

Technical and Economic Advantages and Application Progress of NEUI600 High-Amperage Aluminium Reduction Cells

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Abstract

Aluminium reduction cell is the core equipment for primary aluminium production. Increasing the amperage of the cells has been the main technology development direction in the past few decades. High amperage 600 kA cell technology has been widely applied in last 10 years in China due to its significant technological and economic advantages such as low unit capital expenditure, high single potline capacity, high labour efficiency and faster returns on investment and recovery of construction costs for greenfield smelters. Through optimized design and iterative upgrading of materials and equipment, including new busbar configuration and cell design, the magneto-hydrodynamic (MHD) stability and thermal balance of NEUI600 have made further breakthroughs. The key performance indicators (KPIs) have continuously improved; specific energy consumption has been reduced to 12 300 kWh/t Al and current efficiency increased to over 94 % in the most advanced design using RuC cathodes, which resulted in significant energy-saving and production increase. Using novel high-quality cathode carbon blocks and lining materials, the cell lining life is predicted to exceed 2 500 days, reducing the frequency of cell shutdowns. Low energy consumption and long cell lining life reduce operating and maintenance costs. Optimized fume hooding structure and high purification efficiency reduced pollutant emissions, which meet low emission environmental protection standards.

As one of the early companies in the global aluminium industry which developed and implemented 600 kA cell technology, NEUI600 technology has been widely used in domestic capacity replacement and expansion projects. At the end of 2024, the technology was used in 15 potlines, with a total capacity of 6.180 Mt/a. Following the first successful 600 kA potline in Shandong Weiqiao Aluminium smelter at the end of 2014, the longest operating time is over 10 years. The highest amperage can reach 630 kA or above, and rich experience in design, construction and operation has been accumulated. With the continuous iteration and upgrading of NEUI600 technology and the application of new technologies, the overall maturity continues to improve, and the KPIs have reached the world leading level. NEUI600 has become the preferred cell technology for domestic and overseas projects, contributing to the high-quality and low-carbon primary aluminium production.

Keywords: NEUI600 high-amperage aluminium cell, Technical and economic advantages of high amperage technology, NEUI600 implementation progress.

1. Introduction

Based on NFC/NEUI’s experience in cell engineering design, construction and operation, the cell technology progressed from 160 kA to high amperage of 600 kA [1] as brand names NEUI160, NEUI200, NEUI300, NEUI400, NEUI500, and NEUI600 , Figures 1–4 compare the effects of large-scale production on the productivity per unit area of the cell, labour productivity (based on annual production of 500 kt), unit capacity investment, and single potline production.

In the same equipment configuration and 500 kt/a of aluminium production capacity, for every 100 kA amperage increase from 200 kA to 600 kA, the average productivity per unit area of the cell increased by 4.0 % (Figure 1), the average labour productivity increased by about 22.5 % (Figure 2), the average unit investment decreased by 8.6 % (Figure 3), and the single-line capacity increased by 32 % (Figure 4). If we compare 600 kA technology with 160 kA technology, the production per unit cell area increased by 19.5 %, labour productivity increased by 1.5 times, unit investment reduced by 36.7 %, and maximum single line capacity increased from 160 kt/a to 600 kt/a. This is why we are in the era of 600 kA technology now.

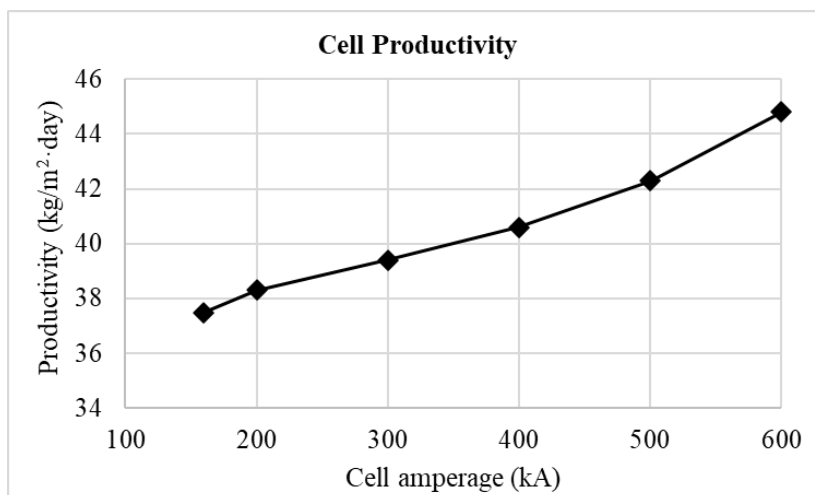


Figure 1. Productivity per cell area for different cell amperages.

