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# Warehouse Layout Optimization based on EIQ Model

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## Abstract

**At present, with the national economic development, the number and scale of enterprises are gradually increasing, and the business volume of enterprises is also increasing. The problem of enterprise warehouse management is becoming increasingly prominent. It is found that the concept of modern warehouse management in China has been widely spread and recognized, and the application of various effective inventory management methods has considerable depth and breadth. Therefore, there must be a major breakthrough in inventory management, and the EIQ analysis method is proposed. In modern manufacturing industry, warehouse management is an important part of manufacturing supply chain management. The efficiency of warehouse management directly affects the efficiency of enterprise supply chain operation. In warehouse management, the rationality and scientificity of warehouse layout planning directly affect the efficiency of warehouse management. EIQ method plays an important role in guiding the layout and optimization of warehouse system. This paper mainly introduces the method of EIQ analysis and the influence of different analysis curves such as EQ / IQ / EN / IK on warehouse plane planning layout, automation degree and capacity planning of warehousing equipment, which provides a scientific basis for warehouse planning, design and management.**

## Keywords

**Inventory Management, EIQ, Inventory Layout, Layout Optimization.**

## 1. Introduction

At present, with the national economic development, the number and scale of enterprises are gradually increasing, and the business volume of enterprises is also increasing. The problem of enterprise warehouse management is becoming increasingly prominent. In recent years, the inventory backlog of Chinese enterprises, especially the inventory backlog of finished products, has not been improved. With the intensification of economic globalization competition and the high integration of information flow and logistics, the requirements for enterprise resources are becoming higher and higher [1]. Whether it is traditional MRP (material requirement planning), MRPII (Manufacturing Resource Planning), or currently popular ERP (Enterprise Resource Planning) and TEP (total enterprise planning), inventory management is a very important foundation. For the decision-makers of enterprises, if the inventory is high and the warehouse management is chaotic, they will have a headache, resulting in excessive waste of enterprise resources. Therefore, rational warehouse planning has always been the focus of enterprises.

Many researches have been carried out on warehouse layout at home and abroad. Yujie Hu uses the EIQ analysis method to analyze the relevant data of his customers and order data, combined with the ABC classification principle to find out the characteristics of customers and orders, such as order quantity, order times and logistics business operation law, so as to provide scientific management ideas and basis for the planning and decision-making of finished product warehouse [2].Qiang Li takes EIQ analysis method as a new method in modern warehouse management. He believes that it

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has remarkable effect in improving warehouse management efficiency and saving cost. Starting with the introduction of EIQ analysis method, he expounds the application steps of EIQ analysis method, and introduces the application of EIQ analysis method through a case [3]. Yexia Qian and Tingting Xie used EIQ method to plan and design the warehousing process of S company from three aspects: warehousing process and warehouse operation [4].

Foreign research on warehouse layout has also made some progress. Richard Muser put forward the system layout design (SLP) theory through long-term research and design, combined with mathematical analysis and step process decomposition, and extended it to practical application[5]. Huertas et al. established a warehouse operation model based on time and resources through simulation, starting with the variables such as warehouse space utilization, goods storage varieties and relevant auxiliary equipment, the optimal operation cost of the warehouse is evaluated through the optimization and adjustment of warehouse layout [6]. Larson, March, etc. started from the storage direction of article classification, analyzed the shelf layout and the size of each storage area in the warehouse for the purpose of improving space utilization and reducing material movement, adopted hierarchical storage strategy, and compared the application effects of hierarchical storage and special storage. It was concluded that adopting hierarchical storage strategy can save storage space and reduce handling volume, effectively improve operation efficiency [7]. Lee. K. y and others proposed that genetic algorithm can be used to calculate the shortest logistics path between facilities with Dijkstra algorithm in graph theory under complex multi-layer facility layout [8].

This paper first analyzes and summarizes the current situation of warehouse management at home and abroad, and then introduces the importance of warehouse management to enterprises. The second part introduces the basic analysis method and specific implementation process of EIQ model in detail. The third part analyzes the current situation of warehouse management in Y enterprise, constructs the EIQ analysis table, and obtains the existing problems of the warehouse by analyzing the two key indicators of IK and IQ. The fourth part is the improvement measures and implementation effect based on EIQ analysis method. The results show the effectiveness of this method. Finally, the importance of EIQ method to warehouse layout is summarized.

