes more labor, but also requires repeated time consuming.

Based on the lean production concept, this article suggests to improve from two aspects: normative action, and merging of processes. These will minimize the number of works in the process to shorten the cycle time for improving productivity levels.

Normative action is to reduce waste from the details. In order to reduce the damage caused by the saw blade when cutting wood, the workers can improve on the sawing action and standardize the sawing action.

About merging of the processes, through the previous calculation of LBR, the first process in the miniature table manufacturing process takes much longer than the last three processes. This has caused an imbalance in LBR. Therefore, the rough grinding part of Cutting can be handed over to the staff of Tenoning & Slotting. This means that the rough grinding part of the cutting process is split into the next process. Among them, the rough grinding process took 2.7 min. In addition, it also needs to combine the two processes, polishing and assemble into one. The new LBR is 76.83%. Compared with the original LBR, the new LBR is 1.77 times higher than the previous 43.35%.

Conclusion

In this article, the waste of micro-furniture in the manufacturing process has been found based on the analysis of VSM. The miniature table of MW craft firm is selected to analyze the current VSM. The non-value-added time waiting for this product in the manufacturing process is too long. Therefore, the improvement plan for the MW craft firm's miniature table has been conducted depend on the results of analysis VSM. The optimization of the layout can shorten the transportation time in the workshop, the standardized operation can reduce the waste of defective products, and the combination of processes can make the production line more balanced. With the business competition has become more significant recently because there is a growing selection of products for customers. However, this research still needs to continue for completing the future status VSM. Thus, the future status VSM and application of Lean Production will be made in the next step of this research in order to design a more perfect improvement plan for the production line of the product.

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