ISSN: 1813-4890

Optimization and Simulation Study of Production Workshop Layout in A Sports Shoe Company

Sen Zhang [a], Jingwen Li [b]

Southwest Petroleum University, Chengdu 610000, China.

[a]2282809128@qq.com, [b]742466604@qq.com

Abstract

This paper takes the production logistics system of A sports shoe company as the research object, analyzes in detail the current situation of A sports shoe production process, summarizes the problems existing in the process from the site, minimizes the idle time of workers' work as much as possible, improves the efficiency of the assembly line, and then optimizes the workshop layout through system layout design to shorten transportation time. Finally, compare and summarize the production efficiency before and after optimization. The main content of this article includes the following three aspects: (1) analyzing the current production process of A sports shoes, using Flexsim simulation software to simulate and analyze the production process of the sports shoes, and outputting the results, summarizing the problems existing in the company's production process system; (2) Utilize system layout design to rearrange the process positions in the production workshop and determine the final optimization plan; (3) Reuse Flexsim software for simulation, compare the production system before and after optimization from four aspects: the number of temporary storage areas, handling waiting time, handling distance, and production efficiency, and confirm the success of the optimization scheme.

Keywords

Flexsim simulation software; System layout design; Production process optimization.

1. Introduction

1.1. Research Background and Significance

1.1.1. Research Background

In 2021, the total export value of shoes and boots in China was about 47.9 billion US dollars, a year-on-year increase of 35%. The upward trend of export prices remains rapid, with a 15% increase in 2021. The shoe-making industry chain and supply chain have shown strong resilience and made positive contributions to stabilizing foreign trade. Due to the rapid development of China in recent years, people's demand for shoe quality has also been constantly picky with the continuous improvement of living standards. The choice of shoes may have evolved from durability and comfort to the current style and appearance. Therefore, both domestic and foreign shoe markets are constantly expanding. In order to improve domestic and international competitiveness, enterprises must constantly upgrade and optimize their production lines and workshop layouts to reduce production costs and survive in fierce competition.

1.1.2. Research significance

This article focuses on the production and operation mode of the sports shoe company, analyzes the unreasonable problems in the logistics system and workshop layout of the shoe workshop, and studies a layout optimization method for the production and manufacturing system of small shoe companies. By reasonably arranging the workshop and improving the production logistics system, the manufacturing efficiency of the company's production system can be improved, thereby achieving the goal of enhancing the market competitiveness of the sports shoe company.

From an academic perspective, the significance of this paper lies in using the system layout method and Flexsim simulation software to integrate lean production ideas into the production and manufacturing system of A Sports Shoe Company, forming a layout optimization method suitable for small shoe companies.

1.2. Current Research Status at Home and Abroad

1.2.1. Current Status of Research on Optimization of Production Logistics Systems at Home and Abroad

Foreign scholars' research on production logistics systems mainly focuses on facility layout planning, material handling, lean production, and production balancing. During the 1940s to 1960s, facility layout planning developed rapidly and formed a complete and independent scientific theoretical system. Facility planning theory also became rich with the development of operations research methods and systems engineering theory. The systematic facility layout method proposed by American scholar R. Muther has the widest application scope. Hosseini S et al. (2014) used the SLP method to improve the layout of the card packaging company, selecting the best solution from three options and comparing it with the initial layout data to demonstrate the efficiency of this solution [1]. Qing Lian Lin et al. (2015) used the SLP method to redesign the facility layout of the medical room at Shanghai Oriental Hospital, which improved the efficiency of patient treatment [2]. In terms of material handling, Banaszak et al. (2000) studied the material flow path of manufacturing systems and considered an integrated modeling method for overall production planning [3]. Regarding lean production, Shahram Taj et al. (2006) used lean thinking to improve production efficiency in automotive assembly plants, making it easy for managers to solve production problems and reduce waste in the production system. S. Nallusamy et al. (2016) used lean thinking to help an automotive parts manufacturing company improve production performance, reducing the entire delivery time from 6.9 days to 3.6 days, greatly shortening the production cycle [5]. Regarding production balance, Yagmahan B (2011) studied the mixed model assembly line balance problem and proposed a multi-objective ant colony optimization algorithm, which achieved better benefits for the production of the factory [6]. Haile Sime et al. (2019) studied the production balance of clothing companies using computer simulation technology and made optimizations [7].

Domestic scholars have conducted research on production logistics systems from the following aspects. Regarding facility layout planning, most scholars have used the SLP method. Wang Heping et al. (2021) constructed a layout optimization model for the factory using the system layout design method to achieve the minimum total material handling distance and maximum layout area utilization [8]. Some scholars combine the system layout method with Flexsim simulation technology to simulate the production workshop and achieve the goal of optimizing production logistics. After optimizing the layout of X company, Li Wenjun (2018) used Flexsim simulation technology to compare the logistics intensity of the workshop layout before and after optimization, and demonstrated the feasibility of the optimized solution with visible data [9]. Li He et al. (2021) used Flexsim software to simulate the initial layout and found the problem of handling waste. They then used the SLP method to rearrange the workshop and re simulate to determine the optimization objectives [10].

1.2.2. Current Status of Simulation Research on Production Logistics Systems at Home and Abroad

In foreign research on production logistics system simulation, Azrin et al. (2013) used Arena software [20] to evaluate the improvement of the layout of carbonated beverage production lines.

Hassanali Aghajani et al. (2014) also used Arena simulation software to model and simulate the diesel production line, and analyzed the improved production line, achieving a 62% reduction in idle time [21]. Jian Liang Peng (2011) simulated the production process using Flexsim software and improved the entire production logistics system [22].

In the research on production logistics systems in China, Liu Gang (2019) simulated the machining workshop of an aviation airborne enterprise using Witness simulation software, optimized the entire logistics production system, and reduced logistics time [23]. Yang Fan (2017) used Flexsim software for simulation to optimize the production process of a sugar manufacturing enterprise, effectively improving the original plan [24]. Wu Bo et al. (2019) greatly improved the production efficiency of a company by modeling and simulating its main reducer assembly line using Flexsim software [25].

