Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

Research on Simulation and Optimization of Production Line Based on Flexsim

Wei Liu*, Jiaxing Lin
Xiamen University Tan Kah Kee College, Zhangzhou, Fujian, China
*Corresponding Author.

Abstract:

As China proposes to accelerate the construction of a new development pattern with the domestic cycle as the main body and the domestic and international dual cycles promoting each other, the coastal manufacturing industry, which has long been developed by relying on foreign trade exports, urgently needs to transform into regional development and transformation dominated by the internal cycle. In this paper, through field research and interviews on a cosmetic organizer assembly line in company Z, We analyzed the process and work elements of the mirror production line of storage boxes. We measured the work time and found the bottleneck process based on this. Then we used Flexsim to simulate the production line and analyze the three indexes of in-process time, idle time, and blockage time. We found that there were problems such as low balance rate of the production line and the large load gap between processes. The method and tools are used to optimize and improve the production line's process flow and bottleneck process and carry out the simulation verification again. To further improve the production line, this article combines the 6S management method to improve the on-site management of Z company. We establish a responsible organization to supervise, and we strengthen training to improve employees' responsibility; in the end, we plan the placement of on-site items. It has a significant reference value for the same type of enterprise to achieve production line balance.

***Keywords**: Coastal industry, Production line balance, Simulation, ECRS, 6S.*

I. INTRODUCTION

Affected by the new coronavirus epidemic, the international situation is turbulent, and the US hegemony in international trade continues to suppress Chinese industries. The security risks and stability of the global supply chain are greatly challenged, and the domestic economic operation is facing new challenges. Under such a situation and background, China proposed accelerating the construction of a new development pattern with the domestic cycle as the main body and the domestic and international dual cycles promoting each other. The domestic resource allocation pattern and focus changes will prompt the transformation and upgrading of the manufacturing industry.

Businesses and academics have proposed various approaches and methods to solve the production line problem. Techniques such as lean production, flexible manufacturing, JIT, and system simulation have

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

been widely recognized in the production practice of manufacturing enterprises. Among them, the use of software to simulate the production line can find possible problems before the production line is established and run so as to improve it; After the production line is put into operation, the existing issues in the production line, such as bottleneck processes can be found through modeling simulation and data analysis. We make improvements, formulate optimization plans, shorten production cycles, achieve less waste, and help enterprises reduce costs.

In this paper, we investigate the production line of company Z to understand the current situation of the production line. We finally decided to research a cosmetic case mirror part assembly line for company Z. We used Flexsim to simulate the production line, and optimized and improved the production line with the 6S management method.

II. THE PRODUCTION LINE BALANCE OPTIMIZATION RELATED RESEARCH

2.1 Production Line Balance

Production line balance is the homogenization of the corresponding processes in the production process to better allocate the operators on the line, so that the workload of each station is reduced. The operating time of each station is balanced to make it as exhaustive as possible, thus making the whole line run more smoothly. Suppose the balance of the production line is not maintained. In that case, it will increase the waste of work in progress, cause the loss of person-hours and even suspend the production line. The production balance of a production line determines its productivity, production site costs, employee satisfaction, etc. It plays a vital role in the efficient operation of the entire line.

The line balance rate is an important indicator to reflect whether the line is balanced or not, and its value is directly related to the efficiency of the line operation.

$$\text{production line balance ratio}=\frac{\text{Total process time}}{\text{Cycle time * Number of processes}}*100\% \qquad (1)$$

2.2 Takt Time and Bottleneck

2.2.1 Takt time

Takt time is the time it takes to produce each product as calculated by the factory based on customer order requirements. It is calculated as the interval time required between two consecutive productions of the same product. There are two types of Takt time: Takt time and Cycle Time. Both are important indicators of the production line and should be guaranteed in practice≥ Process Takt time to achieve the balanced operation of the production line to improve the production efficiency of enterprises. The functions are shown as follows.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

2.2.1.1 Production takt time

The production takt time, abbreviated as TT, reflects how a company can produce a product, defined by the time required to produce the product, in seconds per piece, and calculated as follows.

$$\text{Production Takt time} = \frac{\text{effective working time per production period}}{\text{customer order demand per production period}} \quad (2)$$

2.2.1.2 Process takt time

The process takt time, also known as the cycle takt time, or CT for short, is the time required for a process in a production line in seconds per piece and is calculated as follows.

$$\text{Process Takt time} = \frac{\text{effective working time of the process}}{\text{production of the process during the effective working time}} \quad (3)$$

2.2.2 Bottleneck process

A bottleneck process is a process in a production line that limits the productivity of the entire line, that requires the longest production time, which causes the work-in-process to wait in line, resulting in the capacity of the existing production line in the factory not being able to meet the demand of the customer's order and the production efficiency is seriously affected. Therefore, improving and optimizing the bottleneck process is necessary to improve the production efficiency of the production line and ensure production balance.

