

# Research on simulation based material delivery system for an automobile company with multi logistics center

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**Abstract.** Distribution of different parts to the assembly lines is significant for companies to improve production. Current research investigates the problem of distribution method optimization of a logistics system in a third party logistic company that provide professional services to an automobile manufacturing case company in China. Current research investigates the logistics leveling the material distribution and unloading platform of the automobile logistics enterprise and proposed logistics distribution strategy, material classification method, as well as logistics scheduling. Moreover, the simulation technology Simio is employed on assembly line logistics system which helps to find and validate an optimization distribution scheme through simulation experiments. Experimental results indicate that the proposed scheme can solve the logistic balance and levels the material problem and congestion of the unloading pattern in an efficient way as compared to the original method employed by the case company.

**Key word:** Simulation, material classification, logistics distribution strategy, Kitting, Kanban, Line Stocking

## 1. Introduction

In recent years, the production scale of China's automobile industry has increased the rapid development of logistics industry for automobile companies. In the process of automobile supply chain logistics, inbound factory logistics and production logistics of automobile parts are universally acknowledged as a key to begin function and continuous optimization of the logistics system <sup>[1]</sup>. In these industries, parts supply to the production system in appropriate level can significantly reduce the production time, reduce cost, improve the response to the market and improves flexibility in production. Furthermore, logistics balance in automobile parts assembling can help in the improvement of the supply chain in automobile industry. The problem of internal logistics in automobile manufacturing companies has complex structure and evaluation of these systems is critical to solve using exact mathematical modeling for its

improvement. Therefore, simulation tools has been widely used as a modeling tool to measure the performance of manufacturing systems. In literature simulation tools has been implemented for evaluation of these manufacturing systems. For example, Wang <sup>[2]</sup> used Flexsim to establish a simulation model of collaborative logistic center (CLC) and optimized the model using theory of constraints (TOC). Zhou <sup>[3]</sup> used eM-Plant to simulate logistics distribution in assembly line and studied the relationship between completion time of production planning with buffer size of the material and the loading quantity and velocity of vehicle using design of experiments (DOE). Wan <sup>[4]</sup> studied the existing problem of logistics planning in assembly workshop and used AnyLogic to simulate each alternatives. Zhang <sup>[5]</sup> used a new object-oriented simulation software named Simio to model and analyzed their proposed model. Simio tool has been applied in automobile parts logistics in Yue <sup>[6]</sup> and Wang <sup>[7]</sup> work. They used GA combined with simulation software to optimize path planning in mixed model assembly line. Most of the literature indicates the significance of use of simulation methods for analysis and optimization of complex logistics system. However, the problems of distribution systems investigated in literature are related to different companies and their real situations.

Current research investigates logistics distribution system in an automobile plant in China. The current problem is focused to balance the part delivery to the final assembly line of the automobile assembly plant. The Case Company has problem in its current stocking rules and logistics distribution schedule which needs improvement. Therefore, current research proposed a logistics distribution optimization method based on a real case of automobile assembly plant, simulates the real situation of the logistics, design different experiments of simulation, and proposed an optimal solution of logistics distribution system for the company.

## **2. Company problem description**

Current research investigates Third-Party logistics automobile company which provides services to designated car manufacturing company in China. The main business of the Case Company includes procurement, transportation, scheduling and distribution of parts, and so on. There are two primary warehouses in the case company which are Collaborative Logistics Center (CLC) and the Distribution Collaborative Center (DCC) respectively. The material suppliers transport the parts to the CLC where the supplied parts are stored in CLC. Later, these parts are transported to the DCC according to the products required in the manufacturing plan. The staffs of DCC distributes the required parts from DCC to line-side store from where they are used for assembly.

In the Case Company, there is 67 storage area and 5 shipping platforms in the CLC. Moreover, there are 5 receiving platforms associated with the shipping platforms in the DCC. The DCC is near the assembly line and three assembly lines mainly included in this automobile production plant including, Final assembly (AF), Assembly line of Engine (AE) and Welding line (WE). Layout and work flow chart of the case company is shown in Figure 1. There are two main problems in the studied case Company due to which the current distribution system is inefficient and unbalanced. The problems are unjustified stocking rules and unreasonable logistics distribution schedules.

