

A New Yard Template Design for the Construction of Transshipment Container Terminals in China

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Abstract

In order to accelerate the construction of transshipment container terminal in Chinese mainland, and to strength our global competitiveness about container terminals, a design plan of container yard for transshipment hubs is explored, which is suitable to China's conditions and aims at Shanghai Port mainly. Considering the actual operation of transshipment in Chinese container terminals and overseas, a new yard template planning with mixed handling technology is proposed, which is appropriate for the container terminals located in Chinese mainland. An inbound unloading process model of proposed plan is built by eM-Plant, and the simulation result is analyzed to verify the feasibility and superiority of the new design plan. The exploration and design for transshipment hubs provide new thoughts and ideas for the container terminals development in China.

Keywords: container terminals, transshipment, yard template, handling technology, simulation

1. Instruction

In the past two decades, the global container trade has been rapid development, particularly in Asia. Container throughput of the top ten ports in East Asia grew by a near average of 20% annually. In terms of traffic level, 7 out of 10 biggest container terminals in the world are located in Asia. The competition among the container ports in Asia is increasingly fierce (Yeo, 2010). Up to being an international container hub is the next station to each large container terminals in China, especially Shanghai. Along with the recovery of international shipping and trade, as well as the development of Shanghai pilot free trade zone, Shanghai will pay much more attention on the construction of international economic, financial, trading and shipping center in the future.

There are three types of container activities: import, export and transshipment. According to the major activities performed in practice, container terminals can be classified into import and export terminals and transshipment hubs. All most all ports in China are the first type, except Hong Kong. In the ports of Singapore, Hong Kong, etc., the transshipment of containers is their primary business. About import, when vessels transfer containers from port of shipment to destination port, they are usually berthed relatively close to their storage in the yard. They have to be moored at the quay, where quay cranes (QCs) take containers off the ship and put them onto the internal transportations (ITs). Containers then are transferred to yard for a temporary storage. After receiving information about cargo, consignees will send external trucks to transfer containers out of terminal. The entire process is import activity and vice versa for export activity. The activity of transshipment gets rid of the subprocess transferred by external trucks. The transit containers are unloaded from one vessel. After a short time storage in yard, then be loaded to another destination ports. A schematic diagram of container activities is shown in Figure 1.

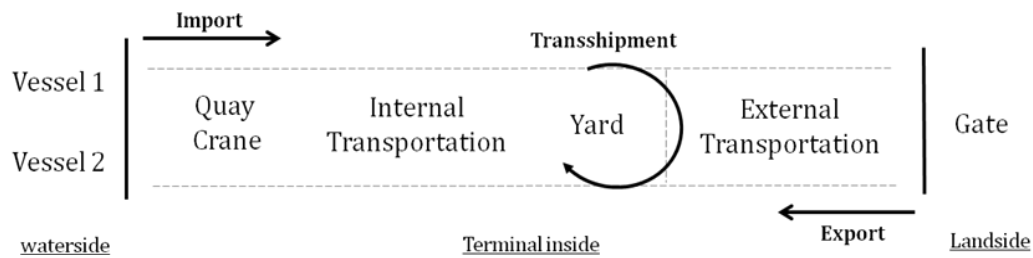


Figure 1. A Schematic Diagram of Container Activities

International transshipment port is usually called as a core position in international economic region of port groups and hub. How to turn Shanghai port to be an international transshipment port is an urgent problem. This is not only the need of the international shipping market development, but also the inevitable choice of enhancing the competitiveness among the surrounding countries in Asia. It is significant to make Shanghai port a success transition to a regional or even global core shipping center. This is our primary motivation for writing this paper. We sincerely hope that the exploration and design for transshipment hubs will provide new thoughts and ideas for the container terminals development in China.

This paper is organized as follows. Section 2 surveys on the relevant literature. Section 3 describes the problem existed in presented terminals when operating transit containers. Section 4 put forth a new design for transshipment hubs considering layout and operation. A simulation model is conducted in section 5 to verify the feasibility and finally section 6 concludes the paper.

2. Literature Review

A large number of researches about container terminals have been published on such topic as storage yard planning, terminal layout and yard resource allocation. The planning and controlling of container terminals has become a trendy subject in international academic research. A literature review about the container terminal yard storage operation was published, which described the terminal yard of the future trends and research direction in detail (Carlo, *et al.*, 2014). By focusing on the studies of technique feasibility and structure security, Zhang (2003) studied and designed for the yard of port from the point of design specification. As the main part of the container terminal, (Lin 2007) applied optimization technology and mathematic theory as well as methodologies to solve the resource allocation of container terminal yard. Furthermore, considering both the distance and the balance of all the workload, an objective programming under the rolling horizon approach is developed for outbound containers (Yan, *et al.*, 2009).

