Chinese Exported Heavy Axle-load Freight Cars

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1 Foreword

After 60 years development, the train load and axle-load of Chinese freight car have been increased dramatically. Axle-load has been increased from 11t to 21t, 23t, train load from 30t to 60t, 70t. Dedicated coal train C76(A, B, C) with axle-load of 25t, train load 75t and C80 gondola car with train load of 80t have been put into service on Daqin line. General freight car with axle-load of 23t, train load of 70t has been widely used.

In recent years, the heavy axle-load freight cars have not been applied to main lines of domestic railway. Due to the demand of international market customer, China has exported freight cars with heavy axle-load of 30t and 40t to Australia, Brazil, Venezuela and other countries. Fig. 1 shows the distribution of import countries. The design of these heavy axle-load freight cars borrow ideas from domestic advanced experience and refer to AAR technical standard of Northern America railway. The heavy axle-load freight cars are popular because of good operation. China has improved its design technology level of domestic heavy axle-load freight cars by exporting railway freight cars with heavy axle-load to abroad. Its successful practical operation results approves China has possessed capability of designing and manufacturing overall heavy axle-load freight cars. The relevant design, manufacture and research of car body, bogie, brakes, coupler & draft gear and supporting facilities have laid foundation for self-developed freight cars with heavy axle-load of 30t and 40t in China, providing experience for the design and manufacture of heavy axle-load freight cars all over the world.

![Fig. 1 Export countries distribution schematic diagram of heavy axle-load freight cars and accessories](image)

2 Characteristics of exported heavy axle-load freight cars

With the opening-up to outside world of domestic economy and the technology level improvement of railway freight cars, its competitive capability in the international market has been greatly improved. In 1998, China exported overall C2 Container flat car to Australia for the first time, which marks the export of Chinese railway freight cars has entered a new
historical era. In recent 10 years, China has exported more than 40 product varieties and nearly 10,000 railway freight car products to Australia, Brazil, Venezuela, New Zealand, Saudi Arabia, Kazakhstan and other 30 countries accumulatively, and has realized batch export, especially the heavy axle-load freight cars with representative heavy load technology, and has also realized the wish of exporting overall railway freight cars to the developed countries all over the world and demonstrated the design and manufacture technology level of domestic railway freight cars. The exported heavy axle-load freight cars are characterized by heavy axle-load, high loading capacity, adaptive multi-car formation and high lightweight. The adopted advanced technologies are applicable to the special operating conditions. The exported freight cars are basically in accordance with the AAR technical standard of Northern America railway, and meet the design requirements of generalization. They also have high efficiency of unloading with safe and stable operation. The main technical parameters of exported heavy axle-load freight cars are given in the Table 1.

Table 1 Main technical parameters of some exported heavy axle-load freight cars

<table>
<thead>
<tr>
<th>Export countries</th>
<th>Australia</th>
<th>Venezuela</th>
<th>Brazil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car model</td>
<td>C2 Hopper car</td>
<td>Ore gondola car</td>
<td>NHWH Hopper car</td>
</tr>
<tr>
<td>Loading capacity/t</td>
<td>95</td>
<td>137.3</td>
<td>95</td>
</tr>
<tr>
<td>Tare weight/t</td>
<td>25</td>
<td>22.7</td>
<td>25.4</td>
</tr>
<tr>
<td>Axle-load/t</td>
<td>30</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Capacity/m³</td>
<td>106</td>
<td>69</td>
<td>106</td>
</tr>
<tr>
<td>Car length/mm</td>
<td>32202/Set</td>
<td>22300</td>
<td>64184/Set</td>
</tr>
<tr>
<td>Car width/mm</td>
<td>3020</td>
<td>3300</td>
<td>3020</td>
</tr>
<tr>
<td>Max. car height/mm</td>
<td>4100</td>
<td>3400</td>
<td>4100</td>
</tr>
<tr>
<td>Length between truck center/mm</td>
<td>12281</td>
<td>6965</td>
<td>12281</td>
</tr>
<tr>
<td>Coupler center line height/mm</td>
<td>910</td>
<td>876±10</td>
<td>990⁺⁻₀²₀</td>
</tr>
<tr>
<td>Center-of-gravity height/mm</td>
<td>1030</td>
<td>1160</td>
<td>951</td>
</tr>
<tr>
<td>Empty car</td>
<td>2237</td>
<td>2257</td>
<td>1714</td>
</tr>
<tr>
<td>Loaded car</td>
<td>115</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Design speed/(km-h⁻¹)</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Car body material</td>
<td>09CuPCrNi-A</td>
<td>Steel</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>Designer and manufacturer (Rolling Stock Works)</td>
<td>QRRS</td>
<td>Zhuzhou</td>
<td>QRRS</td>
</tr>
<tr>
<td>User</td>
<td>FMG</td>
<td>PN</td>
<td>Rio tinto</td>
</tr>
</tbody>
</table>
(1) The exported railway freight cars have heavy axle-load, high loading capacity and multi-car formation. The ore gondola cars exported to Australia FMG have axle-load of 40t and loading capacity of 137.3t, which are the maximum axle-load and loading capacity on the main line for general railway freight car in the world. This ore gondola car can run in the formation of 30,000t~40,000t.

