Research on Production Process Optimization and Improvement Based on a Production Line of Y Company

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Abstract. The target of this optimization is the DT assembly plant line at Y. The first step is to use data analysis to create a value flow diagram and process information sheet to identify waste and problems on the production line. Use Flexsim simulation software to set the relevant parameters and draw up the modeling information sheet. Then draw a fishbone diagram to identify the problem. And then, the process times were measured, and found the bottleneck processes were done using the 5W1H method to find directions for improvement on the production line. Finally, made improvements to the problems in the production line, workers' movements were standardized and adjusted, and merged with the original processes, reducing four processes. The layout of the production line was adjusted and change the linear production line to a U-shaped production line. The improvement results were verified by Flexsim simulation software. The improvements have resulted in increased line availability and production speed. This improvement has been reviewed by the company, meets the criteria for use, and has been put into production.

Keywords: VSM analysis · Flexsim simulation · To optimize production line · 5w1h · To improve the production line layout

1 Introduction

1.1 Research Purpose

The DT assembly workshop is the last process of the company's entire production process. It is responsible for assembly, packaging, and storage. It has a significant impact on the external output efficiency of the company's products. However, the assembly efficiency and personnel utilization rate of the production line are still low, and there are other wastes that make the production line balance rate very low. Therefore, a project is set up to propose improvement [3].

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1.2 Research Tools

This research on the DT assembly workshop production line of Y company uses Flexsim simulation software to simulate the state of the production line. People can directly put the modeling results into the physical system and directly participate in the interaction between the objects. Simulation technology can avoid the shortcomings of general research methods, which are difficult to consider the dynamic influence of various factors, so that the research results are far from the actual situation, and can reduce investment risks and avoid waste of manpower and funds.

2 Key Issues and Analysis

2.1 Data Analysis

In this study, we will use appropriate statistical and analytical methods to analyze the large amount of data collected, summarize, understand and digest them, to maximize the development of data functions and play the role of data. And based on the data foundation combined with the company's supply chain management to draw a value flow diagram [5] (see Fig. 1).

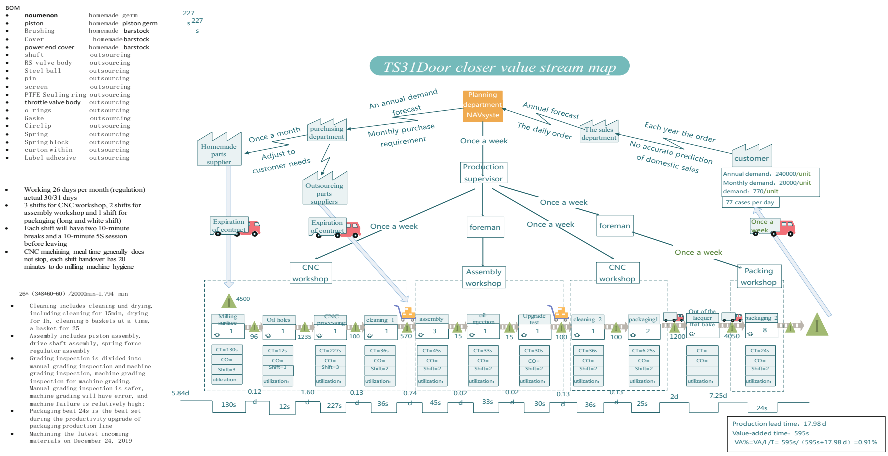

Fig. 1. Value flow chart

On the value flow chart, it can find that DT assembly is the last position in the supply chain, which directly affects the company's external product supply efficiency. It can be seen from the visual observation method that there is still waste in this production line. The drawing process information table as shown in Table 1.

Table 1. Process information table

Number	Job content	Basic operation time (s)
1	Check the appearance	11
2	Ontology spurt the code	8
3	Attach the body label *2	7
4	Down the outer	7.5
5	Cover, place the body, arrange the packing box	10
6	Put the body into a plastic bag and place the body Finishing box	11
7	Guide rail, accessories box online packaging	17
8	Place accessories + Main arm	8.5
9	Place accessories + Instruction Manual	8.5
10	Check accessories + Install sleeve	12
11	One inner box label, origami box, put inner box packing (10 boxes in 1 box)	13

2.2 Data Analysis and Parameter Setting Based on Flexsim Simulation

Collect the data of the station content, including the process division, the time of each process content, the waiting time, the material handling time, and the time required for improvement. Compare the input elements with the material objects to draw a given modeling element comparison table, as shown in Table 2.

