

Optimization of Production System Based on Lean Thinking

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Abstract

Purpose: The purpose of this paper is to find hidden waste and non-value-added activities during the whole process of M company, and then optimize production processes, shorten the production cycle, improve production efficiency, and ultimately achieve just-in-time production mode which response to customer demand rapidly.

Design/methodology/approach: In order to identify and eliminate such kind of non-value added waste, the authors draw a current value stream map and a future value stream map of the SM6 series products in one electric-equipment-manufacturing enterprise. By analyzing the value stream mapping of the whole process of SM6 series products, the authors find hidden wastes and non-value-added activities, and then the authors use industrial engineering "ECRS principle" and "5W2H principle" to adjust and make new production plan model, including the analysis and evaluation of the production process, production line layout and other aspects, then, the authors optimize the working process and set up a new production process.

Findings and Originality/value: By using Kanban and other lean concepts and techniques, the authors finally achieved pull mode of production (just-in-time production), and shorten production cycle, reduce inventory of semi-finished product and end product, eliminate excess production, and save labor cost, realize the "5S" management mode effectively.

Practical implications: The successful application of pull mode of production in the SM6 series products has set an example in implementing lean activities for the company's other product series and most other manufacturing enterprise,

Social implications: it also has a significance guiding for value stream mapping and lean thinking to be practiced in Chinese manufacturing enterprise and other industries.

Keywords: *Value stream mapping, Kanban management, Lean thinking.*

1. Introduction

With the development of science and technology, people's living standard is improved continually. The demand for industrial products also tends to be more and more diversified and personalized. How to solve the contradiction between low volume, many types and lower costs is a challenge to production managers. Lean production mode is the production of Japan's auto industry under the constraint of "low volume, many types" market environment (Alex Teoh, 2006). Thinking of customers, reducing waste continuously, ultimately achieving offer the best quality products at the lowest cost and responding to the changing market landscape quickly is the core contents of lean mode. Lean production as an advanced production method has important realistic meaning to improve the level of manufacture and management and strengthen the competitive of Chinese enterprise.

Based on the theory of lean thinking, using the value stream map and related technologies and methods of modern industrial engineering, through the combination of qualitative and quantitative system analysis method, this paper find hidden waste and non-value-added activities during the whole process, such as

excessive production, transportation, wait and so on, and then optimize production processes, shorten the production cycle, improve production efficiency, and ultimately achieve just-in-time production mode which response to customer demand rapidly.

2. Literature Review

2.1. Lean Production Mode

Lean thinking originated in the 1980s, it is an American scholar of Japan's Toyota Motor Manufacturing of refined manner, summed up and concluded (Taiichi Ohno, 2006). Lean production mode is an enterprise operation way through eliminate the non-value activities, to achieve use minimal resources to meet customer diversification and personalized needs, also get the biggest profit. It can be used at all aspects of enterprise operation such as suppliers, product development and customer relationship. The main tools are just-in-time production, kanban management and value stream map analysis technology.

Building a production system that pursuit of a zero inventory or keep inventory at the minimize level is the core of JIT production mode; it is an obvious feature of the lean production mode. Just-In-Time requires that only when it need, it will provide exact quantity. It will realize the aim of maximal profit by getting rid of waste in pull mode. Kanban management is another important tools of production management in lean production mode , through kanban transfer operation instruction among working procedures, factories and collaboration enterprises, every working procedure do the works according to the kanban information to guarantee produce necessary productions at necessary time and achieve the goal of just-in-time production.

2.2. Value Stream Map Analysis Technology

Value stream is the sum of all activities that needed by manufacture products, which includes the value-added and non-value added activities. According to statistics, the study found value added activities time only occupies 5% of all production activities in the manufacturing company, but non-value activities occupies 95% (Xiangjun Ji, Qi Chen & Yubo Ji, 2005). Therefore, it' s important to identify the non-value added activities in the value stream. The enterprise could eliminate all kinds of hidden waste, reduce costs by continuously improve, at the same time, shorten the production cycle of products, and realize just-in-time production, to achieve customer satisfaction (Fawaz A Abdulmalek & Jayant Rajgopal, 2007).