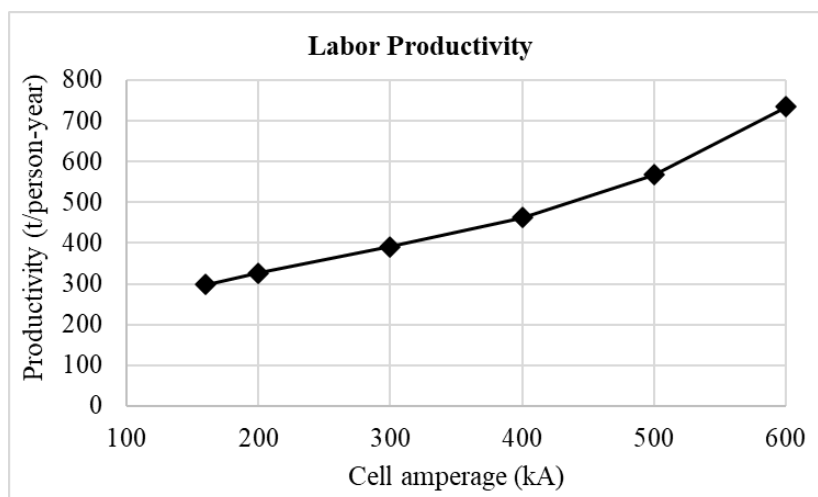


Figure 2. Labour productivity for different cell amperages.

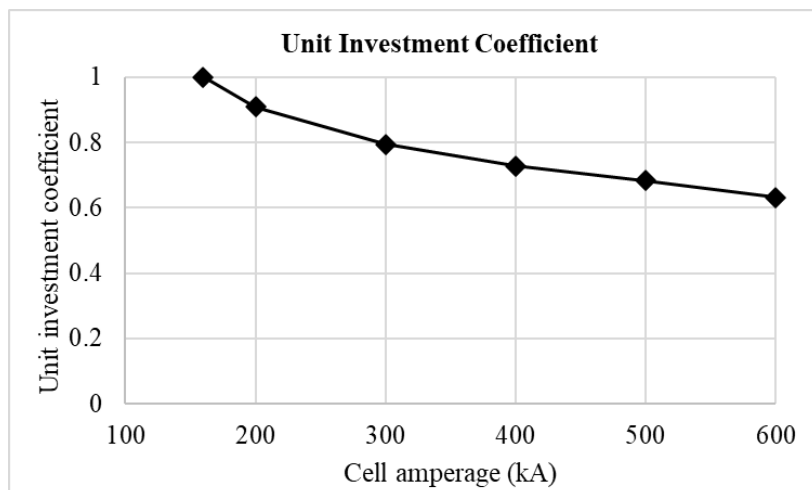


Figure 3. Unit investment coefficient for different cell amperages.

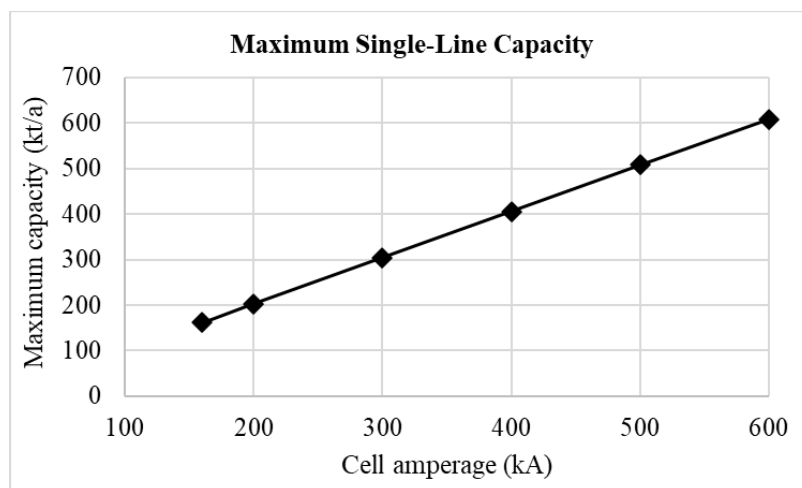


Figure 4. Maximum single-line capacity for different cell amperages.