### *(1) Unjustified stocking rules*

The required material for automobile lines is large in quantity and diversity, as a result, different requirement is needed for different material when making distribution schedules. However, the current stocking rule used in the Case Company do not take this into consideration and a simple stoking rule is adopted for all materials which is not appropriate. The current method for logistics plans is not significantly operational , therefore, classification of materials is necessary to be dine during stocking.

### *(2) Unreasonable logistics distribution schedule*

When planners calculates the operation time, the interval time between two processes is setting too long and all materials use the same scheduling method according to the same distribution strategy without considering the characteristics of the material and the fluctuation of the demand. Such a program leads

to the generation of peak flow and causes congestion and vehicle's waiting line in the storage area.

In view of the present situation of the enterprise, it is important to design different distribution strategies for different corresponding materials and make diverse scheduling. According to the characteristics of the system, current research proposed a logistics distribution optimization method, and uses the simulation method to simulate the status of this logistics system, design the simulation experiments to get an optimal logistics distribution solution.

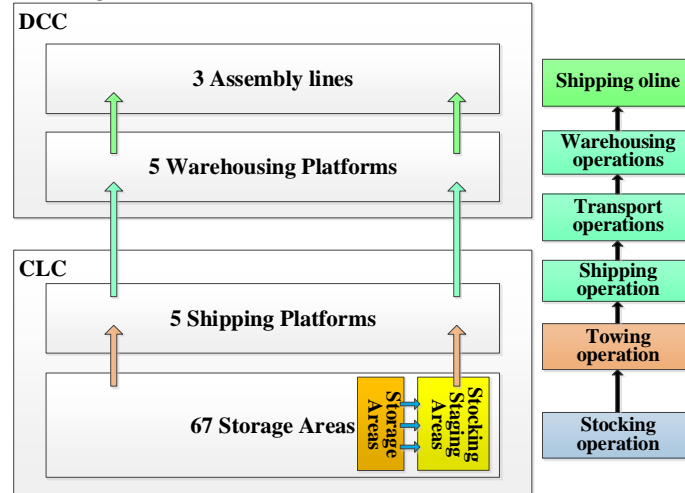


Figure 1. Layout and work flow chart

### 3 Logistics distribution method

For the current situation of Case Company, following logistics distribution optimization steps are employed in the current research.

- Classify the current parts
- Formulate the corresponding material distribution strategy according to the classification of parts
- Give the corresponding online plan for different distribution strategies

#### 3.1 Method of material classification

The core idea of ABC classification is to distinguish between primary and secondary differences in parts of products based on different factors when making a decision and identifying a key factor that determine the role of things and most of the minor factors that have little effects on classifications. In order to maximize the benefits of the logistics distribution system, different material or goods are divided into three groups, i.e. ABC, according to the types of parts. Based on their classification, we can make different distribution strategies for each type of parts and their characteristics. However, traditional method do to consider parts usage rate and number of package volume and other factors during making the classification [8]. Therefore, to determine the classification of parts based on the features of parts and considering the factors that can affect the logistics system rather than relying on the occupation of cost, the volume of the parts and usage rate of the parts are significant and they are considered as a key factor in classification proposed in current research.

The volume is expressed in terms of package number. The larger package number of a batch of parts indicates volume is small and small package number of a batch of parts shows large volume. The package number can define the number of vehicles of one batch. The usage rate of parts is indicated by generality parameter. The calculation formulas of generality and package number are as follows:

$$G_i = N_i / T \quad (1)$$

Where  $G_i$  is generality for part  $i$ ,  $N_i$  indicates the number of car type with the corresponding  $i$  part for one day,  $T$  indicates total number of car type.

$$P_{ij} = P_i / C_{ij} \quad (2)$$

Where  $P_{ij}$  is package number of  $i$  part for a  $j$  car,  $P_i$  indicates package number of part  $i$ ,  $C_{ij}$  indicates number of part  $i$  which assemble in an automobile  $j$ .

