

# Research on Layout Optimization of Furniture Workshop Based on SLP

Linge Li<sup>1,\*</sup>, Zhipeng Wang<sup>2</sup>

<sup>1</sup> School of Economics and Management, Southwest Petroleum University, Chengdu 610000, China

<sup>2</sup> Department of Information Engineering, Shenyang Institute of Science and Technology, Shenyang 110000, China

\* Corresponding author: 1318512878@qq.com

**Abstract:** The reasonable layout of the production workshop not only helps to improve the handling efficiency of the workshop materials, but also can effectively reduce production waste and improve production efficiency. By analyzing the current situation and existing problems of the production workshop layout of a furniture factory, SLP method was used to evaluate and optimize the overall layout of the production workshop, and the optimization results were analyzed. The results show that there are still some problems in the layout of the furniture workshop, such as unscientific division of working units, repeated work of working units, repeated handling and crossing of handling routes. Based on the analysis of the logistics relationship, non-logistics relationship, comprehensive relationship and regional position relationship among the units of the furniture workshop, the optimization scheme of the facility layout of the workshop was put forward. Through the optimization of the space layout, the production beat is reduced by 4752.63 seconds, and the daily output can be increased by 13. According to the market price of 680 yuan/price calculation, the company can earn 265,200 yuan more per month.

**Keywords:** Production workshop, Layout, SLP.

## 1. Research Background

As the main body of the national economic development, the manufacturing industry plays a pivotal role in promoting the development of the economy to the direction of high quality and enhancing the national competitiveness in the world. However, in the current new period of transformation and upgrading, although many manufacturing enterprises are committed to highlighting their advantages in domestic and foreign competition, mainly focusing on product improvement, such as reducing production costs, improving product quality and expanding market share, they often ignore the key to improving the production efficiency of workshop facilities layout optimization. From the long-term production practice, we can observe that in the daily operation of the factory, the processing and waiting time of raw materials, tools and parts account for up to 85% of the share, while the time really used for machine production only accounts for 15%. According to the relevant data of logistics engineering management, when a manufacturing enterprise is manufacturing products, the loading and unloading time of materials accounts for 30% to 40% of the entire production process, and the logistics costs generated by the inventory of raw materials, semi-finished products, finished products and various products in process are as high as 75% of the company's capital. Material handling costs account for 35% to 55% of total production costs. It can be seen that optimizing the layout of workshop facilities is of great importance to improve logistics efficiency, reduce production costs and enhance the overall competitiveness of enterprises.

## 2. Research Purpose and Significance

In the process of manufacturing and production, the layout of the workshop affects the handling distance in the workshop, whether it is congested, and the use of space, which affects the production efficiency and cost of the workshop, and a

reasonable layout will bring better benefits to the enterprise. Therefore, it is of great significance to study the layout of the workshop. More and more multi-variety, small-batch workshop enterprises are gradually emerging in China, but the scientific layout planning of the workshop is not extensive, resulting in higher production costs, lower efficiency, difficult to deal with emergencies and other problems. This paper takes the multi-variety and small-batch production workshop of Company A as an example. After in-depth analysis, 13 working areas are first divided. Then, considering logistics factors, non-logistics factors and the specific situation in the factory, the closeness of the relationship between each working area is calculated, and the specific location of each working area is determined according to the closeness. Finally, combined with the characteristics and layout requirements of the workshop, the optimal layout of the workshop is obtained, which has certain promotion and application value.

## 3. Literature Review

Systematic Layout Planning (SLP), as an important method of production facility planning, has been widely used in logistics planning, logistics efficiency and production workshop layout, and has obtained fruitful research results. In terms of logistics planning, literature [1-3] takes Changzhutan Tobacco Logistics Park, Kangjie Disinfection tableware distribution center and fresh logistics distribution center as research objects, adopts SLP method to optimize the layout design of the park or distribution center, and finds that the optimized scheme can further improve the rationality of relevant layout planning. In terms of logistics efficiency improvement, Yang [4] optimized the layout of signal control box production line by using SLP method and found that the optimization scheme could effectively reduce the material handling distance on the production line. Yang Xuechun, et al. [5] used SLP method to optimize the layout of the functional area of the warehouse of a logistics company, and found that

the optimized handling workload and moving distance were reduced by 17% and 36.5% respectively compared with the original layout. In terms of the layout of production workshops, Khariwal et al. [1] designed a new layout optimization scheme of railway workshops using SLP method in view of the problems such as long moving distance, flow interruption and useless areas in railway workshops. Wang Yunrui [6] took a steel structure company as the research object, optimized the layout of the workshop with the principle of optimal route through SLP method, and found that the optimized scheme effectively improved the handling efficiency; Liu Xiaomin et al. [7], aiming at the unreasonable layout of a mobile phone wiring workstation, adopted SLP method to optimize its layout and found that the optimized scheme greatly improved the closeness between operating units. Literature [8-9] takes production experiment workshop and ship construction valve warehouse as research objects, and uses SLP method to analyze and optimize the layout of workshop. To sum up, scholars have conducted a lot of research and practice on layout optimization problems in various fields by using SLP method, but through combing literature, it is found that SLP method is rarely involved in the research of furniture manufacturing workshop. In view of this, this paper selects the production workshop of a furniture

manufacturer as the research object, analyzes the current situation and existing problems of the production workshop facility layout, and uses SLP method to conduct in-depth evaluation and optimization of the overall layout of the production workshop. Finally, from the aspects of logistics handling route, distance and production line balance rate, the newly proposed workshop layout optimization scheme is further evaluated and verified.

