Achieving lean production through improved RFID technology and the use of GM11 predictive models

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Description

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Abstract

At present, China's freight volume in some goods is large, which is a challenge to the logistics industry practitioners. Some companies are starting to use RFID and electronic tags in their packaging departments. These technologies can greatly speed up the efficiency of the logistics industry. How to use RFID tags, RFID readers, and achieve lean production process is very critical. Through this series of measures, we can reduce the retention of goods in the packaging workshop, reduce the cost of warehouse rental, shorten the packaging time, and let the goods reach the hands of customers faster. To improve the implementation of lean production.

The GM11 forecasting model is a model widely used in production forecasting in China. Production for the coming year can be predicted using data from previous years. This kind of prediction can be done in a computer software, which is a very fast and efficient prediction model.

The procedure for my thesis is this. First, the distance and conveyor speed between several RFID technologies and the goods are selected through the system literature. Test at speeds and distances that the test factory can adjust to understand current best practices and results obtained in similar scenarios. Then the experimental design began. According to the results of literature review, the experiment was designed to adjust the distance between RFID and goods and the speed of conveyor belt. This phase will be carried out in selected company packaging workshops through field tests to determine maximum logistics efficiency. Data collection is also very important, on the basis of the experimental design, the collection of cargo flow, time and other key operational data. This data will be used for subsequent model building and analysis. The next step is to make predictions using the GM11 model

Using the collected data, the GM11 model is applied to predict the flow of goods in the next year. This step uses the GM11 prediction model in the grey system theory to forecast the freight volume of the next year based on historical data. After the prediction is completed, the efficiency improvement analysis is started. Using the predicted amount of cargo combined with the adjusted conveyor speed, calculate the time required to process the same amount of cargo. This time is then compared to the time required to use the original conveyor speed to assess the time saved by adjusting the conveyor speed.

Keywords/tags (subjects)

SRFID technology, lean profuction, gm11 model

Miscellaneous (Confidential information) No

Contents

Vocabulary

Tag: composed of coupling components and chips, each tag has a unique electronic code, attached to the object to identify the target object; Can emit a specific frequency of radio wave energy, used to drive the circuit to send internal data.

Reader: A device for reading (and sometimes writing) label information, which may be designed to be handheld or stationary; It can receive the interpreted data in sequence and send it to the application program for corresponding processing.

Antenna: In the wireless communication system, it is necessary to convert the guided wave energy from the transmitter into radio waves, or convert radio waves into guided wave energy, and the device used to radiate and receive radio waves is called an antenna; Transmitting radio frequency signals between tags and readers; According to directivity, it can be divided into omnidirectional antenna, directional antenna, etc. According to the shape can be divided into line antenna, plane antenna and so on.

Radio Frequency identification (RFID) is a wireless communication technology that enables the identification of specific goods through radio signals and the reading and writing of related data without the need to establish mechanical or optical contact between the identification system and the specific target. Its main principle is to send the data attached to the item, so that the item can be automatically identified and tracked.

1. Introduction

1.1 Research background

China's market demand is getting higher and higher with the development of society, which leads to the efficiency and requirements of factories are also increasing year by year. In this context, more and more companies are trying to use lean manufacturing. This management method can not only reduce waste but also improve production efficiency (Chowdhury, 2007). In this context, packaging workshop as an important part of logistics, its efficiency will directly affect lean production. However, there are many problems in the traditional packaging workshop management, which will affect the ability of subsequent production and logistics. The concept of lean production continued to expand, from the beginning of Japanese companies to multiple companies to help the country's rapid economic rise.

As John Nicholas wrote in his book Lean Production for Competitive Advantage: A Comprehensive Guide to Lean Methodologies and Management Practices, Second Edition pointed out that by adopting lean manufacturing in the United States, Rapidly becoming the dominant country in the global economy (Nicholas, 2018). Lean manufacturing was pioneered by Eiji Toyoda and Naiichi Ohno of Toyota Motor Corporation after World War II, and its economic rise, as well as that of other companies and industries in Japan and elsewhere that adopted lean manufacturing, is a direct consequence of the adoption of lean manufacturing concepts.

To address these challenges, more and more Chinese companies are seeking high-tech solutions to improve lean production in packaging workshops. Bill said in his article that many companies are using RFID technology as a way to improve their supply chains (Bill, 2008). Chinese companies are also following this trend. Among these technologies, RFID technology is a good way. RFID technology transmits radio waves, scans electronic tags, and adds scanned cargo information to the company's database. This makes it easier for managers to make decisions. Reduce the time to re-count. However, the application of RFID technology and electronic tags in the packaging workshop also faces a series of challenges. First of all, the identification accuracy problem, when there are too many pipeline products, the recognition rate is not 100%, Because the device can't read the label fast enough (Sibum, 2004). Over time, the recorded goods and the real number of goods issued are different.

Secondly, how much time can be saved, how much labor cost, and whether the money saved exceeds the investment cost of RFID technology equipment? Nevertheless, with the continuous maturity of technology and the gradual reduction of costs, RFID technology and electronic labels have great potential to improve lean production in China's packaging workshops, which is expected to bring revolutionary changes to the manufacturing industry.

1.2 Introduction of company Norwex

The test was conducted at a cleaning products company in Zhangjiagang, a city in southeast China's Jiangsu province. The company name is Norwex cleaning Products (zhanhjiagang) Co, Ltd.

Table 1 Company data of Norwex (Source: Norwex cleaning Products (zhanhjiagang) Co, Ltd.)

