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# Simulation and Optimization of the Operation Process of an E-commerce Logistics Distribution Center Based on Flexsim

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**Abstract**

This study utilized the Flexsim simulation software to simulate the existing layout and functions of different functional areas in the A e-commerce logistics distribution center, and determined the simulation scheme. In particular, a comparative analysis is conducted on the impact of the combination of influencing factors of different picking strategies on the efficiency of picking operations, as well as the gradual optimization of the number configuration of intelligent handling equipment, to meet the operational requirements while ensuring operational efficiency and reducing costs. Through the collection and analysis of simulation data and the comparison of optimization plans, the bottleneck links and resource waste problems of the A e-commerce logistics distribution center are improved, effectively enhancing the overall operational efficiency and service quality.

**Keywords:** e-commerce logistics distribution center, Flexsim, Modeling and simulation

## 1. Research Background

### *1.1 Background Description*

The distribution center has a wide and relatively stable network of retail and consumer demands, which can ensure that products smoothly enter the circulation field and effectively realize the value of the products. It is particularly important to optimize and improve the planning of distribution centers by achieving the optimal allocation of logistics resources through intelligent means, reducing operation time and costs, enhancing logistics efficiency, and shortening the turnover time of goods. At present, the most notable research field in modern logistics systems is the theory of system modeling, simulation and optimization. Based on the application experience at home and abroad, after improving the logistics system scheme by applying the modeling and simulation analysis method, the total investment can be reduced by about 30%.

In the simulation optimization research of e-commerce logistics distribution centers based on Flexsim, the practical application of the simulation results can provide strong support for their management and decision-making. Simulation models help management gain a deep understanding of operational processes, identify bottlenecks and resource allocation issues in the system, and identify potential efficiency improvement points. This data-driven analysis enables managers to formulate more precise and effective strategies, such as optimizing resource allocation, adjusting operation processes or introducing new technologies, to enhance efficiency and reduce costs while maintaining service quality. In addition, simulation models can serve as training tools, enabling new employees to become familiar with the work processes through a virtual operating environment, thereby reducing errors and enhancing overall work efficiency.

### *1.2 E-commerce Logistics Distribution Center A*

The warehouse area of the A e-commerce logistics distribution center is nearly 20,000 square meters. The logistics center is a single-story linear layout. Loading and unloading platforms are built on both the east and west sides. The east side is the inbound unloading area, and the west side is the outbound loading area. The operation area division of the A e-commerce logistics distribution center mainly includes the inbound storage area, bulk storage

area, bulk storage area, bulk picking area, review and packaging area, equipment storage area, outbound storage area, office area, etc., as shown in Figure 1-1.

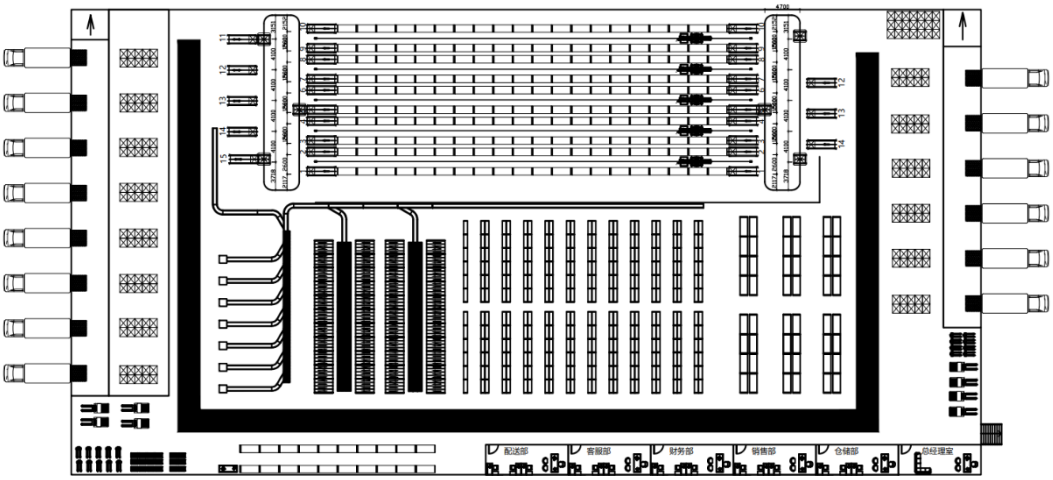

Figure 1-1 Layout plan of e-commerce logistics distribution center A

The operations of the A e-commerce logistics distribution center mainly include warehousing, replenishment, inventory taking, and outbound, etc. The operation tasks are cumbersome and the workload is large. To ensure the timely and effective completion of the operation tasks, it operates 24 hours a day without interruption. Meanwhile, in order to enhance service quality, it has put forward a service guarantee of "24-hour delivery". The order service process and service requirements are shown in Figure 1-2.

