ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research, volume 329
4th International Conference on Contemporary Education, Social Sciences and Humanities (ICCESSH 2019)

Balance and Optimization of Sewing Production Line Based on Action Attention

Mengcheng Qin
School of Economic and Management
Beijing Jiaotong University
Beijing, China

Jiayi Yao
School of Economic and Management
Beijing Jiaotong University
Beijing, China

***Abstract*—Sewing technology has high particularity in textile enterprises and plays an important role in production. So this paper takes the sewing line of plush toys as the research object. According to the characteristics of the enterprise and the problems in the production process, the operator needs to pay attention to the sewing process to ensure the process requirements. Different processes require different intensity of attention, which causes the operator to have a psychological choice of the process. Therefore, the model method is used to divide the attention action required in the sewing process, and the process is split and combined, and the process is assigned to operators with different skills and qualities, so as to improve the balance level of production line. Through case analysis, the attention intensity of movement is optimized to meet the requirements of high quality and efficient production line.**

Keywords—sewing; model method; attention; production line balance

I. INTRODUCTION

Textile enterprises are an important part of the manufacturing industry. The market environment is becoming more and more severe, it is the long-term survival for enterprises by improving production efficiency and reducing production costs. It is an important way to apply industrial engineering methods to improve enterprise efficiency.

The plush toy enterprise is also a part of the textile enterprise. The whole supply chain of the order to the production delivery process of the plush toy is similar to other enterprise. Therefore, the research of plush toy production process management has important guiding significance for plush toy enterprises. it is also an important reference for other types of textile enterprises. The production process of plush toys mainly includes electric embroidery, cutting, sewing, cotton filling, hand-making, packaging and other major processes. The sewing process is the core of the production process of the enterprise. There are some enterprises gaining profit by improving sewing production efficiency and products quality, which shows the complexity of sewing process management.

II. ANALYSIS OF THE CURRENT SITUATION OF SEWING PRODUCTION LINE

A. Sewing Process

The sewing process is the evolution of the traditional sewing, and each sewing process is an important factor affecting the production efficiency of the enterprise. Sewing is one of the production processes with the longest process and longest working time in textile enterprises, and it involves the largest number of people and equipment. It's directly related to production [1]. The layout of sewing production line needs to consider a variety factors comprehensively. Firstly, according to the product process characteristics, the process sequence is strictly defined, the different sewing processes are reasonably assigned to the appropriate operators, and the number of workstations and workstation idle time on the production line are reduced as much as possible. The load between the workstations is even, and each workstation could adapt to the production beat to ensure the lowest time loss rate of the pipeline. The production manager of small and medium-sized textile enterprises is relatively lacking in IE optimization consciousness. It relies solely on the experience of production managers, and the influence of multiple factors cannot be considered comprehensively. Sewing process management is not scientific and rigorous. For small and medium-sized textile enterprises, the cutting-edge methods in a large number of literature researches are not compatible with the actual situation of the enterprise. Therefore, it is very urgent to use the sewing production line control scheme which can meet the needs of the managers of small and medium-sized textile enterprises.

B. Line Balance

The sewing production line balance means that the sewing process is divided into several processes in the sewing production line, and according to the product process requirements, process difficulty, processing time, etc., the workers are reasonably arranged to operate, so that the production speed and quality of each process can be balanced [2]. In order to make the number of products more uniform in each station, the production line runs smoothly, and the qualified products are produced at regular intervals.

However, due to the actual development situation, product characteristics and operations are not incompatible,

and the order of work is constrained, the production line balance level cannot be completely unified. Therefore, the production line balance level is measured by production line balance rate (LBR), staffing efficiency (E), and smoothness index (SI) [3].

$$LBR = \frac{\sum T_i}{CT \times n} \times 100\% \quad (1)$$

$$E = \frac{\sum T_i}{CT \times m} \times 100\% \quad (2)$$

$$SI = \sqrt{\frac{\sum (CT - T_j)^2}{n}} \quad (3)$$

In the formula, Ti represents the standard working time of i process, Tj represents the total standard working time of each process of the j station, CT represents the bottleneck station working time in the production line, n represents the number of stations in the production line, and m represents the number of workers in the production line.

C. Analysis of the Current Situation of Sewing Production in Enterprises

The toy company has several branch factories, and each factory is located in the middle of china. The labor characteristics are relatively obvious. There are several working groups in the sewing production line, the process of producing a plush toy as an example to analyse. Because the company produces a relatively large variety of products, and the production plan is unevenly distributed, the companies usually send production plans to factories, and the specific production plan is determined by the factory production department, so there are many problems in the process of production management. The standard working time for each sewing process is shown in "Table I" about the toys. The load of each station is shown in "Table II".