## 4. Research Program

### 4.1. Category Workshop Production Line Status and Problem Analysis

#### 4.1.1. The current layout of the class workshop

The workshop is a small rectangular workshop of 45mx27m. The on-site picture of the workshop is shown in Figure 2-1. The small rectangular production shop consists of 12 production steps with 12 work areas. No. 6 grinding area is composed of three white grinding tables and two oil grinding tables. There are three workstations in section 13, consisting of two ironing workstations. The remaining areas are managed by one person and one machine. The layout of the workshop is shown in Figure 1.

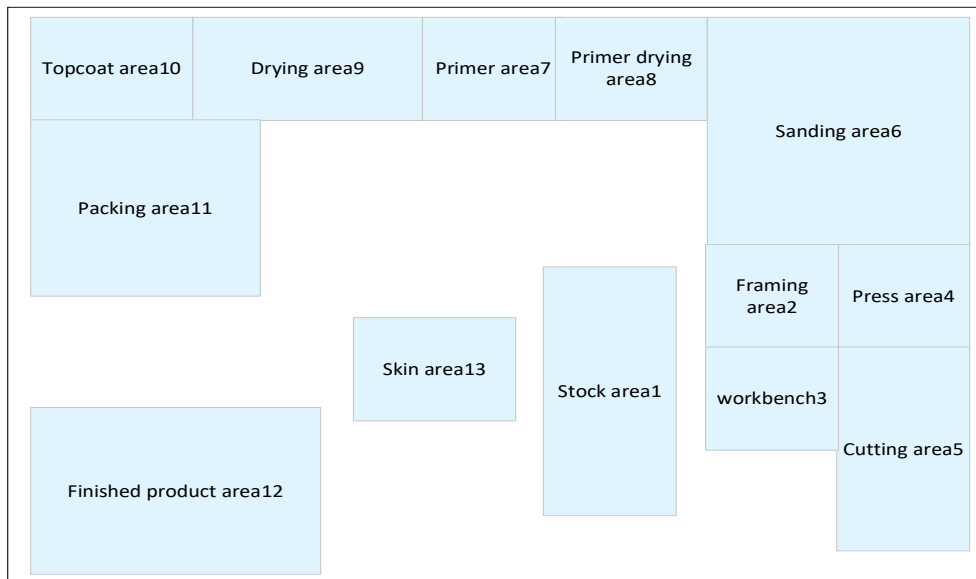


Figure 1. Layout of workshop

#### 4.1.2. Process flow chart of the workshop production line

The process diagram of the production line of the workshop Process diagram is the main analysis tool of process analysis. It is the production process diagram that records the product from the raw material investment to the finished product after

each process. It provides a comprehensive overview of the work flow and the relationship between the various processes, which is easy to find the existing problems and key links in general. The process diagram of the production line in the workshop is shown in Figure 2.

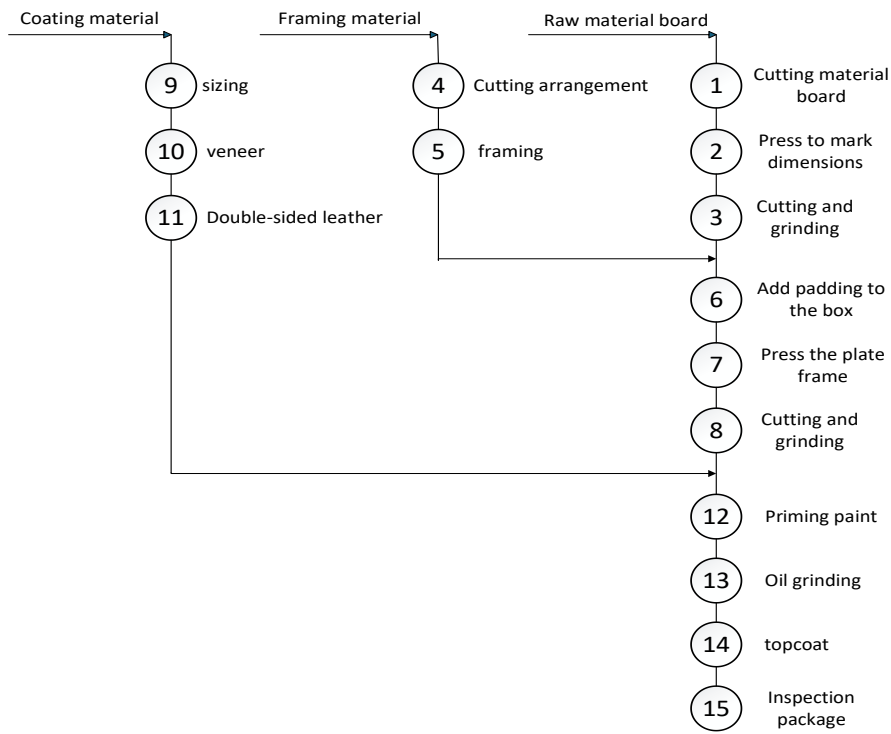


Figure 2. Process procedure of the production line

#### 4.1.3. Stopwatch test research of the production line of the workshop

The representative products determined by the data provided by the workshop are shown in Figure 2-4:

Table 1. represents the products

name	Annual output (PCS)	Unit (yuan)
Oil mixture door	2250	680
Veneer door	750	960
Raw wood door	250	2500
Custom door	100	indeterminacy

Firstly, the representative product is determined by the P-Q analysis diagram.