In the proposed classification Class A is considered as the parts of low generality, and for Class B the parts with higher generality parameter bigger volume is considered. For Class C, and the parts with higher generality and smaller volume are considered the classification standard is shown in Table 1.

**Table 1.** ABC classification method of automobile parts

Type	Generality	Package number per car
A	0—0.8	Medium
B	0.4—1	Smaller than lot size
C	0.4—1	Bigger than lot size

### 3.2 Strategies for distribution of different category of materials

Due to the differences in the usage frequency of different material, the package number and features, different types of parts are required to be matched with different distribution strategies. This can improve the overall efficiency of distribution, reduce inventory and level the material flow.

#### 3.2.1 Kitting

The usage frequency of A type of parts is not particularly high, but suitable for most containers which can use kitting distribution. Kitting distribution is used for packaging some of the demand of material into containers under packaging strategy and send it to the station according to the accurate quantity and time [5]. Kitting distribution is in synchronized with the requirement of the parts according to the assembly sequence. In this way, the quality of the assembly process can be improved, as well line inventory can be reduced, and help in the improvement of the vehicle stowage rate and reduce vehicle's transportation times.

Kitting distribution has two types. The first type of kitting distribution used fixed kitting for each station in which the all the parts that the station needs are distributed in current batch in place. The second type of kitting distribution is mobile kitting distribution in which all parts which a vehicle needs are pulled into a container that follows the production flow. In the automobile assembly lines of the case company, assembly line is suspension type that materials are hard to move following the bodywork, so it is better to use the fixed kitting distribution.

#### 3.2.2 Kanban

B type of parts have a relatively high usage frequency in the case company, but with relatively large volume. These parts include engine, transmission, fuel tank and other large materials. Because of large volume, inadequacy distribution of B parts is one of the key factor to cause the line-side congestion. Kanban management is a means of JIT production mode which as a kind of production management technology to pursue the rationality, efficiency and flexibility of production process, has been used by many enterprises in the world. It is the basic features of Kanban that for specific parts, workers can dispatch the necessary products with necessary quantity in the required time to reduce inventory, costs and improve asset turnover. Therefore, we chose Kanban as the strategy for B type to effectively control the congestion of the line side and improve the overall distribution efficiency.