2.3 Evaluation of the Effect of Line Balancing

Balance delay, a metric used to evaluate the effectiveness of assembly line balancing, shows the percentage of time a product is idle on the line as a percentage of the total time spent on the line, as shown by the following equation 4.

$$Bd = \frac{N * C - Tsum}{N * C} * 100\% \quad (4)$$

N is the number of workstations, C is the production takt time, and T total is the total working time. The judgment criteria of the production line balancing effect are shown in the following TABLE I.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

TABLE I. Judgment criteria of production line balancing effect

Balancing delayed results	Judging results (production line)
Bd≤ 10%	Excellent
10%≤ Bd≤ 20%	Good
Bd≥ 20%	Difference

According to the above, the equilibrium rate can be expressed as n = 1 – Bd

2.4 Simulation Steps of Flexsim

At present, there is much software in the field of system simulation. The commonly used simulation software includes Auto Mod, Witness, Arena, Flexsim, etc. Flexsim is a commercial discrete-event system simulation software produced and distributed by Flexsim software products. This American company entered the field of system simulation software development in 1993 [1].

Flexsim modeling simulations are primarily implemented according to five basic procedures, as shown in Fig 1.

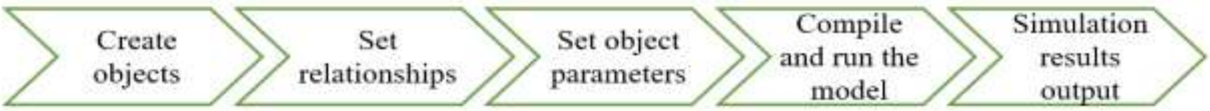

Fig 1: the simulation steps of Flexsim

Flexsim also provides an interface between the simulation model and Expert Fit and Excel. It allows you to fit the input data to the distribution through Expert Fit and change the data in Excel to achieve simultaneous data updates in the simulation model. In addition, the software also provides the optimization module Optquest. It adds an interface to Microsoft Visio to help model quickly [2]. It shows the advantages of intuitive operation, open and straightforward modeling, substantial model expansion, and high extensibility.

III. ANALYSIS OF THE SITUATION OF THE PRODUCTION LINE OF COMPANY Z

3.1 Overview of Company Z

Company Z was founded in 1999 and located in Taizhou City, Zhejiang Province, Z is a professional home storage manufacturer in China, integrating product design and development, marketing, and after-sales service. Company Z has its plant covering an area of 50 acres, 100 sets of injection machines, more than 200 employees, and more than 1,000 kinds of products. In the development, Z company actively transformed into a brand-oriented marketing-oriented enterprise, set up four branches, and improved the supply chain system from production to sales. However, it is not easy to transform from a traditional

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

foreign trade enterprise, and there are still many problems while the business scope of the company is expanding, one of which cannot be ignored is the problem of unbalanced production lines and insufficient production capacity, how to make the company's production keep up with business development has become a thorny issue.

3.2 Analysis of the Current Situation of the Production Line of Company Z

With the company's transformation, the company's design and marketing capabilities have been greatly enhanced, and the company has launched several pop-up products. Take a cosmetic organizer as an example. Since its launch in the second quarter of 2020, more than 600,000 pieces have been sold across the network. Since it is a new product, there is a lack of historical sales data for demand forecasting, and the existing production capacity cannot meet the demand of orders. And there are even channel customers who come to the factory to wait directly for the first time to get the goods.

The assembly line of this cosmetic organizer is a linear assembly line, which is divided into two parts according to the processing process: mirror assembly (later called assembly line 1) and overall assembly (later called assembly line 2). After the mirror part is assembled, it is manually carried to the general assembly line to be made with the mirror body part and packaged. However, the capacity of assembly line 1 is only 1500 pieces a day, but the ability of assembly line 2 is 1700 pieces a day, so the ability of assembly line 1 cannot meet the capacity of assembly line 2 and often needs to wait. Therefore, we analyzed and optimized the assembly line for mirror part assembly of assembly line 1.

3.3 Mirror Part of the Production Line Operation Elements Division

Each company will constantly adjust the division of work elements according to the current production status, staff situation, productivity, and other factors. Sometimes the division of work elements is not done overnight, and the evaluation of operation results is often needed to force the work elements to be readjusted. The division of work elements is too fine, which will lead to complicated and tedious production line operations, and rough division will affect the balance of the production line, so the division of work elements is significant and can help solve the problem of production line balance in a certain sense.

According to the process diagram and the actual production situation of the assembly line of the mirror part of the cosmetic case of company Z, the work elements are divided according to the following principles: (1) the work elements are divided in line with the processes that are fixed in the actual production, (2) the operation time of each work element should be measurable, (3) the processes that cannot be logically continued to be divided can be treated as one work element for Research.

