

Literature Review on Fresh Products Cold Chain Logistics and Distribution Issues

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Abstract: In this paper, the literature on the concepts of fresh product cold chain logistics, the container operation problems related to cold chain transport, product order picking, distribution and the integration of the two problems are sorted out to provide theoretical references for the further study of the transport and distribution problems of fresh product cold chain logistics. Through combing the literature at home and abroad, the current fresh product cold chain logistics transport and distribution mainly exists in the container intermodal transport research object is single, mostly focusing on the railway container centre station; order distribution problems related research is less, vehicle path problem solving algorithms and related mathematical models are less; order picking and distribution of the joint research is less, and most of them stay in the theoretical stage, the method of landing is more difficult and other problems.

Keywords: Cold Chain Logistics; Fresh Product; Literature Review.

1. Introduction

With economic growth and consumption upgrading, consumers are increasingly demanding for food safety and quality, especially the freshness of fresh products is of great concern, therefore, the effectiveness and efficiency of cold chain transport and distribution become particularly important. In recent years, there have been more and more concerns and research results on cold chain logistics of fresh products in the academic world. This paper provides a comprehensive analysis of existing research and summarizes the current status of cold chain logistics and distribution issues of fresh products from three aspects, namely, cold chain logistics of fresh products, container operation, order picking and distribution, aiming to provide theoretical references for further study of the transport and distribution issues of cold chain logistics of fresh products through sorting out the relevant literature.

2. Research Related to Cold Chain Logistics of Fresh Product

2.1. Current Status of Fresh Product Cold Chain Logistics Research

Zhao Mei [1], on the basis of studying the cold chain logistics of fresh agricultural products, analysed the problems of low systematic construction, high technical level threshold and high technical cost in fresh cold chain logistics, and based on this, proposed to strengthen the construction of industrial standardization and improve the level of warehousing management, so as to achieve the purpose of improving the technology of fresh cold chain logistics. Yang Juanling[2] carried out SWOT analysis on the current situation of the development of agricultural products logistics, and the results showed that China's fresh products cold chain logistics enterprises have advantages in many aspects, including China's cold chain logistics has initially formed a large-scale effect; the government and the transport sector attaches great importance to the development of cold chain logistics, and has introduced relevant policies and opinions. At the same time, it also points out that the development of China's cold chain

logistics faced by the short board, mainly in the lack of talent, managers and technical personnel in the number of small, and finally combined with the examples of China's fresh product logistics development direction to put forward the rationalisation of the proposal. Sun Jie[3] used SWOT analysis method on the cold chain logistics enterprise information level construction, cold chain logistics enterprise operation mode innovation, increase the construction of cold chain logistics enterprise infrastructure, and increase the cold chain logistics enterprise aspects of professional talents training efforts.

2.2. Research Status of Container Operation Problems

2.2.1. Research Status Abroad

Multimodal transport container is through two or more modes of transport, the container as a standard transport unit, the goods from the starting point to the end of the transport, and in the conversion process between the modes of transport does not make additional operations inside the container. With the rise of the fresh goods market, the number of cold chain containers at intermodal terminals has been growing, leading to more and more intense competition at the terminals.

In order to adapt to the rapid development of this industry, scholars at home and abroad have carried out in-depth research on intermodal containers. Meisel [4] proposed the problem of terminal crane scheduling restricted to a time window, constructed a mixed-integer planning model and designed a heuristic algorithm based on tree search to solve the problem. Based on the study of Meisel, Bierwlrth[5] classified the new literature using the classification scheme from the previous survey based on the characteristics of the models considered for berth allocation, quay crane scheduling and integrated approach and discussed the methodology for evaluating the models and algorithms to identify the trends in the field of intermodal containers. Guo[6] investigated road-rail intermodal intermodal container terminal gantry crane scheduling problem, considering factors such as crane safety distance, travelling time and non-crossing requirements, constructing a mixed integer planning model, and designing a new discrete artificial bee colony algorithm to solve the

problem; secondly, they also investigated the railway container terminal gantry crane scheduling problem, considering non-crossing constraints between cranes and priority constraints between containers, and at the same time focusing on the crane effective scheduling and fast service time for external trucks, which is also applicable to intermodal terminals. Zhou[7] constructed a mixed integer planning model for simultaneously determining the site crane scheduling and vehicle parking location problems, and designed a two-stage heuristic algorithm to solve the problem. Recently, KiMilay[8] conducted a comprehensive review of 238 literatures related to container terminal operations and proposed a literature classification scheme based on the container terminal crane scheduling problem, yard operation problem and integrated operation problem. Based on the current situation and future trends, it is proposed that in the future, the QC, YC, and Yt scheduling problems should be considered simultaneously in order to maintain the coordination of container terminals, so as to obtain the globally optimal solution; and the container stacking operation and crating equipment scheduling problems should be combined to obtain a more efficient solution.

