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Equivalent Correction Coefficient-based Chemical Enterprise Facility Layout Design and Optimization

Shien Zhang

Henan institute of technology, Henan 453002, China
shienzhang6960@126.com

The paper analyzes the chemical enterprise facility layout design and optimization in chemical industry based on equivalent correction coefficient. Emissions from the chemical industry have strong chemical composition, and they are easily to destroy the natural environment. Therefore, under the condition of environmental protection, the improvement of the natural environment can be achieved through applying the equivalent correction coefficient. Reasonable facilities layout can effectively optimize the process of chemical emissions.

1. Introduction

In China's modern society, the chemical industry greatly contributes to the economic development. However, the relationship between the chemical industry and chemistry is inseparable. Therefore, due to its chemical characteristics, emissions of chemical industry contain extremely strong chemical components, which greatly affect the natural environment. In the traditional chemical industry, there are huge drawbacks in the management of pollutant emission because of the poor facilities layout.
Based on the equivalence correction coefficient, the facility layout of traditional chemical enterprises and the characteristics of the chemical industry, the author designs reasonable chemical enterprise layout models by using corresponding computing method, makes a comparative analysis of these models and draws a conclusion after making data analysis and comparative analysis: whether the model has the optimal effect on emission.

2. Literature review

According to the different research methods, the main methods of facility layout design and optimization are system layout design, mathematical model, computer layout program and so on.
In the traditional system layout design, the famous American system layout scholar Richard Muther proposed the system layout planning (SLP) to solve the problem of facility layout planning. This method is a very logical facility layout technology, which combines the logistics analysis, non-logistics analysis and the close degree analysis of the relation of working units to get a reasonable layout of the factory. In the latter study, many scholars applied it to different aspects: Alssabbagh used the SLP method to adjust the layout design of a car plant, which is based on the redesign of the factory facilities, rather than optimizing the design without the original layout (Alssabbagh et al., 2017). On the basis of systematic analysis of the logistics facilities layout of a process manufacturing enterprise, Carr applied SLP to the design of the logistics facilities layout of the enterprise, and put forward the analysis method of the layout of the logistics facilities based on the SLP thought (Carr, 2017). Ding adopted the simplified SLP (SSLP) technology to design the facility layout of a manufacturing workshop, thus saving the transportation time and improving the productivity of the workshop (Ding, et al., 2017). The SLP method is applied to the layout design of a steel shear distribution center. In the design, the basic elements analysis, logistics relationship analysis, non-logistics relationship analysis and logistics analysis between operation units are carried out, but there is no further improvement in the method. In addition, some scholars used the design of facility layout and the SLP principle in logistics analysis to re-plan and design the facilities layout of the assembly workshop to make the workshop smooth and the transportation route the shortest, shorten the production cycle and reduce the production cost. Moreover, the system facilities layout design method in the facilities planning is used. Through the production process

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analysis, logistics strength analysis, logistics route analysis, logistics analysis, non-logistics analysis and the relationship analysis of operation units, the purpose of optimizing the layout of the oil pump plant is achieved by adjusting the location between the facilities on the basis of the original plant area.

In the mathematical model, Haque and others regarded the facility layout design as the secondary distribution problem of operational research. They used the neural network method to design the facility layout, used AHP (Analytic Hierarchy Process) to evaluate the relationship between adjacent units and evaluate the multiple schemes obtained by the SLP. The AHP method can give the weight of multiple targets here. However, it is not possible to conduct selection evaluation for the majority of alternative schemes (Haque, 2017). Nassiri used the only goal of "minimum transportation cost" to design the facility layout, and applied the AHP and DEA methods to solve the design problem of the facility layout (Nassiri et al., 2017). Reddy introduced some concepts and algorithms, improved the design program of traditional SLP, strengthened the stability of SLP results, improved the application of traditional SLP, and used genetic algorithm to solve specific plane layout scheme. More importantly, it improved the tedious, subjective and unstable design results and other shortcomings in the traditional SLP design process, so as to obtain visual and satisfactory design results with high efficiency (Reddy et al., 2017; Yin et al., 2017).

