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The Prediction of Aluminum Demand Based on S-shaped Regularity and Research on Supply Proposal of China

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Abstract: Aluminum has an important position in the economic development of all countries in the world, especially industrial developed countries. Widely used in many sectors of economic and social development. In 2016, the consumption structure of China's aluminum sector is: 35% of buildings, 19% of transportation, 13% of electricity, and 9% of packaging. It is an indispensable important raw material for many industries today. We use the "S" model method to predict the aluminum demand in 2020 to 2030 in China. It is predicted that the consumption of primary aluminum in China in 2020, 2025, 2030 and 2035 will be 36.8 million tons, 38.4 million tons, 38 million tons and 37.60 million tons, respectively. The peak consumption of primary aluminum in China will be reached around 2025, when the primary aluminum consumption will be about 38.4 million tons. Through the analysis of the latest aluminum industry policy, combined with the current situation in the aluminum industry, related countermeasures and suggestions on the safe supply of bauxite resources, optimization of the structure of the aluminum industry, and green development of the company are proposed.

1. Introduction

As one of the major non-ferrous metal mineral resources, aluminum consumption in the world is second only to iron and steel. It has the advantages of small specific gravity, good conductivity, good thermal conductivity and easy machining. It is widely used in all kinds of alloys, widely used in transportation, packaging, durable consumer goods, household electrical appliances and electric power industries. Therefore, it has a very important position and role in the national economic construction and national defense industry. In the new situation, the demand for future bauxite resources is analyzed, which is related to the safe operation of aluminum related industries and the effective implementation of policy of the state supply side reform. Therefore, it is very important to study the demand forecast and countermeasure analysis of aluminum products in the future.

2. The use, consumption structure and trend of aluminum products

The development of bauxite resources industry has provided an important material basis for the sustainable development of China's economy and society, and promoted the development of the economy and society. Aluminum occupies an important position in China's 10 non-ferrous metals. In 2016, the output of raw aluminum accounted for 60% of the total output of 10 non-ferrous metals, more than half. In the coming period, China's demand for non-ferrous metal products, especially aluminum, will continue to maintain a certain growth trend.

In 2016, the consumption of electrolytic aluminum in China was 31 million 870 thousand tons. The consumption structure of aluminum was as follows: construction industry 32%, transportation 16%, electricity 14%, packaging 10%, mechanical manufacturing 12%, electrical appliances communication 12%, and other 4%. Consumption accounts for about half of aluminum consumption in the field of construction and transportation.

2.1 Situation of supply and consumption of bauxite in China

In 2016, the output of Chinese bauxite was 65 million tons, an increase of 4.3% over the same period last year, accounting for 24% of the world's total bauxite production. From 1958 to 2016, the output of bauxite in China showed an upward trend. After entering twenty-first Century, the output

of bauxite increased sharply. In 1958, it was only 150 thousand tons, to 490 thousand tons in 1970, to 1 million 500 thousand tons in 1980, to 2 million 400 thousand tons in 1990, to 9 million tons in 2000, and to 36 million 837 thousand and 200 tons in 2010. From the proportion of world production, before 1994, less than 4%, 1997 to 6.56%, 2004 to 10.88%, 2010 to 15.68%, 2011 to 14.35%. Bauxite production in China is mainly concentrated in bauxite rich provinces and autonomous regions such as Guangxi, Henan, Guizhou and Shanxi.

The domestic supply capacity of bauxite from 1992 to 2016 was on the rise. The domestic supply capacity of bauxite from 1992 to 2004 was very low 5%, the fluctuation of domestic supply capacity rose in 2005 to 2016, to 53% in 2007, to 40%, and to the highest value of nearly 62.2%.

2.2 Situation of supply and demand of aluminum in China

In 2016, China's original aluminum output was 31 million 870 thousand tons, accounting for 55.83% of the world's total output. From 1953 to 1991, the output of raw aluminum was very small, less than 1 million tons, and rose to 1 million 241 thousand and 900 tons in 1993. After 20 years of development, the output of raw aluminum increased by 25.6 times in 2016, and the average annual increase was 19%. Before 1992, the proportion of raw aluminum production in the world was less than 6%, then increased rapidly, rose to 11% in 2000 and 39% in 2010. The output of raw aluminum in China was concentrated in 9 provinces, such as Henan, Xinjiang, Qinghai, Shandong, Inner Mongolia and so on.

The consumption data of raw aluminum in China are obtained through calculation, that is, the consumption of raw aluminum = raw aluminum output + net imports of raw aluminum. In 2016, the consumption of raw aluminum in China was about 3 million 164 thousand and 800 tons, accounting for 53.9% of the world's total aluminum consumption, ranking first in the world. Since 2000, China has become the largest consumer of raw aluminum in the world. In the past 10 years, almost all the world's original consumption of aluminum originated from China.