Company	Norwex Cleaning Products (Zhanhjiagang) Co., Ltd.	Industry	Textile enterprise
Turnover in	6 400 000 €	No. of Employees	150
Job Title	Logistics Intern	Country of operation	China
Division	Packaging department	Functional Area	Warehouse and packaging workshop

Novo Cleaning Products (Zhangjiagang) Co., Ltd. was established on 2009. The company's business scope mainly includes: household cleaning textiles, and engaged in the above similar products and cleaning tools and accessories import and export trade, cleaning products sold to many overseas countries. The main business of this company is to produce some cleaning products such as rags, bath towels and other products. These products are often produced, processed, packaged and sold by themselves. At the same time, the company also has a number of suppliers to supply some product parts, such as mop handles and other items. Below are some product images from the company's website.

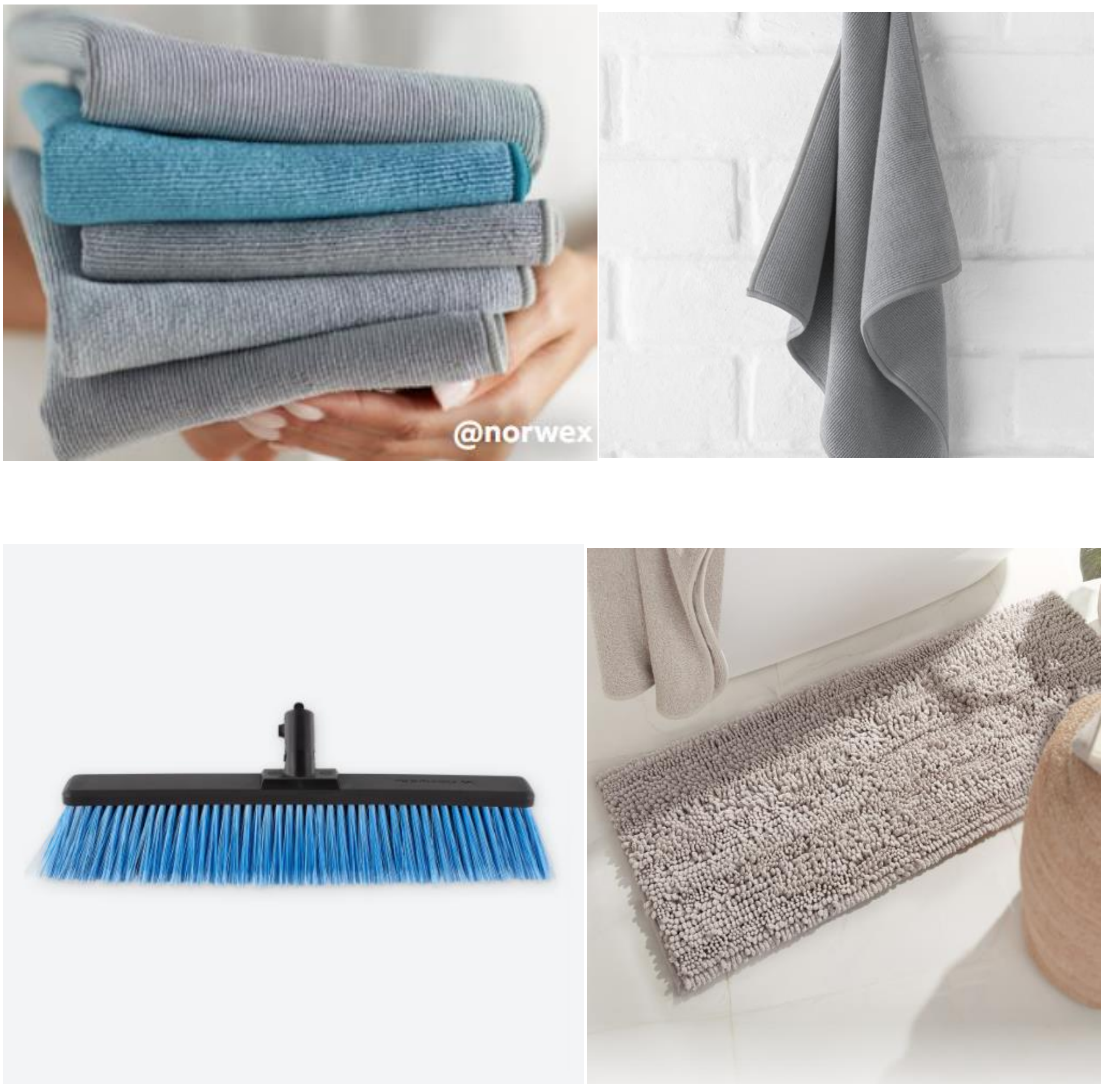

Figure 2 Norwex cleaning Products (Source: Norwex (zhanhjiagang) Co, Ltd.)

In addition to these main businesses, the company also produce some products such as creams and moisturizing creams. In general, the company's products are diverse, and the products produced will be sold to dozens of countries in North America, Asia and Europe.

2.Research significance and method

2.1 Research significance and research questions

Research significance

In recent years, the number of companies of the same type has increased, competition has increased, and consumer needs have become more diverse. Therefore, enterprises need to consider the dual challenges of delivery speed and quality at the same time. In Su's reaearch,, it is found that under the condition of the same level of other conditions, fast delivery speed will greatly help the competitiveness of enterprises (Su,2003). Especially in the packaging workshop, as a key link in product logistics, its operating efficiency directly affects the efficiency of the entire production process and the delivery speed of the final product. Therefore, it has become important to adopt modern information technologies such as radio frequency identification (RFID) technology and electronic tags to improve lean production in packaging workshops.

The application of these technologies has become the key to ensuring the efficient operation of packaging workshops for many companies today. These technologies help achieve more accurate inventory management, avoid the problem of excessive inventory and insufficient inventory, and reduce unnecessary rents and potential wear and tear of enterprises (Singh,2017). Accurate data collection can also provide decision support for enterprises, so that decision makers know the current shipment and inventory, inventory management and supply chain management has a huge role. With the innovation of technology, the cost of RFID equipment has been further reduced. Therefore, more enterprises or factories have begun to adopt this technology, which has a great help for the products of enterprises to further occupy the market. This will be a major step forward for companies that start using RFID technology accurately to improve productivity Research methods (Anthony Narsing, 2005).

