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Research of Lean Improvement on Oil Pump Production Line in Company D by VSM

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Abstract

Applying the analysis method of VSM, we take the oil pump production line of Company D as the object of study and conduct a detailed analysis of the whole production process to find out the waste generated in the production process, including the problems in transportation, work practices, and production line balance. Using the improvement methods of lean manufacturing and industrial engineering, we proposed improvement plans for value-added time, process flow, and production line balance, and optimized production methods and production layout. After implementing the optimization plan, waste in the production process was effectively reduced, production efficiency was greatly improved, and the overall efficiency of the product line was significantly increased.

Keywords: *VSM; Production line balancing; Time to add value; Lean Manufacturing*

1. Introduction

Value Stream Mapping (VSM) uses lean manufacturing tools and techniques to help companies understand and streamline their production processes with the goal of identifying and reducing waste in the production process.VSM identifies value-added and non-value-added activities in the value stream by analyzing the information and material flows in the production process and then mapping out the value stream. Non-value-added activities are the main target of value stream improvement, and more non-value-added activities lead to a lower value-added ratio, i.e. lower productivity. Identify non-value-added parts of the production site to provide a lean direction for improvement. Then, according to the needs of the actual situation, we use lean tools and industrial engineering techniques to make the production site as continuous as possible, thus increasing productivity, reducing production costs, and being able to respond quickly to customer needs.

In this paper, we take the oil pump production line of Company D as an example, and collect the information flow and material flow data of the product in the production process, and obtain the relevant data from suppliers and customers, so as to draw the current value flow diagram; then use Lean tools and IE techniques to optimize and analyze the problems existing in the current value flow diagram, and design the future value flow diagram; finally, we formulate improvement measures and anticipate the improvement effect. The process optimization framework is shown in Figure 1.

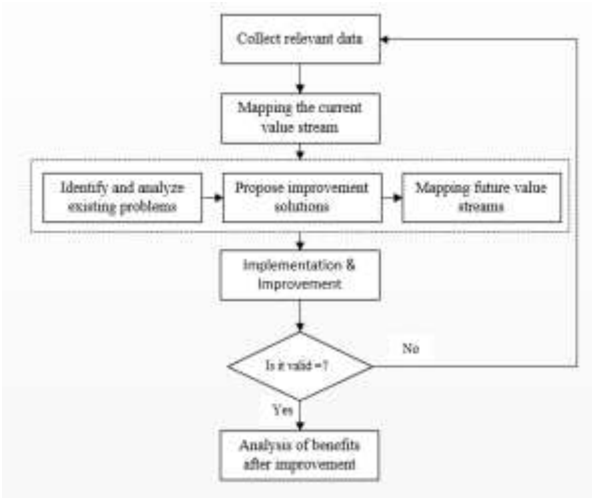

Figure 1 Process Optimization Framework

2. Analysis of the current value stream map

Company D is a company that manufactures automotive parts and components. The company's business scope covers areas related to gasoline systems, diesel systems, and automotive chassis systems. As one of the main products of the company,

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the production process of the oil pump is relatively simple and has a large and stable order in the world, there are many wastes and deficiencies in the production line of this product, therefore, it is chosen as the object of this paper.

2.1 Mapping current value streams

The oil pump manufacturing process includes cleaning process, assembly process, and packaging process. The whole production process has a total of 8 stations and requires 9 employees, of which station T2 is operated by two employees, O1 and O2, and the rest of the stations are operated by one person. The process road map of the oil pump is shown in Figure 2.

