Successful Experience in Organising Baked Anode Production at RUSAL Volgograd

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Abstract

The construction of new capacities that employ the aluminium production technology based on the use of baked anodes at RUSAL's sites increased the need for expensive baked anodes. In order to reduce expenses associated with purchasing baked anodes (BA), the Company decided to build its own capacity to produce BA (Taishet anode factory) and organise BA production at the existing mothballed anode paste operations (Volgograd anode factory). In 2016, a new project for establishing a BA production site, without sacrificing the anode paste production, was launched at the existing anode paste production site in Volgograd. To minimise the costs of organising the BA production site, the following modern and non-standard solutions were used in the framework of the said project:
- an anode-baking furnace has been built within the existing building of the mothballed potroom,
- the pitch coke calcination plant has been retrofitted to produce calcined petroleum coke with a 25 % increase in performance (for the first time in the world practice!),
- technological and construction solutions relating to the anode paste plant were developed, which made it possible to maximise the use of existing equipment for the production of green anodes,
- the existing gas treatment centres of the reduction area have been retrofitted to treat exhaust gases that are simultaneously supplied from the potroom and the anode-baking furnace, and
- energy-efficient technologies have been applied to ensure the complete utilisation of heat from the calcining systems as well as heat and electricity generation.

The project was implemented in the shortest possible time (design, procurement, construction), and the target design of 104 000 t of BA per year were achieved. Thanks to the implementation of the project, the volumes of BA purchased by the Company decreased, and the experience in organising a BA production site, which will be used in the construction of new production facilities, was gained. Quality performance figures of the produced BA correspond to the benchmark. This article provides information on pre-operational testing, start-up and commencement of the BA manufacturing process at RUSAL Volgograd, as well as production figures for the first year of operation.

Keywords: green anode block, baked anode block, paste plant, anode baking area, anode factory.

1. Introduction

Due to the construction of new aluminium production facilities using BA, RUSAL has faced a large shortage of baked anodes. To cover it, RUSAL purchases baked anodes in China. Given changes in the China's domestic legislation, there is a high risk of increased cost of anodes and that their supply will become unsteady. In order to replace Chinese imports and improve the economic efficiency of the Company, in 2015 it was decided to establish in-house production of green and baked anodes at RUSAL Volgograd facilities.

At the time the project was launched, the reduction area at RUSAL Volgograd was partially stopped and mothballed. The total design capacity of the anode paste (AP) production site is 185 000 t/ year. At the time the project was launched, the production was reduced to the amount demanded by the Kandalaksha aluminium smelter – 35 000 t/year and two potrooms of RUSAL Volgograd which was 35 000 t/year. The production capacities of 115 000 t/year were idle. In this regard, it was decided to use the existing reserve capacity and establish a BA production site with a capacity of 104 000 t/year. The project is planned to be implemented for a period of 24 months plus a 12-months period is scheduled in order to achieve the project indicators.

The general contractor responsible for the implementation of the project "Organisation of BA Production" is LLC RUSAL ETC. Within the framework of the project, modern and non-standard solutions were applied. The design activities were carried out by JSC RUSAL VAMI and JSC SibVAMI. The main equipment suppliers are the following companies: Riedhammer, Fives Solios, Storvik, FLSmidt, R&D Carbon, Mogensen, NKM Noel, Tomorrow Technology, Siemens, and PSP.

2. Application of modern and non-standard solutions during the project implementation

2.1. Retrofitting of the pitch coke calcination plant to be able to produce KEP-2 calcined petroleum coke

The calcining systems of the RUSAL Volgograd branch were designed to calcine pitch coke. For this purpose, they have been operated for many years. The design capacity of the calcining furnace for calcined pitch coke is 10 t/h. Considering the change in the anode paste production technology (calcined petroleum coke instead of pitch coke) at RUSAL Volgograd, the calcining systems have been mothballed since 1999.