3.4 Operating Time Measurement

We calculated the standard operating hours. We can find that Station 1 is rotating firmware assembly, one-person operation, composed of three operational elements, standard working time is 12.83 seconds;

Station 2 is outer board preliminary assembly, composed of two operational elements, one-person operation, the time difference between the two operational elements is not significant, the standard working time of the station is 16.95 seconds, slightly longer than the standard working time of station 1; Station 3 is outer board paste LED, a separate operational element, the standard working time is 15.94 seconds. The standard working time is 15.94 seconds, which is not much different from the normal working time of the previous workstation; workstation 4 is the assembly of the outer board circuit board, which is an independent working element, the number of workers is 1. The standard working time is 11.13 seconds, and there is no direct connection with workstation 3. The normal working time for installing the circuit board element is 23.28s. The total working time is 39.72s, which two employees operate; Station 6 is for assembling the electronic parts of the outer board, which is composed of three functional elements. The longest working time is for screwing the inner ring, which takes 18.47s, with two employees working, and the total standard working time is 45.29s; Station 7 is for The standard working time is 23.53s, with one person operating; station 8 is the last station, with 6 working elements and two persons operating, in which the longest time is 48.83s, exceeding the standard working time of all the previous stations. The standard working time of this station is 80.71s, with the longest time, which is the assembly of the mirror part of a cosmetic case. It is the bottleneck process of the production line.

IV. SIMULATION AND PROBLEM ANALYSIS OF MIRROR PRODUCTION LINE OF COMPANY Z BASED ON FLEXSIM

4.1 Establishment Mirror Part of the Production Line Simulation Model

4.1.1 Physical equipment design

According to the process diagram of a cosmetic organizer mirror part assembly line of company Z, the correspondence between the entities in Flexsim and each work station and its operation elements in the line was designed in conjunction with the actual situation in the assembly plant. Since workstations 5, 6, and 8 are in charge of two people, two corresponding entities were set up for simulation, as shown in TABLE II.

TABLE II. Correspondence table between entity and workstation elements

Entity	Workstation elements	
Generator 1	Rotating firmware parts into	
TREATED	1.4	13.5
Processor 1	Workstation 1	Rotating firmware assembly
Processor 2	Workstation 2	Initial assembly of outer panels
Processor 3	Workstation 3	Outer panel with LEDs
Generator 2	Workstation 4	Outboard circuit board assembly
Synthesizer 1	Workstation 5 (1)	Outer board electronic parts assembly
Synthesizer 2	Workstation 5 (2)	Outer board electronic parts assembly
Processor 4	Workstation 6 (1)	Inner and outer panel assembly

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

Processor 5	Workstation 6 (2)	Inner and outer panel assembly
Processor 6	Workstation 7	Surface adhesive
Processor 7	Workstation 8 (1)	Assembled mirrors
Processor 8	Workstation 8 (2)	Assembled mirrors
Shelves	Temporarily store the complete mirror part and send it to the whole assembly line in batches	

According to the explanation of the correspondence table, a simulation model of a cosmetic organizer mirror part assembly line can be created. Since station 4 is assembling the circuit board for station 5, it will be treated according to the generator. The entities are mainly two generators, eight processors, two synthesizers, and one shelf.

According to the flow chart of the relationship between the front and back entities, the four entities of the generator, processor, synthesizer, and shelf are used to build the model in Flexsim software according to the processing logic. The location is set according to the realistic layout of the assembly plant. Still, due to the extended production line, the layout in the simulation model has changed appropriately, as shown in Fig 2.

