

Research on Improvement of Electric Smoothie Machine Production Management Based on Industrial Engineering Methods

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Abstract

This paper focuses on the low production line balance rate and prominent bottleneck processes in smoothie machine production line. It employs industrial engineering methodologies to conduct optimization research. The stopwatch time research method is used to determine the operation time of each workstation, and the standard time of the process is determined by standardization analysis, then the operation status of the production line is diagnosed and evaluated, and the 5W1H question technology and ECRS principle are used to optimize the process. In view of the bottleneck process, the two-hand operation was analyzed, and the operator's two-hand action was improved according to the principle of action economy. The results show that the balance rate, balance rate, loss rate, production takt time and daily capacity of the improved production line have been greatly improved. This study provides effective methodologies and practical case references for household appliance manufacturing.

Keywords

Production Line Balance, Industrial Engineering, Operation Analysis, 5W1H, ECRS

1. Introduction

Under the background of globalization and trade liberalization, the market prospect of household appliances is very broad, and the demand for products continues to grow. Household appliances products continue to circulate and sell in the global scope, so that household appliances enterprises can expand a broader mar-

ket space, but it will also make the household appliances market competition more intense, enterprises need to deal with the development problems of reducing production costs, optimizing product quality, improving production efficiency and so on [1]-[3]. Industrial Engineering (IE) method has become an effective way to solve these problems. With the help of analytical technology, it records and evaluates the processing and assembly links in the production process, so as to establish the optimal operation mode, eliminate ineffective actions as far as possible, achieve efficient and economic operation, and standardize it [4]-[6].

Household appliances enterprises are facing fierce competition, and improving production efficiency has become the key. As a comprehensive household appliance manufacturing enterprise, W Company's smoothie machine production line is facing full-load production due to the surge in orders, and there are some problems such as low balance rate of production line, time-consuming bottleneck process, and insufficient utilization of equipment, so it is urgent to optimize the production process through IE method, shorten the delivery cycle, and enhance the competitiveness of enterprises [7] [8].

W Company is a large-scale comprehensive enterprise mainly engaged in the manufacturing of household appliances, which integrates R & D, manufacturing and sales. Because of the good quality of the products, the products are sold well at home and abroad, and the order quantity is greatly increased. However, through the investigation, it is found that in the production process of W Company, the production efficiency is low, there is waste, and the equipment is in a waiting state for a long time, which brings unnecessary losses to the enterprise.

This paper mainly uses the IE method to study the smoothie machine production line of W company. Through the in-depth analysis of the problems such as low efficiency and long waiting time in the production process of the smoothie machine production line, we can find out the problems, and further use the IE method to optimize and improve the various problems in the production process, so as to improve the production efficiency of the smoothies machine production line, and achieve a balanced state of production and marketing.

2. Production Status and Problems

At present, the production line of smoothie machine is facing the problem of full-load production and rapid increase of production capacity in the short term. Therefore, in order to meet the demand of orders, shorten the delivery cycle, and explore the reasons for the low balance rate of the current restriction of the smoothie machine production line, it is urgent to optimize the smoothie machine production line, put forward feasible improvement measures, improve efficiency, reduce production costs, maintain the leading edge of W company in the refrigeration household appliances industry and enhance the competitiveness of enterprises. Smoothie machine production is a typical pipeline operation, operation process is more, a comprehensive analysis of the production process is helpful to find the existing problems and key links, using stopwatch time research method

to measure the operation of each process, through the division of operation units, determine the number of observations, record the measurement time, eliminate abnormal values, calculate the normal time, determine the relaxation time and other steps.

Job testing refers to the use of scientific methods to determine the time required for qualified operators to complete a task under standard operating conditions. Its key goal is to establish a reasonable standard of working hours, help employees optimize the use of working hours, reduce ineffective labor, prevent waste of resources, and thus improve overall productivity. The stopwatch time research method mainly relies on the timing device to carry out continuous observation and data collection for the operation process of the operator, and then with the help of scientific operation evaluation procedures and the relaxation policy formulated by the enterprise, the operation standard time required to complete the specific operation process is finally accurately calculated.