TABLE I. STANDARD WORKING TIME OF SEWING PROCESS

Serial number	Process name (seam)	Standard working time / S
1	Face fold angle *3/coordinate silk screen	47
2	Face fold angle/Ear ending*2	49
3	Piece brains/fold angle	40
4	Piece head	41
5	Sewing arms	26
6	Overturn arms	6
7	Belt attached to the body	13
8	Piece side body，fold label	28
9	Positioning label	17
10	Sewing base fold label	43
11	Overturn body	9
12	Arms attached to body	32
13	Attach to head	44
14	seal	11
15	Sewing particle bag/trim	12
16	Seal particle bag/trim	8
17	Positioning particle bag	9
18	Pour particles into bag	6
19	Stretch elastic band	15
20	Facade fix pieces	13
21	Piece clothes shoulder	16

TABLE II. ENTERPRISE CURRENT STATION LOAD TABLE

station	process	time
A	1	47
B	2	49
C	3	40
D	4	41
E	5.6	32
F	7.11	22
G	8.9	45
H	10	43
I	12	32
J	13	44
K	14.17	20
L	15.16.18	26
M	19.20	28
N	21	16

The enterprise worked out the balance load table of the toy in sewing production line. The balance level of production line is analyzed by "Table II".

$$LBR = \frac{\sum T_i}{CT \times n} \times 100\% = \frac{481}{49 \times 14} \times 100\% = 70.117\%$$

$$SI = \sqrt{\frac{\sum (CT - T_j)^2}{n}} = \sqrt{\frac{4433}{14}} = 17.794$$

TABLE III. PRODUCTION LINE BALANCE LEVEL EVALUATION PARAMETERS

	LBR	*E*	*SI*
qualified	⩾85%	⩾80%	⩽15
unqualified	⩽85%	⩽80%	⩾15

The staffing efficiency can balance the contradiction between the station time and the number of personnel and increase the scientific nature of the production line balance rate. When there is only one worker at each station, the staffing efficiency is the highest and the LBR and E are equal. By calculating the current station load table of the company's sewing production line. Three kinds of parameter evaluation criteria are shown in “Table III”, the balance level of the production line is low, which does not meet the requirements of high-quality and efficient production line level [3].

There are mainly problems in the production process:

- The industrial engineering department of the company formulates the unit price of the process according to the proportion of working hours, It is unreasonable to divide the unit price of the process with different psychological load intensity.
- The production managers usually make the balance load table of production operation according to the simple combination of process standard timetable, sewing group is not suitable for the implementation of the load table.
- The factory processing is mostly multi-variety and small-volume orders. The sewing line has a low balance rate, which makes the single product not off the assembly line. Individual stations apply for new products to go online. The workshops such as electric embroidery and cutting cannot supply the vehicles on time. Workshops lack direct production planning communication, which makes the sewing group management chaos.
- The combination of process division is unscientific, and the production rhythm of different stations is inconsistent. For the process that meets the employees' psychological expectation, the employees accelerate manufacturing of semi-finished products, and there is a gap between the skill and quality level of the station personnel. Some stations exceed the expected production beat, the number of products in different stations is quite different, these would cause blockage of the assembly line.

The problems in the production process mainly stem from the unreasonable formulation of the station load table. There is no scientific basis for the combination of the process. Except for the time factor, the work of the sewing process itself is not considered to be different from the general labor intensity. The physical labor intensity is relatively small, and the particularity of the sewing process makes the attention intensity of the employees in each process different, and the psychological load will be different. Therefore, the comprehensive analysis is optimized based on the attention required for the process.

III. PRODUCTION LINE BALANCE OPTIMIZATION

The model method is based on various standard methods of booking time. The model method combined with the research results of human factors engineering, and the human physiological structure is fully considered, and the actual operation actions are summarized into 21 basic actions, and according to human actions. The order is determined by the time consumption value of the finger movement once, the fingers move about 2.5cm, and the required time is 0.129s, 1 MOD is equal to 0.129 s, the number of mods determines the time value of each action [4]. The movements determined by the model law are simple in classification, small in number, and easy to remember. Therefore, the model method of action classification can reduce the workload during analysis and greatly reduce the research cost. According to the research needs, the action of the model method attention and some of the actions that bring the psychological load are classified as shown in Table IV. According to “Table IV”, the attention action required for the toy sewing process is shown in “Table V”.