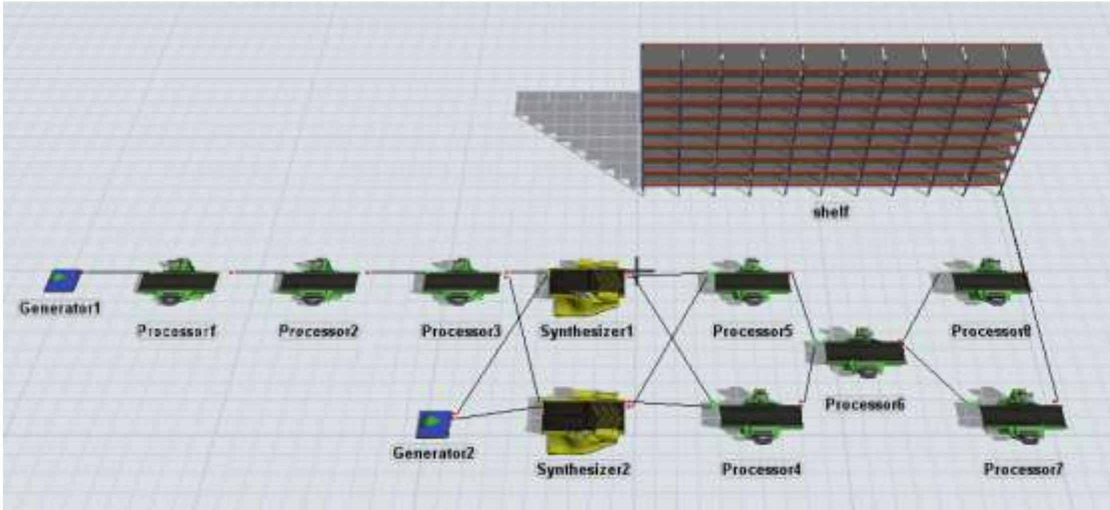

Fig 2: the simulation model of a cosmetic storage box mirror part assembly line

4.1.2 Simulation model parameter setting

4.1.2.1 Generator parameter setting

The actual decision of the production line operation cycle is the one with the highest process beat in the process, so the interval time for generator 1 to generate temporary entities (spare parts of rotating firmware) is the standard working time of the station with the highest process beat, the longest standard

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

working time in this assembly line is station 8, which is 80.71s, but two people are operating in this station, so the interval time (i.e., trigger time) can be set to The parameter setting of generator 2 is set according to the actual production time of assembling circuit boards, which is 11.13s.

4.1.2.2 Processor parameter setting

The employees at the workstations represented by the processor are in fixed positions. They do not move except sometimes they need to get up to replenish semi-finished products or spare parts, so no operator is set up in the simulation model, and the processor processing temporary entities are directly regarded as operators operating. The processing time is the standard operating time of each workstation.

4.1.2.3 Synthesizer parameter setting

The synthesizer in the production line represents the synthesis of two pre-processing stations semi-finished products of station 5, because its operator is also fixed position, so no operator is set, directly using the synthesizer to simulate the assembly action of the operator of station 5, the processing time is set to the standard operating time of station 5 39.72s.

4.1.2.4 Shelf parameter setting

The cosmetic organizer mirror part assembly line assembles the completed mirror parts in plastic baskets, which are then sent in batches to the cosmetic organizer whole assembly line. Set up shelves as a collection of plastic baskets to place the assembled mirror parts.

4.2 Run the simulation model

Through the field research and visit to a cosmetic case assembly line of company Z, we learned that the production line implements a 9-hour working system, excluding the time for rest and meal, the normal working time is 8 hours, one group of one shift per day, so the working time of one group per day is 28,800s, so the simulation time is set to 28, 800s.

After setting the simulation time, click the Reset button in the upper left corner of the Flexsim page and then click Run. Wait for the model to run continuously for 28,800s and then observe the operation of each entity.

4.3 Analysis of the Simulation Results of the Production Line of Company Z

Up to fifty states can be selected for record display in Flexsim software, including idle time, in-process time, waiting for the transport time, and other metrics. This paper establishes three metrics for observation: processing, inactive, and blocked. After running for a set simulation time, the state bar is generated in the dashboards to observe the operation status of each device in the production line model, as shown in Fig 3.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

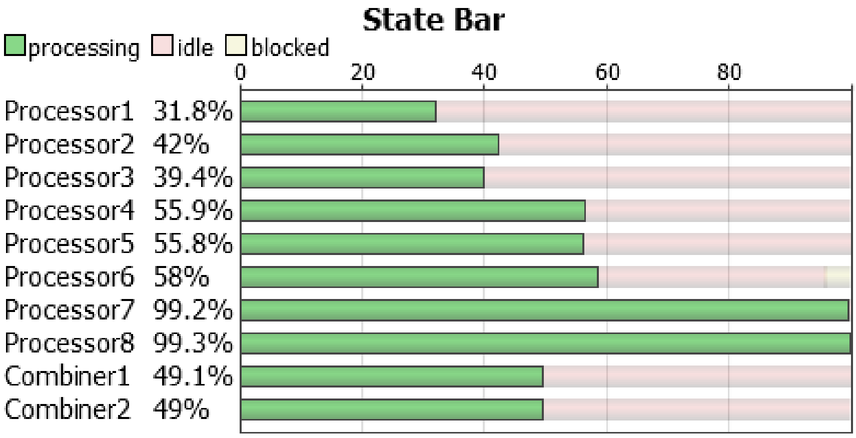

Fig 3: equipment operation status diagram

The detailed work of each station in the simulated production is also exported in the statistics and analysis function with Flexsim.

