Aalto University
School of Business

Research on the Status Quo and Countermeasures of HR Company's Inventory Management

Master's Thesis
Chang Liu
8 May 2019
Information and Service Economy

Approved in the Department of Information and Service Economy

__ / __ / 20__ and awarded the grade

Author Chang Liu

Title of thesis **Research on the Status Quo and Countermeasures of HR Company's Inventory Management**

Degree Master of Science in Economics and Business Administration

Degree programme Information and Service Economy

Thesis advisor(s) Markku Kuula

Year of approval 2019 **Number of pages** 93 **Language** English

Abstract

HR is a manufacturer of electromechanical products in China. Its manufacturing features are muti-variety for orders, mixed batch production mode with small batches and large batches. In recent years, with the development of enterprises, the increase of product varieties and the increase of production tasks, the production process has also encountered new problems of excessive management cost and relatively low production control. The profit rate of enterprises has also declined. The trend of capital cost occupancy has become aware of the importance of inventory management, and it is eager to improve operational management through inventory management.

HR company's long-term inventory management is empirical and extensive management, lacking the guidance of scientific theory. Based on the study of inventory management theory and method, this paper uses theory of constraints(TOC) to analyze the problems and causes in inventory management and find out the improvement. countermeasure. According to the actual situation of the enterprise, using MRP principle and Excel information processing method to build order management, raw material, work-in-process, finished product and production planning data correlative processing platform in order to improve the accuracy of production control. Implement ABC classification for different categories of inventory and select appropriate control strategies.
This paper will propose corresponding countermeasures from the establishment of enterprise database, the construction of data processing platform, production planning and scientific inventory management. The actual problems and root causes of inventory summarized in the research process are representative in SMEs. The proposed inventory management strategy is practical, operable and referable from the perspective of the enterprise and from the technical point of view. It is hoped that this paper can improve the inventory management level of HR companies and can play a reference role for small and medium-sized manufacturing enterprises with the same characteristics.

During the completion of the thesis, there is sufficient communication carried out with the company. The important strategy has been adopted by the enterprise.

Keywords TOC, MRP, ABC analysis, Inventory management

Table of Contents

1 Introduction

Small and medium-size enterprises account for 70% to 80% of the world's enterprises. Their state of operation and development trends largely influence the development prospects of the entire country. They are the responsibility of governments to guide, standardize and promote their progress on the right track. Small and medium-size enterprises in China account for 80% of the number of enterprises, and 90% of the society's employment and 70% of technological innovation. (Yang, 2019) They are an important part of the country's development. However, the cruelty of the competitive environment and its improper management have led to the bankruptcy of many small and medium-sized enterprises. As an important part of the management of the company, the inventory management is not valued by the enterprise managers, resulting in the accumulation of inventory costs in the business operations, which ultimately causes the cash flow to break, and the company can not continue to operate in a painful manner. small and medium-sized enterprise in China generally have the following common problems in inventory management:

1. Quoted “According to statistics, SMEs are lack of information professionals, 16%-36% enterprises did not set special information department, and more than half of the enterprises did not specially-assigned person to manage information.” (Elsner, Oberheitmann,2016). The informatization level of SMEs is generally low, and the effect of inventory information transmission is poor, and the full sharing of inventory information cannot be achieved. The amount of inventory consumed by the company's production and sales cannot be reflected in a timely manner. The production department often does not know the storage status of the stock at all times, resulting in the loss of many resources. The finance department is

also unable to understand the inventory information in time to enable accurate costing and cost control.

2. There is no overall concept for logistics, and inventory management is fragmented. There is no overall idea of logistics. Each department has its own management style, but it needs a big framework to bind. This framework is a holistic concept that connects the various departments together. Without such a holistic concept, each department has a large backlog of inventory, which occupies a large amount of funds, resulting in a downward of capital fluidity.

3. Inventory management decisions are too simple. A good inventory management is often determined by many aspects, and needs to consider various factors. Many companies do not see this level, blindly think that inventory management is only stock, and easily decide to increase or decrease inventory, blindly carry out a one-size-fits-all process. If the last time there is more, the next time, there will be less, but it is not sure how much this amount is. It needs to be comprehensive. So simple decision-making can't help the company develop well.

5. The management technology level is relatively low, and the inventory management is not guided by the theory of scientific norms, resulting in low management level, seriously deviating from the purpose of inventory management, restricting the operation of enterprises, and even leading the enterprise to the abyss of bankruptcy.

Therefore, it is extremely necessary to analyze the inventory management problems of small and medium-sized enterprises, find out the crux, and seek effective solutions. This article will focus on the research and analysis of a small and medium-sized enterprise in China, and give corresponding solutions.

1.1 Research Background and significance

As the market competition becomes more and more fierce, the profit space of enterprises is getting smaller and smaller, and the production and operation environment is facing hard situation. Chinese enterprises are faced with such pressures as structural adjustment and economic transformation. How to improve the management level of enterprises and increase the competitiveness of products, winning customers and winning the market are issues that Chinese traditional manufacturing enterprises need to pay attention to and think about. With the continuous development of operation and supply chain management ideas, inventory management as an important node of supply chain management, has been paid more and more attention by enterprises. Inventory management is one of the important factors affecting the improvement of operational management level and enterprise competitiveness.

Due to the increasing personalized demands of consumers and the acceleration of product upgrades, traditional high volume, Pipeline production methods need to be constantly changed to adapt to market needs, and manufacturers need to constantly adapt multivariate, multi-batch and small-batch production methods. Enterprises also face difficulties in production management:

The required product delivery of customer is getting shorter and shorter, and there are more and more urgent orders. Enterprises need to continuously strengthen internal efficiency management, improve the flexibility of supply chain management and improve the responsiveness to customer needs.

In the current market competition environment, enterprises should combine their own production characteristics to explore the key factors affecting enterprise inventory management, and establish a systematic, holistic inventory management approach with supply chain management thinking as the core,

reducing inventory costs and improving customer satisfaction, letting enterprises stand in an invincible position in the market competition.

The composition of HengRun’s products is not uniform, including electrical products, mechanical products, and electromechanical combined products. At the same time, it is a production mode with small batches and large batches. The production control mode has not been able to form system control, which has caused great confusion. It has led to an increase in the inventory period of unintended use of parts, and the capital is heavily occupied. At the same time, the company is also facing the situation that customers cannot pay back in time, and the raw material suppliers are mostly in the situation of payment before delivery. The turnover of working capital is very difficult. Though enterprise borrowing 10 million in the form of real estate mortgages, the difficult situation has not effectively alleviated.(company field visit)

Faced with the above-mentioned severe test, the traditional management methods have increasingly shown the drawbacks of lack of scientific methods. According to the investigation, the management status of the enterprise is still at the stage of experience management. The company's production arrangements are not based on historical data for qualitative and quantitative analysis, but by production personnel based on experience estimates. There is also no long-term and short-term planning based on the demand for various products to develop a scientific and feasible production plan.

Production plans for the same product are frequently interrupted, resulting in production disruptions, resulting in a backlog of products and a large amount of liquidity. The company's production managers only focus on how to meet the customer's delivery date, passively ringing in response to external environmental requirements, struggling to cope with and use data for scientific and reasonable prediction and planning.

The research in this paper is derived from the problems encountered in actual operations. Thus, this article analyze the problems encountered by HR companies and provide improvement and solutions only from the actual operating angle of the enterprise, explore the technical means to improve the inventory management level of enterprises and the management strategies and methods of production logistics systems, and hope to provide reference for future work.

1.2 International and Chinese research status

This section focuses on the relevant theories, methods, and state of application of the current research used in the paper. For example, the theory of constraints with mature thinking logic and core steps has achieved great success in the manufacturing field, material requirements planning inventory control technology that is gradually being widely used in enterprise production and scientific inventory management methods applied in enterprise raw material management.

1.2.1 Research status of Theory Of Constrains(TOC)

After more than 20 years of development, the Theory of Constraints (TOC) has attracted wide attention in all countries. It was initially applied in the production field and has achieved great success. As a new concept of continuous improvement and management, the research and application of constraint theory has expanded from manufacturing to many other industries, and has gained wide recognition and application.

Cook D.P.(Cook, 1994) used simulation to study the application of constraint theory in production scheduling and control, and compared with the pull production mode about the factors such as capacity production, tact time, number of work-in-progress, and fluctuations. It is concluded that when the production control application constraint theory is reached, the output reaches the maximum. The Production Lead Time has the smallest fluctuations, but the total time of each process and the number of WIPs in stock are higher

Blackstone (Blackstone&Gardiner,1997) studied the role of constraint theory in manufacturing. It mentioned that BalSeal's production cycle was reduced from 6 weeks to 8 days after the introduction of the constraint theory, and the in-process products were reduced by more than 50%. After the TOC was applied by the American Ford company's electronics department, the production cycle was reduced from the original 10 days to 16 hours. Rahman and Shams-us (Rahman, 2002) introduced the constraint theory into supply chain research, applied the causal analysis method in TOC to find the link that caused the biggest bottleneck in the entire supply chain, and proposed that any enterprise in the supply chain should Targeting to increase overall output. Zhang Shijie and Cao Zhenxin (Zhang & Cao, 2004) used the constraint theory in how to discriminate and weaken the bottlenecks in the manufacturing unit, and proposed a balanced integration planning and scheduling system framework for each manufacturing unit based on bottleneck constraints. Li Hao, Shen Zuzhi and Deng Mingrong quantified the order priority of enterprises, and analyzed the bottleneck resources through constraint theory to establish the priority model of the order. Finally, based on the model, the algorithm of order production optimization was proposed. Bai Ming proposed the introduction of constraint theory into the reengineering process of production system, and gave a research on the reconstruction method of enterprise production system based on constraint theory.

1.2.2 Application status of MRP technology

Since the industrial revolution in the 18th century, handicraft workshops have rapidly developed in the direction of factory production, and manufacturing has emerged. Subsequently, the basic operational goal pursued by almost all companies is to invest the capital to get the most profit. The result of pursuing the maximization of profits has led to many problems in the development of manufacturing. In order to solve these problems, in the 1960s, people implemented a material requirements plan (ie, early MRP) on a computer, which was mainly used for inventory control. Over hundreds of years of lengthy research and practice, this type of inventory management software has made great strides. Under this background condition, a series of inventory management software developed on the basis of MRP has achieved rapid and effective development. Among them, ERP is the most popular one.

After the emergence of MRP in the 1960s, it was quickly recognized and accepted. So far, it has experienced four stages of development: basic MRP, closed-loop MRP, MRPII and ERP.

1.2.3 Research Status of Raw Material Inventory Management

The control of inventory cost is actually the control of storage, ordering, and out-of-stock cost. It is showed in figure1 below that here are three main factors in the inventory management research: safety stock, order batch, and purchase lead time. In general, safety stocks have the greatest impact on costs, so they are the most important.

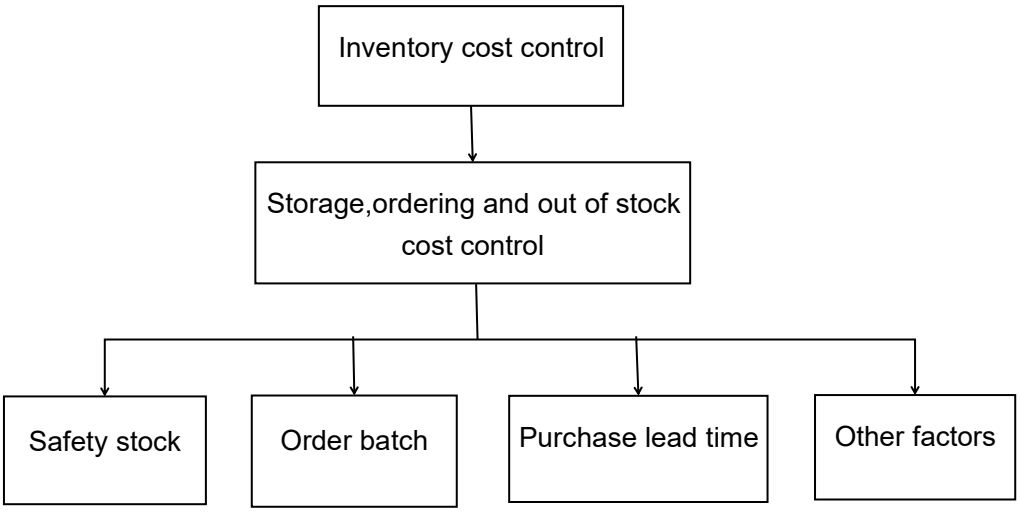


Fig1: Storage,ordering and out of stock cost control

Robert(Robert&Winston,1961) and Winston proposed a safety stock model under the established customer service level in the 1960s. In this model, factors such as average daily sales volume and replenishment cycle were considered, and the amount of safety stocks were obtained through calculation.

Whybark and Williams study the two factors of market demand and supplier service levels for safety stocks, indicating that when there is a strong uncertainty in market demand, or when the supplier's service level is uncontrollable, safety stocks demonstrated the decisive role (Whybark&Williams, 1976). Baker studied the safety stocks of non-independent requirements and discussed the optimal safety issues subject to uniform distribution(Baker, 1985). Inderfurth and Minner analyzed the impact of various customer levels on safety stock in a multi-level inventory system. Zijm and Houtum (Zijm&Houtum,1994) studied the multi-level production inventory system under stochastic demand, and gave the function structure of inventory cost, and compared the optimal safety stock obtained with MRP system. Yang Zhenhua discussed and discussed safety stock from the perspective of supply chain, and proposed a method for determining safety stock based on demand forecast and a time-based optimization method for safety stock. Lu Huifeng studied the prediction and optimization of safety stocks, discussed the inventory model under uncertain demand environment. Through

mathematical experiments, the service level of a single piece of work is usually higher than the cycle service level.

Obviously, international and Chinese research focuses on a specific area, such as changes in market demand, batch factors for economic orders, or supplier service levels. This article will build inventory based on forecast and historical customer demand data. The research of the model has important practical application value for engineering electromechanical enterprises similar to HR with multivariate small batch production mode.

1.3 Main research work and ideas

In order to achieve the goal for HengRun company to eliminate unreasonable occupation of working capital, it is necessary to understand the company's business situation, then dig out the root that caused the problem and finally find the solution to solve the problem.Thus, this topic plans to firstly investigates the internal status of the enterprise, finds out the production characteristics, product composition and current management level, and uses theoretical thinking logic and methods of TOC to find the existing bottleneck and give the direction to be solved. Secondly, use MRP technology to establish a physical processing platform for production, optimizing the correctness of production quantity investment, and eliminating the occupation of funds in the investment of unplanned work in process. The third method is to use the ABC classification of inventory management to provide solutions for the quantity and occupancy of raw material inventory and releases unreasonable capital occupation.

Specifically, this topic is mainly divided into three parts, as shown in Figure 2：

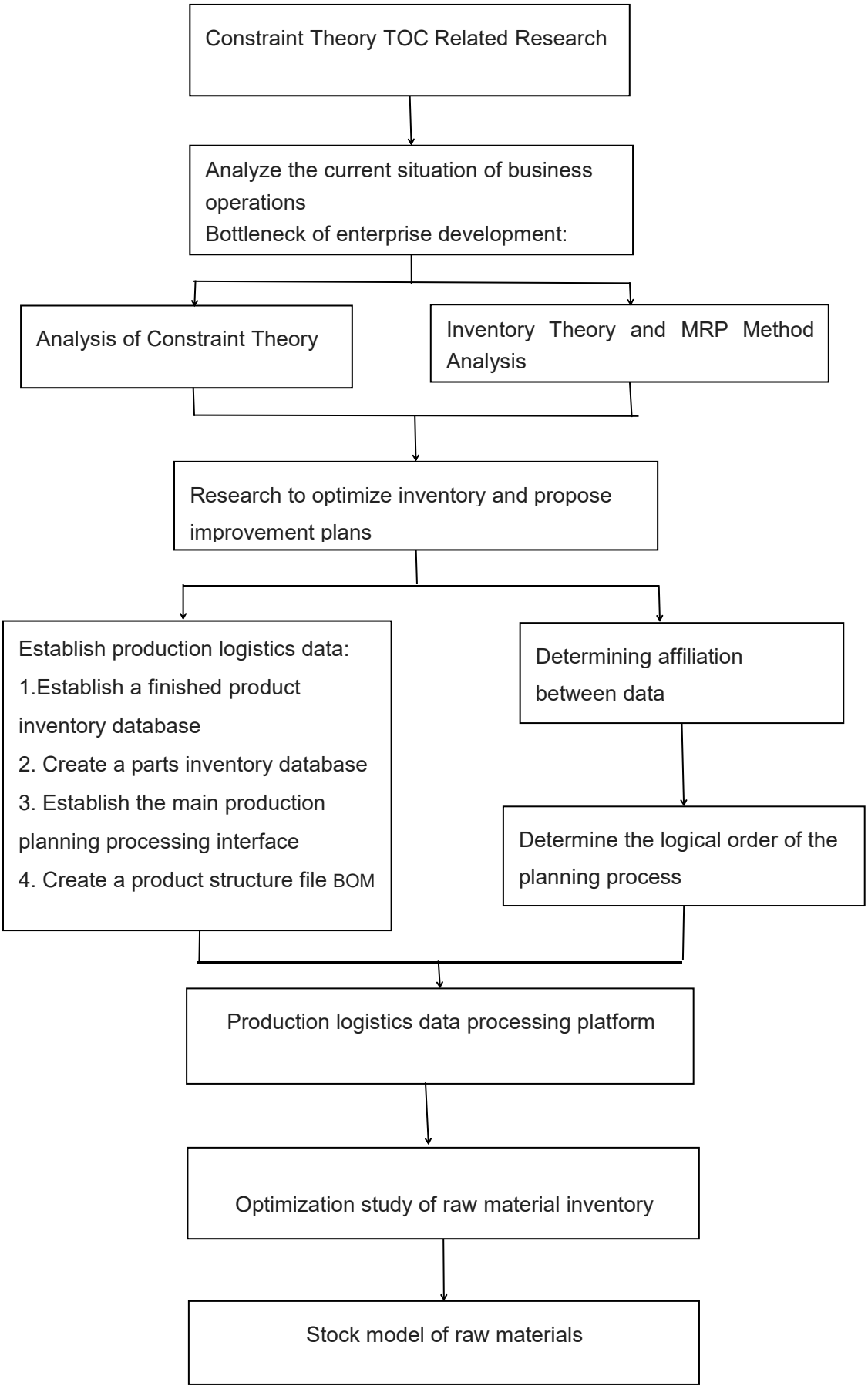


Figure.2 Inventory control map

The first part: analysis of the production status inside the enterprise, found that HR company belongs to order type, multivariate small batch and large batch mixed, discrete production mode.The level of logistics management and inventory management in its own production process are relatively weak, thus causing a great waste of inventory. Since inventory accounts for a very large proportion of management costs, the increase in inventory management will greatly reduce the management costs of HR companies. Through the theory of constraints (TOC), the in-process inventory resources and raw material inventory resources in the production process are analyzed to find out the main reason why the inventory configuration is unreasonable, draw the current reality tree, find the root cause of these problems through the fog elimination method and verify it through the future reality tree. In this way, an optimization plan for WIP inventory and raw material inventory is obtained, which is explained in the second and third parts respectively.