The stopwatch time research method is used to obtain the reasonable operation standard time of each process, and the sample size should be sufficient. Appropriate sample size is helpful to improve the reliability of the data. However, if the sample size is too large, it will cause a waste of resources and prolong the research time. It is very important to determine the number of observations scientifically. In this study, the error bound method is used to calculate the required number of observations. Generally, the confidence level is 95% and the accuracy is 5%, that is, the error range between the sample mean and the population mean is controlled within $\pm 5\%$. In order to ensure that the data conform to the actual production, after communicating with the engineers of W Company, it was decided to carry out eight observations on each process of the production line of W Company's smoothie machine.

Obtain the data of each process. Specific standard operation time is shown in **Table 1**. It is not difficult to see that the bottleneck process is to fix the body and the bottom plate, and the standard operation time is 21.8 s.

Table 1. Standard operation time for each process.

Process content	Standard labor time/s	Process content	Standard labor time/s
1. The sealing ring is installed on the fixed seat.	12.6	30. Vacuum	17.4
2. Locking and fixing base	6.9	31. Fill the refrigerant	16.8
3. The refrigeration bucket assembly is fixed on the motor seat	15.2	32. Weld the tail pipe	19.1
4. Install microswitch	14.9	33. BDP Performance check	17.6
5. The motor bracket is fixed on the motor seat	17.2	34. Adhere EVA glue to the tray/compressor/capillary	11.3
6. The mixing motor is fixed on the motor seat	7.6	35. Halogen leak 1	15.1
7. Move to the next station	6.8	36. Performance testing	7.4
8. Inspection of refrigeration bucket assembly	12.8	37. Halogen leak detection 2	21.1

Continued

9. The refrigeration bucket assembly is fixed on the intermediate tray	15.9	38. Install the large body assembly on the bottom cover assembly	15.5
10. The support iron is fixed to the intermediate tray	15.2	39. Remove and clean the bucket	9.2
11. Fix the bottom plate to the compressor assembly	17.8	40. Clean the refrigeration components/fan blades	16.3
12. Fix the power cord	16.3	41. Lock the body assembly	16.4
13. Plug in the compressor	17.2	42. Fix the rear cover plate to the body	10.0
14. Install the compressor wiring box	8.4	43. Lock the front panel	16.4
15. Fix the ground wire	8.4	44. Fix the body to the base plate	21.8
16. The tray assembly is fixed on the base plate	14.1	45. Install the bucket/fan blade	9.3
17. Fix the condenser assembly	17.8	46. Safety inspection	16.1
18. High frequency welding	12.0	47. Laser coding at the power head	18.0
19. Braze welding	13.7	48. Clean appearance	17.4
20. Connect the front panel cable	15.1	49. Put POP stickers on	20.0
21. Plug in	19.1	50. Appearance inspection	17.8
22. Internal inspection 1	15.5	51. Power on inspection	14.7
23. Fix the power board seat	15.2	52. Label the power cord	16.4
24. Install the power board box	13.6	53. Cover the whole machine with tape and foam at the bottom	17.1
25. Install the lock rod	8.5	54. <u>Pre-folding</u> of color box body	12.7
26. Install the blade/drum	15.9	55. Put foam on the machine/instruction manual	12.5
27. Plug the control panel	17.0	56. Whole machine strapping with packing tape	12.9
28. Check the control panel	7.8	57. Fold the brown box	10.2
29. Internal inspection 2	9.8	58. Color box packing and sealing	18.3

Through field investigation and operation measurement, it is found that the following problems exist in the production line of smoothie machine:

1) Process waste: The refrigeration barrel components need to be handled across the line, the handling distance is 6.4 meters, the time is 6.8 seconds, and there is a waste of waiting.

2) Process imbalance: The bottleneck process of fixing the body and the bottom plate takes 21.8 seconds, which is much longer than other processes, resulting in the restriction of the overall production takt.