TABLE IV. MODEL METHOD ATTENTION ACTION CLASSIFICATION

Action type	Action description	Mark
Tough or grip action	Complexly griping: There is hesitation in grasping the target. Or there are obstacles around the target. Or the target is relatively small. It is not easy to get it. Or the object is easily deformed and fragile. The characteristic is that it requires attention. Under normal circumstances, the two fingers will be hesitation. After the finger or the hand touches the object, it is impossible to grasp it simply by closing with a hand or a finger [4].	G3
Place action	Coordination at the approximate position: The action of placing an object at the destination requires an eye to determine the approximate position of the object.	P2
	Complex placement action: Accurately place the object in the specified position or perform the matching action, accompanied by more than two correction actions, from the beginning to the end, the eye needs to be observed, and the action needs to be considered.	P5
Lower limb movement	Foot movement: it can be used to indicate the action of stepping on the sewing machine pedal	F3
Additional factor action	Visual action (independent action): See the work of adjusting the focus. During the sewing machine work, it is necessary to observe the trajectory of the needle, the piece, the position of the figure, etc.	E2
	Corrective action (independent action)	R2
	Judge action	D3

TABLE V. ATTENTION ACTION IN THE SEWING PROCESS

Serial number	Process name (seam)	Standard working time / S	Action(attention)
1	Face fold angle *3/coordinate silk screen	47	G3*N1 P5*N1 F3*N1 E2*N11 R2*N1 D3*N1
2	Face fold angle/Ear ending*2	49	G3*N2 P2*N2 F3*N2 E2*N2 R2*N2
3	Piece brains/fold angle	40	G3*N3 P5*N3 F3*N3 E2*N3 R2*N3 D3*N3
4	Piece head	41	P2*N4 F3*N4 E2*N4 R2*N4 D3*N4
5	Sewing arms	26	P2*N5 F3*N5 E2*N5 D3*N5
6	Overturn arms	6	E2*N6 D3*N6
7	Belt attached to the body	13	P2*N7 E2*N7 D3*N7
8	Piece side body，fold label	28	G3*N8 P5*N8 F3*N8 E2*N8 R2*N8 D3*N8
9	Positioning label	17	P5*N9 F3*N9 E2*N9 R2*N9 D3*N9
10	Sewing base fold label	43	G3*N10 P5*N10 F3*N10 E2*N10 R2*N10 D3*N10
11	Overturn body	9	E2*N11 D3*N11
12	Arms attached to body	32	P2*N12 F3*N12 E2*N12 R2*N12 D3*N12
13	Attach to head	44	P2*N13 F3*N13 E2*N13 R2*N13 D3*N13
14	seal	11	F3*N14 E2*N14 R2*N14 D3*N14
15	Sewing particle bag/trim	12	F3*N15 E2*N15 R2*N15 D3*N15
16	Seal particle bag/trim	8	F3*N16 E2*N16 R2*N16 D3*N16
17	Positioning particle bag	9	P2*N17 F3*N17 E2*N17 R2*N17 D3*N17
18	Pour particles into bag	6	P5*N18 F3*N18 E2*N18 R2*N18 D3*N118
19	Stretch elastic band	15	F3*N19 E2*N19 R2*N19 D3*N19
20	Facade fix pieces	13	P2*N20 F3*N20 E2*N20 R2*N20 D3*N20
21	Piece clothes shoulder	16	P2*N21 F3*N21 E2*N21 R2*N21 D3*N21

This kind of plush toy process is relatively more, and the factors affecting the balance rate of the production line are determined by the number of stations and the production cycle (bottleneck process time) when the total process time is constant. For products with a large number of such processes, in order to improve the balance of the production line, the number of stations is first reduced, but the station time is inevitably increased. Therefore, the combination of processes and workers is also crucial. According to the nature of the sewing process and the attention required for action to combine the process. It is very important to make the process combination as even as possible in time, but it needs required attention intensity to be uniform. Different workers are assigned to suitable stations, because the skill level of the worker will also have an important impact on the production line [5].

According to the requirements of each sewing process, the attention action required for each process is analyzed. NX indicates the number of attention actions required for the X-th process, which is convenient for distinguishing attention and high for the required attention intensity. The P5, R2, and D3 actions are the main basis for the analysis process. The long process time of the product is concentrated between 40 and 50s, and the number of attention actions is large. Therefore, in the process of bottleneck process, in order to improve the smoothness level of the production line, the process of the remaining short time is combined as close as possible to the bottleneck Process time.

