

Comprehensive Planning of New Plant Under Industry 4.0

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Abstract. The article carries out layout design optimization and warehouse improvement for HF Company. First of all, taking the production management process of the new plant as the research object, set a comprehensive planning of the plant area from the aspects of product mix, production management and logistics management. According to the planning objectives, detailed design, data collection for production forecasting are proposed based on SLP method and mapping of the new plant layout, combined with lean thinking and Industry 4.0 concept. Finally, the expected goals and improve production efficiency are achieved.

1. Introduction

With the rapid development of manufacturing industry, how to deliver goods faster and reduce costs is a problem that all enterprises must pay attention to. Reasonable workshop layout is of great significance to give full play to production capacity and improve product quality [1]. As far as manufacturing mode is concerned, it has shifted from mass production to just-in-time and lean production, and further to computer integrated manufacturing and agile manufacturing. Ma proposed the workshop layout for agile manufacturing, elaborated the workshop layout of the new model, and proposed the idea of distributed layout based on agile manufacturing according to the philosophy of lean production [2]. In terms of computer assistance, MRP-II, ERP, CIMS and other software and facility planning complement each other. Balakrishnan and Cheng [3] solved the DPLP problem combined with mathematical algorithm [4]. Today, facility planning is no longer limited to enterprises, including social services and even supply chain rivals.

Facility planning plays an important role in enterprises. How to achieve the maximum work efficiency in the shortest time is the problem that every enterprise expects to solve [5]. Optimization and improvement of layout become the top priority. In the process of layout, many enterprises have already used SLP, and achieved very successful results. In this paper, SLP method is applied to design and optimize the overall layout of the new factory [6, 7].

2. Plant layout planning

2.1. Analysis of logistics relationship among operation units

Using the logistics relationship classification table and related tables, non-logistics relationships are analyzed. The calculation process is as follows: by consulting and counting the inventory list and historical data of each database in previous years, the materials of the raw material warehouse and the semi-finished product warehouse are transported to the production workshop in a tray manner, the raw material warehouse is transported to the production workshop for 5678 pallets, and the semi-finished product warehouse is 3210 pallets. And the packaging materials stored in the packaging material



warehouse are shipped to the production workshop in one direction. The equivalent material flow rate is 1065 pallets, and the equivalent material flow rate in the production workshop is 5678+3210+1065=8533. Take this as an example and multiply the annual equivalent material flow of each region by the distance between each operating unit to get the logistics intensity.

Table1: Logistics intensity from - to (unit: tray m)

Serial number	1	2	3	4	5	6	7
to							
from							
1 Raw materials library			448562				
2 Semi-finished products lib			224700				
3 production workshop				379718.5	60705		181760
4 Quarantine						849033.5	
5 Packaging material library							
6 Shipping department							
7 Carton recycling area							

According to the function interval flow and the operation batch, the logistics strength analysis is carried out by the logistics relationship classification table, which is represented by the symbol AEIOU as in Tab. 2.

Table2: Logistics intensity from - to (unit: tray m)

The serial number	Logistics route	logistics intension	level
1	4-6	849033.5	A
2	1-3	448562	E
3	3-4	379718.5	E
4	2-3	224700	I
5	3-7	181760	I
6	3-5	60705	O

2.2. Analysis of non-logistics relationship among operating units

In the shop floor layout, there is also a non-logistics relationship between the work units. The non-logistics relationship of the operating unit is similar to the logistics relationship, and is also divided into five different levels which is represented by AEIOU.

2.3. Comprehensive relationship among operation units

In the production arrangement, the relationship between logistics and non-logistics operation units is commonly different. In order to outline the comprehensive relationship between different operational units, it is essential to combine logistics and non-logistics, in order to find out the comprehensive relationship between layouts.

The calculation of the comprehensive relationship is as follows:

$$TR_{ij} = m \times MR_{ij} + n \times NR_{ij} \tag{1}$$

In this paper, A=4, E=3, I=2, O=1, U=0 and X=-1 are used as the amount of the correlation degree. And through the suggestion of the study supervisor, the logistics relationship and non-logistics relationship m:n=2:1 are brought into the formula, and the calculation table of the relationship is achieved.

Table3: Comprehensive relational computation

Unit pair	Relation grade				Comprehensive relationship	
	Logistics weighted values: 2		Non-logistics weighted values: 1			
	grade	Points	grade	Points	grade	Points
1-2	U	0	O	1	O	1
1-3	E	3	A	4	A	10
...
7-9	U	0	U	0	U	0
8-9	U	0	I	2	O	2

According to the scores, the comprehensive relationship table of operation units is achieved.