1.3. Research Content of the Thesis

This paper analyzes and determines optimization methods based on the actual situation of A sports shoe company. The main research contents are as follows:

(1) Simulate the original layout of A Sports Shoe Company's production workshop using Flexsim software, generate data reports, and identify current issues. Analyze the problems based on actual conditions.

(2) Using the system layout design method to rearrange the workshop location, in order to optimize the process and reduce handling waste.

(3) Re simulate the optimized solution using Flexsim software, and compare the data before and after model optimization from four aspects: the number of process temporary storage areas, production logistics handling waiting time, production material handling distance, and production efficiency, to demonstrate the effectiveness of the optimized solution.

1.4. Research Methods

1.4.1. Research Methods

(1)Literature research method

By reading a large amount of literature on production logistics and understanding the current research status, appropriate methods are selected to solve the practical problems of A sports shoe company, filling the gap in the application of relevant theories in this type of enterprise.

(2)System simulation method

Simulate the production logistics system of A Sports Shoe Company using Flexsim simulation software, comprehensively analyze the simulation results of the model output, identify problems in the production logistics system, and optimize the optimized solution using appropriate methods. Simulate the optimized solution and compare the simulated data with the original data to prove the success of the optimized solution.

(3)SLP analysis method

Using the system layout design method, combined with logistics analysis, construct a reasonable production layout. This method is also applicable to the reconstruction and optimization of factories of various sizes or types.

2. Analysis of the Current Status of Production Logistics System in A Sports Shoe Company

2.1. Production Logistics Status

2.1.1. Current Status of Production Layout

The production workshop of A Sports Shoe Company is a rectangular shape with a length of 94 meters and a width of 37 meters. There is a workshop gate on the east side of the workshop.

ISSN: 1813-4890

The materials for making shoes are transported in through the gate, processed in various workshops, and finally stored in the finished product warehouse before being transported out through the workshop gate. The entire workshop includes 11 functional areas, namely office, material area, punching area, sewing area, midsole area, sole processing area, last fitting area, molding area, inspection and packaging area, finished product warehouse, and employee rest area. The floor plan layout of the production workshop of A sports shoe company is shown in Fig .1.

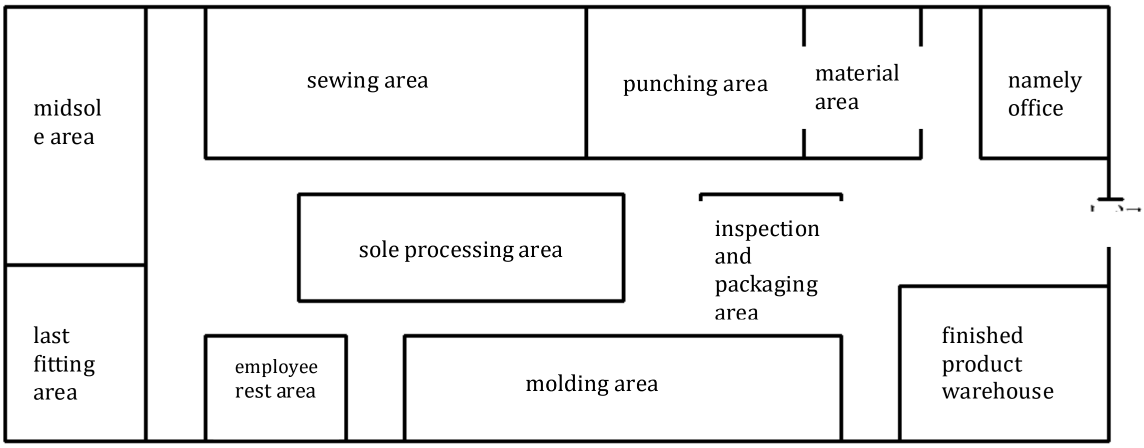

Fig.1 A Workshop Layout of Sports Shoe Company

2.1.2. Current Status of Production Process

The production process of A sports shoes includes: sole making, punching, sewing, last fitting, sole gluing, drying, shoe upper steam softening, shoe upper and sole gluing, fitting and pressing, low-temperature treatment, last stripping, QC inspection, packaging and warehousing.

The number of machines and processing time for each production process are shown in Table.1.

Table .1 Production related data of sports shoes

Serial number	Production process	Equipment name	Number of Machines (pcs)	Average processing time (seconds)
1	Bottom making	Automatic oblique cutting machine	3	14
2	Punching and cutting	Cutting machine	2	9.5
3	Car seam	Needle car	4	19
4	Last making	Last making machine	2	6.5
5	Sole brushing glue	brush	2	8.5
6	dry	Automatic glue dryer	2	9.5
7	Steam softening of shoe upper	Steam softening machine	2	6.5
8	Glue on the upper and bottom of the shoe	Automatic glue spraying machine	2	7
9	Compression fit	Universal wall bottom press machine	2	7
10	Low temperature treatment	Automatic rapid freezing and shaping machine	2	6.5
11	Remove last	Hydraulic claw last pulling machine	2	7

ISSN: 1813-4890

12	QC inspection	Inspection table	2	4
13	Packaging and storage	Packaging table	2	7

2.2. Simulation of Production Logistics Status of A Sports Shoe Company Based on Flexsim

2.2.1. Simulation Objectives and Assumptions for Production Logistics

(1) Simulation target

By establishing an initial production logistics system simulation model, determine whether the production logistics process is smooth; Through simulation experiments and analysis of experimental data, problems were identified in the logistics system.

(2) Assuming conditions

Due to the complexity of production logistics systems in practical situations, some operations or processes need to be simplified or omitted, while retaining the main elements of the production logistics system, as follows:

① In Flexsim software, a processor is used to simulate the processing and handling of products by workers, a synthesizer simulates the process of synthesizing shoe uppers and soles, and a composite processor simulates the two steps of gluing and drying shoe soles. The operator of each process is not displayed in the model, and the worker's operation time and preset time are added to the processing time.