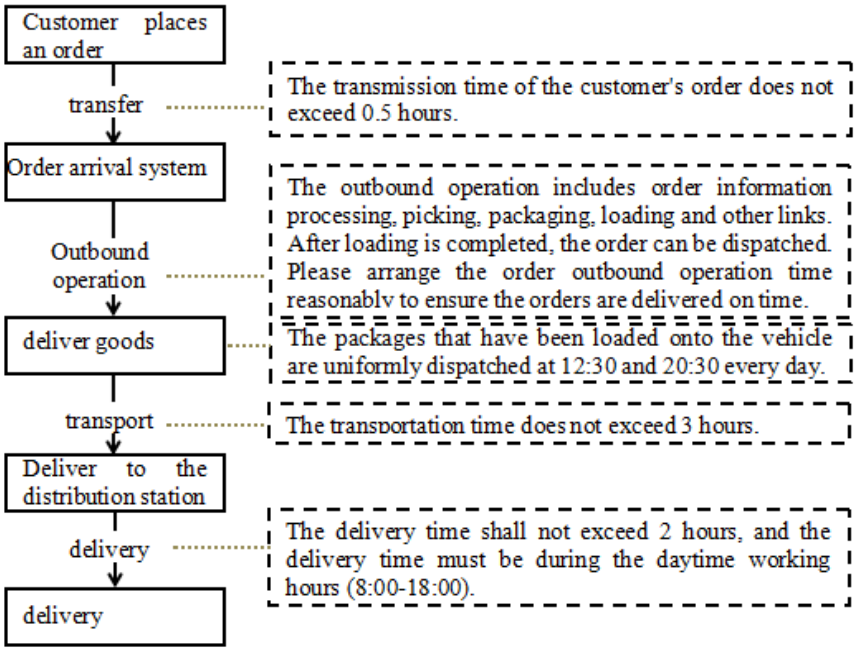


Figure 1-2 Order Service Process and Requirements

**2. Flexsim Modeling and Simulation**

Take the inbound processing area as an example. The physical layout and parameter Settings of the Flexsim simulation modeling are as follows.

The inbound management area is mainly responsible for receiving goods, inspection, sorting and other tasks, and realizes the transfer of materials outside the warehouse. When inspecting the goods upon receipt, if any defective items are found, they cannot be stored in the warehouse and need to be sent to the scrap temporary storage area.

The inbound processing area consists of 4 generators, 1 absorber, 3 processors, 5 conveyor belts, 3 temporary storage areas, 1 synthesizer and 1 forklift, as shown in Figure 2-1.

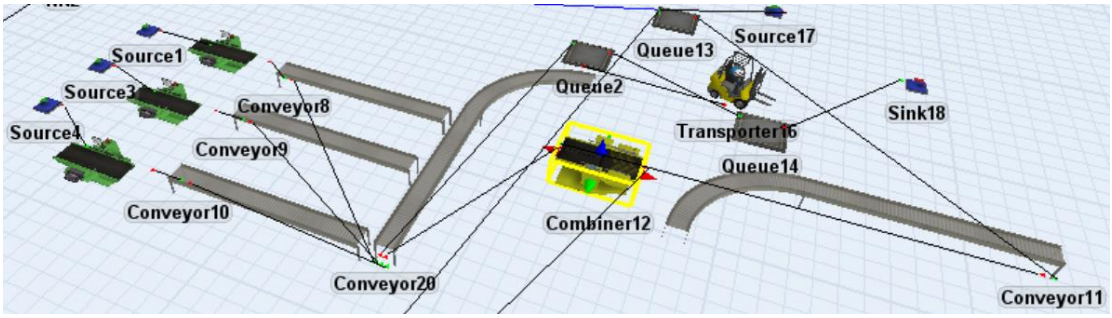


Figure 2-1 Storage processing area

The physical parameter Settings of the inbound processing area are shown in Table 2-1.

