

# Discussion on Related Technology of Railway Piggyback Transportation Equipment Based on Intermodal Transportation



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## Abstract

This paper combines the country's policies and industrial layout to encourage the development of intermodal transportation, and briefly analyzes the main equipment of intermodal unit transportation and railway piggyback wagon in my country, and conducts comprehensive research and analysis on related technologies.

**Keywords:** intermodal transport, railway equipment, piggyback wagon

## 1. Background

Under the strategic background of accelerating the construction of modern logistics industry and comprehensive transportation system in the country, intermodal transportation can give full play to the overall advantages and combined efficiency of various transportation methods, and provide seamless door-to-door services for cargo owners, which represents comprehensive The direction of transportation development. Accelerating the development of intermodal transport in my country is not only an important way to improve logistics efficiency, reduce logistics costs, and promote structural energy conservation and emission reduction in integrated transportation, but also a fundamental requirement for deepening the reform and development of transportation and promoting economic transformation and upgrading. As an important method of intermodal transportation, piggyback transportation is carried out by road vehicles or hoisted to the piggyback vehicle to realize the connection of roads and railways. It has the characteristics of economy, energy saving, environmental protection, safety and reliability, and has good social and economic benefits. . Therefore, the development of piggyback transportation is of great significance to the promotion of intermodal transportation in my country.

## 2. Main equipment and technical characteristics of China railway piggyback transportation

Our country's railway equipment manufacturing enterprises have carried out the research and development of railway piggyback transportation equipment. For the transportation of whole vehicles and semi-trailers, we have successively developed and completed a variety of piggyback transportation railway equipment, laying the foundation for the construction of a

high-start piggyback transportation equipment technology innovation system. At this stage, the main types of piggyback transportation equipment in my country are: self-loading and unloading, hoisting, and road-rail dual-use.

**2.1 Self-loading vehicle**

The self-loading and unloading piggyback transportation equipment mainly includes the QT1, QT2 and X5 models developed for the National Railway Group, and the STX1 and STX2 models developed for the National Energy Group. Among them, QT1, QT2, STX1 and STX2 all rely on the drive of on-board equipment, while the X5 relies on the drive of ground equipment.

**1) Vehicle-mounted device-driven**

The vehicles are equipped with 2 vehicles as one group, and joint connectors are used between the vehicles. The underframe of the vehicle body is a concave bottom structure, which can be driven by the hydraulic and electrical systems of the vehicle to achieve a single-ended swing out, and it is flush with the hardened railway ground to realize the roll-on and roll-off of road trucks or semi-trailers. All vehicles are suitable for the transportation of road trucks and semi-trailers. Among them, STX1 and STX2 piggyback vehicle are equipped with container locking devices on the body to increase the container transportation function. Due to the complex structure of the hydraulic, electrical and transmission devices of the vehicle, it is more difficult to maintain than traditional railway vehicles, but the cost for the station are lower.



**Figure 1-QT1 type piggyback vehicle**



**Figure 2-QT2 type piggyback**



**Figure 3-STX1 piggyback vehicle**



**Figure 4-STX2 piggyback vehicle**

**2) Ground equipment driven**

The X5 type piggyback vehicle is in the form of a bicycle. The truck has a concave bottom load-bearing structure, which is mainly composed of a concave bottom frame and a pallet. The vehicle does not need to be equipped with hydraulic and electrical systems. It lifts and rotates the pallet through ground equipment, and at the same time cooperates with the high platform to realize the self-loading and unloading of road trucks. The structure of the vehicle is simple, but it has high requirements on the station yard, and a dedicated line and supporting facilities are required..



**Figure 5 X5 piggyback**

## 2.2 lifting type

The lifting type piggyback transportation equipment mainly includes the STX3 and STX4 developed for the National Energy Group. The STX3 type realizes loading and unloading through auxiliary pallets. The road truck first drives to the pallet by itself. After the tractor is separated, the pallet and the road semi-trailer are loaded onto the vehicle at the same time by the crane. The STX4 type is suitable for loading a lifting semi-trailer. The semi-trailer is equipped with a lifting interface on the body, and the semi-trailer can be directly lifted to the vehicle by the crane. Both two types vehicles underframe adopt the concave bottom load-bearing structure, and both are equipped with container locking devices, which have the function of container transportation. This type of vehicle has a simple structure, low vehicle manufacturing cost, and low requirements on the station. The loading and unloading operations can be completed by a reach-stacker or a gantry-crane.



**Figure 6-STX3 piggyback vehicle**



**Figure 7-STX4 piggyback vehicle**

## 2.3 Road-rail type

By learning from the technology of road and rail vehicles in the United States and taking advantage of the economy of rail transportation and the flexibility of road transportation, my country has developed road-rail vehicles. Vehicles are converted and transported between road and railway through the air suspension of road semi-trailers. Semi-trailers and bogies are connected and arranged to run on the railway. Disconnected from the connection, they become ordinary semi-trailers and run on the road.