The main difference between the petroleum coke calcination process and the pitch coke calcination process is a high temperature and a larger volume of gases from the calcining furnace due to the high content of volatile matter and coke dust in the petroleum coke. This requires the use of additional equipment (heat recovery and efficient gas treatment equipment, high-performance exhaust fans), the use of more heat-resistant materials, gas ducts with a larger cross-section, etc. Also, to ensure its own need for calcined petroleum coke, the furnace capacity should be increased up to ≥ 12 t/h.

To ensure the production of calcined petroleum coke with a real density of ≥ 2.06 g/cm^3 and increase the furnace capacity up to ≥ 12 t/h, the following technical solutions have been implemented: systems for supplying secondary and tertiary air into the furnace have been installed, a new furnace lining with longitudinal baffle plates and tertiary air has been installed, the furnace's cooling grid has been reconstructed, and a waste heat boiler has been installed at the outlet of the gas path of the calcining furnace.

Thanks to the implemented technical solutions, calcined petroleum coke of anode quality with a true density of ≥ 2.06 g/cm3 was produced and the furnace capacity was increased by 25 % up to 12.5 t/h.

Figure 1. The coke calcining furnace. Left: before the retrofitting, right: after the retrofitting

2.2. Construction of the heat recovery facility

In connection with the retrofitting of the petroleum coke calcining furnace, the heat recovery facility has been built to recover the generated heat energy. The facility includes a boiler house, a turbine house, a gas treatment centre, and a water recycling unit.

Figure 2. Left: a waste heat boiler, right: a gas treatment centre of the heat recovery facility

Figure 3. Left: a turbine-generator, right: a water recycling unit.

For the first time, the Company applied energy-efficient technologies to ensure the complete recovery of heat from the calcining systems as well as heat and electricity generation.

2.3. Retrofitting of the anode paste production site

In order to ensure the production of green anode blocks (GA), the existing anode paste plant has been retrofitted and the following additional equipment has been installed: new screening machine, a horizontal ball mill with an air separation system, flap gate for continuous mixers, a vibrating compactor and cooling conveyor, a GA buffer store. It was difficult to implement the technical solution because the anode paste was fed from two mixers to one vibrating compactor installed in the new building, which required installing a complex system for conveying the anode paste to the vibrating compactor.

Figure 4. Left: a vibrating compactor, right: a GA buffer store.

The implementation of these technical solutions made it possible to produce GA in the required quantity while maintaining the ability to produce the required amount of anode paste.

2.4. Construction of the anode-baking furnace

The construction of the anode-baking furnace was performed in the existing mothballed potroom. In addition, to minimise costs, it was proposed to use the existing dry gas treatment facilities which were used to treat the gases leaving the operating potroom.
As part of the project, technical solutions have been developed and implemented to fit a fifty-two sections anode-baking furnace with three fires into the existing building structures.

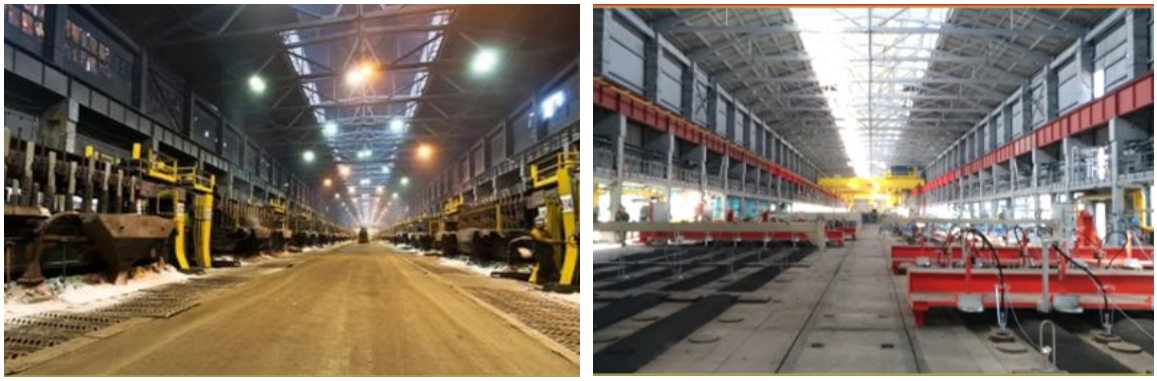

Figure 5. The potroom building. Left: before the retrofitting, right: after the retrofitting

The retrofitting of existing overhead cranes for setting studs in GA and BA stacker cranes was carried out; GA conveyor, BA cleaning, conveyor and a slotting machine were installed.