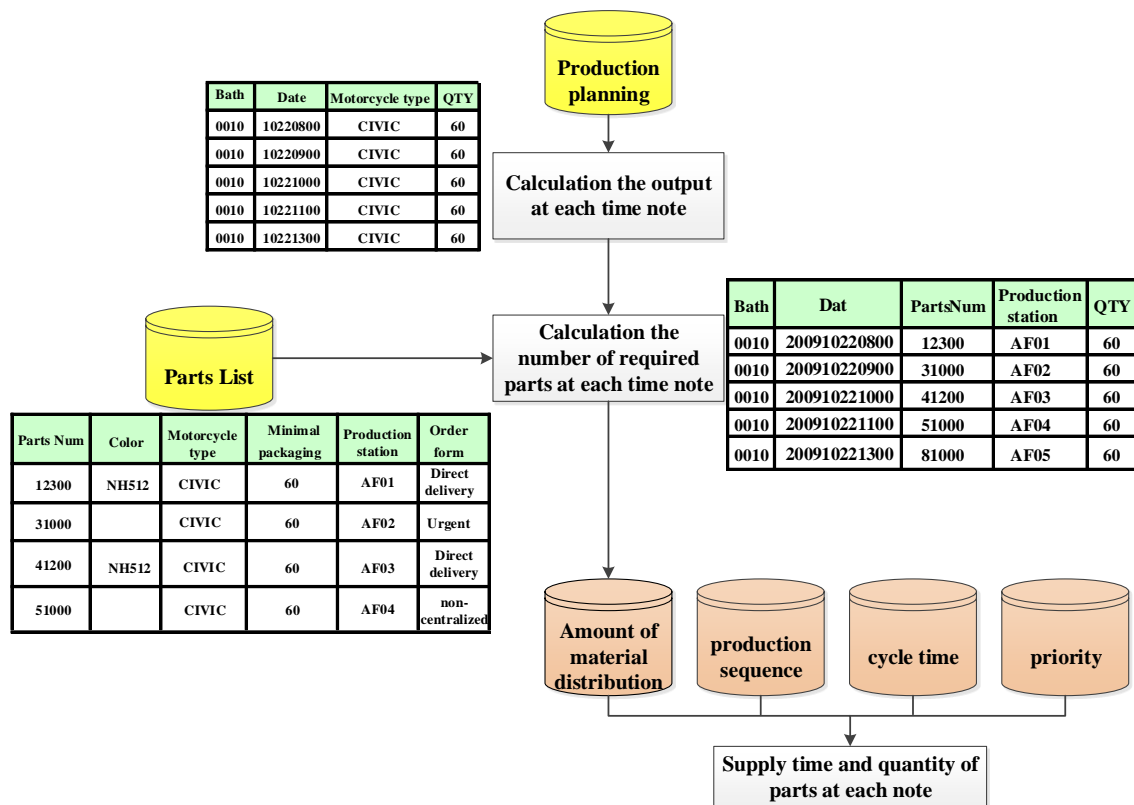
#### 3.2.3 Line stocking

C type of parts have high frequency usage in the case company and small have volume. C type of parts includes Bolts, nuts and other standard parts. In order to increase the efficiency of distribution, decrease turnover work on the middleman, a method of transporting large quantities of materials to DCC at one times is adopted here, namely line stocking distribution. Line Stocking, batch transportation, is a distribution method in which a large quantity of material is delivered directly to the assembly line area without storing it in the intermediate warehouse. In general, the ordinary materials is temporarily stored

in the DCC to release the storage area. However, C type of parts have some characters such as small volume, high use frequency and hardly occupying the assembly line space, so the line stocking distribution that operator directly deliver materials to the assembly line can substantially decrease workload of operators in the middleman and improve distribution efficiency.

### 3.3 Delivery time planning

The production of automobile assembly line runs on a uniform rate (i.e, cycle time of the line). The sequence of assembly of different product models for final assembly is given by master production planning. Production of assembly products at uniform cycle time is relatively easy to obtain the time at which material is required by different stations during assembly. The logistic process operation instructions are synchronized with the time of the delivery of material to different stations in the line. The generation process of the parts delivery time is depicted in Fig.2. Through the method shown in Fig. 2, distribution time of parts can be figure out and it can be used to make a logistics plan.



**Figure 2.** Generation process of the delivery time plan

According to actual situation and parts classification, there are different transport time schedule with various modes of material distribution strategies which are shown in Table 2.

**Table 2.** Time Settings for different distribution strategies

Distribution method	Kitting	Kanban	Line Stocking
Stocking time	120min	120min	120min
Towing time	60min	60min	60min
Transport time	60min	60min	60min
Unloading and storage time	75min	175min	25min
Time of moving to line-side	25min	25min	25min

Operation planning schedule of Kitting, Kanban and LS can be pushed back by the processing start time,