② Assuming that workers work 8 hours a day and the production line remains in operation during these 8 hours.

③ The production logistics system during the simulation process can meet the manpower and material resources required for production, and the machine will not malfunction with a constant processing time.

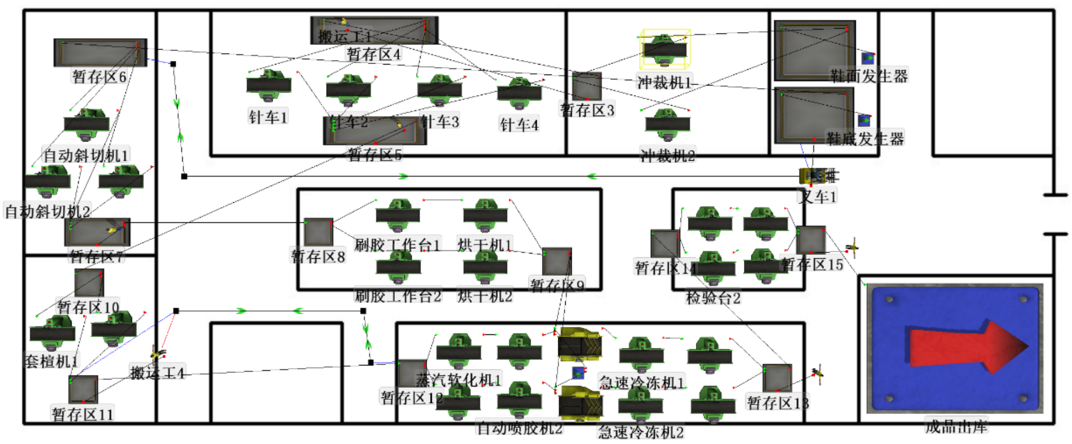

Fig.2 Layout of Production Workshop of Sports Shoe CompanyA

2.2.2. Entity Construction of Production Logistics Simulation Model

Firstly, draw a production workshop layout diagram in Flexsim software, then select appropriate entities to replace various production machines, place them in the corresponding workshops, connect them according to the relationships between machines, and set parameters to achieve the corresponding functions.

This model mainly studies the average waiting time in the temporary storage area of the production logistics system in the production workshop of A sports shoe company, as well as the logistics volume transported by the movers. The entities in the model are connected in sequence using A connections according to the processing flow, and the transport vehicles are connected to the upper level of the movers using S connections. Due to the need for too many entities, the model was split into two parts and connected using absorbers and generators. The connected model is shown in Fig.2.

2.2.3. Parameter Setting for Production Logistics Simulation Model

The following is an explanation of the parameters of important programs in the model.

(1) Generator parameter settings

There are five generators in the model, two of which are the company's sole material generator and upper material generator, respectively used to simulate the purchase of raw materials. The company purchases raw materials that can be used to make 6200 shoes every day. The arrival method is selected as "arrival schedule", and "6200" is filled in the capacity of the schedule. Both the sole and upper are replaced with boxes. In order to distinguish between the two components, the type of upper is changed to "1", and the physical color in the departure trigger is changed to red; The type of sole is changed to "2", and the entity color in the departure trigger is changed to green. The specific settings are shown in the figure. Generator 3 serves as the first input port of the synthesizer, used to simulate the pasting of shoe uppers and soles. The arrival time interval is set to "0", and "Arrival at time 0" is checked. The temporary entity type is selected as "Pallet", and the temporary entity is changed to "3". The generator parameter settings are shown in Figure 3-5.

(2) Temporary storage area parameter settings

The initial model of the production logistics simulation includes 15 temporary storage areas. Temporary storage areas 1 and 2 are placed after the raw material generator for temporary storage of raw materials, and the maximum capacity should be set to be greater than or equal to the quantity of raw materials generated, both of which are set to "7000". In order to better identify issues, the maximum capacity of other temporary storage areas is also set to "7000". As the materials in temporary storage area 2 need to be transported to the midsole area, which is far away, a forklift is chosen as the transportation tool. Check "Use Transport", and the forklift can handle up to 30 items at a time. Therefore, check "Perform Batching" and fill in "30" in the Target Batch Size, which means that the goods will be handled in batches of 30 items. Temporary storage areas 3, 5, 7, 11, 13, and 15 are relatively close in distance, and will be handled by movers. The movers will handle 20 items at once. Check "Use Transport" and "Perform Batching", and fill in "20" in the "Target Batch Size", which means that the goods will be handled in batches of 20. The output terminals of temporary storage areas 4, 6, 8, 10, 12, and 14 are connected to two or more machines. Set the output port to "Random Available Port" in the "Flow" tab of the temporary entity flow, which means to output to a randomly available port. This setting allows the temporary entity in the temporary storage area to output to the next available processor.

(3) Processor parameter settings

Use processors in the model to replace production processes. The number of processors and parameter settings for each production process are shown in the table below. Taking the steam softening machine as an example for parameter setting, in real life, the steam softening machine can process up to 3 shoe uppers at the same time. Double click on the processor and fill in "3" at the maximum capacity. The time for steam softening one shoe upper is about 6.5 seconds. Considering that the processing process may have errors due to human factors, the processing time of the steam softening machine is set to a uniform distribution of ± 0.5, which means that the softening time of one shoe upper is between 6S and 7S. The processing time of the rapid freezer is determined by the machine, so the time is constant at 6.5 seconds. The specific processor parameters are shown in Table .2.