In the aspect of computer layout program: the scholar in the field of layout design represented by JM Moore, based on the study of the traditional layout method, put forward the method of computer aided facility layout, and introduced a number of plane arrangement, such as CORELAP, ALDEP, etc., in the advanced language. For instance, COFAD, CRAFT and so on are procedures used for the newly constructed facilities and COFAD, CRAFT and so on are procedures used for reconstructing layout. Xie and so on studied the role of the computer in the facilities planning and analyzed the contribution of the facility planning to the competitiveness of the enterprise. The effective and efficient layout design was characterized by increasing the production and reducing the spatial configuration of the products (Xie et al., 2017). Zheng and others proposed a data envelopment analysis (DEA) decision method, which combines quantitative and qualitative analysis to evaluate FLD. It cites a computer aided layout planning tool - VisFactory, and uses Flexsim software to model and simulate the existing layout and various optimal layout, and the two optimization methods ensure the feasibility of the workshop reconstruction scheme at last (Zheng et al., 2017).

To sum up, from the current research on the design and optimization of plant facilities layout, SLP is a strongly rational and logical method, and it is widely used in manufacturing enterprises. However, there are the following problems and shortcomings in the study of system layout design at home and abroad. First, as far as the research object is concerned, the study at home and abroad is concentrated on the layout design of the factory facilities in the machinery manufacturing industry, and some of the research focus on the layout design of the facilities of the logistics center. However, there are few studies on layout design. Secondly, in terms of the definition of the concept, the definition of "logistics equivalent" at home and abroad is mainly for the material transportation of the machinery manufacturing enterprises, which is not suitable for the material transportation characteristics of the chemical enterprises. Finally, for the research method, the model of the system layout design at home and abroad is very consistent, and does not make any improvements according to the change of different types of enterprise. It is only improved in the detail steps inside the model. The research mainly focuses on the initial stage of the factory layout design, and the system layout design method is used to design the factory layout. There is no optimization method, that is, to optimize and improve the layout of the finished product. Therefore, based on the equivalent correction coefficient, the facility layout of chemical enterprises is designed and optimized.

3. Method

Based on the related research literature, it is found that the most basic factors that affect the system layout design are the Product, Quantity, Route, Service and Time. Among them, "product" refers to the transported raw materials, semi-finished products and finished products in the factory production logistics; "Quantity" refers to number of product. Both of these two factors relate to facility scale, facility quantity, and transport means used in the process of transportation. "Route" refers to production methods used by the factory, which determines the type of facility and the transportation route of the material. "Service" refers to various departments supporting the production manufacturing, which determines the type and quantity of auxiliary workshops. "Time" refers to the production cycle of raw materials, semi-products and products, and this factor determines the statistical standard of logistics quantity. Figure 1 shows SLP method for chemical enterprises.

The waste-based layout design method for chemical enterprise system should supplement and optimize the traditional SLP from the above two aspects.