By running the simulation model, it can be found that a cosmetic organizer mirror part assembly line of Company Z can operate normally. Still, meeting the order demand, it will cause serious over time with the current capacity. The simulation results show that the assembly line is unbalanced, with a significant degree of busy and idle before and after, and there is a bottleneck process. The sluggish rate of four stations exceeded 50% in the whole production line, and the highest idle rate of station 1 reached 68.22%. In contrast, the idle speed of the two processors in station 8 with the lowest idle rate was as low as 0.82% and 0.68%, with a difference of nearly 67%, which is a big difference between the front and back busy degree.

According to the results, the bottleneck process is station 8. Although two operators have been set up, the processing time for each of the two operators is nearly 100%, and the workload is extremely high, which also checks and balances the productivity of the product. According to formula (1), the production balance rate of the production line is 55.45%. According to the literature, a production balance rate of 70% can be called a production line under general management, and 80% can be evaluated as a production line under lean production management, so the production line needs to be further optimized.

V. PRODUCTION LINE OPTIMIZATION SOLUTION FOR COMPANY Z

5.1 Optimization Mirror Part of the Production Line Balance

According to the analysis of a cosmetic organizer mirror part assembly line of company Z in the previous chapter, the existing production line is optimized by combining the 5W1H analysis method and ECRS principles. The operation process is analyzed according to the 5W1H method, and questions are

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

asked in six aspects: process essence, cause, time, place, personnel, and solution. And combined with the ECRS principles, non-value-added or unnecessary processes in the production line are eliminated. We try to combine several scattered or discontinuous processes into one task and find ways to simplify the processes that cannot be cut. At the same time, you can consider adopting pull production to avoid the waste of material resources occupied by the accumulation of semi-finished products in each piece of equipment[3]. Finally, the two main aspects of the process flow and bottleneck processes are optimized.

5.1.1 Process optimization

By analyzing each process in the assembly process of a cosmetic organizer of company Z, we decompose the process and reconfigure the operation by optimization. The mirror part assembly flow chart is shown in TABLE III.

TABLE III. Mirror part assembly flow chart

Assignment Serial Number	Assignment elements	Assignment Serial Number	Assignment elements
1	Fixed lower part	12	LED outside mounting plastic ring
2	Embedded spheres	13	Screwing and inner ring
3	Screw and upper part	14	Installing the fan
4	Fixed rotating firmware	15	Check if you can run
5	Bonded cells	16	Apply double-sided tape and peel off
6	Paste LED	17	Peel off the component surface film
7	Assembling circuit boards and components	18	Peel off the lens backing film
8	Installing the motor	19	Component Sticky Mirror
9	Plastic plate fixed motor	20	Assembled lenses
10	Installation of circuit boards	21	Machine pressed mirror
11	Wire connection	22	Check if you can run

5.1.2 Optimization of process 7

Process 7 is part of station 4, which is a separate process. By running the simulation model, the blockage rate is 72.43%, which is very high and makes the operator of process 7 waits for a long time. Since Process 7 is a stand-alone process with no preceding process, the board is assembled at the beginning of the assembly process. A staging area can be set up where the operator of process 7 puts the board into the staging area after assembly and places it next to workstation 5 for the operator of

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

workstation 8 to access. After assembling the boards needed for two shifts that day, the work can be stopped, other operations can be performed, and the work of process 7 can be canceled on the second shift, reducing one operator.

5.1.3 Optimization of process 16

Process 16 is to stick and tear the double-sided tape on the combined bodyboard. The operator first tears off a section of tape of about 4cm from the whole roll of double-sided tape, sticks it on the surface of the mirror body, and then tears it off, and repeats this action six times. Through an interview with the workshop director, it was learned that this process could be optimized, and the questioning process. Through successive questions, it was found that the operation method of this process could be improved, which was also used by the employees of another shift. At the same time, with reference to the idea of simplifying the ECRS method, the operation method of this process, which could not be canceled, was simplified so that the operation method of this process was changed to first finish pasting the six corners and then tearing them together. According to the above calculation, the standard working time of process 16 in this study is 23.53s, and the standard working time of this process in another shift is 18.68s with the help of the workshop manager, which saves nearly 5 seconds and improves the working efficiency.

5.1.4 Improvement of bottleneck processes

According to the above calculation and the operation results of the simulation model, it can be obtained that the bottleneck process of a cosmetic mirror part assembly line of company Z is the station 8 assembling mirror. Although station 8 is now equipped with two operators, each equipped with a machine for pressing mirrors, the production efficiency is still severely constrained.

Functional decomposition of station 8 reveals that there is also a great difference in the length of work time between its functional elements, with the longest machine press mirror requiring 48.83s to perform, while the shortest tearing off the component surface film only requires 4.3s to operate. The details are shown in TABLE Ⅳ.