The second part: optimizing the correctness of the production quantity investment, preventing the unplanned WIP capital occupation. Through the establishment of production logistics data processing platform, accurately grasp the actual inventory of various materials, parts and finished products. Prepare a bill of materials (BOM) under the product structure, clarify the relationship between product structure level and quantity,determine the data relationship between self-made parts, purchased parts and raw materials. Prepare a reliable production plan according to customer orders and determine the total demand and actual demand of various materials and parts through logical operations. All the production input data generated after the processing of the logistics data in the form of computer Excel will ensure the accuracy of each component, eliminate the phenomenon of out-of-stock and calculation errors caused by human error in the past, and keep the inventory parts accurate. Within a reasonable range.

The third part: Solving the problem of raw material inventory.

The biggest problem with HR companies in raw material inventory is that there is no good way to manage inventory. The order-based production adopted by the company determines that the output is greatly affected by the market. However, due to the mixed production mode of multivariate, small batch and large batch, the production arrangement of the product also faces many difficulties, which causes troubles for material procurement. It would be very unreasonable to prepare stocks and use the same control for all required materials.

Therefore, the two main problems solved in this section are to prepare sufficient and timely raw material inventory for products with a large proportion of sales, and second, what kind of control strategy should be used for raw material procurement and inventory.In order to solve the above two problems, the ABC classification of the company's products through data analysis needs to be conducted, focusing on the control of the production logistics control of the A-type products, the A-class products again use the ABC classification method to classify the raw materials, and to classify the A and B materials to guide the setting of a reasonable inventory level, thereby reducing high inventory and excessive management cost, release unreasonable cash flow, and enhance the profitability of the company.

2 Research on related methods of inventory optimization

Supply chain, as an effective model for participating in market competition, has been accepted by many companies. The 21st century is the century of supply chain competition. To win in supply chain competition, it must be through

continuous optimization of the supply chain management. In every link of the supply chain, the internal operation system of the enterprise is the top priority.(Littleson, 2008) Thereinto the level of inventory management, an important indicator of the ability of the enterprise operation system, is the wind vane of the level of enterprise management.

As an important influencing factor affecting the capital flow of enterprises, enterprise inventory management has been paid more and more attention by enterprises. Finding out the impact of optimizing inventory management on the movement of circulation founds by analyzing the inventory control mode is the key to control inventory.

The inventory management system is the basis of production. Through the management of warehouses, materials and other types of accounts, the management of inbound and outbound warehouses, and the timely reflection of the warehousing flow of various materials, inventory management system provides a basis for production management and cost accounting.

2.1 Inventory management and control

Inventory control is the management and control of various items, finished products and other resources in the whole process of business operations to keep their reserves at an economically reasonable level. Inventory control is a business method that uses a method of controlling inventory to get a higher profitability. It controls the inventory level of the enterprise under the premise of satisfying the customer service requirements, and strives to reduce the inventory level as much as possible, improve the efficiency of the logistics system, and

improve the market competitiveness of the enterprise.

2.1.1 Inventory and inventory cost

Inventory refers to materials and products that are stored by the company for future use. Inventory management refers to the development of policies and processes to ensure that each inventory has the right amount in the enterprise. (Waters, 2013)It includes a variety of functions within the enterprise that involve inventory decisions.

From the perspective of internal production process,corporate usually sustain 4 types of inventories: raw material inventory, work-in-process inventory, finished goods, and MRO goods.(Inman)

Raw material inventory refers to the inventory of raw materials and parts that are acquired and held by enterprises in order to produce and process products through procurement and other means. The stock of raw materials is for the manufacturing industry, and there is no stock of raw materials in the circulation-type enterprises. The most common source of raw material inventory is from the supplier, and the second is the company's own production.

Work in process inventory refers to the quantity of stock in all machining centers. Work in progress is an unfinished product, that is, it has not yet been converted into a final product that can be sold. For example, 50 chairs have been painted, but it takes 2 hours to paint, then the 50 chairs are in-process inventory.

The finished goods inventory is the stock of finished products that have been manufactured and are waiting for shipment and can be sold externally.

MRO, the abbreviation of Maintenance, Repair and Operations refers to the

non-productive materials required by the factory or enterprise to maintain and repair its production and working facilities and equipment to ensure its operation. These materials may be spare parts used for equipment maintenance and repair, or they may also be equipment and consumables and other materials that ensure the normal operation of the enterprise. It usually refers to materials like tools, lubricants, or spare parts. MRO is an industrial product that is not a raw material.

There are three main types of inventory costs, namely, ordering cost, inventory holding cost and out-of-stock cost (Juneja).

The ordering cost is the cost incurred for the execution of an order for a certain product, including the production cost of the order, the communication fee, the receipt fee, the supervision fee, and the equipment usage fee.

When the company manufactures the product themselves, the ordering cost at this time refers to the batch operation cost, including the production cost of equipment debugging and material testing.

Inventory holding costs are the costs incurred by storing or holding products for a certain period of time. The cost of holding includes fixed costs that are not affected by the quantity in stock over a certain number of ranges and variable costs that are generally proportional to the quantity in stock.

The out-of-stock cost is the economic loss caused by an out-of-stock shortage within the enterprise that cannot meet customer needs or meet production needs.

Enterprises maintain a certain amount of inventory in order to maintain normal operations. Inventory is mainly used to buffer the contradiction between supply

and demand. Inventory plays an important role in the enterprise. It can ensure the continuous and smooth production and sales of the enterprise, which is beneficial to shorten the order-to-delivery cycle and improve the availability of materials, thus improving customer satisfaction. However, excessive inventory holdings can affect operating costs and have certain risks in terms of storage, safety and quality.

Inventory management is a logistics operation that plans, coordinates, and controls the quantity, time, structure, and regional distribution of goods in the logistics process.

From the perspective of the entire supply chain, inventory can be divided into four types, namely:

(1) Cycle stock. Cycle stock is the inventory used for daily operations. Usually, manufacturing companies use a certain batch quantity of production in order to obtain economies of scale, and a single-volume purchase method in order to enjoy the discount of purchase quantity. These recurring stocks of a certain batch quantity are revolving stocks.

(2) Safety stock. Safety stocks are buffer stocks set up to cope with uncertainties. Uncertainties include uncertainty in demand, uncertainty in supply, and uncertainty in operations. Usually it is to prevent the loss caused by objective factors such as out of stock, randomness of customer demand and instability of incoming quality.

(3) Expected inventory. In response to seasonal fluctuations in production and demand, inventories that are in reserve during the off-season are expected to become inventories. Expected inventory is mainly affected by factors such as seasonal fluctuations in demand and storage management costs of additional

inventory.

(4) Transportation stock. That is, in-transit inventory, which mainly includes inventory during transportation and transit. Transportation stock depends on the time of stock in transit and the demand rate during this time.

In the normal production and operation activities of enterprises, stocks usually take up a lot of funds. The inventory of a medium and large-sized enterprise can reach tens of millions or even hundreds of millions. In addition, in order to store inventory, it is necessary to build a warehouse, inventory maintenance and maintenance, and material distribution require a lot of manpower and material resources. Therefore, when the inventory is too high, it will bring many problems to the enterprise:

In the normal production and operation activities of enterprises, stocks usually take up a lot of funds. The inventory of a medium and large-sized enterprise can reach tens of millions or even hundreds of millions. In addition, depositing stocks also requires the construction of warehouses, inventory maintenance, and material distribution, which requires a lot of manpower and material resources. Therefore, when the inventory is too high, it will bring many problems to the enterprise:

(1) Occupation of a large amount of funds: The more items stored in the inventory, the more funds are occupied. Usually, the inventory will occupy 30% to 50% of the working capital.

(2) Inventory storage cost: This also includes interest on the funds used for inventory, custody and insurance expenses. For items that have been stored for too long, there are many costs of loss of value, such as corrosion of parts, scrapping due to failure due to engineering changes, and so on.

(3) Management issues: The existence of inventory can make many problems not exposed in time, and thus can not solve the problems in time.

Therefore, seeking an optimal inventory management model is one of the goals of the company. Whether the company can improve the overall efficiency and reduce the production cost depends largely on whether the company can properly control the inventory. Therefore, how to use the existing inventory management method, adjust and improve the actual situation of the enterprise considering its current status , apply it to inventory management, reduce the inventory amount and increase the inventory turnover rate, which has realistic and far-reaching significance.

Inventory management refers to the data limits such as inventory quantity, inventory level, and order quantity established under the premise of not expiring goods shortage and lowering service level, etc., to meet economic and reasonable requirements. In short, inventory management is the three main issues for business managers, namely when to replenish, which parts to order or replenish, and when to order.

Since the management of inventory is critical to the company's cash flow, balanced production and meeting customer needs, and it is very trivial and cumbersome, it is one of the first and most successful areas of management that uses computer. Moreover, inventory control has become one of the key areas for enterprises to establish competitive advantages. As an important part of the production and operation process of enterprises, the amount of inventory has a significant impact on enterprises. Excessive inventory may indicate higher scrap rates and repair rates, and many internal problems such as raw material quality problems of suppliers, untimely delivery, production and operation plans, and on-site management. On the one hand, the inventory in the enterprise occupies

a large amount of funds, which affects the capital turnover of the enterprise, causing the burden on the enterprise to increase;On the other hand, too little inventory can easily lead to material shortages, production is interrupted and the on-time delivery rate is reduced, and it is more likely or therefore lost sales opportunities, resulting in greater loss of profits.

Reasonable inventory can improve the efficiency of your production operations, including:

1 Proper online inventory allows two different beats to run more economically during production operations

2 In the mixed-line production mode, the appropriate inventory can reduce the adjustment cost per unit of production.compared with frequent adjustment preparation, the inventory is reduced by labor, which increases the proportion of production processing time.

3 Bulk purchases can reduce unit ordering costs. And in some cases, companies can also enjoy price discounts from suppliers.

2.1.2 Basic principles of inventory control

Inventory control, that is, management control of the company's inventory. Usually refers to the management and control of various raw materials, accessories materials, semi-finished products and finished products in the process of processing in order to meet the needs of customers, and maintain these reserves economically and reasonably. At the same time, it is necessary to forecast and plan according to the requirements of the reserve and the ordering characteristics of the stored materials, analyze the reserve materials to make

decisions and execute the inventory reserve plan, and control them.

Inventory management has two opposite goals, namely, the reduction of inventory costs and the improvement of customer service levels. And inventory management is to find the best value between these two goals, that is, to ensure the normal operation of the production, the inventory is maintained within a reasonable range.

The inventory control system can be summarized as the following main factors:

(1) Which parts or items are kept in stock. It is necessary to control the existing inventory at a reasonable level to prevent unnecessary products from being added to the inventory. And this will change over time, so you need to check the inventory regularly to isolate or scrap the items that are no longer needed.

(2) Purchasing cycle and order lead time. The longer the two, the more inventory will be generated, and vice versa, shortening the two can effectively reduce inventory.

(3) Batch and quantity of orders. Determining the batch and quantity of the order is one of the keys to minimizing the total cost. Since each order will have a corresponding management and delivery cost, determining the ordering principle is a very important factor in determining the inventory level.

(4) The geographical location of the warehouse. The farther the geographical position, the longer the transit cycle and the higher the transportation cost.

(5) Supplier delivery performance: The supplier's on-time delivery rate, cooperation, quality, and transportation conditions are all important factors influencing inventory control.

on the measurement of the level of inventory control, companies generally use inventory turnover as a key indicator.

By analyzing the cash flow of manufacturing companies, it can be found that the profits of enterprises are generally generated by the recycling activities of funds, raw materials, products, sales, and funds. Under the same amount of funds, the faster the cycle is carried out, the higher the profit margin. Therefore, the rate of inventory turnover is called the "inventory turnover rate." The inventory turnover rate is also called the inventory turnover number. The calculation formula can be divided into two types: the amount and the quantity:

Inventory turnover (times / year) = annual sales / annual average inventory
Or, inventory turnover (time / year) = annual sales amount / annual average inventory amount

Inventory turnover days corresponding, inventory days = 360 / inventory turnover rate (annual)(Heizer&Render,2011)

2.1.3 Traditional inventory control model

In this section, several traditional inventory control models, including quantitative ordering, regular ordering, and ABC analysis will be introduced.

1. Quantitative control method

By continuously monitoring a certain type of inventory level, an order signal is

issued when the inventory level drops to the reorder point. This system is usually for higher value parts or some important parts.

Assuming the purchase lead time is L, the inventory consumption rate is D, and the inventory level is initially I. In the normal operation of the enterprise, the inventory level I will continue to be consumed at the speed D. When I consumes to the order point O, a new order signal is issued, so the theoretical order point O is calculated as O=D×L. Theoretically, excluding other disturbance factors, inventory will consume exactly to zero when the next batch of orders arrives, so the average inventory level in the model is I/2. Figure 3 shows the relationship between inventory and time in a quantitative control system.

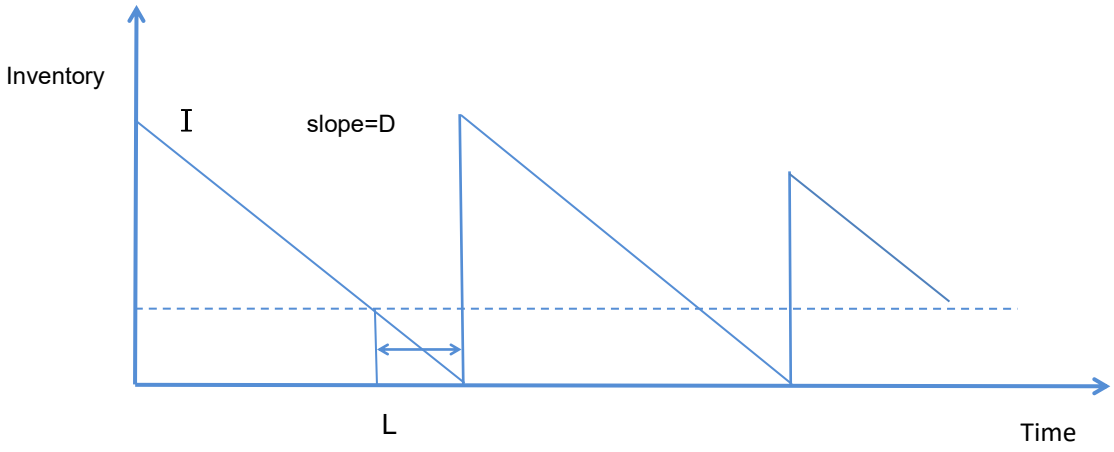


Fig.3 Fixed quantity order system

The quantitative ordering method has the following characteristics: First, the order quantity I is usually stable for each order, and the formulation of I is mainly based on the rule that the total amount of inventory is the lowest. Second, it is necessary to hold a small amount of safety stock to meet the disturbance of demand within the corresponding order cycle. Third, the interval between ordering times is not fixed. When the demand is large, the time interval is short, and when the demand is small, the time interval is long.

