

Feasibility analysis of improving cargo storage efficiency through container "yard reservation"

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ABSTRACT: With the development of the national economy and the flourishing of the freight industry, the container freight industry has become the most popular standardized transportation method for goods in the world today. At the same time, with the increasing prosperity of global trade, container business has also made great progress. In order to solve the problems of congestion, low efficiency, and high container turnover rate in the yard, this article adopts literature review, field investigation, and causal analysis as the main research methods to study the current situation. It analyzes the development status, characteristics, and existing problems of port terminal yards, and explores the advantages and disadvantages of existing optimization solutions. This article summarizes the existing advantages and

disadvantages of port terminal yards, proposes the problem of high container turnover rate in port terminal yards, analyze and explore the feasibility of "container yard reservation".

KEYWORDS: Dock yard; reservation; container

I. INTRODUCTION

1.1 RESEARCH BACKGROUND AND OBJECTIVE

1.1.1 Research Background

Due to the many advantages of container freight, the cargo throughput of various countries will show certain growth in the next few years, but the growth rate will not be consistent. Table 2.1 shows the ranking and growth rate of global port container throughput in 2019 and 2020.

Table 1 Top 10 Global Port Container Throughput Rankings in 2019 and 2020^[1]

Ranking	Port name	2020 (10000 TEUs)	Year on year growth rate	2019 年 (10000TEU)	Growth rate
1	Shanghai Port	4350	0. 4%	4331	3. 1%
2	Singapore Port	3687	-0. 9%	3720	1. 6%
3	Ningbo Zhoushan Port	2872	4. 3%	2753	4. 5%
4	Shenzhen Port	2655	3. 0%	2577	0. 1%
5	guangzhou port	2317	1. 5%	2283	5. 7%
6	Qingdao Port	2201	4. 7%	2101	8. 8%
7	Port of Busan	2181	-0. 8%	2191	1. 1%
8	tianjin port	1835	6. 1%	1730	8. 1%
9	Hong Kong Port	1796	-1. 9%	1836	-6. 3%
10	port of rotterdam	1434	-3. 2%	1481	2. 1%

With the increasingly strong trend of global economic globalization, ports have become a link and bridge for regional economic development, as well as an important engine for promoting national and regional economic development. In a sense, a modern port is like a city.

It is not only a hub and transportation tool for goods import and export, but also a business card for the development of a city, occupying a pivotal position in the national economy.

1.1.2 Research objective

With the development of the container

industry, the management of container port yards and terminals has increased. In order to improve the operational efficiency of the terminals and reduce the time for ships to dock, container operations have become particularly important. Optimizing the space of the port terminal yard without delaying the process and effectively reducing the container overturning rate is the goal that every container yard needs to pursue.

The container throughput of Chinese ports has been continuously increasing, and major ports have established super large, highly automated, and efficient container terminals. Their design, construction, operation experience, and technology are all at the forefront of the world.

1.2 CURRENT RESEARCH STATUS AT HOME AND ABROAD

1.2.1 Research on the current situation of containers in the port yard

With the advancement and development of management technology, port container logistics is constantly moving towards modernization, specialization, large-scale, and intensification. In today's era of economic integration, international trade and cross-border operations are growing rapidly, and more than 90% of international trade needs to be completed through container shipping. Port container throughput is increasing day by day, which brings great challenges to the management and operation of hardware and software inside and outside the port. The main problem currently arising is the high container turnover rate caused by the lack of connection between operations inside and outside the port^[2]. The higher the container turnover rate at the dock, the lower the overall throughput capacity of the dock, the longer the average detention time of container trucks in the yard, and the more obvious the queue situation of container trucks^[3]. The rate of container loading and unloading is the main indicator to measure the severity of container loading and unloading problems at container terminals, usually expressed as the ratio of unloading operations to loading operations^[4].

1.2.2 Research on Optimization Scheme for Port Yard Layout

Zhao Zhongbin^[5] (2022) elucidated the necessity of optimizing the layout of container terminals and established a model of a 9-story staggered three-dimensional storage yard, demonstrating the container areas and positions in the layered yard; Taking the X container terminal yard as an example, He Jiwei^[6] (2018) conducted optimization research on the layout of the container

terminal yard, established an optimization model for the yard layout, and provided a model solving algorithm based on genetic algorithm for optimization verification results; Tian Bowen^[7] (2022) studied the coordinated allocation problem between berths and yards by comprehensively considering the mutual influence relationship between berth selection, ART (the main horizontal transportation equipment of automated container terminals) path, and yard container allocation. A mathematical model was established, and a genetic algorithm was designed to solve it, seeking the berth allocation plan and site allocation plan with the shortest ART travel path; Zhang Ning^[8] (2017) aimed at the current situation of high container turnover rate in Japanese ports, and obtained the optimal solution for container stacking on limited port land through operational research (OR), demonstrating the practical application of maritime container building simulation in warehouse simulation. The warehouse simulation results were obtained and verified; Zhou Pengfei^[9] (2013) proposed a method to optimize the allocation of unloading container slots and reduce the rate of container dumping in container terminal yards. Considering the random and uncertain order of customer container lifting, the method of using container group storage statistics to obtain the unloading container lifting order at the terminal was first explored, and a method for solving the unloading container dumping amount based on the lifting order was proposed.

