Optimization Study of Production Layout of Towel Workshop in Company Z

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Abstract: The rationality of the production workshop layout directly affects the production efficiency of products, logistics efficiency and production costs, which is of great significance to modern industrial production. This paper takes the production workshop of towel factory of Z Textile Company as the research object, and carries out workshop production layout optimization based on the theory of System Layout Design (SLP). Firstly, the layout status quo of the towel production workshop of the company has been comprehensively researched and the problem analysis has been carried out, so that the correlation between each working area and various materials can be sorted out. Secondly, the logistics relationship and non-logistics relationship of each working area in the workshop were analyzed by using the obtained data, and the comprehensive relationship map and location correlation map of each working area in the workshop were drawn. Finally, the whole workshop was optimized based on the SLP calculation method. The optimized workshop layout effectively reduces the logistics intensity, improves the production efficiency in the workshop, and makes the production process smoother. At the same time, the new layout optimizes the utilization of production space, reduces the production cost, and further improves the overall operational efficiency of the enterprise.

Keywords: Textile Mills; Workshop Layout Optimization; Efficiency; System Layout Design

1. Preface

The textile industry is an important part of China's national economy and has a large development potential. With the intensification of market competition and the continuous growth of customer demand, traditional manufacturing enterprises are facing higher production efficiency and quality requirements [1,2]. Reasonable production workshop layout can not only optimize the logistics path and reduce the handling distance, but also effectively improve the production efficiency and enhance the adaptability of enterprises to market changes. Therefore, scientific planning of production workshop layout is crucial for enterprises to enhance competitiveness and realize sustainable development.

Systematic Layout Planning (SLP) theory, in the optimization of the layout of the workshop has been developed more mature and achieved more extensive application [3-6]. SLP theory through the production process and the analysis of logistics and non-logistics in the unit of the relevant relationship to get the work of the integrated relationship diagram, and then the production layout for rational planning, to improve the logistics and production efficiency. production layout for rational planning, to improve the logistics and production efficiency in the workshop.

Based on SLP theory, this paper analyzes the rational planning of Company Z's towel production workshop from both qualitative and quantitative perspectives, and proposes an improvement plan, so as to improve the workshop's productivity reduction due to the workshop's irrational planning and the lengthy material handling routes.

2. Workshop Layout

2.1 Workshop Layout Overview

Production workshop layout is based on certain principles, the scientific planning of each production unit, auxiliary facilities and production equipment within the workshop to ensure the efficient execution of functions and tasks [7]. Optimizing the workshop layout facilitates the entire loading and handling path, reduces logistics costs, and significantly improves production efficiency. Through the

rational arrangement of operating units, the production processes can be closely linked, thus reducing unnecessary transportation links, reducing the waste of capacity, and making the production space more reasonably applied, so that the production process is more fluent.

2.2 System Layout Design Method (SLP)

SLP theory was firstly proposed by American industrial engineering scholar Richard Muther in 1961. The theory for the correlation of the layout unit simulation analysis, the traditional empirical design method into a more accurate mathematical model, and reduce the cost of coordination of logistics, deduced a more reasonable layout of the workshop [8]. SLP theory through the optimization of the layout of the equipment, so that the logistics and handling costs have been significantly reduced, and has been widely used in foreign countries in the field of shipbuilding, welding and suits. etc. [9-11].

On the issue of workshop production layout optimization, many scholars in China have also conducted in-depth analysis and harvested breakthrough results. Fu Qiang et al. [12] successfully applied the System Layout Design (SLP) method in the assembly workshop of tobacco packaging machine, and effectively improved the efficiency of material transportation in the workshop by optimizing the layout scheme. Chen Xiangru et al. [13] used SLP method based on value stream mapping to optimize the layout of the workshop, and the optimized scheme determined after integrating various factors not only effectively reduced the cost of the enterprise, but also enhanced the economic benefits. Huang Qianqian et al. [14] used the SLP method to optimize and obtain the preliminary layout plan, and evaluated the feasibility of the plan using the weighted factor comparison method.