Table 2-1 Entity parameter Settings for the inbound processing area

| Entity name | Object description | Preferences |
|---|---|---|
| Source l、3、4 | Product generator | Source 1.3 and 4 represent the arrival of three types of goods. Set the type and color of the goods. |
| Source l7 | Tray generator | The system immediately generated 340 pallets as soon as it started running. The initial appearance produced by the tray. |
| Processor 4~6 | Storage processing table | Keep the parameters at their default Settings. |
| Conveyor 8~11 | Parts conveyor belt | Keep the parameters at their default Settings. |
| Conveyor 20 | Parts conveyor belt | The probability of defective goods is 10%. |
| Queue 2, Queue l4 | Product temporary storage area | The Queue ll setting uses the transport tool, while the rest of the parameters remain at their default Settings. |
| Queue l3 | Pallet storage area | The maximum capacity is set at 350 |
| Combiner 12 | Load the synthesizer | The pallet load of the synthesizer is 4 pieces |
| Transporter l6 | Pallet forklift | Keep the parameters at their default Settings |
| Sink 18 | Non-conforming items area | Keep the parameters at their default Settings |

## 3. Simulation and Optimization of E-Commerce Logistics Distribution Center A

The overall concept and operation mode of the e-commerce logistics distribution center are shown in Figure 3-1.

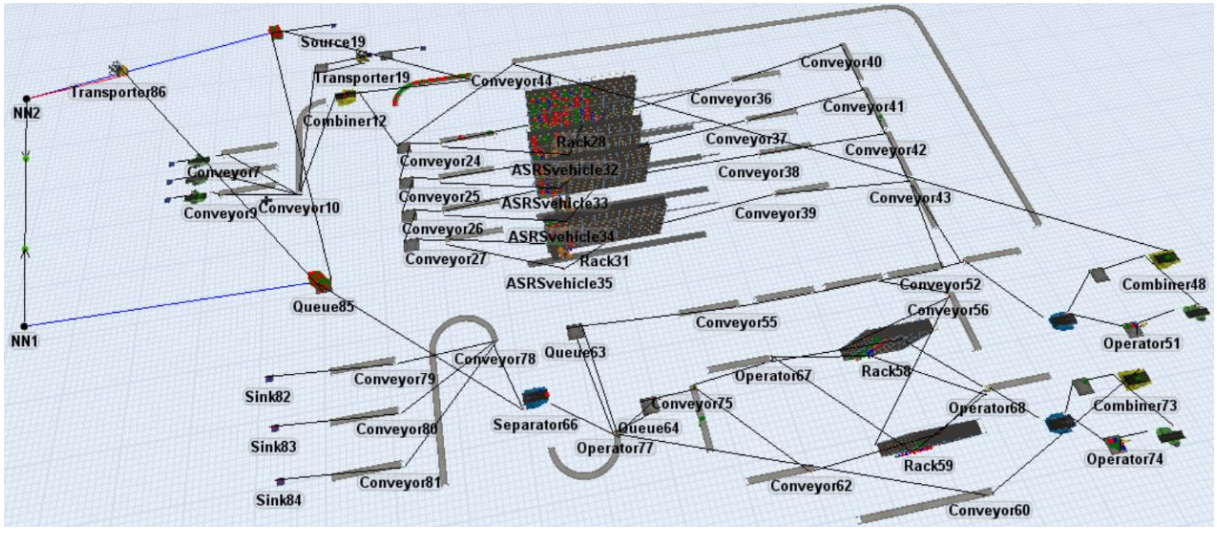


Figure 3-1 shows the overall concept and operation mode of the A e-commerce logistics distribution center

Based on the improved layout of the A e-commerce logistics distribution center, the FlexSim software is used to simulate the business operation process. By analyzing indicators such as equipment utilization rate, order processing volume, and goods dwell time, the impact of different strategies on processing time, cost, and resource utilization rate is analyzed to further improve the bottleneck links and resource waste problems.

*3.1 Simulation Model Operation and Result Statistics*

The most core warehousing operation in the A e-commerce logistics distribution center is the picking operation. Efficient picking operations help to better improve operational efficiency and reduce operational costs. Picking strategy is an important factor affecting the efficiency of picking operations. Different picking strategies should be adopted for different order demands, as shown in Figure 3-2.