II. DEVELOPMENT SITUATION OF DOMESTIC PORTS

2.1 ACCELERATED EXPANSION OF PORT SCALE

Against the backdrop of declining demand for external transportation, it is widely believed that domestic trade routes are the most popular, providing new opportunities for the development of inland ports. The local government's investment enthusiasm for ports remains high, mainly reflected in the expansion of large ports, the increase in the scale of small and medium-sized ports, and the relatively overheated construction of ports. There are indeed some reasonable factors that can meet the growth of market demand. However, too large a scale can also hinder future sustainable development. Therefore, for future sustainable development, there has been no scientific prediction of port expansion space, and blind conformity has occurred.

2.2 REPETITIVE CONSTRUCTION LEADS TO THE CONVERGENCE OF UNIVERSAL FUNCTIONS

Each port has not formed distinct characteristics, their scale is relatively small, and there is a certain degree of convergence in their functions, which will inevitably have a negative impact on the investment efficiency, competitiveness cultivation, and even safety management of the ports. This has led to a significant amount of duplication in the port, which is an important factor contributing to its emergence.

Therefore, ports also need to continuously optimize their own business structure, improve scale and efficiency, in order to not lag behind other ports. Of course, although there is a phenomenon of convergence in port functions, each port still has its unique positioning and service characteristics. In the development of the global economy and logistics, ports can seize opportunities for localization and leverage their advantages to gain competitive advantages and further consolidate their position and scale based on their own resources and market positioning.

III. LAYOUT OF PORT CONTAINER YARD

3.1 DEFINITION

The layout of port container yards refers to a way of storing and managing containers, mainly including the stacking, support, and fixation of containers. In this paper, it specifically refers to the process of container loading, unloading, storage, and management that occurs in the yard of a container terminal. Different layout methods can be adopted for different scenarios and needs. Container port terminals play a crucial role in the overall transportation of containers as a buffer zone between sea and land transportation and the intersection of the two major modes of transportation.

3.2 PROBLEMS IN THE LAYOUT OF PORT CONTAINER YARDS

(1) High stacking density in the yard: Due to limited yard resources at the dock, the stacking density is often high. If not managed properly, containers in the yard are prone to collapse, garbage falling into the boxes, and other problems, making it difficult to carry out yard management work.

(2) High container dumping rate: Due to the uncertainty of the arrival time of ships, there may be situations where the container lifting sequence does not completely match the initial stacking position, resulting in containers that need to be

unloaded earlier being pressed on the lower layer of containers that need to be unloaded later. Therefore, during the container lifting process, it is inevitable to perform container dumping, and even when the dumping location is selected improperly, it may cause secondary container dumping during subsequent container lifting.

IV. OVERVIEW OF "YARD RESERVATION"

4.1 DEFINITION

Container yard reservation refers to the process in which the shipper or its agent reaches an agreement with the yard management department in advance to arrange the handling, storage, and shipment of goods before they arrive at the container yard. This reservation system aims to improve the efficiency of cargo transportation, ensuring smooth handling and scheduled loading, unloading, and transportation of goods.

The specific content and process of appointment may vary due to yard management regulations, regional differences, and the nature of goods. It can effectively alleviate congestion in port yards, store more goods, improve the efficiency of goods storage, help improve the efficiency of goods management, reduce chaos, and ensure safety. Reasonable separation of cargo space can help improve the efficiency of port operations, reduce risks, and promote sustainable port management.

4.2 APPOINTMENT CONTENT AND PROCESS

4.2.1 Appointment Content

(1) Goods information: The shipper needs to provide detailed information about the goods, including the type, quantity, size, weight, value, etc. of the goods. These pieces of information help the yard management department accurately estimate the resources required for processing and storage. If the goods are transported in containers, it is usually necessary to provide the container number, size, type, and any special requirements during the booking process, such as whether refrigeration is required

(2) Shipment date and time: The shipper needs to provide the expected date and time of arrival of the goods at the yard. This helps to arrange appropriate human resources and equipment for the yard to handle goods in a timely manner.

(3) Special handling requirements: If the goods have special handling requirements, such as refrigeration, dangerous goods, fragile goods, etc., the shipper needs to clearly state them in the appointment. This can ensure that the yard can handle the goods properly as required.

(4) Loading and unloading requirements: The shipper may need to provide special requirements regarding the loading and unloading of goods, such as whether the yard needs to provide loading and unloading equipment or manpower.

