

## **AL08 - Development of China's Aluminum Industry and NFC/NEUI Aluminum Smelting Technology Development and Applications**

**Junman Qin<sup>1</sup>, Dingxiong Lv<sup>2</sup>, Qingchen Yang<sup>3</sup>, Jian Zhang<sup>4</sup> and Yungang Ban<sup>5</sup>**

1. Junior Project Manager

4. Project Manager

China Nonferrous Metal Industry's Foreign Engineering & Construction Co., Ltd., Beijing, China

2. Chief Engineer

3. Project Manager

5. Project Manager

Northeastern University Engineering & Research Institute Co., Ltd., Shenyang, China

Corresponding author: banyungang@126.com

### **Abstract**

As of the end of December 2022, China's alumina production capacity has reached 99.55 million tonnes/year, an increase of 9.2 million tonnes/year compared to the previous year. Among them, 10 million tonnes/year of new production capacity has been added, and 0.8 million tonnes/year of outdated production capacity has been phased out, accounting for 57.3 % of the global market. In 2022, China's alumina production reached 79.76 million tonnes, an increase of 6.1 % compared to the previous year, with 57 % using imported bauxite. The average operating rate of alumina production capacity in 2022 is 80.1 %. In 2023, China's alumina production is still showing an increasing trend, expected to reach around 82.2 million tonnes, with an annual surplus of 0.52 million tonnes. As of the end of December 2022, China's primary aluminum production capacity has reached 44.3 million tonnes per year, with an operating capacity of 40.64 million tonnes/year. In 2022, China's production capacity reached 40.33 million tonnes, an increase of 3.7 %, accounting for 58.5 % of global primary aluminum production. In 2022, China's consumption of primary aluminum reached 41.09 million tonnes, an increase of 1.8 % compared to the previous year.

In the past two years, with the gradual deepening and implementation of China's new development concept and dual carbon policy, China's aluminum industry is also facing enormous pressure and tasks of energy conservation and carbon reduction. The government strictly controls the production capacity scale of high energy consumption and high emission industries, and vigorously develops energy-saving and environmental protection industries; NFC/NEUI, as an important technology supplier and service provider in China's aluminum industry, closely revolves around national macro policy requirements to carry out the development and industrial application of green and low-carbon aluminum smelting technology, helping the sustainable and healthy development of China's aluminum industry.

**Keywords:** China's aluminum industry, NFC/NEUI aluminum smelting technology, Development and application of NFC/NEUI aluminum smelting technology.

### **1. Development of China's Aluminum Industry**

After years of construction and development, China's aluminum industry has accounted for more than half of the global industrial scale, continuously improving technology and equipment levels, and continuously enhancing the international competitiveness of aluminum products. It has now become an important industry with certain comparative advantages [1]. In the rapid development process, it is increasingly constrained by factors such as resources, energy, and environmental protection. In the new situation of national macroeconomic regulation, China's aluminum

industry will adhere to the scientific development concept of “green, low-carbon, and high-quality development”, based on domestic demand, optimize and strengthen, and enhance international competitiveness [2].

## 2. China’s Alumina Technology Development

### 2.1 Development History of Chinese Alumina Production Technology

The alumina refinery with single line capacity of 1000 kt/a based on diaspora of China has been successfully put into operation in April 2016. The alumina refinery with single line capacity of 1200 kt/a based on imported gibbsite has been successfully put into operation in Dec. 2021. The basic design of the alumina refinery with single line capacity of 1500-2000 kt/a based on imported gibbsite has been completed.

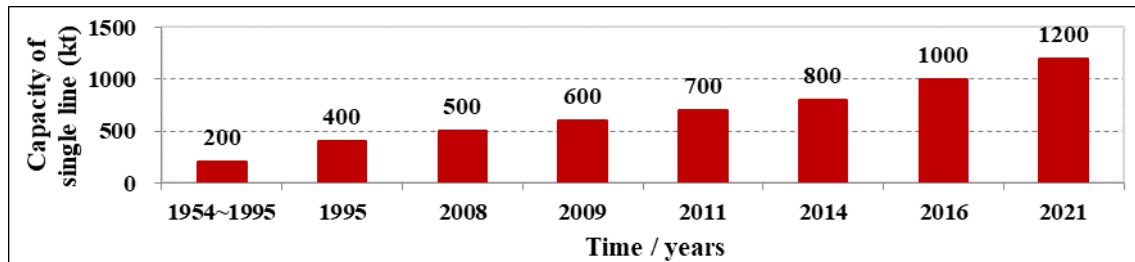


Figure 1. Development history of Chinese alumina production technology.