Early on, few researchers focused on the container operation scheduling problem. By designing a simulation model to describe the container operation process in the system, the main factors affecting the transshipment efficiency of container terminals were explored using the container throughput time as a measure. Cyclic heuristic rules are used for equipment allocation, and new heuristic rules are proposed for track scheduling.

Bostel[9] and others constructed a mathematical model of the container transshipment problem based on sea and rail intermodal yards with the objective of minimising the unnecessary movement of containers in the port, while designing an optimisation algorithm for solving the problem; with the continuous deepening of the research, Boysen[10] gradually became a stalwart in the research of the container operation scheduling problem, and reviewed the collation of the railway yard from the perspective of operations research Container Gating problem, analysed two types of yards: conventional rail-road and modern rail-rail transit yards, and at the same time analysed the basic decision-making problems of the two types of yards. In 2017, Boysen[11] and others carried out a more in-depth analysis of the modern rail-rail transit yards, constructed a mathematical model for the interdependent crane and shuttle scheduling problem arising from the process of moving containers, and designed heuristic algorithms to solve the problem. In the same year, his team compared the operational efficiency of four types of container sorting systems in modern railway-railway transshipment yards. Otto[12] investigated the train arrival assignment problem in intermodal railway yards with the objective of minimising the number of redistributions, and determined the method of calculating the lower bound for the updating. Guo and other scholars[13] addressed the different container hubs with different intermodal transport characteristics, constructed a simultaneous transfer scheduling integer planning model applicable to different container hubs, and also designed a solidification-based heuristic algorithm to solve the problem. Zhen[14] constructed a mixed-integer planning model for the integrated optimization problem of the dock bridge crane and yard vehicle scheduling of container terminals, and also proved that the integrated scheduling problem based on container terminals is a NP- hard problem,

and a particle swarm algorithm is designed to solve the problem. In analysing the loading and unloading operations at the shore bridge of container terminals, Goodchild and other scholars[15] proposed that the loading and unloading operations should be carried out simultaneously, which can greatly improve the efficiency of the quay cranes and container ports compared with the traditional mode of unloading first and then loading. Luo[16] took the minimum time at the berth of the ship as the optimization objective, and constructed a mathematical model that takes into account the vehicles participating in the loading and unloading operations, as well as the unloading A mathematical model considering the factors of container stacking location was constructed, and a heuristic algorithm was designed to solve the problem.

2.2.2. Current Status of Domestic Research

With the rapid development of China's container transport industry, container multimodal transport has gradually become a research hotspot in the domestic industry and academia. Compared with foreign scholars' research on container transport, domestic scholars tend to be more inclined to qualitative analyses at the theoretical and policy levels in the early stage of research on container multimodal transport. For example, Shao Zhenyi[17] and other scholars in 1985 for the first time clarified that the vitality of the container transport process lies in the development of multimodal transport, and proposed that automobile transport is an indispensable link in the container multimodal transport; Xu Shufen[18] in 1994 for the first time on the current situation of the international container multimodal transport as well as the existence of problems for in-depth analysis, and demonstrated that international container multimodal transport of the enormous development prospects; Fei Weijun and others[19] made the first analysis of multimodal transport in container ports in 1996, elaborated that ports must become the centre of container multimodal transport, and pointed out the direction for the subsequent theoretical research on multimodal transport.

Recently, Wang Weiwei[20], Zhang Panpan[21] and Guo Jian[22] and others have studied the current rapid changeover technology between different modes of transport in the railway container multimodal transport, pointing out that there are problems in the development of container multimodal transport, such as weak infrastructure, backward technology and equipment, and the lack of a comprehensive information service platform, and proposing that the railway consolidation and evacuation corridor should be constructed to strengthen the connection with the ports, constructing the It also puts forward development proposals for the construction of railway collection and distribution channels to strengthen the connection with ports, the construction of multimodal transport facilities and equipment, and the completion of container loading programmes.