Table.2 Specific Parameter Settings for Processor

Serial number	Production process	Number of units	Number of workers (person)	Parameter settings
1	Punching and cutting	2	2	uniform(9, 10, 0)
2	Car seam	4	4	uniform(18, 20, 0)
3	Midsole	3	3	uniform(12, 16, 0)
4	Brushing glue	2	2	uniform(8, 9, 0)
5	dry	2	0	uniform(9, 10, 0)
6	Last making	2	2	uniform(6, 7, 0)
7	Steam softening	2	2	uniform(6, 7, 0)
8	Apply glue	2	2	7
9	Low temperature treatment	2	0	6.5
10	Remove last	2	4	uniform(6, 8, 0)
11	test	2	4	uniform(3, 5, 0)
12	packing	2	4	uniform(6, 8, 0)

(4) Synthesizer parameter settings

One of the most important steps in shoemaking is to bond the upper and sole together as a whole. Here, a synthesizer is used for simulation. First, double-click on the synthesizer and change its name to Universal Wall Bottom Pressing Machine. The preset time is 2 seconds, the processing time is 5 seconds, and the synthesis mode is selected as "Package". The first input port of the synthesizer is the tray generator, and the second and third input ports enter entity 1 and entity 2 respectively. In the composition list, entity 1 and entity 2 form one entity.

(5) Transport aircraft parameter settings

There is a forklift and four movers in the model. Forklift 1 can handle up to 30 entities at a time, with a loading and unloading time of 0.8 seconds and an unloading time of 0.7 seconds. Other settings are set to default. All movers are transported in batches of 20, with a loading time of 0.9 seconds and an unloading time of 0.8 seconds.

(6) Absorber parameter settings

There is an absorber in the model used to simulate the final finished product delivery, and the parameter settings can be set by default.

2.2.4. Running simulation models and outputting results

After all the parameters in the model are set and connected, run the model. The simulation running time is set to one day. Assuming that A Sports Shoe Company works for 8 hours a day, the model is measured in seconds. Therefore, the final simulation time is set to 28800 seconds. The state after the model stops running is shown in Fig.2.

After running the simulation model, use statistical functions to output the waiting time in the temporary storage area and the distance of forklift handling. The waiting time in the temporary storage area is shown in Table , and the forklift handling distance is shown in Table.3.

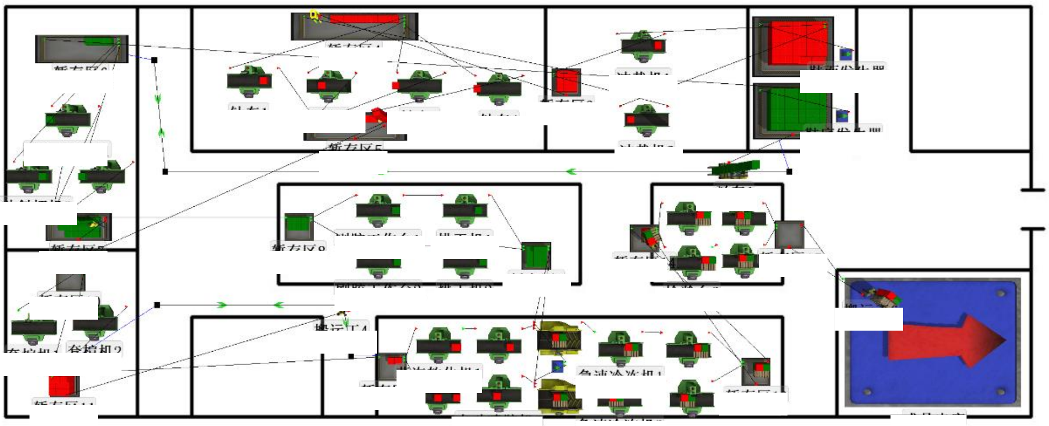

Fig.2 Model running end state

Table.3 Forklift and Mover Handling Distance

Entity Name	Transportation distance (meters)
Forklift 1	31532.88
Mover 1	15402
Mover 2	30204
Mover 3	25362
Mover 4	33248.8
Mover 5	14625.84
Mover 6	176747.74

2.3. Analysis of Production Logistics Issues in Sports Shoe Company A

Optimizing the production logistics system can greatly improve the production efficiency of products. By describing the current production logistics situation of A Sports Shoe Company and analyzing the simulation results, it is found that the company's production logistics system mainly has the following problems:(1)The handling frequency of production materials is high;(2)The distance for handling production materials is too long;(3)The waiting time for material handling in production is too long.Next, we will provide a more detailed explanation of these three issues.

2.3.1. Long waiting time for production material handling

From the waiting time in the temporary storage area of the table, it can be seen that the average total waiting time on the entire production line is 29709.58 seconds. The reason is that there are unreasonable handling settings during the production process. Due to the setting of batch transportation, some movers or forklifts may wait in the temporary storage area until the quantity is enough for one forklift to handle in one batch. From the table, it can be seen that the average processing rate of the two rapid freezers is 47.27%, and the average idle rate is 52.73%. The average processing rate of the two claw type last pulling machines is 47.41%, and the average idle rate is 52.66%. More than half of the time is wasted. At the end of the model run in Figure 3-10, it can be seen that the temporary storage areas after the glue brushing drying machine and claw type last pulling machine do not have physical existence, indicating that there is a shortage of materials. Therefore, it is necessary to change the transportation mode and batch handling to reduce machine waiting.

2.3.2. Long distance for handling production materials

By analyzing the production process of sports shoes, it can be found that punching, sewing, and last fitting are three closely connected processes. From the workshop layout diagram, the last fitting workshop is too far away from the sewing workshop. The midsole, glue brushing, and drying are three closely connected processes, among which the midsole area is far away from the glue brushing distance. In addition, the transportation route from the sewing area to the last fitting area intersects with the transportation route from the midsole area to the glue brushing area. The bottom making process requires the transportation of sole materials from the material warehouse to the midsole area. The transportation route is not only too long, but also intersects with the transportation route from the sewing area to the last fitting area, which will cause periodic interference in the transportation process. Waiting for work can even lead to safety accidents. The transportation route from the last fitting area to the molding area passes through the rest area, which inevitably leads to a winding transportation route and longer transportation time. The situation of intersecting and excessively long transportation routes in the production workshop of A sports shoe company is shown in Fig.3.