Research questions

1. How to improve RFID technology?

2.How to use the GM11 model to help the research?

3.After improving RFID technology, what aspects can help lean production?

2.2 Research methods

This paper mainly adopts quantitative research method. First, we analyze the existing factory data, record the adjusted data, forecast the data of the next year, and finally draw a conclusion by comparing the data before and after the adjustment. The method of literature research, case analysis and empirical research are adopted. Among them, literature analysis is to find out the accuracy rate of RFID technology under different conditions by using previous literature, and case analysis is to analyze and study the test results of our company. The method of empirical research is to use the GM11 model and the company's past freight volume to obtain a large number of factual materials and data, and to forecast and analyze the future data.

Literature research method is a method to obtain data by investigating literature according to a certain research purpose or topic, so as to comprehensively and correctly understand and master the problem to be studied. This article is based on the previous research on RFID in Beijing. What is the accuracy rate of rfid radio frequency technology at different distances, different speeds and different protocols? Master the theoretical and experimental results of relevant papers through text research (Jorma Kananen,2015).

Case analysis is a research method that explores phenomena, problems, or situations through in-depth analysis of specific cases. In case analysis, researchers select representative cases for detailed investigation in order to understand the inherent laws and patterns of a particular phenomenon, problem or situation . The case studies for this article are based on tests I conducted in the workshop. In the packaging workshop I tested, I adjusted the distance between the RF equipment and the cargo, as well as the speed at which the conveyor belt flowed. Record changes in the accuracy of RFID technology. The experimental results are obtained and analyzed and compared (Jorma Kananen,2015).

Empirical research method is based on a large number of facts and data obtained by observation and experiment, the theory and technology of deduced by statistics, and has been tested by strict experience (Jorma Kananen,2015). It introduces the quantitative model to conduct quantitative analysis of social phenomena with the aim of revealing the essential relations of various social phenomena. Empirical research methods mainly carry out quantitative analysis and speak according to data to make the research on social issues more accurate and scientific.This study uses a systematic approach to explore the possibility of optimizing the logistics efficiency of the packaging shop by adjusting RFID technical parameters and conveyor speed, and further uses the GM(1,1) model to predict the flow of goods in the next year. The research began with an in-depth literature review to identify the literature related to RFID technology and belt speed adjustment, and the purpose of this phase was to identify the parameter Settings that could significantly improve logistics efficiency. Subsequently, a series of tests were designed and carried out in the packaging workshop where I used to work, and several reasonable data were selected for testing. Collect data during the test, mainly collect key operational data during the experiment, including cargo flow and processing time accuracy. The gm11 model is used to forecast the flow of goods for the next year, with the aim of assessing the long-term benefits of technological adjustments. Finally, the logistics efficiency before and after the improvement measures is compared, that is, the time required to compare the predicted cargo volume with the adjusted conveyor speed, and the change in accuracy rate. This research method not only ensures the systematic and operability of the research, but also ensures the repeatability of the research by providing enough details, and provides a scientific basis and empirical reference for optimizing the logistics efficiency of the packaging workshop.

Specific process of paper

First, the distance between the various RFID technologies and the cargo and the conveyor speed will be selected based on a literature review of the system. Tests will be conducted at adjustable speeds and distances within the test factory to understand current best practices and similar scenario results. Based on the literature review results, experiments will be designed to modify the distance between the RFID and the cargo and the speed of the conveyor belt. This phase will be field-tested in selected company packaging workshops to determine maximum logistics efficiency. Based on the experimental design, key operational data, including cargo flow and timing, will be collected. These data will serve as the basis for subsequent model construction and analysis. Using the collected data, the GM11 model will be used to forecast the flow of goods for the next year. This step uses the GM11 prediction model in the grey system theory to forecast the freight volume for next year based on historical data. By using the predicted cargo volume and the adjusted conveyor speed, the time required to process the same cargo volume will be calculated. This time is then juxtaposed with the time required to use the original conveyor speed to assess the time saved by the speed adjustment. Evaluate the impact of forecasting on accuracy in raw and adjusted Settings to aid lean manufacturing efforts. Findings and recommendations will be presented based on the findings. Finally, the time savings and accuracy gains achieved by adjusting RFID technical parameters and conveyor speed are detailed. Based on these findings, reasonable suggestions are put forward to help enterprises further optimize lean production.

3. Application of RFID in the workshop

3.1 Introduction of RFID technology and the use of RFID technology in factories

Now more and more factory workshops are beginning to use RFID technology and electronic tags on the assembly line. As highlighted by Miles, Sarma, and Williams (2008) in RFID Technology and Applications, this development will spawn new applications. These new applications are expected to boost the demand for products, further subsidizing research and thus sowing the seeds for the next invention and the next wave of innovation. It is their firm belief that RFID is currently only in its first wave of development.This is of great help to inventory management and to help managers make decisions.