## 2. EIQ Model Introduction and Implementation Process

### 2.1 Introduction to EIQ Model

EIQ (E: order entry, I: item, Q: quantity) quantity model was first proposed and popularized by Mr. Suzuki of Japan Logistics Research Institute. He analyzed the warehousing and outbound characteristics of materials from three aspects: customer order quantity, ordering times and items, so as to provide basis for reasonable planning and layout of warehouses. The following are some of the most important data analysis indicators in the EIQ model.

(1) Analyze the order quantity (EN) of each order. The quantity of order items will affect the picking process and directly affect the size of the picking storage area.

(2) Order quantity analysis (EQ) per order. Through the analysis of EQ, we can directly understand the status of orders, so as to obtain customers' demand for products.

(3) Order quantity analysis (IQ) for each product. Through this index, the order quantity is analyzed, and then combined with ABC classification, different storage and shelf strategies are defined for different products.

(4) Analysis of orders per product (IK). Analyze the number of orders received for each project, analyze the results to obtain various common materials, and consider how to determine the correct and effective inventory location.

(5) Product shipment quantity analysis (SQ). This indicator is used to analyze the shipment quantity of products.

(6) Analysis of product shipment varieties (SEN). This indicator is used to analyze the shipment quantity.

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(7) Order quantity analysis (sik). This indicator is an analysis of the number of internal and external orders.

(8) Distribution customer quantity analysis (DCN). This indicator can analyze the total number of customers.

This paper mainly analyzes the order quantity (IQ), the number of order items (IK) and the cross analysis of IQ and IK. Finally, it is analyzed which index is the leading factor of the warehouse, so as to study the layout planning of the warehouse, divide the goods in the warehouse into three categories of ABC, and provide data support for the layout and planning of the warehouse.

### 2.2 EIQ Implementation Process

According to the implementation process, EIQ can be divided into the following key steps:

(1) Collection and sampling of customer order information. This is the first step in implementing EIQ analysis. In order to adapt to the rapid changes of the market as soon as possible, the sampling time limit of EIQ data is usually determined according to the actual business volume of the warehouse. (2) Analyze the samples and make charts. After collecting samples through statistical methods, it is necessary to analyze various key indicators, such as EQ, EN, IK and IQ. Charts are used to represent various types of analysis data, which reflects the current situation of the warehouse to a great extent. (3) Chart interpretation and re planning. EN method is used to analyze the quantity of a single order, EQ method is used to analyze the quantity of a single order, IQ analysis method is used to analyze the total shipment quantity of a single product, IK method is used to analyze the shipment quantity of a single product, and then conduct IQ and IK cross analysis. After completing the analysis chart, formulate the layout scheme according to the specific requirements, so as to find the existing problems in the warehouse and formulate the improvement scheme. (4) Planning verification and application. After the warehouse is re planned, the feasibility of the plan needs to be verified.

## 3. Current Situation and Problem Analysis of Warehouse Management in Y Enterprise

### 3.1 Analysis on the Current Situation of Warehouse Management in Y Enterprise

The raw material warehouse of enterprise y covers an area of 15000 square meters. It is a single storey structure with a floor height of 10 meters. The whole warehouse is divided into three areas, each with an area of 5000 square meters. Where a and B are shelf storage areas, and building C is ground storage area; There are 6 gates at the front of each area, which are mainly used for goods in and out; At the front end of the gate is the unloading platform of the warehouse; The distance between the warehouse and the processing plant is 8km.

The enterprise has basic operation links and can successfully complete basic operations such as storage and delivery. However, by analyzing the storage of materials in the warehouse, we can find the areas to be improved, mainly as follows:

(1) The overall layout of the warehouse is unreasonable. After the warehouse is completed, the warehouse has not been inspected, but the warehouse is divided into three areas according to the storage mode of goods. Due to the random placement of goods, the on-site material management is quite chaotic, and the mixing phenomenon occurs frequently. Through manual calculation, the average warehousing time of each consignment of goods is 5.4min. The average delivery time of each consignment of goods is 4.9min. Due to the long storage and unloading time, the warehouse operation efficiency is low.