TABLE IV. Workstation 8 operating elements working time (unit s)

Workstation	**Workstation name**	**Assignment Serial Number**	**Assignment elements**	**Standard working hours**	**Standard working hours at the workstation**
8	Assembled mirrors	17	Peel off the component surface film	12	LED outside mounting plastic ring
		18	Peel off the lens backing film	13	Screwing and inner ring
		19	Component Sticky	14	Installing the fan
		20	Assembled lenses	15	Check if you can run

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

		21	Machine pressed mirror	16	Apply double-sided tape and peel off
		22	Check if you can run	17	Peel off the component surface film

We combined with field research and the operators' suggestions, and the machine press mirror and check whether it can run to withdraw from station 8, set station 9, by a dedicated person responsible for; We adjusted station 8 process flow chart. The details are shown in TABLE V.

TABLE V. Working time of operating elements after adjustment of workstation 8 (unit s)

Workstation	Workstation name	Assignment Serial Number	Assignment elements	Standard working hours	Standard working hours at workstations
8	Assembled mirrors	17	Peel off the component surface film	4.30	27.32
		18	Peel off the lens backing film	6.07	
		19	Component Sticky Mirror	8.60	
		20	Assembled lenses	8.35	
9	Machine pressed mirror	21	Machine pressed mirror	48.83	53.38
		22	Check if you can run	4.55	

5.2 Establish and Run the Optimized Simulation Model

5.2.1 Build the optimized production line simulation model

Through the optimization analysis in the previous section, a staging area was added after process 7, so that the operators of process 7 could leave the line and participate in other work after producing the circuit boards needed for the two shifts of the day, reducing one process for the next shift of the line. The operation method of pasting and tearing double-sided tape in process 16 was unified, reducing the working time by 5s to 18.68s. The original work station 8 was dismantled, and the process of pressing the mirror and checking whether the machine could run was separated into work station 9, which a separate person handled, and an additional machine was added, making a total of three machines for processing operations. The optimized entity correspondence are shown in TABLE VI.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

TABLE VI. Optimized entity correspondence

Entity	Workstation elements	
Generator 1	Rotating firmware parts into	
Processor 1	Workstation 1	Rotating firmware assembly
Processor 2	Workstation 2	Initial assembly of outer panels
Processor 3	Workstation 3	LED on the outer panel
Generator 2	Workstation 4	Outboard circuit board assembly
Storage area 1	Workstation 4	Temporary storage of assembled circuit boards
Synthesizer 1	Workstation 5 (1)	Outer board electronic parts assembly
Synthesizer 2	Workstation 5 (2)	Outer board electronic parts assembly
Processor 4	Workstation 6 (1)	Inner and outer panel assembly
Processor 5	Workstation 6 (2)	Inner and outer panel assembly
Processor 6	Workstation 7	Surface adhesive
Processor 7	Workstation 8 (1)	Assembled mirrors
Processor 8	Workstation 8 (2)	Assembled mirrors
Processor 9	Workstation 9 (1)	Machine pressed mirror
Processor 10	Workstation 9 (2)	Machine pressed mirror
Shelves	Temporarily store the complete mirror part and send it to the whole assembly line in batches	

According to the above results, a simulation model of a cosmetic case assembly line was established in Flexsim after optimization, and two processors and a staging area were added on the basis of the original one, as shown in Fig 4.

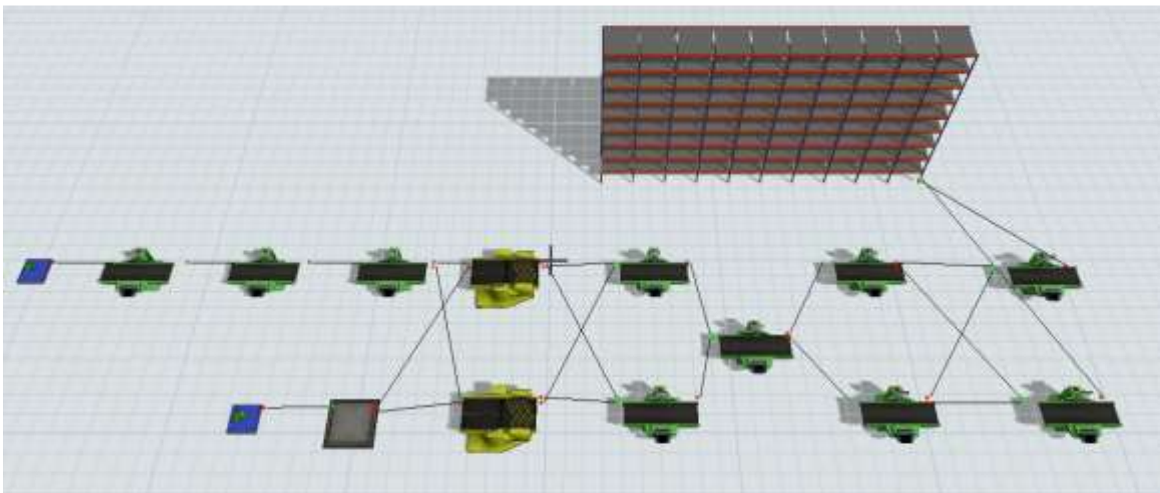

Fig 4: simulation model after optimization

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

5.2.2 Simulation of the effect of the optimized production line

The arrangement of equipment and production line facilities is adjusted according to the actual operation time after optimization. The rest of the parameters remain unchanged. The simulation time is also set to 28,800s, and the three indexes of processing time (processing), idle time (idle) and blocked time (blocked) are observed after running for 28,800s.