In fact, RFID scanning devices have different protocols, which are suitable for working under different conditions such as different conveyor speeds and different distances. Many companies do not consider this when using this technology, which has a considerable impact on the accuracy of RFID. In order to understand how RFID technology can be improved, we must first understand what parts of RFID technology are composed of in the factory. A complete RFID system is composed of three parts: reader and electronic tag, the so-called transponder and application software system.To reference information about RFID technology hardware devices from page six of the book RFID Security by Frank Thornton, Chris Lanthem, and Frank Thornton, published by Elsevier Science & Technology Books on May 25, 2006. Now we are mainly going to discuss the impact of the link between the reader and the electronic tag on the accuracy. The passage from the article by Shangguan, Li, Yang, Li, Liu, and Han 2014 discusses the complexities involved in developing an RFID tracking system for monitoring the sequence of tags in mobile environments. The article highlights the use of the EPC Class 1 Gen 2 RFID standard, which employs a slotted ALOHA mechanism for communication between readers and tags. This mechanism, while reducing collisions, offers limited insights into the physical arrangement of tags due to the random order of tag responses. The authors suggest leveraging temporal correlations in communication sequences as a potential solution, though acknowledge its potential for significant inaccuracies stemming from variable tag sensitivity and placement. They also consider the application of existing localization techniques, which are hampered by the need for extensive system setup and inherent inaccuracies, particularly in cluttered indoor settings. The challenges of spatial constraints for reader deployment and the risk of cross-reading tags from adjacent belts further complicate the issue. The dense placement of items on conveyor belts exacerbates the problem, making it difficult to accurately ascertain the sequence of tags using even advanced localization methods.

It can be seen that the accuracy of RFID is not 100 percent. So next, I did some tests and changed the distance between the reader and the tag. Changes the speed at which the conveyor belt moves goods. It is important to note that the magnitude of the change must be within a reasonable range for a company in the Jiangsu region of China where I work. For example, suppose the optimal speed for a conveyor belt is 0.5 meters per second. At this speed, it's most efficient. But perhaps the maximum speed of the conveyor belt in this factory is only 0.2 meters per second. That means that I can't achieve the theoretical optimal efficiency, depending on the actual situation

3.2 Speed of Goods Transportation on the Assembly Line

The conveyor belt data was measured according to the factory facilities I tested. Before the improvement, the factory line was set at a speed of 0.3 m/s. The conveyor belt can be set at a speed of 0 to 0.5 m/s. However, due to manpower problems, the speed was up to 0.4 m/s. Because the conveyor speed is too fast, workers have no time to assemble, resulting in materials stacked in the packaging workshop, which will bring great risks to the warehouse environment and safety problems. After consultation with the workers and the shop manager, we decided that 0.4 m/s is the most efficient speed. We know that the theoretical maximum speed of a conveyor belt is 0.4 m/s. However, the conveyor belt is not the faster the better, under different RFID protocols, the accuracy may change with the speed, so we also test the RFID protocol of our factory, that is, the impact of different speeds on the accuracy under the FCFS protocol.

David explains what FCFS is in his research. FCFS is one of many RFID algorithms called queued Access service model. It is assumed that the arrival time of new customers to the waiting queue has nothing to do with the arrival time of previous customers and the current state of the system, so the arrival time of new customers to the system is subject to Poisson distribution, and the probability of server S providing services to customers is also subject to Poisson distribution $T = 1/(\mu - \lambda)$ According to the formula, if u is larger, the incoming time is smaller. If T is smaller, the average service time of the process is smaller. If the incoming time is unchanged, the average service time of the process is shorter (David,1988). Li explained the calculation method of FCFS wait time.the arrival time of new customers to the waiting queue is independent of the arrival time of previous customers and the current state of the system. Therefore, the arrival time of new customers to the system follows the Poisson distribution, and the probability of providing services to customers in the server age also follows the Poisson distribution. $T = 1/(\mu - \lambda)$ According to the formula, $\tau = 1$ = 1 / if the entry is larger, the process average service time is 1 / The shorter p is, the shorter the waiting time of the processes in the ready queue and the shorter the average response time (Li, 2009). This indicates that within a certain range, under the premise that the device has time to read, the speed is faster, and the corresponding faster, which may be contrary to our usual conjecture.

In the experimental phase described by Shangguan et al. 2014, the performance of various protocols was evaluated across different conveyor belt speeds. This study shows that regardless of the speed of the conveyor belt, the received signal strength indicator and the read rate ratio indicator maintain their trend and correlation, that is, two protocols other than FCFS. Their accuracy doesn't change with speed. This consistency underscores the protocols' resilience to changes in the conveyor belt's velocity. Additionally, it was observed that the First-Come, First-Served (FCFS) protocol exhibited a slight improvement in accuracy as the belt's speed increased, due to tags being more likely to enter the reader's detection range.

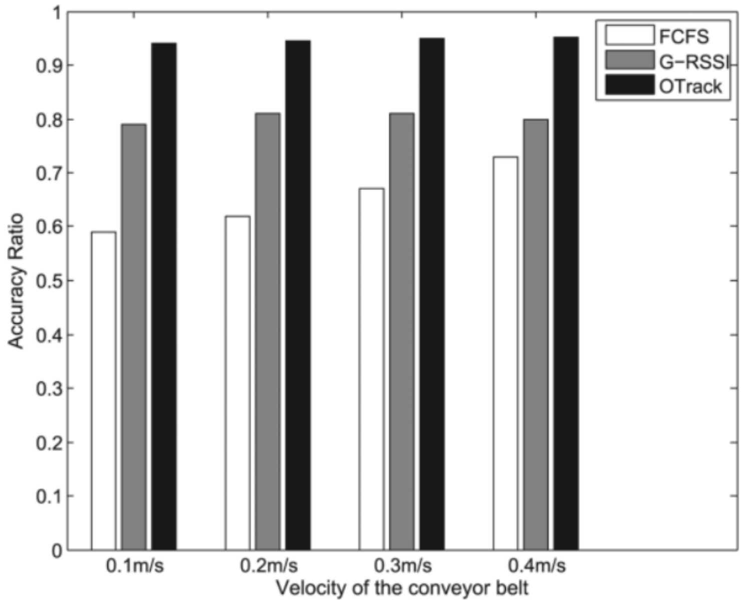

Figure 3 Accuracy of three RFID protocols at different speeds (Source: Shangguan. 2014)

As can be seen from the above research. Under the FCFS protocol, speed and accuracy are proportional, that is, in this speed range, the faster the speed, the higher the accuracy. So we should say that 0.4 meters per second is the most appropriate speed under the current conditions. This ensures both accuracy and speed, and is acceptable to workers. Just to be sure, I ran the test again at my office and here are the results.

