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Production Line Balance Optimization Design of S Company

Wei Liu*, Qinglong Yang

Xiamen University Tan Kah Kee College, Zhangzhou, Fujian, China
**Corresponding author*

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Abstract: With the global emphasis on the development of the manufacturing industry, countries began to vigorously develop and reclaim manufacturing industry. As a global manufacturing power, China's manufacturing industry occupies a pivotal position in the national economy. In this paper, we take a brand stopwatch production line of S company as the research object, we find that there are many problems in the production line in S company, such as work-in-process backlogs, unbalanced process schedules, and confusing equipment management. Therefore, we analyse the current situation of the production line, we measure the standard time of its process operation, we research the bottleneck process, and we use the Flexsim simulation software to model and simulate the production line. we deeply analyze the blockage link and low utilization rate of each process, we improve the bottleneck link, and we merge, decompose or reorganize the workstations. Finally, the balance of the production line of the optimized factory has been significantly improved, the number of processes in the four production lines has been simplified, and the production balance rate reaches more than 60%, especially motherboard pre-processing line, assembly test line, and packaging line reach more than 80%, which greatly reduce the backlog of work-in-process and the waste of resources. then we optimize its product line based on ECRS rule, and we implement 5S management to promote the efficiency of its production line.

1. Introduction

1.1. Research Background and Significance

Under the environment of rapid global economic development, the manufacturing industry is facing a great crisis due to the fierce competition among manufacturing companies and the increasing production costs. With the increasing number of global electronics companies, the competitiveness of the Chinese electronics market has also intensified to a certain extent. At present, in the study of all the production line problems of domestic electronic products enterprises, the main problems include the following: production line balance problems, production flow, production tempo, bottleneck processes, small-lot, multi-variety order patterns, etc. These problems affect the production line efficiency and the production process. These problems affect the enterprise production line efficiency and production cost and restrict the enterprise from breaking through the bottleneck for sustainable development. [1-2]

With the increasing individualization and diversification of market demands, it is no longer a desirable approach for manufacturing companies to use mass production to reduce costs and improve competitiveness. Manufacturing companies around the world are constantly seeking ways to improve their competitiveness, and theoretical techniques such as just-in-time production, lean manufacturing, and production system simulation have been recognized and applied by most companies. [3] However, the use of software for production line simulation can effectively find the problems of the current production line, make bottleneck improvements, and ultimately achieve efficient production in enterprises. Nowadays, the problems of enterprise production are becoming more and more complex, and the mathematical analysis method alone can no longer solve them. Therefore, people pay more and more attention to the wide application of simulation technology in manufacturing production and the deeper research of its theoretical methods. We use computer simulation technology instead of the actual production line operation. We apply the actual data. It is possible to establish a new production line without causing a waste of human, material, financial, and time resources. We compare the data to propose improvement plans, the goal of improving production efficiency and reducing production costs in the workshop is achieved.

1.2. Research Methodology and Ideas

This paper takes a brand watch production line of S company as the research object, we based on the theoretical basis of production line balance, and we used field research on the current situation of S company's watch production line. We understood the current situation of the production plant, we recorded the content of each process in detail, and we measured the processing time of each process and other production data, then we collated and analysed the original data, and we obtained the production process table of a brand watch of the company. Based on the production process table, Flexsim was used to simulate the production line, and the problems of the production line in S company were summarized together with the production schedule and the balance rate of the production line. And finally, the production process was improved through ECRS rule to improve the balance rate of the production line.

2. Theories Related to Production Line Optimization

2.1. Definition and Meaning of Production Line Balance

The production line balancing problem, also known as Assembly Line Balance (ALB), means that all processes of production are averaged, and operations are adjusted load to make each process product time. The technical means and methods are as similar as possible. The purpose is to eliminate the efficiency loss of the imbalance between operations and over-production. The maximum capacity of a production line lies not in the fastest process but in the slowest process. An unbalanced production line often has all kinds of unnecessary waste, resulting in a backlog of work-in-progress between processes, prolonging the production cycle, reducing production per unit of time, and thus increasing production costs. [4]

The optimization of production line balance is of great significance, which is reflected in the ability to shorten product assembly or packaging time, increase output per unit time and reduce production costs; reduce the number of work-in-progress between processes and the occupation of the site; reduce the preparation time between processes and shorten the production cycle; eliminate the phenomenon of employee waiting and enhance employee motivation; change the traditional small-batch operation mode to one stream production, and stabilize and improve product quality, enhance overall factory productivity and reduce various waste phenomena on site. [5-6]

2.2. Production Line Balancing-related Terms

Flow line: It refers to the production procedure composed of the characteristics of flowing operation and generally refers to the production line in a factory.