Figure 6. Left: a BA warehouse equipped with stacker cranes and a slot cutting machine, right: a BA conveyance line

The existing dry gas treatment facilities of the potroom have been retrofitted and enable to simultaneously treat exhaust gases from the anode-baking furnace and trapped gases from the potroom.

Figure 7: Left: the gas treatment centre before the retrofitting, middle: the gas treatment centre after the retrofitting, right: the calcining furnace building with its gas treatment facilities

3. Project phases

The project to establish a BA production site at RUSAL Volgograd was opened in May 2016. The planned project implementation period was 36 months. The project objectives are as follows: to create a state-of-the-art, energy-efficient and sustainable baked anode block production site with a capacity of 104 000 t/year based on the existing main production capacities of the Volgograd aluminium smelter; to provide UC RUSAL production sites with baked anodes to exclude dependence on foreign suppliers (import substitution).

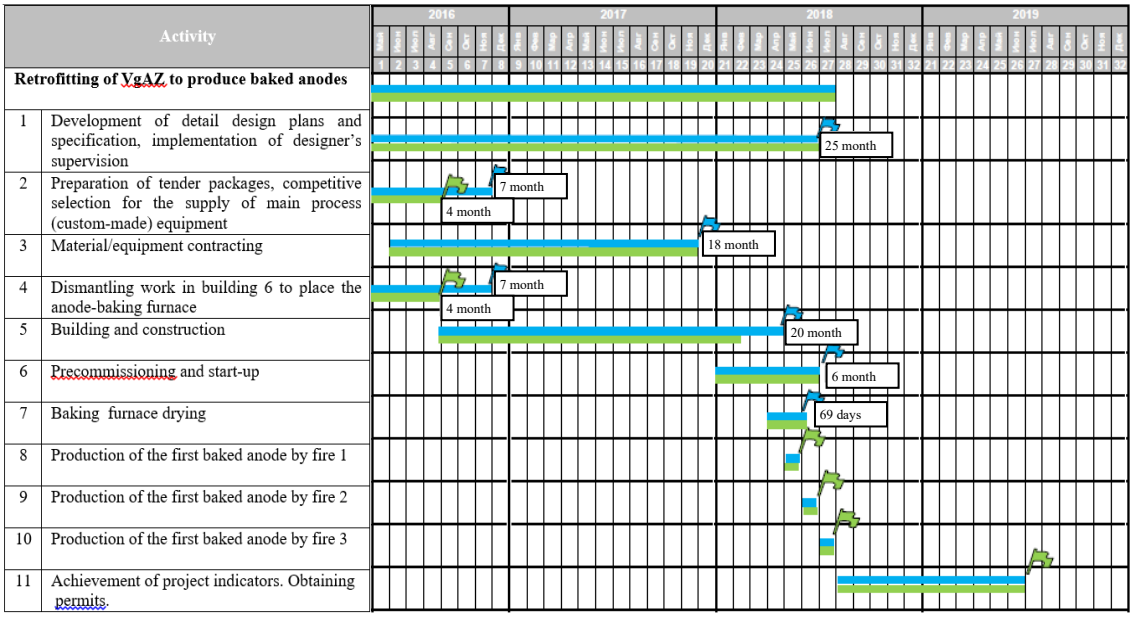

Figure 8. Project schedule

The project was successfully implemented with a slight delay of 2 months. In July 2019, the BA production achieved the project indicators and the design capacity of 104 thou. tonnes of BA per year was achieved as well.