The representative product is the product whose structure and process are representative and the product whose output and labor amount are the largest. The factory produces many varieties of furniture and has special products such as customized models, which belongs to the production mode of multi-varieties and small batches. Through the analysis of the annual output of various varieties of furniture in 2022, the P-Q analysis chart is shown below.

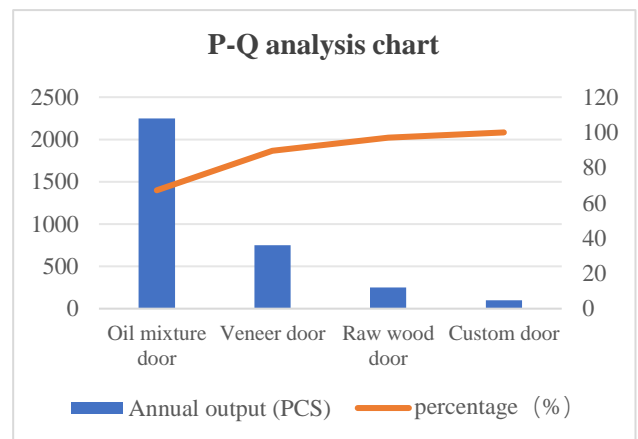


Figure 3. P-Q analysis diagram of production products

According to the 2/8 principle, the main products of the factory are hybrid throttle and wood leather doors.

Then, the stopwatch time research operation measurement method was used to collect a large amount of data for each process, and 9 groups of representative data were selected for each process for analysis, and the data processing and analysis after excluding abnormal values were tested. The results are shown in the following table:

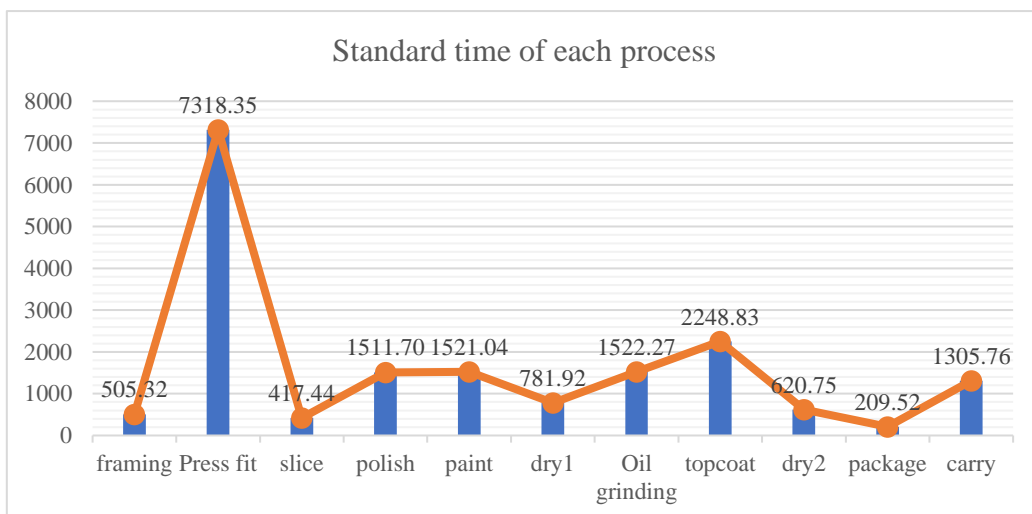
**Table 2.** Stopwatch test study (unit/second)

	framing	Press fit	slice	polish	ming pa	dry	l grind	topcoat	dry	package	carry
1	390	6018	342	1236	1230	624	1242	1818	528	162	1038
2	354	5987	337	1227	1219	621	1217	1801	527	154	1005
3	432	6004	347	1243	1229	635	1260	1841	568	149	1047
4	414	5994	349	1246	1249	657	1239	1813	512	167	1029
5	378	6023	345	1239	1251	660	1263	1852	554	158	1041
6	384	6007	351	1231	1233	637	1213	1833	531	171	1039
7	426	6014	332	1249	1237	652	1269	1849	539	168	1023
8	366	5988	340	1242	1242	648	1204	1824	556	161	1011
9	387	5997	339	1248	1235	639	1227	1817	543	174	1057
Mean value	392.33	6003.57	34244	1240.1	1236.1	64144	1237.11	1827.57	539.79	162.67	103222
Standard deviation	25.05	1228	5.78	7.16	9.52	13.04	22.17	16.33	16.41	7.69	15.9
UCL	467.48	6040.41	359.78	1261.6	1264.5	680.56	1303.62	1876.56	589.02	185.74	1079.9
LCL	317.18	5966.73	3251	1218.6	1207.6	60232	1170.6	1778.58	490.56	1396	984.52
Observation time	392.33	6003.57	34244	1240.1	1236.1	64144	1237.11	1827.57	539.79	162.67	103222
Evaluation	112	1.06	1.06	1.06	1.07	1.06	107	1.07	1.10	1.12	1.1
Normal time	439.41	6363.78	362.99	1314.5	1322.6	679.93	1323.71	1955.5	539.78	182.19	1135.4
allowance	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Standard time	505.32	7318.35	417.44	151170	1521	78192	152227	2248.83	620.75	209.52	1305.8

Evaluation coefficient = (1+ proficiency coefficient + effort coefficient + environmental coefficient + consistency coefficient) \*100% refer to Table 3.