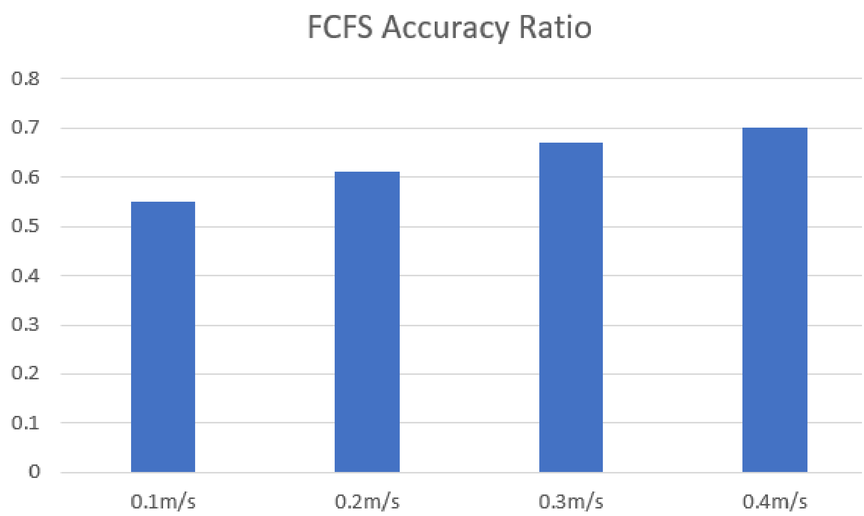

Figure 4 Accuracy of FCFS protocol at different speeds (Source: test in Norwex, 2023)

Our test results, shown in the chart above, are not much different from the Beijing test.To sum up, we set the conveyor belt to 0.4 meters per second.

3.3 Distance between RFID devices and goods

The distance between equipment and cargo is tested based on previous speed adjustments.

Before adjusting the distance, I will first understand the existing environment of the workshop, then understand the application scenarios of different frequencies, and then select the frequency. Finally, different distances are tested according to the selected frequency, and the distance is determined. Rf devices also have a big impact on the accuracy of RFID scans. Different frequencies in different environments, such as indoor workshops, outdoor factories or air conditions with different humidity, the accuracy will change. So my distance adjustments will be based on all the existing factory environments.

First of all, the humidity of the plant measured by the humidifier is 55%, which will not affect the accuracy. And the workshop indoors will not be affected by outside weather. Weis described the different frequencies of RF devices in his research. Usually RFID radio frequency can be adjusted to the following several different frequencies, each frequency has a different application scenario. 125~134KHz Low frequency (LF) 45cm can penetrate most objects. 13.553~13.567MHz High frequency (HF) 1~3m barely penetrates metals and liquids. 400~1000MHz ultra-high frequency (UHF) 3-9m penetration is weak. 2.45GHz Microwave (Microwave) 3m has the weakest penetration (Weis,2007).

The main products of the test company are textile products such as bath towels and rags, and the height difference of each goods is not much, and the equipment can also be placed in a relatively close distance from the goods, so only the frequency of the first LF is 125~134KHz Low frequency is enough (Ranky,2006). Since the frequency is LF, the test distance will be limited to 45 cm. The minimum distance is set at 15 cm, because if the distance is too short, the goods cannot pass through and will get stuck in the assembly line. I tested 15 centimeters, 25 centimeters, 35 centimeters, and 45 centimeters. In the end, we set the distance at the most suitable 15 cm, and then the accuracy is 0.95.

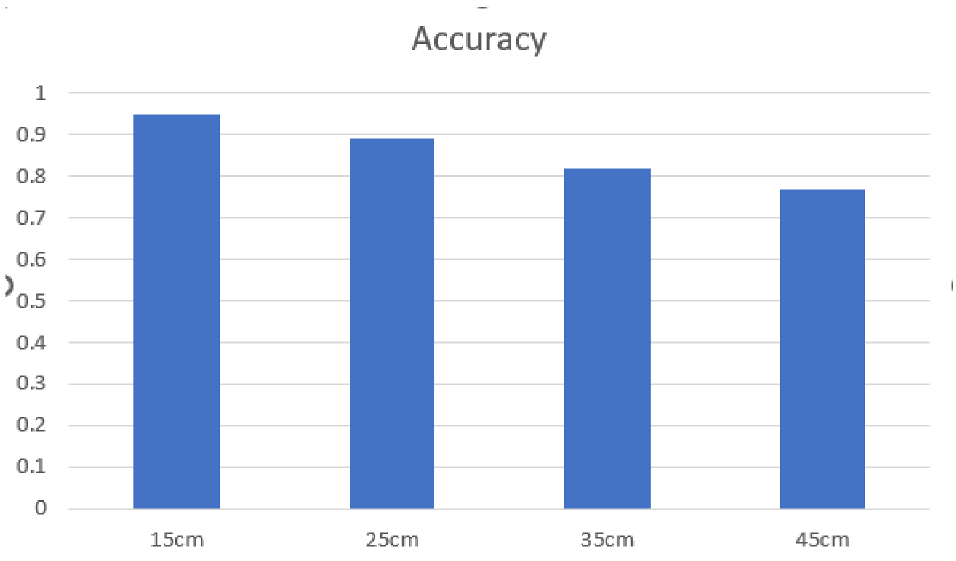

Figure 5 The accuracy of rfid scanning at different distances (Source: test in Norwex, 2023)

3.4 Accuracy After Adjustments

After modifying the conveyor speed and the distance between the RF device and the cargo, our new accuracy rate has been increased from 0.82 to 0.95. To demonstrate the benefits of improving conveyor speed, the next step is to calculate the output that could theoretically be increased by 2023. Originally it could pack 48 cases a day. After the speed change, 48*0.4/0.3 = 64, so 64 boxes of products can be packed after the improvement. There are 360 products in one box. The total number of packaged goods in the original year is 48*360*20*12= 4147200. Now a year can theoretically pack up to 64*360*20*12= 5529600. The output has increased by 1,382,400 units over the past year. In addition, if the quantity of production remains the same. We can also measure the amount of goods that are not scanned accurately each year. The original number of goods that were not accurately scanned in one year was 4147200* (1-0.82) =746496 products. Now the number of goods that are not accurately scanned in a year is 4147200* (1-0.95) =207360 goods. 539,136 less goods were scanned inaccurately in one year.