Table 1. Development history of Chinese alumina production technology with core technologies.

Years	1954~1995	1995	2008	2009	2011	2014	2016	2021
Single line capacity kt/a)	~200	400	500	600	700	800	1000	1200
Core Technologies	Sintering process, Combination process	Autoclave digestion Bayer process technology	Large-scale tube + holding tank digestion Bayer process technology	Large-scale tube + holding tank digestion Bayer process technology	Full tubular digestion Bayer process technology	Full tubular digestion Bayer process technology	Full tubular digestion Bayer process technology	Ful tubular digestion Bayer process technology

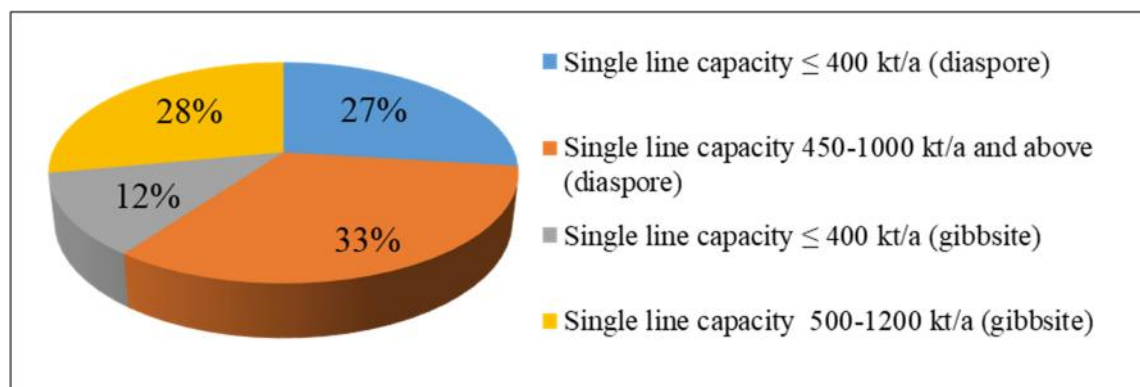


Figure 2. Alumina production capacity vs technologies.

Alumina production with Chinese diaspora: 1954 to 2008, alumina production series technologies with single line capacity  $\leq 400$  kt/a were mainly used in China’s aluminum industry, which even now still occupies about 27 % of total alumina production capacity of China; 2008 till now,

alumina production series technologies with single line capacity at 450-1000 kt/a have been developed rapidly, which now occupies about 33 % of total alumina production capacity of China.

Alumina production with imported gibbsite-based alumina production series technologies with single line capacity  $\leq 400$  kt/a are mainly used now, which is about 12 % of total alumina production capacity of China; Currently, series technologies with single line capacity of 500-1200 kt/a are developed rapidly, which is now about 28 % of total alumina production capacity of China.

### 2.1.1 China's Alumina Capacity and Output Distribution

Generally, global alumina (metallurgical grade) output sees an upward trend, and China is the main contributor. Percentage of China's alumina output among global total has increased from 39.3 % in 2012 to 56.2 % in 2022; In 2022, China's alumina output reached 79.76 million tonnes, which is about 56.2 % of world total; It is expected that China's alumina production capacity will reach 103.35 million tonnes per/year by the end of 2023, with a capacity growth rate of 3.8 %.