In recent years, the consumption of raw aluminum in China has increased rapidly, and the average increase in 2005 to 2016 is 23.3%. In 2016, China consumed nearly half of the raw aluminum in the world, which has become an important force in promoting the development of the aluminum industry in the world. This rate of growth is in line with the law of developed countries in foreign countries. In the accelerated development stage of industrialization and urbanization, the consumption intensity of basic raw materials, such as steel, cement, aluminum and other basic raw materials, is increasing. It is an inevitable phenomenon. Compared with 2014, the consumption of raw aluminum in the world increased by 4 million 400 thousand tons in 2016, of which 80% increased from China, and China has become the main force to stimulate the consumption of aluminum in the world.

3 Aluminum demand prediction theory

3.1 S-shaped Regularity

The "S" model is based on the average per capita consumption of raw aluminum and the "S" pattern of per capita GDP, to analyze the peak value years of the original aluminum consumption in the industrialized process of the typical developed countries, and to define the high, reference and low three schemes according to the target of China's economic growth and development, to analyze the future aluminum demand in China. The law of sector consumption is to divide aluminum consumption into different sectors, and the total consumption of raw aluminum can be obtained through consumption and total consumption of each department.

According to the statistics of the per capita consumption of raw aluminum and GDP per capita in China's history, and according to the law of China's economic development, the future trend of economic development in China and the trend of our population in the future are predicted, and the per capita GDP level in the future is obtained. According to the per capita consumption of aluminum and the "S" rule of per capita GDP, the per capita consumption of aluminum in China in the next 17 years is forecasted.

In order to make the prediction of aluminum demand of China more scientific and reasonable, this

paper uses a new round of national mineral resources guarantee degree demonstration office to provide GDP forecast and annual average annual growth rate from 2015 to 2035, and forecast the economic development as three scenarios, such as reference scheme, high scheme and low scheme. In the 3 scenario, GDP and its growth rate in different stages of development is different (table 3-1).

Table 3-1 2020-2035 years' total GDP and per capita GDP forecast in China

Year	Situation	GDP Hundreds of millions dollar（1990GK）	GDP per capita（1990GK/person）	Annual average growth rate（%）
2020	high	201349.14	14052.18	6.00
	medium	194832.93	13597.41	5.00
	low	188489.73	13154.72	4.00
2025	high	266908.59	18420.40	5.00
	medium	246293.48	16997.67	4.00
	low	227121.52	15674.54	3.00
2030	high	340650.51	23439.84	5.00
	medium	299653.67	20618.88	4.00
	low	263296.09	18117.15	3.00

Under normal circumstances, China's industrialization path should be similar to that of industrialized countries in the next 20 years, and there will be no compression of industrialization. Because the industrial process in the industrialized countries of the West has taken a long time, decades are the first hundred years, and the evolution of China's industrialization is rapid and squeezed industrialization. The main reason is that the government's support for the construction of real estate and infrastructure is closely related, which leads to the compression of the process of industrialization in China. If the process of industrialization is not taken into account, the per capita raw aluminum demand in China will continue to grow in a very long period of time, but because of the compression of China's industrialization, the per capita consumption of raw aluminum and the index of economic growth are growing rapidly. Therefore, the extruded "S" model method is used to predict the demand for aluminum. The selected indicators and parameters of raw aluminum demand in China are based on extrusion. According to the 3 different scenarios of China's economic growth pattern, the demand for raw aluminum in China from 2015 to 2030 was forecasted (table 3-2,3-3).

Table 3-2 GDP growth rate of China in the future

Situation	GDP growth rate（%）			
	2015～2019	2020～2024	2025～2030	2031~2035
High	7.0	6.0	5.0	5.0
medium	6.5	5.0	4.0	4.0
low	6.0	0.4	3.0	3.0

Table 3-3 Economic development trend of China in the future

Situation	Population (100 million)				GDP（1990GK Trillions dollars）			
	2020	2025	2030	2035	2020	2025	2030	2035
High	14.32	14.48	14.53	14.49	20.13	26.70	34.07	43.48
medium					19.48	24.63	29.97	36.46
low					18.85	22.71	26.33	30.52

3.2 demand forecast results

From the above, the per capita GDP of $18 to $20 thousand (1990 GK), the per capita consumption

of raw aluminum reached the peak, but the peak value was closely related to the economic development model of various countries. According to the forecast of China's future economic trend, the peak demand of China's original aluminum will come around 2028. However, based on the reality of China's compressed industrialization, per capita GDP is at a peak of 1.5 to 17 thousand dollars per capita, that is, the peak value of the original aluminum demand is about 3-8 years in advance, that is, the peak of the demand for the original aluminum will arrive around 2023 (Figure 3-1).

