Analysis on the Layout and Capacity Adaptability of China's Coastal Iron Ore Unloading Terminals

Haiyuan Yao1,2, Dachuan Wang1, Yijun Li1, Mengchao Su1 and Guo-lei Tang3

1 Division of Waterway Planning, Transport Planning and Research Institute, Ministry of Transport, Beijing 100028, China;
2 School of Civil Engineering, Tianjin University, Tianjin 300072, China;
3 Faculty of Infrastructure Engineering, Dalian University of Technology, Dalian, 116024, China

*Corresponding author’s e-mail: yaohy@tpri.org.cn

Abstract: As the most important raw material for the iron and steel industry, demand for iron ore is rapidly recovering with the steady recovery of domestic machinery, manufacturing and other iron and steel-related industries. Recently, the number of ore ships waiting to berth has increased significantly at the major iron ore unloading ports along the coast of China. Factors, such as weather influences and concentrated arrivals, make the problem of port ore ships under pressure reappear. This article describes the overall situation of China’s iron and steel market and coastal iron ore transportation and analyzes the characteristics of iron ore import transportation in various regions. The construction layout, stockpiling situation conditions and the capacity adaptability of China’s iron ore terminals are systematically studied. And it proposes that the specialized ore unloading terminals generally need to meet the demand of foreign trade imports. However, the capacity of the Bohai Rim, the Yangtze River Delta and the regions as along the coast is still tight, and the local port pressure is still prominent. In the future, further research and the optimization of China's iron ore unloading terminal system should be done. Through AIS dynamic data monitoring, port and shipping big data mining and analysis, and the other new technical means, the adaptability of iron ore unloading capacity at terminal is refined research, the peak arrival of ships and other situations are properly handled, and China’s iron ore foreign trade Import transportation is protected stably and safely.

1. Introduction

The iron and steel industry is an important basic industry of the national economy and an important symbol of the country's economic level and comprehensive national strength. It has played an important pillar role in China's rapid economic development and population growth in the past few decades [1,2]. Iron ore is the most important raw material for the iron and steel industry, and the demand is also rising with the development of the iron and steel industry. China is already the country with the largest iron ore consumption in the world, as well as the largest foreign trade volume of imported iron ore[3]. In view of the poor endowment of China’s iron ore resources, there are some problems, such as limited reserves, low mining volume, low grade, complex ore types, and high mining costs, which are far from satisfying the needs of domestic iron and steel enterprises. A large imports of iron ore have become the norm, and the degree of dependence is more than 70% [4]. At the same time, as a bulk cargo, iron ore has a very obvious scale effect in its transportation. China’s coastal ports play an irreplaceable role in undertaking iron ore imports. The import volume of iron ore in the port is used as a
A physical quantity indicator to reflect the import situation of iron ore, and can also reflect the change trend of domestic iron ore transportation and demand [5,6]. The spatial layout of iron ore unloading docks in coastal areas of various countries in the world plays an important role in the world’s iron ore transportation system. Overseas Sakaradhorn, Lee Taehwee, etc. discuss the spatial pattern of iron ore unloading ports in Thailand and the concentration of bulk cargo ports on the west coast of North Korea respectively on rate and other issues [7,8]. Domestic Hao Xiaoqing, Zhang Mengtian, Zhang Zhenlin and others have studied the evolution of international iron ore logistics networks, the spatial pattern of iron ore ports in China and the water transport network of imported iron ore in the Yangtze River Basin [9-11]. In recent years, with the increasing capacity of ore ships and the further structure adjustment of the domestic coastal iron and steel industry, the overall plan of 400,000-ton ore ship unloading ports and the layout of the iron ore transportation system in coastal ports has been researched deeply and adjusted at the national level.