3) Non-standard operation: some employees do not operate according to the standard process, and their actions violate the economic principles, such as frequent one-handed operation, inconvenient access to tools.

4) Insufficient equipment management: under high load operation, the equipment maintenance is not timely, the failure rate is high, and the production continuity is affected.

5) Site management is chaotic: materials are stacked at random, tools are placed in disorder, and 5S management is missing, resulting in limited operation space and production interruption.

The balance effect of smoothie machine production line is not ideal, so it is necessary to find out the root cause of imbalance from many aspects and optimize the balance. In order to deeply understand the problems of production line balance, after communicating with operators and engineers, analyze from five aspects: personnel, machines, materials, methods and environment, and find out the root causes of the problems. The fishbone diagram is drawn to facilitate the subsequent optimization of the production line balance. The result of the fishbone diagram analysis is shown in **Figure 1**.

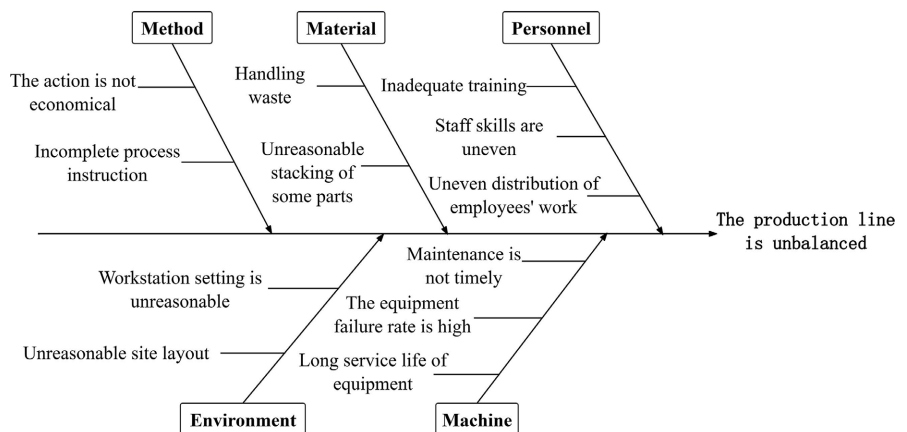


Figure 1. Results of fishbone diagram analysis.

The fishbone diagram is used to analyze the current production situation of the smoothie machine. The imbalance of the production line is caused by the interaction of many factors, mainly including the following aspects:

1) In the actual production process, if the production process can be carried out smoothly and efficiently, it is necessary to reduce or eliminate waste. Among. Taking the production of refrigeration barrel components as an example, after the production is completed on another line, the components need to be transported to the final assembly line by special staff, the transportation distance is up to 6.4 m, and it takes 6.8 s to go back and forth. Long time handling will not only cause staff fatigue, which is not conducive to the health of employees, but also reduce the speed of handling, and the next process will appear waiting phenomenon, resulting in unnecessary waste, thus affecting the smooth progress of production. In addition, the refrigeration barrel assembly is manually handled, which requires additional personnel and increases production costs.

2) The bottleneck process of the production line, fixing the body and bottom

plate, has a standard operating time of 21.8 s, which is longer than the standard operating time of other processes. It can be found that the operators do not operate according to the standard process by investigation, but rely on their own experience to operate, and their actions generally violate the principle of action economy, which has a direct impact on the efficiency of the production line. In order to improve the balance rate and production efficiency of the production line, it is necessary to focus on solving this problem. It is very important to optimize the bottleneck process.

3) Due to the large number of orders, the production line has been in a state of high load operation for a long time, and the utilization rate of equipment is high. At the same time, the production plan is often overfull or conflicting, which hinders the maintenance of equipment and makes it difficult to carry out effectively, resulting in untimely maintenance. Some minor abnormal situations can not be dealt with at the first time, and only after the expansion of the problem can they be paid attention to, which affects the normal production. In addition, due to the lack of instructions for handling abnormalities on site, employees are unable to deal with some simple equipment abnormalities at the first time. Employees have weak awareness of maintenance and do not cherish the equipment. The non-standard operation of some employees leads to the increase of equipment failure rate. At the same time, there is no standby equipment, which can not be replaced in time when failure occurs. Some equipment has a long service life, and the equipment may be aging, resulting in frequent mechanical failures of equipment in the workshop.