(5) Safety and regulatory requirements: The shipper needs to ensure that the goods comply with relevant safety and regulatory requirements, and provide necessary documents and proof in the appointment, such as transportation permits, dangerous goods handling certificates, etc.

(6) Contact information: The shipper needs to provide valid contact information, including name, phone number, email address, etc., so that the yard management department can contact them to confirm appointment details or handle emergencies.

(7) Confirmation and notification: The yard management department usually provides the shipper with a confirmation letter or delivery note, specifying the specific arrangements and conditions for the appointment. The shipper needs to carefully read and confirm the reservation details, and communicate and coordinate with the yard management department when necessary.

By providing accurate and complete appointment information, shippers can ensure timely and safe handling and transportation of goods, while also helping yard management departments to arrange resources reasonably and improve transportation efficiency.

4.2.2 Appointment process

(1) Contact the yard management department: Firstly, the shipper needs to contact the management department or person in charge of the required yard. The shipper can contact them through phone, email, or online appointment system.

(2) Provide necessary information: During the appointment process, the shipper may need to provide some necessary information, such as the shipment date, container number, cargo description, quantity, size, weight, etc. Ensure the accuracy of the information provided by the shipper, so that the yard can accurately arrange the handling of the goods.

(3) Choose an appropriate appointment time based on the shipper's needs and the availability of the yard. It is best to make an appointment in advance to ensure that the shipper's goods can be processed within the required time.

(4) Confirm appointment: After confirming the appointment with the yard management department, ensure that the shipper has received the confirmation letter or delivery note. This can avoid any confusion or misunderstanding and ensure that

the shipper's goods can be processed and shipped according to plan.

(5) Comply with yard regulations: Different yards may have different regulations and procedures. It is important to understand and comply with yard regulations before making an appointment, which may involve specific document requirements, safety requirements, and communication with yard staff.

(6) Dishonest punishment: If one party fails to fulfill their appointment commitments or frequently violates appointment regulations, resulting in losses for the other party, different punishment measures can be taken based on the value of the losses for appointment dishonesty.

(7) Flexible response: Although the shipper has made an appointment, there may still be some unforeseeable situations, such as transportation delays, yard congestion, etc. Therefore, it is very important to maintain flexibility and communicate with the yard management department.

Through container yard booking, shippers and yard managers can better coordinate the handling and transportation of goods, improve the efficiency of the entire supply chain, and ensure the safe and timely arrival of goods at their destination. Taking into account these factors when placing container cargo can help ensure the smooth operation of the yard and generate positive social and economic benefits locally. In addition, optimizing the configuration of containers in the yard can improve stacking efficiency and reduce storage costs. The optimization of container configuration in the yard can also be achieved through reasonable stacking design, cargo classification management, container layout optimization, inventory control, and optimized facility selection. It can also be achieved through modular design of containers^[10-11], implementation of yard sharing strategies^[12], optimization of TPS truck scheduling systems^[13], and other optimization schemes to improve yard efficiency.

V. CONCLUSION AND PROSPECT

5.1 CONCLUSION

Since the implementation of 40 years of reform in China, container ports have always been driven by technological innovation to promote industrial development. They have gone through a difficult process of self research and development, introduction, digestion, absorption, and re innovation, cultivating a group of professional port technicians. The main technologies of several ports have made breakthrough progress, and the optimal choice of container warehousing methods has been

implemented. This has enabled us to make scientific and rational choices for the construction of port transportation and logistics, effectively organize port logistics, coordinate distribution, reduce container freight costs, and increase the attractiveness of ports^[14].

The operation of moving and returning upper level containers in order to retrieve them from the lower level of the port terminal yard is called container dumping, which can result in waste of time, labor, and cost, as well as damage to the cargo. The container loading and unloading process is a crucial step in port container ship loading operations, as well as container handling and transfer operations. The container loading rate directly affects the loading and unloading efficiency and container loading and unloading efficiency of the terminal, with a particularly significant impact on loading operations. Reducing the container turnover rate can help improve the ship's punctuality rate and plan fulfillment rate, reduce port loading and unloading costs, and enhance economic benefits^[15].

5.2 PROSPECT

The widespread involvement and development of container transportation are seen as a symbol of modernization in the country's cargo transportation, which also drives the development of port terminal container center stations. They are key nodes in multimodal transport and urgently need to accelerate their development pace, carefully consider the location sharing within container blocks, in order to improve overall container freight efficiency and meet the requirements of modern logistics^[16].

With the continuous deepening of globalization and the continuous development of container transportation, container ports and terminals, as important hubs of trade logistics, have increasingly broad development prospects, and container yards are also constantly evolving and developing. The main purpose of this study is to prepare for further in-depth research, therefore the exploration and analysis of the optimization plan for "yard reservation" still remain at the theoretical level.

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