Table 2. Modeling element analysis table

Model elements	System elements	Note
Flow item	Product elements	Set up as a solid - like block shape
Processor (1–9)	Employee process processing	The nine processors process services at different rates. The data is calculated based on the normal distribution of the processing time of the entity
Sink	End of product packaging	Products are finally warehoused
Conveyor belt	Product delivery	Product transportation time and processing time for a unified input measurement

In order to prevent data anomalies, the data is first tested for homogeneity and independence, then eliminating abnormal data, put data into the Flexsim simulation software for modeling processing [4], which strictly guarantees the reliability of the data and the feasibility of the project. And draw a table for input (see Table 3).

Table 3. Input table of modeling information

Affiliated entities	Entity elements	Parameter name	Parameter value
Generator 1	Material distribution start process	Material time interval	Constant 1
Processor 1	Employee process processing 1	Process time project	Processing time - normal distribution
~	~	~	~
Processor 9	Employee process processing 9	Process time project	Processing time - normal distribution

2.3 Summary of the Problem

In this study, we will analyze the problem from the five perspectives of man, machine, material, method, and environment. Analyze the waste problem under various conditions. It is analysis that the system has the problem of irregular operation of staff, disordered process, and low equipment utilization. At the same time, it was found that the production line was greatly affected by the bottleneck process, the layout was not standardized, and the utilization rate of land occupation was low. According to the problem, make a fishbone diagram (see Fig. 2).

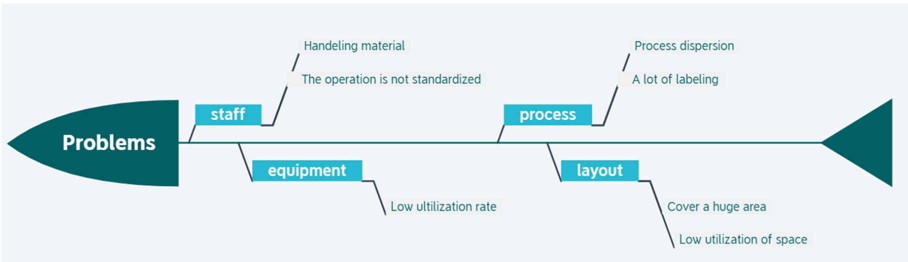

Fig. 2. Current fishbone diagram

3 Solution

3.1 Production Line Optimization and Improvement

First, the bottleneck process is detected when the steps are performed, and then the DT process time is sorted out, similar to the difference table, which is convenient for ECRS improvement. Analytical improvements are shown in Table 4.

Table. 4. Similar differences of processes

DT packaging process time, similar and different				
Serial number	Job content	Basic operation time (s)	Similarities and differences	Plan 1 team of 5
1	Check the appearance	11	Similar products	The combined station is 1 and the introduction of label machine
2	Ontology spurt the code	5.5	Similar products	
3	Body label	4	Fluctuations ranged from 2 to 8 with a weighted average of 4.5 labels	
4	Fold the outer	5.5		The combined station is 2
5	Cover, place the body, arrange the packing box	8	Similar products	
6	Body into plastic bags, place the body, finishing packaging box	10	According to the need	
7	Guide rail, accessories box online packaging			Add station 3
8	Place accessories + main arm	8.5	Similar products	The combined station is 4
9	Place accessories + Instruction manual	8.5	Similar products	
10	Check accessories + Install sleeve	12	Similar products	The combined station is 5
11	Attach one inner box label, fold paper box, place inner box packing (10 boxes per box)	13	Similar products	
12	Takt Time	15.5		24

Note: 1. The accessories can be directly packaged online, and the middle three processes can help each other and adjust properly.
2. If the number of labels exceeds the beat time, consider adding one person to station 1 (before the label machine is put into use) 3. 2 material preparation and distribution personnel and 1 team leader:
(1) Mainly do non-standard parts processing such as laser marking, pad printing, cleaning u-shaped cover, etc.
(2) Material supply, finished products warehousing, recycling bins and garbage clearance.
(3) Quality inspection and treatment outside the line.