2. Regular order method

The regular order method is an inventory control method that replenishes orders on a scheduled order time interval to supplement inventory. The idea is to check the stock of inventory items every fixed time period. The quantity of each order is determined based on the difference between the count result and the predetermined target stock level. It is assumed here that the demand is a random change, so the reserve amount at each inventory is unequal, and the amount that needs to be replenished to reach the target inventory level T also varies. Thus, the decision variables for such systems should be: check time period P, target stock level T, various amounts that need to be ordered is Q(in this case $Q_1Q_2Q_3Q_4$). The change in the reserve of this inventory control system is shown in the figure4 (Hheizer&Render,2011):

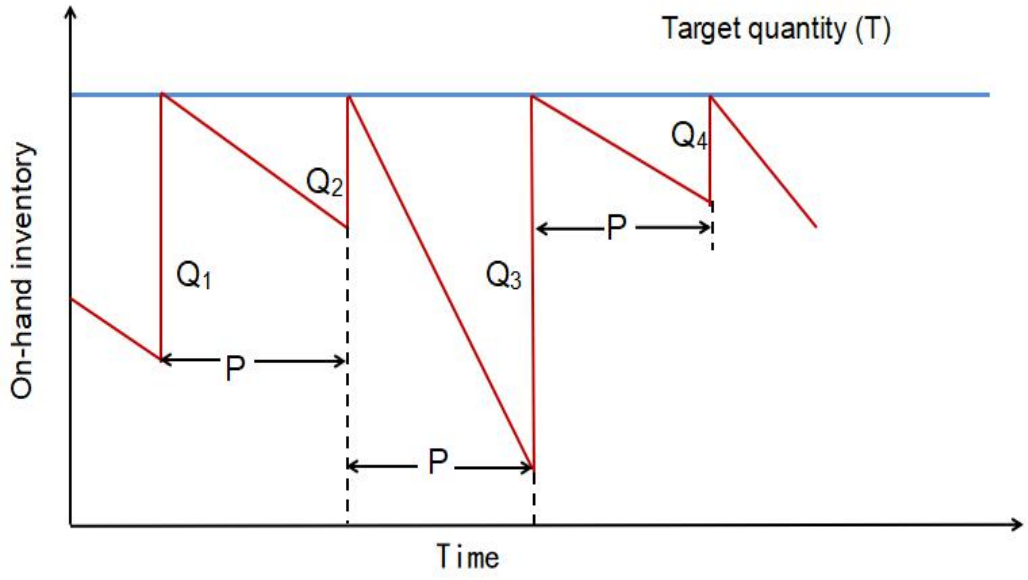


Fig.4 Fixed time order system

3. ABC classification

The ABC classification method is based on the classification of production materials in terms of cost, delivery period, and technology. This achieves a method of differential treatment and management. The ABC classification is a method derived from the Pareto principle. The difference is that the Pareto principle focuses on grasping the key. The ABC classification focuses on distinguishing the relationship between the primary and secondary, thus dividing the research object into three categories: A, B and C.

For manufacturing enterprises with a wide variety of materials in multivariate and small-volume, if the primary and secondary are all managed in a unified manner, the efficiency and effectiveness of management will be very low. The ABC classification is to divide the materials into three categories according to the priority of these three types, so as to achieve more effective management effects. Therefore, the application of this rule in inventory management can greatly improve work efficiency.

There is no clear threshold for each category, and it can be classified according to objective and criteria. ABC analysis is similar to the Pareto principle. In 'A' items, it is generally less in quantity and higher in value (Lysons&Farrington, 2006).

Examples of ABC classification as it shows in figure 5 below(Heizer&Render, 2011):

‘A’ items – 15% of total items, 80% of annual consumption.

‘B’ items - 30% of items, 15% of annual consumption.

‘C’ items - 55% of items, 5% of annual consumption.

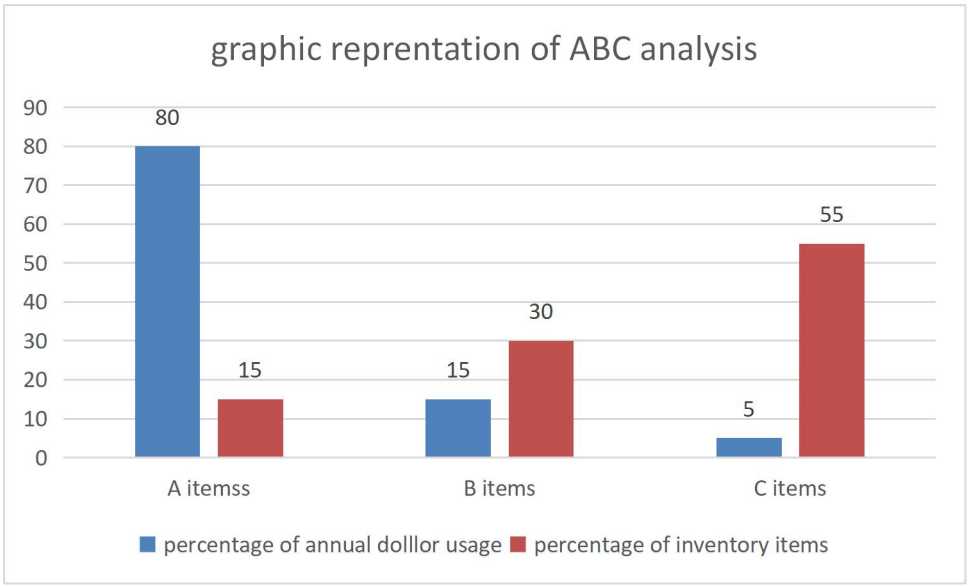


Figure 5. Graphic representation of ABC analysis

In addition, it is recommended to decompose the ABC level (Wild, 2002)::

"A" is about 10% item, 66.6% value

"B" is about 20% of items, 23.3% of value

"C" is about 70% of items, 10.1% worth

For construction machinery companies, the variety of materials is usually very large. A management of a job often costs a lot of labor, but often no results are obtained, and confusion may still occur. The ABC classification can prioritize the problem, deal with the main problem first, and often the secondary and unimportant problems become simple.The processing objects we face can be divided into two categories, one is quantifiable and the other is not quantifiable. For those that cannot be quantified, we usually only judge by experience. For quantification, classification is much easier and more scientific.

Figure 6 illustrates how to classify with the ABC taxonomy, a basic process is usually as follows:

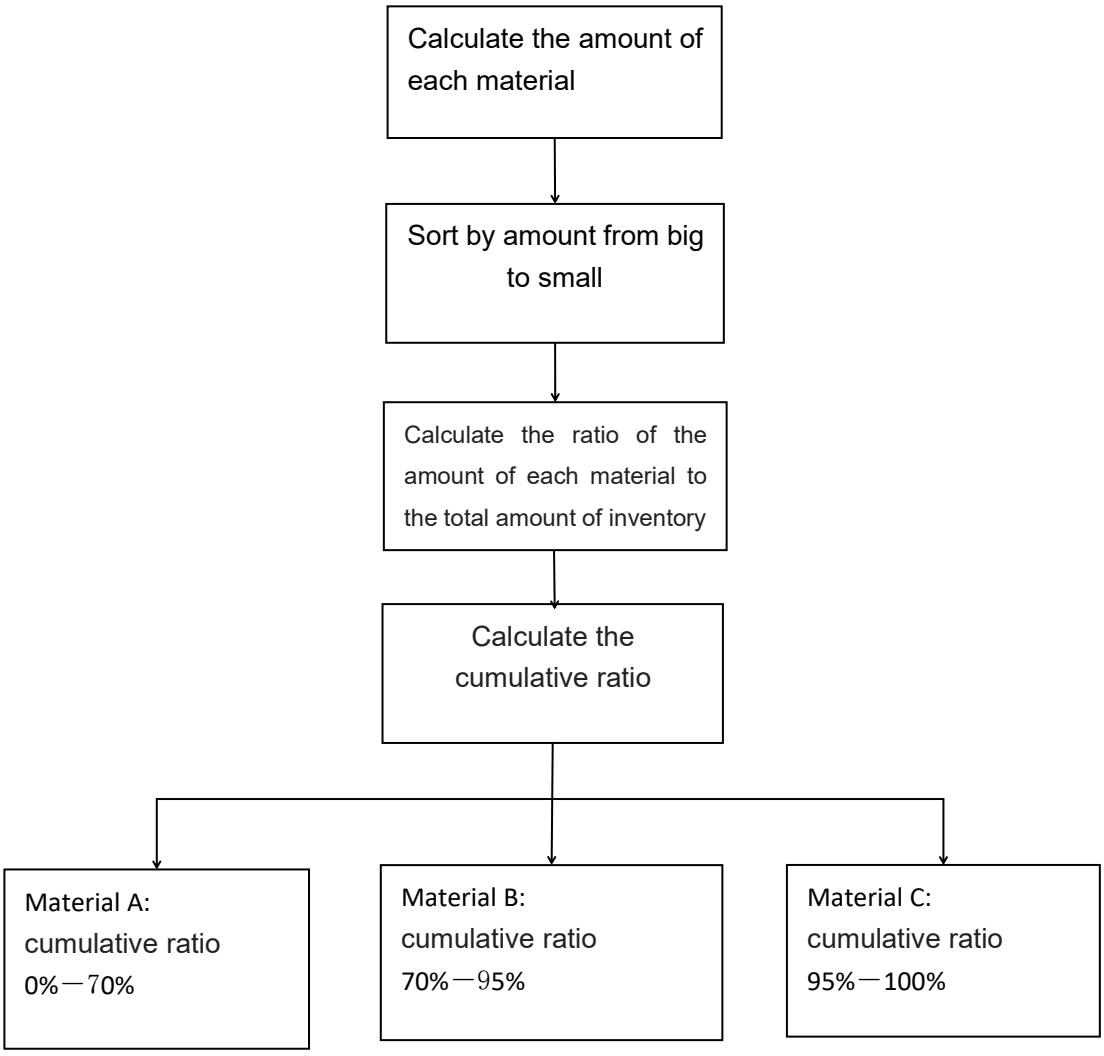


Figure6. Basic process for ABC category

According to the above, the first step is to calculate the amount of each material.

The second step is to sort the amounts according to the amount from large to small and form a table. The third step is to calculate the ratio of the amount of each material to the total amount of inventory.The fourth step is to calculate the cumulative ratio. The fifth step, classification. The cumulative ratio between 0% and 70% is the most important class A material; the cumulative ratio between 70% and 95%, is the second most important class B material; the cumulative ratio between 95% and 100%. For class C materials that are not important.

2.2 Concepts and ideas of constraint theory

Since the early 20th century, Taylor has proposed scientific management to the rapid development of electronic information technology in the 21st century. The manufacturing industry has also experienced manual workshops, mass production, multivariate small batches and personalized custom production, and production planning and control have also evolved from qualitative to quantitative, from extensive to fine to flexible. The highly competitive market environment poses new challenges to the company's production and logistics management, and promotes the continuous development of its theory and technology. Constraint theory is one of them.

2.2.1 Basic concept and development of constraint theory

“The Theory of Constraints is a methodology for identifying the most important limiting factor that stands in the way of achieving a goal and then systematically improving that constraint until it is no longer the limiting factor. In manufacturing, the constraint is often referred as a bottleneck.”(Lean Production)

There are five core steps of TOC:
First of all, the constraint in system needs to be identified. Secondly, company needs to find effective ways to exploit the constraint. With the solution at hand, all activities shall subordinate and synchronize to the solution for the constraint. And then to execute and evaluate the performance of the constraint till it no longer is one. The last step is to repeat the process so the internal improvement goes on continuously.

Constraint Theory (TOC) is a management method developed by the Israeli physicist Eliyahu M. Goldratt (Cox, Goldratt& Eliyahu, 1986) on the basis of Optimized Production Technology (OPT), which proposes some standardized methods for defining and eliminating constraints in manufacturing operations to

support continuous improvement. It was originally a philosophical theory applied in field operations management and capability management. Later, it evolved to form a set of thinking tools and began to become an management tool with a wide range of applications.

TOC is considered to be a more influential production improvement method after the Toyota Model's Just In Time Production (JIT). Its theory and method have been proved by many enterprises to prove that this is a management tool that has a significant effect on the improvement of the production site. Many companies around the world who have taken the lead in their respective fields have the experience of successfully using TOC, ranging from small factories of less than 50 people to multinational companies such as 3M, General Motors, and Intel. TOC is an effective tool for companies to stay competitive and beat their competitors.

In addition, the theory of constraints also emphasizes that any manufacturing company has a common goal, that is, to maintain profitability now and in the future. At the same time, Goldratt also proposed a set of indicators to measure whether the operation of the company is directly related to the production operations, namely, the amount of inventory, effective output and operating costs.

Managers can make appropriate decisions on the operation and management of the production system through these three indicators, and the personnel in the organization can also judge whether their individual behavior can contribute to the profit of the company through their respective indicators, so as to guide production and achieve the goal of corporate profitability.

2.2.2 TOC's way of thinking

Similar to the Pareto rule, in the TOC thinking mode, it is also believed that in any actual and objective system, most common factors are controlled by a few key factors. And if you can control these very few key factors, you can usually get twice the result with half the effort.

Every company has its own development direction and goals, and the realization of the company's goals depends on the joint efforts of all employees. Personally excellent work performance is difficult to make a big contribution to the company, and depends largely on the performance of the team. So the weakest link in the organization will determine the effectiveness of the organization. The weakest link is usually the fundamental problem.

In fact, the fundamental problems in the enterprise are deeply ingrained, thus they are often well known but they have always been lack of solutions. This approach must solve the fundamental problems in the enterprise, eliminate the bad phenomena, without producing new negative effects.

2.2.3 thinking process analysis of TOC

TOC's thinking process analysis is based on a summary of the thinking process. The most basic language used in TOC to express causality is, eg: "if A, then B."

In the TOC, the thinking process still strictly follows causal logic to answer three questions:

(1) What to improve?

(2) What to change it into?

(3) How to change?

First of all, the first question must be to understand what the current state of the system is, and to find out what constraints exist in the system. At this point, it is necessary to establish a "Current Reality Tree". Since the status quo in the enterprise is often complicated with many problems, so the "current reality tree" is established. Once the theory is successfully completed, it naturally comes to the answer to the first question, "What to improve."

The second question is “What to change it into”. There are two steps to answer this question:
First of all is to find a solution that can solve the constraints in the system; the second is to ensure that the program does not cause other problems. At this time, the Evaporating Cloud method could to analyze the constraints in the enterprise currently and propose a solution. Finally, through the Future Real Tree, it is confirmed that the solution can truly transform the internal status of the enterprise into the required state. As a result, this gives the answer to the second question.

The third question "How to improve".
To put it simply, the formulation of an improvement plan needs to consider the few people most affected by it. It is important to seek the opinions of these people and to let people who are directly involved in the transformation develop the action plan needed to implement the transformation. By doing the above, the implementation plan is basically formed.

The thinking process is: When you don't understand one thing, you need to first understand the causal relationship between one thing and one thing, and gradually understand to achieve a certain goal by discovering what should be done. Therefore, the thinking process of thinking is summarized as:

"If A, then B", then "If A, then B, because.....", this exposes some implicit assumptions, and helps to better grasp things by figuring out the process and results. On the other hand, the inevitability of things can be described as: "for A, must B", or "for A, must B, because.....", through this form can help understand why this is necessary. And the continuous extension of these descriptions will produce: "If A, then B; if B, then C; ....." or "for A, must B; for B, must C;.....". Whether the continuity is expressed in a horizontal or vertical manner, the structure is the same.

The most commonly used technical tools in the thinking process are

(1) Current Reality Tree, CRT

To answer “what to improve”, it is often started from the available cases, that is, the obvious shortcomings in the system, these shortcomings can be collectively referred to as “Undesirable Effects” (UDE). In fact, UDE is not a real problem, it is a superficial phenomenon. Drawing the logical diagrams that tie these UDEs together can greatly help to find the root cause of the real problem and display it at the outermost part of the graph. The logic diagram is the current reality tree, through which it answers the question of “what to improve”.

(2) Evaporating Cloud

The Evaporating Cloud method is usually used to solve conflicts in the enterprise. The cloud of the cloud-evaporating method, as the name implies, is a conflict in the enterprise. The metaphor are clouds, cause it obscures the eyes of employees so that they cannot clearly and accurately explain the root causes of these conflicts. The Evaporating Cloud method is to dispel the confusing clouds around the conflicts in the enterprise, and to point out the root causes of these conflicts in order to give a solution.

In order to answer the second question, “What to change it into”, we must first understand the “real problems” that are found out from the current reality tree. Undoubtedly, if these problems are simple, they will not exist in the enterprise for a long time. After identifying these conflicts and fundamental problems, it is needed to find a breakthrough idea to solve the problem, which is called injection of a new idea in the TOC. In fact, in addition to finding groundbreaking ideas, it is also necessary to test whether they really have the expected impact on the system, and this requires the use of a “future reality tree”.

(3) Future Reality Tree, FRT

Using the "Evaporating Cloud" to see the problems and conflicts and find a breakthrough idea is "injection." But it is not necessarily a correct and complete solution. In order to ensure the feasibility and effectiveness of the program, it is necessary to test its actual operational results. How to test it is to return to the current realistic tree diagram originally drawn, and add "injection" to the link to break through. After re-splicing the various logical relationships, the future reality tree is drawn on the current real tree. If the expected solution is found in the new "injection", they are just like the "leaves" of the future reality tree. Therefore, the future reality tree can well map the effect of implementing “injection”, and the proposed scheme can be verified from the future reality tree.

2.3 Material Requirements Planning MRP

The definition of material requirements planning by the American Production and Inventory Control Society (APICS): Material requirements planning is a practical technology based on information such as the main production plan (MPS), bill of materials, inventory records, and orders that have not been placed. Calculate the demand status of various Dependent demand materials, propose various new

order replenishment suggestions, and modify various orders that have been issued.

2.3.1 The meaning and content of the material requirement plan

The material requirement plan refers to the subordinate and quantitative relationship of items at different levels according to the product structure. Taking each item as the planning object, the completion time is the time-based reverse plan, and the order of the scheduled time is determined according to the length of the lead time. It is an industrial manufacturing enterprise material plan management mode. MRP is based on the market demand forecast and customer orders to develop the production plan of the product, and then based on the product generation schedule, form the material structure table and inventory status of the product. It is a practical technique for calculating the processing progress and ordering schedule of materials by calculating the demand and time of demand for materials.

MRP's main content includes customer demand management, product production planning, raw material planning, and inventory records. Customer demand management includes customer order management and sales forecasting, combines the actual number of customer orders with the scientific customer demand forecast to determine what and how much the customer needs.

2.3.2 Main idea of material requirements planning

MRP was proposed by the American Stock Association in the early 1960s. Previously, the company's material inventory plan usually adopted the order point method. When the stock level was lower than the order point, the order was

started. This management method is applicable when the material consumption is stable, but it is not applicable to order production.

Due to the development of computer technology, it is possible to manage materials by dividing them into dependent demand and independent requirements. According to the bill of materials, inventory and production plan, the related demand schedule of materials is prepared according to the required materials, and the materials can be purchased in advance according to the required materials, so that the inventory can be greatly reduced.