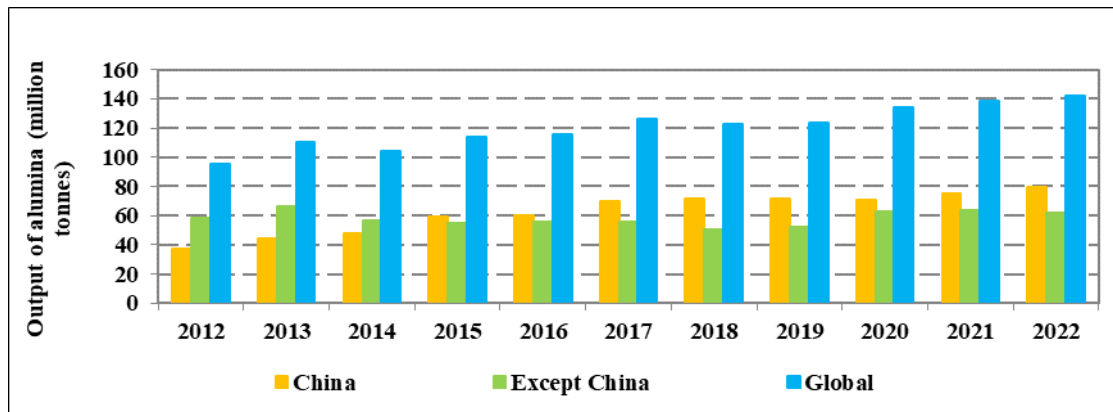


Figure 3. China and global alumina output comparison chart from 2012 to 2022.

In the past decade, China's alumina production capacity has maintained stable growth, but the average capacity utilization rate is 79.2 %; In 2022, China's alumina production capacity reached 99.55 million tonnes, with a production capacity of 79.76 million tonnes and a capacity utilization rate of 80.1 %.

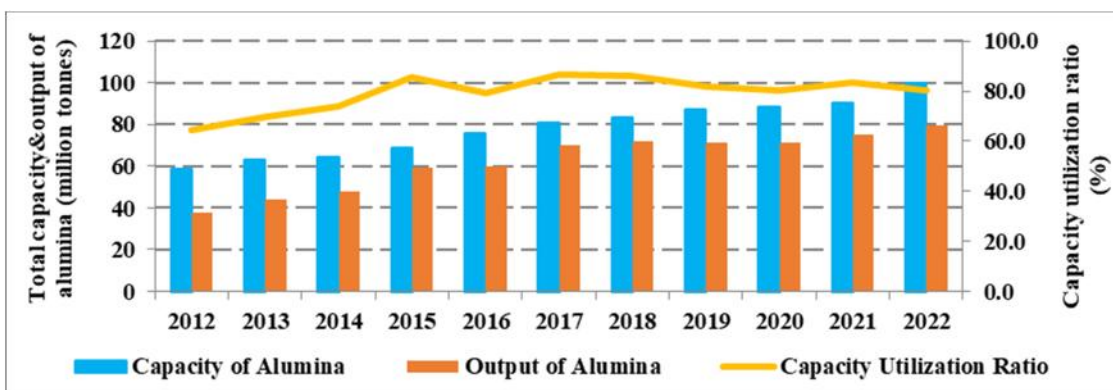


Figure 4. China metallurgical grade alumina capacity and output comparison chart from 2012 to 2022.

China's alumina production capacity is mainly distributed in areas with resource advantages such as Shandong, Shanxi, Guangxi, Henan, Guizhou province, etc., 57 % of the bauxite required for China's alumina production in 2022 is imported.