At present, the COVID-19 epidemic is spreading around the world, and the international market environment will become more complicated in the future. The steel industry is facing many difficulties, such as shrinking international demand, a significant reduction in exports, and rising prices of raw materials and fuels. At the same time, China’s main macroeconomic indicators and downstream industry operations have shown a trend of improvement month by month. Most indicators have turned from negative to positive. Domestic machinery, manufacturing and other steel-related industries have recovered steadily, and the demand for iron ore has quickly recovered. Since June 2020, the Baltic Dry Bulk Index (BDI) has significantly strengthened, rising from 353 points in mid-May to the highest point of 2097 in October, as shown in Figure 1. From August to October 2020, the number of ore ships waiting to berth has increased significantly at the major iron ore unloading ports along the coast of China. At the end of October, the number of ore ships waiting to be berth reached 66. At Yingkou Port, Tangshan Port, Tianjin Port, Qingdao Port, and Rizhao Port, there were all 5 or more ships waiting to berth as shown in Figure 2. The problems of iron ore unloading difficulties and port congestion reappear.

All ports have responded strongly to the continuous increase in the number of iron ore ships at the port due to weather, concentrated arrivals, etc., resulting in some iron ore being stranded and unable to enter the market for circulation. The China Iron and Steel Industry Association has also repeatedly reported the relevant situation to the Ministry of Transport. Aimed at the above-mentioned problem, it is necessary to deepen the research on the layout of iron ore specialized terminals on China’s coast and analyze the adaptability of the main iron ore unloading ports.

![Baltic Dry Index (BDI) in 2020](image)
2. Overall situation of China's steel industry and coastal iron ore transportation

2.1. Development status of China's steel industry

Since 2000, with the rapid development of the iron ore industry in Asia, especially China, the world's iron ore consumption has increased rapidly, and the production scale of iron ore has also expanded [12,13]. In this context, China is increasingly dependent on imported ore, and the source of imported iron ore is relatively concentrated, mainly from Australia, Brazil, India and other countries [14]. In 2019, the output of crude steel and pig iron in China reached a record high of 996 million tons and 809 million tons respectively, which accounted for about 50% and 60% of the world's total output with year-on-year growth of 8.3% and 5.3%.

2.1.1. Development stage

China is in the mid-stage of industrialization, and the heavy chemical industry is developing rapidly. Housing and transportation demand have created a huge demand for steel. Therefore, since 2000, China's steel production and consumption have grown rapidly, with the output growth rates of crude steel and pig iron being 11.3% and 10.1%, respectively, as shown in Figure 3. Since 2005, China has become a net exporter of steel, and is currently the world's largest one [15].

Before the economic crisis in 2008, the output of China's iron and steel industry grew rapidly under the demand-driven output. From 2000 to 2007, the average annual growth rate of China's pig iron output was as high as 20.3%. Affected by the economic crisis in 2008, steel demand fell, and pig iron production fell 1.2% that year.

After 2008, under the stimulus of the national four trillion policy, large-scale public facilities such as highways, railways, subways and airports have been continuously improved during the "12th Five-Year Plan" period. 10 million sets of guaranteed housing have been constructed, and the rapid development of real estate and infrastructure has driven steel demand growing rapidly. From 2008 to 2013, pig iron output increased by 8.5% annually. In 2013, pig iron output reached 710 million tons. Among
them, in 2010, in order to achieve the goal of reducing GDP by 20%, the state introduced a macro-control policy for the steel industry to restrict production and eliminate outdated production capacity, resulting in a slight drop in China's imported iron ore in 2010 compared with 2009 [16].

After 2013, one is affected by the international economic crisis, and the other is that China's steel production has reached a high plateau period and began to fluctuate at a high level. From 2013 to 2017, China’s pig iron production basically fluctuated between 690 million tons and 710 million tons.

From 2018 to 2019, driven by national strategies such as the “Belt and Road”, the integration of Beijing-Tianjin-Hebei, and the Yangtze River Economic Belt, the macro economy will transition from high-speed growth to high-quality growth. Industry 4.0 will promote the transformation and upgrading of the steel industry, and steel production will continue to rapidly grow, the benefits of iron and steel enterprises have generally improved, and the output has continued to increase [17].