Process 1, 2, and 3 are not only stitching the "face" and the "back brain", but the process 1 also ensures that the silk screen pattern and its position. Therefore, this process required attention intensity is relatively high. Although the standard time of process 5, 6 and 7 is relatively long, the size of piece is relatively large, and the sewing path is single, therefore these processes can be combined., post-merger work-station time is close to bottleneck work-station time. Simpler processes compare with the process 8, 9, and 10, the label needs to be positioned during the label calibration process, so the attention is required and the strength level is high, the selected process is close to the process 10 after combing process 8 and process 9. For the particle bag, it is relatively simple, and the sewing is carried out separately. As a toy interior, the process requirements are lower, it is relatively simple, and the attention intensity is lower. Therefore, the action attention level of 14.15.16.17.18 process is lower, and they can be combined and integrated. In comprehensive analysis, not only the process time is close to the bottleneck process time, but also the attention action quantity is as close as possible to the bottleneck process. Therefore, based on the comprehensive "Table IV" and process characteristics, an operation balance optimization table is prepared, as shown in "Table VI".

TABLE VI. ENTERPRISE CURRENT STATION LOAD TABLE

station	process	time
A	1	47
B	2	49
C	3	40
D	4	41
E	8.9	45
F	10	43
G	5.6.7	43
H	11.12	41
I	13	42
J	14.15.16.17.18	46
K	19.20.21	44

The optimized job balance load table has 11 stations and a minimum of 11 workers.

$$LBR = \frac{\sum T_i}{CT \times n} \times 100\% = \frac{481}{49 \times 11} \times 100\% = 89.239\%$$

$$SI = \sqrt{\frac{\sum (CT - T_j)^2}{n}} = \sqrt{\frac{384}{11}} = 5.908$$

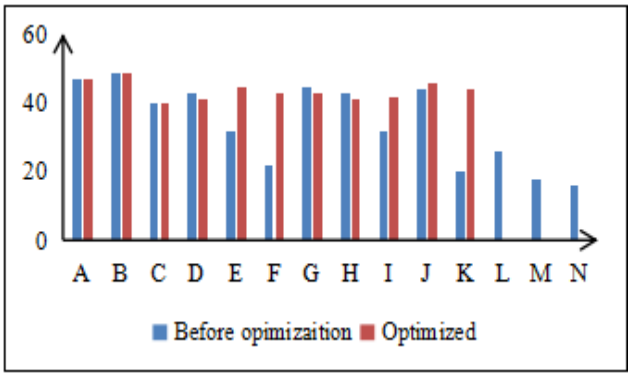

Fig. 1. Station time comparison.

As can be seen from the foregoing, the optimized production line balance rate is 19.122% higher than the current level of the enterprise, the staffing efficiency can reach up to 89.23%, the smoothness index is reduced by 11.87, the three parameters reach the balance level requirement of high efficiency and quality production line. The number of stations before optimization is 14 and the time fluctuation of each station before optimization is large. The number of stations after optimization is reduced to 11. The station time is concentrated and the fluctuation is small, which is conducive to the balance of the production line. Therefore, the optimization scheme is reasonable.

IV. CONCLUSION

The special nature of the sewing production line is different from the general production line. The psychological load caused by the attention factor of the sewing process in the labor process is not considered by the general researchers, and the psychological characteristics of the female-dominated labor group are very special. In the face of different processes, there is a certain psychological choice tendency for the process. The main reason for affecting this psychological selection tendency is the psychological load intensity which is caused by the sewing process. This difference will cause the imbalance of the production line and the complexity of management. Therefore, through the model method of action classification method, the actions that require attention in each process are described in a concentrated manner, and the skill level of employees is divided into several levels, but on the basis of not violating other methods of industrial engineering. Finally based on the basis of the merger, and each station is assigned appropriate workers, the work balance load table is developed to achieve the high efficiency production line balance standard, which has a high significance for the sewing production management of textile enterprises.

REFERENCES

[1] Chen Yan. Workplace Arrangement of Garment Production Line [J]. Jiangsu Silk, 2004(02): 23-25

[2] J.Song Ying.Study on the balance of garment production line under IE quantitative method [J]. Clothing Journal, 2017, 2 (03): 208-211.

[3] Zhang Lei, Li Zhongyuan. Research on the balance of assembly line based on IE method — Taking Company A as an example [J]. Industrial Engineering, 2017, 20(03): 45-52+74.

[4] Yi Shuping, Guo Fu. Basic Industrial Engineering [M]. Mechanical Industry Press, 2006.

[5] Sun Yinghui, Du Jinsong. Simulation and optimization of garment single-piece production line [J/OL]. Journal of Donghua University (Natural Science Edition) 2019-04-07: 1-7.

[6] Li Yinzhi.Study on the Balance Method of Sewing Production Line [J]. Journal of Textile Research, 2002(03): 54-56.

[7] He Manhui, Zheng Kai.Research on the improvement of PC assembly line balance using MOD method [J]. Modern Manufacturing Engineering, 2017(07): 51-55.