**Table 3.** Reference table of evaluation coefficient

proficiency		effort		stability		Working environment	
superfine	0.15	superfine	0.13	ideal	0.04	ideal	0.06
superfine	0.13	superfine	0.12	optimal	0.03	optimal	0.04
optimal	0.11	optimal	0.1	good	0.01	good	0.02
optimal	0.08	optimal	0.08	average	0	average	0
good	0.06	good	0.05	normal	-0.02	normal	-0.03
good	0.03	good	0.02	bad	-0.04	bad	-0.07
average	0	average	0				
normal	-0.05	normal	-0.04				
normal	-0.1	normal	-0.08				
bad	-0.16	bad	-0.12				
bad	-0.22	bad	-0.27				



**Figure 4.** Standard time of each process

In order to more intuitively analyze the specific conditions of each station, the data in the table are represented by Figure 4: As can be seen from the figure, the unit output time of the hybrid throttle is 7318.35 seconds, and (13\*60\*60)

/7318.35≈6 hybrid throttles can be assembled every day (Note: The factory working time is two shifts, each shift is 7.5 hours), the production line per hour capacity =3600/ production beat =3600/7318.35≈0.49.

**Table 4.** Utilization rate of assembly line working hours before improvement

Serial number	Job content	workstations	Number of people	Standard time/s	Utilization rate of working hour
1	framing	1	1	505.32	6.90%
2	Press fit	1	1	7318.35	100.00%
3	slice	1	2	417.44	5.70%
4	polish	3	3	1511.70	20.66%
5	paint	1	1	1521.04	20.78%
6	Air dry	0	1	781.92	10.66%
7	Oil grinding	2	2	1522.27	20.80%
8	topcoat	1	1	2248.83	30.73%
9	Oil grinding	0	1	620.75	8.48%
10	pack	0	1	2099.52	2.86%

Note: Man-hour utilization rate = unit operating time/production beat

As can be seen from Table 4:

Production beat (CT): 7318.35 seconds

Number of workers: 14

Number of workstations: 10

Production capacity per hour = 0.49 units

Production line balance rate = total time of each process / (number of processes \* CT) 100% = 22.8%

It can be seen that the bottleneck process pressing, grinding, primer, top paint, drying, oil grinding and other processes take a long time, resulting in low balance rate of the production line, and the utilization rate of each working hour is mostly lower than 30%, which needs to be improved.

**4.1.4. Analysis of problems existing in the production line**

M company has developed rapidly in recent years, but there are still many problems in the production line, which seriously affect the production efficiency of the company and the completion of the goal. At present, the company has the

following problems:

The working procedure arrangement is not reasonable. Because the workers need to take raw materials for assembly, and the raw materials come from different places in the raw material area, unreasonable arrangements lead to workers moving around more, delaying the assembly time.

The layout of the station machine is unreasonable. According to the work sequence of the production line, the machine arrangement leads to too many repetitions of the workers in the handling process, so that the handling time is seriously wasted.

**4.2. Analysis and Processing Based on SLP**

**4.2.1. Logistics relationship analysis**

Taking the main product obtained from the P-Q analysis table as the representative product, SLP was applied to conduct the logistics relationship analysis, and the distance of the main product was obtained from the table as shown in Table 5.

**Table 5.** Distance from to table

From To	Ingredient	Framing	Workbench	Press	Slice	Polish	Veneer	Priming pa	Dry1	Topcoat	Dry2	Package	Product ar
Ingredient		13.5	0	0	0	0	0	0	0	0	0	0	0
Framing	0		4	0	0	0	0	0	0	0	0	0	0
Workbench	0	0		9	0	0	0	0	0	0	0	0	0
Press	0	0	0		7	0	0	0	0	0	0	0	0
Slice	0	0	0	0		17	24.5	0	0	0	0	0	0
Polish	0	0	0	0	0		34	0	0	42	0	40.5	0
Veneer	0	0	0	0	0	34		20	0	0	0	0	0
Priming pa	0	0	0	0	0	0	0		6	0	0	0	0
Dry1	0	0	0	0	0	0	0	6		0	0	0	0
Topcoat	0	0	0	0	0	0	0	0	0		12	0	0
Dry2	0	0	0	0	0	0	0	0	0	0		17.5	0
Package	0	0	0	0	0	0	0	0	0	0	0		13.5
Product ar	0	0	0	0	0	0	0	0	0	0	0	0	

Based on the distance from the above figure to the table, and combined with the number of handling operations, the

handling workload from the table to the table is integrated, as shown in Table 6.