The main idea of MRP is:

1. Breaking the boundary between the product variety and the set, and logically treating all products, parts, raw materials, middleware, etc. involved in the production process of the enterprise as material.

2. Divide all materials into two types: independent demand and dependent demand. In the MRP system, “material” is a broad concept, which refers to raw materials, work in progress, purchased parts and products. All materials are divided into two categories: independent demand and related demand.

1) Independent demand: If a requirement is not related to the demand for other products or components, it is called independent demand. It comes from outside the company, and its demand and demand time are determined by the external demand of the company, such as products ordered by customers, spare parts for after-sales, etc. The demand data is generally determined by forecasting and ordering, and can be processed according to the order point method.

2) Dependent demand: If the demand for certain projects depends on the demand for other projects, the demand is dependent. It happens in the manufacturing process and can be calculated. The demand for raw materials,

blanks, parts and components comes from the manufacturing process and is related to the requirements. MRP deals with such dependent demands.

2.3.3 Basic principles of MRP

As showed in fighre7 below which explains the logic of MRP , the basic logical principle of MRP is to determine the production time and production quantity of all parts of the main product layer by layer by the master production schedule (MPS) and the hierarchical structure of the main product. Among them, if the parts are produced in-house, it is necessary to arrange the production time in advance according to the length of each production time to form a production plan for parts and components; if the parts need to be purchased from outside the company, they should be determined according to their respective order lead times. The time of each order and the quantity of purchases will be issued in advance to form a procurement plan. It is true that production in accordance with these production plans and procurement in accordance with the procurement plan can realize the production plan of all parts, thereby not only ensuring the delivery time of the products, but also reducing the inventory of raw materials and reducing the occupation of liquidity.

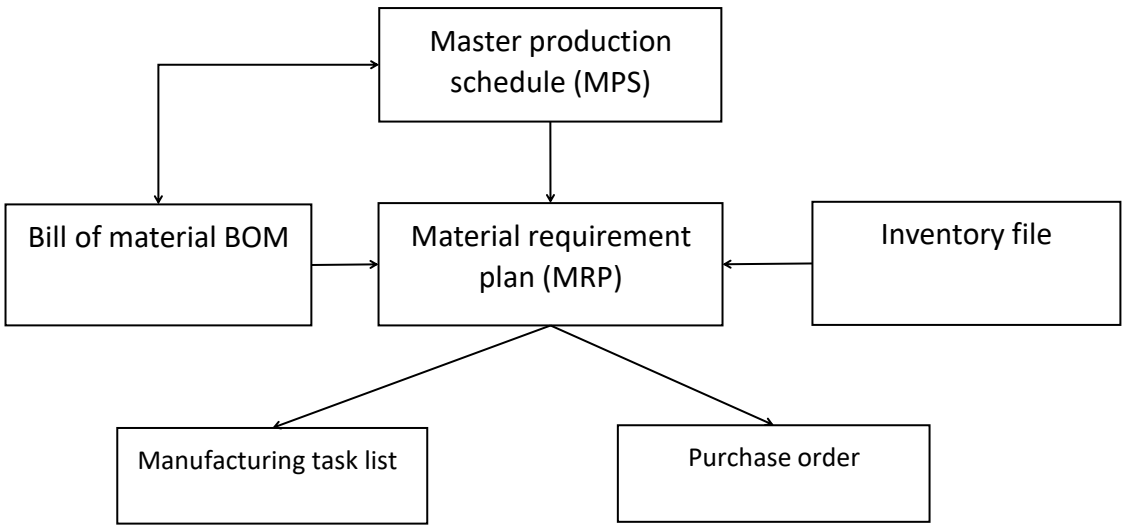


Figure 7.MRP logic schematic

Thus, the MRP is formed based on the Master Production Schedule (MPS), the structure file (BOM) of the main product, and the inventory file.

The main product is the finished product that the enterprise uses to supply the market demand. For example, cars produced by automobile manufacturers and TV sets produced by television factories are the main products of their respective companies.

The main product's BOM (Bill of Materials) mainly reflects the hierarchical structure of the main product, the structural relationship and quantity composition of all components. Based on this document, it is possible to determine the required quantity, time required, and assembly relationship of the main product and its various components.

Master Production Schedule (MPS), which mainly describes the production progress of the main product and the parts determined by the BOM of its structural file, which is expressed as the production volume in each time period, and has the production time, production quantity or assembly time. The number of assemblies and so on.

The product inventory file, which includes the stock of the main product and all its parts, the quantity that has been ordered, and the amount that has been allocated but not yet taken. One guiding idea in developing a material requirements plan is to minimize inventory.Priority is given to stocks. If there is enough in the warehouse,there will no longer schedule for production and procurement. When there are not enough inventory in the warehouse, but only the part that is not enough is put into production or purchase.

The product production plan and the product procurement plan are regenerated by the material requirement plan,then organize production and procurement according to production planning, which generates manufacturing order orders and purchase order forms, and send them to the manufacturing department for production or to the purchasing department for purchase.

2.3.4 Characteristics of MRP

1. Relevance of demand: In circulation enterprises, various needs are often independent. In a production system, demand is relevant. For example, after determining the quantity of the required product according to the order, the quantity of each component and raw material can be derived from the new product structure file BOM. This amount of material derived from the logical relationship is called the relevant demand. Not only is the number of varieties relevant, but the demand time is also related to the decision of the production process.

2. Deterministic requirements: The requirements of MRP are accurately calculated according to the main production schedule, product structure documents and inventory documents. The variety, quantity and demand time are strictly required and cannot be changed.

3. The complexity of the plan: According to the production plan of the main product, the product structure file, the inventory file, the production time and the procurement time, the MRP plan accurately calculates the quantity, time, and relationship of all the parts and components of the main product. When the product structure is complicated and the number of parts is particularly large, the calculation workload is very large, and the manpower is simply not competent. The computer must be implemented to implement the project.

2.3.5 Basic data before MRP

The following basic data must be available before the material requirements planning:

The first data is the master production plan, which specifies the various products and spare parts that should be produced during a planned time period. It is one of the most important data sources for material requirements planning.

The second item is the bill of materials (BOM), which indicates the structural relationship between the materials and the quantity of each material requirement. It is the most basic data in the material requirements planning system.

The third item is the inventory record, which reflects the actual inventory status of each item and the actual status of the planned acceptance.

The fourth item is the lead time, which determines when each material starts and when it is completed.

These four data are all vital and indispensable. Missing any of them or missing any data for any of them, the material requirements planning will be inaccurate. Therefore, before completing the material requirements planning, all four data must be completely established and guaranteed to be absolutely reliable and executable.

2.3.6 The goal of the MRP

(1) Obtain the raw materials and parts required for production in time to ensure that the products required by users are supplied on time.

(2) Guarantee the lowest possible inventory level.

(3) Plan the production activities and procurement activities of enterprises,
Accurate time and quantity requirements for parts, purchased parts and assembly requirements produced by various departments

MRP is mainly used in the manufacturing of "assembled" products. When implementing MRP, a sales plan that is commensurate with market demand is the most basic element of MRP success. But MRP also has limitations, that is, resources are limited to internal enterprises.

2.3.7 Operating steps

(1) According to market forecasts and customer orders, correctly prepare reliable production plans and production operation plans, and specify the varieties, specifications, quantities and delivery dates of the production in the plan. At the same time, the production plan must be compatible with the existing production capacity. s plan.
(2) Properly prepare the product structure drawing and the material list of various materials and parts.
(3) Correctly grasp the actual inventory of various materials and parts.
(4) Properly specify the purchase delivery date of various materials and parts, as well as the order period and order quantity.
(5) Determine the total required amount of various materials and parts and the actual required amount by MRP logic operation.
(6) Issue a purchase notice to the purchasing department or issue a production order to the production workshop of the enterprise.

2.4 Chapter summary

This chapter introduces many different concepts and ideas, including inventory and inventory cost which covers different types of each; problems that a high inventory holding may cause; benefits that a reasonable inventory level could bring; main factors that made up the inventory system; traditional inventory control models; theory of constrains that continuously solve the bottleneck in the enterprise and the very important material requirements planning.

3 The status quo and problems of inventory management

This chapter starts to take the research into a practical stage which takes the real situation of a certain existing company to help solving and try providing some constructive ideas or even solutions to cope with. It introduces the HR company and its product types, analyzes the financial status of the inventory status, and analyzes the current inventory status.

3.1 Company Profile

HR is a small manufacturing company with a 15-year operating history. There are 96 employees, including 25 technical R&D personnel. The production site is 15000m2, all kinds of processing equipment 86 units,monitoring and testing equipment 264 units, including an electrical product assembly workshop, a mechanical product assembly workshop, a mechanical processing workshop, warehouse area of 1568m^2. It is mainly engaged in the supply of electrical

products and mechanical products used in construction vehicles. It belongs to the order-based production mode. In recent years, it has gradually developed a new type of accessory products combining mechanical and electrical. In 2015, the output value was 61.25 million yuan, and the output value in 2016 was 75.8 million yuan. The output value in 2017 was 91.42 million yuan. It is increasing year by year and the business prospects are improving.

Figure 8 below reflects the company's staff composition and department structure in order to get a general image of it.

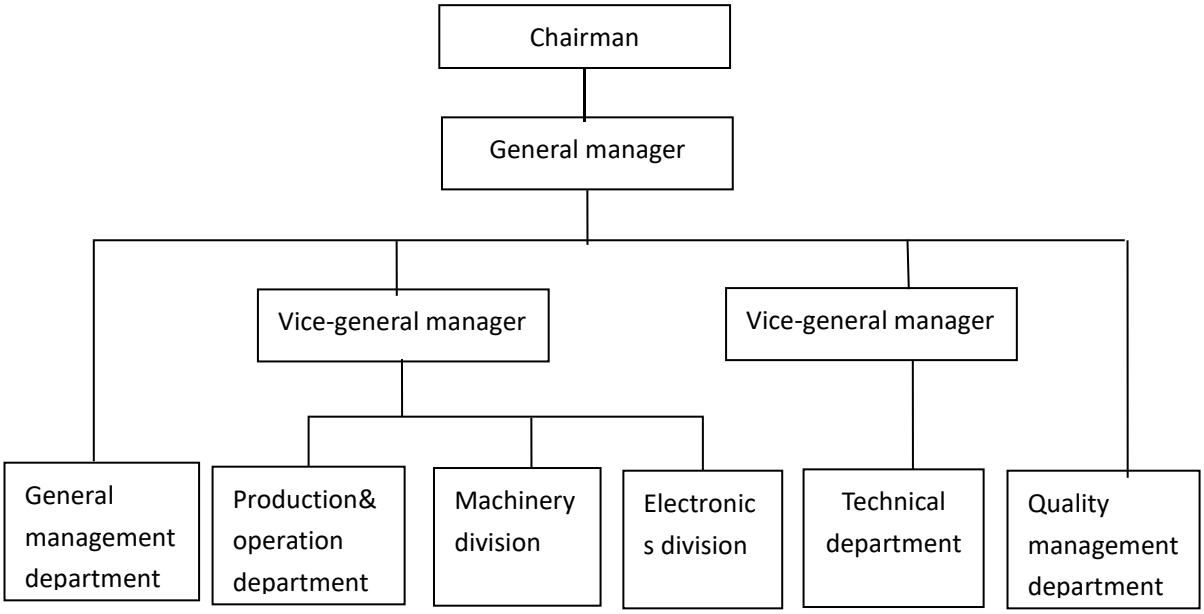


Figure 8. Organization chart

3.2 Analysis of the financial status of inventory funds

With the help of the Finance department, company's inventory level of 2015.2016 and 2017 were obtained for analysis and comparison. From the financial figures in the table below, we can see that the annual sales value of HR

company has increased by 25%, the inventory has increased by 35%, and the inventory turnover has also declined.

Table1. Inventory financial data(unit: million¥)

Item / Year	Raw material	Work in progress	Total inventory	Finished goods inventory	Sales	Annual total number of materials
2015	8.13	5.02	14.23	1.08	61.25	32.32
2016	6.95	10.86	19.26	1.45	75.80	38.74
2017	8.70	13.80	26.00	3.50	91.42	46.65

3.3 Inventory status analysis

The inventory level of HR company in 2017 is shown in Figure 9. The average in-process inventory is 8.5 million Yuan. It is equivalent to 1.2 months of output value, 2.2 times the actual required semi-finished products. The raw material inventory is maintained at around 12 million Yuan. It is equivalent to 1.6 times the monthly industrial output value, which is 3.6 times of the actual raw materials required. The entire inventory is too large.

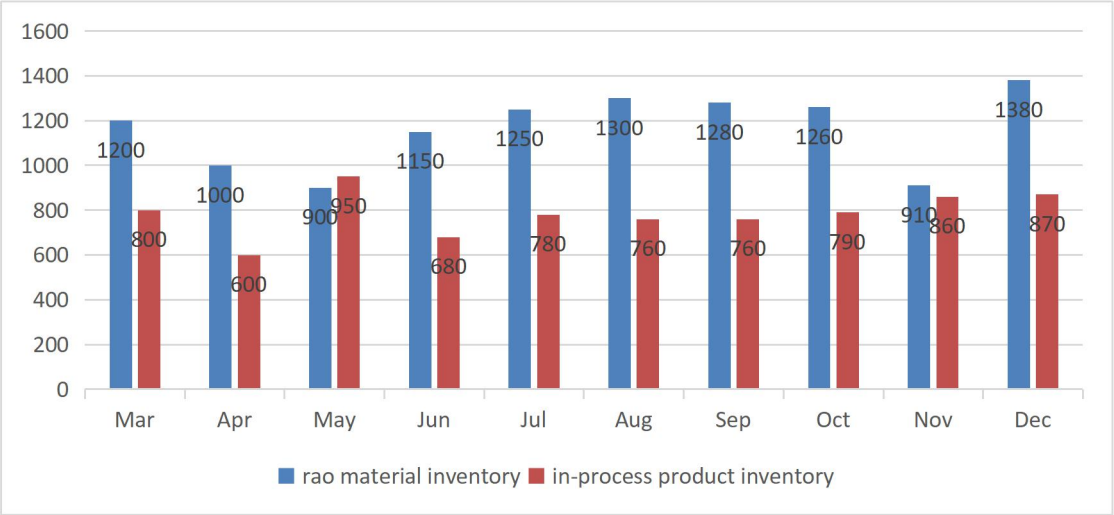


Figure 9. 2017Annual inventory level (Unit: ten thousand Yuan)

3.4 Using constraint theory to find out the optimal inventory plan

In this section,Through the theory of constraints, the in-process inventory resources and raw material inventory resources in the production process are analyzed to find out the main reasons for the unreasonable inventory configuration and based on them draw the current reality tree. Find the root cause of these problems by means of evaporating cloud and verify them through the future reality tree

3.4.1 Analyze the status quo by using the real tree

According to the actual situation that HR companies are currently facing, the main bad performances(UDE) in the entire production logistics system are:

UDE1. Higher raw material inventory levels

UDE2. In-process inventory is too high

UDE3. High production costs

Draw the current reality tree through three UDE.

It can be seen from the current reality tree (see Figure 10) that the factors causing high production costs are formed by the high amount of raw materials and in-process inventory. The reasons for the problems are as follows:

1.Raw material inventory information is not accurate

2. There is no standardized calculation method for material procurement.

3.The main production plan, raw material inventory information and semi-finished product information asymmetry

4.The structure of the product material plan is not clear, and the number of inputs is prone to errors.

5. No shared data processing platform between production logistics

6.No logical relationship between data

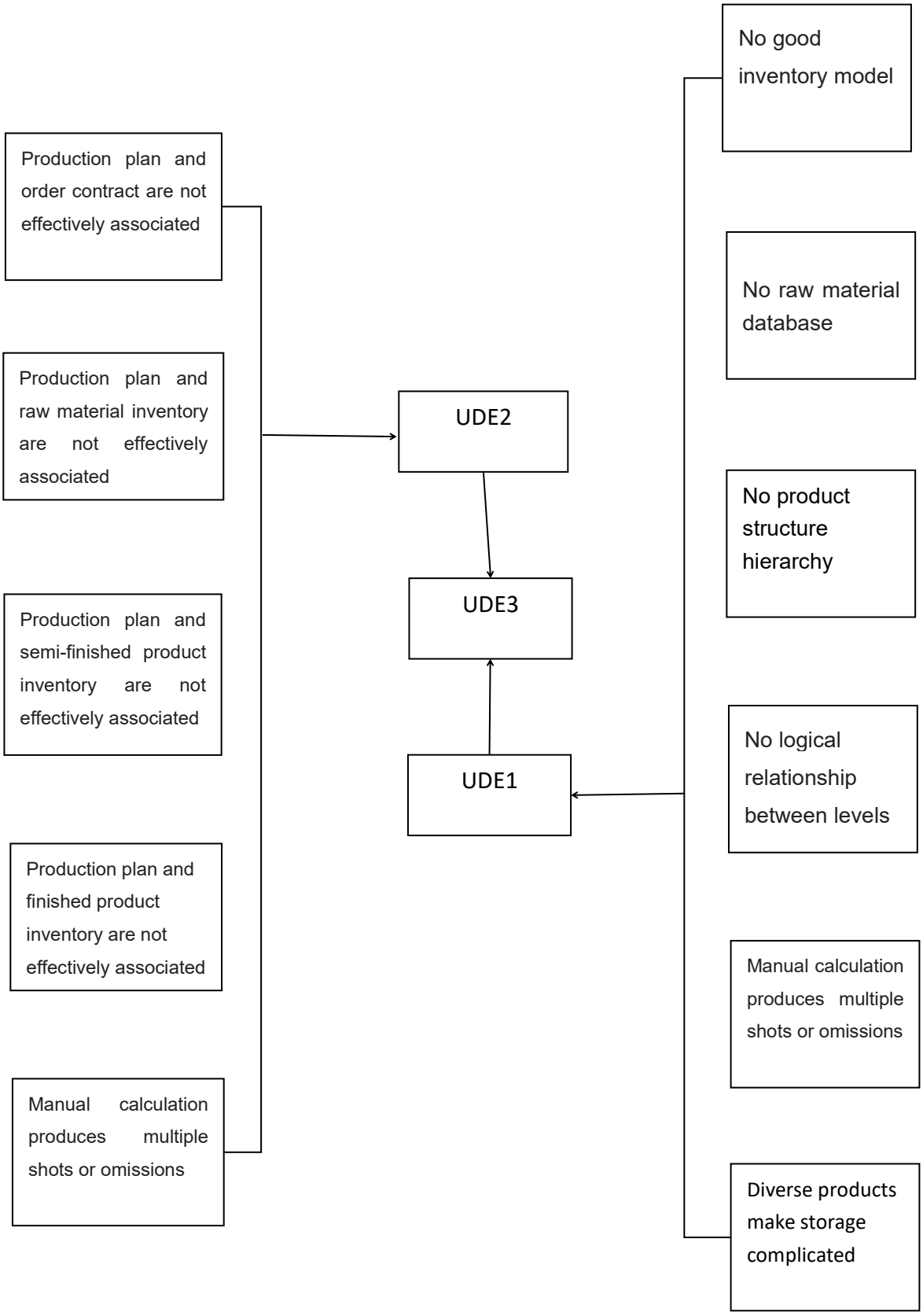


Figure10. current reality tree

3.4.2 Analysis of the causes of problems caused by evaporating cloud

Since overstocking is mainly concentrated in WIP inventory and raw material inventory, the reasons for these two states are analyzed separately below.