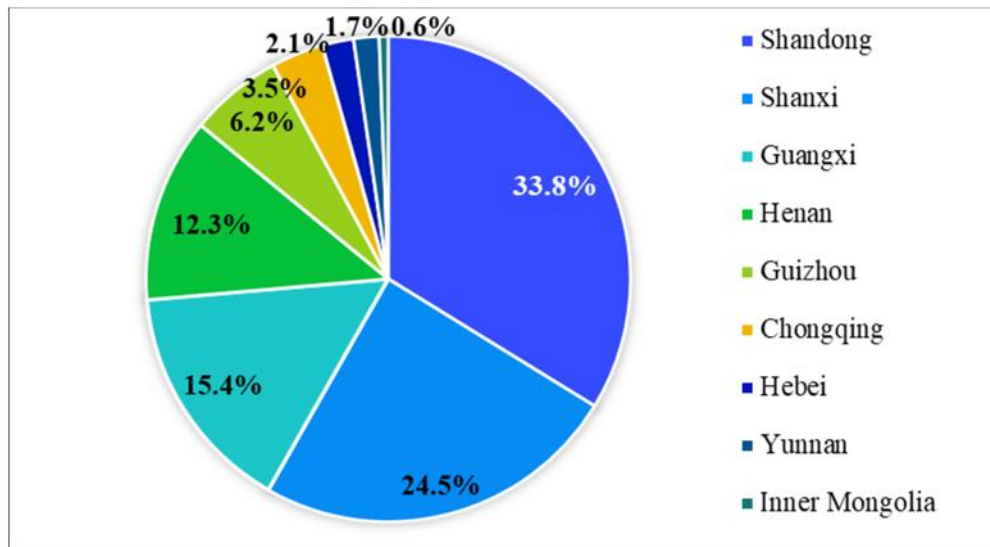


Figure 5. Distribution of alumina production capacity in China in 2022.

## 2.2 Brief Introduction of Aluminum Reduction Technology Development in China

### 2.2.1 Development History of Aluminium Reduction Technologies

Since the 160 kA pre-baked anode reduction cells were introduced from Japan in 1970's, China has successively developed and applied 200 kA, 240 kA, 280 kA and 300 kA high amperage pre-baked anodes reduction cells with its own IP.

Since 2007, China has been taking a leading role in developing the high amperage reduction cell technology. In 2008, NEUI developed the world's first 400 kA family aluminum reduction potline and applies it to operation. In 2011, the 500 kA family aluminum reduction potline was put into operation. In 2014, the 600 kA family super high amperage aluminum reduction potline, which is the highest amperage potline in the world developed by NEUI, was put into operation. Its main techno-economic indicators have reached world's leading level.

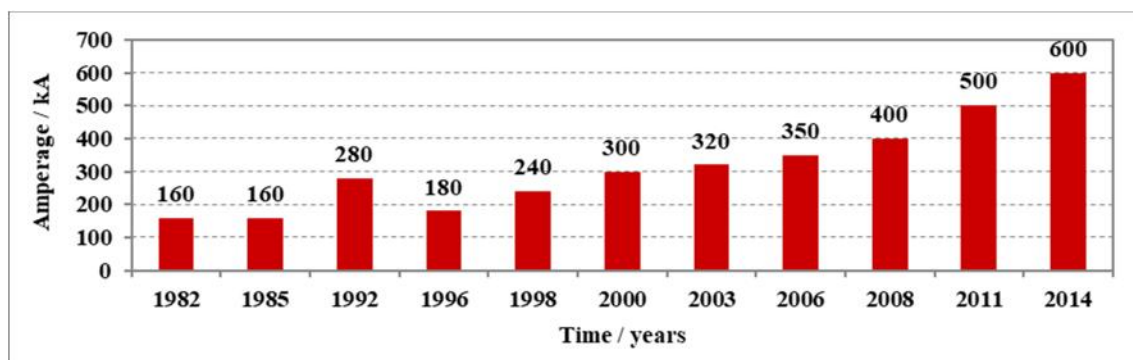


Figure 6. Development history of aluminium reduction technologies in China.

Now most aluminium reduction cells in China are running at 400-500 kA, making up 62.7 % of the total capacity. With the rapid development of 600 kA family reduction pot technologies, the capacity based on these technologies will grow year by year. Now it has already taken 12.54 % of the total capacity.

Potlines running at the amperage lower than 200 kA will exit the market in proper order. At present, the vast majority of domestic capacity transfer projects used 600 kA technology.

