Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 13, No. 3, 2024

Research on Workshop Layout Optimization Based on SLP Method

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Abstract: With the rapid development of the market economy and the increasing personalized needs of customers, the production mode of the production workshop is gradually shifting towards small batch and multi batch production mode, which has a significant impact on the production efficiency, logistics costs, and other aspects of the production workshop, posing huge challenges to the layout of production workshop facilities. A reasonable workshop layout can not only reduce the distance and cost of material handling, but also save product production time and shorten the production cycle. This article takes DY Company's machining workshop as the research object, and through investigation, it is found that there are problems such as logistics distribution routes crossing and overlapping in the workshop. In response to the above issues, data was collected from the workshop and analyzed using the SLP method, ultimately obtaining the optimal solution for optimizing the layout of the machining workshop, achieving a dual improvement in the production capacity and efficiency of the machining workshop.

Keywords: Machining workshop, SLP, Workshop layout.

1. Introduction

Workshop layout planning directly affects the production efficiency of enterprises and plays a fundamental role in the production process[1]. A reasonable workshop layout can not only reduce the distance and cost of material handling, but also save production time and shorten the production cycle. At the same time, a reasonable planning of workshop layout can help enterprises improve the utilization rate of site area, avoid safety problems caused by excessive congestion in the workshop, and facilitate worker operation and material handling. However, most manufacturing enterprises in China rely solely on worker experience for workshop layout design, which seriously affects their competitiveness[2]. Therefore, in order to achieve long-term development and achieve the goal of cost reduction and efficiency improvement, Chinese manufacturing enterprises urgently need to use scientific theories and methods to guide workshop layout.

This article takes DY Company's machining workshop as the research object, aiming to minimize the logistics cost of the workshop, and uses the SLP method to optimize and transform the workshop layout. Based on this, optimize the layout of the company's machining workshop, improve the logistics efficiency of the workshop, reduce logistics costs, enhance enterprise competitiveness, and provide certain reference value and practical significance for other related manufacturing enterprises.

2. Current Situation and Problem Analysis of DY Company's Machining Workshop

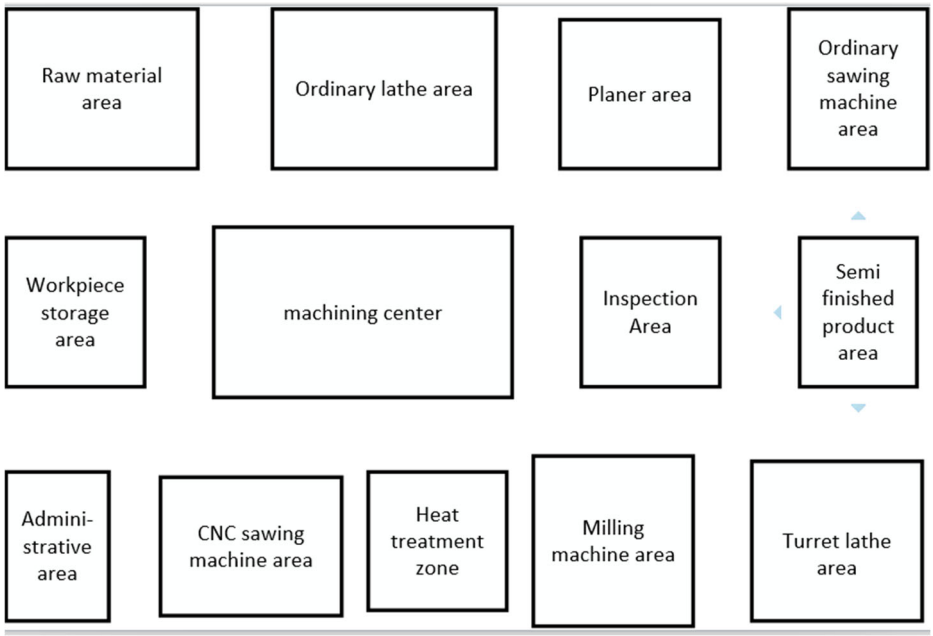

Figure 1. Original layout of DY Company's machining workshop

DY Machinery Company (hereinafter referred to as "DY Company") was established in 2005 and is a machinery manufacturing enterprise located in Zibo, Shandong. The company mainly produces surface treatment equipment, including sandblasting machines and a series of related components in the automotive industry. This article takes the machining workshop as an example, which mainly produces shot blasting machine related accessories, such as blades, shot splitters, directional sleeves, with over a hundred product specifications and types. With the increase of market orders and the variety of products, there is a serious phenomenon of cross flow and backflow during the material handling process in the workshop, and logistics efficiency is low, which has affected the timely delivery of market orders. At the same time, the logistics cost of the workshop has also increased sharply, and optimizing the workshop layout is urgent.