(2) The exported railway freight cars have high lightweight and optimized car body structure with the adoption of computer simulation technical analysis, which reduces the tare weight of car. The ore gondola cars exported to Australia FMG have tare weight of 22.7t and tare weight coefficient of 0.165.

(3) With the adoption of advanced technologies and high technical level of components and accessories, this ore gondola car is applicable to the special operating condition abroad. The ore car with axle-load of 35.7t, exported to Australia in batch, use stainless steel car body, high strength coupler, forged coupler yoke and high performance bogie (See Fig. 2). The ore car with axle-load of 40t, exported to Australia, use electro-pneumatic brakes, unit braking bogie and other advanced technologies. The control car is equipped with FR Rotary coupler at one end, and the slave car is equipped with F Fixed coupler at one end, with application of SL-76 draft gear. Both types of ore cars meet the requirements of special operating condition abroad (See Fig. 3). The freight car bolster, side frame, high strength coupler, forged coupler yoke, high capacity draft gear, pneumatic control valve and other rolling stock accessories designed and manufactured independently by Chinese railway have been successfully applied abroad.

Due to the differences of transported commodity and operating conditions of different countries, the different personalized requirements are proposed for the same type of car used for different countries. For example, Venezuela ore gondola car with axle-load of 30t use car dumper for unloading, with door-less design, car body shape wide at the top and narrow at the bottom and high efficiency of unloading (See Fig. 4).

(4) The technical standards of exported heavy axle-load freight car, bolster, side frame, high strength coupler, forged coupler yoke, high capacity draft gear, etc. are basically in
accordance with the AAR technical standard of Northern America railway and have been accepted by overseas user and popularized step by step internationally. It is proved from practice that the relevant technical conditions of railway freight car meet the application requirement of abroad.

(5) The bogie technology has reached a high level and its vehicle dynamics performance criteria are above the requirement of AAR standard. The bogie has been upgraded from traditional three-piece design and manufacture to cross-braced bogie and radial bogie. At the same time, the welded bogie has also been applied, with loaded car running speed of 80km/h and empty car running speed of 115km/h.

3 Technical characteristics of exported heavy axle-load freight car (Car type and structure, technical standard and operating condition)

3.1 Car type and structure

The heavy axle-load freight car exported to abroad are mainly used for transportation of coal and ore. The main car types contain ore gondola car, special gondola car (Door-less) and open-top hopper car.

Most of coal & ore cars in the fixed formation, exported to Australia, Brazil, Venezuela, etc., are special gondola car and open-top hopper car. In order to reduce the transportation cost, the car capacity is increased and the car tare weight is decreased to the greatest extent, to add the loading capacity of car. For GDT Gondola car exported to Brazil, see Fig. 5.

The car body of ore hopper car exported to abroad is of orthodrome sheathing structure, which can increase car capacity and sideway stability, comparing with structure of flat side wall. This type of car has aesthetic appearance and good operation effect (See Fig. 6).

The car body of ore gondola car exported to Australia is of flat tub door-less structure. The middle part of car body is designed with reinforced wall that increase the overall stiffness of car body.