4) There is a lack of 5S management in the production site, some materials are stacked at will, and some materials are stacked too much, which squeezes the operation space of the operators, hinders the operation of the operators and reduces the work efficiency. Items unrelated to production are not placed in the specified area in some posts. Items unrelated to production are not placed in the specified area in some posts. There is no clear location of tools, and some employees place them in the working area at will after using the working tools. Employees did not clean the responsible area as required after work, resulting in waste around the production line. Workstation accessories do not have containers for waste materials, and waste screws may be discarded around the line body. Often, screws are stuck in the chain of the transmission line, causing the production line to be interrupted. Some posts require wearing electrostatic bracelets, and employees do not wear them as required.

Line balance rate is a key index to measure the matching degree of operation time of each process, which can reflect the level of production line balance. The range of its value is from 0 to 1. If the balance rate value is low, it means that there is a very prominent difference in operation time between each station. Such an unbalanced state will lead to a decline in production efficiency. Loss rate is a reverse indicator corresponding to the balancing rate, which is the ratio of the total waiting time of each operation to the total production cycle. This indicator can

intuitively reflect the degree of production efficiency loss caused by the imbalance between operations.

3. Optimal Design of Production Line Balance

3.1. Production Line Process Optimization

The 5W1H questioning technology is used to continuously carry out a series of questions on process 37. After analysis, it is determined that the process can be cancelled and will not affect the production quality. Then this method is extended to other processes to systematically identify the unreasonable links in the process. The specific situation is as follows:

1) Process 14 and process 15 can be combined into one process. The processing time of the two processes is relatively short. After the installation of the compressor wire box is completed, the ground wire is fixed. The two processes can be combined into one process. It eliminates the waste of personnel waiting in process 14 and process 15, reduces the operation time, improves the production efficiency, and reduces one operator. After optimization and re-calculation, the standard operation time after the combination of operation 14 and operation 15 is 14.9 s.

2) Process 25-installation of lock rod and process 26-Installation of fan blade and charging bucket can be combined. Before optimization, process 25-installation of the lock bar is started after the installation of the power board box in process 24. However, it is found that the two processes can be carried out simultaneously, and process 26-installation of the lock bar takes a relatively short time and will not affect each other. After the two processes are combined, the waiting time for process connection is eliminated, the production efficiency is improved, one independent operation post is reduced, the personnel is simplified, and unnecessary investment can be reduced.

3) Process 28-control panel check can be cancelled. This inspection procedure is mainly to check the operation content of procedure 27-control panel cable insertion, and check whether the cable is inserted in the wrong position. Since the operation of the process 27 is less complicated, the probability of misoperation by the operator is small, and the inspection process 35 can be completed synchronously during the operation, so that the basic inspection task of the control panel can be completed while ensuring the quality of wiring. Avoid repeated setting of independent inspection process, and reduce the manpower allocation of one post.

4) Process 50-appearance inspection can be cancelled. If the machine has scratches, scratches, bumps and so on, it will be judged as unqualified, so the appearance inspection is important. Process 50-appearance inspection is mainly to check whether the product appearance has scratches, scratches, bumps and other problems, but before process 48-appearance cleaning and process 49-put POP stickers pasting, the operators of process 48 and process 49 will inspect the appearance first, and then carry out subsequent operations. Therefore, process 50 – appearance inspection is a repeated inspection and is not necessary, so this process is cancelled to reduce the workload.

The production process was optimized by using 5W1H questioning technology and ECRS principle, and three unnecessary processes of halogen leak detection, control panel inspection and appearance inspection were cancelled; the two adjacent processes of installing the compressor box and fixing the ground wire were merged, and the two adjacent processes of installing the lock bar and installing the fan blade/bucket were merged. It can be Shown in **Table 2** for comparison before and after process optimization. After optimization, the number of processes is reduced from 58 to 52, which shortens the operation time and improves the production efficiency.