With the continuous deepening of the research on container intermodal transport, the research direction of domestic container intermodal transport gradually tends to apply quantitative analysis at the technical level. Park Hui-suk[23] and others constructed a mathematical model for the optimisation problem of integrated loading, unloading and transport operations of container intermodal transport system and designed a heuristic optimisation algorithm to solve the problem. Mei Yiqun[24] and others considered factors such as berth resources as well as shore and bridge resources, and at the same time considered factors such as berth preference and the frequency of movement of shore and bridge,

constructed a two-phase mathematical model of the berth-shore-bridge joint scheduling problem, and at the same time designed an improved adaptive variational particle swarm algorithm to solve the problem. Wang Hui[25] constructed a mathematical model of the container intermodal transport optimisation problem considering the influencing factors such as fuzzy transport demand, container box type and mode of transport, and designed an improved particle ant colony algorithm to solve the problem; Liu Qing and others[26] constructed a mathematical model of the Yangtze River mainline container intermodal transport path optimisation problem considering the factors such as transport cost and time and risk and carbon emission, and further designed a genetic algorithm to solve the problem. Tang Yinying[27] constructed a mathematical model of container intermodal transport path selection problem considering multi-node time window differences with the objective of minimizing transport cost and transport time, and designed a non-dominated sorting genetic algorithm to solve the problem; Xu Suhui[28] constructed a mathematical model of the optimization problem of scheduling a rail-type container crane in a railway container centre station, and designed an adaptive neighborhood search algorithm to solve the problem. He Xun[29] studied the problem of scheduling optimization of synchronous transfer operations of container trains, constructed a mixed integer planning model with the objective function of maximizing the number of successful synchronous transfer containers, and designed a breakthrough local search algorithm to solve the problem. Sun Yujiao[30] studied the sequential scheduling problem of container terminal loading and unloading operations and constructed a mathematical model of the problem with the objective of minimising the completion time.

In summary, the current research direction on intermodal container transport mainly focuses on the railway container centre station, with less research on container terminals. In the research related to the container transfer problem of intermodal container terminals, the constraints such as the equipment crossover problem of the cold chain container transfer equipment at the service point of the container terminal and the remaining capacity of the cold chain container transfer equipment have not been taken into account.

2.3. Research Status of Order Picking Problems

This type of problem is usually solved with the objective of minimising the delay time cost and designing relevant heuristic algorithms. Order picking is a very complex, time-consuming and most critical logistics link in warehouse operations, and although picking may account for 60% of all labour activities and 65% of all operating costs in a warehouse, many picking problems are still not well handled. Therefore, there is a great need for an in-depth study of the order picking problem to improve order picking efficiency, shorten order fulfilment time, and reduce the operating costs of the company.

For the minimisation order problem, Henn[31] constructed a joint scheduling problem model for order batch picking with the objective of minimising the total delay time for a given set of customer orders, and designed the variable neighbourhood descent method and variable neighbourhood search method to solve the related problems. Then, Henn[32] constructed a mathematical model of the order batching problem with the objective of minimising the total order picking cycle time, and

at the same time designed two optimisation algorithms based on the principle of forbidden search to solve the problem, namely the classical forbidden search algorithm and the attribute-based mountaineer algorithm. Chen [33] constructed a joint order batching, sequencing and routing nonlinear model of the scheduling problem by designing a hybrid genetic algorithm to obtain an approximate solution for order batching and sequencing, and an ant colony algorithm to obtain the optimal order picking paths. Albareda and others[34] constructed a mathematical model of the order batching problem in warehouses with the objective of minimising the total order fulfilment time, and designed a heuristic algorithm based on variable neighbourhood search to solve the problem. Jason[35] constructed a mathematical model of the order picking problem with the objective of minimising the total order fulfilment time by taking into account the influencing factors such as shipping time and waiting time, designed a simulation software based approximation method to implement the heuristic storage allocation policy algorithm, and compared the average running time under different storage allocation policies. Qin Xin [36] constructed a mathematical model of the order batching problem with the objective of minimising the number of handling times, and designed a batching strategy based on a clustering algorithm to improve the efficiency of the picking operation. Xiao Ke and others[37] constructed a mathematical model of the order batching optimisation problem with the objective of minimising the sum of order delay time and picking time, and designed a heuristic seeding algorithm based on compound similarity to solve the problem.

Based on the research of order batching, many scholars try to study the sorting path problem in the order picking process. For example, Shizhen Li[38] who constructed a mathematical model of the order batching problem with the objective of minimising the distance of the travelling path, and designed a seed heuristic algorithm to obtain an approximate solution of the problem, which provides a reference value for the distribution centre and the distribution warehouse.

For the order batching problem, Kulak[39] have proposed an optimisation algorithm based on clustering algorithm. Unlike most picking path inspired, Kulak abstracted the picking path problem into a classical traveller problem and proposed the corresponding solution. Yanyan Wang [40] proposed optimisation methods such as first-come-first-served and genetic algorithm to optimise the picking path and order batching problems, which effectively reduced the order picking cost. Tang Niannian[41] launched the analysis from the two aspects of picking mode and picking operation, and constructed a mathematical model of the express mail assignment problem with the objective of the shortest total operation time.