(2) Unreasonable allocation of warehouse location. The enterprise uses the warehouse management module of sap, which needs to be saved to the database according to the staff's own experience. However, because there is more than one employee in the warehouse, the goods are placed disorderly. Therefore, the location allocation is unreasonable, resulting in the low efficiency of workers' picking business.

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(3) Unreasonable warehouse management. There is no visual area in the warehouse. When the goods arrive, some do not even have a delivery note, or the delivery note is damaged; When leaving the warehouse, the delivery orders written by many managers are very sloppy, and even some people don't write them. It's also relatively slow to make up the orders afterwards. The inconsistency between materials and accounts has become a criticism. When the warehouse personnel are transferred greatly, a lot of time will be wasted in picking materials, resulting in low operation efficiency of the warehouse.

## 3.2 Warehouse Problem Analysis based on EIQ Method

**Table 1**. EIQ analysis

| Shipment order | Shipment type | | | | | | | | | | | | Order shipment quantity | Order shipment type |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I1 | I2 | I3 | I4 | I5 | I6 | I7 | I8 | I9 | I10 | I11 | I12 | | |
| E1 | 100 | 0 | 50 | 60 | 800 | 2300 | 2600 | 2400 | 1300 | 1000 | 1000 | 200 | 11810 | 11 |
| E2 | 0 | 200 | 100 | 120 | 600 | 2400 | 2500 | 1800 | 2400 | 1000 | 800 | 100 | 12020 | 11 |
| E3 | 50 | 100 | 100 | 60 | 600 | 2400 | 3300 | 0 | 1600 | 0 | 800 | 100 | 9110 | 10 |
| E4 | 100 | 0 | 100 | 120 | 1200 | 3600 | 0 | 1500 | 0 | 1500 | 400 | 0 | 8520 | 8 |
| E5 | 0 | 150 | 0 | 100 | 600 | 2600 | 2600 | 1800 | 1500 | 1000 | 0 | 0 | 9750 | 8 |
| E6 | 50 | 100 | 50 | 60 | 500 | 1500 | 2400 | 1500 | 1300 | 0 | 400 | 200 | 8060 | 11 |
| E7 | 100 | 150 | 100 | 120 | 500 | 2300 | 2600 | 0 | 1500 | 2000 | 300 | 100 | 9770 | 11 |
| E8 | 50 | 0 | 0 | 120 | 600 | 2400 | 2500 | 1800 | 0 | 1500 | 0 | 100 | 9070 | 8 |
| E9 | 0 | 100 | 100 | 120 | 1200 | 2000 | 2300 | 1500 | 1400 | 0 | 300 | 50 | 9070 | 10 |
| E10 | 120 | 80 | 0 | 60 | 800 | 1800 | 2600 | 1800 | 1200 | 1500 | 600 | 50 | 10610 | 11 |
| E11 | 80 | 50 | 50 | 100 | 500 | 1500 | 0 | 1500 | 1600 | 2000 | 300 | 50 | 7730 | 11 |
| E12 | 120 | 100 | 100 | 60 | 700 | 0 | 2800 | 1000 | 1300 | 2000 | 300 | 150 | 8630 | 11 |
| E13 | 100 | 0 | 80 | 150 | 600 | 1900 | 2600 | 1500 | 1400 | 1500 | 600 | 200 | 10630 | 11 |
| E14 | 80 | 50 | 60 | 100 | 800 | 1700 | 2800 | 1000 | 1300 | 1300 | 600 | 0 | 9790 | 11 |
| E15 | 80 | 90 | 0 | 120 | 900 | 1500 | 2200 | 1500 | 1400 | 2000 | 0 | 150 | 9940 | 10 |
| E16 | 90 | 50 | 80 | 150 | 800 | 1600 | 2400 | 1800 | 0 | 1500 | 300 | 200 | 8970 | 11 |
| E17 | 80 | 60 | 90 | 120 | 1000 | 1500 | 2000 | 0 | 1500 | 1800 | 300 | 150 | 8600 | 11 |
| E18 | 0 | 50 | 120 | 150 | 600 | 1400 | 2300 | 1600 | 1500 | 1600 | 200 | 100 | 9620 | 11 |
| E19 | 60 | 60 | 200 | 120 | 1000 | 1200 | 2000 | 1500 | 1800 | 0 | 600 | 150 | 8690 | 11 |
| E20 | 70 | 0 | 80 | 150 | 800 | 0 | 2400 | 1800 | 2400 | 2300 | 300 | 0 | 10300 | 9 |
| E21 | 90 | 90 | 80 | 150 | 800 | 1700 | 0 | 1900 | 0 | 1500 | 300 | 100 | 6710 | 10 |
| E22 | 0 | 100 | 0 | 120 | 1200 | 2600 | 2300 | 0 | 1600 | 1700 | 200 | 50 | 9370 | 9 |
| E23 | 60 | 100 | 60 | 130 | 600 | 1200 | 2000 | 1800 | 1500 | 1800 | 0 | 80 | 9330 | 11 |
| E24 | 80 | 50 | 60 | 60 | 800 | 1500 | 3000 | 1400 | 1400 | 0 | 100 | 60 | 8510 | 11 |
| Shipment quantity of single product | 1560 | 1730 | 1660 | 2620 | 18500 | 42600 | 51600 | 32400 | 30900 | 30500 | 8700 | 2340 | 225110 | |
| Shipment times of single product | 19 | 19 | 19 | 24 | 24 | 22 | 21 | 20 | 20 | 19 | 20 | 20 | | 247 |