The workshop is 80 meters long and 60 meters wide, covering a total area of 4800 square meters. According to the production process of the product, the workshop currently has 13 work units, namely the raw material area, CNC sawing machine area, planer area, ordinary sawing machine area, turret lathe area, ordinary lathe area, milling machine area, machining center, heat treatment area, inspection area, semi-finished product area, workpiece storage area, and office area. The original layout of the workshop is shown in Figure 1.

The production process of the product mainly involves processing the raw material through lathes, planers, saws, milling machines, and machining centers to obtain semi-finished products. After passing inspection by the inspection department, the semi-finished products are subjected to heat treatment and finally transported to the semi-finished product area for assembly by the shot blasting machine. The specific production process diagram of the product is shown in Figure 2.

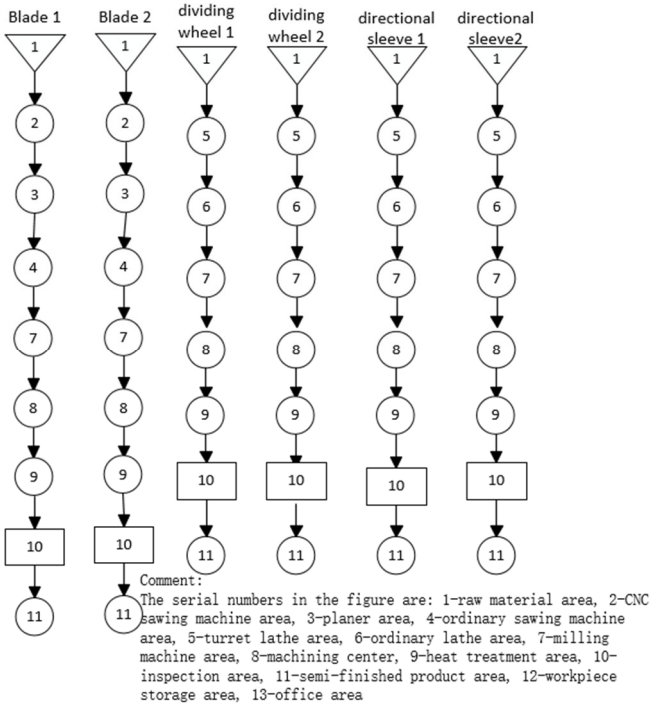

Figure 2. Process flow diagrams for various products

3. Design of optimization plan

3.1. Analysis of Workshop Logistics Relationship

According to the process route of the product, collect data on the distance and logistics volume between related work units, and characterize the logistics intensity using the product of distance and logistics volume. The specific data is shown in Table 1.

Table 1. Logistics intensity table

Serial Number	From - to	Logistics distance (m)	Logistics volume (t)	Logistics intensity/m · t
1	1-5	74	65	4810
2	5-6	54	46	2484
3	4-7	38	37	1406
4	2-3	44	28	1232
5	7-8	21	49	1029
6	6-7	38	25	950
7	1-2	20	33	660
8	8-9	14	32	448
9	9-10	18	23	414
10	3-4	13	24	312
11	10-11	12	17	204

According to the data in Table 1, the logistics intensity of each operating unit in DY Company's machining workshop was sorted in descending order, the results are shown in Table 2.

Table 2. Logistics intensity sorting and classification

From - to	Logistics intensity/m · t	Grade
1-5	4810	A
5-6	2484	E
4-7	1406	E
2-3	1232	I
7-8	1029	I
6-7	950	I
1-2	660	O
8-9	448	O
9-10	414	O
3-4	312	O
10-11	204	O

Based on the sorting and classification table of logistics intensity, in order to observe the logistics relationship of each operating unit more intuitively, a logistics related diagram of the machining workshop operating unit is drawn, as shown in Figure 3.