Workstation: A designated work location on a production line where an operator can complete a specific process operation.

Job element: The process of work is divided into one non-divisible unit of operation.

Bottleneck: The part of the production line with the slowest production tempo. The existence of bottlenecks not only restricts the output speed of the assembly line, but also makes the workload of some processes uneven, leading to an increase in the production beat and affecting the smooth operation of production.

Idle time: The time during working hours when equipment or people are not performing effective tasks and not generating benefits. Idle time is generated in processes other than the bottleneck process when there is a process in the production line whose beat is not consistent with other processes.

Total operating time: The time it takes to produce a complete product on the production line in terms of the entire production process. It includes the total operating time of the operating processes that produce the product.

Order of precedence constraint: The order of processing between job elements. In pipeline job assignment, a job element can be assigned when and only when all previous job elements of that job element have been assigned.

Cycle Time: It is the interval time between two identical products completed in sequence under the stable condition of the production line. [7]

2.3. Evaluation of Production Line Balance

2.3.1. Balance Rate

The line balancing effect can be evaluated by the balancing rate indicator. The line balance rate is expressed as a percentage, which reflects the degree of balance of the operating time of each process in the product line. The higher the line balance rate, the more consistent the processing time of the production line, the less waiting between processes, and the higher the overall work efficiency. The balance of the production line is calculated as follows.

$$\textit{Production linebalancerate} = \frac{\textit{sum of production line process time}}{\textit{bottleneck hours} \times \textit{number of processes}} \times 100\% \tag{1}$$

2.3.2. Production Line Smoothing Index

The production line smoothing index reflects the degree of deviation of the operating time between each process. If the time required for each process is different and unevenly distributed, the larger the value is, the more unbalanced the production line is; on the contrary, if the time used for each process is almost the same, the smaller the value is, the more balanced the production line is, and the deviation of each process operation time distribution is smaller. The calculation formula is as follows (2).

$$SI = \sqrt{\sum_{i=1}^{m} (\mathrm{CT} - \mathrm{T}_i)^2 / m} \tag{2}$$

Where, CT: production beat, and T_i : operating time of process i, m: number of workstations.

2.4. The ECRS Rule of Production Line Balance

The ECRS Rule, namely Eliminate, Combine, Reorganize and Simplify, is one of the industrial engineering. It is used to optimize the production process in order to reduce unnecessary processes, thus achieving a relatively balanced production line and higher production efficiency.

Eliminate: First, consider whether the work has the possibility of being eliminated. If the work, process, and operation can be canceled without affecting the quality of semi-finished products and assembly progress, this is the most effective improvement. For example, unnecessary processes, handling, inspection, etc., should be eliminated, with special attention to those assembly operations with a large workload; if not all can be eliminated, they can be considered partially eliminated.

Combine: Combine is to turn two or more objects into one, such as the merging of processes or work, the merging of tools, etc. Combine can effectively eliminate the duplication phenomenon and can achieve a greater effect. When there is an imbalance in production capacity between processes, and when there are uneven workloads and uneven workloads, it is necessary to adjust and merge these processes. Some of the same work can be spread out in different departments, and the possibility of combining them in one process can be considered.

Reorganization (Rearrange): Reorganization is also called replacement. It is to improve the work by changing the work procedure so that the sequence of work is regrouped. For example, the exchange of front and back processes, the change of hand movements to foot movements, then Production site Adjustment of the position of machines and equipment, etc.

Simplification: After the cancellation, consolidation, reorganization, and then furthermore in-depth analysis of the work, the existing methods to simplify as much as possible to minimize production time and improve efficiency. [8-10]

3. Analysis of the Current Situation of Production Line of S Company

3.1. Analysis of the Current Situation of Production Line of S Company

3.1.1. A Brand of Bicycle Code Table Production Process

S Company is a manufacturer of different series of bicycle heart rate meters, yardsticks, and sensors. Its production line is a linear line, and the workshop works 8-10 hours per day. In this paper, a series of bicycle yardstick watches is studied as the object. The production process of this product is divided into four engineering sections: motherboard pre-processing, shell pre-processing, assembly and testing, and packaging.