The longest operating time of the NEUI 600 kA potlines is more than 10 years in Shandong Weiqiao Aluminium & Power Co., Ltd, where the first 600 kA potline was started in December 2014 [1, 2], With continuous accumulation of operating experience, technological iterations and upgrading, and successful construction of new 600 kA potlines, the overall technology maturity and the operating key performance indicators (KPIs) continue to improve. At the end of 2024, a total of 15 potlines with NEUI600 cells have been built or are in construction, with a total capacity of 6.180 Mt/a in China. Among them, 12 potlines have been put into operation with a total capacity of 4.73 Mt, accounting for about 10 % of total operating capacity in China. Three 600 kA potlines are under construction in Yunnan Honghe smelter, with one potline started in July 2025, for a total capacity of 1.93 Mt/a in four potlines. Currently, NEUI600 has become the preferred cell technology for domestic capacity replacement projects and new potlines.

2. Technical Characteristics and Continuous Upgrading of NEUI600 Cells

As a professional engineering and research institute in light metals metallurgical industry, NEUI has developed core design and engineering tools, which allowed to design 400 kA [3] to 600 kA [2, 4, 5] technology. During more than ten years, continuous optimization and upgrading have been carried out on the core technology of the NEUI600, mainly in MHD stability improvement, thermal balance, cathode design, strengthening of cell steel structure and fume collection efficiency.

2.1 Advances in Core Technologies for MHD Stability

The magnetic field compensation is the design process for balancing the magnetic field distribution in the liquid metal and bath by proper configuration of the cell-to-cell busbars and by compensating the magnetic field generated by the current in the adjacent potroom. Because of the complexity of the cell busbar arrangement and the impact of numerous ferromagnetic materials on the magnetic field, advanced 3D mathematical models have to be used for the calculation of the magnetic field distribution in the cell. NEUI uses ANSYS-based models, developed in-house for this purpose and validated with measurements.

NEUI600 mainly uses self-compensation with cathode ring busbars, and on top of it a magnetic compensation loop with a current of 20–30 kA at the duct end of the cells to compensate vertical magnetic field from the neighbouring rows and decrease its gradients. This magnetic compensation loop also reduces the busbar voltage drop and the mass of the cell-to-cell busbars. By optimizing the busbar structure, the busbar current distribution is self-balancing and has anti-interference ability against abnormal cell conditions so that the instability in a cell is not spread to adjacent cells.

In addition, the cathode design has also been optimized to reduce horizontal currents in the metal pad in order to improve the MHD stability further [4]. Some design features and high conductivity collector bars reduce horizontal current in the liquid aluminium by 50 % to 70 %, which further improves the MHD stability. In cells with RuC cathodes, which are being tested on large scale (110 cells), the cathode voltage drop has also been reduced to approximately 167 mV (predicted average over assumed cell lifetime) [6]; this allows operation at low working voltage and low specific energy consumption of 12 300 kWh/t Al in these cells at current efficiency higher than 94 %.

Figure 5 shows current density distribution in the metal pad for RuC cathodes, which is more uniform than for steel collector bars. Figure 6 shows the vertical magnetic field in the liquid metal pad. We see that the vertical component of the magnetic field is very small in the whole area of the metal pad. The interface deformation of the aluminium pad (Figure 7) is also smaller, which allows reducing the anode-cathode distance (ACD) further, and enables the NEUI600 cell to operate stably and efficiently at lower working voltage.

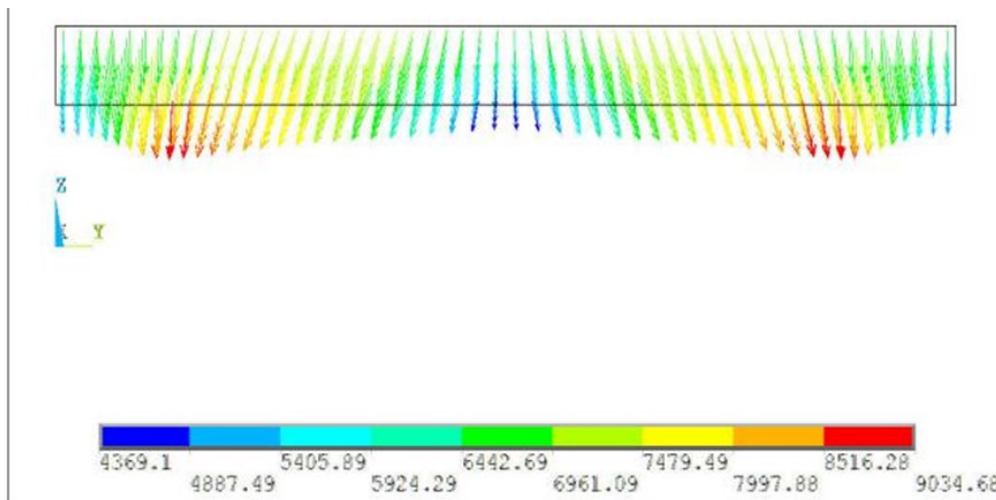


Figure 5. Vector diagram of current distribution in aluminium liquid pad in NEUI600 cell with RuC cathode block technology.