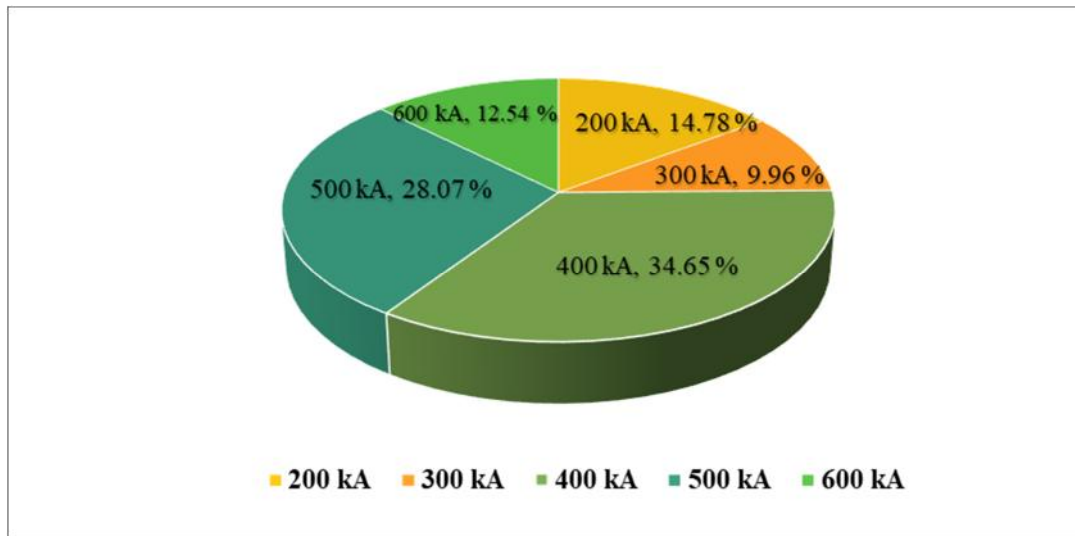


Figure 7. Capacity vs aluminium reduction technologies.

### 2.2.2 China’s Aluminum Capacity and Output Distribution

The growth of global primary aluminum production in the past decade has mainly come from China, with an average annual growth rate of 6.9 %. In 2022, China’s primary aluminum production reached 40.33 million tonnes, accounting for 58.5 % of the global total production.

Except for China, the production of primary aluminum in other regions has remained stable.

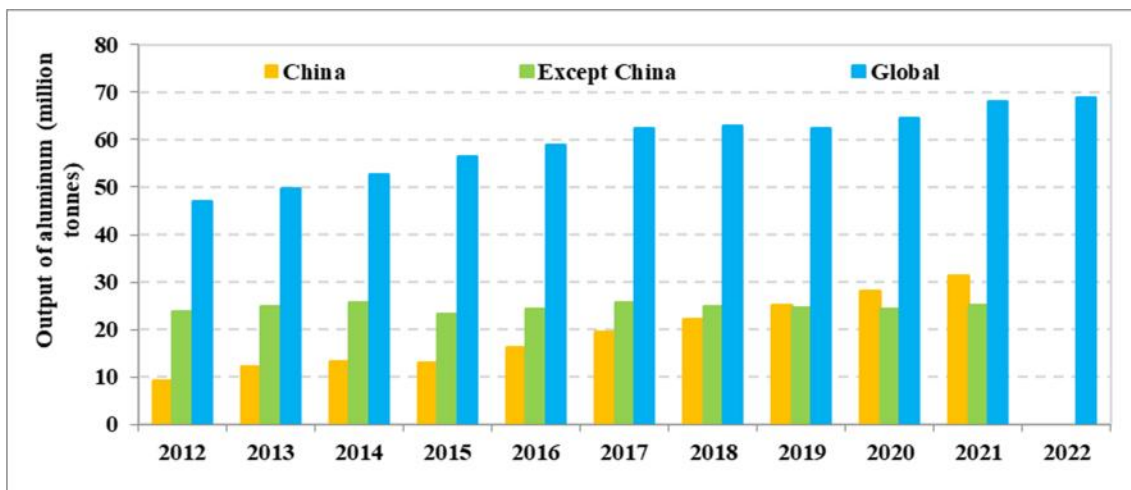


Figure 8. China and global aluminum output comparison chart from 2012 to 2022.

In the past decade, China’s primary aluminum production capacity has steadily increased, with an average capacity utilization rate of 84.1 %. In 2022, China’s primary aluminum production capacity reached 44.3 million tonnes, with a production capacity of 40.33 million tonnes and a capacity utilization rate of 91.0 %.