In the field of container terminals design and management, many researches proposed considered handling technology in the past years. Li (2010) established mathematical evaluation model of the container terminal layout and also developed a further research on handling technology and the new techniques. To improve the efficiency of port operation, Liu (2011) put forward not only to the handling technology innovation, but also to various intelligent production system supporting container terminals. Wang, *et al.*, (2006) then conducted a comparison between four efficient handling technologies for container terminals and finally concluded that the fully automatic handling technology system will be the key development orientation for modern container terminals.

Another import subject in the literature is the application of simulation optimization technology. It is often used for analyzing the behavior and the performance of container terminals. Wang (1987) has already applied simulation technology to the research on container terminals as early as last century. Later, a novel discrete modeling and

corresponding simulation system for the design of stevedoring technology scheme are proposed (Sha 2003). Except simulating the process of operation, simulation technology can also support the design of terminals. Zhong, *et al.*, (2012) proposed an improved stacking strategy and applied simulation software Flexsim to analyze the effect if different size. Zhang (2011) used the simulation software Witness to analyze a new handling process for bulk terminals simulation and built a simulation model about terminal technology system.

Summarizing the existing literature, we can find that the research about transshipment hubs is very little comparing with import and export container terminals. Zhen (2011, 2013) made large contributions in transshipment hubs, no matter under certainty or uncertainty. He developed an integer programming model for berth template and yard template planning in 2011. On the basis of the original research, in 2013, Zhen with his team work added the uncertain factors and put forward the yard layout and storage solutions with robustness, which is closer to actual operation. Due to the start-up development of transshipment hubs in China, the research on container transit terminals especially for China is much fewer. Wang *et al.*, (2010) put forward a new optimization model for solving transshipment port yard storage problem and Ding, *et al.*, (2012) gave out the selection model to solve the location problem for developing China's inland export transit port.

3. Problem Description

With the fierce competition between sea ports in East Asia, much more seaports in China mainland decide to broaden their business in order to improve their quality of service. Through increasing a significant throughput, it is important for terminals to strengthen their international competitive while drive surrounding areas to develop economics. International transshipment hub is always regarded as a core shipping center, so many container terminal operators get focus on transition service simultaneously. Operators are not only the thought, but also to do so. Taking Shanghai port as the example, with the policy support from government and the development of free trade zone, the volume of transit containers is increasing year after year.

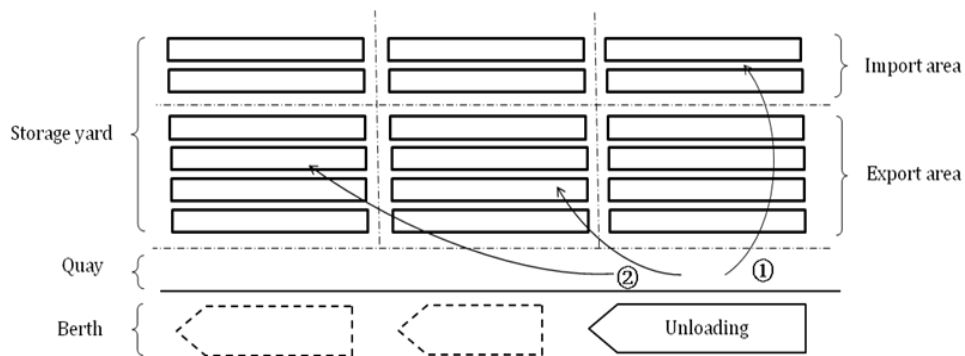


Figure 2. The Most Common Yard Layout in Chinese Container Terminals

However, the share of throughput going to transit containers is still in a low value. The reason of this situation is that almost all Chinese container terminals have still been keeping the conventional layout, shown in Figure 2. Storage yard is the area for stacking containers temporarily in terminals. It is always composed of two main segments, for inbound and outbound containers separately. Due to an exporting superpower of our country, export area is much bigger and closer to waterside than the import. Multiple rectangular blocks have position parallel to the quay and one yard crane usually serve one or more blocks. Internal trucks travel in the track lanes (shown as dotted lines) transport containers from quayside to back yard or reverse. After vessel arriving at a berth allocated

before, quay cranes are fully equipped for unloading. Internal trucks will move containers from this vessel to the nearest import area which has been arranged in previous yard planning.

This kind of configuration is really suitable for the past composition of shipping trade in China, while the introduction of transit will lead to a large number problem, such as route scheduling, storage space assignment and equipments dispatching. As shown the arrow lines in Figure 2, because there is no specific area for transit containers, they have little choice but to be sent to other areas. One destination of transit boxes is import area, the same as where import containers are planned to stack (as arrow line 1 in Figure 2). After completing the unloading process, the import area will be reshuffled to divide these two kinds of container. Redundant operations will not only generate additional transport costs, but also increase the load of equipments. Another destination is export area directly, dividing the containers from one vessel at the beginning of move (as arrow lines 2 in Figure 2). Then internal trucks should send different containers to different blocks, no matter near or far. Although to do so could avoid a certain process of reshuffle, it will still cause some troubles, such as the difficulty of vehicles dispatching and the waste of resources. Even more, the increase in complexity might influence the process of unloading and the turnaround time of vessel in port.