Value stream map is a tool for drawing and designing the material flow and information flow which adopt product family as the unit, use graphics to draw all kinds of activities include customers and suppliers, and track production paths. Then we analyze the necessity of each activity in the value stream map from the perspective and view of the customer, draw the ideal future value stream map and make a new implement able plan (Wenhua Jiang, 2006). The analysis of value stream map can help to monitor and understand the material and information flows, identify the hidden non-value activities, and then determine which part need to be improved, to achieve lower production costs and timely response to market demand (Jun Li & Mingqiang Xu, 2008).

To sum up, the core of lean thinking is eliminate all kinds of waste to improve the production efficiency and rapidly response capability by using the tools of value stream map analysis technology, kanban management and just-in-time production

and so on, enterprise find and eliminate hidden non-value activities during the whole process.

3. Present Situation Analysis of M enterprise

3.1. Present Production Situation Analysis of M enterprise

M company is an advanced electric equipment manufacturing enterprise. Producing the required production to customers in the shortest time to response the market demand quickly is one of the production features of this company. Relying on its own core technology, M company own a seat in the Chinese market; but at the same time, it also faces many problems. First of all, from the external environment, the cost of raw materials is rising, but intensifying competition made the company have to keep or even cut down the price and moreover offer more kinds of production. Second, from the enterprise internal, with the expansion of the production operation and the increase of product variety and quantity, Company is facing a lot of problems, such as raw material purchase cycle and delivery cycle is too long, stocks rise sharply, and a large number of waste in the manufacturing process , labor force and equipments are used inefficiently.

By analyses the existing problem of M company, through the introduction of lean production mode, on the basis of the material flow and information flow data collection and drawing, this paper use the value stream map analyses the production process in detail at the aspect of material flow and information flow, find the hidden waste and ways to eliminate the waste. By mapping "ideal state figure" provide goals for continuous improvement, the company could reduce the delivery time greatly, create a new and more flexible production processes, response to changing external environment timely and rapidly, and keep advantage in the competition.

SM6 series products is the most representative products of this company, it also conform to the characteristics of "many varieties, small batch". Therefore, we choose SM6 series products as the research object.

3.2. Production Material Flow and Information Flow of SM6 Series Products

3.2.1. Production Material Flow of SM6 Series Products

Load switch SM6 production line is divided into four parts as switch core line; install mechanism line, speed test line, and packaging line in M company's actual situation. Switch core line is used to produce switch cores of SM6 production, After we select mechanism according to the order, the mechanism is installed on the switch core; then we use speed line to test whether the production qualified. If the test is passed, we hang the productions on the packing line and push them to the sealing machine, it can sealing and packaging automatically. After the productions be packed, they will be send to the customers in the next level. As shown in figure 1:

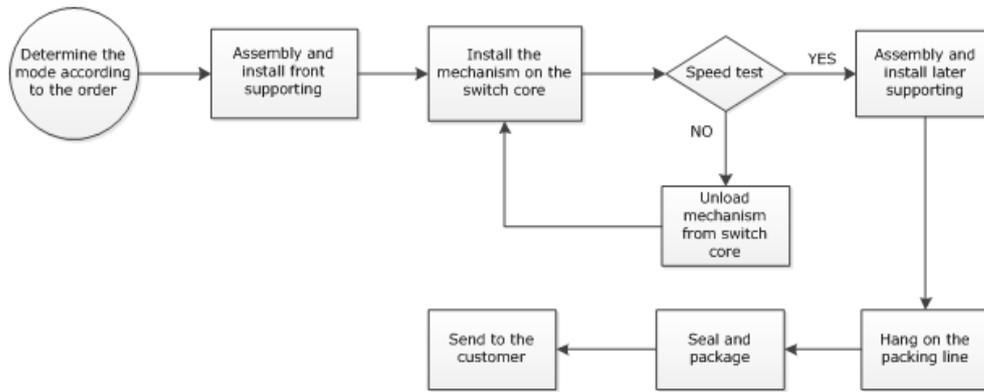


Figure 1. Linear Flow Chart of SM6 Production

3.2.2. Production Information Flow of SM6 Series Products

Production planning department of M company subdivide the production plan and deliver it to the switch core line, install mechanism line, speed test line, and packaging line respectively after get the load switch SM6 forecast orders every month from sales department, then the program staff of production line produce the production plan of each shift and the kanban information of the product line.

3.3. Value Stream Map Analysis of SM6 Series Products

According to the situation of the company, using the value stream map, we draw the current value stream map of SM6 series load switch firstly, analyze all the works and elements in the production process, identify waste and find ways to eliminate. Then we map the future value stream which provide goals for the continuously improvement, and the purposes of reducing costs, improving product and service quality and timely delivery will be achieved ultimately.

3.3.1. Draw the Current Value Stream Map of SM6 Series Products

Before drawing the value stream map, we go deep into the production workshop, collect and sort the basic data in the operation process. According to the production plan and raw material property list, we select the desired data and record them detailed. This paper selected the data in the production process are: total production time per shift; available production time at each day; the delivery number of every month or day; the time for work issues; the production cycle time(C/T); the number WIP; time for the mold(C/O); shifts at every day, the deliver and other non-value time between process, processing time (P/T), the normal operation of the machine efficiency (Uptime) *etc.* All the data will be used in the current and future value stream map.

The process of drawing the current value stream is as follows: we draw icons of customers, suppliers and production control department and mark the customer's requirements above the customer icon, then draw the delivering and receiving information, map the operation process and information flow, and, finally, mark inventory and material flows. The current value stream map is shown as Figure 2:

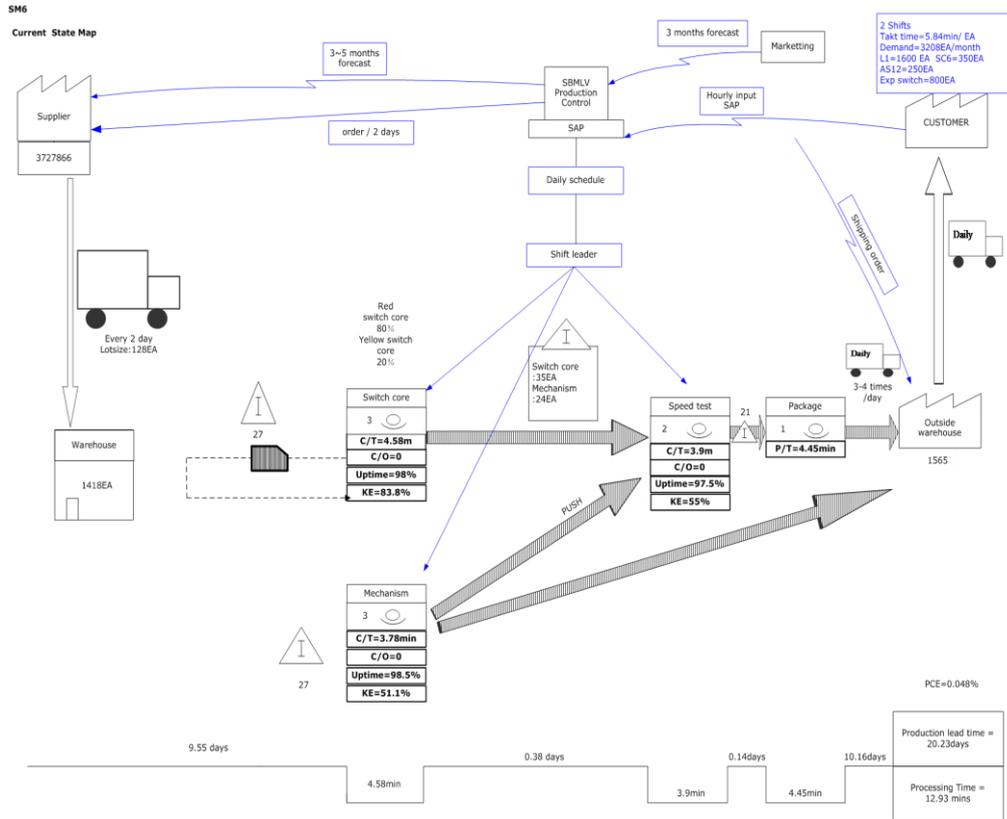


Figure 2. The Current Value Stream Map

After drawing the current value stream map, we analyze the data on map, as following:

We calculate the value time, non-value time of load switch SM6 products in the whole process from entering the production process to finished production into the warehouse.

Add-value time (AT) is the actual work time.

$$AT = \sum CT_i \quad (1)$$

non-value-added time(UT) is the production lead time.

$$UT = \sum \overline{CT}_i \quad (2)$$

Production cycle efficiency(PCE) shows the percentage of AT in the total cycle time(AT+UT),(working hours is 22h every day).

$$PCE = \frac{AT}{AT + UT} \quad (3)$$

Based on the current value stream map above, there are mainly four problems: 1. in the whole production cycle, the production cycle efficiency is only 0.0484%. Time consumed in non-value added activities such as waiting and ineffective moving; 2. in the aspect of production process, process arrangement is not reasonable, this lead to operation process tedious, move too much, wait for too long time; 3. in the aspect of suppliers, materials delivery cycle is very long which lead to the inventory of raw material is too high; 4. Using push production mode in the mechanism line results in highly inventory of semi-finished product and end product. These problems will be improved in the future value stream map.

3.3.2. Draw the Future Value Stream Map of SM6 Series Products

Mapping the value stream map aims to highlight the source of waste. We can improve the situation by mapping the future value stream map which can be a can be realized in the short-term. After drawing the current value stream map, through data analysis and process analysis, we find the hidden waste in the whole production process and then create out a new future value stream map, design a more efficient value stream. According to the situation of the value stream map, the waste in the whole process as shown in Figure 3:

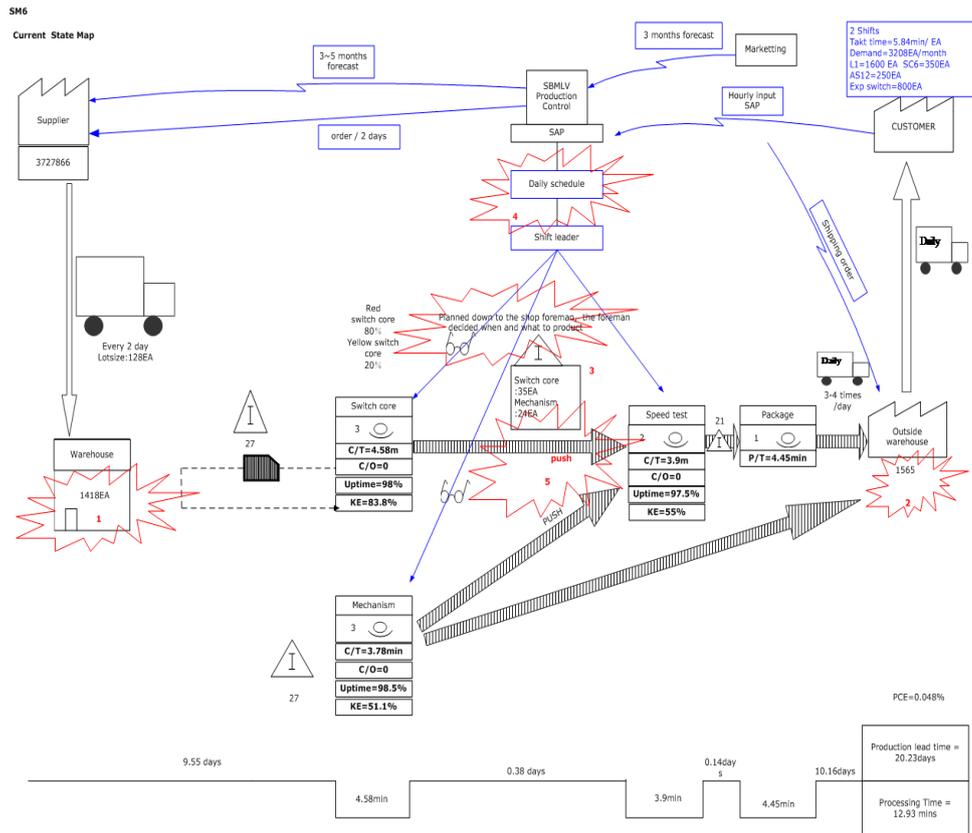


Figure 3. The Improvement Points of the Current Value Stream Map

According to the above analysis, we found the source of waste that exists in the value stream. We draw a future value stream map which can be realized in the short term future on the basis of customer demand, material and information flows, as well as improvements to support, as shown in Figure 4:

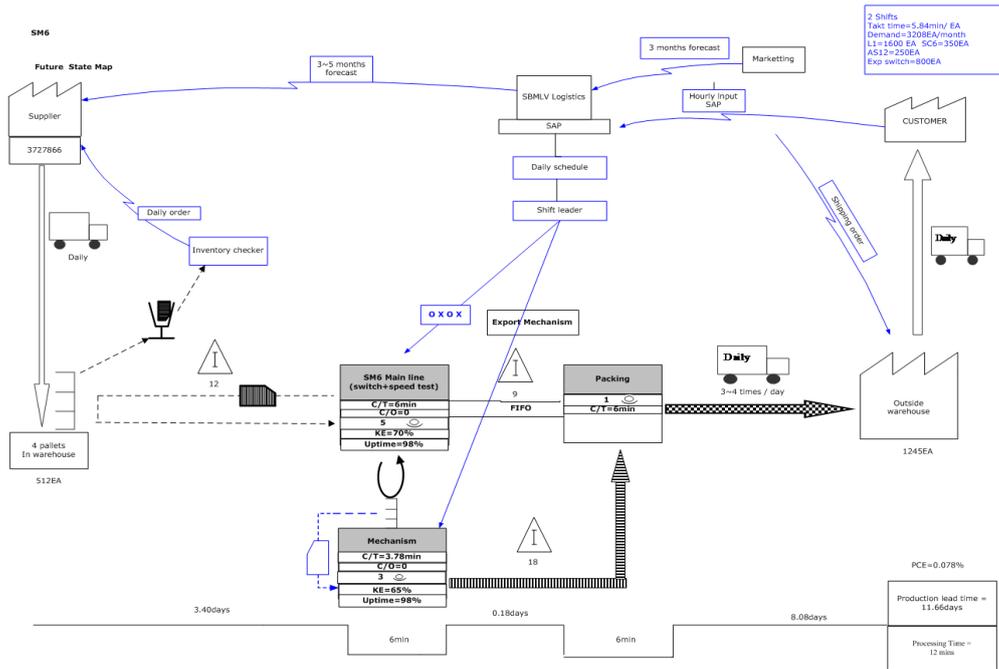


Figure 4. The Future Value Stream Map

By comparing the current value stream map and future value stream map, we can realize that wait is the most serious waste in the current value stream map. The exist of wait partly due to the process transfer cannot be output to the next and partly because the output of first few steps can't be used as the production capacity in the next step.