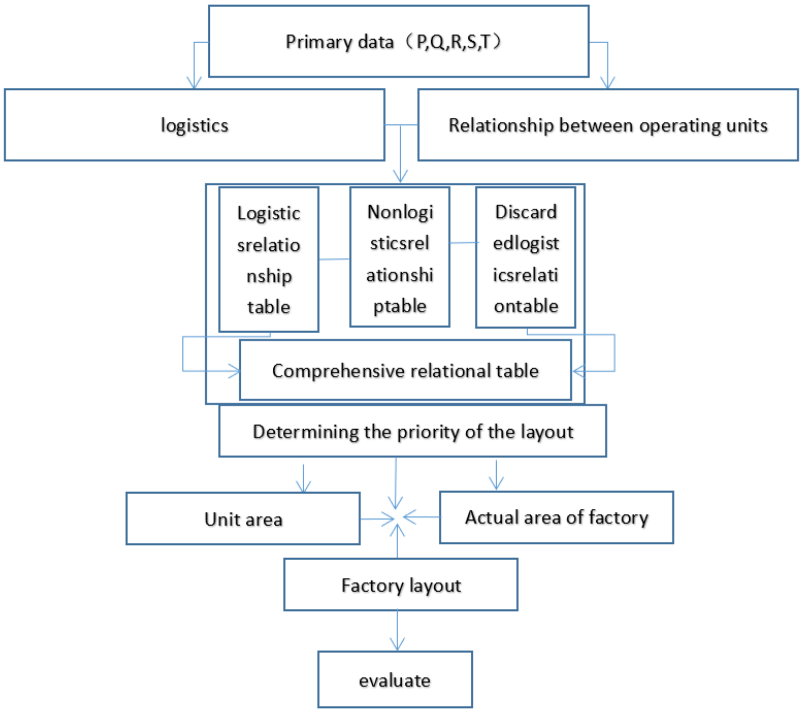

Figure 1: SLP method for chemical enterprises

3.1 Characteristics of the material in the logistics

First, in a logistics system, the geometry, physical state and chemical state of the materials are very different. The difficulty degree in materials transport or handling varies greatly. It is not reasonable to take the material weight as a calculation unit of logistics quantity simply. Therefore, in the process of planning and design, a more widely used criterion must be developed. All the materials in the system are converted into a unified quantity through the amendment, namely equivalent logistics flow, for comparison, analysis and calculation. The materials transportation in the production flow of a chemical enterprise generally applies pipes, and the actual transportation energy consumed is stable, that is, the transportation energy consumed is the same in a period, no matter how much material is transported. However, one of the important features of chemical material transportation is that many of the materials transported are flammable, explosive, poisonous or environmental unfriendly, which should be taken into account when calculating the logistics equivalent. When calculating the logistics equivalent, the author determines the equivalent correction coefficient of logistics based on the actual flow data, certain principles and certain types of materials, and then determines the logistics relationship table with the actual flow data multiplied by the correction coefficient.
Second, the determination of the traditional SLP comprehensive relationship table for waste logistics is a combination of the logistics relationship table and the non-logistics relationship table by a certain proportion. The chemical industry is characterized by a lot of waste generated in the process, especially many of the waste being harmful to the environment and human health, so in the SLP we must fully consider the logistics status of waste in the factory, and analyze the logistics status, non-logistics status and waste.

3.2 Analysis method of logistics system state

The key steps to optimize the design of factory facilities layout is to find the unreasonable logistics through analyzing the current situation of logistics, and then to put forward the corresponding concrete solution. Therefore, to make an objective analysis of the logistics status is the first step in optimization, and analysis model of logistics system is a commonly used method of analyzing the logistics status as shown in Figure 2. Among them, the flow distance diagram (F-D) is drawn onto the rectangular chart according to the logistics flow volume (F) and distance (D) between two points. According to analysis demand, determined logistics volume and distance, the figure is divided into four parts, and then the author analyzes the unreasonable part to find out the unreasonable logistics and puts forward feasible solutions for its adjustment, finally the author verifies whether the result is optimized.

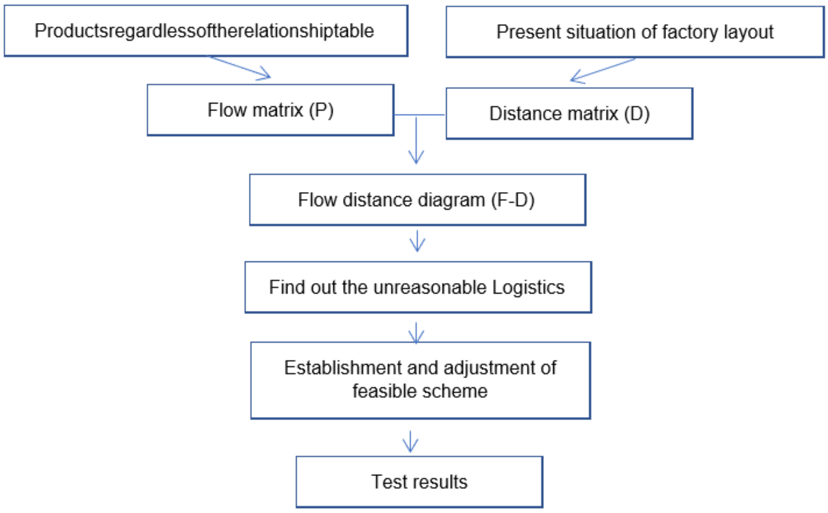

Figure 2: Model of state analysis of logistics system

From the analysis steps of logistics system state, we can see that this method can be applied into the optimization of chemical company facilities layout under the following conditions:
First, the model is built based on the current situation. First, the author collects the information including logistics product, logistics quantity, route, service department and time, makes the product logistics relationship table, and then makes an analysis of the logistics status by combining the product logistics relationship table and factory layout. Based on the status, logistics flow matrix and distance matrix form.
Secondly, the basic method of finding unreasonable logistics is put forward. The author makes logistics flow matrix using the logistics flow of different facilities and distance matrix by the transportation distance between different facilities. The author then finds out the unreasonable logistics from the current logistics situation obtained by analyzing the logistics matrix and the distance matrix.

4. Results and analysis

4.1 SLP method for chemical enterprises

Table 1: the factors affecting the relationship between the three parties.