3.1.2. A Brand Code Table Operation Element Division

The reasonable division of each operation element in the production line helps to study the balance of the production line. By collecting and investigating the information on the production process of a brand of bicycle heart rate watch of S company, the production process and operation time of a brand of bicycle heart rate watches are organized

3.1.3. A Brand of Code Watch Production Line Operation Time Measurement

The operating time of a brand of code watch production line in S company was collected by combining the leniency rate and using the stopwatch zeroing method to measure the operating time required for each process in S company's production line. In order to guarantee the accuracy of the collected operation time, 10 measurements were made for each process, and at the same time, the site managers and operators were questioned and confirmed, and the average value was taken as the final measurement time.

Table 1: Standard operation schedule for each process of a brand of code table of S company (unit: second)

Work sequence	Job Description	Average time	Standard deviation	Evaluation Coefficient	Relaxation rate	Standard time	Operation People
1	CPU burn-in	62	2.79	1	10%	63.1	1
2	Bluetooth burn-in + split board	55.8	0.77	1	10%	56.9	1
3	High temperature adhesive for shield cover	43	3.29	1	10%	44.1	1
4	Snap shield cover	24.3	1.68	1	10%	25.4	1
5	Motherboard Functionality Test	65	7.79	1	10%	66.1	1
6	Battery foam + conductive sponge	31.2	1.33	1	10%	32.3	1
7	Mainboard USB holder dispensing	23.8	0.75	1	10%	24.9	1
8	LCD paste copper foil + high temperature adhesive	50	6.11	1	10%	51.1	1
9	Solder buzzer wire	16.3	1.00	1	10%	17.4	1
10	Sticker breathable film + sticker buzzer	13	1.00	1	10%	14.1	1
11	Double-sided tape + press fit	17	0.89	1	10%	18.1	1
12	Install USB tail plug	18	0.94	1	10%	19.1	1
13	Tail plug + buzzer spot glue	17.6	0.49	1	10%	18.7	1
14	Light guide bracket mounted light guide column	15.2	0.60	1	10%	16.3	1
15	Keyed O-ring*6	12	0.77	1	10%	13.1	1
16	Keyhole oiling	30.1	0.94	1	10%	31.2	1
17	Install side button spring*3	42.9	2.21	1	10%	44	1
18	Install side buttons*3	30	1.61	1	10%	31.1	1
19	Install bottom button spring*2	17.3	0.46	1	10%	18.4	1
20	Install bottom button*2	24.8	0.87	1	10%	25.9	1
21	Install the power button spring + install the power button	17.4	0.80	1	10%	18.5	1
22	Sticker battery + install GPS cable + sticker foam	76	1.34	1	10%	77.1	1
23	Installing the motherboard	86.7	6.65	1	10%	87.8	1
24	Lock main board + light guide bracket	73.2	6.38	1	10%	74.3	1
25	Semi-finished product waterproof test	67.6	1.96	1	10%	68.7	1
26	Semi-finished functional tests	67.1	1.45	1	10%	68.2	1
27	Dispensing	40.8	0.60	1	10%	41.9	1
28	Screen closing + connector foam sticker	34.8	0.75	1	10%	35.9	1
29	Pressure-holding	22.2	0.60	1	10%	23.3	1
30	Whole machine waterproof test	58	2.00	1	10%	59.1	1
31	Appearance Inspection	45.2	1.78	1	10%	46.3	1
32	Whole machine function test	85	2.98	1	10%	86.1	1
33	Aging	36.5	0.81	1	10%	37.6	1
34	Accessory bagging	57.3	3.74	1	10%	58.4	1
35	Origami box (internal)	13.9	1.22	1	10%	15	1
36	Instruction manual, accessory bag in	15.9	2.12	1	10%	17	1
37	Box selection	30.9	0.70	1	10%	32	1
38	Formatting	31.5	1.50	1	10%	32.6	1
39	Film + code sheet wipe	58.8	2.04	1	10%	59.9	1
40	SN code	5.7	0.46	1	10%	6.8	1
41	Weighing sticker sealing sticker	21.5	0.81	1	10%	22.6	1
42	Code table in, carton in	11.9	0.83	1	10%	13	1
43	Packing	7.5	0.50	1	10%	8.6	1

