SLP-based Technical Plant Layout Planning and Simulation Analysis

Xiaorong Xu
Beijing Jiaotong University, Beijing, 100044, China

Abstract. This paper analyzes the current situation and shortcomings of the assembly and the whole material flow in a technical workshop. Through the process analysis, this paper uses the SLP method to optimize, and combines the data analysis to adjust the unreasonable place, and gives the optimized layout plan. Finally, using Flexsim modeling, the whole process of the program is simulated, and the time-consuming reduction of the whole process is verified.

Keywords: Layout Planning; Process Optimization; Simulation; SLP.

1. Existing problems and research trends
In the production process, materials are stored and transported in 90% to 95% of the time. Therefore, it is of great significance to optimize the production system for logistics [1], and good layout design is the best means to improve the logistics process. The material handling cost is reduced, and the moving distance between personnel and transportation equipment is shortened, thereby improving the overall production efficiency and optimizing the production system. This paper will use the SLP method [2] to optimize the layout of a technical plant to achieve testing, decomposition, storage, assembly, and transshipment of a large product. Initially set up seven functional areas: storage area, test area, decomposition area, transfer area, storage area, assembly area, and outbound area: the test area is tested after the product is put into storage and before the warehouse is released; the decomposition area decomposes the whole machine. The storage area stores large and small sections and other parts and facilities; the assembly area carries out the work of connecting large and small sections. All relevant parts of the operation use the corresponding means of transport. The design purpose is as follows: the product takes the shortest time from the segment state to the whole machine. The overall process consists of two processes. The overall process is schematically shown in Fig 1. Warehousing process: warehousing testing decomposition packaging storage; Outbound process: picking processing assembly loading testing out of the library.
Based on this, the research content and technical route of this paper are determined as follows:

Layout planning: space layout and facility planning, and promote the U-shaped layout of the overall assembly line to avoid the location and construction difficulties brought by the linear type;

II) Simulation evaluation: simulation verification of the assembly process and layout

2. Plant planning and spatial layout

The method and technology of factory layout has always been a problem that is constantly explored in the field of industrial engineering. Among the many layout methods, SLP is the most famous system design [3]. This method can be used not only for plant and production system design, but also for hospital, school, and office building design [4]. This paper also uses the Systematic Arrangement Method (SLP) for the layout design of the plant.

2.1. Determination of the Relative Position of the Operating Unit

The layout of the facility is determined by the closeness of the process between the operating units. There are two kinds of relationship between logistics and non-logistics. The former uses the logistics intensity to indicate the close relationship between the two operating units. The latter cannot be quantitatively expressed and can only be distinguished by qualitative analysis [5]. In the research of this paper, logistics movement is the main part of the whole process, and its turnover efficiency directly affects the completion speed of the whole process. Therefore, quantitative logistics analysis becomes the core work of factory layout design. Logistics analysis should not only consider the route of each component and facility in the factory, but also follow the principle of “two minimum” and “two avoidance” [6]: Two minimum principles: minimum distance and minimum logistics cost; Two avoidance principles: avoiding roundabouts and avoiding crisscross;

2.1.1. Analysis of the Relationship between the Operating Units. Here, we mainly analyze the seven functional areas closely related to the whole process: the storage area, the test area, the decomposition area, the transfer area, the storage area, the assembly area, and the delivery area, in which the products are in storage and before delivery. It is necessary to pass the test area for performance and accessory inspection, and the whole machine packing work before leaving the warehouse is arranged in the test area. Before estimating the degree of relationship between the operating units, first agree on the meaning and nature of the different levels of representation, as shown in Table 1:

| symbol     | A          | E          | I          | O          | U          | X          |
|------------|------------|------------|------------|------------|------------|------------|
| Quantitative value | Absolutely important | very important | important | general | unimportant | Don’t approach |
| Number of lines | 4          | 3          | 2          | 1          | 0          | -1         |
| proportion(%)  | 2-5        | 3-10       | 5-15       | 10-25      | 45-80      | base on needs |

Table 1. Work unit relationship classification

Figure 1. Schematic diagram of assembly and decomposition
There are 7 areas that need to determine the relative position, and 21 pairs of corresponding relationships. Refer to Table 1 for the number of different levels to appear, and obtain Table 2:

| Relevance | Number |
|-----------|--------|
| A         | ≤1     |
| E         | ≤2     |
| I         | 1-3    |
| 0         | 2-5    |
| U         | 10-17  |
| X         | base on needs |