Weidinger[42] defined the order picking path problem for a mixed-shelf warehouse, which is used by many e-tailers, and designed an improved genetic algorithm to solve the problem, but only considered the case of a single picker. In real-world warehouses, multiple pickers work in parallel, and they interact with each other to influence the shelves they visit and the inventory they retrieve from them. Zhao Lan[43] studied the order batching problem and constructed a mathematical model of the problem by considering the influencing factors of picking walking time and order picking time, and designed a genetic algorithm to solve the batching model to obtain the optimal batching results. However, the factors such as the picking task corresponding to each batch,

the preparation time corresponding to the picking task, and the waiting time between operations were not considered in this literature. GadeMann[44] investigated the problem of processing orders in batches in parallel aisle warehouses, and defined the problem as a set partitioning problem with the objective of minimising the total transportation time, and designed a column generation algorithm to solve its linear programming relaxation problem.

Comprehensively, the above literature shows that previous studies mainly focus on the order batching and picking path problem, but do not consider the subsequent order distribution problem. Order distribution is an important part of the logistics system, which needs to be distributed according to the type of goods, time and location.

2.4. State of the Art of Order Delivery Problem Research

The order delivery problem can be abstracted as an order delivery path optimisation problem. As early as 1959, Dantzig and others[45] proposed the vehicle path problem for the first time, and since then, the problem has received extensive attention from academia and the industry. Scholars at home and abroad have carried out in-depth research and analysis on the vehicle path optimisation problem from the theoretical and practical levels, and their research results have been widely used, such as supermarket distribution systems, shared bicycle systems, express delivery systems, school bus routing and so on. It is worth noting that the traveller problem has been proved to be an NP-hard problem, so the order delivery path optimization problem is also considered to be an NP-hard problem.

In recent years, Xia Yangkun[46] studied the vehicle path problem with soft time window restrictions, proposed an adaptive forbidden search algorithm to solve this problem, and designed the 'multi-neighbourhood structure' and 'adaptive mechanism' to improve the performance of the algorithm. Wang Dengqing[47] proposed an improved genetic algorithm to solve the logistics and distribution path problem with time windows in the new retail model. Ge Xianlong constructed a mixed integer planning model for the fresh order distribution problem by considering various influencing factors such as fresh loss and distribution distance, and designed an adaptive genetic algorithm to solve the problem. He Bingqian[48] analysed the actual delivery situation of the 'last mile' delivery link in the express industry, analyzed four factors such as loading and unloading mixing, dynamics, time window and capacity constraints, constructed a mathematical model of the express delivery problem, and designed an improved taboo search algorithm to solve the problem.

The research of vehicle path problem with time window is constantly deepening, and the multi-return vehicle path problem with time window has gradually gained the attention of scholars. Chen Ting[49] added constraints such as itinerant distribution and full direct distribution to the VRP problem, constructed a mathematical optimisation model for the problem, and designed a genetic algorithm to solve the problem. Liu Hong[50] people constructed a mathematical model of the multi-trip distribution problem with the objectives of maximum customer satisfaction and minimum transport cost, and designed a forbidden search algorithm to solve the problem. Based on this, Hong Liu[51] further constructed a mathematical model of multi-trip distribution problem with grey demand by constructing a grey-Markov

model to predict the grey demand of customers and designed a taboo search algorithm to solve the problem.

Exact algorithms such as column generation and dynamic programming proposed by Quandt[52] and others are algorithms based on strict mathematical planning. Although they cannot outperform AI algorithms in large-scale problem solving time, they can converge to an exact solution in a limited time. For example, branch pricing algorithms combine column generation algorithms with branch delimitation algorithms, including an important preprocessing phase, appropriate pricing implementations, and specialised branching strategies. Jie Wan-chen[53] and others constructed a mixed-integer planning model for the vehicle path problem of a multi-model electric vehicle, designed a branch pricing algorithm to solve the problem, and proposed two acceleration strategies to enhance the effectiveness of the algorithm. Shenglong Dai designed the branch pricing algorithm to solve the vehicle scheduling problem in the vehicle sharing system, and designed a two-way dynamic planning algorithm to improve the algorithm solving efficiency during the subproblem solving process. Wang Pei[54] designed branch pricing algorithm to solve the heterogeneous multi-vehicle piggyback delivery problem in reconnaissance satellite system.