Table 2. Comparison before and after process optimization.

Order number	Process name	Optimize content	Operation time before and after optimization/s
1	Halogen leak detection ²	Cancel the process	Before: 21.1 After: 0
2	Install compressor line box and fix the ground wire	Merge the two processes	Before: 16.8 After: 14.9
3	Install lock rod, blade and bucket	Merge the two processes	Before: 24.4 After: 15.9
4	Check the control panel	Cancel the process	Before: 7.8 After: 0
5	appearance inspection	Cancel the process	Before: 17.8 After: 0

3.2. Bottleneck Process and Two-Hand Operation Optimization

Based on the process analysis and the actual situation, the improvement measures are put forward: adjusting the process layout, moving the production line of refrigeration barrel components to the front end of the assembly line, eliminating the waste of handling through the conveyor belt, reducing the waiting time and reducing the labor cost. Add all-round workers to solve the problem of employees leaving their posts, ensure the continuity of production and improve efficiency. The material placing rack is additionally arranged, so that the material taking time is shortened, the bending action is reduced, the labor intensity is reduced, and the production efficiency is improved. This paper analyzes all the procedures of the smoothie machine production line by using process program analysis, optimizes the production process from five aspects of operation, inspection, handling, waiting and storage, and puts forward the following improvement measures in combination with the actual situation of the production line:

1) Move the line bodies from process 1 to process 6 to the front end of the final assembly line. The refrigeration barrel assembly is produced on a nearby line. After the production is completed, the staff will carry it to the assembly line for the next step of production. The carrying distance is 6.4 m, and it takes 6.8 s to go

back and forth. Long time handling will not only cause employees to feel tired and bored, but also reduce the speed of handling, resulting in the waste of waiting in the next process, which is not conducive to the normal and smooth production. During the field investigation, we communicated with the company's engineers to see if we could improve it. After discussion, we decided to adjust the production line of the refrigeration barrel assembly to the front end of the assembly line. After the completion of production, it was directly transported to the assembly line by the conveyor belt, eliminating unnecessary handling waste and waiting waste, so that the production process was smooth.

2) In the production process, each process is a special post, that is, each post is responsible for the corresponding operation. However, operators may temporarily leave their posts due to personal affairs, such as going to the toilet and dealing with temporary emergencies, which will lead to the stagnation of the production line and affect the fluency of production. In order to solve this problem, one or more all-round workers can be added to ensure the continuity of production when other workers are temporarily offline.

3) A material placing rack is additionally arranged. A material placing rack is additionally arranged at the working procedures of installing a power supply plate box, a locking rod, a fan blade, a charging bucket and the like and is used for storing corresponding materials, so that an operator can take the materials more conveniently and quickly, the working procedure operation time is reduced by shortening the material taking time, eliminating the action that the operator frequently bends down to take the materials and reducing the labor intensity, and the overall production efficiency is improved.

Through the optimization of the production process, six unnecessary processes are eliminated, including two processing processes, one handling process and three inspection processes, the unnecessary handling distance is shortened by 6.4 m, and the total unnecessary production time is reduced by 67.3 s. The optimization effect is good, which can reflect that the scheme is effective and feasible.

Analyze the bottleneck of smoothie machine production line and optimize the action of operators. Improve the operation method and site layout, increase the efficiency, and reduce the fatigue and operation time. For procedure 39-fixing the body and baseplate, the two-hand work analysis method and the principle of motion economy were used for optimization. Draw the two-handed operation analysis for this process as shown in **Table 3**.

This paper analyzes the two-hand operation of the bottleneck process of the smoothie machine production line, observes the operation process of the operators, combines with the principle of action economy, optimizes the operator's action by improving the operation method and site layout, makes the action more reasonable and efficient, reduces the fatigue of the operators caused by long-term one-hand operation, and achieves the purpose of reducing the operation time and improving the production efficiency.