In 2019, affected by trade disputes and slowdown in international demand, both the scale of imports and exports declined. In that year, China’s steel exports totaled 64.29 million tons, a year-on-year decrease of 7.3%. Driven by the substantial increase in output and quality, the substitution effect of domestic steel on imported steel has further emerged. The imports of steel is 12.3 million tons, down 6.5%.

2.1.2. Regional distribution
In recent years, the steel industry has continued to shift to coastal areas and southern regions. In 2019, China’s iron and steel industry will continue this trend, and a number of large-scale iron and steel projects along the port have been planned.

Among them, North China has always been the largest steel production area in China. In 2019, the output of pig iron, crude steel, and steel in this region was 320 million tons, 350 million tons, and 420 million tons respectively, accounting for 39.2%, 35.2%, and 35.0% of the national output. Mainly due to the rapid development of private steel enterprises in this region, especially in Hebei Province. East China is the second largest steel production area in China. In 2019, the output of pig iron, crude steel, and steel in the region was 210 million tons, 290 million tons, and 380 million tons, accounting for 26.2%, 29.6%, and 31.9% of the national output. In addition, the output of pig iron, crude steel, and steel in Northeast China and Central China ranks second, as shown in Figures 4.
2.1.3. Consumption

With the development of China’s steel industry, the actual consumption of steel (steel production plus imports minus exports) increased from 140 million tons in 2000 to 1.04 billion tons in 2014, with an average annual increase of 15.4% and a rapid growth rate. After 2014, steel consumption has basically remained around 1 billion tons. In 2018, steel consumption returned to a high level of 1.05 billion tons once again. In 2019, China’s steel consumption reached 1.2 billion tons with a year-on-year increase of 9.8%.

The apparent consumption of crude steel in China increased from 610 million tons in 2010 to 770 million tons in 2013. Since then, the apparent consumption of crude steel fluctuated between 7.0 and 750 million tons. In 2018, the apparent consumption of domestic crude steel was 870 million tons with a year-on-year increase of 14.8%, reaching the highest level in history, when the domestic self-sufficiency rate exceeded 98%. It is basically consistent with the changes in China’s steel production.

2.2. The overall situation of China’s coastal iron ore transportation

The main importers of iron ore in China are Australia, Brazil, India, and South Africa, where Australia and Brazil are largest. The track density of bulk carriers of 100,000 tons and above is shown in Figure 5 (Quoted from Ship News Network). In recent years, the concentration of iron ore importers in China has become higher and higher and the export market share of small mines in other countries has become smaller and smaller, so that the advantages of low-cost mines in Brazil and Australia have gradually emerged [18].

The iron ore throughput of China’s coastal ports is composed of foreign trade entry, transit, and domestic trade transportation. Among them, foreign trade imports, that is, iron ore imports completed by sea, mainly come from Brazil and Australia and flow to the Bohai Rim and the Yangtze River Delta; the transfer volume refers to the iron ore unloaded by some coastal ports. The export volume of domestic trade formed by reloading ships is the “secondary” launch volume, which includes both foreign trade imported mines and domestic mines; domestic trade unloading volume, that is domestic import throughput of iron ore completed by coastal ports, included two parts. One is the throughput generated by receiving and unloading the domestic iron ore one-time launch, and the other is the through-

![Graph showing China's production of pig iron, crude steel and steel by province in 2019](data-sourced-from-the-National-Bureau-of-Statistics)
put formed by receiving and unloading the turnover of surrounding ports.

Figure 5. Thermal map of global track of bulk carriers of 100,000 tons and above (November 30, 2020)

Since 2000, the iron ore throughput of China’s coastal ports has been increasing year by year, but the growth rate has gradually decreased. The current throughput fluctuates around 1.7 billion tons, as shown in Figure 6. In 2019, the total iron ore throughput of China’s coastal ports reached 1.718 billion tons, of which foreign trade imported ore is 1.125 billion tons, up 0.5% year-on-year, accounting for 65.5% of the total throughput, with a decrease of 0.1% from 2018; the transfer volume is about 234 million tons, accounting for 13.6% of the total throughput, which mainly concentrated in Ningbo Zhoushan Port, Shanghai Port, Qingdao Port, Rizhao Port, Dalian Port, Lianyungang Port, Zhanjiang Port, Fuzhou Port; domestic trade ore handling capacity is about 187 million tons, accounting for 10.9% of the total throughput. This is an increase of about 0.4% compared to 2018.