As the actual operation is influenced by the staff's operational proficiency, working environment, motivation, and other factors, the measurement time of all processes tested in practice need to be considered in conjunction with the evaluation coefficient and the leniency rate as Table 1 shows. The formula for calculating the standard time is as follows (3).

$$Standard\ time = observation\ time \times rating\ factor \times (1 + leniency\ rate) \tag{3}$$

3.2. The Problem with a Brand of Code Watch Production Line in S Company

Through the field research of S company, according to its on-site production operation and production line scheduling situation, the company's development status and operation are relatively good, but there are still certain problems in the production line, in order to improve production efficiency and expand production, we must start from the production line, according to its own actual situation, and at the same time we learn from the production line optimization experience of excellent enterprises in the same industry, we take relevant measures to production line optimize and improve the production line.

3.2.1. Production Line Balance Problem

We take a brand watch production line as an example. The bottleneck process leads to a large gap in the production line production tempo. In the process of working hours statistics found that some work stations on the workers are very busy, while some work stations on the workers are relatively idle, there will be waiting time, which will affect the production efficiency of the whole production line, in addition, the inconsistency of the workload of employees makes the production line of each process workload imbalance, hindering the smooth operation of the production line, In addition, the inconsistent workload of employees makes the workload of each process in the line unbalanced, which hinders the smooth operation of the line.

3.2.2. Equipment Management Issues

Through the workshop site inspection, the workshop equipment room management is relatively chaotic. Employees usually take the equipment and put the equipment as they go, with no standardized management. Whenever the production equipment is replaced, there will be the situation that the required equipment can’t be found quickly, which leads to a lot of time wasted and affects the overall production efficiency.

4. Flexsim-based Line Balancing Optimization of S Company

4.1. Simulation Problem Analysis and Target Determination

Through the field research and analysis of the workshop of S company, a brand of code watch of S company is divided into five engineering sections, which are pre-processing of the main board, pre-processing of shell, assembly, testing, and packaging. Due to the actual site constraints, staffing and production plans, the five engineering sections of a brand of code watches are not carried out simultaneously, but after the completion of one engineering section and then continue to the next engineering section, based on this combined with the actual situation of a brand of code watch production line is further divided into four production lines: main plate pre-processing line, pre-processing shell line, organizational testing line, and packaging line.

In this paper, we simulate the motherboard pre-processing line, case pre-processing line, assembly test line, and packaging line through flexsim to find out the bottleneck process of each line and reflect the in-process backlog situation, and then we optimize the balance of each line to improve the balance rate of each sub-production line as much as possible, and finally achieve the overall efficiency improvement.

4.2. Flexsim Simulation Model Building

4.2.1. Simulation Element Definition

According to the process flow diagram of a brand code watch production line of S company, Flexsim simulation software is used to model the simulation entities. The simulation and modelling of the production line involve personnel and machines and equipment, etc., which are defined by the object entities in the entity library, and the correspondence between each production element in the production line and the object entities in the entity library is shown in Table 2 below.

Table 2: Correspondence table between each production element and object entity in the production line

Production elements	Object entities	Remarks
Raw Materials	Generator	Raw Material Sourcing Service
Each work station in the production line	Processor	Machines and equipment at each workstation
Semi-finished products	Temporary storage area	Storage links between different processes
Finished product	Absorber	Where to go at the end of the finished product

According to the above Table 2, we combined with the process flow diagram of a brand code watch production line of S company, it is known that the object entities in the production line simulation model to be established include 4 generators, 43 processors, 43 staging areas and 4 absorbers. By further dividing the production lines, the number of corresponding entities required for the motherboard pre-processing line, the pre-processing shell line, the assembly, and testing line, and the packaging line are shown in Table 3 below.