To realize the future value stream, we should establish a continuous "flow" production chain and each individual active process of it is connected to the front process through continuous or "pull" system. And each active process produces product when the customers need as far as possible. That is, through the application of lean manufacturing concepts and methods, we make the various production material flow and information flow in the produce process flow continuously as possible, and solve the problems in the production process.

4. Optimize Production Process and the Effect

Through drawing the value stream map, we found the hidden waste and non-value activities, lean production tools will be used to achieve future value stream map, and eliminate waste in all activities.

4.1. Realize Production Synchronization and Line Balancing

Realize production synchronization and line balancing is a basic principle of JIT production. Combined with enterprise production process and the current production status, we found that the switch core and mechanism of SM6 products production are independent of each other in the production processes, the operator of the two processes can produce at the same time when they received orders and make sure two kinds goals, we must adjust and redesign the layout of the location of the production process and production site, to keep production material flow smoothly and reduce the overstock of WIP before the working procedure.

Based on the program analysis in industrial engineering analysis of the four major "ECRS" principles and "5W2H" questioning technology, we question and analyze

the current work one by one from the operation, moving, inspection, storage and waiting five aspects:

Eliminate: Its means to consider the operation process and determine whether it's possible to cancel, If the answers of "what finished", "if necessary" and "why" is not satisfying, we should cancel this operation process. SM6 product line have no redundant operations, and also have no process should be canceled.

Combine: If there no process could be canceled, we should consider to combine two or more than two process in order to save time and energy. In accordance with this principle, the speed test and the produce of switch core can be combined to one production line, this could reduce the total processing time and moving distance of the switch core.

Rearrange: After use the principles of eliminate and combine, in order to achieve the purpose of improving, we should change the working procedure and process according to the problem of "who, when, where". From this principle, we rearrange install mechanism after the speed test process and install mechanism on the qualified switch core directly ,this eliminate the unloaded operation if the speed test can't be past and save the labor resources.

Simplify: We should analysis and study the process more deeply to improve the work after the work of eliminate, combine and rearrange, simplify the current program as far as possible, to shorten the operation time, save labor, costs and improve work efficiency.

Figure 2 and 4 shows: after combine and rearrangement, the production cycle of switch core produce and speed test is 6 min. New production cycle of packaging process increased from the original 4.45 min to 6 min. The balance of the production line reduces the inventory of semi-finished product and makes the flow of value flow continuously in the process of production.

4.2. The Implementation of Kanban Management

Kanban management is an important means in lean production method of production and management; it is a management tool about production, transportation, and material flow. Through the figure 3: we found raw material inventory is too high and the stock of WIP is serious. On the issue of high inventory of raw material, kanban management can be used between suppliers and enterprises warehouse. According to the information from kanban of raw materials inventory, supplier offer raw materials at the right amount and types, the inventory of raw materials be reduced effectively. In the production process, we can arrange a kanban at the place where is used to prepare for raw materials of switch core. When the raw material will be used up, kanban will sent the demand information to the material flow department and the warehouse; warehouse will sent raw materials to production site according to the information from kanban. Works at mechanism line produce the mechanism at the right quantity and types according to the requirement of the kanban which set in the Mechanism production line. After the works are finished, worker hang up the kanban, the install machine operators will receive corresponding types of mechanisms according to the kanban. In this way, each production process is carried out in accordance with the kanban information to ensure produce necessary production at the needed time. This way could reduce the stock of WIP and finished production and also improve the level of production management. The implementation of kanban management reduces waste and non-value added activities effectively, shorten product life cycle, improve the production efficiency, and ultimately achieve the goal of just-in-time production.

4.3. Improve Material Flow Path

After the application of kanban management, the production process of SM6 products was optimized. At the same time, the production material flow path also needs to be arranged.

The four lines (switch core line, install mechanism line, speed test line, and packaging line) of SM6 products are separate, mechanism line is a u-shaped line, when the produce of mechanism and switch core are completed, the mechanism and switch core will be sent into the speed test process, and finally into the packaging process.