Table 1. The total throughput of coastal iron ore and the completion of foreign trade imports

|                  | 2018     | 2019     | Growth rate |
|------------------|----------|----------|-------------|
| Total            | 17.05    | 17.18    | 0.8         |
| Foreign trade imports | 11.19    | 11.25    | 0.5         |
| Liaoning Coastal | 0.85     | 0.73     | -13.4       |
| Tianjin-Hebei Coast | 3.29    | 3.35     | 2.0         |
| Shandong Coast   | 2.49     | 2.49     | 0.1         |
| Yangtze River Delta | 3.39    | 3.44     | 1.5         |
| Southeast coast  | 0.28     | 0.31     | 9.3         |
| Pearl River Delta | 0.13     | 0.14     | 6.7         |
| Southwest coast  | 0.77     | 0.79     | 2.6         |
In terms of subregions, except for coastal ports in Liaoning that had the sharp decline in the loading and unloading volume of foreign trade ore, coastal ports in other regions have achieved various degrees of growth. Details are as follows:

At Liaoning coastal, the handling volume of foreign trade ore in 2019 was 73.29 million tons, a year-on-year decrease of 13.4%. But the throughput dropped significantly, which fell 16.2%, 8.1% and 18.2% at Dandong Port, Dalian Port and Yingkou Port respectively.

The Tianjin-Hebei coast, the Shandong coast and the Yangtze River Delta are still key areas for iron ore transportation. The production of pig iron in the hinterland of Tianjin-Hebei and Shandong coastal ports both increased in 2019, and the demand for regional iron ore increased. In 2019, the Tianjin-Hebei coastal and Shandong coastal ports completed iron ore throughputs of 3.41 and 326 million tons, respectively, up year-on-year 1.7% and 6.3%; Affected by the decline in the volume of ore transfers and domestic trade in Shanghai Port, the Yangtze River Delta completed a throughput of 808 million tons, a year-on-year decrease of 0.5%.

Especially in the Yangtze River Delta and areas along the Yangtze River, after the 12.5-meter deepwater channel is connected to Nanjing, 200,000-ton ore ships can reduce loads and take the tide to reach Jiangyin Port, Zhenjiang Port and other ports. In addition, the public terminals at the mouth of the Yangtze River such as Nantong Langshan exit, and the pattern of unloading into the river has changed. The foreign trade unloading volume of Shanghai Port and Nantong Port was 23.41 million tons and 4.2 million tons, down 21.5% and 74.6% year-on-year; Zhenjiang Port and Jiangyin Port completed the unloading volume of 13.74 million tons and 37.24 million tons, respectively, up 19.8% and 20.2% year-on-year.

The iron ore throughput of the southeast, the Pearl River Delta and the southwest coastal ports also achieved growth. Due to the commissioning of the Luoyu Ore Terminal in Meizhou Bay and the increase in the output of pig iron in Fujian and Jiangxi, the export volume of ore in the southeast coastal ports increased significantly to 50.39 million tons, up by 9.3% year-on-year. The Pearl River Delta ports completed iron ore throughput of 24.76 million tons, an increase of 4.6%; the southwest coastal
ports completed iron ore throughput of 95.72 million tons, an increase of 2.0%.

3. China's iron ore terminal layout and storage capacity

3.1. Wharf layout
At present, China's coastal areas have formed a basic pattern of large-scale unloading terminals of 200,000 tons and above as the main body, one-way unloading along the coast + transit transportation from the Yangtze River to the sea. The layout of iron ore unloading terminals in each region is as follows:

(1) Bohai Sea Rim
The Bohai Rim area is dominated by ports such as Tangshan, Qingdao, Rizhao, Tianjin, Dalian, Yingkou, and Huanghua. Among them, ports such as Dalian, Yantai, and Qingdao are actively expanding ore mixing and other functions by using port locations and water depth conditions of terminal.