3. Towel Production Workshop Layout Status and Problems

3.1 Towel Workshop Layout Status Quo

Z Company was founded in 1996 with a registered capital of 15 million yuan. The workshop currently has three professional production lines and can carry out production operations simultaneously, mainly producing towels, bath towels, square towels and other towel products. Meanwhile, the company has advanced production technology with jacquard, printing, computerized embroidery and other product processes. Since its establishment, the company has always run through the ISO9001 quality assurance system policy, the production of towel products, are selected from high-quality cotton yarns carefully woven, not only with excellent durability, but also a very high degree of pure white, excellent water absorption, soft and comfortable to the touch. At the same time, the color of the products is bright and colorful, which is very suitable for both daily use and decorative embellishment. With these outstanding characteristics, the product is favored and praised by domestic and foreign users, and has become a high-quality choice in the towel market. At present, the products have been successfully exported to many countries, including Russia, Japan, Malaysia, etc., and have been recognized by foreign customers.

Z Company towel production workshop has 11 different functional areas, including: raw material warehouse, weaving area, dyeing area, printing area, finishing area, quality inspection area, waste area, marking area, packaging area, finished product area, office. The left side of the workshop is the raw material warehouse storing cotton yarn, bamboo fiber yarn, polyester-cotton blended yarn, etc., waiting for workers to use forklift trucks according to the requirements of its delivery to the designated location for different varieties, specifications of the yarn in accordance with the technological requirements of the classification of the arrangement; the right side of the workshop for the finishing area and finished products area, used to pile up the towels ready for shipment after the completion of the production. The production area is located in the middle of the workshop, the whole process is mainly divided into: weaving, dyeing, printing, finishing four steps, in the weaving process, accurate control of the loom's speed, tension, lead time nodes and other important parameters, is to ensure that the towel organization meets the standard key. Only by strictly controlling these parameters can the towel have a clear texture, uniform texture and ensure that the product quality meets expectations. The floor plan of the workshop is shown in Figure 1.

In the towel production workshop, the

transportation of materials is mainly undertaken by forklifts to ensure the smooth operation of the production process. Workshop logistics transportation route is shown in Figure 2.

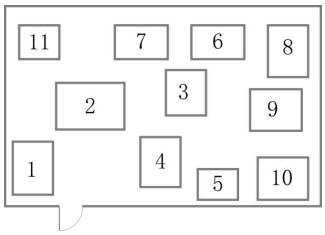

Figure 1. Initial Floor Plan of the Workshop

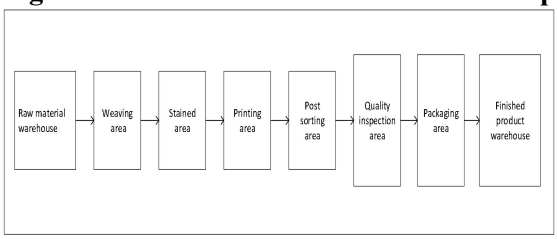

Figure 2. Logistics and Transportation Roadmap

3.2 Problems with the Layout of the Towel Shop

Workshop layout has an important impact on the time consumption and cost of material handling. When there are defects in the workshop layout planning, it is very easy to cause the material handling path to be greatly extended, and at the same time, it will make the employees face a lot of inconvenience in obtaining the production materials, increase the unnecessary material handling distance, so that the loss of transportation tools, labor costs, and then drag down the overall production efficiency and raise the cost of production[15]. Company Z with the gradual expansion of the market is facing the problem of mismatch between the production demand and the layout of the status quo, and low space utilization. Mismatch between production demand and layout status and low space utilization.

(1) Mismatch between production demand and current layout. With the continuous expansion of the company's market scale, the company is facing the problems of insufficient storage space and unreasonable workshop layout. The current workshop layout does not keep pace with the changes in production demand, the production line lacks close connection with each other, and the logistics and transportation efficiency is low. This not only leads to a sharp rise in production costs, but also seriously extends the delivery cycle, which greatly weakens the competitiveness of the enterprise in the fierce market competition.

(2) Space utilization rate is low.

The current layout of the workshop is scattered, there is a large number of idle interval area, especially the southwest corner of the workshop, the distance between the production area is far away, which directly leads to the site costs rise, while the material transportation route is elongated, the production efficiency is greatly reduced.

Therefore, the company's immediate task is to re-plan and optimize the current production layout. As the number of orders continues to rise, the original layout model is no longer sustainable, the only way to ensure that the production process can be adjusted to ensure the orderly progress of product quality. At the same time, cutting down the cross frequency of material transportation routes not only helps to achieve a greater increase in production efficiency, but also allows the complex production process to be streamlined, realizing cost reduction and efficiency.