Table4: Operational units

num ber	Name of operation unit
1	1 Raw materials library
2	2 Semi-finished products library
3	3 The production workshop
4	4 quarantine
5	5 Packaging material library
6	6 Shipping department
7	7 Carton recycling area
8	8 Conference office area
9	9 Staff rest area

3. Layout design

In this paper, the unit of work unity relationship is transformed into a form of a triangular matrix to quantify the level.

Table5: Sorting table for comprehensive approximation of operating units

to \ from	1	2	3	4	5	6	7	8	9
1 Raw materials library		<u>O</u> 1	<u>A</u> 4	<u>U</u> 0	<u>I</u> 2	<u>U</u> 0	<u>U</u> 0	<u>O</u> 1	<u>U</u> 0
2 Semi-finished products library	<u>O</u> 1		<u>E</u> 3	<u>U</u> 0	<u>O</u> 1	<u>U</u> 0	<u>U</u> 0	<u>O</u> 1	<u>U</u> 0
3 The production workshop	<u>A</u> 4	<u>E</u> 3		<u>E</u> 3	<u>I</u> 2	<u>U</u> 0	<u>E</u> 3	<u>I</u> 2	<u>O</u> 1
4 quarantine	<u>U</u> 0	<u>U</u> 0	<u>E</u> 3		<u>U</u> 0	<u>A</u> 0	<u>U</u> 0	<u>O</u> 1	<u>U</u> 0
5 Packaging material library	<u>I</u> 2	<u>O</u> 1	<u>I</u> 2	<u>U</u> 0		<u>U</u> 0	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0
6 Shipping department	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0	<u>A</u> 0	<u>U</u> 0		<u>U</u> 0	<u>U</u> 0	<u>U</u> 0
7 Carton recycling area	<u>U</u> 0	<u>U</u> 0	<u>E</u> 3	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0		<u>U</u> 0	<u>U</u> 0
8 Conference office area	<u>O</u> 1	<u>O</u> 1	<u>I</u> 2	<u>O</u> 1	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0		<u>O</u> 1
9 Staff rest area	<u>U</u> 0	<u>U</u> 0	<u>O</u> 1	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0	<u>U</u> 0	<u>O</u> 1	
Synthetic proximity	8	6	18	4	5	0	3	6	2
Sort	2	3	1	6	5	9	7	4	8

It can be seen that the unit with the highest comprehensive proximity is the serial number 3, which is placed in the middle position of the position map, and the work unit of the A grade is found to draw 1-3 and 4-6. The A-level work unit pairs are connected by four lines and separated by one-unit distance, then the E-level work unit pairs 2-7, 3-7, 3-4 are found. Connected by three lines, the working unit pairs are separated by two-unit distances. Finally, the working unit pairs of I and O are processed, respectively, with two lines and one line, and the working unit position correlation diagram is drawn.

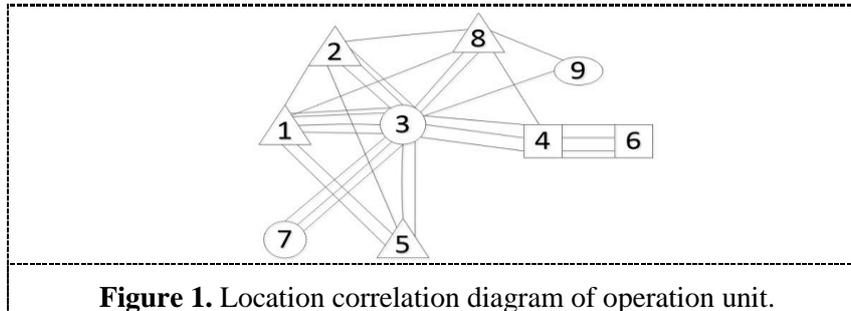


Figure 1. Location correlation diagram of operation unit.

According to (Fig.1), each work unit is designed according to the shape and proportion by area graphic method, and the general layout plan of the HF Company is obtained.