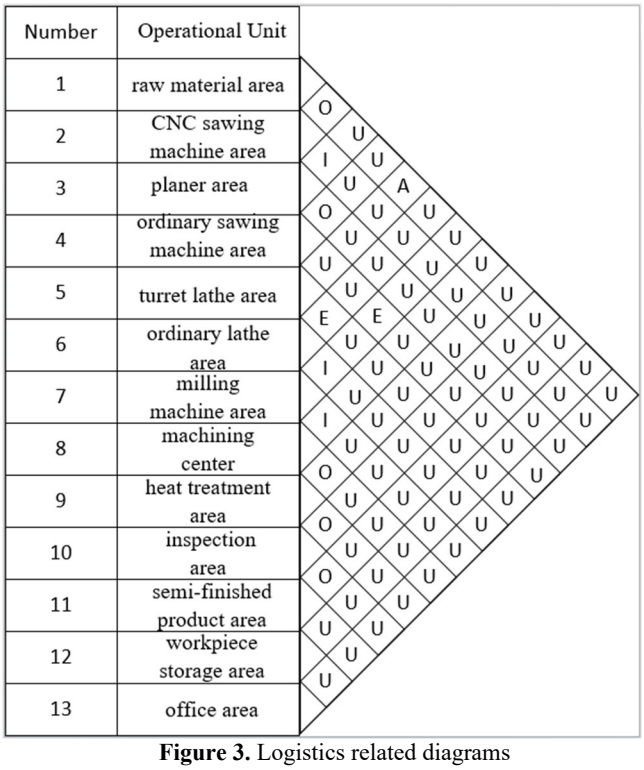

Figure 3. Logistics related diagrams

3.2. Analysis of non logistics relationships in the workshop

The arrangement of work units in the machining workshop not only considers the logistics relationship between work units, but also non logistics relationships that cannot be ignored. The specific non logistics relationship influencing factors are shown in Table 3.

Table 3. Influence factors

Number	Influence factor
1	Continuity of process flow
2	Similarity of homework nature
3	Frequent personnel turnover
4	Convenient information transmission
5	Efficient supervision and management
6	Air and noise pollution
7	Security

According to Table 3, draw non logistics related diagrams between various operating units in the machining workshop, as shown in Figure 4.

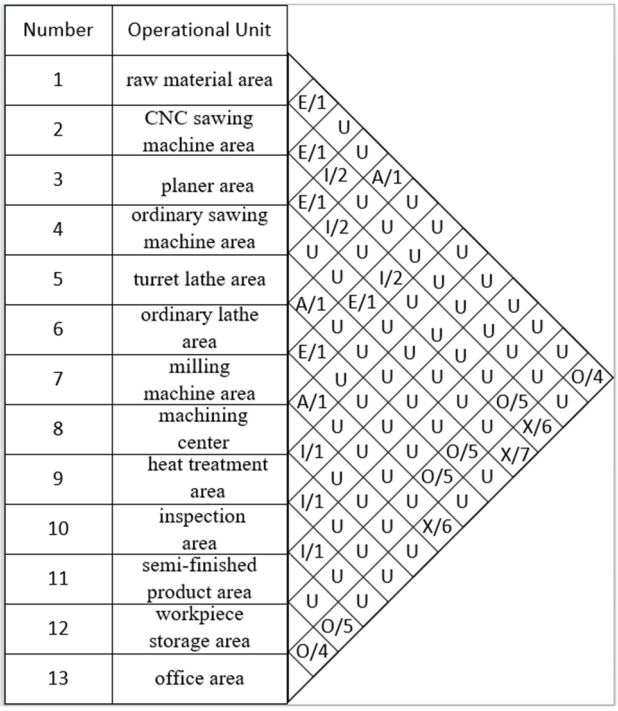

Figure 4. Non logistics related diagrams

3.3. Comprehensive relationship analysis

The workshop layout should consider both logistics and non logistics relationships between work units. According to the actual situation of the machining workshop, logistics relationships are more important than non logistics relationships, so the weight ratio is determined to be m:n=2:1.

The calculation formula for the comprehensive relationship is shown below.

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

I and j respectively represent the job unit i, job unit j, TR_{ij} represents the comprehensive relationship value between job unit i and job unit j, MR_{ij} represents the logistics relationship value, and NR_{ij} represents the non logistics relationship value.

After calculation, a comprehensive correlation chart of workshop operation units was obtained, as shown in Figure 5.

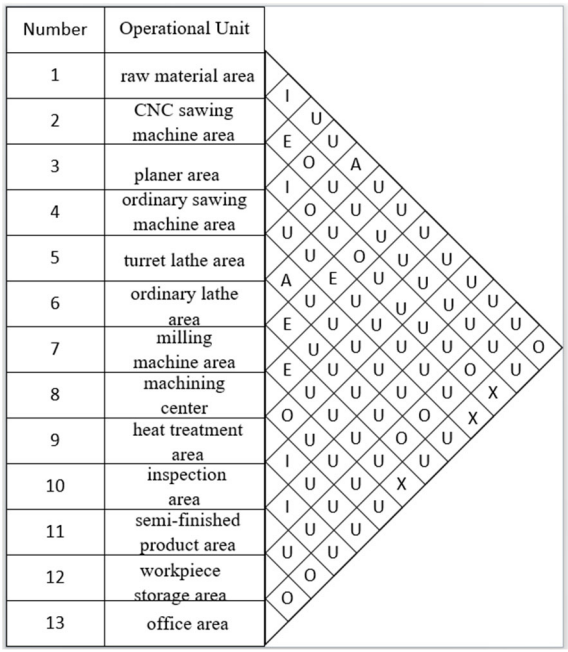

Figure 5. Comprehensive relationship analysis

Comprehensive proximity ranking of each homework unit is shown in Table 4.