Through two-hand operation analysis and 5W1H questioning, the traditional electric screwdriver is replaced by a hand-held automatic screw machine, which

Table 3. Analysis of two-handed operation before optimization.

The left hand	Process	Carry	Wait	Hold on	Process	Carry	Wait	Hold on	The right hand
	○	→	D	▽	○	→	D	▽	
Wait			D			→			Move to the electric screwdriver station
Wait			D		●				Pick up the electric screwdriver
Wait			D			→			Move to the front of the body
Move to the screw box location		→					D		Wait
Pick up six screws	●						D		Wait
Move to the front of the body		→					D		Wait
Align the screw head with the electric screwdriver	●				●				Electric screwdriver aligns with the screw head
Hold the remaining screws				▽	●				Align the screw with the screw hole
Hold the remaining screws				▽	●				Press the switch and tighten the screws
Hold the remaining screws				▽		→			Release the switch and pick up the electric screwdriver
Screw moves to the electric screwdriver position		→				→			Move the electric screwdriver to the screw position
Align the screw head with the electric screwdriver	●				●				Electric screwdriver aligns with the screw head
Hold the remaining screws				▽	●				Align the screw with the screw hole
Hold the remaining screws				▽	●				Press the switch and tighten the screws
Hold the remaining screws				▽		→			Release the switch and pick up the electric screwdriver
Screw moves to the electric screwdriver position		→				→			Move the electric screwdriver to the screw position
Align the screw head with the electric screwdriver	●				●				Electric screwdriver aligns with the screw head
Hold the remaining screws				▽	●				Align the screw with the screw hole

Continued

Hold the remaining screws		▼	●		Press the switch and tighten the screws
Hold the remaining screws		▼		→	Release the switch and pick up the electric screwdriver
Screw moves to the electric screwdriver position	→			→	Move the electric screwdriver to the screw position
Align the screw head with the electric screwdriver	●		●		Electric screwdriver aligns with the screw head
Hold the remaining screws		▼	●		Align the screw with the screw hole
Hold the remaining screws		▼	●		Press the switch and tighten the screws
Hold the remaining screws		▼		→	Release the switch and pick up the electric screwdriver
Screw moves to the electric screwdriver position	→			→	Move the electric screwdriver to the screw position
Align the screw head with the electric screwdriver	●		●		Align the electric batch on the screw head
Hold the remaining screws		▼	●		Align the screw with the screw hole
Hold the remaining screws		▼	●		Press the switch and tighten the screws
Hold the remaining screws		▼		→	Release the switch and pick up the electric screwdriver
Screw moves to the electric screwdriver position	→			→	Move the electric screwdriver to the screw position
Align the screw head with the electric screwdriver	●		●		Electric screwdriver aligns with the screw head
Wait		D	●		Align the screw with the screw hole
Wait		D	●		Press the switch and tighten the screws
Wait		D		→	Release the switch and pick up the electric screwdriver

eliminates the actions of taking and holding screws, as well as the steps of frequently aiming at the screw head, reduces the waiting time, reduces the operation time of the bottleneck process, improves the efficiency of both hands, alleviates

the fatigue of one-hand operation, and ensures the balance of two-hand operation.

The original traditional electric screwdriver is replaced by a hand-held automatic screw machine, the actions of taking and holding screws are cancelled, and the frequent action of aligning the electric screwdriver with the screw head can also be cancelled, so that unnecessary waiting waste is eliminated, the operation time of a bottleneck process is reduced, It relieves the fatigue caused by long-term single-handed operation and ensures the balance of two-handed operation.

The optimized two-hand operation analysis is shown in **Table 4**.

Table 4. Analysis of optimized two-handed operation.