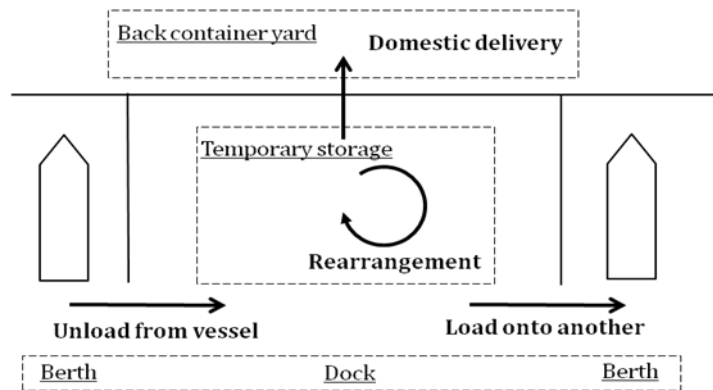


Figure 3. Operation in Singapore Port

Singapore, the most famous transshipment hubs on the world for unique location, has always been remarked as the core joint-point of global trade. 80 percent of containers handling there are transit boxes, so the terminals in Singapore have the most perfect operating system of transshipment. Here is one of the port operations in Singapore (Figure 3). Different from most marginal quays in China, convex quays are chose to build for larger ships. More than one ship can be handled on both sides of a convex quay at the same time. A dock between two opposite berths is arranged a special storage yard. The characteristic of its transshipment is that it is used to sort out the import ones and the transit ones. After unload process, the yard crane in this special place would do some rearrangement for those containers to separate them. Import ones will be sent into back yard by internal trucks and transit ones are waiting still there for loading to another ships (Gordon, *et al.*, 2005). In this way, it can not only simplify the scheduling of the trucks when doing unload process, but also quicken the speed of it to release berths as soon as possible for follow-up ships.

In spite of merits of the handling technology mentioned above, it still has some weakness. By comparing with conventional ones, import containers are handled one more times. This kind of handling technology would increase the burden of yard equipments and the energy consumption of the whole terminal. For transit ones, if the time between its loading and unloading is very short, the process, send it into the yard first and then pick it out, will create needless waste. They can move from the unloading berth to the

next one where their destination ship is docked. Smarter, greener and safer is the development trend of terminals. How to put forward a new yard template planning to satisfy the trend of our times and to accommodate the growth needs of our country. We should discard the dross and select the essence from today's equipments and technology and then create a subverted style terminal yard with new ideas. That is the purpose we always insist in later design.

4. Transshipment Hubs Design

4.1. Reclassification of Transit Containers

With the rapid development of container transportation these years, the machines, using in various aspects such as container ports, logistics, management, and ancillary equipment side, are put forward higher requirements. Because of the vigorous of the container transportation, the competition between ports is more and more intense. How to ensure the minimization of the time vessels stay in port and the maximization of handling rate has become a crucial factor for all terminal operators. After a comprehensive analysis of the existing port operation mode and the international excellent transshipment terminal above, this paper proposes a new kind of transfer mode. When designing a new transshipment terminal, we insist that the productivity of gantry cranes loading and unloading should be maximized in order to achieve the goal of shortest time in port. Finally we verify the feasibility and superiority of new design planning through comparing the efficiency of handling equipments and the whole system with conventional container terminals.

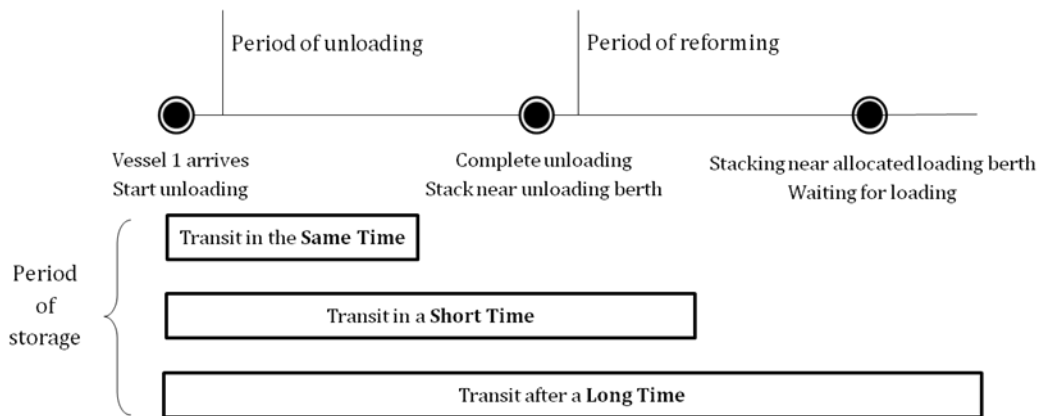


Figure 4. Proposed Containers Classification in New Yard Template Planning

In our design of new yard template planning, we present a new category of arriving transit containers. We classify them according to their storage period that internal time between two origin and destination ships, as shown in Figure 4. Here are three types of transit containers and they are called "same time", "short time" and "long time" for short respectively.