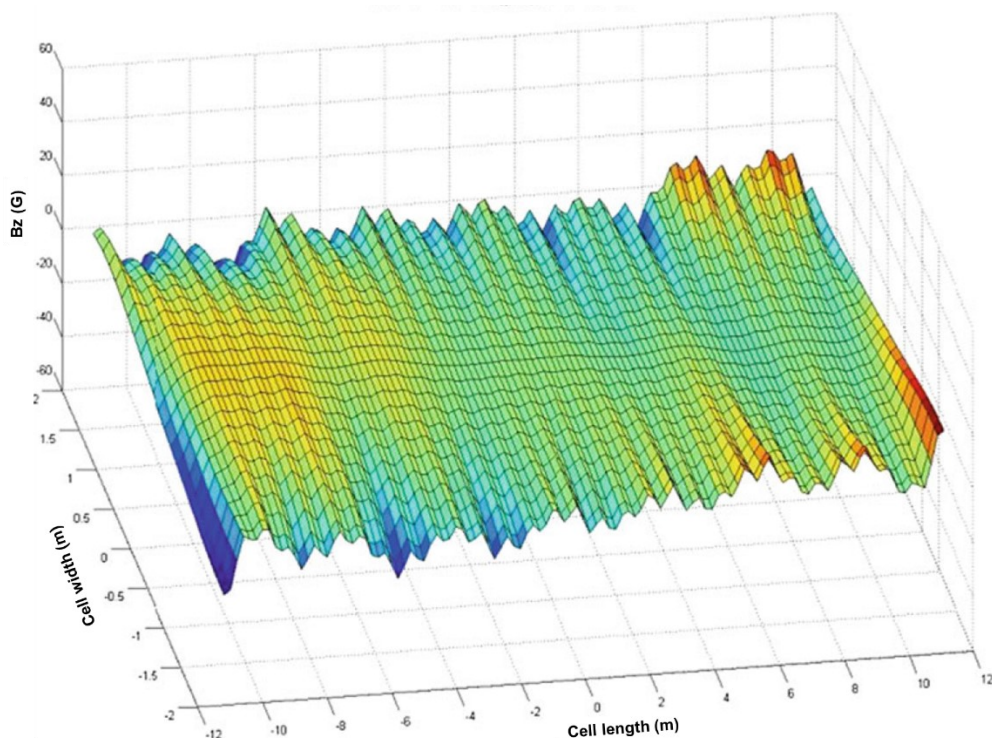


Figure 6. Distribution of vertical magnetic field in the metal pad in NEUI600 cell [2].