3.2 Production Line Layout Improvement

5W1H analysis of the production line, summarized in Table 5.

Table 5. 5W1H analysis table

Inspection point	First question	Second question	Third question
purpose	Optimizing line balance	Production line layout optimization	Continue to improve
Why	Bottleneck process; Three employees have labeling operations; Action is not standard resulting in action waste; Too many transfers cause waste of waiting	Site waste caused by personnel reduction; The utilization rate of floor space decreases; Logistics handling route waste	Need to do
Time	8: 00–20:00	8: 00–20:00	8: 00–20:00
Personnel	Operator	Operator, Porter	Operator, Porte
Methods	Ask and analyze the production line according to ECRS principles and 5W1H, measure and record the actions of employees, reset the working procedure content, formulate standard working methods, and add a mover to handle materials	Analyze the logistics, plan the new production line, and replan the layout	Keep looking for Improvements

3.3 Bottleneck Process Improvement

Bottleneck Process Analysis

Analysis of bottleneck process, we will draw a three-product diagram of the production line to find the balance of each process and the bottleneck process (see Fig. 3).

It can find that the bottling process is mainly labeling, and based on this, the bottleneck process is improved.

The Bottleneck to Improve

This time, we will take three steps to solve the improvement of the bottleneck process.

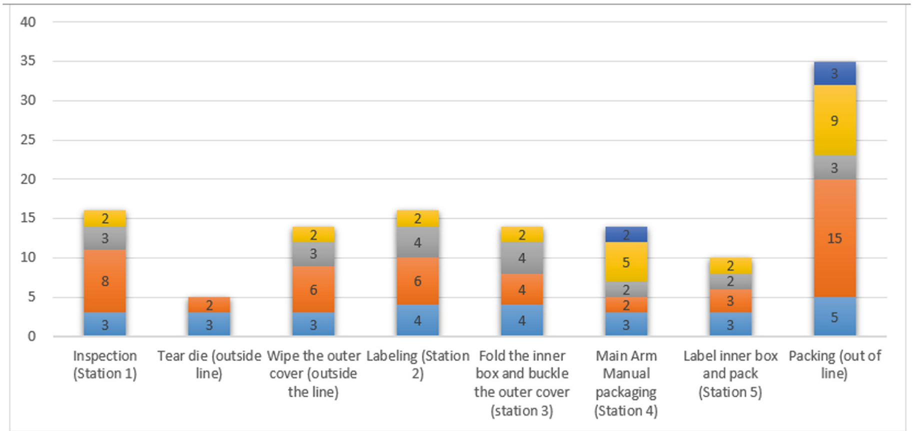

Fig. 3. Three-product diagram of production line

(1) The line job is metric merged. The original steps 1, 2, and 3 were merged, the steps 4, 5, and 6 were merged, the steps 8 and 9 were merged, and the steps 10 and 11 were also merged.

The original 9 workstations were simplified to 5 workstations by merging and rearranging, and the number of production line operators was reduced from the original 9 to 5.

(2) With the addition of a labeling machine, the labeling efficiency has increased from 2–5 pieces/min to 8–12 pieces/min.

(3) Using a flow production method, a linear production line should be converted into two U-shaped production lines to improve production efficiency [5] (see Fig. 4).

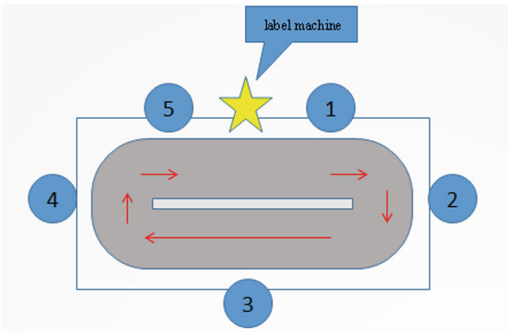

Fig. 4. Improved effect diagram

4 Improve Results Comparison

4.1 Comparison of Production Line Optimization and Improvement Results

By calculating the rate of return as the key basis for analyzing the feasibility of the project, an improvement rate of return table is established as one of the quantitative indicators to compare the improvement effect [6], as shown in Table 6 below.