(2) Yangtze River Delta
Outside the Yangtze River estuary, Ningbo Zhoushan Port and Lianyungang Port are the bases of one-way unloading iron ore for foreign trade, and form 200-300,000-ton iron ore unloading berths outside the Yangtze River estuary and direct load reduction and two-way unloading in the Yangtze River estuary. With the iron ore sea-in-river transportation system that matches the unloading and transit, Jiangyin, Changzhou, Taizhou and other riverside ports rely on the advantages of nearby steel plants to undertake the iron ore transportation function in the region.

(3) Southeast Coast
The function of unloading iron ore in the southeast coastal area is mainly undertaken by the Dongwuoluoyu ore terminal of Putian Port and the general berths of Bili and Niutouwan of Fuzhou Port.

(4) Pearl River Delta
The function of unloading iron ore in the Pearl River Delta region is mainly undertaken by the ore berths of Zhuhai Port Gaolan, Zhanjiang Xiashan and Donghai Island, and the general berths of Guangzhou Xinsha Port.

(5) Southwest Coast
The function of unloading iron ore in the southwest coastal area is mainly undertaken by the specialized ore terminal in the Fangcheng Port Enterprise Shagang District and the 70,000-200,000-ton general-purpose bulk berth in the Yuxi Port District.

3.2. Storage capacity and inventory situation
According to the data from China United Steel Network, by the end of October 2020, China's coastal iron ore stockpiles reached 127 million tons, and there were 17 ports (port areas) with an average stockpiles of more than 2 million tons, as shown in Figure 7. Among them, by the end of October 2020, the inventory of Tangshan Port Caofeidian Port Area and Jingtang Port Area reached 16.1 million tons and 13.8 million tons respectively, ranking the top two for unloading iron ore in the country’s coastal ports. It also shows that there are 8 bulk carriers with a length of more than 320 meters in the vicinity of Caofeidian Port at the same time, as shown in Figure 8. The average iron ore stockpiles of Qingdao Port, Rizhao Port and Tianjin Port are also more than 10 million tons.

In addition, the overstock of iron ore ports is also related to the expected price of iron ore, railway transportation capacity, and national macro-control policies. The growth in the number of iron ore stocks in Hong Kong will increase port throughput and railway transportation pressure, and will also create the illusion of strong iron ore demand in China. For example, the National Development and Reform Commission, the Ministry of Transport, the Ministry of Railways, and the Ministry of Commerce formulated the "Notice on Discharging Imported Iron Ore in Hong Kong" in 2008, which requires iron and steel production companies and trading companies to remove iron ore as soon as possible. In ports, it is strictly forbidden to borrow a large amount of stock in the port yard.
Figure 7. China's iron ore stocks in coastal ports (port areas) in 2020 (data sourced from China United Steel Net)

According to the data of China United Metal Network, the ratio of the unloading to the storage capacity is about 0.6 at port (port area). Ports with a storage capacity of more than 10 million tons include Tangshan Port (Caofeidian Port Area, Jingtang Port Area), Qingdao Port, Rizhao Port (excluding Lanshan Port Area), Tianjin Port, Lianyungang Port, Yingkou Port and Fangcheng Port, as shown in Figure 9. However, according to actual port investigations, the above-mentioned “storage capacity” should refer to the storage capacity of all bulk cargoes in the port (port area). For example, the storage capacity of Yingkou Port is estimated to be 12 million tons, but the actual average storage capacity of iron ore is only 2.51 million tons, and the port congestion is more serious.
Figure 9. China's coastal ports (areas) iron ore inventory, trade transportation and storage capacity (data source from China United Steel Net)

4. Adaptability analysis of handling capacity of China's imported iron ore terminals

Table 2 lists the number and capacity of berths of 100,000 tons and above by region. As of the end of 2019, China had 58 specialized berths for imported iron ore of 100,000 tons and above, with a handling capacity of approximately 780 million tons. The total volume of imported ore was 840 million tons in 2019, with the capacity adaptability of 0.9. In addition to the large-scale specialized unloading berths for iron ore, 25 bulk cargo berths above 100,000 tons (currently dedicated for imported ore) with the total unloading capacity of about 120 million tons also play an important supplementary role in the iron ore transportation system. These berths are mainly located in Tianjin, Tangshan, Yantai, Rizhao, Jiangyin, Suzhou, Fangcheng and other ports. And the total amount of imported ore was about 290 million tons in 2019.