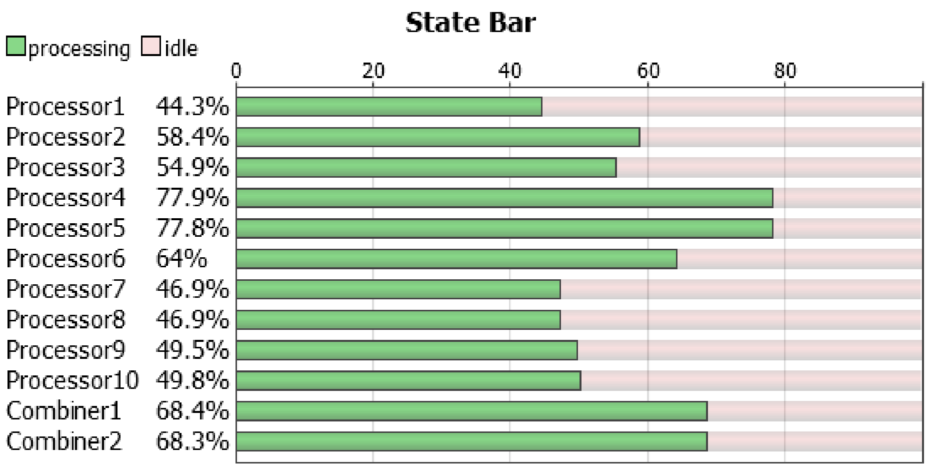

Fig 5:optimized equipment operation status diagram

The detailed work of each station in the simulated production is also exported in the statistics and analysis function that comes with Flexsim. It can be found that the load between stations is more balanced after optimization, with the highest idle rate of 53.09% and the lowest of 22.14%, which is a great improvement over the data before optimization. The original bottleneck process has also been well improved. The blockage rate of workstation 7 and workstation 4 has been significantly reduced. The optimized equipment operation status diagram are shown in Fig 5.

5.2.3 Simulation optimization effect evaluation

By setting the write global table operation at the entry trigger of the shelf, the number of products output before and after the production line was counted. After optimization, the output of one shift of this production line was increased from 707 to 956 pieces, and the production efficiency was improved significantly. According to Equation (1), the production balance rate of this production line after optimization is calculated to be 69.38%, which is close to 70%. Through optimization, the production capacity of this line has been increased and the line is more balanced. The simulation optimization effect are shown in TABLE VII.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

TABLE VII. Simulation optimization effect

Projects	Before optimization	After optimization
Capacity	707 pieces	956 pieces
Production balance rate	55.45%	69.38%
Workstation	8	9
Operators	11	12
Remarks	The first shift workstation 4 employees can leave after completing the day's operation target and participate in other work; reducing one workstation and operator for the second shift of the line	

5.3 Implementation of 6S Management Method

6S management method includes Seiri, Seiton, Seiso, Setketsu, Shitsuke, and Safety[4]. It is often used in the management of production sites.

In the Research and analysis, it was found that there were more problems in the production environment of Z's assembly workshop first: production waste was piled up randomly, pungent gas was generated, improper use of production boards, and outsourced parts were placed randomly. To a certain extent, this will also limit the production efficiency of the production line, restrict the production balance and increase the safety risks. 6S management can be implemented in Company Z to help Company Z improve the environment of the assembly production hall and increase productivity.

5.3.1 Establishment of relevant responsible organizations

Any activity requires a special organization to be in charge, which lays the foundation for the success of the activity. 6S management in company Z should also establish a relevant responsible organization, which can be headed by the plant manager and the head of each department as a member of the organizing committee, and be responsible for the implementation of their respective departments. The organizing committee should develop incentives, issue guiding documents, and carry out inspection and supervision to urge each employee to form good working habits and team consciousness and consciously abide by the rules and regulations.

5.3.2 Strengthen the training of 6S management

New things often encounter obstacles in the implementation, Z company in the implementation of 6S management in the early stage, the staff will certainly have resistance. The company should hold regular training courses and invite experts in the field of 6S site management to strengthen the pride of all employees, deepen their understanding of 6S management and eliminate misconceptions. At the same time, 6S slogans are set up at the production site to publicize the content of 6S, so that employees can invariably remember the relevant concepts and remind themselves at all times while working in the production plant.