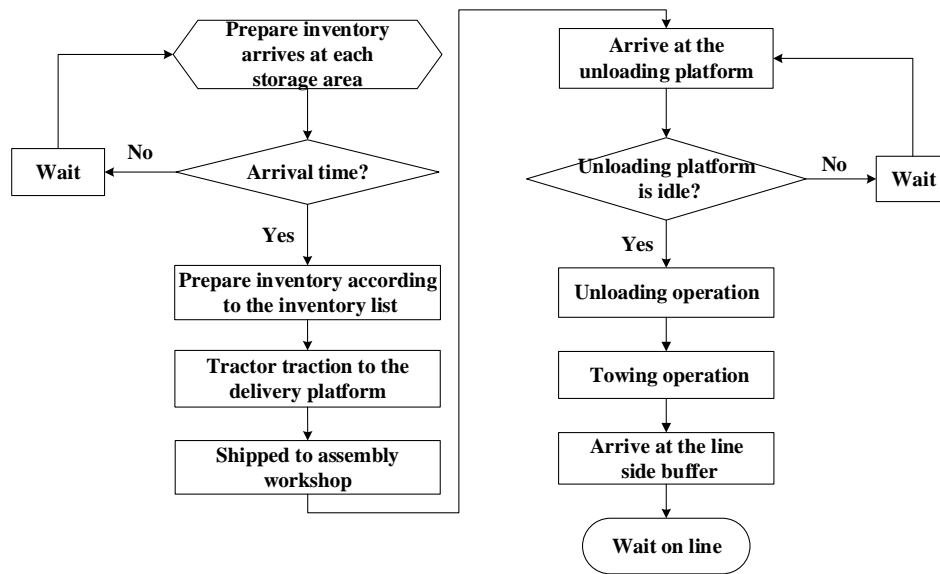
such as online time, departure time, start stocking time, according to the operating time interval taken from Table. 2. The difference is that the distribution plan of LS parts directly sends all parts of the same kind required on the same day to assembly lines without stored in DCC in one times.

The plan figured out through this way is accurate to every second. In fact, the distribution plan only tells the operator a probably working time, so we need to set an appropriate interval time to generate distribution command. The rationality of current plan setting one hour as interval time requires improvement. Therefore, in the subsequent experimental design, we will test a variety of time intervals to choose the best setting.

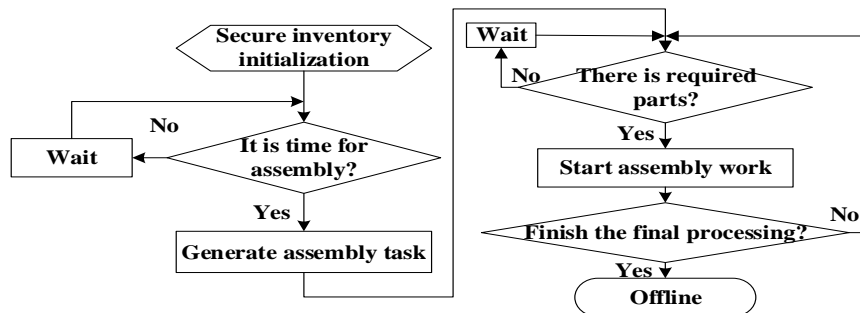
#### 4 Simulation experiments for evaluation of the distribution plan

##### 4.1 Construction of the simulation model

Data import module is used to import various useful data into the system, which mainly include row materials table, the BOM table, production sequence table, vehicle flow table, table of parts requirement, table of stocking inventory, etc. All data information is managed through Excel, and there are conjunctions between some specific columns in order to convert Excel file to the data format which the simulation system can identify.



**Figure 3.** Logic diagram of dispatching parts

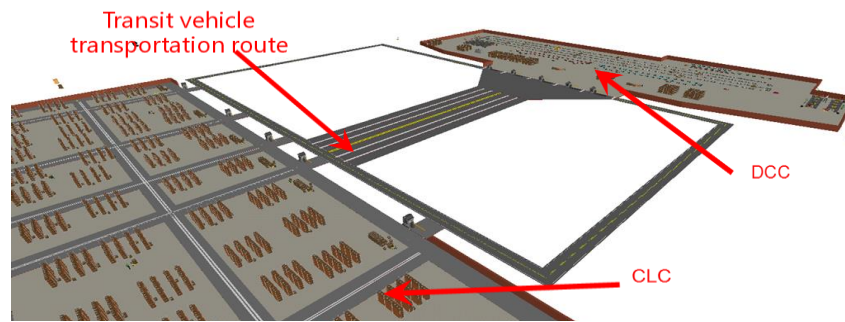


**Figure 4.** Logic diagram of production process

Based on the primary information and combined with Simio modeling features, simulation model is building to analyze automatic part dispatching. Moreover, system modeling concept is considered in the current research experiments. Fig.3 illustrated the logic diagram of dispatching parts from the CLC to the line-side for storage.