Key milestones:

- June 9, 2018: the first green anode was produced;
- July 31, 2018: the anode production site started operation in a pilot production mode;
- August 16, 2018: the first baked anode was produced;
- December 17, 2018: A Rostekhnadzor's (Federal Environmental, Industrial and Nuclear Supervision Service of Russia) Opinion confirming the compliance of the constructed and reconstructed facilities of the anode factory with the requirements of technical regulations and design plans and specification was obtained (Statement of Conformity);
- May 28, 2019: the Facility Commissioning Permit was obtained.

4. Achievement of the project indicators and baked anode quality

During the achievement of the project indicators, the performance of the petroleum coke calcining furnace, paste plant and baking area was raised in stages according to the developed programmes. During the work performance, the project faced various problems, such as: a high volume of defective GA, a large number of BA with visual defects, in particular, cracks and stub hole deformation. However, thanks to the implementation of measures to stabilise the operation of the equipment and optimise the green coke calcination process parameters, the green anode

production and the anode baking parameters, the number of rejected anodes has been reduced to the design figures.

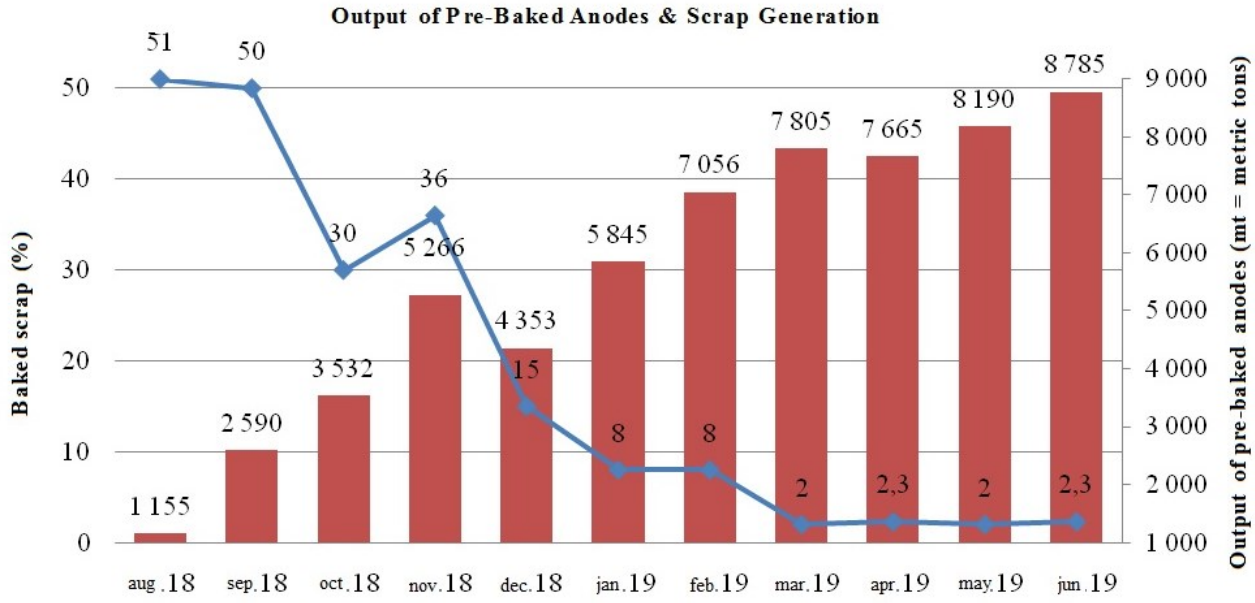

Figure 9. BA production and defective products volume

The quality of the produced BA: CRR > 90 %, the specific electrical resistance < 58 µOhm*m, the apparent density > 1.56 g/cm^3, the mechanical strength < 50 MPa, the air permeability maximum 1.5 nPm.

5. Conclusion

The project 'Establishment of a BA production site at RUSAL Volgograd' was implemented in the shortest possible time (design, procurement, construction), and the project indicators of 104 thou. tonnes of BA per year were achieved. Non-standard solutions were applied to achieve these goals. Thanks to the implementation of the project, the volume of BA purchased within the Company was reduced, and an experience in establishing a BA production site, which will be used in the construction of new production facilities, was gained. The baked anodes qualities are at the benchmark level.