Table 6. Similar differences of processes

	Improvement 1	Improvement 2	Improvement 3	Overall improvement	note
Improve the content	Improve production line efficiency	Add a label machine to replace human laboring	Improve production line	Total improvement is a collection of improvements one, two, and three	
The required material	Lean pipe, metal joint, working table	Label making machine x 2	Lean tube, metal joint, pin pole, motor, conveyor belt, lamp tube, fan, frame, tape, jet printer, working table, chair	Label machine x 2, lean tube, metal joint, pin pole, motor, conveyor belt, lamp tube, fan, frame, tape, jet printer, workbench, chair	
Cost	2 000	60 000	28 000	90 000	The total cost
Direct income	240 000	60 000	160 000	460 000	Total revenue
Indirect benefit	Production efficiency improvement, employee compliance rate balance, conducive to the formation of benign development of the company	Reduce the labor cost of labels, improve the beauty of product labels, and enhance the comprehensive competitiveness of products	The addition of one production line can increase the output by 200 per day, which greatly improves the competitiveness of the company in the industry	The comprehensive competitiveness of products, the company's market competitiveness greatly for the rise	
The yield	+1200%	0%	+571%	+511%	

Comparison of Actual Improvement Results
By optimizing and improving the operation process, decrease the non-value-added and unnecessary waste in the process flow and improve the process by applying the ECRS method to eliminate, merge, rearrange and simplify.

The order of operating stations before improvement is: 142356789.

The improved operation station sequence is 12345, as shown in Fig. 5.

Fig. 5. Comparison of actual improvement results

4.2 Comparison of Production Line Layout Improvement Results Production Line Layout Comparison

Comparison of production line layouts, as shown in Fig. 6. Comparison of production line footprint, as shown in Fig. 7.

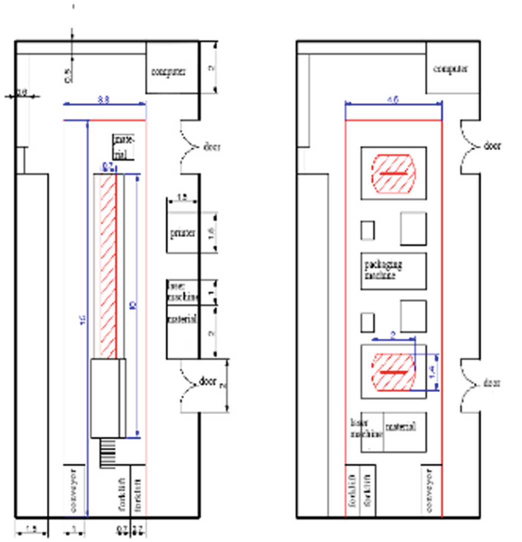

Fig. 6. Comparison of production line layout (left before improvement, right after improvement)

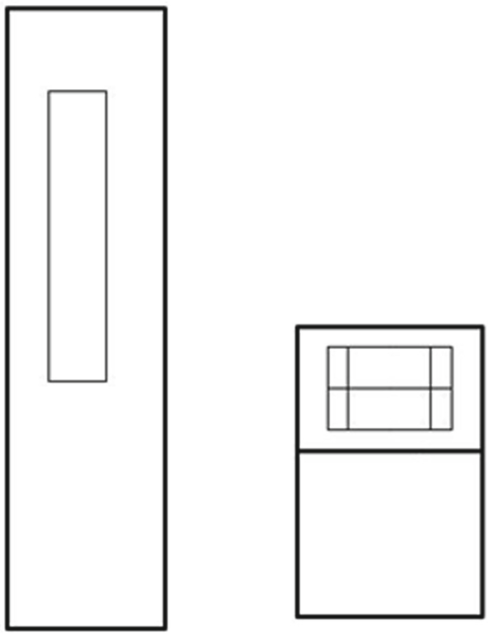

Fig. 7. Comparison of actual occupied area (left before improvement, right after improvement)

Before improvement: production line area = $1 \times 7 = 7$ m^2

After improvement: production line area = $2 \times 2 + 0.5 \times 0.5 \times 3.14 = 4.785$ m^2

When the number of production lines is the same, the theoretical area of a single production line before and after the layout improvement comparing with the actual area. The area utilization rate before improvement is 12.28%, and the area utilization rate after improvement is 14.18%, as shown in Table 7.