Considering the different types of ships arriving at the port from different sources, the imported volume of iron ore required for unloading at berths of 100,000 tons and above is lower than the total imported volume. According to the data of the ship arrivals from 2010 to 2014, most arrival ships from Brazil and South Africa and some arrival ships from Australian are ships of 100,000 tons and above.

Table 2. Berths for iron ore (including the specialized berths) of 100,000 tons and above in coastal ports in 2019 (unit: numbers, 10,000 tons)

| Port             | Specialized iron ore terminal | General bulk cargo terminal dedicated for imported ore |
|------------------|-------------------------------|-------------------------------------------------------|
|                  | Berth Number | Berth Capacity | Berth Number | Berth Capacity |
| Total            | 58           | 78200          | 25           | 12133          |
| Bohai Bay        | 30           | 46900          | 15           | 7088           |
| Yangtze River Delta | 19         | 19700          | 9            | 3895           |
| Southeast Coast  | 1            | 1600           | 0            | 0              |
The ArcGIS tool was used to plot the number of berths and the number of ships waiting to berth in China’s coastal iron ore unloading ports in 2020, as shown in Figure 10. The capacity adaptability of specialized terminals for iron ore in different regions is as follows:

(1) Bohai Sea Rim
The handling capacity of berths is insufficient in the Bohai Sea Rim, with a loading capacity of 470 million tons and a completed loading and unloading volume of 660 million tons. Even some general cargo berths are included, the unloading capacity is still slightly insufficient. Among them, the insufficient handling capacity of ports in Shandong Province is particularly prominent. For example, the Ports of Qingdao and Rizhao have unloading capacities of only 100 million tons and 60 million tons, respectively, while 130 million tons and 170 million tons have been completed. It is extremely common that the ports of Huanghua, Tangshan, Yantai, Qingdao, Rizhao and other ports unload iron ore in general berths.

Lots of ore ships have to wait for berths in the ports of Bohai Rim iron. At the end of October 2020, there are 6, 8, 10 and 11 ore ships waiting to be berthed in the ports of Qingdao, Rizhao, Yingkou and Tangshan, reflecting the pressure of concentrated ship arrivals, as shown in Figure 10. Taking into account the ore and general bulk cargo capacity under construction of Huanghua, Rizhao and other ports, the total handling capacity is about 100 million tons. Without a significant increase in production capacity, it can basically meet the recent demand for unloading ores from ports around the Bohai Sea.

(2) Yangtze River Delta
The problem of insufficient capacity in Yangtze River Delta is serious, with 197 million tons of unloading capacity and 340 million tons of completed unloading. Ningbo Zhoushan Port outside the Yangtze River estuary has a one-way unloading capacity of 120 million tons, and completed unloading 140 million tons of ore. In addition, ports such as Qingdao and Rizhao still transfer about 30 million tons of ore along the Yangtze River. Play a certain supplementary role in the one-way unloading system. Ports along the Yangtze River are basically one-way load shedding or two-way unloading ports. Even considering the capacity of general bulk cargo berths (special ore berths), the one-way load shedding and unloading capacity of ports such as Suzhou Port still cannot meet the load shedding of large ships fully.

At present, ore ships in Taicang Port have to wait more than 5 days. Considering the Zhongzhai ore berth under construction in the Chuanshan Port area, the ore berths off the Yangtze River Delta in the next two years will be able to meet the transportation needs of the development of the steel industry in the Yangtze River Delta and areas along the route.