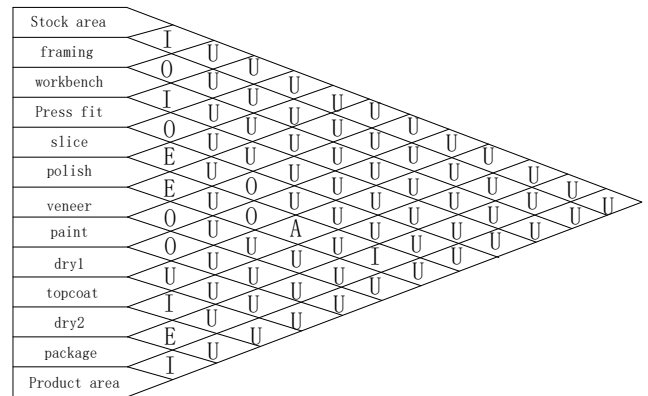
**Table 6.** Transfer workload from to table

From To	Ingredient	Framing	Workbench	Press	Slice	Polish	Veneer	Priming pa	Dry1	Topcoat	Dry2	Package	Product ar
Ingredient		189	0	0	0	0	0	0	0	0	0	0	0
Framing	0		56	0	0	0	0	0	0	0	0	0	0
Workbench	0	0		126	0	0	0	0	0	0	0	0	0
Press	0	0	0		98	0	0	0	0	0	0	0	0
Slice	0	0	0	0		221	24.5	0	0	0	0	0	0
Polish	0	0	0	0	0		272	0	108	504	0	162	0
Veneer	0	0	0	0	0	34		60	0	0	0	0	0
Priming pa	0	0	0	0	0	0	0		18	0	0	0	0
Dry1	0	0	0	0	0	0	0	0		0	0	0	0
Topcoat	0	0	0	0	0	0	0	0	0		144	0	0
Dry2	0	0	0	0	0	0	0	0	0	0		210	0
Package	0	0	0	0	0	0	0	0	0	0	0		189
Product ar	0	0	0	0	0	0	0	0	0	0	0	0	

After merging the same operating units, the handling workload is sorted from large to small, and each operating unit pair is classified according to the logistics intensity level table (Table 7). After the classification, the logistics relationship diagram is drawn, as shown in Figure 5.

**Table 7.** Logistics intensity grade table

letter	Logistics intensity class	The proportion of grades
A	Ultra	10%
E	higher	20%
I	larger	30%
O	normal	40%
U	minimum	0%



**Figure 5.** Logistics relationship diagram

**4.2.2. Non-logistics relationship analysis**

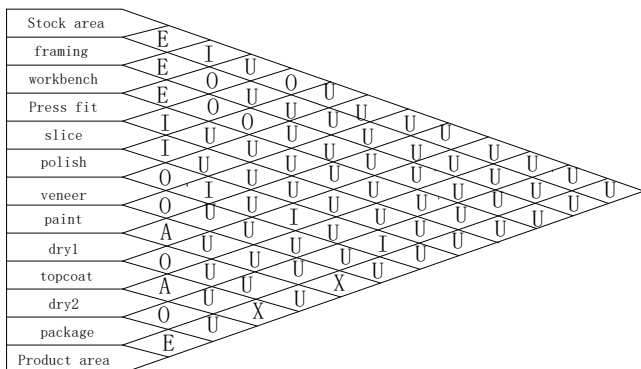
In addition to considering the logistics relationship between various operating units, non-logistics factors also have a great influence on the layout of this factory workshop. Based on the actual situation and consulting some experienced teachers in the workshop, the classification of non-logistics intensity was made according to the classification table (Table 8), and the mutual relationship diagram of operating units was finally made, as shown in Figure 6.

**Table 8.** Classification of non-logistics intensity

Relationship level	symbol	Work unit to ratio (%)	Relationship level	symbol	Work unit to ratio (%)
Absolutely necessary to be near	A	≤5%	normal	O	A+E+I+O≤40%
Particularly important proximity	E	A+E≤12%	insignificance	U	≥50%
importance	I	A+E+I≤25%	Do not wish to come near	X	≤5%

**4.2.3. Comprehensive correlation analysis**

Considering the comprehensive logistics and non-logistics factors and the actual situation in the factory, since the logistics relationship is more important in the production of main products, the weighted value of the logistics relationship among all operating units is 2, and the weighted value of the non-logistics relationship is 1. According to the weighted score, the grades are divided by the comprehensive relationship level and division scale table (as shown in Table 9).

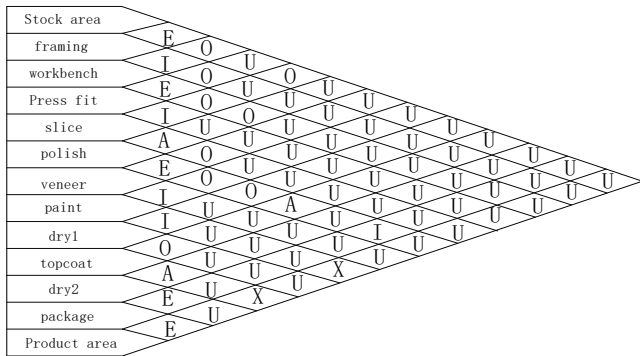


**Figure 6.** Inter-relationship diagram of operating units

**Table 9.** Comprehensive relationship level and division scale table

Relationship level	symbol	Work unit to ratio (%)	Relationship level	symbol	Work unit to ratio (%)
Absolutely necessary to be near	A	1-3	normal	0	5-15
Particularly important proximity importance	E	2-5	insignificance	U	20-85
	I	3-8	Do not wish to come near	X	0-10

After the grades are divided, the comprehensive relationship diagram of operating units is made, as shown in Figure 7.