1. In-process inventory

Reasons for high in-process inventory:

(1) Inventory management type is extensive management. Finished goods inventory, raw material inventory, and semi-finished product inventory data is incomplete and inaccurate.

(2) Product structure level and affiliation is not clear

(3) Due to lack of scientific theory guidance, the production plan input amount has no logical data operation processing, which belongs to empirical management. In order to avoid shortage, it is easy to invest more.

(4) In order to maintain the production line without stopping production, artificially increase the input of parts with more raw materials inventory.

The analysis of the evaporating cloud for the in-process inventory is shown in the following Chart 11.

The old inventory management mode often occurs inaccurate data record, which directly leads to the inaccuracy of structural hierarchy affiliation. Doubtlessly, the planned investment will not be correct. Finally, the artificially increased investment raised the funds occupation. With the consideration of these consequences, corresponding measures shall conquer the problem step by step by establish production logistics information processing platform that insures the

validity of the data. Correct data recording makes production inputs and production costs certain, and this could effectively avoid excessive work in process inventory and expenses in the end.

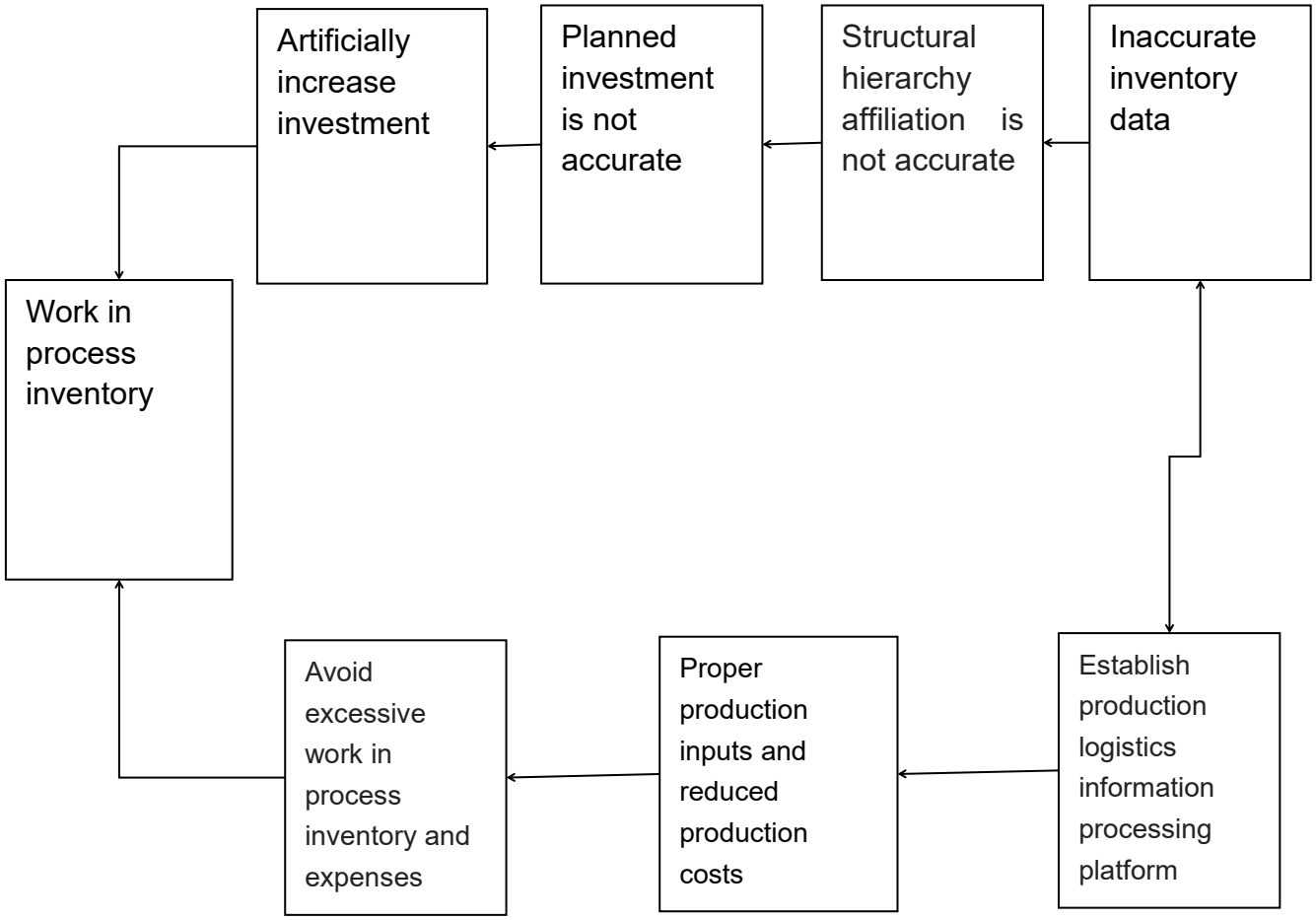


Figure11. Evaporating cloud analysis on WIP inventory

Therefor,the main reasons for the high inventory of finished products are:

① No established inventory database,lack of accuracy in production planning input

② Product structure level affiliation is not clear

③ Production plans and inputs cannot be effectively invested in scientific control

2. Raw material inventory

Due to the relatively large variety of products, the demand for each product varies greatly, it has not been possible to define a suitable inventory model for many years. In order to ensure the continuity of production, HR has not made up its mind to reduce inventory. Therefore, the inventory of raw materials has been maintained at a high level. As the sales value increases, the inventory of raw materials also rises. Therefore, evaporating cloud method is used to analyze root of the problem as shown in figure 12.

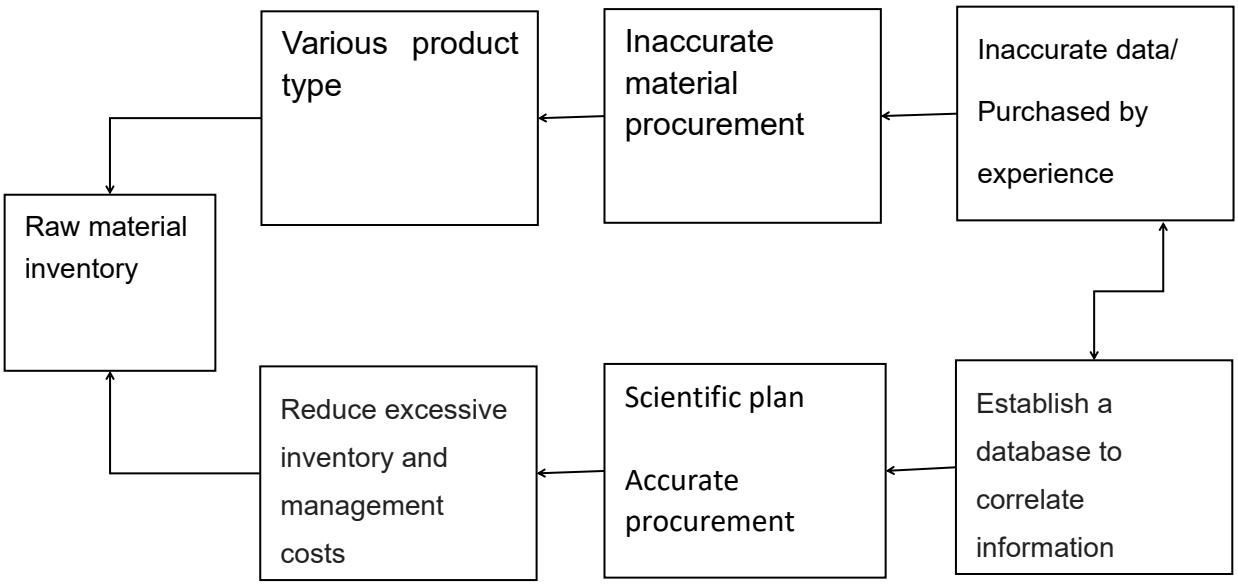


Figure12. Evaporating cloud analysis on warehouse inventory

Reasons for high raw material inventory:

① There is no standard requirements for raw material inventory management,and procurement has no rules to follow.

② There is no corresponding logical relation between the raw material procurement plan and the master production plan.

3.4.3 Build a Future Reality Tree

Through the analysis of the evaporating cloud method, it can be found that in order to reduce the management cost and achieve the goal of controlling inventory, the company needs to optimize the in-process inventory and raw material inventory.

The solution for in-process inventory optimization is: Using the basic principles of MRP and applying information processing technology, establishing finished product inventory, raw material inventory information database through Excel, incorporating all inventory information of the enterprise into management, constructing product-level affiliation logic related information, realizing the correlation of inventory data between the order data, the product production plan and the part production plan, so that the production plan input quantity is accurate and reliable, and the in-process inventory is greatly reduced.

The solution for optimizing raw material inventory is to establish a good dynamic inventory model of raw materials to solve Two problems that plague management decisions: First, which products should be prepared for raw material inventory, and second, what kind of control strategy should be used for raw material procurement and inventory.

The future reality tree optimized by these two aspects is shown below in Chart 13.

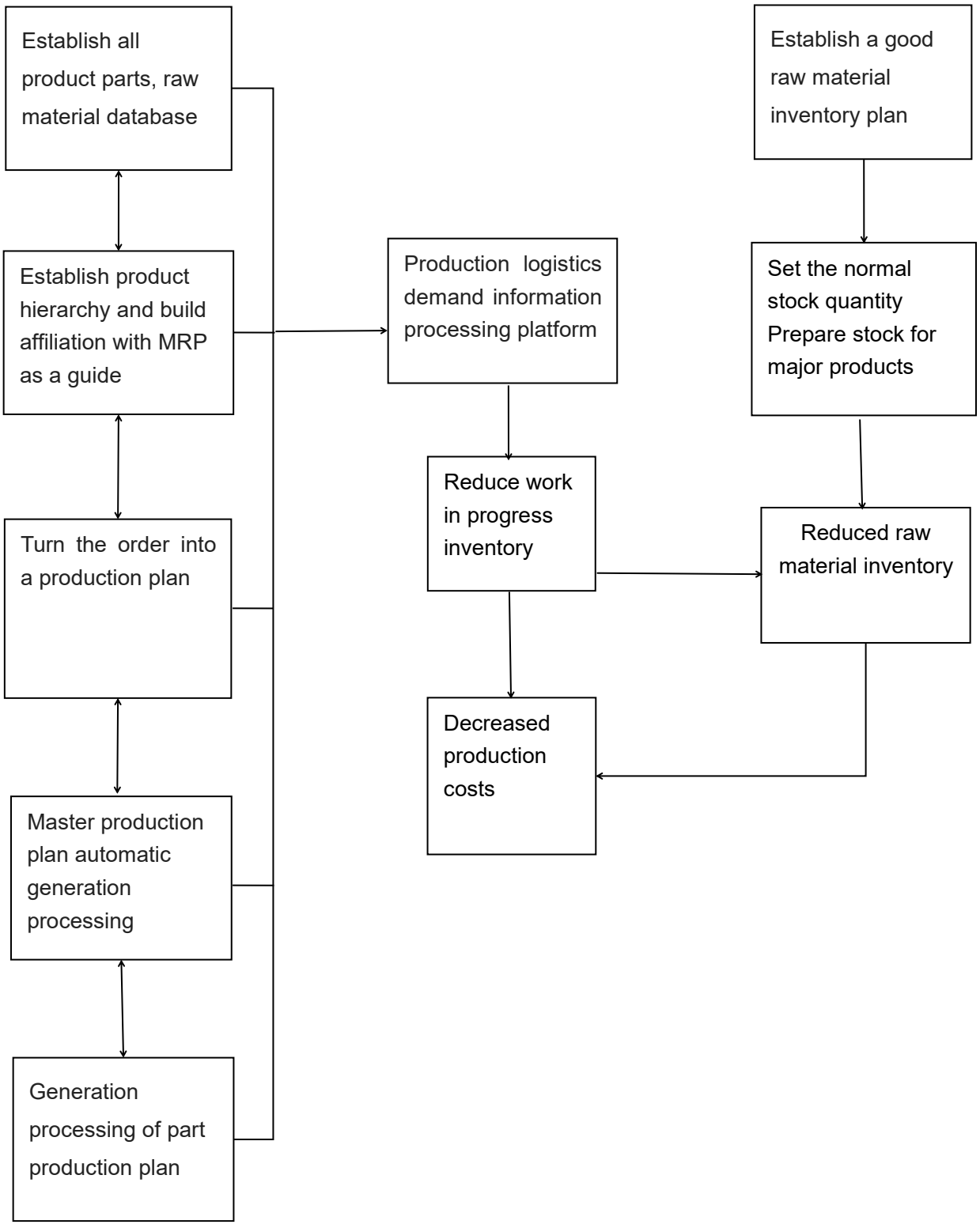


Figure.13 future reality tree

3.5 Chapter summary

This chapter introduces the HR company and its product types, analyzes the financial status of the inventory status, and analyzes the current inventory status. Then it uses the three steps of the thinking process theory in the constraint theory (TOC) to analyze, the first step It is to use the real tree to summarize the status quo problem, the second part uses the evaporating cloud method to generate the root cause of these problems, and finally proposes a feasible optimization plan by constructing the future reality tree.

4 Optimization analysis of work in process inventory

This chapter focuses on how to use the basic elements of MRP in the main production plan, bill of materials, inventory records, combined with the VlookU function relationship in the most widely used computer office software Excel in the enterprise, to develop standardized information processing templates,and carry out optimization of work in process inventory.

MRP refers to the subordinate and quantity relationship of each level of products according to the product structure.

Taking each item as the planning object, back scheduling plan based on the completion time and the order of the scheduled time for each item is determined according to the length of the lead time. It is a mode of material planning management in industrial manufacturing enterprises. Its main content includes customer demand management, product production planning, raw material management and inventory records. The customer demand management

includes customer order management and sales forecasting, and comprehensively considers the actual customer order quantity and scientific customer demand forecast and safety stock and manufacturing process product qualification rate to form the plan content for guiding production.

Due to the maturity of the company's cycle of purchasing materials and the production cycle of self-made parts, it will not be the focus of analysis and discussion. This article will be applied in order management, product production planning, parts production planning, finished product inventory, and parts inventory with VlookUp to develop the logic of related requirements logic. It realizes the data collection, transmission, storage, processing, classification and digitalization, and the operation automation of production business management, ensuring objective and accurate data between all links, so that each process is correct in the required quantity, avoiding all kinds of human error and causing possible increase in inventory, improving the efficiency of production and operation of enterprises and profitability.

4.1 In-process inventory optimization

For the optimization of WIP inventory, the main aspects are as follows,and each of the following aspects will be expanded and discussed later one by one.

1) Establish a inventory product database

2) Establish an advice note database

3) Establish product inbound order database

4) Establish a parts database

5) Establish a parts out database

6) Establish a parts storage database

7) Establish a contract summary database

8) Establish the original contract database

9) Establish product production planning processing interface

10) Establish a part production planning processing interface

11) Establish a comprehensive information processing platform for production management

4.2 Establishment of inventory product database

The inventory product is the product that has completed all the manufacturing contents and passed the inspection and is ready to be issued. In order to ensure the accuracy of the production input and overcome the blind input. In addition to the order requirements, the inventory control must also check the quantity of the inventory products to avoid unintended expansion of the inventory resulting in inventory backlog. Use the Excel table function to establish the finished product inventory database.