**Figure 8-Road-rail vehicle**

## 2.4 Technical characteristics

Based on different loading and unloading technologies, the involved vehicle structure, manufacturing cost, loading and unloading efficiency, and station facilities are different. The

technical comparison and analysis of several kinds of piggyback transportation equipment are as follows:

- 1) Vehicle-mounted device-driven and Ground equipment driven piggyback transportation have the highest loading and unloading efficiency and are suitable for point-to-point automated loading and unloading transportation, but the vehicle structure is complex and the initial investment cost is high;
- 2) Lifting type piggyback transportation has high loading and unloading efficiency, simple vehicle structure, low vehicle and station investment costs, and is suitable for point-to-point transportation in stations with lifting equipment;
- 3) Road-rail piggyback transportation, the vehicles can be transported on both roads and railways. Therefore, the car body needs to be equipped with interfaces that connect road tractors and railway bogies, and the vehicle structure is relatively complicated. , Suitable for road-rail integrated transportation.

**Table 1 Comparison and analysis of piggyback transportation technology**

Driving mode	Type	Vehicle structure	Vehicle manufacturing cost	Handling efficiency	Station construction cost
Vehicle-mounted device-driven	QT1, QT2, STX1, STX2	Complex	High	High	Lower
Ground equipment driven	X5	Simple	Common	High	High
Lifting type	Stx3, Stx4	Simple	Low	Higher	Low
Road rail type	Road rail vehicle	Common	Common	Common	Lower

### 3. Discussion on relevant technology of railway piggyback transportation equipment

Through the absorption and transformation of mature technologies in Europe and the United States, my country has formed a variety of technical models of railway piggyback transportation equipment. However, the development of piggyback transportation is a systematic engineering, not only railway equipment, but also elements closely related to piggyback transportation, such as carrying units, supporting station facilities, etc., are also related to the development of piggyback transportation. Therefore, it is necessary to analyze the key technologies from the perspective of railway equipment, carrying units and supporting facilities of the station, find out the restrictive factors and propose solutions to promote the rapid development of piggyback transportation.

#### 3.1 Railway equipment

Railway equipment suitable for intermodal transport in Europe has formed standardization and pedigree. For example, UIC571-4 regulates the types and interface dimensions of railway freight cars suitable for multimodal transport, and UIC596-5 regulates the semi-transportation applicable to multimodal transport. The trailer interface, including vehicle type, wheelbase, traction pin height, structural characteristics and contour envelope diagram, is used to guide the production of special semi-trailers for piggyback transportation. Due to the fact that the piggyback trucks in our country are in their infancy and the technology is quite different, the applicable transportation object interfaces are not unified standards, and the piggyback transportation semi-trailers cannot be mass-produced, which has become an important factor restricting the development of my country's piggyback transportation. Therefore, it is imperative to develop and expand the scale of piggyback transportation, and it is imperative to standardize railway equipment, supporting facilities and interfaces.

### **3.2 Intermodal unit**

As European and American countries are the origins of multimodal transport, the standardization of carrying units is of great significance to my country. American intermodal transport uses containers (including international standard containers and 53-foot domestic standard containers) and 53-foot van semi-trailers as the main carrying units. Unlike the American intermodal transport standard carrying units which are limited to containers and van semi-trailers, European intermodal transport uses three basic standardized carrying units, namely, in addition to containers and van semi-trailers, there are swap bodies.

#### ***1) Container***

As an important carrier of intermodal transportation, containers have become the most widely used carrying unit. Due to the very high degree of international standardization of containers, through the transformation of international standards and the issuance of related standards, my country's container standard system has achieved integration with the world. In order to meet the transportation needs of railway bulk cargo, my country has also developed a railway inland container with a total weight of 35t. Therefore, the international standard container and the inner railway container should become the main carrying unit of our country's railway piggyback transportation equipment.

#### ***2) Road Trucks and semi trailers***

Our country's road trucks and semi-trailers are produced and manufactured in accordance with the provisions of GB 1589-2016 "Outer Dimensions, Axle Load and Quality Limits of Road Vehicles". Since our country's piggyback transportation is still in its infancy and the standards have not yet been perfected, the matching degree of road vehicles and railway piggyback transportation equipment. Therefore, road trucks or semi-trailers need to meet the following requirements when transporting with railway piggybacks:

- (1) The outline dimensions, axle load and mass limits of road vehicles meet the requirements of GB 1589-2016.
- (2) The road vehicles used for piggyback transportation should be able to meet the operating requirements of railway freight cars, which is mainly reflected in the strength of the vehicle components to withstand the influence of longitudinal force, lateral force and centrifugal force during railway transportation.
- (3) Reasonably shorten the interface size between road vehicles and piggyback vehicles, shorten the length of railway vehicles, improve line utilization and transportation economy, and road vehicles used for piggyback transportation should have foldable rear safety gears.
- (4) The semi-trailer suitable for the loading of lifting type piggyback shall be equipped with hoisting interface, which can adapt to the hoisting operation of hoisting machinery.
- (5) Trailers suitable for road-rail integrated transportation should be equipped with special hook and slow coupling interfaces, bogie interfaces, etc.