At first, according to the principle of minimal handling material flow path of products, the production materials handling line should avoid the cross and circuitous as much as possible, so that the production material be handled and transported in the shortest path and the transport time and costs tend to minimum. Next, the distance between the operations and processes should be arranged reasonable. Its means we should arrange the process and layout of the operation department which are related closely in the same area by the nearby principle. Sometimes, we can also combine multiple processes or operations according to the actual situation, and then design the production line layout design.

According to the actual situation of M Company, because of machine core volume is larger than mechanism, the mechanism moves more convenient, on the minimum distance principle, we arrange the switch core produce process, speed test process and packing process into a production line, mechanism produce process is a u-shaped line alone. When the production is finished, the mechanism will be send to the speed test process directly. This avoids the non-value movement of the mechanism and the switch core, speed test, installation and packaging can be handled in a production line directly.

4.4. Effect of Production Process Optimization

Hidden waste in the process of production, play an important role in the long production cycle in the manufacture enterprise. Using the value stream map analysis technology, we present the basic date about material flow and information flow diagrams at the current situation on the value stream map. By analyze material flow and information flow transmission path and method, we identify waste and find ways to eliminate waste, The implementation of kanban management, the synchronization of production, and the improvement of production material flow path, promote the use of "pull" mode in the enterprise. These also have significantly effect in the aspect shorten production cycle, control the inventory of raw material and finished product.

4.4.1. The Reduce of WIP and Finished Product

The number of WIP waiting to enter the next process is controlled effectively, the table shows the data before and after the improvement, the number of mechanism and the finished products was reduced obvi-ously after the improvement, as shown in Table 1:

Table 1. WIP and Finished Products Statistical Table

Date and time		The number of mechanism (ge)	The number of finished product (ge)
6/17	9:30	22	9
	16:30	20	3
6/21	9:30	16	8
	16:30	8	5
6/22	9:30	2	6
	16:30		

4.4.2. Shorten Product Life Cycle

By comparing the actual data which is measured from the new production process with the date from the future value map which is designed at before, the production cycle time of load switch SM6 product from the warehouse of raw materials to produce shipping department reduced from 20.23 days to 11.6 days, its improved 42.3%. PCE is 0.0484% before improvement, and now it is 0.0779%, increased by 37.87%. SM6 production line achieves the goals to reduce the non-value added activities and shorten the production cycle, which is consisted with the desired state.

4.4.3. Realized the Transfer from Multipoint Push Production to Single Point of Pull Production

Before the improvement, the produce of switch core and mechanism were separated, there has been no contact between two processes. There are a large number of mechanisms and switch cores waiting for the speed test in the waiting area before the test process. Through the use of kanban management tool in the production lines, the production plan be delivered directly by the production department, production material flow department supply the raw materials according to the production plan. The enterprise eventually achieved fully “pull production mode” from supplier to the products sent to the customer hands. At the same time, the enterprise also shortened the production cycle, reached the purpose of just-in-time production. Raw materials, products inventory and production costs were reduced. Single point of pull production model as shown in Figure 5:

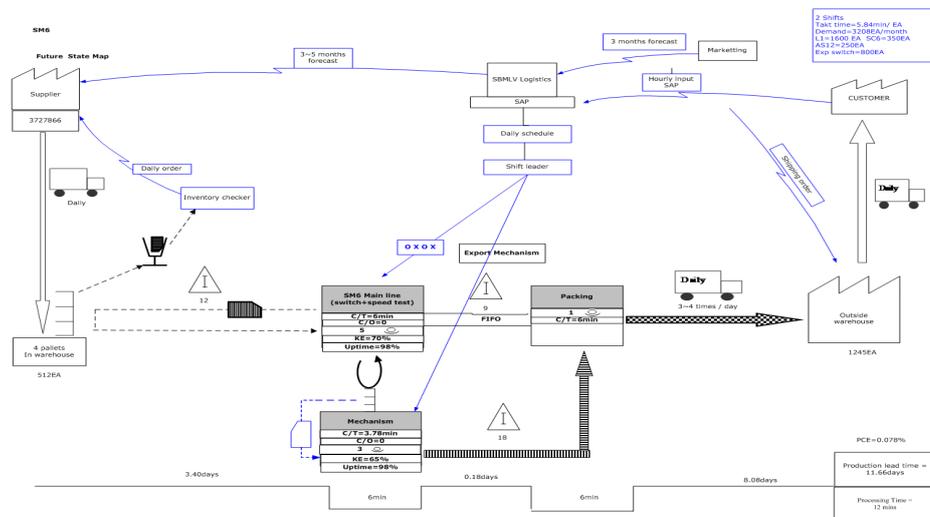


Figure 5. Single Point of Pull Production Model Figure

4.4.4. Realized the Optimization of the Production Process and Workshop Layout

Due to the combine of switch core line and speed test line, and the synchronization of the production of switch core and mechanism, the warehouse which is used to store the mechanism that wait for test are canceled, the material flow that sent finished switch core and mechanism to speed test process is reduced and the production material flow process also be simplified. The available area is greatly increased by transformation the production process and widens the line space. The factory layout is more orderly. New production workshop layout figure as shown in Figure 6:

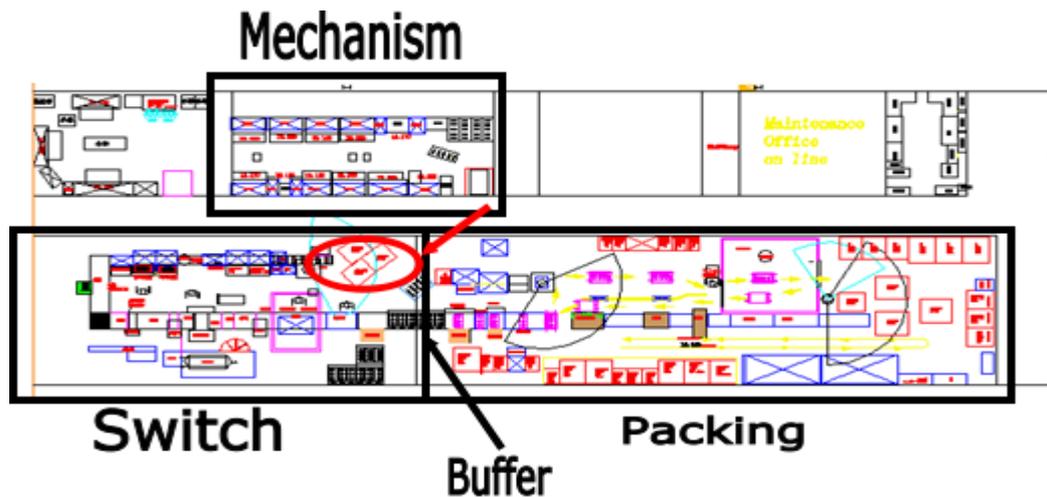


Figure 6. Production Line Layout Figure

5. Conclusion

On the basis of lean manufacturing principles and relevant theories, this paper analyze the activities deeply in manufacturing enterprise production and business operation by using the value stream map analysis methods and just-in-time production methods. Combined with industrial engineering technology, This paper research the production process of load switch SM6 series products carefully to realize just-in-time production methods by focusing on all links of load switch SM6 series products manufacturing enterprises including suppliers and customers, and conclude a set of practical and feasible improvement schemes which are implemented successfully. After drawing the present and future value stream map of SM6 series products, this paper analyze the production lines problems and find the hidden waste in the business operation activities, and put forward the improvement scheme and arrange the production material flow path reasonably. Those measures reduce the non-value added waste, such as excessive production, production interruption, inventory, transportation un-timely, achieve synchronization of production and a steady flow of value stream, shorten the production cycle time and response to customer's requirement timely. At the same time it improve the production efficiency of the enterprise.

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