The "same time" transit container means internal time between two handling process is very short. It is shorter than the period of unloading. This kind of containers needs to be transferred to another berth, loaded to destination ship and ready to export immediately after unloading. There will be conflict-prone when they are planned to be sent to storage yard in discharging plan and to destination berth in loading plan at the same time period. The internal time of "short time" is a little longer than the one of previous. Their loading time is after the period of discharging before last ship, while it is before the time point of completing rearrangement. If this kind of containers is stacked into temporary yard with others and waiting for rearrange together, they may be planned to be transferred to new

berth to load before the complement of rearrangement. It really can be picked up from the storage yard while reforming, but the transportation and operation in such a small piece of area would be complexity. The last kind of transit containers is the most common one. The loading time point is after all processes, including the operation of unloading and reforming. Their destination ships will reach after such a long time.

4.2. Layout Planning of Terminal Yard

Considering the current situation of Chinese shipping trade, the new design of our yard template still remains the big-picture of conventional container terminals. As shown in Figure 5, from seaside to landside the infrastructures are, in order, berth, quay, marshalling yard, back yard, CFS, administration building and others. We can see that the main handling facilities are yard cranes, represented by black rectangles. The handling technology system of yard cranes has been proved to be the most suitable technology for China. Comparing with the system of trailer chassis, 4 to 5 tiers stacked by yard cranes can save the valuable land resources in container terminals effectively; comparing with the system of straddle carrier, lower cost in manufacturing, operating and repairing is much more attractive.

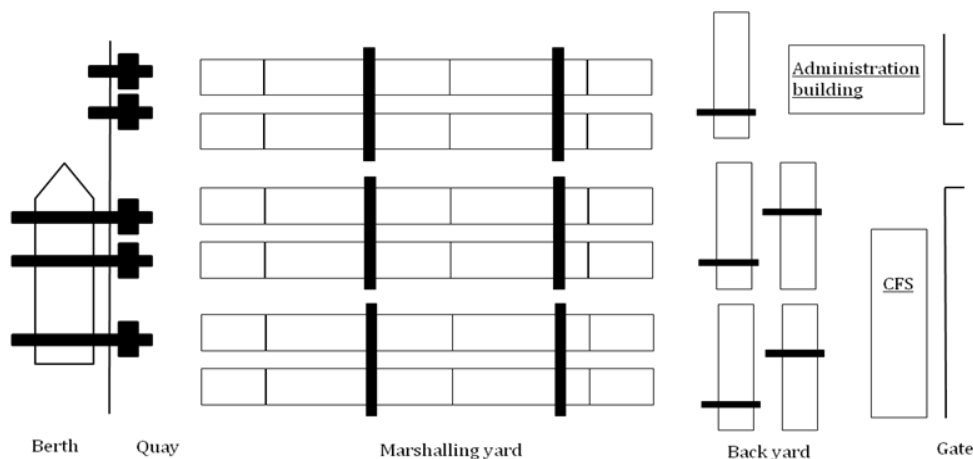


Figure 5. Vertical View of Yard Template Planning of Transshipment Hubs

The most striking difference you can see from the Figure 5 is the layout of marshalling yard. The storage yards close to seaside are filled in perpendicular to the sea, and the layout of back yard follows conventional one. The reason why we part terminal yard into two modules and use different layouts is that we consider the advantage of integration. Horizontal layout with rubber tyre gantries (RTGs) is familiar with Chinese container terminal operators. Its flexibility and effectiveness help it to be the most favorite stacking equipment in terminal yard. Vertical layout with rail mounted gantries (RMGs) is a new type of layout. It is widely used in European container terminal, especially in automated container terminals. The RMG, who can cross near 12 rows, owns higher capacity. Mounted in rails let it easier be automatic controlled. Considering the development trend of shipping trade and container terminal, we make a bold trial to design a new template. Seen the sectional view of this new template (Figure 6), a detailed function division is shown in it.