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

5.3.3 Reasonable planning of site items placement

Reasonable and scientific planning of the location of the items on site is an important measure, at present, Z company has the problem of disorderly placement of purchased parts and random throwing of production waste. It is necessary to reasonably plan the placement area of outsourced parts, so that the items can be clearly seen at a glance, reducing the time to find the items and allowing the operators to see and quickly grab them when they need to use them. At the same time, we can prevent storage baskets beside the production line for operators to organize production waste and clear the backlog of items on the ground, so that the workplace is bright, neat and orderly. The planning of the location of the items on the site is also planning the movement trajectory of the operators and trolleys, according to the principle of economy of movement, the workpieces of each process will be carried to the next equipment in time to achieve the optimal intensity of handling [5].

5.3.4 Improvement of hardware facilities

Company Z should improve the work environment in response to employee feedback about their dissatisfaction. Such as the known problems of pungent gas and strong light. The air quality can be improved by introducing a new air system to increase the air circulation in the workshop; equipped with heat-blocking effect of the blackout curtains to reduce the discomfort of direct sunlight. It should also strengthen the maintenance of equipment to reduce the quality problems and safety problems brought by equipment factors, create a safe working environment and prevent accidents.

Strengthen the use of production Kanban, which includes production performance, quality performance (finished product rate, rework rate, project progress and other information); early warning for different states, such as equipment failure downtime, abnormal commodity quality conditions, managers can instantly grasp the global state.

VI. CONCLUSION

Influenced by the national policy and epidemic, the competition in the domestic daily necessities market has become more and more fierce, and the former foreign trade type manufacturing enterprises must accelerate the transformation to ensure the production line balance to improve product quality and production efficiency and occupy the dominant position in the market. This paper mainly focuses on a cosmetic organizer mirror part assembly production line of company Z. Based on the production line balance theory, It provides some reference for related enterprises to solve the production line balance problem.

A cosmetic organizer mirror part assembly line of Company Z has a series of problems such as unbalanced production line, poor production site management and unscientific production process. The production line balance was initially evaluated by measuring the standard operating time, and then the

Forest Chemicals Review
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2022 Page No. 1969-1985
Article History: Received: 02 April 2022, Revised: 15 April 2022, Accepted: 24 April 2022, Publication: 04 May 2022

simulation model of the production line was constructed by using Flexsim simulation software to track the simulation results of equipment utilization, product in-process time and obstruction rate to find the bottleneck process. The calculation shows that the production line balance rate is only 55.45%, the production line loss rate is 44.55%, and the production capacity is 707 pieces. After optimization, the production capacity of this production line increased from 707 to 956 pieces in one shift, and the production efficiency was significantly improved. The production balance rate after optimization was 69.38%, which was close to 70%. It was also implemented to help the company improve the on-site management of the assembly production plant and create a safe and clean working environment. The optimization of production line balance and the implementation of site management improve the work of each workstation and can bring significant benefits to the enterprise.

Scholars and enterprises have never stopped researching and exploring the optimization of production lines. In the face of the emergence of more and more information-based, digital and intelligent production lines today, the previous optimization methods and measures are no longer fully applicable, and mathematical models can be appropriately used to optimize the relevant problems. In addition to process optimization, modern information technology can be used to solve production line problems, and the use of electronic data interchange, bar code technology, radio frequency technology and other technologies can be implemented at the production site to improve the efficiency of internal and external communication and collaboration and help improve production efficiency.

Some optimization methods for bottleneck processes are already using mathematical models, such as using 0-1 integer programming models to find the optimal solution. These are also the directions that can be further studied in the future.

REFERENCES

[1] Semih Önüt and Umut R. TuZkaya and Bilgehan Doğaç (2007) a particle swarm optimiZation algorithm for the multiple-level warehouse layout design problem. Computers & Industrial Engineering, 54 (4): 783-799.

[2] Ishak Aulia, FaiZ Zubair Ahmad, Sekar Cendani Assilla (2020) Production Line Simulation In Vise Using The Flexsim Application. IOP Conference Series: Materials Science and Engineering, 1003 (1): 012103

[3] Wang W, Zhang Y, Zhong R Y (2020) a proactive material handling method for CPS enabled shop-floor. Robotics and Computer-Integrated Manufacturing, 61: 101849.

[4] Liu G, Peng M H, Destech Publicat I (2017) Construction and Practice of a Smart Laboratory Based on "6+1"S Management Model. proceedings of the 4th International Conference on Economics and Management (ICEM), Chongqing, PEOPLES R CHINA, 6: 24-25.

[5] Lu Z, Zhuang Z, Huang Z, Et Al (2019) A Framework of Multi-Agent Based Intelligent Production Logistics System. Procedia CIRP, 83: 557-562.