3.2 Train traction and formation

In order to reduce the longitudinal impulse among cars and adapt to long train formation, the couplers are not used for coupling in most cases but the drawbar and appropriate braking system, which changes the operating environment of car.
Every two C32 Coal hopper cars can be recognized as a set, which are coupled with drawbar device, decreasing the car length and increasing the train formation. The Australia composite brake system is adopted for pneumatic system to increase the braking performance of car on the long ramp.

Every two 40t Axle-load ore gondola car exported to Australia FMG can be recognized as a set, which are coupled with drawbar device in the middle part, in the formation of 240 cars. The total weight of train traction is 38400t. ECP electro-pneumatic braking and TMX braking system are used for decreasing the longitudinal impulse of train, to reduce the component wear, car structure fatigue, and commodity damage and derailment risk accordingly.

3.3 Axle-load

Increasing the axle-load is an effective method for improving loading capacity and cutting operating cost. However, it is necessary to take two main railway infrastructures into consideration, line and bridges. In the point of load per linear meter, the loading capacity per linear meter of heavy axle-load freight car used by foreign countries has been equal to or more than 10t/m.

According to the user requirement, the axle load of exported heavy axle-load freight car is all 30t, in which the maximum axle load is 40t. It is proved from practice that the application of heavy axle-load coal & ore cars can bring significant economic benefit.

3.4 Material

High-strength steel and stainless steel material can reduce tare weight and increase loading capacity, increasing the transportation efficiency. The main structural materials used for manufacture of exported heavy axle-load freight car are Q450NQR1 High-strength anti-corrosion steel with yield strength of 450MPa and 09CuPCrNi-A Atmospheric corrosion-resistant steel with yield strength of 345MPa. The main material of car body of ore gondola car for FMO is Atmospheric corrosion-resistant steel with yield strength of 550MPa.

In the aspect of material application, Q450NQR1, Q550NQR1 and other atmospheric corrosion-resistant steels, T4003, 4003mod, 5Cr12Ti and other stainless steels, Grade B, B+, C, E Cast steel specified in AAR Standard have been accepted step by step by international market users and applied to design and manufacture of exported cars successfully with good results.

3.5 Speed and bogie

Increasing the running speed of heavy axle-load freight car is one of the effective methods for cutting the commodity transportation expenses and increasing the production efficiency.

As the railway freight transportation of Australia and other countries always take the heavy load transportation as a major and apply long train formation to the special line. Therefore, the running speed of loaded heavy axle-load freight is not high, which is about 60km/h~80km/h.
According to the requirements of users abroad, Chinese railway has designed and manufactured cross-braced bogie, radial bogie, etc. for heavy axle-load freight car on the basis of design and manufacture of traditional three-piece bogie, combining the experience in research, development and operation of domestic bogie.

3.6 Standard and accessory

In most cases, Car Strength Design Specifications is a technical specification specifying the manufacturing technology of car, at the same time it is an important document ensuring the operating reliability of car structure. Generally, this specification should be revised at least 1 time every 10 years, to reflect science development level and new operation condition. But the individual clauses of China freight car strength design specification have not been modified in the past few decades. With the increase of freight train formation and traction load, the longitudinal impulse of train shall be inevitably increased. Therefore, it is necessary to revise the relevant standards of vehicle design and test, especially the assessment criteria for longitudinal force of car. For example, the standard of longitudinal loads over 10,000 tons in the first and second working conditions. Thus, the Chinese standard TB/T1335–1996 Railway rolling stock strength design and test evaluation specification cannot meet the demands of heavy load technology development for freight car speed-up nowadays, which is also required to be revised.

By exporting heavy axle-load freight cars, we know more about AAR specification during the application. But it is difficult to apply some clauses, and there is doubt for application condition, for example, the value and assessment criteria of longitudinal force and the value and assessment criteria of lateral compression on the end wall. It is expected that we can communicate and collaborate with preparer and reviser of specifications. The products should be able to work normally in the import country In accordance with the international standard requirements. And it is easy to overhaul and replace. The theoretical and experimental analysis should be carried out on the working condition of freight cars under actual load, to revise and amend the standards about static strength, impact, car dynamics, and fatigue strength design of freight cars. By improving the design and assessment criteria, the technology progress on railway freight cars shall be promoted.