Total goal	Subgoal	Two level subtarget
Heald close shut system surface U	Product logistics relationship U1	Product logistics volume U_{11}
		Transportation distance of productsU_{12}
		Correlation between operating unitsU_{13}
	Non logistics relationship U2	Personnel safety and environmental requirementsU_{21}
		Requirements for maintenance and serviceU_{22}
		The same public facilities are used by different operating unitsU_{23}
		Connection frequency between operating unitsU_{24}
		Comfort level of workersU_{25}
	Waste logistics relationship U3	The amount of logistics of wasteU_{31}
		Transportation distance of wasteU_{32}
		Safety and environmental requirements of personnel in the course of transportationU_{33}

The traditional SLP is a method for manufacturing factory layout design However, the system layout design is not specifically optimized for a specific type of manufacturing enterprise. In addition, the traditional SLP method was developed in the 1960s when the method was developed for the general manufacturing enterprise; therefore, the traditional SLP method is mainly suitable for general manufacturing enterprises, and the disposal issues of chemical waste produced in various processes of chemical enterprises is not taken into account in this method.

The determination of traditional SLP comprehensive relationship table is a combination of the logistics relationship table and the non-logistics relationship table by certain proportion. The chemical industry is characterized by a lot of waste generated in the process, especially many of the waste being harmful to the environment and human health, so in the SLP we must fully consider the logistics status of waste in the factory. After analyzing the logistics status, non-logistics status and waste logistics status, the author makes logistic relationship table, non-logistics relationship table and waste logistics relationship table. Finally, the author makes the comprehensive relationship table, as shown in Table 1, through combining these three tables by certain proportion.
Then, the author establishes the judgment matrix, see Table 2, 3, 4.

Table 2: U - Ui comparison matrix (k = 1, 2)

U	U_1	U_2	U_3
U_1	1	a_{12}	a_{13}
U_2	$1/a_{12}$	1	a_{23}
U_3	$1/a_{13}$	$1/a_{23}$	1

Table 3: U1 - U1K comparison matrix (k = 1, 2)

U_1	U_{11}	U_{12}	U_{13}
U_{11}	1	b_{12}	b_{13}
U_{12}	$1/b_{12}$	1	b_{23}
U_{13}	$1/b_{12}$	$1/b_{23}$	1

Table 4 U2 - U2K comparison matrix (k = 1, 2, 3, 4, 5)

U_2	U_{21}	U_{22}	U_{23}	U_{24}	U_{25}
U_{21}	1	c_{22}	c_{13}	c_{14}	c_{15}
U_{22}	$1/c_{12}$	1	c_{23}	c_{24}	c_{25}
U_{23}	$1/c_{13}$	$1/c_{23}$	1	c_{34}	c_{35}
U_{24}	$1/c_{14}$	$1/c_{24}$	$1/c_{34}$	1	c_{15}
U_{25}	$1/c_{15}$	$1/c_{25}$	$1/c_{35}$	$1/c_{15}$	1

4.2 Results and analysis

Theoretically, the optimization program of chemical industry facilities layout can be established from the following three aspects:
First, adjust the process. This method aims to change the logistics flow between different facilities, namely, F in the diagram F-D through changing the manufacture process of chemical products, thereby making the unreasonable logistics (I) enter a reasonable range (II, III , IV).
Second, adjust the facility location. This method aims to change the transportation distance of the materials between various facilities, namely, D in the diagram F-D through the changing the distance of various facilities in the chemical enterprises, thereby making the unreasonable logistics (I) enter a reasonable range (IV).
Thirdly, while adjusting the process, and the facilities location, the facilities layout of a chemical enterprise should be optimized in the light of the actual conditions and the relatively easy and easy-to-implement method should be adopted. If the process for a certain part is adjusted, many related processes will change instead, which will make the entire optimization process be complex and be of weaker controllability. Therefore, this paper chooses to adjust the facility location as an overall plan to optimize the facilities layout in the chemical industry.

5. Conclusion

Basing the analysis of the concept of logistics equivalence and combining the logistics characteristics of the chemical industry, this paper points out the problems of applying logistics equivalent in the design and optimization of facility layout in chemical industry. The concept of correction coefficient is then introduced to correct the logistic equivalent logistics in the chemical enterprises, which makes the logistics equivalent in the material transportation process reflect the transport space occupied and difficulty degree of handling and reflect the chemical characteristics such as being material flammable, explosive, harmful to human health and the environment. It accurately reflects the importance degree of materials in the chemical enterprises.
In the design model and optimization model of chemical industry facilities layout, the author introduces waste logistics relationship constraints, product logistics relationship and non-logistics relationship, which form a

comprehensive relationship of chemical industry production logistics. This paper identifies the relationship between the three parties with certain degree subjectivity. In-depth study can be conducted on this issue so that the determination of the relationship between the three parties can be more objective.

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