Table 3: Correspondence table of the number of entities in each production line

Simulation production line/number	Generator	Processor	Temporary storage area	Absorber
Motherboard pre-processing line	1	8	8	1
Housing pre-processing line	1	13	13	1
Assembly and testing line	1	12	12	1
Packaging line	1	10	10	1

4.2.2. Simulation Parameter Setting

(1)Setup of the generator

Generator corresponds production elements for raw materials, corresponding to the motherboard pre-processing line, pre-processing shell line, tissue testing line, and package line of raw materials, where the motherboard pre-processing line of raw materials for the initial raw materials, while the other lines of raw materials are the previous line of processing and semi-finished raw materials. As in the actual production will be prepared in advance for each production line of raw materials, so when production begins, raw materials can be continuously supplied, all the generator arrival time interval is set to 0 seconds.

(2)Processor settings

The processors in the simulation model correspond to each process of each production line.

Since the operators at each station of the production line do not perform mobile operations, no operator is set in the model, but the processing time of the corresponding station is set in each processor, which is the standard operating time of each station.

(3)Setting of temporary storage area

The staging area in the simulation model is used to store the work-in-progress of each process, and the backlog of work-in-progress of each process can be observed by the number of work-in-progress stored in the staging area, and the maximum capacity of all staging areas is set to 1000 in order to fully reflect the backlog of work-in-progress.

(4)Setting of the absorber

The absorber corresponds to the production elements of semi-finished output and finished output. The absorber of the motherboard pre-processing line in a brand code watch production line, the absorber of the pre-processing shell line corresponds to the semi-finished output, and the absorber of the assembly test line and packaging line corresponds to the finished output.

(5)Simulation runtime setting

According to the site research of a brand code watch production line of S company, it is known that its workshop starts working at 9:00 am and ends at 12:00 noon each, and starts working at 1:30 pm and ends at 6:30 pm or 8:30 pm, so the production line works 8-10 hours per shift. Now assume that the working time of a brand code watch production line is 8 hours, due to the 15 minutes break in the middle of each morning and afternoon, so the actual working time of the production line is 7 hours and 30 minutes, that is, the daily working time is 450 minutes and 27000 seconds, in order to maintain the coherence of flexsim operation, the running time of the Flexsim simulation model is directly set to 27000 seconds.

4.3. Run an Analysis of Simulation Results

According to the above definition of simulation elements and the setting of simulation parameters, and combined with the production process of a brand of Swatch.

When the Flexsim simulation model is run for 27000 seconds, four production line statistical reports are exported for the motherboard pre-processing line, the case pre-processing line, the tissue testing line and the packaging line.

4.3.1. Motherboard Prep Processing Line

Table 4: Mainboard pre-processing line simulation statistics report

Work sequence	Process name	Vacancy rate	Processing rate	Clogging rate
1	CPU burn-in	0.00%	100.00%	0.00%
2	Bluetooth burn-in + split board	10.04%	89.96%	0.00%
3	Snap shield cover	59.99%	40.01%	0.00%
4	High-temperature adhesive for shield cover	30.37%	69.63%	0.00%
5	Motherboard Functionality Test	0.70%	99.30%	0.00%
6	Foam	51.54%	48.46%	0.00%
7	Motherboard USB Dispensing	62.73%	37.27%	0.00%
8	LCD paste copper foil + high temperature adhesive	23.59%	76.41%	0.00%

Through the operation of the motherboard pre-processing line can be seen, when running 27000 seconds, can produce 403 semi-finished products, which in the process of button shield cover there is a large backlog of work in progress.

In addition, when the production line is running after the process buckle shield cover, paste shield cover high-temperature adhesive, paste foam, and motherboard USB dispensing four processes idle rate are high, running 27000 seconds after the statistical report shown in Table 4 below.

4.3.2. Shell Pre-processing Production Line

Through the operation of the pre-processing shell line, we know that when running 27000 seconds, 608 semi-finished products can be produced, among which there is a large backlog of in-process products at the process of applying double-sided adhesive + pressing, loading key O-ring *6 and keyhole oiling.

In addition, when the production line was run after the process of loading the bottom button spring*2, loading the bottom button*2, and loading the power button spring + loading the power button, the idle rate of the 3 processes was high, and the statistical report after running for 27000 seconds is shown in Table 5 below.