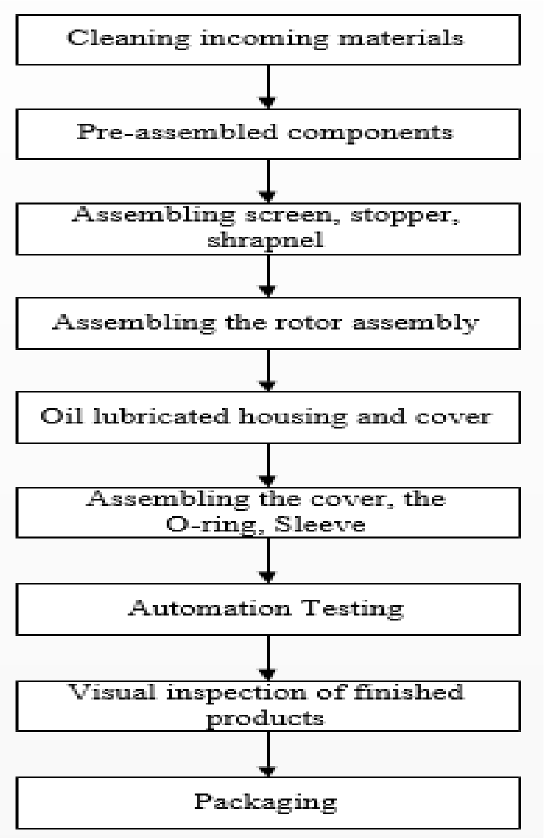

Figure 2 Oil pump process road map

Collect information about the entire process of the product from the raw material supplier to the final customer, such as the time of each process, material flow, information flow, and standard time in the assembly line area, and draw the current value stream map. The standard time (CT), machine working time (PT), number of operators (Q), work allocation, and workstation layout for each workstation are shown in Figure 3.

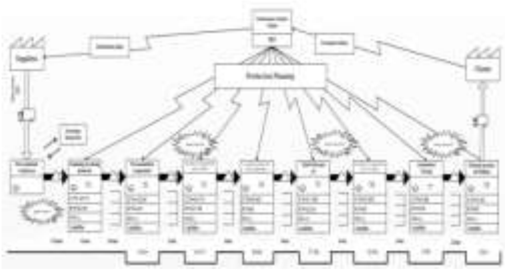

Figure 3 Oil pump status value stream diagram

2.2. Analysis of the current situation based on VSM and line balancing

Based on the visual and detailed data provided by the current value stream map and combined with the current production situation, we applied the theory related to lean production to analyze the value stream value-added situation and production line balance.

2.1.1. Value-added value streams

Looking at the current value stream diagram, we can see that the value-added processes are assembly and packaging, while the non-value-added processes are transportation, handling, and cleaning.

Value-added time:

$$AT = \sum_{i=1}^{k} T_i = 15.81 + ... + 35.8 = 201.74s = \frac{201.74s}{21*3600s} = 0.0027d$$

Non-value-added time:

$$UT = \sum_{i=1}^{k} \overline{T_i} = \frac{150+124\ min}{21*60\ min} = 0.2175d$$

2.1.2. Manufacturing cycle:

$$MPT = AT + UT = 0.0027d + 0.2175d = 0.2202d$$

Value-added ratio:

$$R = \frac{AT}{MPT}*100\% = \frac{0.0027d}{0.2202d}*100\% = 1.2262\%$$

Production line balance

Line balancing is an industrial engineering approach to improve production systems, find bottleneck processes, improve them, and optimize production processes, and is an important goal of lean manufacturing. The balance rate of this product line is(n denotes the number of stations, CT_i denotes the station beat):

$$L = \frac{\sum_{i=1}^{n} CT_i}{Max(CT_i)*n}*100\% = \frac{15.81+...+35.8}{45.37*8}*100\% = 55.6\%$$

Labor cost is also an important part of the enterprise cost, the utilization rate of the front-line operation staff of this production line(Q_i indicates the operating workload of workstation i):

$$OP = \frac{\sum_{i=1}^{n} CT_i*Q_i}{Max(CT_i)*\sum_{i=1}^{n} Q_i}*100\% = \frac{26.7*1+...+35.8*1}{45.37*9}*100\% = 60.5\%$$

Through the above analysis, the main problems of the production line were found to be: long production cycle, low value-added ratio, many wastes; unbalanced production line tempo, low line balance rate, and low personnel utilization.

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3. Optimization and improvement of the current value stream map

To address the problems of the oil pump production line, we applied knowledge related to lean manufacturing to optimize both the non-value-added content and line balance.

3.1. Non-value-added content optimization

3.1.1. Optimization of individual station operations based on MTM

The full name of MTM is Methods-Time-Measurement, which means that the time to complete a job depends on the applied method. It is an important improvement tool in lean manufacturing, which not only allows to obtain objective and accurate standard time but also provides a detailed description of the specific operation method of each workstation, thus optimizing each action.

Based on the MTM operation description and MTM optimization principles, the following optimization is performed: 1. Remove non-value-added actions. 2 . Improve the layout of the site, place tools and materials within the optimal reach, thus shortening the distance and reducing the action time. 3. Design corresponding devices to reduce the input of visual and mental control during the action process, thus reducing the degree of control of the action elements and reducing the time consumed. 4. Simultaneous completion of multiple actions, mainly including body movements and hand movements, for example, in the process of walking around to pick up materials; in the delivery of materials to complete the visual inspection of materials.