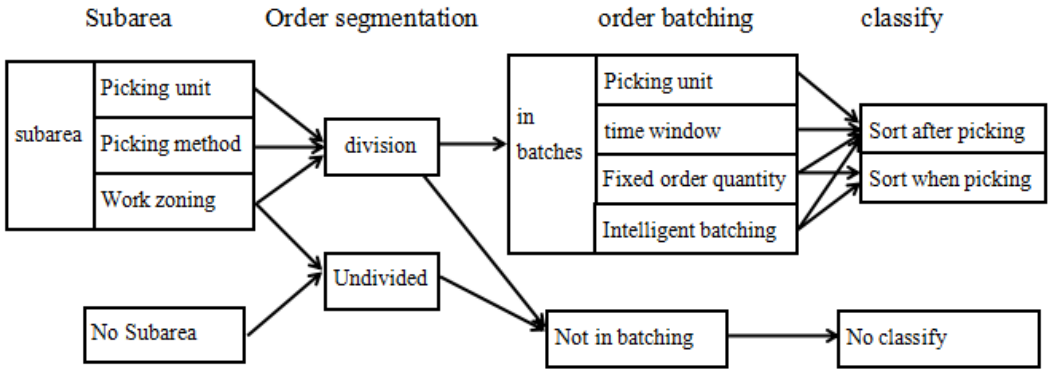


Figure 3-2 Selection strategy

After the model is established, it can be compiled and reset. Then, you can click on the "Run" of the simulation time control to run the model.

Table 3-1 Report and Statistics Table

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Flexsim Summary Report | | | | | | | | | | |
| 2 | Time: 36000 | | | | | | | | | | |
| 3 | Object | Class | stats_content | stats_contentmin | stats_contentmax | stats_contentavg | stats_input | stats_output | stats_staytimemin | stats_staytimemax | state_current |
| 4 | Source1 | Source | 0 | 0 | 0 | 0.998417 | 0 | 656 | 0 | 0 | 5 |
| 5 | Source2 | Source | 0 | 0 | 0 | 0.998528 | 0 | 650 | 0 | 0 | 5 |
| 6 | Source3 | Source | 0 | 0 | 0 | 0.999778 | 0 | 654 | 0 | 0 | 5 |
| 7 | Processor4 | Processor | 0 | 0 | 1 | 0.182222 | 656 | 656 | 10 | 10 | 1 |
| 8 | Processor5 | Processor | 0 | 0 | 1 | 0.180556 | 650 | 650 | 10 | 10 | 1 |
| 9 | Processor6 | Processor | 1 | 0 | 1 | 0.181611 | 654 | 653 | 10 | 10 | 2 |
| 10 | Conveyor7 | Conveyor | 0 | 0 | 1 | 0.18251 | 656 | 656 | 10 | 10.61 | 6 |
| 11 | Conveyor8 | Conveyor | 0 | 0 | 1 | 0.180697 | 650 | 650 | 10 | 10.61 | 6 |
| 12 | Conveyor9 | Conveyor | 0 | 0 | 1 | 0.181592 | 653 | 653 | 10 | 10.61 | 6 |
| 13 | Conveyor10 | Conveyor | 0 | 0 | 3 | 1.263069 | 1959 | 1959 | 22.853981 | 32.24398 | 6 |
| 14 | Queue11 | Queue | 0 | 0 | 2 | 0.043176 | 243 | 243 | 6.003534 | 16.885981 | 6 |
| 15 | Combiner12 | Combiner | 1 | 0 | 2 | 0.999504 | 2146 | 2145 | 0 | 174 | 7 |
| 16 | Conveyor13 | Conveyor | 30 | 1 | 30 | 29.987302 | 460 | 430 | 17.853981 | 2705.553955 | 4 |
| 17 | Queue14 | Queue | 0 | 0 | 1 | 0 | 242 | 242 | 0 | 0 | 6 |
| 18 | Sink15 | Sink | 0 | 0 | 1 | 0 | 242 | 0 | 0 | 0 | 7 |
| 19 | Queue16 | Queue | 47 | 0 | 339 | 151.071933 | 507 | 460 | 0 | 25819.30078 | 8 |
| 20 | Transporter19 | Transporter | 1 | 0 | 1 | 0.039634 | 243 | 242 | 5.878911 | 5.878911 | 15 |
| 21 | Source19 | Source | 0 | 0 | 339 | 0 | 0 | 340 | 0 | 0 | 5 |
| 22 | Queue20 | Queue | 0 | 0 | 1 | 0 | 544 | 544 | 0 | 0 | 6 |
| 23 | Queue21 | Queue | 0 | 0 | 1 | 0 | 267 | 267 | 0 | 0 | 6 |
| 24 | Queue22 | Queue | 0 | 0 | 1 | 0 | 135 | 135 | 0 | 0 | 6 |
| 25 | Queue23 | Queue | 0 | 0 | 1 | 0 | 71 | 71 | 0 | 0 | 6 |
| 26 | Conveyor24 | Conveyor | 3 | 0 | 4 | 0.636109 | 277 | 274 | 21.268833 | 305.390564 | 4 |

*3.2 Optimization of the A E-Commerce Logistics Distribution Center*

After comparison, it can be found that the order completion time and the average working efficiency of operators in the fruit-picking without zoning scheme are both better than those in the zoning scheme. Therefore, the fruit-

picking without zoning scheme is chosen. The order completion time and the average operator work efficiency of soil-type picking without zoning are both superior to those of soil-type picking with zoning. Therefore, the soil-type picking without zoning solution is chosen. To sum up, whether it is fruit-picking or soil-picking, the unpartitioned picking scheme is the best.