Table 5: Simulation statistics report of pre-processing shell line

Work sequence	Process name	Vacancy rate	Processing rate	Blockage rate
1	Solder buzzer wire	0.00%	100.00%	0.00%
2	Air permeable film buzzer	19.02%	80.98%	0.00%
3	Double-sided tape + press fit	0.12%	99.88%	0.00%
4	Install USB tail plug	0.18%	99.82%	0.00%
5	Tail plug + buzzer spot glue	2.34%	97.66%	0.00%
6	Light guide bracket mounted light guide column	14.94%	85.06%	0.00%
7	Keyed O-ring*6	31.68%	68.32%	0.00%
8	Keyhole oiling	0.43%	99.57%	0.00%
9	Install side button spring*3	0.55%	99.45%	0.00%
10	Install side buttons*3	29.82%	70.18%	0.00%
11	Install bottom button spring*2	58.49%	41.51%	0.00%
12	Install bottom button*2	41.66%	58.34%	0.00%
13	Install the power button spring + install the power button	58.33%	41.67%	0.00%

4.3.3. Assembly and Testing Line

Through the operation of the assembly test line, it can be known that when running for 27000 seconds, 300 finished products can be produced, of which there is a large backlog of work-in-progress at the process of applying battery, loading GPS line and applying the foam.

In addition, the idle rate is higher when the production line runs the 5 processes of post-process dispensing, screen closing, connector foam application, pressure-holding, appearance inspection, and aging. The statistical report after 27000 seconds of operation is shown in Table 6 below.

Table 6: Assembly test line simulation statistics report

Work sequence	Process name	Vacancy rate	Processing rate	Blockage rate
1	Sticker battery + install GPS cable + sticker foam	0.00%	100.00%	0.00%
2	Installing the motherboard	0.29%	99.71%	0.00%
3	Semi-finished product waterproof test	22.39%	77.61%	0.00%
4	Semi-finished functional tests	23.21%	76.79%	0.00%
5	Dispensing	52.94%	47.06%	0.00%
6	Screen closing + connector foam sticker	59.67%	40.33%	0.00%
7	Pressure-holding	73.85%	26.15%	0.00%
8	Lock main board + light guide bracket	15.89%	84.11%	0.00%
9	Whole machine waterproof test	33.88%	66.12%	0.00%
10	Appearance Inspection	48.32%	51.68%	0.00%
11	Whole machine function test	4.06%	95.94%	0.00%
12	Aging	58.16%	41.84%	0.00%

4.3.4. Packaging Line

Through the operation of the packaging line, it can be seen that the idle rate is high when the line is running after the two processes of SN code application and boxing. In addition, after 27000 seconds of operation, 609 finished products can be produced, among which there is a large backlog of work-in-process at the folding box, instruction manual, accessory bag loading, SN labeling, and sealing labeling.

In addition, when the production line is run after the process of applying SN code, boxing, folding carton and 4 processes of applying film + code table wipe, the idle rate is high, and the statistical report after running 27000 seconds is shown in Table 7 below.

Table 7: Packaging line simulation statistics report

Work sequence	Process name	Vacancy rate	Processing rate	Blockage rate
1	Accessory bagging	0.00%	100.00%	0.00%
2	Origami box (internal)	19.02%	80.98%	0.00%
3	Instruction manual, accessory bag in	0.12%	99.88%	0.00%
4	Box selection	0.18%	99.82%	0.00%
5	Formatting	2.34%	97.66%	0.00%
6	Film + code sheet wipe	14.94%	85.06%	0.00%
7	SN code	31.68%	68.32%	0.00%
8	Weighing sticker sealing sticker	0.43%	99.57%	0.00%
9	Code table in, carton in	0.55%	99.45%	0.00%
10	Packing	29.82%	70.18%	0.00%

4.4. Optimization Solution of Production Line Balance

Unbalanced production lines are usually caused by bottleneck processes and inconsistent production schedules of each process. Generally speaking, reducing the working time of the bottleneck process can be done by improving the operator's operation level, adding high-tech equipment, or improving the layout of the shop line. The ECRS rule of Eliminate, Combine, Rearrange and Simplify can be used to optimize the production process to reduce unnecessary processes, thus achieving a relatively balanced production line and higher production efficiency.

4.4.1. Mainboard Pre-processing Line Optimization

From the point of view of the bottleneck process, through the S company of a brand of code watch motherboard pre-processing line research found that the bottleneck process of the production line for the main board function test, the need to use the instrument motherboard tester. On the one hand, because the instrument is relatively expensive, the workshop has only one; on the other hand, the operation time of the process is limited by the operation time of the instrument, can not improve the operator's operating level and shorten the operation time, so the bottleneck process can not be improved in the short term.