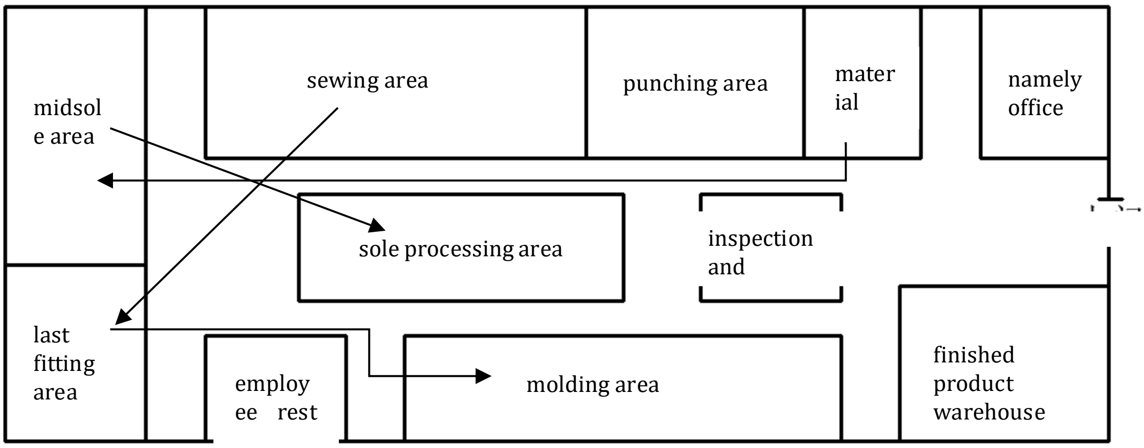

Fig.3 Intersection of workshop layout and handling before optimization

The reason for the long distance of material handling and the intersection of handling routes in production is the unreasonable layout of the production workshop, so it is necessary to rearrange the production workshop to solve these problems. In addition, when actually arranging the workshop, it is also necessary to consider the need for a quieter and cleaner surrounding environment for the office and rest area.

3. Optimization of Workshop Layout Based on SLP

The production process and process procedures for A sports shoes have been optimized above. In this section, the layout of the workshop will be rearranged based on the optimized production process, with the aim of adapting the workshop layout to the adjusted production process and reducing handling time.

3.1. Logistics Relationship Analysis of Homework Units

The production workshop of A sports shoe company is divided into material area, punching area, sewing area, midsole area, last fitting area, sole processing area, molding area, packaging area, finished product warehouse, office, and rest area. For the convenience of subsequent table making, each homework unit will be numbered with numbers, namely: 1- Material area, 2- Punching area, 3- Sewing area, 4- Midsole area, 5- Last setting area, 6- Sole processing area, 7- Forming area, 8- Packaging area, 9- Finished product warehouse, 10- Office, 11- Rest area. Based on the production process of sports shoes and the actual situation on site, draw the product process route and transportation volume table5, as well as the distance from the operating unit to the table, as shown in Tables 4-2, 4-3, and 4-4. Then calculate the logistics intensity and generate the logistics intensity from table to table, as shown in Table.6.

Table.5 Process Route Table

Serial number	Process route
1	1→4→6→7
2	1→2→3→5→7→8→9

Table.6 Logistics Intensity from to Table

to / from	1	2	3	4	5	6	7	8	9	10	11	total
1		86594		472993								559587
2			154020									154020
3					302040							302040
4						253620						253620
5							332488					332488
6							154662					154662
7								146258				146258
8									176477			176477
9												
10												
11												
total		86594	154020	472993	302040	253620	487150	146258	176477			2079152

The basic principles of logistics analysis are to minimize logistics volume, minimize costs, and avoid cross cutting. There are five levels of homework units, and the specific logistics level table is shown in Table.7.

Table.7 Logistics Level Proportion Table

Logistics level intensity	Symbol	proportion
Ultra high logistics intensity	A	10%
Ultra high logistics intensity	E	20%
High logistics intensity	I	30%
General logistics intensity	O	40%
Negligible handling	U	0

According to the size of logistics intensity and the proportion of logistics intensity levels, logistics intensity is divided into five levels, and a logistics intensity correlation chart is obtained, as shown in Fig.

3.2. Analysis of Non Logistics Relationships of Homework Units

Logistics analysis is the quantitative analysis of relationships between different operational units through specific data analysis, but there are not only logistics relationships but also other non logistics relationships between them. There are several situations where non logistics factors are the main factor:

(1) Some factories with relatively few transported materials cannot be analyzed solely based on logistics relationships.

(2) There is generally no logistics relationship between production workshops and public facilities, but their relationship should be considered, such as the close relationship between rest rooms and production areas.

(3) In most service-oriented facilities, such as offices and maintenance rooms, there is generally no real logistics, so the flow of personnel can be regarded as the flow of logistics.

(4) Some processes may cause pollution or harm, so it is important to stay away from quiet areas such as offices and rest areas. Therefore, the process sequence should not be the only consideration.

Therefore, when analyzing the interrelationships between homework units, both logistics and non logistics relationships should be considered. But they generally cannot use quantitative methods for analysis, and need to use some relevant reasons to rate the degree of closeness between pairs, including A, E, I, O, and U. The proportion is generally shown in Table.8.

Table.8 Proportion of Non Logistics Relationship Levels

Symbol	A	E	I	O	U	X
significance	Absolutely important	Especially important	important	commonly	unimportance	Don't get close
Quantitative value	4	3	2	1	0	-1
Number of lines	4 items	3 items	2 items	1 item	nothing	1 polyline
Proportion (%)	2~5	3~10	5~15	10~25	45~80	As needed

The non logistics factors to be considered in this article are shown in Table.9.