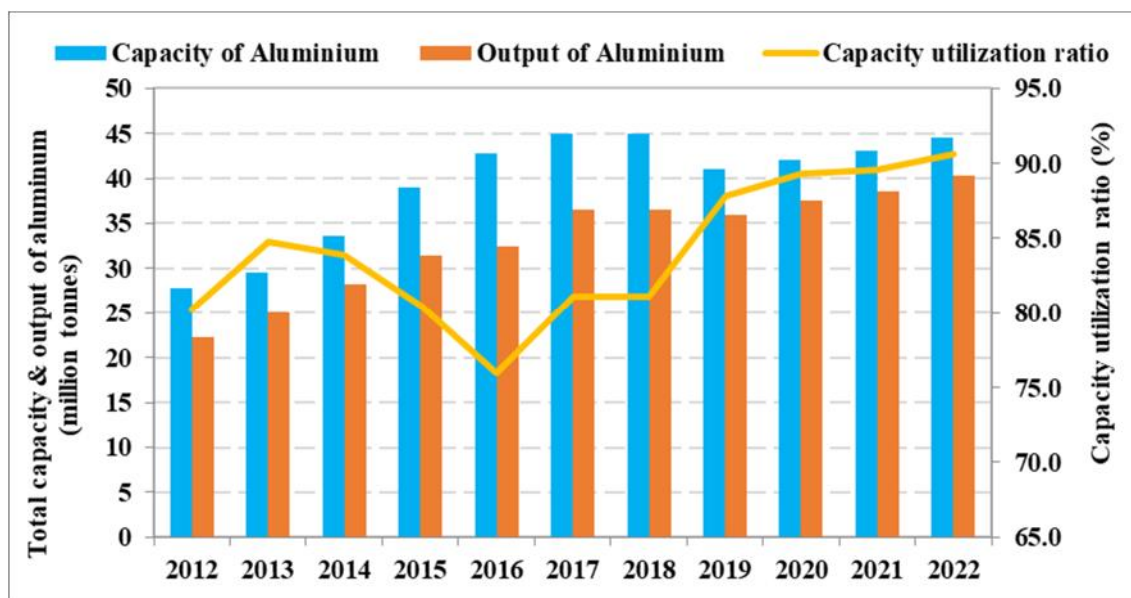


Figure 9. China aluminum capacity and output comparison chart from 2012 to 2022.

### 2.3 Low Carbon and Green Development of China's Aluminum Industry

At the United Nations General Assembly, China committed to the “30 · 60” goal of “carbon peak, carbon neutrality”. At the same time, the development goals, timelines, and action plans for “green” and “high-quality” have been further clarified, advocating for increasing the proportion of clean energy. Strictly control the production capacity scale of high energy consumption and high emission industries, and vigorously develop energy-saving and environmental protection industries. Prioritize energy and resource conservation, implement a comprehensive conservation strategy, and continuously reduce energy and resource consumption and carbon emissions per unit of output.

By 2025, the energy consumption per unit of GDP will decrease by 13.5 % compared to 2020. The carbon dioxide emissions per unit of GDP will have decreased by 18 % compared to 2020. The proportion of non-fossil energy consumption will reach around 20 %. The forest coverage rate will reach 24.1 %. By 2030, the carbon dioxide emissions per unit of GDP will decrease by more than 65 % compared to 2005. The proportion of non-fossil energy consumption reaches about 25 %, and the total installed capacity of wind and solar power generation reaches over 1.2 billion kilowatts. The forest coverage rate has reached around 25 %, and the carbon dioxide emissions have reached their peak and achieved a steady and gradual decrease. By 2060, the economic system of green and low carbon cycle development and the clean, low carbon, safe and efficient energy system will be fully established, the energy utilization efficiency will reach the international advanced level, and the proportion of non-fossil energy consumption will reach more than 80 %.