4 Predicting Next Year's Goods with the gm11 Model

4.1 Introduction to the gm11 Model

The GM(1,1) model is derived from the grey system theory, which was proposed by Chinese scholar Professor Deng Julong in 1982. Grey system theory aims to solve the problem of uncertainty in system analysis and decision making, especially when the system information is incomplete and the amount of data is insufficient (Ma Wang et al., 2023). The term "gray" indicates a state of information between "black" (system information is completely unknown) and "white" (system information is completely known), that is, a state of information that is partially known and partially unknown.

The core idea of grey system theory is to use a small amount of information inside the system to reveal and use the development trend and internal law of the system. GM(1,1) model, as a basic model under the theory, is mainly used for the prediction of sequence data, and predicts future data points through a series of processing and model building on the original data. The development background and application scenarios of GM(1,1) model reflect Professor Deng Julong's unique views on dealing with uncertain information. He recognized that in many practical situations, decision makers are faced with incomplete information and limited data, and the traditional perfect information decision model is often not applicable in these situations. Grey system theory and GM(1,1) model provide a new methodology to make effective system analysis and prediction even under the condition of incomplete information.

Since it was put forward, grey system theory and its model have been widely applied and developed in many fields such as economic forecasting, social science, environmental engineering, energy management and so on. GM(1,1) model is particularly popular in practical applications because of its simplicity and effectiveness. In addition, in view of its limitations and specific application requirements, researchers continue to extend and improve GM(1,1) model to improve its prediction accuracy and application range. The GM(1,1) model is an important model for forecasting data, for making predictions about the future that contain uncertainty. GM" means Grey Model, where "1,1" indicates that the model is a first-order differential equation. This forecasting method can be used in different industries. For example, this model is often used to forecast sales and production within a company. In addition, it can be used to predict future traffic volumes and to predict future disease infections.

Conditions suitable for using this model. This predictive model is best suited first of all for dealing with places where the volume is not huge. For example, data from a workshop in a factory. A workshop only a few lines, the amount of goods will not be particularly large, very suitable. In addition, this prediction model is suitable for problems where a certain piece of information is missing. For example, the number of products processed by a workshop in the following year is uncertain. However, we know the number of processing in previous years, we know the location of the plant and the equipment it has. In this case, you only have one future data missing, other data are available and the amount of data is not large, you can use this prediction model.

4.2 Data Collection

Through the analysis of the equipment information in the packaging workshop and the volume of packaging goods last year, the production efficiency, equipment operation status and possible improvement direction are revealed. By collecting and analyzing this data, we are able to have a comprehensive understanding of the operating efficiency and production capacity of the packaging shop and make recommendations for optimization accordingly.

The data sources of this study are mainly divided into two parts: one is to directly observe and record the equipment information of the packaging workshop, including the type and quantity of equipment; The second is to obtain data on the volume of packaged goods for the whole year of last year by asking the production manager. The third is direct measurement, using the factory ruler to measure the distance between the goods and the RF equipment. The collection of these data provides reliable first-hand information for this study. Device information analysis. Type and quantity of equipment: the type and quantity of all equipment in the packaging workshop are listed in detail, and the main functions and application scenarios of each equipment are briefly described. Equipment health: Analysis of equipment health, including failure rate, maintenance frequency, mean trouble-free uptime and other key indicators. This helps to assess the reliability and maintenance costs of the equipment. Equipment efficiency: Evaluate the packaging efficiency of each equipment, such as the amount of cargo that can be handled per hour, and factors that may affect efficiency, including but not limited to equipment aging, operator skills. Packaging volume analysis. Monthly volume changes: Displays the monthly volume of packaged goods last year and analyzes seasonal changes or other factors that may affect the volume of goods. Relationship with equipment operating status: Explore whether changes in the volume of packaged goods are related to equipment operating status (such as failure rate), and evaluate the impact of equipment performance on production capacity. After asking the manager of the packing shop, we got the information about the volume of packing goods in previous years.

Table 2 The number of products in the last four years (source: Norwex Co, Ltd)

Year	Quantity of goods
2020	3 627 200
2021	4 077 600
2022	4 546 800
2023	4 147 200

4.3 Analysis and Interpretation of Predictive Results

After we get the volume of goods in the packaging workshop for the previous three years, we can use the GM11 model to make predictions. First, the GM11 model needs to add up the previous data to get the following table. Then, by entering the data into the GM11 computer program, we can get a one-difference cumulative cargo volum. At this time, you can officially begin to forecast, the content of the forecast is the amount of goods entering the packaging workshop in 2024.