1) Establish a database of all finished products of the company
2) All stock products must have a unique product code and name
3) Defining the original stock quantity
4) Set up the warehouse summary quantity item (data association reference)
5) Set up the outbound summary quantity item (data association reference)
6) Real-time inventory quantity is generated by G=D+E-F logic operation

The finished product inventory database table is as follows:

Table2. Finished product inventory database

A	B	C	D	E	F	G
S/N	Product model	Product name	Original inventory	Inbound summary	Outbound summary	Real-time inventory
1	J0231	recognizer	2	11	2	11
2	K05	sensor	5	5	5	5
3	Y412	Display box	10	10	10	10
4	Y421	Start box	5	5	5	5
5	S706.01	tester	20	5	20	5
6	H641	Switch panel	25	4	25	4
7	H642	clapboard	40	8	40	8
8	H643	Switch box	41	10	41	10
9	H647	Distribution box	42	12	42	12
10	H648	Electrical box	47	15	47	15
11	H652	Work box	10	10	10	10
12	Q-1	Drive box	10	8	10	8

The relationship between finished goods inventory and outbound and inbound as shown in figure 14:

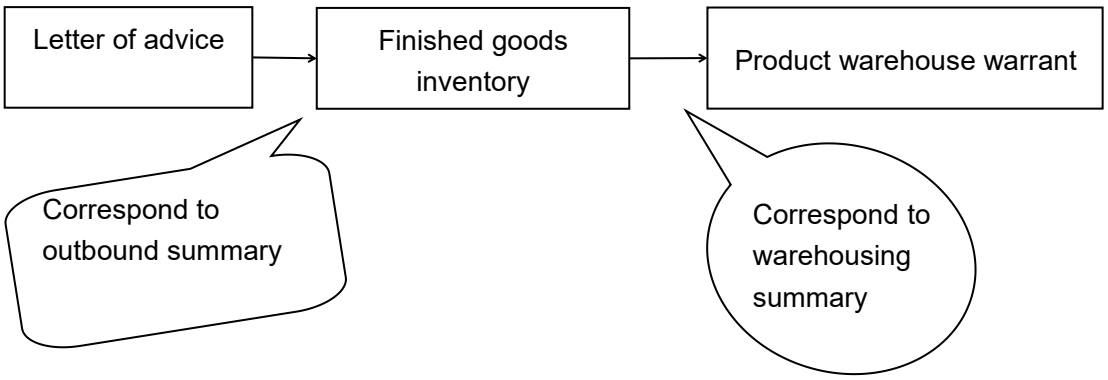


Figure14.Associated factors of finished goods inventory

4.2.1 Delivery notice database

The delivery notice is a voucher for selling the finished goods to the customer according to the order requirements. All the documents are entered into the product release information database by the delivery personnel according to the document content requirements to ensure accuracy.

(1) Shipment finished products must have unique product code and name

(2) The delivery notice must indicate the corresponding contract number

(3) Set the number and unit of products shipped

(4) Set the receiving unit and delivery date

The table below is built based on meeting all the requirements mentioned above to make sure the accuracy of the database.

Table3. Delivery notice database (interface)

S/N	Product model	Product name	unit	quantity	Contract number	consignee	date
1	J0231	recognizer	set	2	XXHR-18001		
2	K05	sensor	set	5	XXHR-18002		
3	Y412	Display box	set	10	XXHR-18002		
4	Y421	Start box	set	5	XXHR-18002		
5	S706.01	tester	set	20	XXHR-18002		
6	H641	Switch panel	set	25	XXHR-18002		
7	H642	clapboard	set	40	XXHR-18002		
8	H643	Switch box	set	41	XXHR-18002		
9	H647	Distribution box	set	42	XXHR-18003		
10	H648	Electrical box	set	47	XXHR-18003		
11	H652	Work box	set	10	XXHR-18003		
12	Q-1	Drive box	set	10	XXHR-18003		

4.2.2 Product warehousing database

The warehousing notice is the certificate that the production workshop has transferred the products that have met the technical requirements and passed the inspection into the finished product warehouse. All documents are entered into the product warehousing database by the warehouse administrator according to the document content requirements to ensure accuracy.

1 Warehousing products must have a unique product code and name(reflected in the 2nd and the 3rd column of the table below).

2 Incoming notice must indicate the inbound order number(reflected in the 6th column)

3 Incoming notice must indicate the date of storage(displayed in column 7)

4 Set the number and unit of inbound products (shown in column 4 and 5)

An example of warehousing notice management interface is shown in Table 4.

Table4.inbound notice database

S/N	Product model	Product name	unit	quantity	Inbound order number	Date of inbound
1	J0231	recognizer	set	11	HR1810001	2018.10.10
2	K05	sensor	set	5	HR1810005	2018.10.11
3	Y412	Display box	set	10	HR1810006	2018.10.20
4	Y421	Start box	set	5	HR1810006	2018.10.20
5	S706.01	tester	set	5	HR1811002	2018.11.5
6	H641	Switch panel	set	4		
7	H642	clapboard	set	8		
8	H643	Switch box	set	10		
9	H647	distribution box	set	12		

10	H648	Electrical box	set	15		
11	H652	Work box	set	10		
12	Q-1	Drive box	set	8		

The delivery notice and the warehousing notice content will be recorded as the original data into the delivery notice summary and the product warehousing summary data repository, showing only the status of all information of the shipment and warehousing. The outbound and warehousing information will be Will automatically feedback to the finished product database to form real-time product inventory data.

4.3 Establishment of a qualified parts database

Qualified warehousing parts are the parts of the manufacturing workshop that complete all the process contents according to the processing requirements and are inspected and put into the warehouse to be assembled into products. In order to ensure the accuracy of production input and product assembly, avoid expanding production and increase inventory, in addition to the order requirements, the inventory parts must also be checked to avoid unintended investment resulting in inventory backlog.

Use the computer office software Excel table function to establish a qualified parts inventory database.

(1) Enter the original data for the inventory of all parts of the company

(2) All parts only correspond to the part number and do not correspond to the product model.

(3) Set the number of parts in the warehouse summary item

(4) Set the outbound summary quantity item

(5) The quantity of real-time parts is generated by F=C+D-E logic operation

Table5. part inventory data form

A	B	C	D	E	F
Part model	name	raw data	Inbound summary	Outbound summary	Real-time inventory
J18E-9P（20419）	plug	1	236	188	49
J18E-9S（20419）	plug	5	175	12	168
J18E-9PD	socket	9	121	121	9
J18E-9SD	socket	200	141	15	326
ZH852510N12B10GPNH	socket	100	75	15	160
RJ14-0.25W-1K±5%	resistance	40	4037	56	4021
RJ14-0.25W-2.7K±5%	resistance	70	1136	115	1091
RJ14-0.25W-33K±5%	resistance	12	1430	56	1386
HG313S	Infrared light emitting diode	50	367	369	48
3DU133	Silicon photo-transistor	54	361	258	157
3DG8C	transistor	500	254	555	199

The materials in the production process of the enterprise are divided into two types: independent demand and related demand. In MRP application technology, material is a broad concept, which refers to raw materials, work in progress, purchased parts and products. The internal demand of the enterprise is the demand for certain other requirements, such as raw materials, parts, and purchased parts. This demand is related to the demand, it occurs in the manufacturing process, and can be obtained through MRP technology calculation.

It is not bounded by the variety of products and the number of matching, but to manage the materials needed in the manufacturing process uniformly to form a

material that can be used in multiple places, centralized purchasing or manufacturing, and effectively control production input.

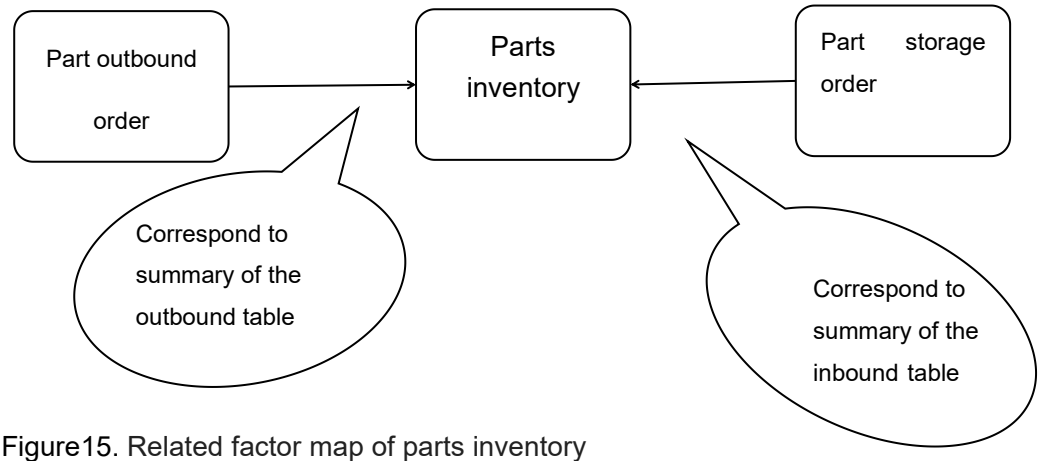


Figure15. Related factor map of parts inventory

4.3.1 Part outbound database

The parts outbound notice is the certificate for sending the parts to the assembly site according to the quantity of the assembly plan. All the documents are entered into the parts inventory database by the warehouse personnel according to the document content requirements to ensure accuracy.

1) Outbound parts should have part model and name
2) The outbound parts should have the number of shipments every time
3) Outbound parts should have an outbound order number
4) Outbound parts should have time for delivery

The interface of the part outbound notice management as shown in the following table 6

Table 6. parts outbound notice database

Parts model	name	Number of outbound	Outbound order number	Outbound time
J18E-9P（20419）	plug	188		
J18E-9S（20419）	plug	12		
J18E-9PD	Socket	121		
J18E-9SD	Socket	15		
ZH852510N12B10GPNH	Socket	15		
RJ14-0.25W-1K±5%	Resistance	56		
RJ14-0.25W-2.7K±5%	Resistance	115		
RJ14-0.25W-33K±5%	Resistance	56		
HG313S	Infrared emitting diode	369		
3DU133	Silicon photoelectric triode	258		
3DG8C	audion	555		

4.3.2 Part warehousing database

Part warehousing notice is the certificate that the manufacturing workshop transfers the parts that meet the technical requirements and passed the inspection to the parts library. The documents are entered into the parts database by the warehouse administrator according to the contents of the documents.

(1) Incoming parts should have part model and name

(2) The warehousing parts should have the number of warehousing each time

(3) The inbound parts should have an inbound order number

(4) Warehousing parts should have warehousing time

Covering all the requirements mentioned above, the interface of the part inbound notice management database is as shown below

Table7. Part inbound notice database(interface)

Part model	name	Number of warehousing	Inbound order number	Inbound time
J18E-9P（20419）	plug	236		
J18E-9S（20419）	plug	175		
J18E-9PD	socket	121		
J18E-9SD	socket	141		
ZH852510N12B10GPNH	socket	75		
RJ14-0.25W-1K±5%	resistance	4037		
RJ14-0.25W-2.7K±5%	resistance	1136		
RJ14-0.25W-33K±5%	resistance	1430		
HG313S	Infrared emitting diode	367		
3DU133	Silicon photoelectric triode	361		
3DG8C	audion	254		

The parts outbound notice and the inbound notice contents are entered as the original data into the parts outbound order and the part inbound order data repository. Only the information status of the inbound and outbound notice is presented. The outbound and warehousing information will be Automatic feedback to the parts database to form real-time all part inventory data.

4.4 Establishment of contract summary database

The customer procurement contract is an important source for the company to obtain production tasks and continue to obtain profit targets. It is the ultimate

task that needs to be completed in the production process of the enterprise. It will directly determine the scale and investment of production, so it must be accurately managed to avoid contract management error results in increased inventory or out of stock.

1) The contract summary content should determine the product model and name
2) Set the total number of identical models of the contract
3) Set the delivered quantity item
4) Quantity to be delivered F=D-E (see table 8)

Table8. Contract summary database (screenshot of its interface)

A	B	C	D	E	F
S/N	Product model	Product name	Total number	Delivered quantity	Quantity to be delivered
1	J0231	recognizer	50	2	48
2	K05	sensor	50	5	45
3	Y412	Display box	80	10	70
4	Y421	Start box	80	5	75
5	S706.01	tester	80	20	60
6	H641	Switch panel	230	25	205
7	H642	clapboard	230	40	190
8	H643	Switch box	230	41	189
9	H647	Distribution box	230	42	188
10	H648	Electrical box	230	47	183
11	H652	Work box	20	10	10
12	Q-1	Drive box	15	10	5

The logical association of the contract summary with the original contract and the delivery notice is shown below in figure16:

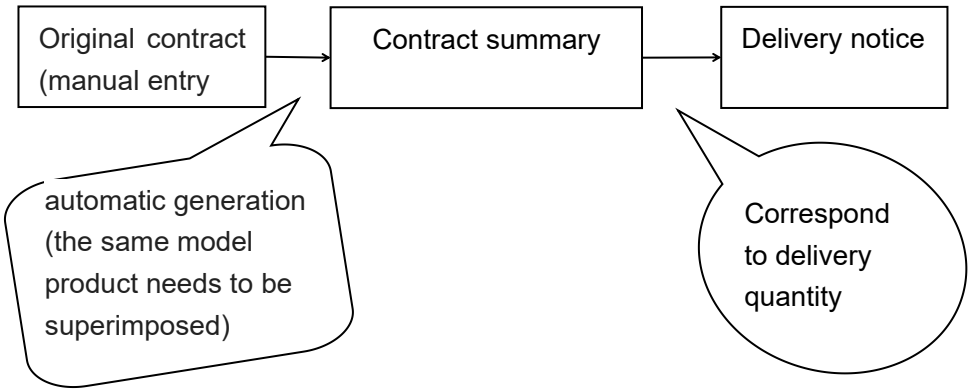


Figure16. Contract summary database related factors

4.4.1 Original contract database

(1) Each contract should have a contract number corresponding to it

(2) The contract content should correspond to the product model and name

(3) Set the contract quantity requirement

(4) Set the number of contracts delivered

(5) Undelivered quantity G=E-F

The original contract database is shown in the following table

Table9. Original contract database

A	B	C	D	E	F	G
S/N	Contract no.	Product model	Product name	quantity	Delivered quantity	Undelivered quantity
1	XXHR-18001	J0231	recognizer	50	2	48
2	XXHR-18002	K05	sensor	50	5	45
3	XXHR-18002	Y412	Display box	80	10	70
4	XXHR-18002	Y421	Start box	80	5	75

5	XXHR-18002	S706.01	tester	80	20	60
6	XXHR-18002	H641	Switch panel	230	25	205
7	XXHR-18002	H642	clapboard	230	40	190
8	XXHR-18002	H643	Switch box	230	41	189
9	XXHR-18003	H647	Distribution box	230	42	188
10	XXHR-18003	H648	Electrical box	230	47	183
11	XXHR-18003	H652	Work box	20	10	10
12	XXHR-18003	Q-1	Drive box	15	10	5

4.5 Product production planning demand interface

The production plan is the arrangement made by the enterprise for the production task. It specifically formulates the variety, quantity and schedule of the production products. It is an important part of the business activities of the enterprise and an important basis for the production management of the enterprise. Therefore, the production plan is accurate. Whether it will directly determine the operating efficiency of the company.

1) Clear product model, product name

2) Set the total contract demand

3) Set the number of work in process items

4) Set the stock quantity item

5) The quantity to be put into production G=D-E-F

Table10. Product production planning database(interface screenshot)

A	B	C	D	E	F	G

S/N	Product model	Product name	Required quantity	In-process quantity	invent ory	Production quantity
1	J0231	recognizer	48	2	11	35
2	K05	sensor	45	8	5	32
3	Y412	Display box	70	0	10	60
4	Y421	Start box	75	10	5	60
5	S706.01	tester	60	4	5	51
6	H641	Switch panel	205	8	4	193
7	H642	clapboard	190	0	8	182
8	H643	Switch box	189	20	10	159
9	H647	Distributio n box	188	40	12	136
10	H648	Electrical box	183	41	15	127
11	H652	Work box	10	1	10	-1
12	Q-1	Drive box	5	1	8	-4

The relationship between product production plan and product contract summary, work in process inventory and product inventory is shown in Figure 17 below.

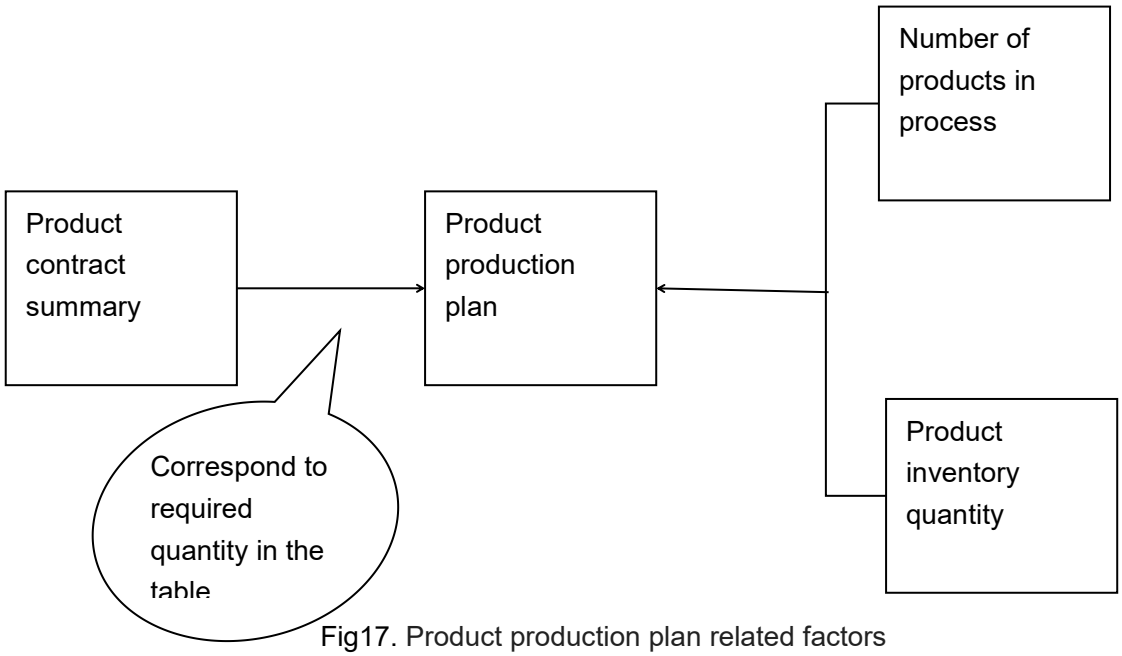


Fig17. Product production plan related factors

4.6 Information processing interface for part production planning

The part production plan is to determine the production requirements of each specific part, which is the execution level of the MRP technology application. The object of the plan is the most basic unit that constitutes the product. The accuracy of the part production plan requirements will directly determine whether the product can be completed according to the contract requirements. If the relevant information is wrong, it will lead to unintended increase of inventory or shortage of products caused by out of stock. Out of stock affects sales on the one hand, and cannot recover funds in time. On the other hand, it will also occupy inventory funds, increase management costs, and reduce Business efficiency.

