Analysis of the operation mode of combined transport of railway and water on containers

Xiangru Menga
Shandong Weihai Institute of Foreign Affairs, 264504 Rushan Silver Beach, China
a Corresponding author: mxr6465201@126.com

Abstract. Combined transport of railway and water is a combined transport mode carried out by railway and water transport enterprises. As a part of the comprehensive transport system, the combined transport of railway and water is a transport service system composed of two modes of transport: railway and water transport. This paper expounds the relevant concepts of the combined transport of railway and water, analyzes the main economic subjects and institutional framework of the combined transport of railway and water. This paper emphatically analyzes the direct pickup mode of the combined transport of railway and water and the storage mode of the combined transport of railway and water.

1. Introduction
There are two problems in China's railway and water combined transport: one is that the railway line cannot be seamlessly connected with the pier, which leads to the need for lightering and transportation in every transfer, which increases the logistics cost and labor force. Secondly, the two modes of transport have different transport documents. For waterway transport, waybill and bill of lading are used, while for railway transport, waybill and bill of lading are used. As the form and function of transport documents are quite different, the waybill must be filled again for each connection of goods. All these problems lead to the low efficiency of the operation of the combined railway and water transport.

2. Related concepts of combined transport of railway and water
Railway and water transport as the main mode of transport, and other modes of transport assisted by cooperation to complete the spatial displacement of goods, this mode of transport is called railway and water combined transport. The entities of the railway and water transport service mainly include transportation enterprises (railways, water transport, ports, highways), transportation operators (agents), and relevant government regulatory departments (first customs, third inspection, etc.). The transportation process is shown in Figure 1.
3. Main economic entities and institutional framework of the combined transport
All departments, enterprises and government agencies in the whole transport link jointly constitute the railway and water intermodal transport system. Each part, under certain organization and management, adopts relevant technical equipment and facilities to complete the designated transportation tasks through certain operation mode. The main economic entities of the combined transport of railway and water include Shippers, Mainline transporters, Ports, Operators (Freight forwarders) of the combined transport of railway and water, and Government agencies.

3.1 The owner
The owner of the cargo, that is, the demander of the combined transport mode of railway and water, refers to the shipper and consignee, which are generally in the first and last link of the combined transport chain of railway and water.

3.2 Main line transporters
The main line transporters mainly include railway enterprises, shipping companies and shipping companies, which usually have relatively large transport capacity. They are the main carriers in the combined transport of railway and water, and are responsible for the transportation from Port (Station) to Port (Station).

3.3 Port
Port is the connection port of various transport modes, which plays the role of loading, unloading, handling or transfer of cargo in the combined transport of railway and water.

3.4 Combined transport operator of railway and water (freight forwarder)
To carry out the transportation business in the transportation sections such as water and land, it is necessary for someone to organize, arrange and coordinate the whole transportation of the goods, and sign the transportation contract with the cargo shipper, that is, the operator of the combined transport of railway and water.

As a general rule, a combined railway and water operator may be the actual carrier or port enterprise involved in a particular section of transport or may be the operator who does not participate in the actual transport. The operator of combined railway and water transport refers to himself or any person who enters into a contract of combined railway and water transport through his or her representative. It can be seen that the railway and water combined transport operator is an independent legal entity, and its identity is a carrier with contractual responsibility to the owner (shipper) [1]. Generally, consignor can be divided into two categories according to the client. One is to find the operator of transport capacity for the owner of the cargo, and the other is to find the operator of source of goods for the transport enterprise, such as the agent of railway company, Ship company.
3.5 Government agencies
For the container railway and water intermodal transport, the customs department, the quarantine department (One Customs Three Inspection) are the main participating government agencies. The Customs is responsible for the collection of import and export duties, customs clearance of goods, the collection or refund of value-added tax and the statistics of import and export trade. Inland customs declaration needs customs escort, customs clearance dock check. The health and quarantine bureau belongs to the field of public health, carrying out health quarantine on import and export goods, transport equipment, ships, etc. The import and export commodity inspection bureau belongs to the ministry of foreign trade and economic cooperation and is mainly responsible for the inspection of import and export commodities. The bureau of animal and plant inspection is affiliated to the ministry of agriculture and is responsible for animal and plant quarantine [2]. The relationship between the parties is shown in Figure 2.

Figure 2. Relation schema of each department

4. Direct pickup mode of container railway and water combined transport vehicle
4.1 Layout form of vehicle and ship direct access mode
When the cargo of container railway and water combined transportation has high requirements on timeliness, and the customer demands to realize the replacement between railway and waterway transport modes as soon as possible, the replacement of container cargo between train and ship can be realized directly when operating conditions permit, which is often referred to as "direct pickup" mode. Generally speaking, there are two kinds of direct transport modes. The first port adopts the forward layout, and the bank bridge is used to replace the containers between the ship and the train. At present, most container ports in China are the "direct access" mode of rear layout, and the operation process of this mode is analyzed below [3].