### 3. NFC/NEUI Performance in Aluminum Industry

Domestic projects are distributed in provinces & municipalities nationwide, covering China’s main aluminum reduction areas including Shandong, Shanxi, Henan, Inner Mongolia, Guangxi, Ningxia, Xinjiang & Guizhou province, etc. Overseas projects are located in Kazakhstan, Kirghizstan, Iran, India, Cambodia, Lao Peoples' Democratic Republic, Malaysia, Indonesia, Saudi Arabia, Egypt, Guinea, Ghana, Trinidad and Tobago, Republic of Guyana, Brazil and Australia, etc. As of Dec. 2022, NFC/NEUI Performance in Aluminum Industry is showed in Table2.

**Table 2. NFC / NEUI performance in aluminum industry.**

<b>Project</b>	<b>Qty. of Production Lines</b>	<b>Design Capacity (kt/a)</b>	<b>Operation Capacity (kt/a)</b>	<b>Remarks</b>
<b>Alumina</b>	153 trains (79 refineries)	101 400	44 950	Nearly 55 % of the total alumina capacity of China
<b>Aluminum</b>	114 potlines (28 smelters)	32 650	21 310	Nearly 45 % of the total aluminium capacity of China
<b>Carbon</b>	28 production lines	5 750	2 310	

#### **4. Development and Application of NFC/NEUI Aluminum Smelting Technologies**

##### **4.1 Elements for NFC/NEUI Aluminum Smelting Core Technology Development**

NFC/NEUI have an aluminum reduction core technology development team, who have accumulated experience throughout the whole process in each stage of the technological development of China's aluminum industry and has been committed to technological development of core technologies and equipment package for aluminum smelting for forty years. By adopting "Numerical Simulation<sup>+</sup>" core technology development mode, NFC/NEUI achieve an accurate simulation on pot physical field and successfully develop and apply 200-600 kA high amperage aluminum reduction technologies. By adopting "Numerical Simulation" core technology development mode, NFC/NEUI achieve an accurate simulation of elements in each link of an alumina refinery and successfully solve the element balance optimization problem in each link of the large scalization development of alumina refineries.

##### **4.2 Development and Application of NFC/NEUI Alumina Technologies**

###### **4.2.1 NEUI400 kt-1250 kt/a Large-Scale Tube and Holding Tank Digestion Bayer Process Technologies Based on Diaspore**

In 2007, NEUI first develops the large-scale tube and holding tank digestion technologies and equipment with the biggest single - train capacity of 500 kt/a in China at that time, which was put into operation in Xing'an Chemical Co., Ltd. in December, 2008, with difficult core technology problems successfully solved. It is the first large scale tube and holding tank digestion unit with a single train capacity of 500 kt/a of alumina in China at that time using Bayer process to process diasporic bauxite.

Afterwards, NEUI continues to optimize and develop large scale alumina technologies and successively develops NEUI600 kt/a-700 kt/a-800 kt/a-1000 kt/a tube and holding tank digestion technologies, with the first industrial application of the NEUI700 kt/a technology achieved in Shanxi Zhaofeng Aluminum Co., Ltd. in 2012, which is the alumina refinery with currently the biggest large-scale tube + holding tank digestion technology in China.

#### **4.2.2 NEUI400 kt/a-1250 kt/a Large Scale Full Tubular Bayer Process Digestion Technologies Based on Diaspore**

With the continuous development of NEUI large scale tubular and holding tank digestion technologies, NEUI successively develops NEUI600 kt/a - 700 kt/a - 800 kt/a - 1000 kt/a full tubular digestion technologies and equipment in order to further optimize alumina refinery core technologies, with the first industrial application of NEUI 800 kt/a technology achieved in Shanxi Fusheng Aluminum Co., Ltd., which is currently the biggest large scale full tubular digestion technology alumina refinery in China, successfully completing the re-innovation of large scale alumina core technologies. In April, 2016, NEUI1000 kt/a technology is put into industrial application in the alumina refinery project in Lingshi, Shanxi, which again makes a history in the development of large scale full tubular digestion technologies for alumina refineries.

At present, NEUI has successfully developed NEUI1250 kt/a large scale full tubular digestion Bayer process technology based on diaspore; currently basic engineering has been completed using this technology for the alumina refinery project in Lingshi, Shanxi; next it is going to be put into industrial operation.