Table.9 Non logistics Factors Table

number	reason
1	Continuity of workflow
2	Safety and Pollution
3	Easy material handling
4	Easy to supervise and manage
5	Personnel Contact
6	Handover of data

Based on the classification table of non logistics relationship levels and the table of non logistics relationship factors of the operating units, draw a non logistics factor correlation diagram of the operating units. Each grid in the correlation diagram not only needs to represent the level of closeness between the two production workshops, but also needs to indicate the reasons below the level.

3.3. Comprehensive relationship analysis of homework units

When optimizing the layout of the workshop, it is necessary to comprehensively consider the logistics and non logistics relationships of the workshop, obtain a comprehensive logistics relationship, and based on this, provide appropriate planning solutions. The mutual relationship levels of non logistics units are divided into six levels: A, E, I, O, U, and X. Each level has a value of A=4, E=3, I=2, 0=1, U=0, and X=-1. In addition, it is necessary to determine the proportion of logistics and non logistics relationships in the production workshop, which is represented by the ratio m: n and should generally not be outside the range of 1:3~3:1. According to the relative importance of the two, the ratio can be 3:1, 2:1, 1:1, 1:2, 1:3. Due to the fact that the logistics relationship in the production workshop of A sports shoes is more important than non logistics relationships, m: n=2:1 is chosen here. By substituting the values into formula (1) for calculation, a comprehensive quantitative table of the interrelationships between production workshops can be obtained, as shown in Table.10.

$$TR_{ij} = mMR_{ij} + nNR_{ij} \qquad (1)$$

In the formula, TR_{ij} is the quantified value of comprehensive logistics interrelationships, while MR_{ij} and NR_{ij} represent the level of logistics interrelationships and non logistics interrelationships, respectively.

Table.10 Comprehensive Relationship Quantification Table

	1	2	3	4	5	6	7	8	9	10	11
1		6	0	12	0	0	0	0	0	1	0
2			5	0	0	0	0	0	0	1	1
3				0	9	0	0	0	0	1	2
4					0	7	0	0	0	1	2
5						0	9	0	0	1	2
6							7	0	0	1	1
7								4	0	1	2
8									6	1	2
9										1	1
10											2
11											

According to Figure , convert the six relationships A, E, I, O, U, and X into the numbers they represent, and obtain the comprehensive correlation and ranking of the 11 homework units, as shown in Table 11.

Table.11 Ranking of Comprehensive Proximity of Homework Units

Assignment Unit Code	1	2	3	4	5	6	7	8	9	10	11
Comprehensive proximity level	8	7	8	10	9	8	11	8	5	11	15
sort	7	10	8	4	5	6	3	9	11	2	1

According to the data in the table, the higher the score, the more central the production workshop needs to be placed, and the lower the score, the more marginal the production workshop should be placed. Prioritize A-level relationships and place the one with the highest A-level relationship score at the center, represented by four lines. E. I, O, and U level relationships are represented by three lines, two lines, one line, and no line segments, respectively. Create a location related line graph, as shown in Fig.4.

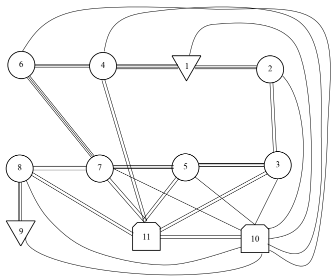

Fig.4 Position related line diagram

3.4. A Optimization Plan for Layout of Sports Shoe Production Workshop

The original production workshop only had one gate, where materials were stored and finished products were stored. The new production layout will add a gate, with two gates located near the material area and finished product warehouse for convenient transportation. Due to the use of ECRS's four major improvement principles in the previous section to merge the inspection process into the sewing and bonding processes, the area of the packaging area has been reduced to the molding and sewing areas. The specific area of each homework unit is

ISSN: 1813-4890

shown in Table12. Based on the specific area of each homework unit and the position related line diagram in Fig5, a floor plan layout can be drawn, as shown in Fig.5.

Table.12 Area of Each Homework Unit

Serial number	Homework area	Area (m2)	Serial number	Homework area	Area (m2)
1	Material area	96	7	Forming area	421
2	Punching area	240	8	Packaging area	165
3	Car seam area	385	9	Finished product warehouse	235
4	Mid bottom area	231	10	office	145
5	Last area	210	11	Rest area	149
6	Sole processing area	279			

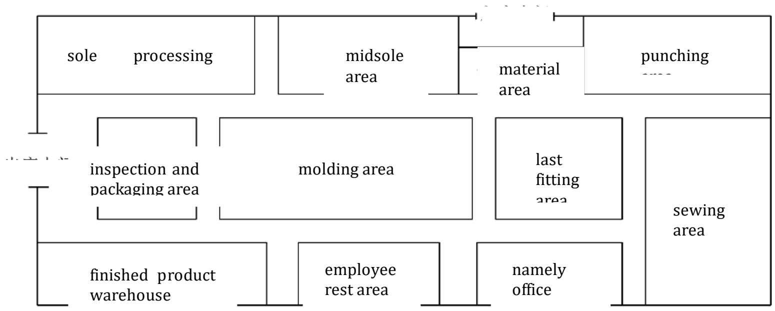

Figure.5 Optimized Layout Plan

4. Evaluation of the Scheme for Optimizing Effects

Chapter 2 has already optimized the production process and layout of A sports shoes. This chapter will use Flexsim software to model and simulate this optimization plan, and evaluate its effectiveness.

4.1. Entity Construction of Optimized Production Logistics Simulation Model

Firstly, import the optimized production workshop layout into Flexsim, place corresponding entities in each workshop area, connect them according to the adjusted processing flow sequence, and set them according to the optimized handling method. The operation time is set to 8 hours per day, which means the simulation time is set to 28800 seconds. The optimized production logistics simulation model of A sports shoe company is shown in Fig.6.