(3) Southeast Coast
In 2019, the ports in the southeast coastal area completed 31 million tons of iron ore, with the handling capacity of specialized terminals of 16 million tons. However, the overall demand for iron ore unloading in this area is not large, and the market hinterland is relatively scattered. A large part of iron ore is unloaded through general berths. The structure of the wharf is basically reasonable, and the capacity basically meets the demand of Southeast Coast, thus, the phenomenon of ships waiting for berths is not obvious.
(4) Pearl River Delta

Ports in the Pearl River Delta region completed 14 million tons of iron ore with 16 million tons of iron ore handling capacity in 2019. It shows that the capacity basically meets the demand of Pearl River Delta.

(5) Southwest Coast

In 2019, the ports in the southwest coastal area completed the unloading capacity of 84 million tons of iron ore and the unloading capacity of 84 million tons, which is generally adapted to development needs. The problem of ships waiting for berths occasionally occurs in the Shagang District of Fangchenggang Port Enterprises. With the construction of a new land-sea channel in the west, the expansion of the Guangxi steel base project and the settlement of the Jinxin metallurgical project, the demand for iron ore along the southwestern coast will further increase. At that time, the problem of tight iron ore terminal unloading capacity will be highlighted, and the 200,000 tons need to be unloaded, and
large-scale bulk cargo receiving and unloading berths are needed to construct.

5. Conclusion

(1) China's iron ore import demand is closely related to the development of the domestic steel industry. In 2019, China's steel consumption has increased to 1.2 billion tons, and iron ore import demand remains strong. Since 2017, the iron ore unloading volume of China's coastal ports has fluctuated at the level of 1.7 billion tons, mainly imported from Australia, Brazil, India, South Africa and other countries. After promoting the elimination of outdated production capacity at the national level, the efficiency of iron and steel enterprises has generally been improved, and the export of pig iron, crude steel and steel products has continued to increase steadily, with being at historical highs in 2019.

(2) With the steady recovery of the domestic machinery, manufacturing and other steel-related industries, the demand for iron ore has recovered rapidly, and the number of ore ships waiting to be berthed at major iron ore unloading ports has increased significantly, superimposed on the impact of weather, and concentrated in ports, etc. As a result, there were 66 ore ships waiting to be berthed in the coastal areas at the end of October, and the problem of ore ships waiting for berths reappeared, especially in the northern ports.

(3) China's coastal areas have formed a basic pattern of large-scale unloading berths of 200,000 tons and above as the main body, with one-way coastal unloading transfer transportation in the Yangtze River. 58 specialized berths of 100,000 tons or more of iron ore, with a handling capacity of about 780 million tons. The total volume of imported ore in 2019 was 840 million tons, and the capacity adaptability was 0.9. However, the problem of iron ore ships waiting for berths in the Bohai Sea Rim is more serious, and it is mainly concentrated in Qingdao Port and Rizhao Port. Yingkou Port and Tangshan Port are also facing the pressure of unloading large ore ships. The one-way unloading capacity of berths outside the Yangtze River estuary is also tight, and ports such as Qingdao and Rizhao are required to provide iron ore transfer services for areas along the Yangtze River.

(4) In the coastal areas of China, Dalian, Yingkou, Tangshan, Tianjin, Qingdao, Rizhao and other ports with enough water depth have specialized iron ore unloading berths, while in other ports, a large amount of iron ore is still transported via general bulk cargo. At the same time, the multi-way transfer of ore transportation or the load reduction and loss of large ships will also increase transportation costs and reduce transportation efficiency. In addition, the supporting collection and distribution capacity still needs to be improved to ensure the normal production of the terminal. The collection and distribution system includes the facilities for collection and distribution of iron ore, and the methods and management of collection and distribution of iron ore also affect the ability of the iron ore transportation logistics chain system.

In the future, for the layout planning of coastal iron ore unloading berths, new technical means such as AIS data, port and shipping big data and other new technical means should be used to carry out refined research on the adaptability of iron ore unloading berths. Thus, more evacuation capacity and storage space are planned scientifically to ensure the stability and safety of iron ore transportation in China, and properly responds to the emergence of ships arriving at the port at peak times.

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