4. Towel Workshop Production Layout Optimization Scheme Design

In the workshop layout design, need to follow the principles: ① process principle, that is, in line with the requirements of the towel production process, so that the workshop processing procedures in line with the towel production process, to ensure that the various production links can be advanced in accordance with the process flow in an orderly manner, to avoid the transportation of the intersection between each other as well as the circuitous transportation situation. ② Overall optimization principle. In the planning and layout, priority should be given to the overall benefit of the system so that the overall benefit can be greater than the local benefit, the high degree of correlation of production operations in close proximity to the arrangement of departments to maximize the benefits of resource integration. In addition, attention should be paid to the impact of the production environment on the psychological and work efficiency of the operating personnel, through the optimization of space design to enhance employee satisfaction with the work environment.

4.1 Logistics Relationship Analysis

Combining the coordinates of the location of each operating unit, and based on the volume of material flow of the towel production line in a day, calculate the distance Di (where i represents the operating unit) between the operating units that have logistics traffic in the towel production process, and measure the weight of material handling Wi between the operating units that have material transport, respectively, the specific formulas are as follows:

$$E = \Sigma Di \times Wi \quad (1)$$

Utilizing the quantitative analysis attributes in the improved SLP method, different logistics intensity levels are represented by A, E, I, O, U, where "A" refers to the highest logistics intensity, "E~U" refers to higher, larger, general and negligible, respectively, and the proportion of logistics volume is 40%, 30%, 20%, 10%, 0. The total logistics volume handled between operating unit pairs is used to represent logistics intensity, and the logistics intensity is divided according to the logistics intensity level. The proportion is 40%, 30%, 20%, 10%, 0. The total handling volume of logistics between pairs of operating units indicates the logistics intensity, and the logistics intensity is divided according to the logistics intensity level, and the logistics intensity table between operating units is shown in Table 1.

Table 1. Logistics Intensity Analysis Table

serial number	The operating unit is responsible for	Transportation handling volume (kg-m)	logistics intensity
1	1-2	5096	A
2	2-3	2400	E
3	2-4	855	O
4	3-4	1770	I
5	4-5	3500	E
6	5-6	4375	A
7	6-7	375	o
8	6-8	1800	I
9	8-9	1200	o
10	9-10	1505	I

According to the results shown in Table 1, the logistics relationship between the raw material warehouse and the weaving area (1-2), and the finishing and quality control area (5-6) is the closest, with the highest logistics intensity (A). This is followed by the weaving and dyeing zones (2-3), and the printing and finishing zones (4-5), which are of high logistic intensity (E). Dyeing area and printing area (3-4), quality control area and labeling area (6-8), packaging area and finished product area (9-10) are of high logistics intensity (I), the logistics relationship between the remaining operating units is of general logistics intensity (O), and the logistics intensity level between the operating units that do not exist is U, which is not within the scope of consideration of the facility layout. The logistics correlation diagrams of the 10 operating units are shown in Figure 3. The logistics correlation diagram for the 10 operating units is shown in Figure 3.

4.2 Non-Logistics Relationship Analysis

In workshop layout planning, logistics factors are certainly key considerations, but the actual production operation also needs to take into account the comprehensive impact of a variety of non-logistics factors. Through the field study of Company Z's towel production plant, the following key non-logistics factors were identified: personnel collaboration efficiency, production environment standards, cross-functional collaboration needs, and management convenience requirements, etc. As with the above, the logistics intensity was categorized into five levels from high to low. Similar to the above logistics factors, the logistics intensity is still categorized into five grades from high to low, which are A, E, I, O and U. The logistics intensity of each work area is shown in Table 2.

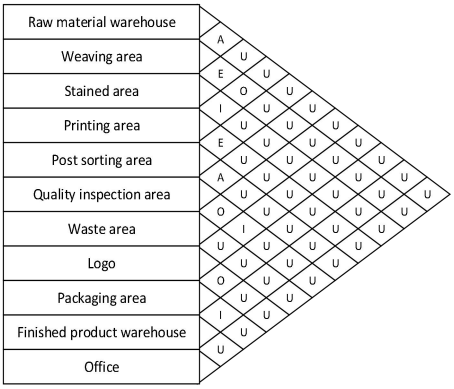

Figure 3. Logistics-Related Diagram

Table 2. Non-Logistics Relationship Rating Scale

hierarchy	A	E	I	o	U
Relationship strength	Absolutely important.	particular importance	critical	general	unimportant
proportions	2-5	3-10	4-15	10-25	45-80

On the basis of clarifying the key non-logistics factors and referring to the correlation rating

criteria in Table 2, we carried out a non-logistics correlation assessment of the 10 work areas in the production plant and drew a network diagram of non-logistics interactions based on the on-site research data, as shown in Figure 4.