Production line modeling process describes the whole process from parts allocating on line to end of the line. The logic diagram of the model is depicted in detail in Fig. 4.

Three-dimensional simulation model for logistic distribution system according to the operations combined with actual logistics information is indicated in Fig. 5.



**Figure 5.** Three-dimensional simulation model of logistics system

## 4.2 Simulation experiments

### 4.2.1 Designing of alternative solutions

Different distribution strategies are made according to part groupings in different parameters conditions at different patterns of Time division and they are shown as alternatives in Table 3.

**Table 3.** Designing of alternative solutions

Time division (minute)	Simulation experiments	Kitting pattern	Kanban pattern		Line stocking pattern	
		Generality parameters	Generality parameters	Packing number	Generality parameters	Packing number
30	1	<70%	≥70%	≤60	≥70%	>60
	2	<60%	≥60%	≤60	≥60%	>60
	3	<50%	≥50%	≤60	≥50%	>60
	4	<40%	≥40%	≤60	≥40%	>60
45	1	<70%	≥70%	≤60	≥70%	>60
	2	<60%	≥60%	≤60	≥60%	>60
	3	<50%	≥50%	≤60	≥50%	>60
	4	<40%	≥40%	≤60	≥40%	>60
60	1	<70%	≥70%	≤60	≥70%	>60
	2	<60%	≥60%	≤60	≥60%	>60
	3	<50%	≥50%	≤60	≥50%	>60
	4	<40%	≥40%	≤60	≥40%	>60
90	1	<70%	≥70%	≤60	≥70%	>60
	2	<60%	≥60%	≤60	≥60%	>60
	3	<50%	≥50%	≤60	≥50%	>60
	4	<40%	≥40%	≤60	≥40%	>60

### 4.2.2 Simulation experiment conclusions

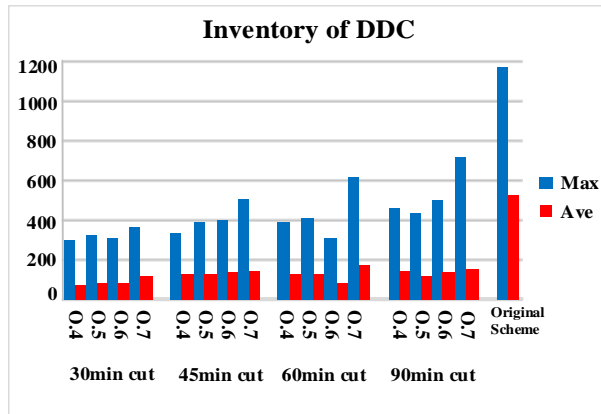
The inventory of DCC, the vehicle queue length, equilibrium of logistics and the number of vehicle

deliveries are the main evaluation indicators of simulation optimization, as described in table 4.

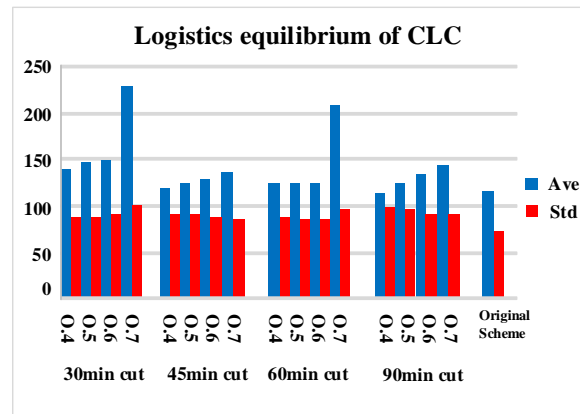
**Table 4.** Evaluation indicators of simulation optimization