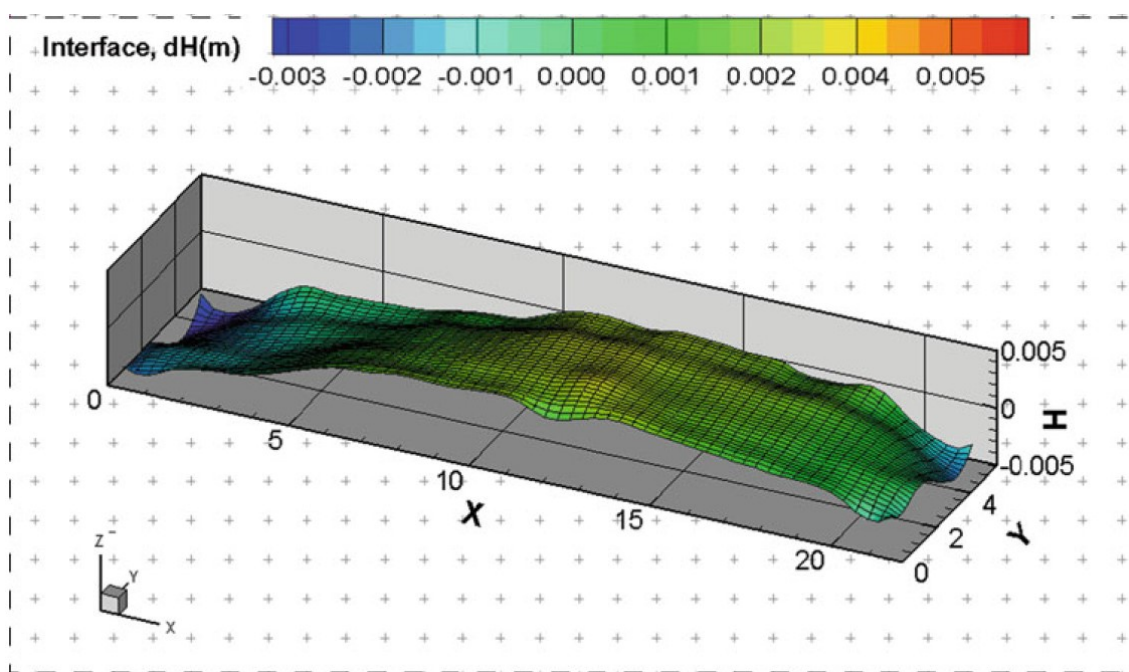


Figure 7. Simulation result of interface deformation of NEUI600 cell [2].

2.2 Improvement of Thermal Balance and Lining Optimization

The key issue for designers is to ensure the energy balance of ultra-high-amperage cells with low working voltage and achieve adequate ledge shape and lining temperature distribution. NEUI has performed repeated simulations to NEUI600 cells with ANSYS-based 3D thermo-electronic

simulation software developed inhouse, and has optimized the lining of NEUI600 cells. The heat balance is well matched with the cathode, potshell, ventilation system design, and operating process parameters. The design shifted towards increasing insulation to decrease heat loss from the cathode and cell exhaust and allow low cell voltage operation. Figure 8 shows the simulation results of thermal field in the NEUI600 cell.

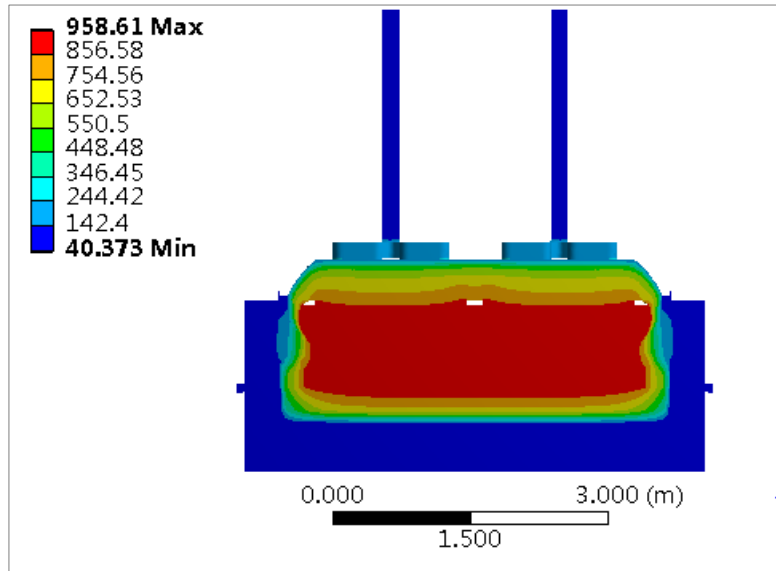


Figure 8. NEUI600 simulated temperature distribution.

2.3 Improvement of Potshell and Superstructure Design

By continuously optimizing the integrated welding potshell structure, smaller potshell deformation can be achieved while having better thermal balance adjustment capability.

By optimizing the superstructure of the multi-stage split type pipe truss beam, better stress performance, more effective stress release, and better cell ventilation is achieved. At the same time, it is better integrated with the fume collection structure.

2.4 Optimization of Fume Collection Structure

By optimizing the high-level partition fume collection structure, system resistance was reduced, negative pressure uniformity was improved, exhaust gas volume flowrate was reduced, energy loss was minimized, and cell energy consumption was reduced. At the same time, higher fume collection efficiency was achieved.

2.5 Continuous Development

The optimization of NEUI 600 kA cell design continues in all areas discussed above. One goal is to increase anode current density to above 0.90 A/cm². Another goal is to increase potline safety. Digital technology is being developed for cell operation and control.