**Figure 7.** Comprehensive relationship diagram of operating units

**4.2.4. Layout design scheme**

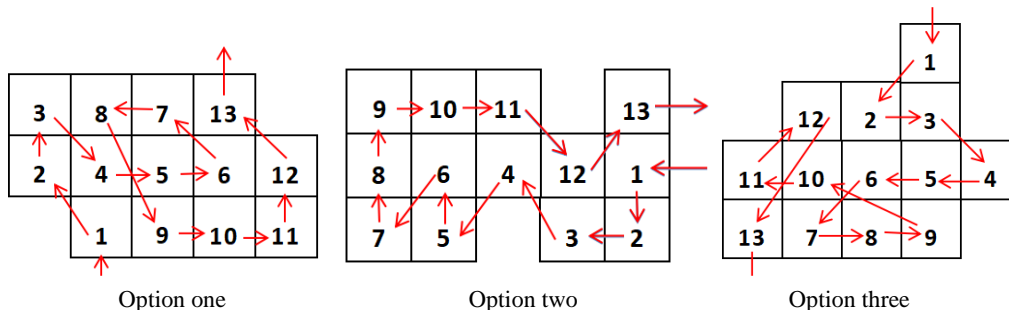
Tompkins' relationship technical table was used to generate the non-area layout scheme, and the relationship worksheet was made by synthesizing the relationship diagram of operating units, as shown in Table 10.

**Table 10.** Relationship worksheet

Operating unit	A	E	I	O	U	X
1. Stock area		2		3,5	4, 6, 7, 8, 9, 10, 11, 12, 13	
2. framing		1	3	4	5, 6, 7, 8, 9, 10, 11, 12, 13	
3. workbench		4	2	5, 6, 1	4, 6, 7, 8, 9, 10, 11, 12, 13	
4. Press fit		3	5	2	1, 6, 7, 8, 9, 10, 11, 12, 13	
5. slice	6		4	7, 1, 3	2, 8, 9, 10, 11, 12, 13	
6. polish	10, 5	7	12	8, 9, 3	1, 2, 4, 11, 13	
7. veneer		6	8	5	1, 2, 3, 4, 9, 10, 11, 12, 13	
8. Priming paint			9, 7	6	1, 2, 3, 4, 5, 10, 11, 12	13
9. dry1			8	10, 6	1, 2, 3, 4, 5, 7, 11, 12, 13	
10. topcoat	11, 6			9	1, 2, 3, 4, 5, 7, 8, 12	13
11. dry2	10	12			1, 2, 3, 4, 5, 6, 7, 8, 9, 13	
12. package		13, 11	6		1, 2, 3, 4, 5, 7, 8, 9, 10	
13. product area		12			1, 2, 3, 4, 5, 6, 7, 9, 11	10, 8

Then the non-area block is carried out, and three non-area layout schemes are obtained after being placed. The designed block diagram is evaluated. According to the analysis diagram

of logistics flow on the block diagram (as shown in Fig. 8), scheme 2 is the best scheme.



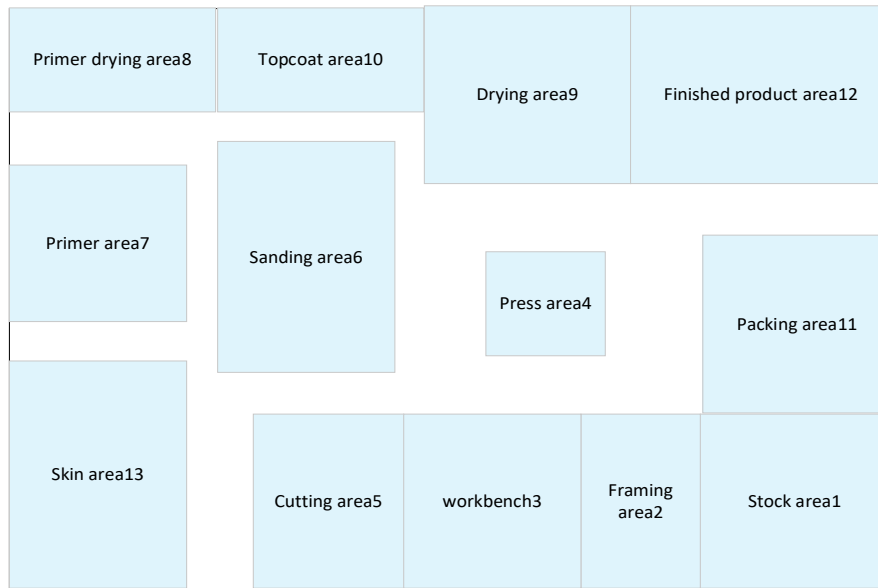
**Figure 8.** No-area layout scheme

The floor space required by each working unit in the workshop is shown in Table 11.

**Table 11.** Floor space required by each work unit

Serial number	Operating unit	S/m <sup>2</sup>	Serial number	Operating unit	S/m <sup>2</sup>
1	Stock area	72	8	Priming paint	36
2	framing	20	9	dry1	36
3	workbench	20	10	topcoat	36
4	Press fit	20	11	dry2	108
5	slice	36	12	package	72
6	polish	81	13	product area	120
7	veneer	60			

According to the best no-area layout scheme and the floor area required by each working unit, the optimal factory layout is shown in Figure 9.