Establish a part production planning requirements processing interface:

(1) Enter all product models of the company.
(2) Enter the code and name of part of each product.
(3) Identify the number of parts for each product
(4) Set the total demand quantity of each product
(5) Set the total demand requirement of each part G=E×F
(6) Set the in-process part item
(7) Set inventory item of each part
(8) Quantity of parts to be produced J=G-H-I
(9) Set the purchaser or the status of the parts
(10) Set the procurement cycle or production cycle of the part

The logical relationship between the parts production plan and the product plan, the number of individual packages, the total quantity of parts, the parts in stock, the work in process and the parts purchased are as shown in figure18:

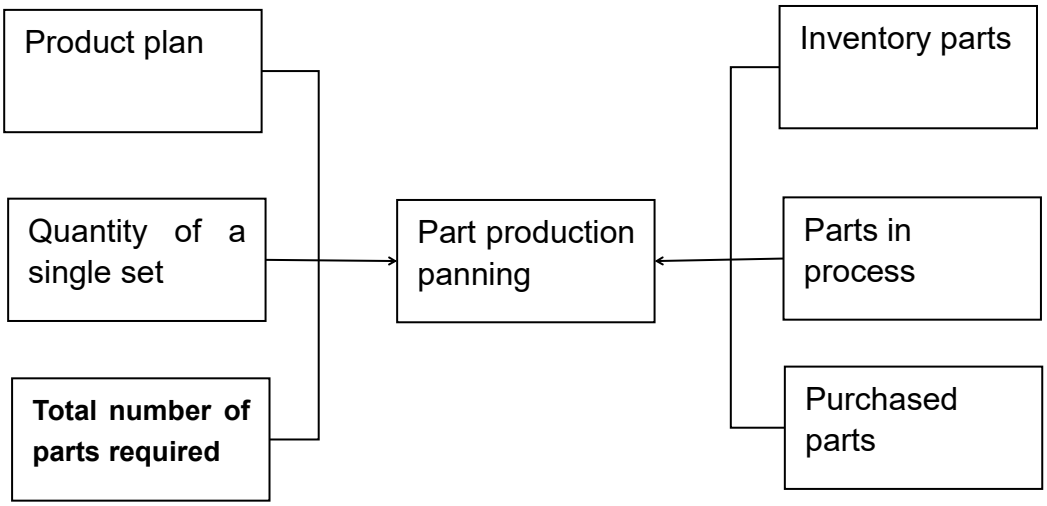


Fig18.Related factors for part production planning

The part production planning information processing interface is shown in the following table11.

A	B	C	D	E	F	G	H	I	J	K	L
S/N	Product model	Part/component code	Name	Single quantity	Total demands	To be matched	In-process/purchased	inventory	To be put into	manufacturer	Purchase/ produce period
1	J0231	J18E-9P（20419）	plug	1	35	35		49	-14	guiyag	4weeks
2	J0231	J18E-9S（20419）	plug	1	35	35		168	-133	guizhou	4weeks
3	J0231	J18E-9PD	socket	1	35	35		9	26	guilin	4weeks
4	J0231	J18E-9SD	socket	1	35	35		326	-291	cixi	4weeks
5	J0231	ZH852510N12B10GPNH	socket	1	35	35		160	-125	guangxi	4weeks
6	J0231	RJ14-0.25W-2.7K±5%	resistance	6	35	210		1091	-881	yousheng	1week
7	J0231	RJ14-0.25W-33K±5%	resistance	6	35	210		1386	-1176	changchun	1week
8	J0231	HG313S	Infrared emitting diode	6	35	210		48	162	longguang	2weeks
9	J0231	3DU133	Silicon photoelectric triode	6	35	210		157	53	liuyiqi	2weeks
10	J0231	3DG8C	audion	6	35	210	200	199	-189	baotou	4weeks
11	J0231	UC-2	Wiring fixing button	1	35	35		295	-260	guangzgou	1week

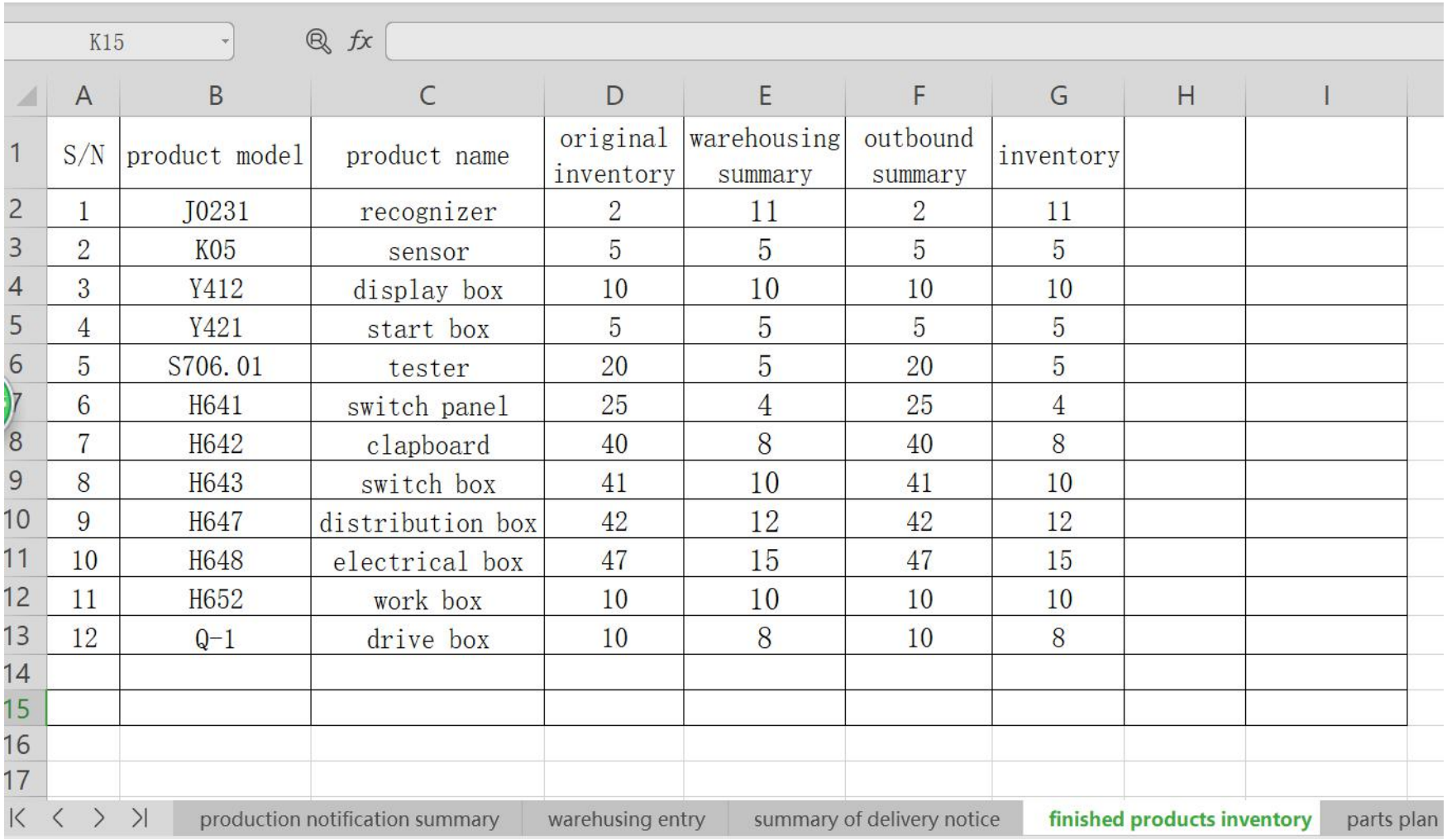
12	J0231	J0231.015	Accept printed board	1	35	35		97	-62	hangling	4weeks
13	J0231	J0231.016	Launch printed board	1	35	35		86	-51	hangling	4weeks
14	J0231	J0231.001	cover	1	35	35		173	-138	homemade	1week
15	J0231	J0231.002	nameplate	1	35	35		363	-328	homemade	1week
16	J0231	J0231.003	cover plate	1	35	35		130	-95	homemade	1week
17	J0231	J0231.004	stent	1	35	35		136	-101	homemade	1week
18	J0231	J0231.010	tank	1	35	35		67	-32	homemade	6weeks

Table11. Parts Production Planning Information Processing Interface

4.7 Production management information processing platform

In order to make the whole database system easier to operate and with better visuality, they are all put together on one platform so that each one of them could be called up right away. The interface of the platform which gathers all database looks just as the following Table12, and they are named Production management information processing platform

Table12.Production management information processing platform



	A	B	C	D	E	F	G	H	I
1	S/N	product model	product name	original inventory	warehousing summary	outbound summary	inventory		
2	1	J0231	recognizer	2	11	2	11		
3	2	K05	sensor	5	5	5	5		
4	3	Y412	display box	10	10	10	10		
5	4	Y421	start box	5	5	5	5		
6	5	S706.01	tester	20	5	20	5		
7	6	H641	switch panel	25	4	25	4		
8	7	H642	clapboard	40	8	40	8		
9	8	H643	switch box	41	10	41	10		
10	9	H647	distribution box	42	12	42	12		
11	10	H648	electrical box	47	15	47	15		
12	11	H652	work box	10	10	10	10		
13	12	Q-1	drive box	10	8	10	8		
14									
15									
16									
17									

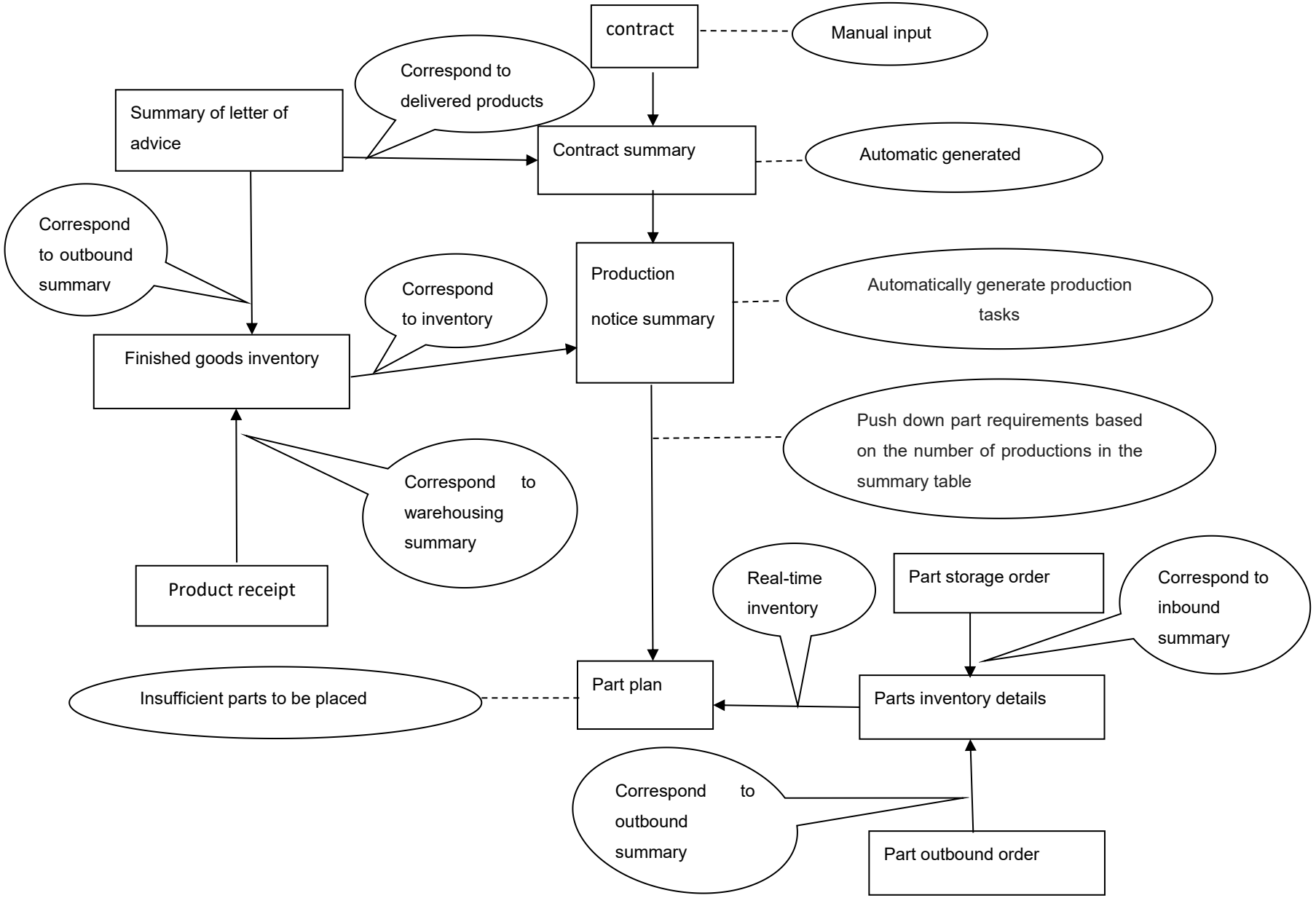

contract
Manual input
Correspond to delivered products
Summary of letter of advice
Contract summary
Automatic generated
Correspond to outbound summary
Correspond to inventory
Production notice summary
Automatically generate production tasks
Finished goods inventory
Push down part requirements based on the number of productions in the summary table
Correspond to warehousing summary
Product receipt
Real-time inventory
Part storage order
Correspond to inbound summary
Insufficient parts to be placed
Part plan
Parts inventory details
Correspond to outbound summary
Part outbound order

Fig19 Data information processing platform logical association

Thus far, the whole data information processing platform logical association chart could be drew integrally, which is the figure 19 above.

4.8 Chapter summary

In this chapter, by using the technical principle of MRP and computer information processing functions, relying on the basic information such as the finished product database and parts database, the information processing platform from order management, product production planning and parts production planning is built. The associated data is automatically converted according to logic. The formation of calculations ensures that accurate data results can be obtained between all links, thus avoiding unintended production plans caused by human error, and making the past empirical and extensive management conditions improved under the control of scientific methods. At the same time, it also provides support for the implementation of MRP management of stock raw materials.

5 HR company raw material inventory management countermeasures

Since the analysis reflects that the work in process and raw material inventory are the two kinds occupies the funds the most, in this chapter, we will try to figure ways out to manage the raw material reasonable.

5.1 Analysis of raw material inventory status

The current status of HR company's raw material inventory is analyzed in the third

chapter through the TOC method, which is basically empirical, extensive management, lacking of guidance from scientific theory. Due to the variety of products, the various demand for each product, the relatively large types and quantity of raw materials with no effective database, it leads to incomplete and inaccurate inventory information, and cannot provide basic support for the formulation of production plans and the formulation of procurement plans.

In the fourth chapter, through the establishment of the system processing platform, company realizes the sharing of all data of all the company's products from contract signing, master production planning, parts production planning to the stocks, which ensures the accuracy of all production inputs, overcomes the drawbacks of blind investment and control the inventory cost of WIP as well. Then, warehouse management of raw material also needs to analyze and formulate measures through inventory management strategies, thereby reducing the cost of raw material inventory and improving the overall operating efficiency of the company.

5.2 Improvement ideas and methods of raw material inventory

This section mainly introduces the method that the company is going to use for optimizing inventory management and control and lists the steps to be implemented.

5.2.1 Improvement ideas for raw material inventory

In view of the current situation of HR company's weak management and poor professional level, the design should adhere to the principle of combining science and enterprise reality, and establish a management method that utilizes scientific inventory theory and is suitable for business characteristics. Effective methods include ABC classification, quantitative ordering, regular ordering and material demand planning. These methods have been widely used in industrial enterprises, and they are highly operable, which will bring scientific guidance to inventory management of HR company .

Due to the variety of products (more than 70 kinds of products), the annual demand and capital occupancy of each product vary greatly. It is unrealistic to use the same attention for each material, so it is necessary to carry out ABC classification and develop different management strategies. The demand attribute of raw materials belongs to non-independent demand, and its final demand is determined by the production plan of the corresponding product. Therefore, the raw materials can be managed by the material demand plan. Therefore, the raw materials can be managed by the material demand plan. The main products produced by HR company are relatively fixed in process, the order cycle and the procurement cycle is relatively stable, and with the operability of implementing the material demand plan.

5.2.2 Improvement for raw material inventory management

According to the analysis of the problems and causes of inventory management, and the research ideas and basic principles of inventory management countermeasures, the improvement of inventory management of HR company is

implemented by the following steps:

1) Classify products according to ABC management methods
2) Implement ABC classification for raw materials of Class A products
3) Implement MRP for Class A raw materials
4) Implement quantitative order management for Class B raw materials

5.3 main solution for raw material inventory management

This part introduced the implementation of the ABC analysis on products and on raw material of a chosen A-class product ZL-100

5.3.1 ABC classification of products

HR company has 75 products, and the production and operation are basically based on customer orders. The probability of occurrence of excess finished goods inventory is small. It can also be seen from Table 1 (Financial Status Analysis Table) that the inventory of the entire finished product inventory is small, and the large proportion of the inventory funds is the raw material inventory. Therefore, it is necessary to distinguish which products are Class A products and which are Class B and Class C products by the proportion of annual sales volume of finished product sales, and implement targeted management of the raw materials of Class A products.