From the above literature, for the vehicle path problem with time windows, most of the solution algorithms use artificial intelligence algorithms to find an approximate solution, and fewer use exact algorithms to solve the problem. Most of the scholars only studied the order delivery problem, which did not involve the analysis of the order picking operation before receiving orders, and failed to consider the problem as a whole. However, the above literature provides a theoretical basis and research direction for the distribution link of the order picking and distribution problem. In fresh food distribution, the mathematical model of the fresh food distribution problem will be constructed by considering the comprehensive factors such as the weight of the order, the vehicle capacity, and the customer's time window.

2.5. Research Status of Order Picking and Distribution Integration Problems

Regarding the integration problem of order picking and order distribution, there is less relevant literature at home and abroad. Wang Xuehui[55] constructs a joint optimisation model of order picking sequencing and distribution problem under new retail scenario with the objectives of minimum total order delay time, minimum default rate and minimum total cost of fulfilment, and determines the order picking and distribution strategy of new retail fresh product supermarkets by designing genetic algorithms. Christian[56] who combines the production scheduling and outbound delivery scheduling and considers the job-related factors such as processing time, delivery time window, service time and destination, constructed a mixed integer planning model with the objective of minimising the total delay, and proposed a genetic algorithm to solve the problem.

In the above literature, most of them abstract the order picking session as a parallel machine scheduling problem, without considering the practical situation where a sorter can pick multiple items at the same time. For example, Xuping Wang[57] proposed a joint picking and scheduling model with the objective of minimising the order fulfilment time, and designed a three-stage heuristic algorithm to solve the corresponding model. Pei Jun[58], on the other hand,

modeled the integrated production and transportation scheduling problem with the objective of minimising the span time and total transportation cost, and used a multi-objective hybrid intelligent algorithm combined with a relevant multi-attribute decision-making method to solve it, thus obtaining a better scheduling solution. Mao Zhang[59] constructed a mathematical model of the order batch picking and distribution optimisation problem with the objective of minimising the order fulfilment time by taking into account factors such as the dynamic arrival of orders, and designed a three-stage heuristic algorithm to solve the problem.

However, these studies analysed the order distribution problem in terms of batch distribution conditional on the delivery date, without considering factors such as multiple trips of vehicles and the relative distance of customers, which could not achieve the global optimum. Belo-Filho[60] built a mathematical model of the production and distribution problem of perishable goods and designed an adaptive large-scale neighbourhood search algorithm to solve the problem. Dan Liu[61] who analysed the processing flow of a fresh food supermarket, considered factors such as the known departure time of delivery vehicles, constructed a mathematical model of the online order batch picking problem with the objective of minimising the total order service time and the delay time, and solved the problem using the seeding algorithm and the saving algorithm. Kergosien[62] who investigated the production and delivery of medical goods in the context of chemotherapy in hospitals problem, constructed a mathematical model for the joint medical item production and delivery problem, and designed a heuristic solution based on the Benders decomposition, which makes it possible to solve feasible solutions and lower bounds.

In summary, there are fewer literatures that study the joint order picking and order delivery. Most of the literature does not start from the actual situation and does not abstract the order picking link as a parallel machine scheduling problem, nor does it abstract the order delivery link as an order delivery path optimisation problem, so it is difficult to achieve the overall optimality.

3. Conclusion

Through sorting out the literature, domestic and foreign research on fresh cold chain logistics transport and distribution mainly suffers from the following deficiencies:

(1) At present, the research direction on intermodal container transport mainly focuses on railway container centre stations, with less research on container terminals. In the research related to the container transshipment problems of intermodal container terminals, the constraints such as the equipment crossover problem of cold chain container transshipment equipment at the service points of container terminals and the remaining capacity of cold chain container transshipment equipment have not been taken into account.

(2) Most of the current researches focus on the problems of order batching and picking paths, and do not further explore the problems of subsequent order distribution. Meanwhile, for the vehicle path problem with time windows, most of the solution algorithms use artificial intelligence algorithms to find approximate solutions, and fewer use exact algorithms to solve the problem. However, the above literature provides a theoretical basis and research direction for the distribution aspect of the order picking and delivery problem. In fresh food distribution, the mathematical model of the fresh food distribution problem will be constructed by considering the

comprehensive factors such as the weight of the order, the capacity of the vehicle, and the time window of the customer.

(3) Currently there are fewer literatures that study order picking and order distribution jointly. Most of the literature does not start from the actual situation and does not abstract the order picking link as a parallel machine scheduling problem, nor does it abstract the order distribution link as an order distribution path optimisation problem, so it is difficult to achieve the overall optimum.

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