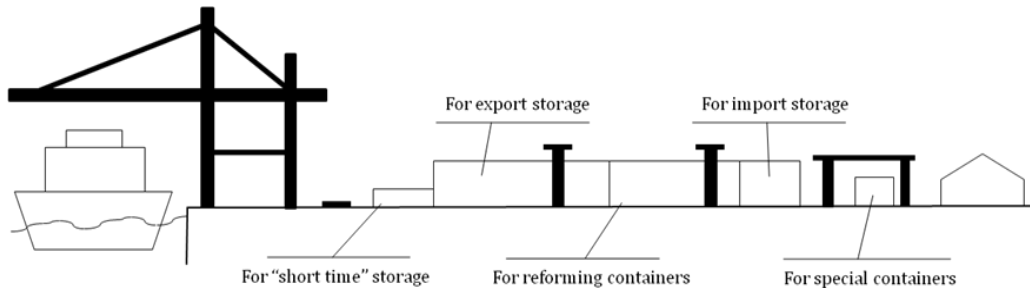


Figure 6. Sectional View of New Function Division of Transshipment Hubs

Due to transient internal time, the closest storage to quayside is used to stack "short time" transit containers. No matter pick from quayside or sent them to it, the short distance is conducive to transport quickly. Next to the "short time" storage is arranged a large stacking area for export containers, including domestic exports and waiting for transfer. We could not deny the fact that China is being and will have been a major exporter for a still long time. That is why we distribute the largest area to those who ready for shipment. Another large storage area is used for unloading containers, except "same time" and "short time" transit ones. Design of this area uses the experience of Singapore Port operation mentioned in Section 3 for reference. After unloading process, the equipments in this area are responsible for rearrangement. "Long time" transit containers are sent to relevant export storage which is near loading berth and import containers would be transferred to the area behind it. Import storage is close to landside and convenient for consignees receiving.

General containers, whatever import, export or transit, are stacked in marshalling yard. Besides, the back yard still retains for special container's temporary storage, including empty container, refrigerated container, danger goods container and so on. As "same time" containers are transited by horizontal transportation from berth to berth directly, there is no area for them. Just maybe a temporary parking area beside quay cranes for queue when the delivery of "same time" is too fast to load. It would be easily found that different storage owns different height because different handling technology is assigned to them. We give a detailed introduction in next sub-section.

4.3. Mixed Handling Technology Strategy

The efficiency work is the prominent advantage of the container terminal and the reasonable loading and unloading process design is the guarantee to improve the working efficiency of the port. Choosing a handling technology reasonable is the prerequisite of container terminal production operation. Every process system has the characteristics of their own, and they are different in the process, advantages, disadvantages and applicable wharf, as shown in Table 1. As the mixed system can bring the characteristics of each machine into fully play, enhancing advantage and avoiding disadvantage can make the whole system more reasonable and perfect. When designing for transshipment container terminals in China, we discard the conventional handling technology and create a new mixed one.

Table 1. Multiple Comparisons between Several Kinds of Handling Technology (E-excellent, G-good, A-average, P-poor)

| Compare in different fields | Handling technology based on straddle carriers | Handling technology based on yard cranes | Mixed handling technology |
|-----------------------------|--|--|---------------------------|
| Capacity of storage | G | E | E |
| Cost of investment | G | G | E |

| | | | |
|-------------------------------------|---|---|---|
| Difficulty level of technology | G | P | A |
| Efficiency of handling | G | G | E |
| Flexibility of equipments | G | P | A |
| Damage of containers | P | G | G |
| Cost of maintenance | P | G | A |
| Possibility of expansion | G | P | G |
| Adaption of automation | P | G | G |
| Convenience of multimodal transport | P | G | G |

Considering different characteristic of each type of containers, as the classification put forward in sub-section 4.1, we select different equipments to handle them, thus different kind of containers have different operation process. Different stacking equipments, straddle carrier, RTG and RMG, lead to the mixed handling technology using in this whole terminal. Due to the integration of old and new in our new yard template design, a part of operation still follows convention, for example the transit of special containers. Our paper focuses on the research of transit containers. We have proposed a new classification and storage distribution. Next, we elaborate several processes for transit containers, as shown in Figure 7.

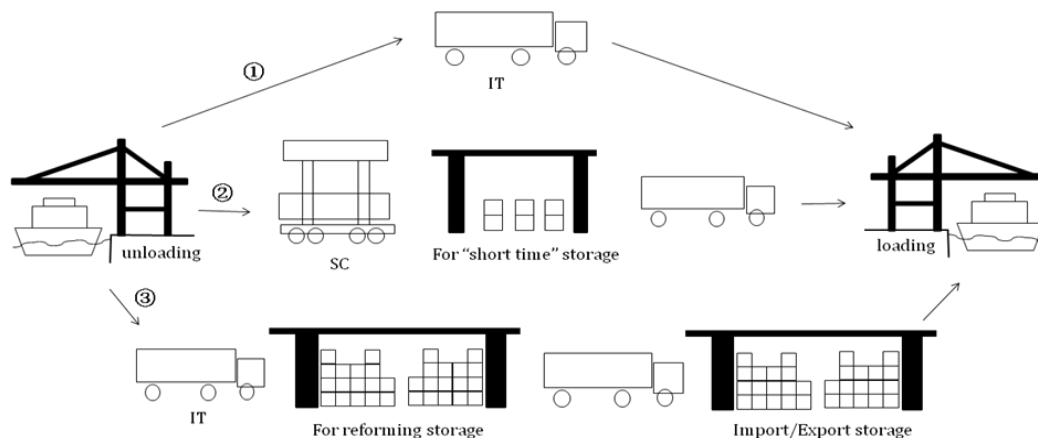


Figure 7. Operation Processes for Different Kinds of Transit Containers

On account of a much shorter time comparison with other kind of transit containers, internal trucks are scheduled to pick up "same time" transit containers from unloading berth in a particular time period and then sent them to corresponding loading berth. Theoretically, as the first process shown in Figure 7, as soon as internal trucks reach the loading area, the quay cranes on the loading berth handle the "same time" transit containers. If there is not enough time to operate export containers before, there will be a small parking area for temporary queuing.