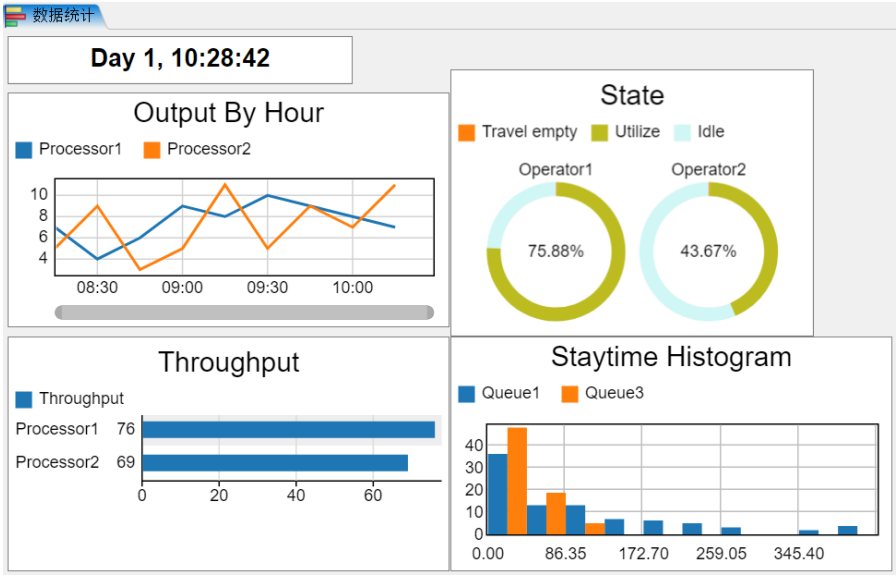


Figure 3-3 Simulation data of picking operations and intelligent handling equipment configuration

Based on the above analysis, the reason for the low utilization rate of stacker cranes and shelves is the small quantity of goods arriving. To address this issue, a synthesizer with the same efficiency can be added to the goods entry area to package the goods, enabling more packaged goods to be sent from the entry area to the storage area within the same period of time. This can effectively increase the utilization rate of shelves and stackers. Additionally, the upper limit of the input port for closing the shelves in the storage area can be modified. Based on this data, the model can be modified and run again. Analyze the simulation results and continuously adjust the parameters for optimization.

Table 3-3 Comparison Table of Work Efficiency Before and After Modification

| **Equipment** | **Work efficiency before modification** | **Work efficiency after modification** |
|---|---|---|
| conveyor | 12.63% | 16.33% |
| Pallet forklift | 14.75% | 18.93% |
| Sorting conveyor belt | 15.56% | 20.45% |
| mechanical arm | 12.53% | 16.33% |
| Tray disassembler | 47.75% | 65.81% |
| Assembly disc synthesizer | 35.01% | 50.15% |

Table 3-4 Comparison Table of Picking Operation Data Before and After Modification

| **target** | **before modification** | **after modification** |
|---|---|---|
| Picking rate (order per hour) | 120 | 140 |
| Picking accuracy rate | 86% | 91% |
| rate of utilization of work hour | 70% | 75% |
| rate of equipment utilization | 62% | 71% |
| inventory carry rate | 0.95 | 0.975 |
| On-time delivery rate | 93% | 94.5% |

Based on the above results, it can be proved that the optimization plan we chose is correct. Through simulation analysis, after optimizing the resource allocation of the system, the goal of improving system efficiency and optimizing investment returns has been achieved.

## 4. Summary and Prospect

This study utilized the Flexsim simulation software to simulate the existing layout and functions of different functional areas in the A e-commerce logistics distribution center, determine the simulation scheme, and compare the obtained data to identify solutions to the problems existing in the distribution center and optimize and improve them. Finally, the optimal scheme design was refined to form a research report.

There are two key research directions in the future. The first one is the joint optimization of "quantity and scheduling" for intelligent material handling equipment. Second, explore more advanced and forward-looking picking strategies and technologies. By focusing on these directions, subsequent research can more comprehensively address the shortcomings of the current project, providing more forward-looking, robust and implementable optimization solutions for the A e-commerce logistics distribution Center and the broader e-commerce logistics industry, and achieving an integrated improvement in efficiency, cost, service, sustainability and employee well-being.

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