First, multiply the annual unit price by the annual sales amount to calculate the annual capital occupation amount. Then sort according to the amounts from large to small, and calculate the cumulative sales amount as a percentage of the total sales amount, and calculate the corresponding cumulative quantity as a

percentage of the variety. The finished product with a cumulative sales occupancy of 68.15% and a cumulative product accounted for 5.33% is classified as Class A. The total amount of funds occupied is 21.97%, and the quantity accounts for 40% of the number of items divided into Class B. The funds are 9.88%, and the quantity accounts for 54.67% of the total number of items is classified as Class C.

It can be seen from the table that there are many varieties of products, and the annual demand and sales of each product are very different. It is unrealistic to use the same attention for each product. The sales of Class A products are high. However, there are few types of products, which are the targets that should be managed. This paper takes the representative ZL-100 products to analyze the raw material inventory.

Table 13 ABC classification of product

S/N	Product name	model	Unit price(Yuan)	Annual sales quantity	Sales（Yuan）	Sales share（%）	Sales accumulation（%）	Variety accumulation（%）	classification
1	reducer	ZL-100	4940	6400	31616000	31.98	31.98	1.33	A
2	reducer1	ZL-200	2600	6312	16411200	16.58	48.56	2.67	A
3	Brake hub	ZD-100	2160	6288	13582080	13.74	62.30	4.00	A
4	Display box	Y412	2875.2	2010	5779152	5.85	68.15	5.33	A
5	Start box	Y421	991.5	230	1219545	1.23	69.38	6.67	B
6	Switch panel	H641	852	1000	952000	0.96	70.34	8.00	B
7	clapboard	H642	645	1860	1199700	1.21	71.46	9.3	B
8	Switch box	H643	633	1260	797580	0.81	71.55	10.67	B
9	Distribution box	H647	372	1240	461280	0.47	72.83	12	B
10	Other product（25）	……	……	……	17093659	17.29	90.12	45.33	B
11	Other product（41）	……	……	……	9752231	9.88	100	100	C
total	75				98864427				

5.3.2 Raw material inventory control method

In the same way with how the products are classified, under the principal and guide of ABC analysis，The raw material ABC classification result of product ZL-100 is as follow:

Table14. Raw material ABC classification result of product ZL-100

Part number	name	quantity	Unit price (Yuan)	Occupation of funds(Yuan)	Occupancy ratio (%)	Occupation accumulation (%)	Type proportion (%)	classification
-1	frame	1	748.5	748.5	21.48	21.48	4.55	A
-2	Gear ring	1	597	597	17.14	38.62	9.1	A
-7	Planetary gear	5	111	555	15.93	54.55	13.64	A
-8	Planetary gear shaft	5	300	1500	8.61	63.16	18.18	A
-3	Ring gear tray	1	282	282	8.1	71.26	22.73	A
-4	bracket	1	262.2	262.2	7.53	78.79	27.27	A
-5	Sun gear	1	168	168	4.82	83.61	31.82	B
-6	End cover	1	135	135	3.88	87.49	36.36	B
-14	Planetary gear piece	10	96	960	2.76	90.25	40.9	B
-22	Needle roller	250	90	22500	2.58	92.83	45.45	C
-9	Lock ring	1	49.5	49.5	1.42	94.25	50	C
-10	Bearing cover	1	45	45	1.29	95.54	54.55	C
-16	bolt	5	44.25	221.25	1.27	96.81	59.09	C
-18	Spacer ring	5	30	150	0.86	97.67	63.64	C
-11	Sun gear piece	1	24	24	0.69	98.36	68.18	C
-12	Plug screw	1	16.5	16.5	0.47	98.83	72.73	C
-13	Lock ring	1	13.5	13.5	0.39	99.22	77.27	C
-15	Plug screw	1	9.3	9.3	0.27	99.49	81.82	C
-17	Paper pad	1	8.4	8.4	0.24	99.73	96.36	C
-20	screw	10	7.5	75	0.22	99.95	91.91	C
-19	Seal ring	1	1.5	1.5	0.04	99.99	95.45	C
-21	Seal ring	1	0.45	0.45	0.01	100	100	C

(1) Using the MRP model to obtain the demand plan for Class A raw materials.

According to historical order data and analysis of market forecasts, the annual order quantity of ZL-100 is basically stable at about 6,400 units per year. It should be delivered in ten months according to demand, 640 units per month, and theproduction economic volume is 160 units per week. There are 6 types of Class A materials that need to be used in the product. The actual production procurement cycle is as follows:

Table15. Class A material production procurement cycle(Note: Assume that the current inventory and planned inbound volume is 0)

Part number	name	Quantity	Production batch(gross demand)	status	Production cycle(week)	Purchasing cycle (week)
-001	Frame	1	160	blank	1	1
-002	Gear ring	1	160	component	no	1
-007	Planetary gear	5	800	component	no	1
-008	Planet pin	5	800	component	no	1
-003	Gear ring tray	1	160	component	no	1
-004	Bracket	1	160	blank	1	1

Class A part structure hierarchy is shown below

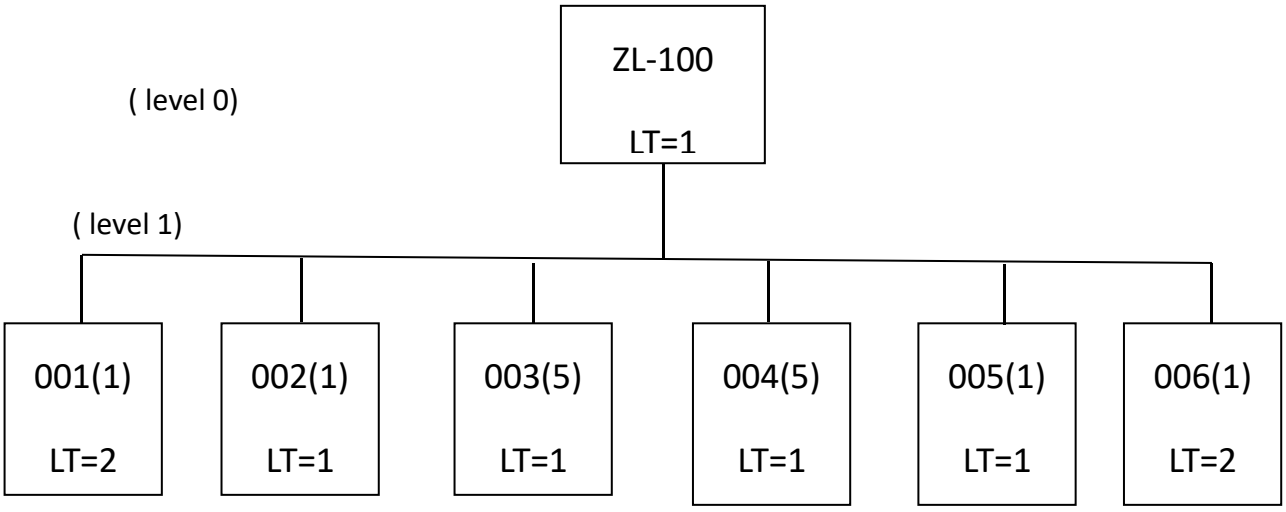


Fig20. Class A part structure hierarchy (6 parts are all one layer)

Advance time (week)	product	week	1	2	3	4	5
1	Zl-100	Gross demand			160		
		Planned order		160			

001material procurement schedule

Advance time (week)	part	week	1	2	3	4	5
2	001	Gross demand			160		
		Planned order	160				

Advance time (week)	part	week	1	2	3	4	5
1	002	Gross demand			160		
		Planned order		160			

Advance time (week)	part	week	1	2	3	4	5
1	003	Gross demand			800		
		Planned order		800			

Advance time (week)	part	week	1	2	3	4	5
1	004	Gross demand			800		
		Planned order		800			

Advance time (week)	part	week	1	2	3	4	5
1	005	Gross demand			160		
		Planned order		160			

Advanc e time (week)	part	week	1	2	3	4	5
2	006	Gross demand			160		
		Planned order	160				

From the chart above, the following conclusions can be drawn: The optimal production cycle for ZL-100 reducer products under economic production batch is three weeks. Taking into account the manufacturing process of the parts, the transportation process and the uncertainties of the supplier, it is safer to set the production cycle under the economic production batch to 4 weeks. The ordering period of each material is expected to be one week ahead of the actual situation of purchasing in different periods, that is, the raw materials form a product after 4 weeks of rolling. At present, the average inventory of raw materials of the company is 8 weeks of inventory. The raw materials that cannot be put into production occupy a large amount of liquidity, and the personnel and site expenses incurred for storing raw materials are the aspects that enterprises must improve. HR Company Will use the analysis of this paper as a guide to gradually consume the current excess inventory, and reduce the effective inventory to a reasonable state.

(2) Using the quantitative order method to obtain the demand for raw materials of class B

The quantitative order method refers to an inventory control method for order replenishment according to the specified quantity (economic batch) when the stock falls to the predetermined minimum stock quantity (order point), that is, a predetermined order point O and order quantity Q are determined in advance. Inspect the inventory at any time during the production and consumption process. When the inventory falls to O an order quantity Q is issued.

Determination of the order point:

The company is an order-based production method, no need to set up safety stock. According to the historical qualification rate of the actual purchased component quality, this factor should be added at the time of ordering as a safety measure for production guarantee.

Order point = demand for purchase lead time + purchase lead time demand × failure rate

= daily demand × order lead time + (daily demand × order lead time) × failure rate

$$= \frac{monthlydemand}{30days} \times \text{order lead time} + \frac{monthlydemand}{30days} \times \text{order lead time} \times \text{failure rate}$$

005 Sun gear:

Order lead time 30 days, monthly demand 640, failure rate 5%

O_1=640/30×30+640/30×30×5%=672

006 End cover:

Order lead time 25 days, monthly demand 640, failure rate 2%

O_2=640/30×25+640/30×30×2%=545

014 Planetary gear piece:

Order lead time 40 days, monthly demand 6400, failure rate 1%

O_3=6400/30×40+ 6400/30×40×1%=8619

Determination of the order quantity: The economic order quantity is the order quantity that minimizes the total inventory cost, and is obtained by balancing the ordering cost and the storage cost.

The calculation formula for the economic order quantity is as follows

EOQ= $\sqrt{2DS/H}$

D－annual demand, S－cost per order, H－Unit storage cost

Warehousing costs consist of custodian salary and occupancy cost of the warehouse. The unit storage cost is calculated by dividing the total storage cost by the average inventory quantity. The raw material inventory occupied by HR company is 950m2, the cost per square meter is 25¥ per month, the annual warehouse cost is 285000 ¥/year, and the custodial staff expenses include basic salary, welfare and social insurance, etc. 4652 ¥/month, and two of them have a total cost of 111,648 yen/year per year.

Thus the cost of storage is 285000+111648= 396648 ¥/year. According to the inventory data of 2018, the average inventory quantity is 661080. The unit storage cost H=0.6¥/year.

The ordering cost consists of the production of the purchase order, the handling of the materials, the counting of the materials, the delivery to the warehouse and the processing of invoices, and the settlement and so on. The working hours of the relevant personnel of the HR company multiplied by the hourly cost is the ordering cost for each time.

The total processing time for each order is 1.5 hours, and the hourly fee is 30¥/hour, then the cost per order is S= 1.5×30=45¥

Calculation of part order quantity

005 Sun gear :

Annual order quantity D=6400 ordering cost S=45¥ unit storage cost H=0.6¥/year

Economic order quantity $EOQ_1=\sqrt{\frac{2DS}{H}}=\sqrt{\frac{2*6400*45}{0.6}}$ =978

006 End cover :

Annual order quantity D=6400 ordering cost S=45¥ unit storage cost H=0.6¥/year

Economic order quantity $EOQ_2=\sqrt{\frac{2DS}{H}}=\sqrt{\frac{2*6400*45}{0.6}}$ =978

014 Planetary gear piece

Annual order quantity D=64000 ordering cost S=45¥ unit storage cost H=0.6¥/year

Economic order quantity $EOQ_3=\sqrt{\frac{2DS}{H}}=\sqrt{\frac{2*64000*45}{0.6}}$ =3096

Through theoretical analysis and discussions between enterprises, the company will carry out material requirement planning and quantitative ordering method management for all Class A products of the company, and control raw material inventory to eliminate the occurrence of unreasonable inventory. After comprehensive evaluation, after taking inventory management measures, current inventory level could releases 35% to 40% of liquidity, which injects vitality into business operations.

5.4 Chapter summary

This chapter solves two problems that plague enterprise inventory management by establishing raw material inventory countermeasures: First, it must carry out key control on Class A finished products to ensure the correct and timely supply of raw materials, and the second is to implement material requirement planning management for Class A raw materials in Class A finished products, and implement quantitative ordering control for Class B raw materials.

6 Conclusions and prospects

The research in this paper mainly focuses on the traditional research on inventory management optimization of individual enterprises. The research shows that the traditional small and medium-sized manufacturing enterprises such as HR companies are facing increasingly severe market competition. In order to win competition and win customers, It is imperative to deliver products to customers faster, at lower cost, and with better service. Companies must improve overall

operations and supply chain management. Inventory management is an important node of the company's overall operation and supply chain management. Inventory management can not be studied only from a single perspective, but should be studied from the entire company's operation management system. Inventory management optimization can not only reduce inventory and the use of funds in inventory can also improve customer satisfaction, reduce corporate management costs, and improve corporate competitiveness.

This paper puts forward various management solutions based on the current situation of inventory management of HR company.This paper designs inventory management strategies for product demand forecasting, production planning, material procurement, inventory control, etc. It is comprehensive and systematic. It can not only solve the current inventory management problems of HR company, but also help HR companies to establish comprehensive and systematic inventory management system, and the management methods adopted are in line with the company's actual conditions, practical and operative. The actual problems and root causes of inventory summarized in the research process are representative in SMEs. The proposed inventory management strategy possesses practicability, operability and reference from the perspective of enterprise and technology.

Through in-depth analysis of the current situation of inventory management, this paper points out that HR companies must establish an invoicing planning system to solve the inventory management problem fundamentally and effectively, and propose that the company should establish a sales forecasting plan, under this premise, consider the overall optimization method of raw materials and finished products, measure the economic production batch and ordering point of finished products through the inventory control quantitative model, and use this as the basis to formulate the production plan of the product and the material requirement planning of raw materials. Through the above-mentioned overall planning for the

production of raw materials and products, the inventory cost can be effectively reduced. Due to the weak management foundation of HR company, it is necessary to start from the basic management and continuously improve the overall operation of the company and the level of supply chain management. This is the prerequisite for improving inventory management and the only way for the company to enhance its competitiveness. Of course, the improvement of inventory management level is a long-term, continuous and arduous task. The company needs to continuously strengthen the management awareness of employees, create a corporate culture of continuous optimization of inventory management, and constantly adapt to environmental changes according to its own characteristics with constant adjustment and optimization. In the process of improving inventory management in accordance with the countermeasures proposed in this paper, enterprises must continuously build various management skills. Do a good job in the collection and classification of various basic data, create conditions for the full application of ERP management technology in enterprise management, so that enterprises can strengthen themselves in the market competition and continue to grow and develop.

Reference

Baker, KR.,(1985), “Safety stocks and component commonality, Journal of operations management, PP. 6:13--22”

Blackstone J,H.,Gardiner　L, R. & Gardiner S, C.,(1997), “A Framework for the system Control of Organization, International Journal of Production Research” 35（3: 597--609

Cook, D, P.,(1994),”A Simulation Comparison of Traditional, JIT and TOC Manufacturing System in a Flow shop with Bottlenecks, Production and Inventory Management Journal”, PP. 73--78

Cox, Jeff, Goldratt & Eliyahu M., (1986), “The goal: a process of ongoing improvement”.

Elsner, A. & Oberheitmann, A., (2016) “New Trails for SMEs in Germany and China: Co-operations. Opportunities. Challenges. Perspectives.” , PP. 65

Heizer, J., Render, B.,(2001), “Operations management”, PP. 525

Heizer, J., Render, B.,(2001), “Operations management”, 10th Ed., P. 501--502

Juneja, P., “Inventory Costs”. Managemet study guide, Available at: https://www.managementstudyguide.com/inventory-costs.htm

Littleson, Randy., (2008) “Companies don’t compete, supply chain compete” Available at: https://blog.kinaxis.com/2008/11/companies-dont-compete-supply-chains-compete/

Lysons, K.,Farrington, B.,(2006) “Purchasing and supply Chain Management”

Lean Produdion., “Theory of Constraints ” Available at: https://www.leanproduction.com/theory-of-constraints.html

R, Anthony, Inman., “Inventory types”, Reference for business. Available at: https://www.referenceforbusiness.com/management/Int-Loc/Inventory-Types.html

Robert Fetter, Winston C., (1961), “Decision Models for Inventory Management ”, PP.105--118

Waters, D., (2013), “Inventory control and management, 2nd edition”, Part 1.

Wild, T., (2002), “Best Practice in Inventory Management”, 2nd edition, P. 40

Whybark, D, C., Williams, J, G., (1976), “Material requirements planning under uncertainty”, PP. 595-606

Yang, C, C. (2019), “Opinion: Supporting SMEs enhance China’s economic health”, Available at: https://news.cgtn.com/news/3d3d674d3555444d32457a6333566d54/share_p.html

Zijm & Houtum, (1994), “On multi-stage Production/ Inventory systems under stochastic demand [J]”, “International Journal of Production Economies”, PP. 35: 391-400

Zhang, S,J & Cao,Z,X., (2004), Analysis and Solutions of Manufacturing Cell Bottleneck Based on Constraint Theory[J], Mechanical design and manufacturing, 5(4), PP. 109-111