Because of the speediness in transit containers from quay side to storage, we choose straddle carrier as the horizontal transportation in "short time" transit containers discharging process. It can save operation time effectively. The internal time between loading and unloading is short and uncertain, so it is essential for terminal operators to stack "short time" transit containers into storage as soon as possible. Then the subsequent process will not be influenced. Due to the high cost of straddle carrier's transport, we choose yard cranes in the loading process for this kind of transit containers. Internal trucks receive them and transport to destination berth, no matter close or far (shown as the

2nd process in Figure 7).

The last process shows that import containers and "long time" transit ones are all sent to reforming storage. Yard cranes accept them temporarily and then rearrange after the completeness of unloading. Through the process of reforming, different containers are transported to relevant storage by internal trucks waiting for next operation. "Long time" transit boxes would be stacked into corresponding export storage, where their next ships berth near the storage. Together with domestic exporter containers, be loaded into new vessels and shipped to next destination port. Import containers would be moved to import storage which is close to the reforming one. Consignees assign external trucks to container terminal and receive their cargoes.

5. Simulation Experiment

5.1. Simulation Modeling

According to the yard template planning put forward, the layout of the terminal is vertical arrangement, which is different from conventional container terminals in China. The interface of simulation is shown in Figure 8. Adapting to the new arrangement and large throughput of transshipment terminals, Rail gantry cranes are chosen to be responsible for the containers handling in yard. Due to the restriction on the rail, they are only allowed to move freely on the perpendicular to the direction of the wharf apron. Storage area for short time transit containers, export containers, long time transit containers and import containers are distributed one by one from quay side to hinterland.

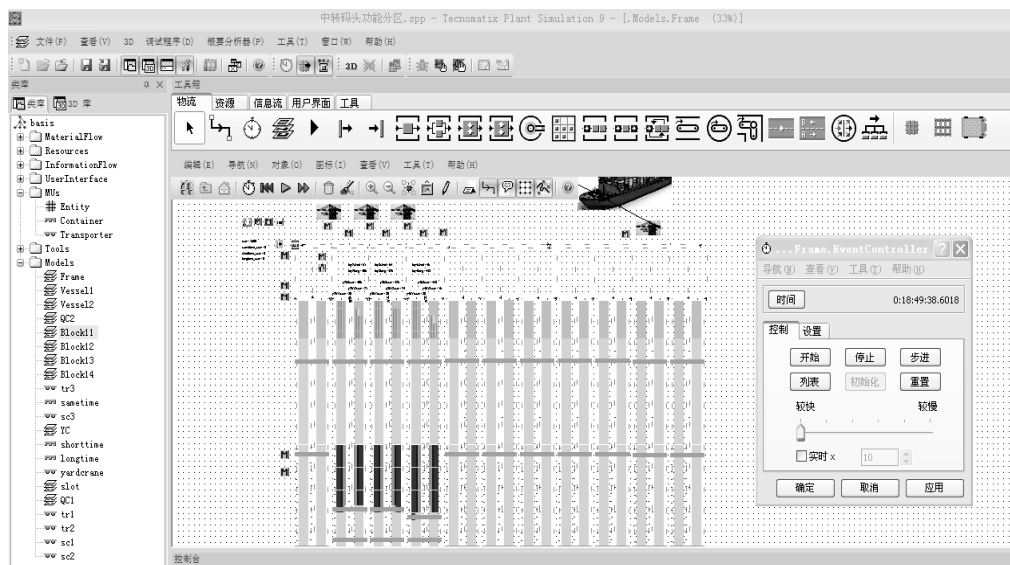


Figure 8. The Interface of Simulation

When designing the simulation model, it is important to balance the dependency between practical operation and abstract simulation. Simulation could not mirror the fact absolutely, so we always put simulations under a certain condition. The assumptions of simulation model in this article are as follows:

(1) Limited period hypothesis: The whole simulation time are segmented to several periods. The distribution of handling equipments at the end of last period is the initial conditions of the next. Turn the problem of infinite discrete system into finite discrete system problems.

(2) Always satisfy capacity: The randomly distributed jobs and operations are in a scope of the yard capacity. One or more handling equipments are always allowed to be allocated

for one job.

(3) Information completeness hypothesis: All the information of equipments resource and allocation decision are complete, certain and known.