**Figure 9.** Factory layout after improvement

### 4.3. Analysis of Optimization Results

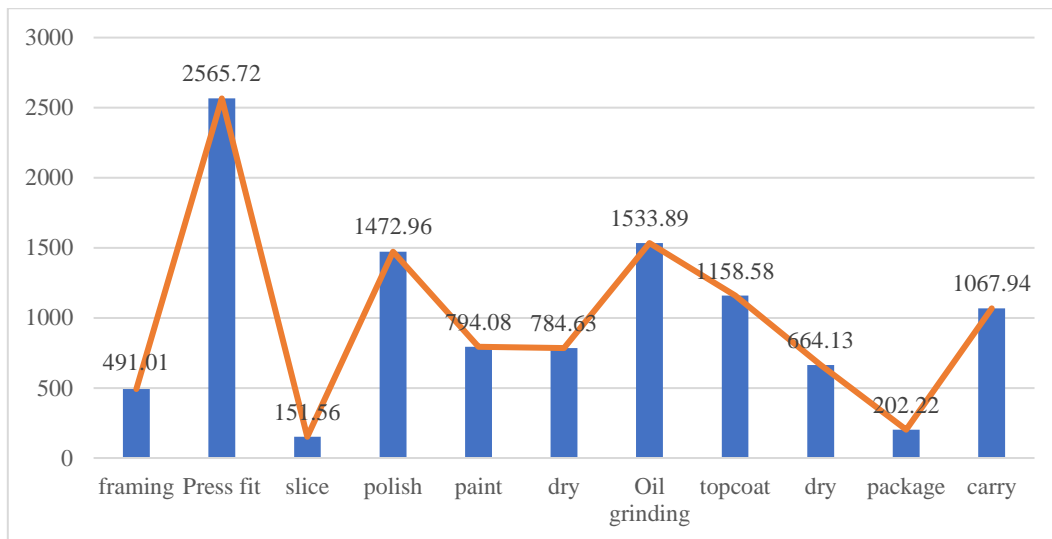
Productivity improvement effect: Combined with the new

workshop layout, the standard schedule of each process can be obtained as shown in Table 12:

**Table 12.** Standard schedule of each process

	framing	ress fit	slice	polish	riming pair	dry	oil grindin	topcoat	dry	package	carry
1	371	2089	117	1209	637	624	1249	943	528	157	831
2	387	2107	128	1197	629	657	1237	926	538	153	847
3	365	2093	131	1187	644	673	1251	937	509	167	836
4	392	2124	126	1224	641	639	1241	961	557	148	827
5	389	2113	115	1237	653	611	1239	952	495	159	855
6	373	2085	134	1195	628	652	1245	939	512	146	848
7	376	2116	127	1216	658	644	1253	945	522	149	868
8	392	2095	112	1221	673	634	1245	941	523	161	829
9	386	2121	129	1189	645	659	1259	930	541	173	8570
Mean value	381.22	2104.8	124.33	1208.3	645.33	643.67	1246.56	941.56	525	157	844.22
Standard deviation	9.5	13.77	7.27	16.4	13.51	17.99	6.72	10.02	17.63	8.55	13.49
UCL	409.72	2145.3	146.14	1257.5	685.86	697.64	1266.71	971.63	577.88	182.65	884.69
LCL	352.72	2062.7	102.52	1159.5	604.8	589.7	1226.4	911.49	472.12	131.35	803.76
Observation time	381.22	2104.8	124.33	1208.3	645.33	643.67	1246.56	941.56	525	157	844.22
Evaluation	1.12	1.06	1.06	1.06	1.07	1.06	1.07	1.07	1.1	1.12	110
Normal time	426.97	2231.1	13179	1280.8	690.51	682.29	1333.81	1007.46	577.5	175.84	928.64
allowance	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Standard time	491.01	2565.7	15156	1473	794.08	784.63	1533.89	1158.58	664.13	202.22	106794

The bar chart of standard time of each process is shown in Figure 10:



**Figure 10.** Bar chart of standard time of each process

Combined with the information in Table 12 and Figure 11, it can be seen that the unit output time of the hybrid throttle is 2565.72 seconds, and  $(13 \times 60 \times 60) / 2565.72 \approx 18$  hybrid throttles can be assembled every day. The working time of the

factory is two shifts, each shift is 7.5 hours), the production line per hour capacity =  $3600 /$  production beat =  $3600 / 2565.72 \approx 1.40$ .

**Table 13.** Improved utilization rate of assembly line working hours

process	Job content	Work station number	Number of people	Standard time/s	Utilization rate of working hour
1	framing	1	1	491.01	19.14%
2	Press fit	3	1	2565.72	100.00%
3	slice	3	3	151.56	5.91%
4	polish	3	2	1472.96	57.41%
5	paint	2	1	794.08	30.95%
6	Air dry	0	1	784.63	30.58%
7	Oil grinding	2	2	1533.89	59.78%
8	topcoat	2	1	1158.58	45.16%
9	Oil grinding	0	1	664.13	25.88%
10	pack	0	1	202.22	7.88%

As can be seen from Table 13:

Production beat (CT): 2565.72 seconds

Number of workers: 14

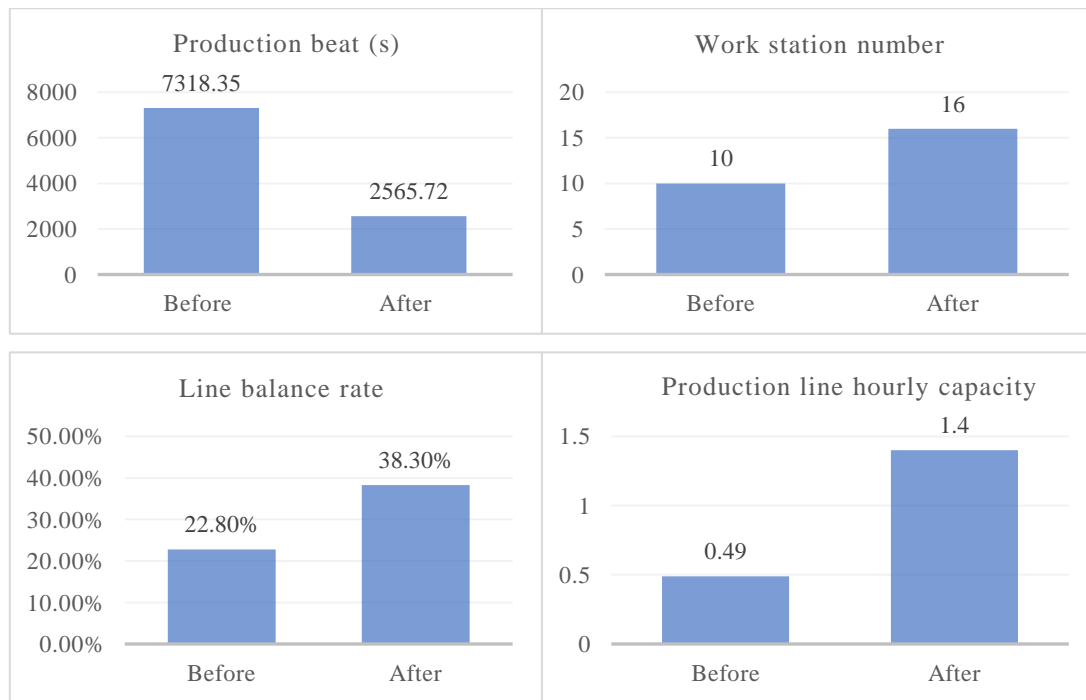
Number of workstations: 16

Production capacity per hour = 1.4 units

Production line balance rate =  $\frac{\text{total time of each process}}{(\text{number of processes} \times \text{CT})} \times 100\% = 38.3\%$

**Table 14.** Comparison of production indicators before and after station improvement

Production index	Before	After
Production beat	7318.35	2565.72
Work station number	10.00	16.00
Number of workers	14.00	14.00
Line balance rate	22.80%	38.30%
Production line hourly capacity	0.49	1.40



**Figure 11.** Improved rendering

Through the optimization of the space layout, the production beat is reduced by 4752.63 seconds, and the daily output can be increased by 13. According to the market price of 680 yuan/unit price calculation, the company can gain 265,200 yuan per month. The annual output value can be increased by 3,182,400 yuan.

## 5. Conclusion

Taking a furniture company as an example, this paper uses SLP method to optimize the layout. Firstly, the workshop is divided into 13 working areas, and the moving quantity is calculated from to table. Then the working units are sorted and assigned corresponding levels according to the proportion, and the logistics mutual relationship diagram is made. Then according to the actual situation in the factory, the non-logistics relationship diagram is made. Secondly, combined with the weighted value, the value of comprehensive correlation closeness is calculated. Tompkins method is used to generate the non-area layout scheme, and the optimal scheme is determined through the logistics flow chart. The analysis shows that the workshop can reduce the congestion generated in the process of product handling, reduce unnecessary waste, improve the working environment, improve the operation efficiency of the workshop, and reduce the production cost of the enterprise through the optimization and improvement of the layout.

## References

[1] Khariwal S, Kumar P, Bhandari M. Layout improvement of railway workshop using systematic layout planning (SLP):a

case study [J]. *Materials Today: Proceedings*, 2021, 44: 4065-4071.

- [2] Li Y. Research on layout planning of disinfection tableware distribution center based on SLP method [J/OL]. *MATEC Web of Conferences*, 2020, 325(1) [2023-08-01].
- [3] Zeng Dandan, Chen Xiaoyuan. Optimization of fresh logistics Distribution center layout based on SLP [J]. *Logistics Technology*, 2023, 42(1):91-94.
- [4] YANG K. Layout optimization of signal control box production line based on SLP [J/OL]. *E3S Web of Conferences*, 2021, 253 [2023-08-01].
- [5] Yang Xuechun, Cheng Xianzhi. SLP analysis of warehouse functional area layout of Logistics Company [J]. *Logistics Technology*, 2021, 44(9):159-161.
- [6] Wang Yunrui. Research on Optimization of Production workshop Layout of a steel structure company based on SLP [J]. *Modern Manufacturing Engineering*, 2019(3):31-37.
- [7] Liu Xiaomin, Qu Min, Chen Liang. Layout planning of mobile phone cabling robot Workstation based on SLP-CORELAP [J]. *Chinese Journal of Construction Machinery*, 21, 19(2): 123-130.
- [8] Ma Xiaotian, Li Tao, TAN Peng. Layout optimization of a production test shop based on SLP algorithm [J]. *Logistics Technology*, 2022, 41(12):109-111.
- [9] Wang Ping, LAN Hao. Optimization of Valve warehouse layout for Ship construction based on SLP and SHA [J]. *Logistics Technology*, 202, 41(9):104-109.