Evaluation indicators	Introduction
Warehouse inventory of DCC	Logistics volume of DCC( Collect freight yard, storage yard )
The vehicle queue length	The vehicle queue length of each cargo platform
(DCC, CLC) Equilibrium of logistics	Logistics volume is the total number of Flat car and Trolley per hour
	Standard deviation statistic of Logistics fluctuation
Number of deliveries	Number of vehicle deliveries and tractor deliveries

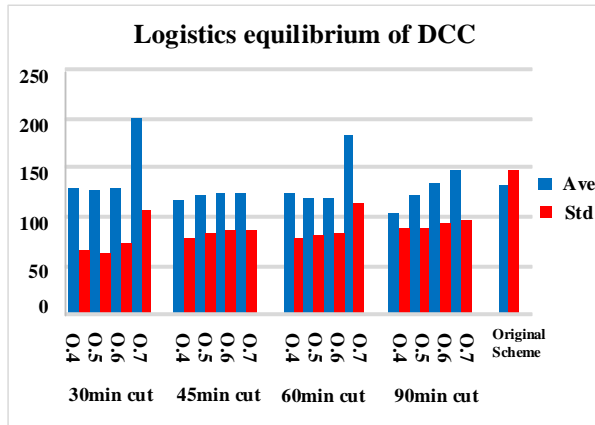
According to the designed experiments, the simulation results obtained are presented here. The comparison of warehouse inventory of DCC at different time intervals is indicated in figure 6. It can be seen from figure 6 that optimization schemes can significantly reduce inventory.



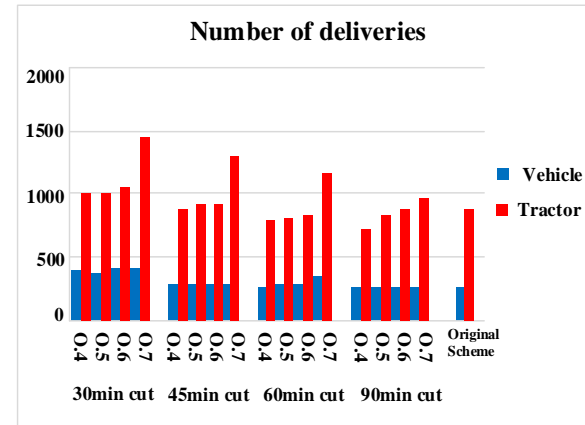
**Figure 6.** Comparison of inventory of DDC



**Figure 7.** Comparison of CLC logistics equilibrium



**Figure 8.** Comparison of DCC logistics equilibrium



**Figure 9.** Comparison of deliveries number

The results of equilibrium of the logistics for CLC and DCC are indicated in figure 7 and 8. It can be seen from figure 7 and figure 8 that optimization schemes mainly reduce the logistics volume and improve the equilibrium of logistics with lower standard deviation. The results for number of deliveries is indicated in figure 9. And the results of queuing on unloading platform shows that the problem of warehouse inventory of DDC indicates that the waiting time after unloading is improved and there will be no need to wait for unloading after optimization. These results indicate that the congestion problem is significantly solved here. It can be seen from figure 9 that Kitting mode is the logistics balance but with higher workload and lower container 's loading, this problem will be discuss in following.



#### 4.2.3 Optimal scheme

According to simulation results of different alternatives under different evaluation indicators in 3.2 section, the weight method and expert evaluation method are used to evaluate each plan, specific steps are below:

**Step1:** For each evaluation index, grade them into 16 scheme (score 1-16)

**Step 2:** Set weight for each evaluation indicator according to the actual need and expert evaluation

**Step 3:** Select the best program according to the comprehensive score

In this way, It can be find that the optimal scheme for inventory is to set 1 hours as the division unit, and generality parameter is set to 50%, and the material classification and distribution mode considered are as follows:

Kitting pattern: generality parameters  $< 50\%$

Kanban pattern: generality parameters  $\geq 50\%$  , packing stock  $\leq 60$

Line stocking pattern: generality parameters  $\geq 50\%$  , packing stock  $> 60$

A comparison between the optimal scheme and original scheme are made as following:

##### (1) Results of optimization of Warehouse inventory of DDC and equilibrium of logistics

The maximum and average values of warehouse inventory of DCC were significantly decreased, the maximum reduced from 1168 to 401, and average values reduced from 524 to 127. This results indicate that unloading platform congestion problem is solved through creating a logistics equilibrium model.