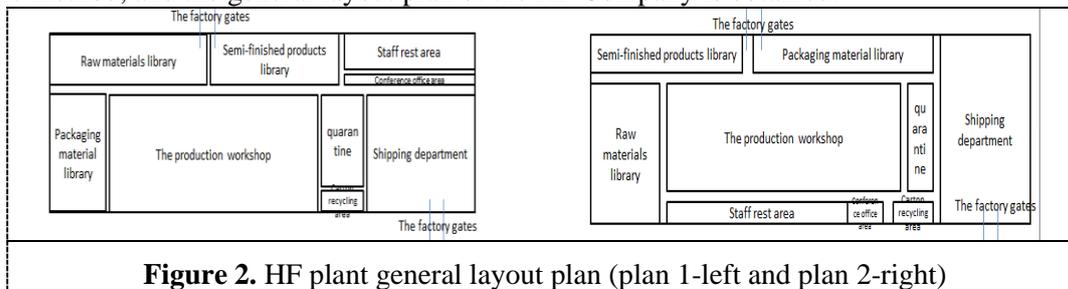


Figure 2. HF plant general layout plan (plan 1-left and plan 2-right)

The weighting factor method is used to prioritize the layout scheme and then optimize for the preferred scheme.

Table6: Weighting factor method to evaluate factor weights

Evaluation factors	A	B	C	D	E	F	G	sum	weight %	sort
facility utilization A		0	0.5	0.5	0.5	1	1	3.5	12.5	3
transport rationalization B	1		1	1	0.5	0.5	1	5	25	1
Investment cost C	0	0		0.5	0	0	0.5	1	5	6
Working environment D	0.5	0	0.5		0.5	0.5	1	3	15	4
Technological process E	0.5	0.5	1	0.5		1	1	4.5	22.5	2
Flexible F	0	0.5	0.5	0.5	0		1	2.5	12.5	5
The original layout mode G	0	0	0.5	0	0	0		0.5	2.5	7
Total								20	100	

Then, the two schemes are analyzed with 3 as the highest score and 1 as the lowest score.

Table7: Program evaluation preferred form

Evaluation factor	Weights	Point	product	Point	product
facility utilization A	12.5	2	25	2	25
transport rationalization B	25	3	75	2	50
Investment cost C	5	2	10	2	10
Working environment D	15	3	45	1	15
Technological process E	22.5	2	45	2	45
Flexible F	12.5	2	25	2	25
The original layout mode G	2.5	2	5	2	5
Total	100		230		175
Priority order			1		2

Mainly comparing the differences between the two schemes, we draw the following conclusions.

The employee rest area and conference office area of Option 1 are located in the upper right corner to reduce the impact of noise generated by the production workshop on the rest staff, the waste area and the conference office are far apart, which can reduce the impact of pollution on the health of employees, It is placed adjacent to the package library to facilitate the management of warehouse personnel. In Scheme 2, there is still a long distance between the pairs of operating units with strong logistics correlation. Based on the above analysis, the first solution is the optimal layout scheme. And make improvements. According to the principle of smooth logistics, carry out u-shaped layout in the production workshop to save space.

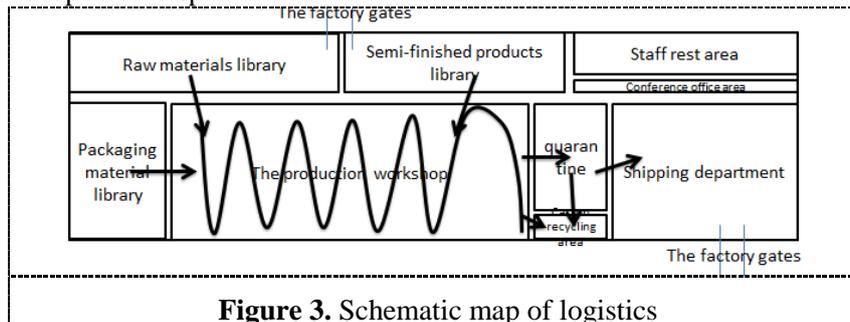


Figure 3. Schematic map of logistics

By optimizing the layout of the production area, the production cycle of the whole product is shortened, the logistics cost is reduced, the logistics is more economical and smoother, and the cross-flow of people is avoided, and the production efficiency of the factory is improved. Expected goals: (1) the production efficiency of the production line increased by 15%, (2) the annual logistics cost decreased by 10% after re-planning.

4. Conclusion

Producing products faster and more efficiently and improve space utilization are quite crucial to manufacturing companies worldwide. This paper introduces the SLP method used in facility planning, and comprehensively plans the entire new plant from the aspects of product, production process, logistics, etc. The comprehensive planning method of plant layout proposed in this paper shortens the cycle of product manufacturing, reduces logistics costs, avoids the intersection of people flow, and effectively improves the production efficiency of the factory.

It is hoped that this study can bring new changes to the enterprise, and through its comprehensive workshop planning, it can improve the chaotic production model in the old factory area, make the workshop logistics smoother, and finally get a future factory that is more in line with lean thinking.

Acknowledgments

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