The left hand	Process	Carry	Wait	Hold on	Process	Carry	Wait	Hold on	The right hand
	○	→	D	▽	○	→	D	▽	
Wait			D			→			Move to the automatic screw machine location
Wait			D			→			Pick up the automatic screw machine
Hold the fuselage				▽	●				Align the bit with the screw hole
Hold the fuselage				▽	●				Press the switch and tighten the screws
Hold the fuselage				▽		→			Release the switch and pick up the electric screwdriver.
Hold the fuselage				▽	●				Align the bit with the screw hole
Hold the fuselage				▽	●				Press the switch and tighten the screws
Hold the fuselage				▽		→			Release the switch and pick up the electric screwdriver.
Hold the fuselage				▽	●				Align the bit with the screw hole
Hold the fuselage				▽	●				Press the switch and tighten the screws
Hold the fuselage				▽		→			Release the switch and pick up the electric screwdriver.
Hold the fuselage				▽	●				Align the bit with the screw hole
Hold the fuselage				▽	●				Press the switch and tighten the screws
Hold the fuselage				▽		→			Release the switch and pick up the electric screwdriver.
Hold the fuselage				▽	●				Align the bit with the screw hole

Continued

Hold the fuselage	▼ ●		Press the switch and tighten the screws
Hold the fuselage	▼	→	Release the switch and pick up the electric screwdriver.
Hold the fuselage	▼ ●		Align the bit with the screw hole
Hold the fuselage	▼ ●		Press the switch and tighten the screws
Wait	●	→	Release the switch and pick up the electric screwdriver.

3.3. Optimization of Production Line Management

Carry out 5S management, including tidying, rectifying, sweeping, cleaning and self-cultivation, improve the environment of production site and improve efficiency. Optimize the staff management system, improve the training system, implement the reward and punishment system, and improve the enthusiasm of employees. 5S has the advantages of simple implementation and quick effect, which is a common method to improve the production site environment. Through the implementation of 5S management, we can clarify the location of goods, ensure the safe production of contracts, reduce production costs, train the quality of employees and improve production efficiency. Specifically, it includes the following aspects:

1) Seriri means organize employees to inspect all aspects of the workstations they are responsible for, including places that are extremely difficult to detect. Secondly, according to their own work needs, employees classify all materials and tools on the workstation, keep the necessities, and carry the non-necessities to the specified place for storage.

2) Seiton means classify the remaining items needed for their own work after seriri, make clear the placement location, carry out fixed-point and positioning placement, count the quantity, and mark the relevant effective marks.

3) Seiso specifically refers to the timely removal of the waste generated during the operation process, so as to eliminate the interference caused by the waste to the production process. During the period of shutdown, it is necessary to use special maintenance tools to clean and maintain the equipment in accordance with the regulations, so as to prevent equipment damage caused by improper human operation.

4) Seiketsu means that the previous 3s work should be done carefully, maintained in daily production, and institutionalized and standardized. Formulate a reward and punishment system, check the cleanliness, reward the good posts and punish the bad posts. Establish a leadership mechanism, requiring leaders to take the lead in inspection, only when leaders attach importance to it, can they make good demands on employees, so as to implement it among employees.

5) Shitsuke is to abide by the company's rules and regulations and maintain 4S management. On the one hand, good literacy is reflected in the compliance of rules and regulations, on the other hand, it is reflected in whether we can actively find the shortcomings of the system and optimize and improve it. We should also strengthen the behavior habits of employees through regular training, eliminate the negative and slack mentality, and maintain the normalization of a good style of work.

4. Conclusion

In this paper, a company's smoothie machine production line is taken as the research object. By utilizing stopwatch time measurement to determine standard process times and applying the 5W1H and ECRS principles to merge redundant processes and eliminate repetitive inspections, smoothie machine production line has significantly improved production efficiency through process balance optimization on the premise of ensuring production capacity and product quality. The improvement of bottleneck process has shortened the production cycle, and the number of processes has been reduced from 58 to 52. In addition, production line personnel have been streamlined, unnecessary waste has been reduced, and labor costs have been reduced accordingly. After the balance optimization, all the indexes of the production line have been improved, and the balance rate of the production line has increased by 9.99% compared with that before the optimization, reaching a level of more than 75%, and the overall operation efficiency of the line has achieved a better balanced state.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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