Table 4. Comprehensive proximity table

Sort	Operational Unit
1	5
2	6
3	7
4	1
5	3
6	2
7	4
8	8
9	10
10	12
11	9
12	11
13	13

3.4. Workshop layout optimization schemes and evaluation

3.4.1. Optimization schemes

According to Table 4, draw a map of the location of the machining workshop's operating units, as shown in Figure 6.

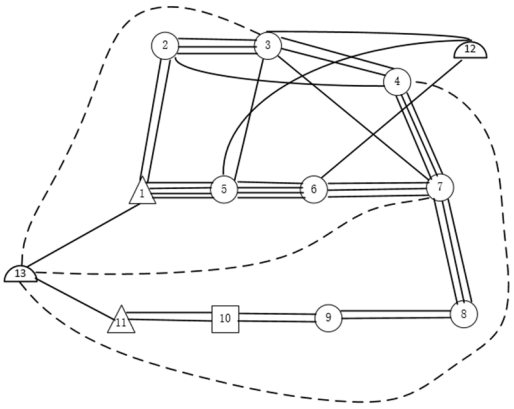

Figure 6. Position related diagram

According to Figure 6, draw a layout diagram of the machining workshop. During this process, adjust it appropriately according to the actual situation of the workshop, and finally obtain two layout schemes for the machining workshop, as shown in Figures 7 and 8.

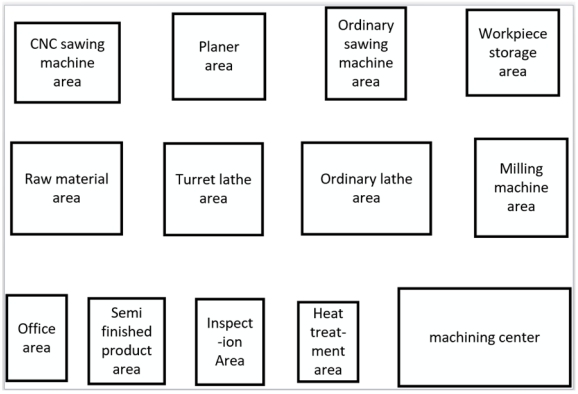

Figure 7. Optimization scheme 1

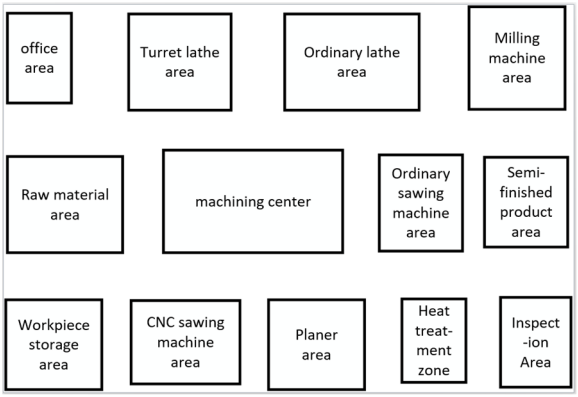

Figure 8. Optimization scheme 2

3.4.2. Evaluation and Selection of Optimization Schemes

The layout of this workshop needs to consider multiple factors, combined with the characteristics of this workshop, mainly from the following aspects[4]:

(1) Reserve area.Another difference between the two schemes is the placement of reserved areas.DY Company is in a stage of rapid development, with the increase of product models, the introduction of new equipment is imminent, so it is necessary to reserve a certain space in the machining workshop for new equipment.

(2) Safety. Safe passages and facilities should be set up in the workshop to facilitate rapid evacuation of employees in emergency situations.Both schemes can ensure safety.

The above two points have been fully considered for both options, and there is no clear distinction between the two.

(3) Process coherence.The workshop layout should consider the production process of the product, which means that the relevant workstations should be close to each other to reduce transportation and waiting time[5].

Plan one can better reduce the phenomenon of cross flow and backflow during material handling compared to plan two, which is more conducive to improving logistics efficiency.

In summary, through statistics and analysis based on the SLP algorithm, combined with the actual needs and planning of the machining workshop, and by comprehensively comparing various factors, Plan One is selected as the final layout plan.

4. Conclusion

This article takes DY Company's machining workshop as the research object, with the goal of minimizing logistics costs in the workshop, and uses the SLP method to optimize and transform the layout of the machining workshop. Two optimization schemes are proposed and applied in the machining workshop to make the layout more reasonable, greatly improve logistics efficiency, reduce logistics costs, and lay a good foundation for the company's future development.

In short, optimizing workshop layout has important strategic significance for the development of manufacturing enterprises. At present, many scholars have proposed many theories and methods to study workshop layout optimization. Due to the diversity of production workshops in enterprises, specific theoretical and methodological research and analysis are required for optimizing workshop layout. How to combine the advantages of various theories and methods to make the workshop layout more reasonable is of great significance for the development of enterprises and the country.

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