Table 7. Floor area improvement table

	Number of production line	Theoretical floor area of a single production line	Actual floor space of a single production line	Total actual floor space	Utilization of floor space
Improve the former	1	7	57	57	12.28%
After the improvement	2	4.785	33.75	67.5	14.18%

Comparative Analysis of Follow-Up Improvement Results Based on Flexsim Simulation Modeling

Arrange and input the data before and after the improvement, so that the data and layout are strictly by the actual situation, model the data with Flexsim simulation software, and record the data for comparison as an important basis for verifying the feasibility of improvement.

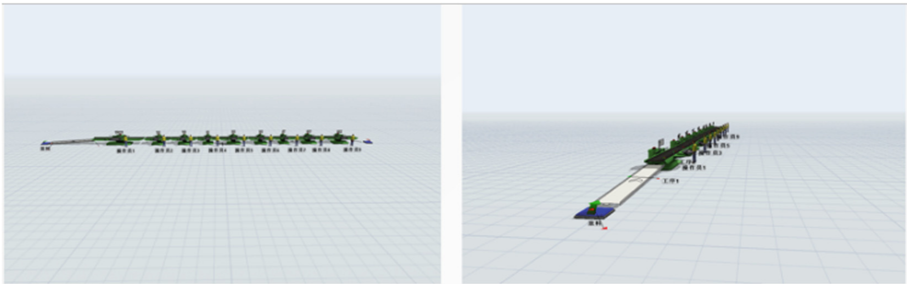

Fig. 8. Modeling diagram before improvement

The modeling diagram before improvement is shown in Fig. 8 and the modeling diagram after improvement is shown in Fig. 9.

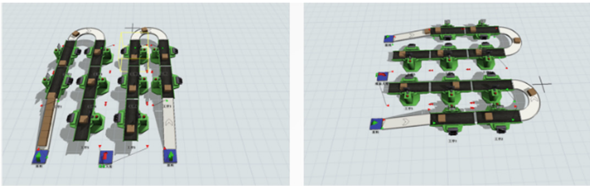

Fig. 9. Improved modeling diagram

4.3 Comparison of Bottleneck Process Improvement Results

Through analysis, it is known that the bottleneck process of the production line is labeling. In the complete production process, the labeling process accounts for 3, and they are all time-consuming processes. Therefore, an additional labeling machine is introduced to improve the production line. After adding the labeling machine, the labeling speed increased from 2–5 pieces/min to 8–12 pieces/min, and the overall efficiency increased by 6–7 pieces/min. The following is a comparison table of bottleneck process improvement, as shown in Table 8.

Table 8. Comparison table of bottleneck process improvement

	Operator	Speed parts/min
To improve the former	Employees	2–5
After the improvement	Label making machine	8–12

5 Summary

This research applies industrial engineering knowledge to practice and solves the problems of low production balance rate and unreasonable layout of the original production line in the DT assembly workshop of Y company. The original production line was analyzed by applying a value flow chart, fishbone diagram, 5W1H analysis, and other methods, and found the existing problems of the original production line. By improving worker action, the production line reduced 4 processes and adds a machine to improve the efficiency of the production line. According to the improved procedures and a machine of the production line, the area utilization rate of the production line is analyzed, and the layout of the production line is redesigned as a U-shaped production line. According to the Flexsim simulation software, verify the improvement of each part, and the verification results are in line with the actual application [7]. The improvement project has been put into production after being reviewed by the company to meet practice standards.

References

1. Huiyong, S., Yijun, B.: Research on high-quality development strategy of Chinese manufacturing industry. Zhongzhou Acad. J. **01**, 23–27 (2019)
2. Zhang, J., Liu, J., et al.: Value engineering (15), 280–284 (2020)
3. Wang, H.: Production Line Simulation and Lean Optimization based on Flexsim. Beijing University of Civil Engineering and Architecture (2016)
4. Li, Y., Ding, S., et al.: Design and Optimization of Assembly Line Layout Based on Simulation. Manufacturing Technology & Machine Tool (01), 51–54, 55 (2021)
5. Liu, Z., Sun, X.: Balance analysis and improvement of "one flow" U-shaped production line. Res. Dev. (02), 090–093 (2013)
6. Lu, J.: Research on GB Company Production Line Balance and Simulation Based on Lean Production Theory. China University of Mining & Technology (Jiangsu) (2019)
7. Tao, C.: Research on Production Line Balancing Method based on Value Stream and Its Application. Zhejiang Sci-Tech University (2016)