At present, 4325 kinds of materials are stored in the warehouse. There are 1084 material numbers in No. 1 processing plant; 687 item numbers of No. 2 processing plant; 1439 item numbers of No. 3 processing plant; There are 276 material numbers in No. 4 processing plant. At present, there are two ways to store raw materials, namely, two shelf storage areas and one ground storage area. There are 13990 shelves. According to the current storage situation of the material warehouse, the material

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categories are mainly divided into bean products I1, meat products I2, candy I3, dairy products I4, dried fruits I5, aquatic products I6, coarse grains I7, vegetables I8 and fruits I9. There are a class of beverages, such as I10, cooked foods I11 and semi-finished products I12. The warehouse regularly sends the goods to 4 processing plants once every 4 hours and 6 times a day.

Table 1 is the EIQ table based on the one month delivery of the warehouse, and analyzes the two key indicators of IQ and IK of the products in the warehouse. See Table 1 for EIQ analysis of specific data.

### 3.2.1 IQ Analysis

As shown in Table 2, according to the IQ-ABC classification method, the shipment quantity of a single item is analyzed from the largest to the smallest, and the percentage of each item is calculated. Then, according to the results of IQ analysis, the materials can be stored in different storage areas, and the storage amount and storage unit of each material can be set to different storage levels according to the size of the commodity.

**Table 2**. IQ analysis

| Shipment type | Shipment quantity of single product | Percentage | Cumulative percentage |
|---|---|---|---|
| I7 | 51600 | 22.92% | 22.92% |
| I6 | 42600 | 18.93% | 41.85% |
| I8 | 32400 | 14.38% | 56.22% |
| I9 | 30900 | 13.74% | 69.95% |
| I10 | 30500 | 13.54% | 83.50% |
| I5 | 18500 | 8.24% | 91.74% |
| I11 | 8700 | 3.85% | 95.59% |
| I4 | 2620 | 1.16% | 96.75% |
| I12 | 2340 | 1.04% | 97.79% |
| I2 | 1730 | 0.77% | 98.56% |
| I3 | 1660 | 0.74% | 99.30% |
| I1 | 1560 | 0.70% | 100.00% |

### 3.2.2 IK Analysis

**Table 3**. IK analysis

| Shipment type | Shipment times of single product | percentage | Cumulative percentage |
|---|---|---|---|
| I5 | 24 | 9.72% | 9.72% |
| I4 | 24 | 9.72% | 19.44% |
| I6 | 22 | 8.92% | 28.36% |
| I7 | 21 | 8.09% | 36.85% |
| I8 | 20 | 8.10% | 44.95% |
| I9 | 20 | 8.10% | 53.05% |
| I11 | 20 | 8.10% | 61.15% |
| I12 | 20 | 8.10% | 69.25% |
| I1 | 19 | 7.69% | 76.94% |
| I2 | 19 | 7.69% | 84.63% |
| I3 | 19 | 7.69% | 92.32% |
| I10 | 19 | 7.69% | 100.00% |

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Order the shipment times of single products from the maximum to the minimum, each material is a necessity of the factory, so it is necessary to send some goods to these four factories regularly, and the delivery frequency is almost the same. It can be seen from the figure that the shipment volume of I5 and I4 is 19.44%, and the shipment proportion is 16.67%, which can be determined as class a goods; The number of shipments of I6, I7, I8, i9, I11 and I12 accounts for 49.81%, and the shipment proportion is 50.00%, which can be determined as class B goods; I1, I3, I2 and I10 accounted for 30.75% of shipments and 33.33% of shipments, and were identified as class C goods. The specific analysis is shown in table 3.