Several assumptions above guarantee the execution of simulation. Then we program codes for this proposed planning to check the performance. According to yard operation of the business flow diagram and the layout plan of yard, the yard resource allocation simulation model is divided into the following modules according to their function, shown in Table 2.

Table 2. A Brief Introduction of Different Types of Simulation Module

| Type of Module | Function | Including |
|--------------------------|--|---|
| Layout module | Show the new layout of yard template planning, the rough size and relative location of each divisions. | Berth, quay side, transportation lanes, handling equipments, different kinds of block and other construction facilities. |
| Generation module | Produce relevant containers and horizontal transportation, according to certain time interval distributions. | Attributes of containers: origin, type, size and volume; attributes of transportation: type, speed, routing and destination. |
| Cranes operation modules | Control and display the handling process of QCs and YCs dynamically. | Main working parameters of cranes, and certain rules of lifting or loading container from ships or to storages. |
| Yard storage module | Dynamically display the usage condition of yard storages, and show the occupancy rate directly. | The number and location of yard cranes allocated to each storages, and the number of slots for different kinds of containers in them. |
| Output & Analysis module | Output the results of simulation and present reports about production performance parameters. | Summarization of the key input parameters, performance of handling equipments and the whole system. |

5.2. Statistical Parameters

As an important part of Shanghai's first port, Yangshan deep-water port, both in the location and logistics aspects, the development to the international transfer function is the inevitable choice in the future which has a long-term significance to promote the construction of Shanghai shipping center (Fei, *et al.*, 2014). The data of the simulation experiment is on reference of the layout of the third phase of Yangshan deep-water port to determine the corresponding terminal quay berth length, depth and size of the container area. Making assumptions of the Loading and unloading capacity of ship and the order and configuration level transport numbers of the quay crane. Each length and capacity of the area is determined by the percentage of each type containers. Mechanical parameters is the average according to the relevant literature, as shown in Table 3.

Table 3. Series of Basic Parameter about Wharf, Vessel, Handling Sequence and Equipments

| Parameters about | | Details | | | | |
|------------------|----------------|------------------|-----------------------------------|----------------------------------|-------------------------------|------------------------------|
| wharf | Length | Depth | For short time transit containers | Block size (600) | | |
| | | | | For export containers | For unloading containers else | For import containers |
| | 264+182+282 | 80+600 | 60*60 | 60*180 | 60*300 | 60*60 |
| vessel | Container size | Shipping ability | Import containers | Percent of container type (100%) | | |
| | | | | Same time transit containers | Short time transit containers | Long time transit containers |
| | 40' (12*2*2) | 50,000 DWT | 30% | 3% | 22% | 45% |

| equipments | | Quay cranes | Yard cranes | Internal trucks | Straddle carriers |
|-------------|--|--------------|----------------------|-----------------|-------------------|
| Number | | 3 QCs/Vessel | 3 YCs/Vertical block | 4 ITs/QC | 2 SCs/Vessel |
| Performance | | 2.5 min/TEU | 2 min/TEU | 8.3 m/s | 4.8 m/s |

The number of slots in the ground results the size of each storage yard. According to the parameters given above, the number of slots in the ground can be defined by the formulas below.

$$E_y = \frac{Q_h t_{dc} K_{BK}}{T_{yk}} \quad N_s = \frac{E_y}{N_1 A_s}$$

N_s means the number of slots in the ground. E_y , the major variable to calculate N_s , means the required capacity in one container terminal. Q_h stands for the annual amount of one container terminal (TEU); t_{dc} stands for the average storage period of arriving containers (d); K_{BK} means the unbalanced coefficient of container storage yard, the value range is 1.1 – 1.3, and the value range of working days of it T_{yk} is usually between 350 to 365 days. After getting the value of required capacity, with the tiers one type of stackers can handle and the utilization factor of one storage yard, the number of slots in the ground can be finally worked out. These two variables are represented by N_1 and A_s separately.

Except the basic parameters, we also calculate different transport time of different horizontal vehicles, straddle carrier goes into the different bay and rail gantry crane stacks containers into different rows and tiers. The stacking time of the straddle carrier includes in-time, storage period and out-time. The stacking time of the rail gantry crane includes suitcase, driving into the booked rank, releasing and driving into the rail. The specific calculation results are shown in Table 4 and 5.