Consider the logistics and non-logistics relationships between the operating units: The transfer speed from the storage area to the assembly area has a great impact on the whole “outbound process”, and the relationship between them is closely connected, so the degree of correlation between them is set to “A”; in addition, the outbound process is also including the end of the assembly into the test area, the end of the test is ready to go out of the library, so the degree of their relevance is set to "E"; in order to reduce congestion when warehousing, the "incoming area" and "decomposition area" should be reasonably placed. The degree of correlation between the two is set to “I”; most of the segments that have been decomposed by the “decomposition zone” can smoothly enter the “transportation zone” and the rational design of the “transportation zone” has a great effect on the smooth storage of most segments, so this will be The correlation between the two groups was also set to "I". The relatively important correlations of the above six groups A, E and I are assigned to the directly connected working unit groups, which means that the non-logistics analysis is based on the logistics related strength. In addition, it is determined that the degree of correlation "O" is 5 and the number of "U" is 10. The "assembly area" and "decomposition area", "inflow area" and "outbound area" are not excluded from joint placement or space. There is an intersection on the upper side and the value is “O”. The “U” with the most occurrences indicates that there is no interference or interference between the two operation units. Combined with the above description, the following Fig 2 is obtained:

![Figure 2. Comprehensive relationship diagram of the operating unit](image)

In the SLP, the facility layout does not directly consider the floor space and geometry between the work units, but arranges the relative positions between the units based on the close relationship between the work units. The distance is near and the distance is low. According to the “comprehensive proximity”, the unit of work with the same degree of correlation is solved: the comprehensive proximity of an operating unit is equal to the sum of the quantified degree between the unit and all other units. Based on this, the following table as Table 3:
Table 3. Work unit comprehensive proximity ranking table

| Unit code | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|-----------|----|----|----|----|----|----|----|
| 1         | -  | I  | U  | U  | O  | U  | O  |
| 2         | I  | -  | O  | O  | I  | U  | O  |
| 3         | U  | O  | -  | A  | U  | I  | U  |
| 4         | U  | O  | A  | -  | E  | U  | U  |
| 5         | O  | O  | U  | E  | -  | U  | E  |
| 6         | U  | I  | I  | U  | U  | -  | U  |
| 7         | O  | U  | U  | E  | U  | -  | -  |
| Proximity | 4  | 7  | 7  | 8  | 8  | 4  | 4  |
| Sort      | 3  | 2  | 2  | 1  | 1  | 3  | 3  |

The level of the comprehensive proximity value reflects whether the work unit is in the center position or the edge position in the layout drawing. Accordingly, the relative position of each work unit is obtained by an appropriate planar arrangement method.

2.1.2. Plane Layout. The commonly used layout methods are the Muther line graph method and the Tompkins relation table technique, and the former is used here. The line graph method uses different numbers of equal line segments to indicate the degree of correlation between the two operating units. It first puts the work units with A and E relationship into the layout drawing. The same level is represented by the same length of the line segment. The A level is the shortest, indicating that the contact is the closest, taking it as one unit; the E level is twice the length of the A level. And so on, I, O, and U-level relationships are arranged according to the same rules. Then adjust the position of each department to meet the limit of multiple degrees of intimacy; finally put the area of each department into the layout diagram to generate a spatial relationship diagram. Combined with the comprehensive approach of Table 3, and referring to the three factors of the degree of correlation between the arranged units, the ranking of comprehensive proximity, and the highest degree of correlation carried by themselves, 7 operating units will be arranged on the layout map in turn. As Fig3:

Figure 3. Job unit position correlation diagram

The connection is removed, and the arrangement is relatively dense. The overall process follows the U-shaped route [7]. Combined with the needs of the layout method, the floor area of different areas is estimated, and the area factor is added to fine-tune the relative position arrangement. The main area of the operating unit is mainly from the static land occupation of facilities and materials [8], but because of the large scale of the plant facilities in this paper, the floor space mainly comes from the dynamic operation of the facilities, and the safety around the large facilities. Distance, personnel access and redundancy design to meet the rule layout [9]. Adding the in/out storage area and the non-working unit in the whole site, the layout design of the whole factory is shown in Fig 4:
2.2. Summary of This Chapter
This chapter carries out the overall layout of the plant, combined with the assembly line analysis, according to the system layout design method (SLP) to carry out the relative position arrangement of each functional area, and finally gives the design of the overall layout of the plant.