Table 3 Cumulative number of products over the last four years (source: Norwex Co, Ltd)

Year	Add up the quantity of goods
2020	3 627 200
2021	7 704 800
2022	12 261 600
2023	16 408 800

Table 4 one-difference cumulative cargo volum (source: GM11 model)

Year	One difference cumulative cargo volume
2020	-
2021	4 077 600
2022	4 556 800
2023	4 147 200

The next step is to code the GM11 prediction. First, we need to input the code of GM11, such code can be found in the book GM11 Model Introduction Method (Ming,2014). So we just need to copy the code into the software and then modify the original data (p,147-148). Only the red part needs to be modified, and the red part refers to the quantity of goods in the previous four years. The red part represents how many years in the future, you need to predict the next year's data, so change the red part to 1, the rest of the same. The number 0 in this line of code represents the starting year 2020, and the following 1 represents the 2021 data, because we add up and predict backwards based on the 2021 data. This is followed by the forecast of 2024 and the last year 2023. Modify the red data, and the other parts remain unchanged.

```
import numpy as np

# Original data
X = np.array([3627200, 4077600, 4546800, 4147200])
```

```
# Calculate the accumulated generation sequence
X1 = np.cumsum(X)

# Calculate the first-order difference sequence
Y = np.zeros(len(X1))
for i in range(1, len(X1)):
    Y[i] = X1[i] - X1[i-1]
```

```
# Calculate the model parameters
a, b = np.dot(np.dot(np.linalg.inv(np.dot(B.T, B)), B.T), X[1:])

# Calculate the prediction for 2024
X_2024 = (X[0] - b / a) * (1 - np.exp(a)) * np.exp(-a * (2024 - 2023)) + b / a

print("The predicted amount of goods for 2024:", X_2024)
```

In this way, all the code is completed, and the system will automatically generate the formula and the calculation result of the formula. The following is a formula that GM11 will automatically generate, so it will be displayed automatically without calculation. We round up, and the data should be in the whole hundred, so the final forecast result is that there will be about 4,6 million units in the packaging department in 2024.

$$\hat{X}(k+1) = (X_1 - \tfrac{b}{a}) \cdot (1 - e^{a}) \cdot e^{-ak} + \tfrac{b}{a}$$

$$\begin{aligned}\hat{X}(2024) &= (X_1 - \frac{b}{a}) \cdot (1 - e^{a}) \cdot e^{-a(2024-2023)} + \frac{b}{a} \\ &= (4147200 - \frac{4455640.079}{-0.0731}) \cdot (1 - e^{-0.0731}) \cdot e^{-(-0.0731)(2024-2023)} + \frac{4455640.079}{-0.0731} \\ &\approx 4552601.69\end{aligned}$$

5. Reduce overproduction and increase conveyor speed to achieve lean production

5.1 Principles of Lean Production

Lean Production (Lean Production, referred to as LP) is the United States Massachusetts Institute of Technology digital International Automobile Project organization (IMVP) experts to Japan's Toyota JIT (Just In Time) production mode of praise. Fine, that is, less and fine, do not invest excess production factors, but produce the necessary amount of market urgently needed products (or products urgently needed in the next process) at the appropriate time; Benefit, that is, all business activities should be beneficial and effective, with economic benefits. Lean production method originated from the Toyota production method, is organized by the Massachusetts Institute of Technology, experts and scholars from 17 countries in the world, spent 5 years, cost 5 million US dollars, to the automobile industry, a typical example of mass production and lean production method JIT industry, summed up after theory. The superiority of lean production is not only reflected in the production and manufacturing system, but also in product development, cooperation, marketing network and management and other aspects. It is the best production organization system and mode in the current industry, and will become the standard global production system in the 21st century.

Lean production is the result of the "resource scarcity" and the "multi-variety, low-volume" market restriction of the Japanese automobile industry after the war. It started from Toyoda Sangsaakirai, through the joint efforts of Toyoda Kiichiro and Ohno Niichi and others, until the 1960s to gradually improve and form. Lean production has many principles, such as eliminating the eight major wastes. The eight most common wastes in the enterprise are: overproduction, waiting time, transportation, inventory, process, movement, product defects, and neglect of employee creativity. Among them, the use of RFID technology in the packaging workshop can reduce excessive production. Because before the improvement of RFID technology, the accuracy of scanning equipment is not high, resulting in many goods passing through the pipeline are not identified, and then their quantity will not be recorded in the middle of the inventory. When this happens, workshop managers mistakenly believe that not enough product is being produced and ask the factory to continue production. When the final delivery to the customer, it is found that the goods have far exceeded the demand, resulting in excessive goods are stacked in the warehouse, and finally these excess goods may be wasted. At the same TIME, after improving the conveyor speed, it also helps the company IN lean production JUST IN TIME. The specific basic concept of JIT is: only when needed, according to the amount needed, produce the required products, so it is also known as just-in-time production, timely production mode (White et al., 2001).

The goal of Lean is to completely eliminate ineffective labor and waste. Here are some specific goals of the Lean. The first is the minimum amount of scrap (zero defects). Lean requires the elimination of various unreasonable causes, and every step of the processing process requires the best level. The second point is minimum inventory (zero inventory). In Lean inventory is the proof of unreasonable design of production system, uncoordinated production process and poor production operation. In JIT production the preparation time (zero switching) is the essence. The length of the preparation time is related to the batch selection, if the preparation time approaches zero, the preparation cost also approaches zero, it is possible to use a very small batch. The last point is the shortest production cycle (zero stagnation). The system has short production cycle, small batch, strong strain capacity and good flexibility.

In addition to reducing inventory and reducing waste, it can also reduce the waiting time for the next process by improving the use of RFID in the packaging shop. In the packaging shop, the next step is to deliver the packaged goods to the customer. So as long as the goods in the packaging shop are qualified and the production is accurate, the delivery time to the customer can be reduced to achieve JIT (Danese,2012). Reducing the waiting time of the next process is mainly accomplished by reasonably increasing the movement speed of the assembly line. I will calculate how much waiting time can be reduced in the case of the same amount of goods based on the reasonable speed discussed above. This chapter will mainly consider from two aspects, one is to reduce waste by increasing the accuracy rate of RFID radio frequency, and the other is to achieve JIT by reasonably speeding up the speed of pipeline operation.