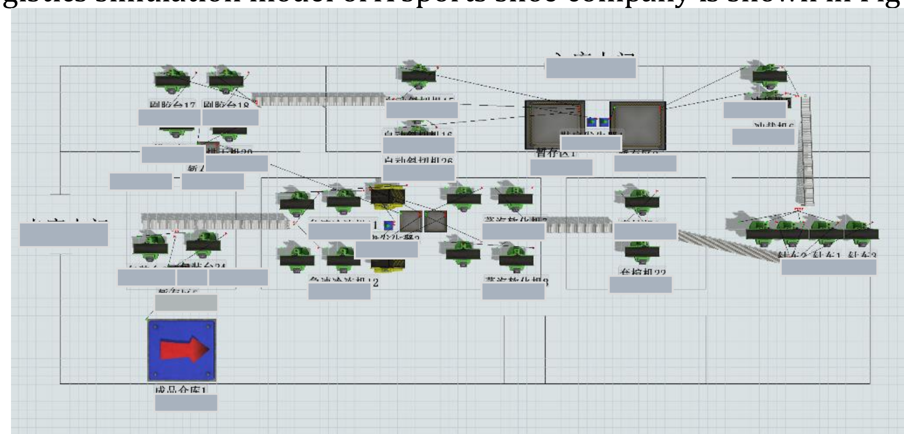

Fig.6 Optimized Production Logistics Simulation Model of A Sports Shoe Company

ISSN: 1813-4890

4.2. Main parameter settings for optimized production logistics simulation model

The optimized production logistics simulation model has eliminated 9 temporary storage areas, 1 forklift, and 4 movers. The original manual handling and temporary storage area combined handling method has been changed to conveyor belts. The inspection process before packaging has been cancelled, and 5 conveyor belts have been added. Other settings are the same as the initial model. The parameters of the conveyor belt are set by default. Run the final optimized model as shown in Fig.7.

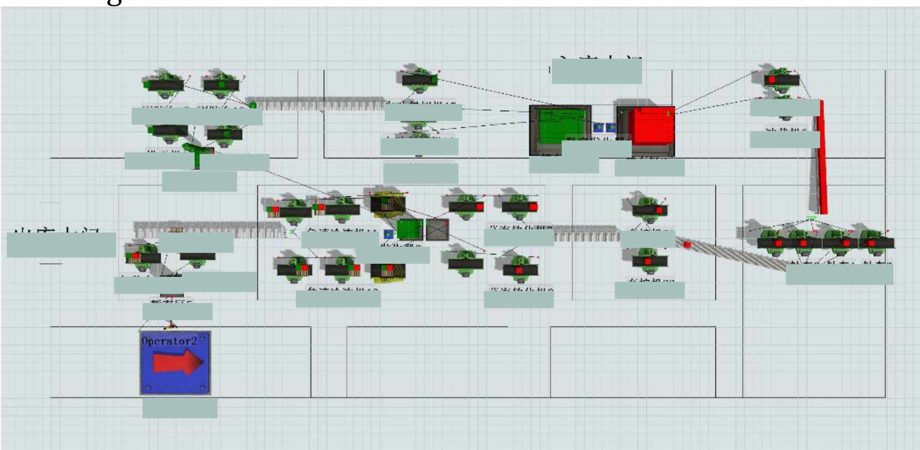

Fig.7 End state of optimized model operation

4.3. Comparison of pre - and post optimization effects

4.3.1. Comparison of the number of temporary storage areas in the process

By comparing the number of temporary storage areas in each process, the number of material handling times before and after optimization can be obtained.It can be seen that before optimization, the number of temporary storage areas in the model was 15, but after optimization, it has increased to 5, reducing the number of temporary storage areas by 10, significantly reducing the number of temporary storage areas and to some extent reducing the number of material loading and unloading operations.

4.3.2. Comparison of waiting time for production material handling

Export the temporary storage waiting time through the statistics and reporting function in Flexsim software, as shown in Table.14. Comparing the average waiting time of the temporary storage area before and after optimization, the initial layout model had an average waiting time of 29463.75 seconds, while the optimized model had an average waiting time of 29196.69 seconds. The total waiting time was reduced by 267.06 seconds, confirming the effectiveness of optimizing the production logistics system of A Sports Shoe Company.

Table.14 Optimized Waiting Time for Temporary Storage Area

entity	name	Minimum waiting time	Maximum waiting time	Average waiting time
Temporary storage area 1	Queue	0	28790.14	14385.62
Temporary storage area 2	Queue	0	28798.03	14361.25
Temporary storage area 3	Queue	0	738.1703	333.7931
Temporary storage area 4	Queue	12.53935	104.8206	61.35507
Temporary storage	Queue	11.74495	97.61288	51.26096

Temporary storage area 5				
Temporary storage area 6	Queue	0	86.76718	3.41159

4.3.3. Comparison of Material Handling Distance in Production

By adjusting the production layout, it can be seen from the front and back production layout diagrams that the two workshops with similar processes are also close, avoiding waste caused by crossing workshops during transportation. After measuring the total distance traveled by the movers and forklifts in the initial layout, that is, the total distance measured from the material area to the punching area, punching area to the sewing area, sewing area to the last fitting area, last fitting area to the forming area, forming area to packaging area, material area to the midsole area, and midsole area to the sole processing area, the total distance before optimization was 306.4 meters, and the total distance after optimization was 179 meters. The total handling distance has been reduced by 127.4 meters, greatly reducing handling waste. In addition, the optimized layout of material handling routes does not intersect, and the rest area is close to the center, making it convenient for workers to rest. Overall, from the perspective of material handling distance, the company's production logistics system workshop layout optimization has been successful.

4.3.4. Comparison of Production Efficiency

Comparing production efficiency is an important step in determining whether the production system is optimized. After simulating the optimized production logistics system, the statistical and reporting functions in Flexsim software are used to export data on the processing status of each production process, as shown in Table. Compare the obtained results with those shown in Table.15, and summarize the processing before and after optimization in Table 5-4. It can be seen that the average idle rate before and after optimization decreased from 14.48% to 12.57%, the average processing rate increased from 77.71% to 80.85%, the blocking rate increased from 4.48% to 3.18%, the collection rate increased from 1.75% to 1.80%, and the overall production efficiency increased.