From the production schedule of each production process, combined with flexsim analysis report, it can be seen that the production line of high-temperature adhesive paste shield cover, and buckle shield cover two processes with a high idle rate, respectively, and its immediate pre-process and immediate post-production schedule difference is large, and the two processes are adjacent processes, so they can be combined into one process. Similarly, the battery foam + conductive sponge and the motherboard USB holder dispensing situation is similar, and can also be combined into one process. The improved production process is shown in Table 8.

Table 8: Table of pre-processing process of main board after improvement

Project section	Work sequence	Job Description	Standard time	Operators
Motherboard pre-processing	1	CPU burn-in	63.1	1
	2	Bluetooth burn-in + split board	56.9	1
	3	Stick shield cover high temperature adhesive + buckle shield cover	69.5	1
	4	Motherboard Functionality Test	66.1	1
	5	Sticker battery foam + conductive sponge + motherboard USB seat point glue	57.2	1
	6	LCD paste copper foil + high temperature adhesive	51.1	1

4.4.2. Shell Pre-processing Line Optimization

Table 9: Improved shell pre-processing process table

Project section	Work sequence	Job Description	Standard time	Operators
Housing pre-processing	1	Solder buzzer wire	17.4	1
	2	Sticker breathable film + sticker buzzer	14.1	1
	3	Double-sided tape + press fit	18.1	1
	4	Install USB tail plug	19.1	1
	5	Tail plug + buzzer spot glue	18.7	1
	6	Light guide bracket mounted light guide column	16.3	1
	7	Keyed O-ring*6	13.1	1
	8	Keyhole oiling	31.2	1
	9	Install side button spring*3	44	1
	10	Install side buttons*3	31.1	1
	11	Installed bottom button spring *2 + installed bottom button *2	75.1	3
	12	Install the power button spring + install the power button	18.5	1

The bottleneck process of this line is loading side button spring*3, which can be improved by adding more workstations, and considering the large difference in production tempo between loading bottom button spring*2 and loading side button spring*3 in the process immediately after it, the two processes can be combined and then add more workstations. The improved production process is shown in Table 9.

4.4.3. Assembly and Testing Line Optimization

According to the brand of S company's code watch assembly and testing pre-production line, we found that the bottleneck process of the production line is the installation of the motherboard, and the process can reduce the operation time by replacing skilled operators, thus becoming a non-bottleneck process. After improvement, the bottleneck process is the whole machine function test, the process needs to use the whole machine tester, also on the one hand, because the instrument is relatively expensive, the workshop has only one; on the other hand, the operation time of the process is limited by the operation time of the instrument, can not improve the operator's operation level and shorten the operation time, so it can not be further improved in the short term.

From the production schedule of each production process, we combined with the flexsim analysis report, we can see that the production line has a high idle rate for the three adjacent processes of dispensing, screen closing, and pressing, and combined with the actual operation of the workshop, dispensing requires special instruments, so it is not convenient to combine with other processes, so the screen closing and pressing can be combined into one process. In addition, through the observation and understanding of the production line, the two processes of appearance inspection and whole machine function testing can be reorganized, so that the sequence can be switched, and the appearance plus inspection and aging can be combined into one process. The improved production process is shown in Table 10.

Table 10: Improved assembly test process table

Project section	Work sequence	Job Description	Standard time	Operators
Assembly test	1	Sticker battery + install GPS cable + sticker foam	77.1	1
	2	Installing the motherboard	85	1
	3	Lock main board + light guide bracket	74.3	1
	4	Semi-finished product waterproof test	68.7	1
	5	Semi-finished functional tests	68.2	1
	6	Dispensing	41.9	1
	7	Close the screen + paste the connector foam + pressure-holding	59.2	1
	8	Whole machine waterproof test	59.1	1
	9	Whole machine function test	86.1	1
	10	Appearance inspection + aging	83.9	1

4.4.4. Packaging Line Optimization

The bottleneck process in the packaging line is laminating film code table wiping, in addition to the parts bagging as a secondary bottleneck process, so the efficiency of the bottleneck process can be improved by increasing the number of work stations. The processes of folding cartons and instructions, and bagging accessories can be combined into one process due to the high idle rate. Similarly, the SN code and the weighing and sealing stickers, the code table loading, and the carton loading and boxing can be combined into one process. The improved production process is shown in Table 11 below.