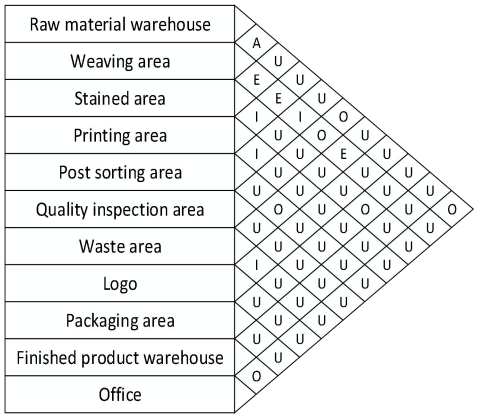

Figure 4. Non-Logistics Relationship Diagram

4.3 Integrated Relationship Analysis

This paper aims to optimize the layout of the workshop, and aims to effectively reduce the material transportation distance and the crossing of handling paths through the reasonable planning of the relative positions of the operating units, so as to improve the efficiency of space use and production operation. In this goal-oriented, the material flow relationship between operating units becomes a key consideration, based on this:

(1) In this study, the weighted calculation method is used to determine the integrated correlation between operational units, where the weight ratio of logistics and non-logistics relationships is set at 2:1, as shown in Equation (2).

$$T_{ij} = m \times M_{ij} + n \times N_{ij} \quad (2)$$

where i, j denote job pairs, and M and N denote the scores corresponding to different levels of logistics and non-logistics relationships, respectively.

(2) Quantify the intensity level of logistic and non-logistic relationships by taking A=4, E=3, I=2, O=1 and U=0.

By assigning values to the logistic and non-logistic relationships, a comprehensive relationship table for the towel production plant is obtained, as shown in Table 3.

Table 3. Synthesized interrelationships

political line (e.g. right revisionist road)	Closeness of relationship				synthesize relations	
	Logistics (Weighted value: 2)		Non-logistic relations (Weighted value: 1)			
	hierarchy	mark	hierarchy	mark	hierarchy	mark
1-2	A	4	A	4	A	12
2-3	E	3	E	3	A	9
3-4	I	2	I	2	E	6
4-5	E	3	I	2	E	8
5-6	A	4	U	0	E	8
6-7	O	1	U	0	o	2
7-8	U	0	I	2	O	2
8-9	0	1	U	0	o	2
9-10	I	2	U	0	I	4
1-6	U	0	o	1	U	1
1-11	U	0	O	1	U	1
2-4	O	1	E	3	I	5
2-5	U	0	I	2	0	2
2-6	U	0	o	1	U	1
2-7	U	0	E	3	I	3
3-9	U	0	o	1	U	1
5-7	U	0	0	1	U	1
6-8	I	2	U	0	I	4

Analyzing the ranks and values between the 12 job pairs of the kind in Table 3, the integrated relationship of job units is plotted, as shown in Figure 5.

4.4 Improved Program Design

When constructing the location correlation map of operation units based on the SLP method, it is necessary to be oriented to the optimization of facility layout, and it is necessary to consider key indexes including the reduction of material transportation cost, the optimization of space use efficiency and the enhancement of production system

operation efficiency. According to this principle, the stronger the logistic correlation between operation units, the higher the proximity requirement of their spatial arrangement. The quantitative analysis of the comprehensive interrelationship table leads to the following priority ranking: 2, 4, 3, 5, 6, 1, 8, 7, 9, 10, 11.

Based on the consolidated relationship table and the consolidated ordering of the operational units, a correlation map of the location of the operational units is drawn. When drawing the location correlation diagram, use different lines to indicate the relationship between the operating units, the more the number of lines, the closer the relationship, and the fewer the number, the more distant the relationship. As shown in Figure 6.