## 4. Optimization Scheme and Implementation Effect based on EIQ Analysis

### 4.1 Optimization Scheme

After the EIQ method is used to analyze the warehouse of enterprise y, the optimization scheme is as follows:

Improve the overall layout of the warehouse, improve the previous chaotic and messy storage mode, and plan the whole warehouse into three storage areas from inside to outside. Goods can be placed in the corresponding area according to the principle of ABC inventory method, which can make the inflow and outflow of goods more clear. In order to realize the effective trade relationship between the company and other trading companies, it is necessary to establish a modern information system, especially the use of high technologies such as the Internet, complete the coordination, control and management of the whole logistics process, and realize all intermediate process services from the front end of the network to the back end of the network.

### 4.2 Implementation Effect

(1) According to the analysis results of EIQ method, the storage area of goods in the warehouse is re planned, and different types of goods are stored in different areas of the warehouse according to the attributes and frequency of goods. After improvement, the average storage time of class a materials is calculated to be 4.3 minutes / ton; The average storage time of class B materials is 4.6 minutes / ton; The average storage time of type C material is 4.8 minutes / ton. The average material storage time is 5.4 minutes / ton. Therefore, compared with the previous warehousing time, the efficiency of class a materials is increased by 18.87%; The warehousing efficiency of class B materials was increased by 13.21%; The warehousing efficiency of class C materials was increased by 9.43%. A. the average delivery time of materials is 3.7 minutes / ton; B. the average delivery time of materials is 4.2 minutes / ton; The average time for the outflow of class C materials is 4.4 minutes / ton, and the time for leaving the original materials is 4.9 minutes / ton. After using the new warehouse layout, the outflow efficiency of material a increased by 22.92%; The delivery efficiency of class B materials was increased by 15.23%; The delivery efficiency of class C materials was increased by 11.45%.

(2) After distinguishing the procurement area from the shipping area, the relative time of goods delivery and storage is accelerated, and the efficiency is improved by 13.23%. In addition, the mixed problem is fundamentally solved, and the logistics of the whole warehouse tends to be balanced.

(3) After the forklift storage area is divided, the operation of the warehouse is more efficient, the previous channel congestion will not occur again, and ventilation devices and fire alarms are installed. At the same time, the forklift maintenance work is newly designed, and the daily maintenance and management of the forklift are carried out. Each forklift is in the best condition before work, and the forklift is regularly maintained in the inspection records. It is a good foundation for the safe and effective use of forklift in the warehouse and improves the work efficiency.

## 5. Conclusion

EIQ analysis method starts from enterprise orders and combines ABC classification cross analysis method according to customer demand characteristics. Analyze orders at different levels and obtain the characteristics of goods acceptance, storage, picking and transportation in the warehouse.

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Effectively mastering the logistics characteristics and providing an entry point for the macro perspective of the planning process will eventually become the decisive factor of warehouse planning. Through EIQ analysis, the company can obtain a lot of useful information, including understanding logistics characteristics, obtaining logistics system modules matching logistics system characteristics, selecting logistics equipment, simulation analysis, and realizing the basic planning of logistics system. EIQ analysis has been widely used in the management of logistics and related industries to provide decision-making and guidance for overall planning. This paper combines EIQ analysis, ABC analysis and cross analysis to analyze customer orders, projects and quantities. Effectively master the operation rules and characteristics of Y enterprise warehouse, provide reference for warehouse layout planning in a classified way, and provide reference for warehouse transportation mode and layout planning. Combined with the influencing factors and operation characteristics of other actual conditions of the warehouse, ensure the comprehensive and stable operation and management of Y enterprise, and provide theoretical support for improving comprehensive benefits.

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