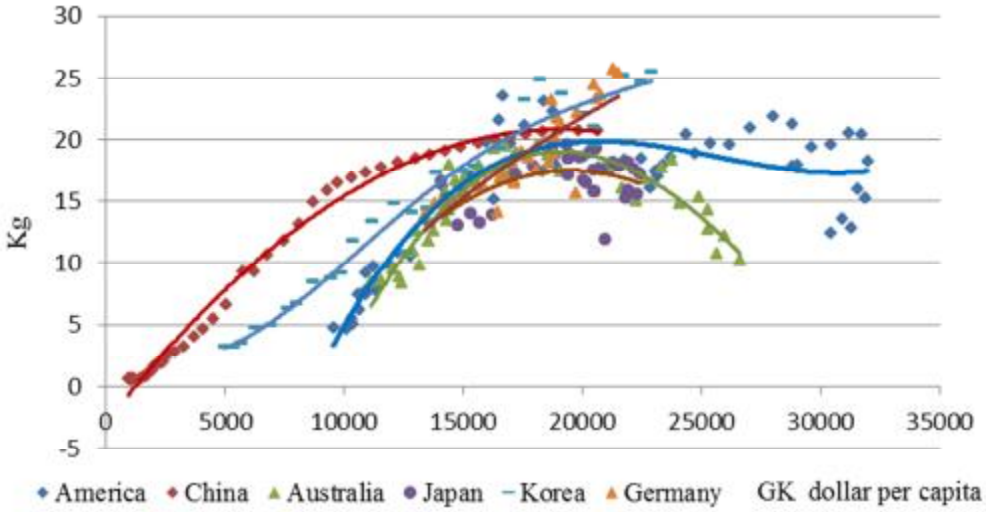

Figure 3-1 changes in per capita aluminum demand in China and typical countries

1) Under the high situation, the peak value of China's raw aluminum demand will arrive before and after 2020, and the demand for raw aluminum will be about 39 million tons, with a per capita demand of about 27.80 kg. It is estimated that the demand for raw aluminum in 2025 and 2035 is about 36 million 410 thousand tons, 34 million tons and 33 million 200 thousand tons, respectively, and the per capita demand is 25.74 kg, 24.02 kg and 23.29 kg respectively.

2) Under the medium situation, the peak value of China's raw aluminum demand will arrive before and after 2023. The peak value of the original aluminum demand is 2~3 years ahead of the higher situation, the demand for the original aluminum is about 37 million tons, and the per capita is about 26.21 kilograms. The demand for raw aluminum in 2020, 2025,and 2035 is about 35 million tons, 35 million 810 thousand tons, 33 million tons and 32 million 100 thousand tons, respectively, and the per capita demand is 24.95 kg, 25.31 kg, 23.31 kg and 22.42 kg respectively.

3) Under the low situation, the peak value of China's raw aluminum demand will arrive around 2025. The peak value of the original aluminum demand of the reference scenario will be postponed for about 2~3 years, the demand for raw aluminum is about 35 million tons, and the per capita raw aluminum demand is about 24.74 kg. The demand for raw aluminum in 2020, 2025and 2035 is about 32 million 940 thousand tons, 35 million tons, 32 million tons and 31 million 200 thousand tons, respectively, and the per capita demand is 23.48 kg, 24.74 kg, 22.61 kg and 21.89 kg respectively (table 3-4, table 3-5). Compared with other countries in the same stage of industrial development, the average per capita consumption of raw aluminum at the peak of China is approximately 26.21 kg, which is close to those of Australia, the United States and South Korea. The cumulative consumption of raw aluminum per capita in the past 2014~2020 years is about 163.52 kg, the cumulative consumption of raw aluminum per capita in 2021~2025 years is 128.2 kg, the cumulative consumption of raw aluminum per capita in 2026~2030 years is 120.43 kg, and the cumulative consumption of raw aluminum per capita in 2031~2035 years is 115.21 kg. It is close to South Korea at the same stage of development, but it is higher than that of the United States and Germany. The consumption of raw aluminum is at high level, which is related to the rapid industrialization process in China.

Table 3-4 Prediction of per capita aluminum demand in different scenarios from 2015 to 2035 of China, Kilogram per person

Situation	2015	2020	2023*	2025	2030	2035
high	22.53	27.80	26.51	25.74	24.02	23.29
medium		24.95	26.21	25.31	23.31	22.42
low		23.48	24.20	24.74	22.61	21.89

Table 3-5 Prediction of aluminum demand for the next 20 years of China, Ten thousand tons

Situation	2015	2020	2023*	2025	2030	2035
high	3100	3900	3743	3641	3400	3320
medium		3500	3700	3581	3300	3210
low		3294	3416	3500	3200	3120

4 Conclusions

(1) Forecast the aluminum demand in 2020, 2025, 2030 and 2035 by using the two prediction methods of "S" model method and sector consumption method. The two methods can be concluded that the consumption of raw aluminum in China in 2020, 2025, 2030 and 2035 was 36 million 800 thousand tons, 38 million 400 thousand tons, 38 million tons and 37 million 600 thousand tons. The peak value of China's aluminum consumption will reach around 2025, when the original aluminum consumption will be about 38 million 400 thousand tons. In the future, the consumption of raw aluminum in China is still on the rise.

(2)The shortage of bauxite resources in China is large, it is necessary to make a long-term layout of the source of the import quantity, and change the import structure of the bauxite resources, and increase the import of alumina and raw aluminum. We can firmly implement the policy of "going to capacity", improve the production of high-end aluminum products, reduce the production capacity of low-end aluminum products, and develop three aspects of renewable aluminum resources to optimize the structure of aluminum industry.

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