#### ***3) Swap body***

The swap body originated in Europe and is widely used. Compared with containers of the same series, swap bodies have more advantages in terms of size and volume, which can maximize the efficiency of transport vehicles. For example, the length, width, and height of a 20-foot container are 6058 mm, 2438 mm, and 2591 mm, respectively, and the length, width, and height of the swap body of the same system are 7450 mm (or 7820 mm), 2550 mm, and 2980 mm. The shape and structure of the swap body is very similar to that of the container, but the swap body has four foldable legs. In road transportation, vehicles carrying the swap body do not need to wait for the swap body to load and unload, and can be self-loaded and unloaded without lifting equipment or forklifts. Compared with the container, the operation of

the railway transport swap body is basically the same, but the swap body has the advantages of volume and is more suitable for the transportation of lightly thrown white goods such as express delivery, fresh food and electronics. Therefore, the current swap body in my country is mainly used in express delivery and logistics enterprises, and the application of automobile trains. In the field of railway transportation, due to the lack of corresponding railway vehicles, it has not been carried out yet.

Based on the above three kinds of carrying units, the piggyback transportation should be combined with my country's national conditions. The initial development of the container, road trucks, and semi-trailers of the piggyback transportation, the later development of railway equipment that can be applied to the three types of carrying units at the same time, and the comprehensive development of the piggyback transportation.

### **3.3 Station facilities**

According to the development experience of Europe and the United States, combined with the existing piggyback transportation technology in China, the requirements for piggyback operation station and supporting facilities are as follows:

#### ***1) Freight hub distribution***

Considering the logistics connection function and transfer efficiency in the process of road rail combined transportation, the station suitable for piggyback transportation should be able to cover a radius of 400km and have the distribution function of logistics hub.

#### ***2) Set up operation area and ground hardening***

The piggyback transportation operation area is reserved in the station to meet the loading and unloading conditions of the whole train of piggyback vehicles. The ground is hardened and basically consistent with the height of the rail surface. At the same time, considering the factors such as the turning of road freight cars, the safe operation space for workers, the temporary parking and loading of heavy-duty trucks, and the operation space of lifting machinery, the reasonable width of the operation area should be set.

#### ***3) Setting clearance and weighing inspection***

The station is equipped with vehicle outline detection device, clearance detection device, partial load detection device, large weighbridge (60 tons) and safety inspection equipment to prevent overload and overloading of piggyback vehicles after loading and ensure transportation safety. The existing stations and yards in China basically meet the above requirements, and the new gauge and weighing inspection are needed. The scale of station and yard reconstruction is small and the cost is low.

#### ***4) Supply of electricity***

Ground power supply devices, such as Qt1, QT2, stx1 and Stx2 piggyback vehicles, shall be installed in the stations with self loading and unloading piggyback technology. As the vehicle has hydraulic and electrical systems, the freight yard needs to be equipped with power supply. The power plug is waterproof and dustproof, and has leakage protection function. The existing stations in China are not equipped with ground power supply, but the reconstruction scale is small and the cost is low.

#### ***5) Provide lifting equipment***

Gantry crane or front crane, such as stx3 and stx4 type piggyback truck, shall be equipped in the station with lifting piggyback technology. The freight yard shall be able to meet the hoisting requirements of containers and semi trailers, and no catenary shall be set in the operation area. The gantry crane or front crane for the existing container loading stations in China only considers the container lifting conditions, and the rated lifting capacity is generally 36t, and a small part is 40t. In order to meet the hoisting demand of semi-trailer

(total weight 40t), the rated hoisting capacity of gantry crane or front crane should be upgraded to 45t or above.

#### **6) Transformation of translational platform**

For the X5 type piggyback vehicle, it needs to be equipped with guide rail type mobile platform and crane. China's existing stations and yards can not meet the special requirements of vehicles, so it is necessary to transform the ground devices of stations and yards as a whole, add transfer platform and control system, and the transformation scale is large and the cost is high.

#### **4. Conclusion**

A comprehensive analysis of my country's railway equipment, carrying units, and supporting facilities at stations and yards. At this stage, the focus of the development of my country's piggyback transportation is to carry out pilot trials, improve basic supporting facilities, establish and improve standards, and summarize experience. With unique development advantages such as safety, high efficiency, energy saving, and environmental protection, the piggyback transportation will improve my country's comprehensive transportation capacity, build a green and efficient modern logistics service system, reduce social logistics costs, and promote transportation structure adjustment and sustainable economic and social health. Development provides a reliable guarantee.

#### **5. Reference:**

- Han Yuhao, Sun Xiaoyun, Jin Long, etc. Analysis on the development of my country's railway freight equipment technology [J] . Railway Technical Supervision, 2019, 47-07.
- Wu Rongkun, Li Hua, Yu Yuebin, et al. Thoughts on the development of piggyback transportation technology in my country [J] . Railway vehicles, 2016, 54 (11), 9-12.
- Zhang Simei, Chen Jingliang, Liu Zuoyi. Research on the Technical Route for the Development of Railway Carriage Transport in my country [J] . China Railway, 2016 (11), 32-35