Table 11: Improved packaging process table

Project section	Work sequence	Job Description	Standard time	Operators
Packaging	1	Accessory bagging	58.4	2
	2	Origami box + instructions, accessories bagged in	32	1
	3	Box selection	32	1
	4	Formatting	32.6	1
	5	Film + code sheet wipe	59.9	2
	6	Sticker SN code + weighing sticker sealing sticker	29.4	1
	7	Code table loading, carton loading + boxing	21.6	1

4.4.5. Comparative Analysis of Production Line Optimization

Table 12: Production line optimization comparison table

Project section	Optimization Comparison	Total number of work processes	Total number of operators	Bottleneck process time (sec)	Production balance rate
Motherboard preaddition Industrial production line	Before optimization	8	8	66.1	68.82%
	After optimization	6	6	69.5	87.27%
Shell preaddition Industrial production line	Before optimization	13	13	44	49.98%
	After optimization	12	15	31.2	65.33%
Assembly and testing line	Before optimization	12	12	87.8	67.04%
	After optimization	10	10	86.1	81.71%
Packaging line	Before optimization	10	10	59.9	44.39%
	After optimization	7	9	32.6	93.93%

After the optimization of the motherboard pre-processing line, pre-processing case line, organization test line, and packaging line, the number of processes in the four production lines has been simplified, and the production balance rate has been improved, reaching more than 60%, including the motherboard pre-processing line, assembly test line, and packaging line have reached more than 80%, greatly reducing the backlog of work in progress and waste of resources, while improving the production efficiency. The comparison table of production line optimization is shown in Table 12.

4.5. Equipment Management Optimization

Through the research of S company, we found that the equipment management of S company is relatively chaotic, whenever the production equipment is replaced, there will be a situation that the required equipment cannot be found quickly, which leads to a lot of time wastage and affects the overall production efficiency. The root cause of this phenomenon is that the workshop equipment room is not standardized and standardized management, resulting in more random storage of equipment, which in turn leads to an increase in the search time for equipment. [11]

In order to save the time of equipment replacement and improve the efficiency of the production line, 5S management is needed for the equipment put. First, according to the function, size and utilization rate of all equipment, three attributes of classification, and then named according to the classification results; second, according to the classification results of the equipment put shelves posted labels, to achieve all equipment point storage. Finally, to strengthen the workshop personnel's 5S awareness, so as to achieve the standardization of equipment, and standardized management.

5. Conclusion

As the country pays more and more attention to the real economy, it is an opportunity and a challenge for manufacturing enterprises. There is no doubt that the competition faced by the product manufacturing industry will become bigger and bigger, and the continuous optimization of production lines will become an important guarantee for the development of manufacturing enterprises. In this paper, we study the production workshop of S company, we use the production line optimization theory, we analyse and study the internal production line through flexsim simulation software, then we optimize its product line based on ECRS rule, and we implement 5S management to promote the efficiency of its production line, we hope that it can be a reference for other manufacturing enterprises' workshop production system optimization.

In the simulation modelling and optimization of the production system of S company, through the comparison and analysis of the simulation data, it can be concluded that the balance of the production line of the optimized factory has been significantly improved. After the optimization of the motherboard pre-processing line, pre-processing case line, organization test line, and packaging line, the number of processes in the four production lines has been simplified, and the production balance rate has been improved, reaching more than 60%, with the motherboard pre-processing line, assembly test line, and packaging line reaching more than 80%, it greatly reduced the backlog of work-in-process and waste of resources, while improving the production line's balance rate and production efficiency. At the same time, through the implementation of workshop 5S management, we have strengthened the management of workshop personnel and equipment management, we reduced ineffective working time and improved the efficiency of the workshop.

The production line balancing problem is research with great theoretical significance and application value. Although many scholars and enterprises have done a lot of exploration and research in this field so far and have achieved certain success, the optimization of production lines is a work that needs continuous improvement, plus the theoretical methods and software tools that need to be used for different problem directions in different industries are also different, therefore, the production line balancing problem, Therefore, the research of production line balancing problem needs active participation and research contribution from all walks of life.

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