5.2 Minimizing defective products for the next year

After adjusting the distance between the scanning equipment and the goods and the speed of the conveyor belt movement, the accuracy rate of RFID technology is greatly improved. Through the

GM11 forecast, we have predicted the volume of goods in the packaging shop for the whole year of 2024. So we just need to multiply the predicted number of goods by the accuracy to get the exact amount of goods scanned in 2024. It can be seen from the above that the predicted quantity of goods in 2024 is 4550000, and the accuracy rate of the adjusted scanning equipment is 0.95. Therefore, we can calculate that the number of goods accurately scanned in 2024 is 4550000*0.95= 4 322 500 goods. Then calculate the number of goods accurately scanned in 2023 as 4147200*0.65 =2 695 680 products. It can be seen that our improvement of the accuracy of RF equipment is of great help to the company. Then get the number how many more products are identified accurately in 2024 than in 2023. We can know that about (4322,500 − 2695,680 = 1 626 820) products. 1.6 million more products will be accurately identified in 2024 than in 2023.

5.3 Enhanced Efficiency Through Increased Speed

Based on previous adjustments to the speed of the conveyor belt, we will also make the amount of goods passing through the conveyor belt larger. So how much will this speed help the packaging workshop to increase the speed of packaging goods? Now I'm going to calculate this. I am going to calculate how many days it will take before and after the speed improvement in the case that the quantity of goods is the same (both are the quantity of goods predicted by GM11 for 2024).

According to GM11's forecast, 4,6 Million shipments are forecast for 2024. The company's goods are generally 360 goods for a box. Then we can get the total number of boxes of goods is (4 600 000 / 360=12778) 12778 boxes. At the original rate, Originally it could pack 48 cases a day. After the speed change, 48*0.4/0.3 = 64, so 64 boxes of products can be packed after the improvement. Finally, calculate how many days it will take. At the original rate, It takes (12778/48 = 266.21) 267 days to complete. After we change the speed, we need (12778/64 =199.66) 200 days to complete. Finally, I can save (267-200 = 67) 67days. I can come to this conclusion, if other conditions remain unchanged, the delivery time can be 67 days in advance.

5.4 Improve lean production

According to the above calculation, we can find that. We can achieve both excessive production and increased productivity. Reducing overproduction often means less waste, which is in line with the principles of lean production. Improving production efficiency means improving delivery speed, which is also in line with the concept of just in time in lean production. Therefore, the previous adjustment is of great help to improve lean production.

6. Results

We can improve RFID technology by increasing identification accuracy and conveyor speed. Forecast 2024 data through the GM11 forecast model. It is used to help later in the calculation of productivity. For the first part, the identification accuracy is improved to avoid overproduction. Accuracy increased from 0.65 to 0.85. We can calculate from the previous calculation that approximately 1.6 million more products will be identified in 2024 than in 2023. Through RFID technology, the identification accuracy can be improved, overproduction can be avoided, and the production efficiency of the packaging workshop can be improved by reasonably improving the speed of the conveyor belt.

We can't directly calculate how many products to avoid overproduction, because it depends not only on the accuracy of the scan, but also on the reaction time of the manager. Also, the first overproduction of the product can be used in the next order, so each order of overproduction of the product does not mean that they will be wasted. But even if this is the case, we can show through the data that increased accuracy would be good for overproduction. Let's leave aside the response time of managers. Assuming that an order has 10 000 products, approximately 5385 more products need to be scanned according to the original accuracy of 10 000/0.65 = 15 384.63. If the current accuracy is used, 10,000/0.95 = 10,526.32, about 526 more products need to be produced. We can see that other conditions being equal, the overproduced products before the adjustment are about ten times the adjusted ones. Such an outcome would undoubtedly go a long way towards reducing overproduction.

For the second part, the production efficiency of the packaging workshop is improved by increasing the speed of the conveyor belt. The calculation shows, that we can conclude that the speed of the conveyor belt has increased from 0.3m/s to 0.4m/s. If the order for 2024 had taken 267 working days to complete at the original rate, it would have taken only 200 working days at the adjusted rate. It can obviously improve the production efficiency of packaging workshop.

7 Conclusion

The idea of this paper is to first improve the RFID technology, and then use the GM11 model to predict the next year's cargo volume. Finally, by calculating efficiency in 2024, we can get an idea of how much our improvements to RFID technology will help lean manufacturing.

The first is to improve RFID technology. There are two main focus points to improve RFID technology, one is to improve the scanning accuracy of RF equipment, and the other is to reasonably improve the speed of the conveyor belt. After many tests and adjustments, the accuracy and conveyor speed have been improved to varying degrees. The second point is the use of the GM11 forecasting model. The GM11 prediction model is used mainly to get an idea of how much cargo there will be in 2024. In this way, we can calculate how much help to lean production. We predict how much cargo there will be in 2024, based on the volume of cargo in previous years. Then, the data obtained from the first two points. We compared the over-production before and after the adjustment of the same quantity of products and found that my adjustment could significantly reduce the over-production. We also calculated how much faster we could speed up production for 2024 because of our adjustments. Finally, it can be concluded that I have successfully improved lean production in this company's packaging shop by reducing overproduction and increasing production efficiency.

In the future, more and more enterprises will begin to use RFID technology in their production processes. And depending on the actual situation of the factory, different factors such as the RFID protocol or the distance between the radio frequency equipment and the goods will be adjusted. After the adjustment, not only the production efficiency will be improved, but also the decision-making of managers will be greatly helped. Due to the improvement of RFID identification accuracy, the number of goods being recorded will be more accurate, and the manager's prediction of the future will be closer to the actual situation. IN addition, RFID technology will also help lean production in different aspects, such as reducing overproduction and achieving JUST IN TIME. In general, more enterprises will use and improve RFID technology in the future, and achieve more corporate profits by increasing production efficiency and reducing excessive waste.

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