4.2 The "direct access" mode of the layout in the latter mode
In this form of port layout, the replacement work between the ship and the train needs to be carried by horizontal transport equipment with the shore bridge, track door crane. For imported containers: (1)
the container ship stops at the berth, the bank bridge runs to the designated position, and the container is unloaded from the ship; (2) the container is loaded on the shore bridge when the container is under the shore bridge; (3) the container is transported to a specific loading position in the railway operation area by the container collection card; (4) the container is unloaded from the collection card by the track door crane running to the loading position; (5) the container is hoisted to the designated position on the train by the track door.

For export containers: (1) the railway container train stops at the loading and unloading line in the railway operation area, and the containers are unloaded from the train by the track door crane at the designated unloading position; (2) the container is hoisted by the rail door and loaded onto the rail card when the container is hoisted by the rail door; (3) the container is transported by the container truck to the designated shipping position on the port front; (4) the container is transported to the designated position on the bank bridge and unloaded from the container truck; (5) the containers are loaded to the designated position of the ship by the shore bridge. The job flow is shown in Figure 3.

![Figure 3. Working flow chart of the straight fetching mode](image)

The whole process of loading and unloading operation is easy to operate, realizing seamless connection of loading and unloading operation. This effectively saves manpower and material resources for loading and unloading operations, and shortens the horizontal transportation distance, which is conducive to improving the efficiency of loading and unloading operations. Due to the mismatch of container loads between ships and trains, as well as the inconsistency of arrival time and loading and unloading plan for vehicles and ships, this operation mode has not been widely adopted in China for the normal operation of the entire loading and unloading system.

5. Storage mode of container railway and water combined transportation yard

5.1 Types of storage modes in the yard
Due to the mismatch between the container load of the ship and the train, and the inconsistency between the arrival time of the ship and the train and the loading and unloading plan, it is more effective to store the containers in the yard. Therefore, the current storage mode of the yard is the mode adopted by most of the ports in China in the railway combined transportation.

Generally speaking, the storage mode of the yard can be divided into two modes: the first mode generally adopts the combined operation mode of railway and water with port layout as the latter mode, and the second mode adopts the combined operation mode of railway and water with port layout as the remote mode. The horizontal transport distance of container trucks and the use of storage yards are the main differences between the two operation modes.

In the first mode, the horizontal transportation operations are usually performed by container trucks within the port because of the relatively close distance between the railway operation area and the port operation area, while in the second mode, the horizontal transportation operations are usually performed by container trucks outside the port. In addition, the port storage yard is the first kind of main storage yard, while the railway storage yard and the port storage yard can be the second kind of storage yard. In the far way layout, rail and water transfer between operation due to the railway station and port are far apart need a road to complete, this model compared with "transport straight take" model, the model adds external set card transport links, also increases the whole loading and unloading operation of transportation cost and time cost, and does not facilitate the molten railway intermodal overall coordinated management. Due to the involvement of external container trucks, the whole operation process is more like the joint of "waterway - highway" and "highway - railway", which is not as close as the "direct access" mode.

5.2 Operational process of post-port layout

This stacking operation mode increases the use of facilities compared with the "vehicle and ship direct access" mode, which is mainly composed of two links: ship and yard, yard and train. The operating process of the storage mode of the container railway water combined transport yard is shown in Figure 4[4].
Figure 4. Flow chart of stacking mode

For imported containers, the containers arriving at the port are unloaded by the shore bridge, transported by the container truck to the storage yard, and then stowed by the yard crane. When loading, the container is transported from the storage yard to the railway operation area by the container truck. The specific operation procedures of "ship-yard" and "stack-train" are as follows:

(1) Operation process of ship-yard:
   ① The container is unloaded from the ship on the shore bridge running to the designated location;
   ② The container trucks are transported to the container trucks under the bridge;
   ③ The container is transported by the container truck to a specific location in the storage yard;
   ④ The container is unloaded from the container truck by the field crane which moves to a specific position;
   ⑤ The container should be lifted to a specific position in the storage yard.

(2) Operation process of stack-train link:
   ① The container is lifted from the storage yard by the field crane which runs to a specific position;
   ② The container is hoisted on the container truck when the container is loaded on the container truck.
   ③ The lifting containers are transported by horizontal container trucks to a specific location in the railway operation area;
   ④ The container is unloaded from the container truck by the rail door crane;
   ⑤ The container is lifted by the rail door to a specific loading position on the train.

Operation process of export containers: Firstly, the containers served by the train are unloaded by the rail door crane, then transported by the container truck to the storage yard, and then stowed by the yard crane. When loading, the containers are transported from the storage yard by container trucks to the front of the dock[5].
6. Conclusion
In conclusion, the two modes of combined railway and water transport have their own characteristics. The "direct access" mode of loading and unloading is more efficient, and various facilities and equipment are more closely connected. However, the arrival time of vehicles and ships cannot be determined and there is no detailed coordinated management plan, so the cargo needs to be processed in the yard for further transportation. In China, the operation mode of the storage yard is more suitable for the situation that the policies and regulations related to the combined transport of railway and water are not perfect and the management level is not very coordinated.

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