Table 4. Different Operation Time of Each Container Stacked to Different Slot by Straddle Carrier

| Position | Number of rows based on quay side | | | | | Position |
|----------|-----------------------------------|---------|---------|--------------|-----------------|----------|
| Quay | 1 38 | 2 41 | 3 44 | 4 47=50-3 | 5 50=1+24+10 | Yard |

Table 5. Different Operation Time of Each Container Stacked to Different Slot by Yard Crane

| Position | Number of columns based on truck lane | | | | | | Position |
|----------|---------------------------------------|-----------|-----|-----|-----|-----|----------|
| | 120 | 118 | 116 | --- | --- | --- | |
| | 104 | 102 | 100 | 98 | --- | --- | |
| Rails | 88 | 86 | 84 | 82 | 80 | --- | Lanes |
| | 72=56+1*16 | 70 | 68 | 66 | 64 | 62 | |
| | 56=4*2+8*2 | 54=56-1*2 | 52 | 50 | 48 | 46 | |

5.3. Result Analysis

Due to the design in our paper focusing much on unloading process, we only simulate the containers transferred from quayside to storage or another berth. According to the model established and parameters set before, after near 20 minutes, the vessel is completely unloaded and all containers have been send to their destination separately. As shown in Table 6, 3 quay cranes are assigned to this 50,000 DWT vessel and the efficiency of them is about 27 move/h. The number of horizontal transportation use in our system is very qualified. Although we distribute 4 internal trucks for each QC, one truck is enough to cooperate with one QC under our assumption.

Table 6. The Result of Simulation

| Operation time | Number of quay cranes | Move times each QC each hour | Number of horizontal transport each QC |
|----------------|-----------------------|------------------------------|--|
| 0:18:49:38 | 3 QCs | 27 move/h | 1 Truck/QC |

In addition, on the basis of the successful experience for 50,000 DWT vessel, we decide to do more simulation on different size of vessels. From 10,000 DWT to 150,000 DWT, we appropriately change some parameters according to design standards and do another 6 simulations to find the relationship between terminal efficiency and size of vessels. Results are shown in Figure 9. Although general trend is always growing, some phenomenon can still be found by comparing the data between actual and simulation. And conclude which terminal is much more suitable for the construction of transshipment template.

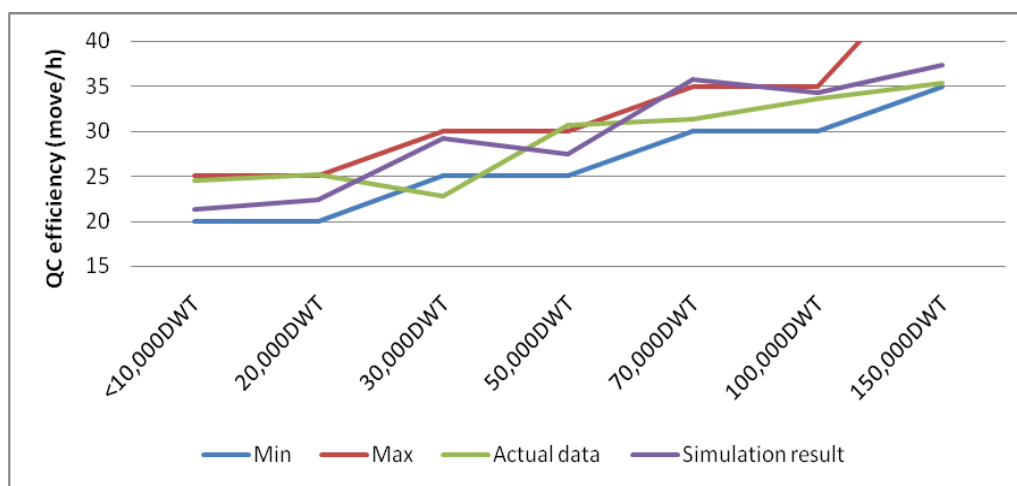


Figure 9. Compare QC Efficiency between Data Range, Actual Data and Simulation Result

The red and blue lines in Figure 9 represent the data range of QC efficiency corresponding to different size of vessels generally. The red means the maximization of its range and the blue one means the minimization. The value in this area between this two broken lines is desirable. The green line shows the QC efficiency in actual operation and the purple shows the results of several simulations. The comparison between these two lines shows that when vessels are relative small (<30,000DWT), the result of simulation is not very satisfying. But it behaves better than actual data when the size of vessels is larger. That is because the different treatment we design for each kind of containers. If vessel is small, that means the container it ships are relatively less. The number of containers distribute to each types is still a small number, so the advantage of new design does not play an important role in that situation. Only there is a large number of transit containers unloaded, then the inadaptation of conventional process will be appeared. This result proves our design of transshipment container terminal conforms to the trend of times. In future, vessels will be larger and larger to meet the need of global trade.

6. Conclusion

The time used in uploading is a main indicator to measure the efficiency of the terminal. In the paper, a new layout and operation pattern have been designed by referencing the survey of the situation of Chinese terminals and the excellent case of the foreign terminals. Taking the relevant data of the Yangshan port in Shanghai, a analogue simulation has been

made to prove the effectiveness and operability of the scheme and hope to provide the new thought for the transformation of Chinese port and the development of the Shanghai Free Trade Zone. In future, vessels will be larger and larger to meet the need of global trade. Our design of transshipment container terminal not only conforms to the reality of China, but also complies with the trend of times.

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