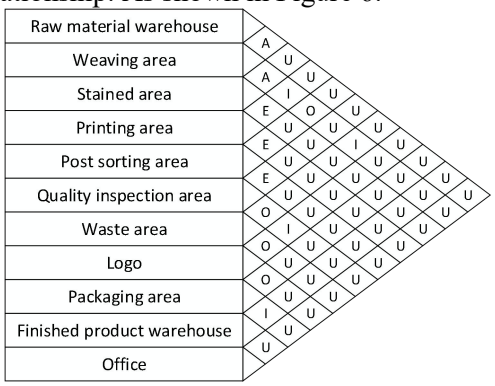

Figure 5. Integrated Relationship Diagram

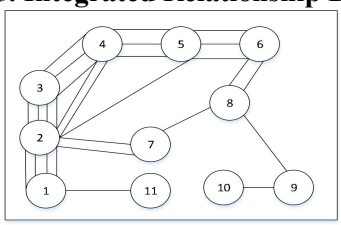

Figure 6. Operational Unit Location Correlation Map

5. Evaluation of Improvement Programs and Comparison of Effects

5.1 Improvement Program Evaluation Options

After completing the preliminary positioning of each functional area of the workshop, according to the relevant diagram of the operation location, combined with the actual area requirements of each operation unit, the use of Visio professional drawing tools, and finally formed the plan layout design scheme of the towel production workshop. As shown in Figure 7.

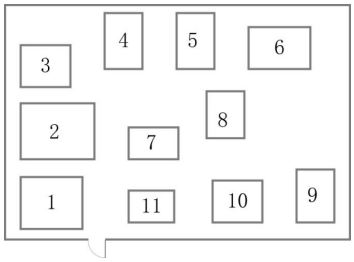

Figure 7. Optimized Layout Scenario

5.2 Comparison of optimization effects

The reasonableness of the layout scheme can be quantitatively assessed by means of logistics intensity indicators. Among them, the material transportation distance between operating units is taken as the distance between the intersection of the line connecting the center points of two units and the center line of the main road in the plant, while the transportation volume is determined according to the total daily material flow between units. Table 4 shows the change of logistics intensity before and after layout optimization in comparison.

Table 4. Comparison Table before and after Optimization

responsibility for	Volume of material flow (kg)	pre-optimization		post-optimization	
		Transportation distance (m)	Lifting workload (kg-m)	Transportation distance (m)	Lifting workload (kg-m)
1-2	182	28	5096	6	1092
2-3	120	20	2400	6	720
2-4	57	15	855	8	456
3-4	118	15	1770	6.5	767
4-5	175	20	3500	7	1225
5-6	175	25	4375	7	1225
6-7	25	15	375	12	300
6-8	150	12	1800	8	1200
8-9	150	8	1200	8.2	1230
9-10	150.5	10	1505	6	903
add up the total	1302.5	168	22876	74.7	9118

As shown in Table 4, the total logistics intensity of Company Z's towel production workshop is 22876kg-m before optimization and 9118kg-m after optimization, which is 60.14% lower than that before optimization; the transportation distance is 168m before optimization and 74.7m after optimization; the transportation distance is 55.54% lower than that before optimization. The transportation distance of the pre-optimization layout scheme is 168m, and the transportation distance of the post-optimization layout scheme is 74.7m, which is a reduction of 55.54%. The optimized layout of the production workshop significantly improves the production efficiency and reduces the operation cost, which effectively enhances the profitability and market competitiveness of the enterprise and lays the foundation for sustainable development.

6. Summary

Based on the analysis of the current situation of the layout of the towel production workshop of Company Z, this paper sorted out the problems of the current layout of the towel production workshop of Company Z through the analysis of the logistics relationship and non-logistics relationship in each operation unit; used the SLP method to optimize the layout of the production workshop, and drew up an optimization scheme for the layout of the workshop operation unit; finally, through the total logistics intensity and logistics handling distance of the workshop, we made a comparative analysis of the layout scheme of the towel production workshop before and after optimization to verify the reasonableness of the scheme. Finally, through the total logistics intensity and logistics handling distance of the workshop, the pre-optimization and post-optimization layout of the towel production workshop are compared and analyzed, and the rationality of the scheme is verified.

The optimized layout of the workshop significantly shortens the logistics distance between the operating units, effectively reduces the ineffective turnover in the process of material transportation, and thus achieves savings in operating costs. This improvement not only enhances the production capacity and space utilization efficiency of the workshop, but also optimizes the working environment of the employees, and the layout model fully reflects the core idea of lean production. The optimized layout of the workshop significantly enhances the efficiency of the production system, achieves the cost control objectives, effectively improves the company's market competitiveness and lays the foundation for its sustainable development.

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