Before MTM optimization, video is recorded for all workstations, then the workstations are divided into doing small units, then each action within the operation unit is divided into specific action elements, and the influencing factors of the action elements are determined, such as distance, time, quantity, etc. Based on the standard time value table, the standard time of the workstation and the detailed description of the operation are accumulated, so as to find the non-value-added time within the action and to optimize it. Due to the limitation of space, this paper only takes the optimization content of workstation T3 as an example. The MTM analysis of the operation content before improvement is shown in Table 1, and the MTM analysis of the operation content after improvement is shown in Table 2.

Table1 MTM analysis of operation contents before improvement of T3 workstation

Steps	Left-hand movements	Q*F	Code	TMU	Code	Q*F	Right-hand movement
1				21.2	R40B	1	Reach for the screws
2				9.1	G4B	1	Grabbing screws
3				15.6	M40B	1	Move to left hand
4	Grabbing screws	1	G3	5.6			
5				2.0	RL1	1	Release
6				16.8	R40C	1	Reach to the stopper
7				9.1	G4B	1	Gripping stopper
8				15.6	M40B	1	Move to left hand
9				5.6	P1SE	1	Set on the screw
10	Release	1	RL1	2.0			
Total time value of this operation				102.6TMU	=102.6*0.036=3.69s		

Table2 MTM analysis of operation contents after improvement of T3 workstation

Steps	Left-hand movements	Q*F	Code	TMU	Code	Q*F	Right-hand movement
1	Reach to the stopper	1	R40B	21.2	R40B	1	Reach for the screws
2	Gripping stopper	1	G4B	9.1			

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3				9.1	G4B	1	Grabbing screws
4	Move to right hand	1	M30B	13.3	M30B	1	Move to left hand
5	Set on the screw	1	P1SE	5.6			
6	Release	1	RL1	2.0			
	Total time value of this operation			60.3TMU	=60.3*0.036=2.17s		

3.1.2. Overall value stream non-value added content optimization

An in-depth investigation of the cleaning process revealed that the oil pump has high requirements for cleanliness, and since the cleanliness of the original workshop of supplier H is low and there is a risk of soiling the shell during transportation, the incoming shell needs to be cleaned. Now the workshop of company H introduces 6S management, focusing on strengthening the cleaning capacity of sweeping and cleaning, while using exclusive trucks in the transportation process to reduce the risk of dirtying the shell, and can sign an agreement with the company to ensure that incoming materials meet the cleanliness requirements, in addition to strengthening its own 6S management as well as on-site management to ensure the cleanliness of the workshop. After eliminating the cleaning process, it can save time about 65min.

When observing the production site, it was found that the distance between the test and packaging stations was long, the transportation time was long and a small temporary stock existed between the two stations, increasing the length of non-value-added operations and also reducing productivity. We now move the packing station to the side of the testing station, reducing the handling distance to 40% of the original one. In addition, the temporary inventory in the middle is eliminated and a FIFO lane is set up to achieve continuous flow and reduce inventory waste, resulting in a reduction in handling time from 22min to 8min.

3.2. Line balance optimization design

Line balancing is the technical means and method to analyze the production system, find the bottleneck process, improve the bottleneck process, optimize the production process, and adjust the unreasonable arrangement of facilities so that the operating time and intensity of each process are in a more balanced state as much as possible through industrial engineering methods.

According to the above calculation and the actual situation of the site research, the current balance of the production line is poor and there is a serious imbalance in the production line, so the production process needs to be improved, especially the bottleneck process must be improved accordingly. From the VSM, we can see that the bottleneck process of this line is station T3, and the production beat of this station is 45.37s. The work is to go to station T2 to pick up the production pre-assembled components CRV, then load them into the housing and assemble the components such as filters and baffles. After the study, it was found that the assembly component CRV can be split to T2 station, and the production time of T2 station is 28.61s. In addition, after the optimization of MTM analysis, the production time of T5 station is reduced from 27.58s to 25.84s.

4. Mapping of future value streams and evaluation of optimization effects

4.1. Mapping future value streams

Based on the above improvement elements and the expected standard time calculated by MTM, the future value stream is mapped out in Figure 4.