The overall car technology applied to exported freight cars is basically approximate with AAR standard. The standards of bolster, side frame, high-strength coupler, forged coupler yoke and other accessories have the same level as foreign advance standards, which attributes to foreign advanced technology sufficiently used for reference by domestic freight car design.

3.7 Matching between car and ground handling facility

The heavy axle-load freight car should meet the car requirements required by ground handling facility in terms of strength, working space, working efficiency, etc. The heavy axle-load freight car should match with the ground handling facility of users abroad, such as car dumper, conveyor belt, etc. Chinese railway attaches great importance to the discharging methods for gondola car and hopper car, and have gained plentiful experience. These experiences have
positive effects on the design of heavy axle-load freight cars exported, which have been successfully applied to the design of exported car.

4 Conclusion and recommendation
The development history of heavy axle-load freight car exported by China shows that the technologies applied by domestic railway freight cars and exported railway freight cars are mutually improved and supported. The technology for domestic railway freight car has laid a firm and substantial technology foundation for exported freight car. And the export of railway freight car also boosts the further development of domestic freight car technology. China has held a great proportion in the manufacturing industry of heavy axle-load freight car around the world. With the further development of heavy load speed-up technology after separation between passenger line and freight line, Chinese railway transferred from equipment export to technology export, promoting and leading the rapid development of freight car technology in the world.

(1) The successful export and operation of heavy axle-load freight car can attribute to the close attention to international rolling stock market, strong market research, control of latest technology development of foreign rolling stock by Chinese railway. At the same time, the export of products bring energy to enterprises, training a large number of technology and management talents specialized in heavy axle-load freight car, raising prestige of enterprise, and increasing the competition capability of enterprise in the international market.

(2) By exporting freight cars with axle loads of 30t and 40t to Australia, Venezuela, etc., the level of design technology for Chinese heavy axle-load freight car has been improved. The successful results of application and practice prove that China has had the capability of designing and manufacturing overall heavy axle-load freight car. The design, manufacture and localization research of its car body, bogie, brakes, coupler & draft gear and other supporting facilities have laid a design and manufacture foundation for domestic freight cars with axle load of 30t and 40t.

(3) As the exported heavy axle-load freight cars are designed basically in accordance with AAR standard, the design experience should be applied sufficiently, and the application situation of exported heavy axle-load freight cars should be tracked and studied. AAR standard can be used as design reference for freight cars with axle loads of 30t and 40t. Meanwhile, the adaptability of AAR standard to changes of railway operating condition should be studied further.

(4) Aiming at present development situation of exported heavy axle-load freight cars, we should attach importance to issues including axle load, speed, material, standard, etc., on the basis of introducing advanced technology of foreign countries and combining independent innovation. We should strengthen the research on car body, bogie, brakes, coupler & draft gear, line and bridge, station, handling and other supporting facilities for heavy load freight car, to improve safety, reliability and economical efficiency of heavy
load transportation, and to create conditions for self-developed heavy axle-load freight cars for China.

(5) Symmetrical research on standard system of heavy axle-load freight cars. Summing up development experience of 70t and 80t freight cars, combining the separation situation of passenger line and freight line in China, referring to foreign standard of heavy axle-load freight car (AAR standard) and using the experience of heavy load transportation, we shall carry out comprehensive analysis and research on domestic lines, bridges, gauges, station track length, train formation, etc. in the process of overall design, to improve the transpiration efficiency. It is recommended that heavy axle-load freight cars with axle load of 30t and above can be applied to special freight line of Chinese railway.

5 References

[1] LiChunyu,WeiHongliang,LiXiaofeng, Development of NHWH Type of Coal Hopper Car, ROLLING STOCK (12)(2007)13-15.

Abstract: To meet the needs of international users, heavy axle load freight cars of 30t, 40t are exported to Australia, Brazil, and other IHHA members. This paper describes present situation and development trend of exportation of Chinese heavy axle load freight car, analyzes relevant technical standards and main technical characteristics of exported heavy axle load wagons on train/composition, axle load/speed etc. Technical issues which should be considered for exported heavy axle load wagons are proposed. This may give reference to the study of heavy axle load wagon in the world.