Table.15 Comparison of Processing Conditions of Various Processes Before and After Optimization

	Idle rate	Processing rate	Blockage rate	Collection rate
Before optimization	14.48%	77.71%	4.48%	1.75%
After optimization	12.57%	80.85%	3.18%	1.80%

5. Summary and Prospect

5.1. Summary

This article focuses on the actual production situation of the production workshop of A Sports Shoe Company. Firstly, Flexsim simulation software is used to simulate the current status of the sports shoe production logistics system. Combined with the actual production situation, the simulation results are analyzed, and some solvable problems are found in the production logistics system of A Sports Shoe Company; Secondly, the SLP method was used to rearrange the production workshop, and the Flexsim software was used for modeling and analysis to obtain the final optimization plan. The results before and after optimizing the production logistics system were compared from four aspects, proving the effectiveness of the optimization plan. The research conclusions of this article are summarized as follows:

(1) On the basis of understanding the production process and layout of A Sports Shoe Company, a simulation model of the production logistics system was established. Through analysis, it was found that the production workshop of A Sports Shoe Company has problems such as frequent

loading and unloading of production materials, long waiting time for production material handling, and long distance for production material handling.

(2) On the basis of adjusting the production process, readjust the layout of the production workshop; Finally, simulation is conducted based on the adjusted production process and workshop layout, and the simulation results are compared with the original data to obtain the final optimization plan.

(3) Comparing the production logistics plan before and after optimization from four aspects: the number of process temporary storage areas, material handling waiting time, material handling distance, and production efficiency, it was found that in the final optimized plan, the number of process temporary storage areas decreased by 10, the material handling waiting time decreased by 267.06 seconds, the handling distance for each sports shoe produced decreased by 127.4 meters, the average idle rate on the production line decreased by 1.91%, the average processing rate increased by 3.14%, and the quantity increased by 240 in the same time.

5.2. Prospect

Due to limited time and capacity, there are still areas that need improvement in this article, as follows:

(1) When analyzing the production logistics system of A sports shoe company, this article only considers the sports shoe production workshop with serious production logistics problems. This is only a part of A sports shoe company's production logistics system. The production logistics system is a huge and complex system, and in the future, the scope of the simulation model will be expanded as much as possible to conduct a more comprehensive analysis of the enterprise.

(2) There are many types and styles of sports shoes, and different materials and styles lead to different product models. In the process of production logistics simulation, there is no distinction between product models, and in the future, multiple product types will be analyzed.

(3) When using software to simulate the model, simplification was made without considering the time waste caused by the actual production of handling. The simulation results may not be as many as those in real production, and there is still room for improvement. It is hoped that in future research, more comprehensive considerations can be made to improve the model and more realistically reflect the real production logistics system.

References

[1] Hosseini S S , Wong K Y , Mirzapour S A , et al. Multi-Floor Facility Layout Improvement Using Systematic Layout Planning[J]. Advanced Materials Research, 2014, 845:532-537.

[2] Qing-Lian Lin et al. Integrating systematic layout planning with fuzzy constraint theory to design and optimize the facility layout for operating theatre in hospitals[J]. Journal of Intelligent Manufacturing, 2015, 26(1):87-95.

[3] Banaszak Z A , Tang X Q , Wang S C , et al. Logistics models in flexible manufacturing[J]. Computers in Industry, 2000, 43(3):237-248.

[4] Shahram Taj,Lismar Berro. Application of constrained management and lean manufacturing in developing best practices for productivity improvement in an auto-assembly plant[J]. International Journal of Productivity and Performance Management,2006,55(3/4).

[5] S. Nallusamy,V. Saravanan. Lean Tools Execution in a Small Scale Manufacturing Industry for Productivity Improvement- A Case Study[J]. Indian Journal of Science and Technology,2016,9(35).

[6] Yagmahan B . Mixed-model assembly line balancing using a multi-objective ant colony optimization approach[J]. Expert Systems with Application, 2011, 38(10):p.12453-12461.

[7] Haile Sime and Prabir Jana and Deepak Panghal. Feasibility of Using Simulation Technique for Line Balancing In Apparel Industry[J]. Procedia Manufacturing, 2019, 30:300-307.

[8] Wang Heping, Yang Zimo, Chen Mengkai Research on Layout Optimization of Prefabricated Parts Factory Based on Artificial Bee Colony Algorithm [J/OL]. Systems Engineering: 1-9 [2021-10-04] http://kns.cnki.net/kcms/detail/43.1115.N.20210622.1419.004.html.

[9] Li Wenjun Optimization of overall workshop layout and logistics routes using SLP combined with Flexsim dynamic simulation [J]. Journal of Yibin University, 2018, 18 (12): 61-64+124

[10] Li He Research on Simulation and Optimization of Production Logistics System of K Furniture Company, 2021, 80-82

[11] Azrin B M S M , Ismail N B . Virtual Production Line Layout Modeling Using Arena Simulation Software[J]. Applied Mechanics & Materials, 2013, 393:42-48.

[12] Hassanali Aghajani,Hamzeh Samadi,Hossein Samadi,Hossein Lotfi. A simulation approach for assembly line improvement of Iran Heavy Diesel Company[J]. 2014,6(4).

[13] Jian Liang Peng. Optimization on the Improvement Schemes of Production Logistics System Based on Flexsim Simulation[J]. Advanced Materials Research,2011,1250.

[14] Liu Gang, Zhang Guangtao Research on Logistics Simulation for Aircraft Processing Workshop of Airborne Enterprises [J]. Logistics Technology, 2019, 42 (07): 45-48

[15] Yang Fan Optimization of Production Line Simulation Based on Flexsim [J]. Logistics Engineering and Management, 2017 (12): 125-127

[16] Wu Bo, Tian Liang Optimization design of main reducer assembly line based on Flexsim [J]. Digital Manufacturing Science, 201