#### **4.2.3 NEUI400 kt/a-2000 kt/a Single Stream Tubular Digestion Bayer Process Technologies and Dual Stream Tube-in-shell Digestion Bayer Process Technologies Based on Gibbsite**

NEUI is the first to develop NEUI400 kt/a -1000 kt/a single stream large scale tubular digestion technologies based on gibbsite and technologies for producing sandy alumina with new two stage precipitation, with the first industrial application of the NEUI400 kt/a technology achieved in Shandong Nanshan Group Aluminum Co., Ltd. in July, 2011, which is currently a tubular digestion alumina refinery with the biggest single train capacity based on gibbsite and the only alumina refinery that uses two stage precipitation technology to produce sandy alumina in China. In 2012, NEUI500 kt/a technology is first to be put to industrial application to Shandong Weiqiao Aluminium Co., Ltd., which is currently the biggest single stream large scale tubular digestion alumina refinery with one stage precipitation in China.

Currently, NEUI has successively developed NEUI1000 kt/a, NEUI1500 kt/a and NEUI2000 kt/a super large dual stream tube-in-shell Bayer process digestion technologies based on gibbsite and the associated auxiliary equipment technologies and short process technologies successfully, which have been successfully applied to Weiqiao Group's projects in Indonesia, Nanshan Group's project in Indonesia, and Jinjiang Group's project in Indonesia respectively; currently basic engineering has been completed; next it is going to be put into industrial use.

### **4.3 NFC/NEUI Aluminum Reduction Technology Development and Application**

#### **4.3.1 NEUI400 Aluminum Reduction Pot Technology Development and Application**

NEUI is the world first to develop the high amperage reduction pot technology using the development mode "numerical simulation", with NEUI400 (I) aluminum reduction pot developed in 2007. In August, 2008, the world first 400 kA potline was put into operation in Henan Zhongfu Industry Co., Ltd. with annual capacity of 240 kt. Thereafter, continuous optimization of the NEUI400 (I) aluminum reduction pot technology is followed, and NEUI400(II)-(VIII) aluminum reduction cell technologies were developed. At present, all of them have been put into industrialized operation with a total capacity of 10 400 kt/a.

#### 4.3.2 Development and Application of NEUI500 & NEUI600 Aluminum Reduction Pot Technologies

Based on the same “numerical simulation” development mode, NEUI500 & NEUI600 aluminum reduction potline technologies were developed in 2009 following more strict technical development standards.

In December, 2014, the world first 600 kA potline was put into operation in Shandong Weiqiao Aluminum & Power Co., Ltd, with annual production capacity of 600 kt (300 kt×2). As of December, 2022, NEUI has completed the design of 15 potlines of NEUI600kA, with a total design capacity of 6180 kt/a. Among them: 11 potlines with a capacity of 4250 kt/a has been put into operation, 4 potlines with a total capacity of 1930 kt/a are under construction. As of December, 2022, NEUI has completed the design of 8 potlines of NEUI500 kA, with a total design capacity of 2620 kt/a. Among them: 7 potlines with a capacity of 2170 kt/a have been put into operation, and 1 potline with a capacity of 450 kt/a are under construction.

### 5. Conclusions

In the past decade, the industrial scale and core technology level of China’s aluminum industry have developed rapidly, making important contributions to the development and technological progress of the world’s aluminum industry. In recent years, China’s aluminum industry has paid more attention to optimizing the industrial layout, promoting structural adjustment, innovating and developing green low-carbon technology, optimizing process technology, improving system energy efficiency, promoting the construction of green manufacturing system, establishing a standard system for the non-ferrous metal industry with the goal of carbon peaking and carbon neutrality, and promoting the emissions trading of electrolytic aluminum carbon. NFC/NEUI has developed and applied a series of advanced energy-saving and low-carbon innovative technologies, contributing an important force to the healthy and green development of China’s aluminum industry.

### 6. References

1. Zhang Bo, Discussing the development plan of China's aluminum industry together [J]. *China Non-ferrous Metals*, 2021 (22): 1.
2. Jiang Yujing. Development of China's aluminum industry under the new policy [J], *Light metal (in Chinese)*, 2017 (11): 4.