3. Simulation verification and optimization
In this paper, Flexsim is used for simulation modeling and experimental process to observe whether the design scheme is scientific. Among them, Fig 5 shows the main facilities layout and relative position layout of the factory building:

![Figure 5. Schematic diagram of facility layout](image)

Fig 6 shows the process relationship after the connection, which is used to indicate the whole process of the process, and compares the impact of the number of facilities and relative spacing on the actual process and facility idle rate. The processing facilities with successive relationships use the “A” connection. The “S” connection between the upstream processing facilities and the handling equipment that needs to use the transportation equipment during the connection process, and the “Use transportation tools” in the properties of the processing facilities are selected.
For the warehousing process, first disconnect the storage area of the large and small sections and the downstream, and simulate the process of putting the product into the warehouse. The time interval between the arrival of the product and the factory is subject to a normal distribution with a mean of 500 and a variance of 10; the "conditional port" setting is adopted for the two parallel decomposition activities, so that the two entities generated by the decomposition flow to the two outputs respectively. Simulate the decomposition-storage process and get the statistical report of Table 4.

**Table 4. Decomposition - Stored Procedure Statistics Report**

| Object           | Class     | stats content avg | idle | processing | blocked | waiting for transporter |
|------------------|-----------|-------------------|------|------------|---------|-------------------------|
| Wait test        | Queue     | 2.433             | 0    | 0          | 0       | 1355.090                |
| decompose        | Separator | 1.530             | 2152.889 | 7831.315 | 0       | 0                       |
|                  | Queue     | 5.927             | 0    | 0          | 0       | 0                       |
| Large part       | Queue     | 3.364             | 0    | 0          | 0       | 0                       |
| Input            | Source    | 0.956             | 0    | 0          | 0       | 0                       |
| Gantry crane1    | Transporter | 0.488           | 218.357 | 0          | 0       | 0                       |
| AGV              | Transporter | 0.224           | 0    | 0          | 0       | 0                       |
| Input test       | Processor | 0.445             | 5544.471 | 4211.431 | 228.303 | 0                       |
|                  | Processor | 0.481             | 5184.204 | 4800      | 0       | 0                       |
| Temporary104     | Queue     | 0.263             | 0    | 0          | 0       | 2629.083                |

In the table, "waiting for test" and "temporary storage area 104" wait for a long time for the forklift, indicating that the number of gantry cranes 1 and AGV has an influence on the upstream process, and the "decomposition zone" has a long idle time and also verifies the number and installation of the gantry crane 1. The deficiencies caused by the unloading efficiency. Consider adding these two transportation facilities and collaborating using the task distributor controller. Add the outbound process and simulate the acquisition-assembly-outbound process, as shown in Fig 7.
The temporary storage area 982 indicates the waiting line area of the section line after the preceding processing is completed. After 100,000s of simulation (32 finished products out of the warehouse), the idle rate of upstream equipment is between 10% and 15%, and the congestion rate is below 10%, which verifies the effectiveness of layout optimization.

Based on the second chapter, this chapter carries out the modeling and simulation of the current layout scheme, including the assembly area assembly line and the overall planning of the plant. Combined with the analysis of statistical data, the superiority of the layout scheme is verified.

4. Conclusion
Based on the background of the project and the knowledge of industrial engineering, human factors engineering and facility planning, this paper designs a technical workshop with relatively reasonable layout and relatively efficient process, and uses Flexsim to simulate and verify. In conclusion, the layout of the plant designed by using relevant methods and tools has played a corresponding role, achieving efficient storage and assembly of heavy-duty columns, and giving additional design outside the main layout process, taking into account humanization and actual conditions. But limited by time and effort, modeling and simulation analysis part of this article failed to implement a realistic model to demonstrate the actual facilities, only use the same type or the same purpose of the software internal entity module instead, after assigning time and route data, although It will not affect the results of the experimental verification, but it is not visually prominent and needs to be improved.

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