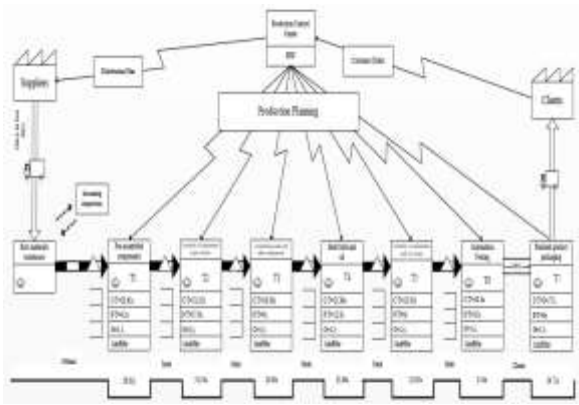

Figure 4 Oil pump future value stream map

The relevant indicators after improvement are calculated as follows:

Value-added time:

$$AT=\sum_{i=1}^{k}T_i=28.61+...+34.71=197.42s=\frac{197.42s}{21*3600s}=0.0026d$$

Non-value-added time:

$$UT=\sum_{i=1}^{k}\overline{T_i}=\frac{160+3+5+9+5+5+8\,\text{min}}{21*60\,\text{min}}=0.1548d$$

Manufacturing cycle:

$$MPT=AT+UT=0.0026d+0.1548d=0.1574d$$

Value-added ratio:

$$R=\frac{AT}{MPT}*100\%=\frac{0.0026d}{0.1574d}*100\%=1.6518\%$$

Production line balance rate:

$$L=\frac{\sum_{i=1}^{n}CT_i}{Max(CT_i)*n}*100\%=\frac{28.61+...+34.71}{34.71*7}*100\%=81.2\%$$

Employee Utilization Rate:

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$$OP = \frac{\sum_{i=1}^{n} CT_i * Q_i}{Max(CT_i) * \sum_{i=1}^{n} Q_i} *100\% = \frac{28.61*1+...+34.71*1}{34.71*8} *100\% = 82.3\%$$

Compared with the pre-improvement period, it is found that all kinds of indicators are significantly optimized, and the specific optimization effect is shown in Table 3.

Table3 Comparison of production indexes before and after optimization

Optimization metrics	Before optimization	After optimization	Rate of change
Manufacturing cycle	0.2202	0.1574	-28.52%
Value-added ratio	1.2262%	1.6518%	34.70%
Production line balance rate	55.6%	81.2%	46.04%
Number of workstations	8	7	-12.50%
Number of operating employees	9	8	-11.11%
Employee Utilization	60.5%	82.3%	36.03%

5. Conclusion

This paper takes the oil pump produced by Company D as the research object. From the actual situation, we use the VSM tool to map out the current value stream of the oil pump, find out the waste and deficiencies in the whole production system, and then apply the lean production method to improve the production line, including production process optimization, employee operation method optimization and pull production, and on top of that, we map out the future value stream. This has led to a significant increase in production targets, which in turn has reduced production costs, improved production efficiency, and enabled us to better meet customer needs and achieve the goal of lean production.

Since VSM is a process of pursuing perfection, excellence, and continuous improvement, drawing a future value stream map does not mean that lean has been achieved, so in order to achieve the most ideal state, it is still necessary to use this future value stream map as the next current value stream map and make continuous improvement.

References

1. ZhaoLei Wu, JinLong Liu.Lean improvement study of maintenance workshop of coal mine machine repair plant based on VSM[J].Shandong Coal Technology,2023,41(01):152-155+164.
2. ShiHai Tian,WenRui Yang,ChunMeng Wang.Optimization and simulation of VSM-ISM-based aluminum flat tube production line for automotive air conditioners[J].Industrial Engineering and Management,2023,28(02):79-89.
3. QingQing Fu.VSM-based optimization of prefabricated component production[J].New Technology New Process,2021, No.405(09):1-4.
4. ChunHong Zhang.Optimization of supply chain management system based on value process mapping[J].Modern Enterprise,2019, No.409(10):27+15.
5. ZiQiu Gan.Lean value stream-based production line improvement study at Company B[D]. Jiangxi University of Science and Technology, 2018
6. XiaoLiang Yi, ZhiFeng Li, Lean improvement based on value stream mapping techniques[J].Practical Automotive Technology, 2018(20): 264-26.
7. Lindskog E, Vallhagen J, Berglund J, et al. Improving lean design of production systems by visualization support[J]. Procedia CIRP, 2016, 41: 602～607.
8. Babu P M, Jeff S, Dave M. Waste reduction using lean tools in a multicultural environment[J]. Journal of Cleaner Production, 2020, 265: 121～681.

*Corresponding Author: Jiao Cheng