The comparison of the logistics volume data of each hour in a day for original and optimal scheme and are indicated in figure 10 and figure 11 for CLC and DCC respectively. It can be seen that fluctuations of CLC and DCC logistics volume flatten out. According to the diagram, we can know that logistics of CLC and DCC achieve equalization.

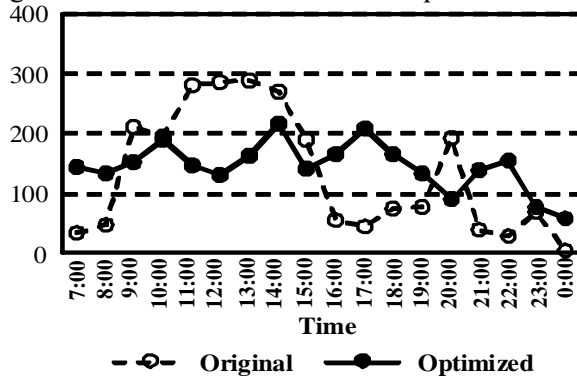


Figure 10. Comparison chart of CLC logistics volume

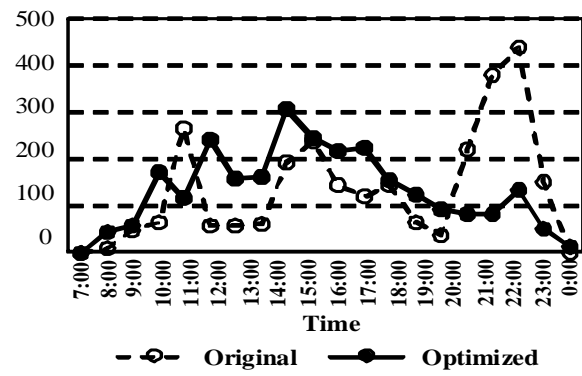


Figure 11. Comparison chart of DCC logistics volume

##### (2) Waiting time of unloading vehicle

In original scheme, 44% vehicles have waiting time is more than 30 minutes, but the results of optimization scheme basically do not exist and have waiting queue and the average waiting time is reduced by 20%.

##### (3) Optimization results of vehicle and tractor

The optimization results of the vehicle and tractor obtained from the proposed simulation model are indicated in table 5. The results shown in table 5 that the characteristic of Kitting mode is the logistics balance but with higher workload and lower container's loading. These results are because Kitting accounts for a large proportion, the optimization scheme will can increase the delivery number of vehicle but reduce the number of tractor and vehicle. So the optimization scheme can achieve the goal of reducing costs.

**Table 5.** Optimization results of vehicle and tractor

Scheme	Total number of vehicle delivery	Number of vehicle	Deliveries' number per vehicle and per day	Total number of tractor delivery	Number of tractor	Deliveries' number per tractor and per day
<b>Original</b>	265	40	6.625	878	48	18.291
<b>Optimization</b>	270	35	7.714	823	44	18.705

## 5 Conclusions

The paper studies the distribution method optimization of the logistics system in a Third-Part logistics company that provides professional service for the designated automobile manufacturing company in China. The proposed study classifies different parts according to the critical factors and determined appropriate logistics distribution mode and optimized the logistics distribution schedule. The simulation software Simio is applied to model and simulate the assembly line, which helps to find and validate an optimization distribution scheme through simulation experiments. Experimental results indicate that the proposed optimization scheme can solve the problems of logistics balance and congestion of the unloading platform in efficient way as compared to the original method used in the case company. In the future, there are two points needed to do more in-depth investigations. First, it's necessary to design containers for different types of parts. Another one is doing more experiments using intelligent algorithms to find optimal solution.

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