3. Application of NEUI600 Cell Technology

At present, there are 12 potlines operating using NEUI600 technology in China, with a total production capacity of 4.73 Mt/a, accounting for about 10 % of total capacity in China. A few typical potlines are as shown in Figures 9–12.



Figure 9. A NEUI600 potline in Shandong Weiqiao Aluminium & Power Co., Ltd. aluminium smelter.

The Shandong Weiqiao Aluminium & Power smelter in Shandong province has 6 NEUI600 potlines in operation (Figure 9), with a total production capacity of 2.21 Mt/a and the longest operating time of over 10 years. The operating current is between 600 kA and 605 kA, and the current efficiency is 92–94 %. By using different cathode designs, different DC energy consumption has been achieved. Among them, NEUI600 cells using graphitized cathodes with steel collector bars have an average DC energy consumption of 12 750 kWh/t Al, the NEUI600 cells using graphitized cathode with copper insert collector bars have an average DC energy consumption of 12 550 kWh/t Al, and NEUI600 cells using RuC technology have an average DC energy consumption of 12 300 kWh/t Al and current efficiency exceeding 94 %. Successful testing of RuC technology in 110 cells in Weiqiao led to the decision that this technology will be further expanded within the company.

China Hongqiao Group is the aluminium subsidiary of Shandong Weiqiao Pioneering Group [7]. Recently, Hongqiao has been relocating its smelter capacity from Shandong to Yunnan (Yunnan Hongtai and Yunnan Honghe smelters) in order to shift the production from coal generated power in Shandong to hydro-electric power in Yunnan. When these projects are completed, over 60 % of China Hongqiao's aluminium smelting capacity will have been transferred from Shandong Province to Yunnan Province, from coal-based electricity to hydroelectricity [7]. The low carbon emissions goal has been already achieved in Yunnan Hongtai smelter, which obtained Aluminium Stewardship Initiative (ASI) certification in February 2023 [8].

The total capacity of Hongqiao Group is 6.46 Mt of aluminium. The operational capacity of Hongqiao in Shandong is 4.232 Mt. As the Yunnan projects are progressively commissioned, capacity in the Shandong region is gradually reduced, while the total capacity of Hongqiao Group remains unchanged.

The Yunnan Hongtai smelter in Wenshan prefecture, Yunnan province (Figure 10), has two NEUI600 potlines in operation with a capacity of 0.77 Mt/a, and four 400 kA potlines with capacity of 1.26 Mt/a, with a total production capacity of 2.03 Mt/a. It was put into operation from September 2020 to January 2022. In the NEUI600 potlines, the operating amperage is between 610 kA and 616 kA, and the current efficiency is between 92.5 % and 93.5 %. The NEUI600 cells using graphitized cathodes with steel collector bars achieved a DC energy consumption of 12 700 kWh/t Al, while the NEUI600 cells using RuC technology achieved DC energy consumption of 12 300 kWh/t Al and current efficiency exceeding 94 %.



Figure 10. NEUI600 potlines in Yunnan Hongtai aluminium smelter.

The Yunnan Honghe smelter (Figure 11) in Honghe prefecture, Yunnan province, will have four NEUI600 potlines with a total production capacity of 1.93 Mt/a. The first potline was commissioned in July 2025 [9], the other three potlines are under construction. This project uses the latest version of NEUI600 cell technology, NEUI600+, with further optimized and upgraded cells. The operating amperage is designed to be 630 kA, and it is expected that it will also achieve the best KPIs.



Figure 11. NEUI600 potlines under construction in Yunnan Honghe aluminium smelter.

The NEUI600 potline in Inner Mongolia (Figure 12) was put into operation in May 2018. Currently, the operating amperage is between 600 kA and 603 kA and the current efficiency is between 92.5 % and 93.5 %. NEUI600 cells using graphitized cathodes and steel collector bars

achieved DC energy consumption of 12 700 kWh/t Al, while NEUI600 cells using graphitized cathodes with copper insert collector bars achieved DC energy consumption of 12 500 kWh/t Al.



Figure 12. NEUI600 potline in Inner Mongolia aluminium smelter.

4. Conclusions

The longest operating time of the NEUI600 cells has been more than 10 years, with continuous accumulation of operating experience, technological upgrading, and the application of new technologies. In the last 10 years, NEUI600 technology has been expanded to 15 potlines. The overall maturity of the technology is growing, and the operating KPIs continue to improve. NEUI600 has become the preferred cell technology for domestic capacity replacement projects and overseas projects, continuously contributing to the high-quality and low-carbon development of primary aluminium industry.

5. Acknowledgements

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