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THE FIRST RESULTS OF THE INDUS TRIAL APPLICATION OF THE ECOSØDERBERG TECHNOLOGY AT THE KRASNOYARSK ALUMINUM SMELTER

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Abstract

The RUSAL Engineering & Technology Center has been developing a new EcoSøderberg concept for VSS Søderberg technology since 2005. The concept includes the following:

• colloidal anode paste with a binder content of less than 26 %
(a binder is based on pitch enriched with fine fractions of petroleum coke),
• a new cathode that allows for the following: a 20 cm lower metal pad and a 1.5% increase in current efficiency (in comparison
with conventional cells), and
• a new gas removal system that provides for better sealing and less
fluoride emissions (roof emissions.)

There has been a pilot area for testing cells since 2006. Currently there are 20 cells in the pilot area. The main technical solutions (found in the pilot area) have been used in 5 potrooms of the Krasnoyarsk aluminum smelter since March 2010. There are 197 EcoSøderberg cells in operation today. Various tests have proved the efficiency of the new technology. This technology has been chosen as the basis for the conversion of RUSAL's VSS capacities.

Introduction

The paper [1] describes the EcoSøderberg technology and contains the reasons that have motivated UC RUSAL to develop and continue improving the technology.

In this paper are shown the results of the industrial application of the technology and an evaluation of the potential for the further development of the technology. The problems detected during the industrial application of the technology and the ways for eliminating these problems are also described.

EcoSøderberg technology has been implemented in 5 potrooms at OJSC RUSAL Krasnoyarsk since 2010.
197 EcoSøderberg cells have been installed since then. (The upgrade of the conventional cell to EcoSøderberg is performed during the process of cell relining.)

The projects are set up to convert the Krasnoyarsk, Bratsk, Volgograd aluminum smelters and part of the Novokuznetsk aluminum smelter to EcoSøderberg technology from 2012 to 2017.

The results of the application of EcoSøderberg technology show that the conversion of the Company's VSS capacities to EcoSøderberg technology will lead to the followings:

- decrease PAH emissions by more than 2 times;
- decrease the specific consumption of pitch used for the production of anode paste by 30 kg; and
- decrease the specific consumption of aluminum fluoride by 1 to 1.5 kg / t Al.

The main elements of the EcoSøderberg technology are:
- colloidal anode paste,
- mechanization of operations,
- upgraded cathode design,
- upgraded bus bar,
- automated raw material feeding system.

Each element of the technology will be discussed in detail below.

Colloidal Anode Paste

Colloidal anode paste is used for improving the environmental indicators of the EcoSøderberg technology. The colloidal anode paste, in comparison with dry and conventional anode pastes, contains less pitch. VCM emissions are reduced due to the absence of free pitch on the anode surface. It helps decrease PAH emissions by more than 2 times (Figure 1). It is the main difference between the colloidal anode and the dry anode that the colloidal anode is stable toward the separation of liquid and solid phases in the anode top in an interval of 100 to 300ºC (the temperature in the non-baked part of the anode.) As a result, it excludes exfoliation and helps decrease PAH emissions from the anode surface.

In addition to environmental benefits, less pitch in colloidal anode paste provides for pitch economy.

Colloidal Anode Paste Production

The process for the production of colloidal anode paste is different from the process for the production of conventional anode paste [2]. The process for the production of colloidal anode paste includes a separate operation for mixing dust with pitch.

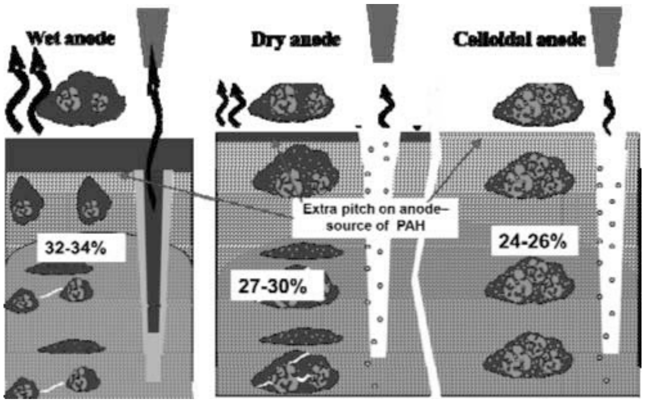

Figure 1. Cross section of the wet Søderberg anode, the dry Søderberg anode and the colloidal anode

The main principle of this operation is a high-intensive dust-pitch composition mixing in the cavitation field [3]. The flow chart for colloidal anode paste production is given in Figure 2.

The colloidal anode paste technology developed by the RUSAL ETC carbon laboratory has been scaled up and integrated into th e existing process flow for anode production at OJSC RUSAL K rasnoyarsk. The integration took place in 2008. (The paste plant is now able to provide five EcoSøderberg potrooms with colloid al anodes.)

The projects will be carried out to convert the whole paste plant at the Krasnoyarsk aluminum smelter (in order to provide 20 potrooms with colloidal anodes), the paste plant at the Bratsk aluminum smelter (so the whole smelter can be provided with colloidal anodes), the paste plant at the Volgograd aluminum smelter and the paste plant at the Novokuznetsk aluminum smelter (partially) to this technology.

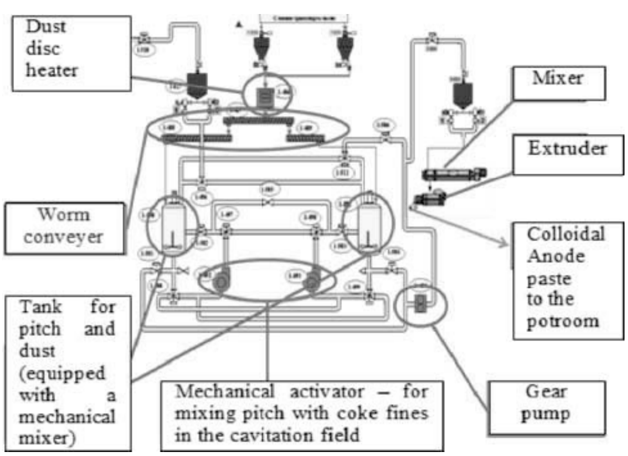

Figure 2. The flow chart for colloidal anode paste production

A System for Burning and Removing Gases

Considerable changes have been made to EcoSøderberg (in comparison with conventional Søderberg) in order to decrease emissions:
- no conventional burners. Burning occurs in the gas channel;
- the side channel (the space between the side wall and the anode) has been increased. Skirt sections have been upgraded.

The automated system for positioning the anode casing has been improved. As a result, no crust breaking is required during cell operation (even during tapping and AE quenching).

At present, a 4-dome gas removing system is used for EcoSøderberg cells (Figure 3).

For developing the system, math modeling has been used and the testing of pilot cells has taken place.

RUSAL is continuously upgrading the design of the EcoSøderberg gas removal system in order to decrease OPEX , facilitate the installation and maintenance of the system, decrease the weight of the system and improve the process of burning CO and PAH.

In order to decrease the manufacturing cost and OPEX, a 2-dome gas removal system is being considered for use.

Figure 3. 4-dome gas collection system (one side)

Mechanization

In order to decrease emissions and manual labor for the EcoSøderberg technology the different tending vehicles are used.

Individual tending vehicles (to perform one operation), as well as upgraded vehicles with detachable equipment (to perform several operations) (Figure 4) are used.

The following operations are mechanized by use of such vehicles:

- cleaning of the pipes of the gas removal system;
- gas channel cleaning;
- crust breaking in the corners of the cell;
- vacuum cleaning of the anode, cathode and bus bar.

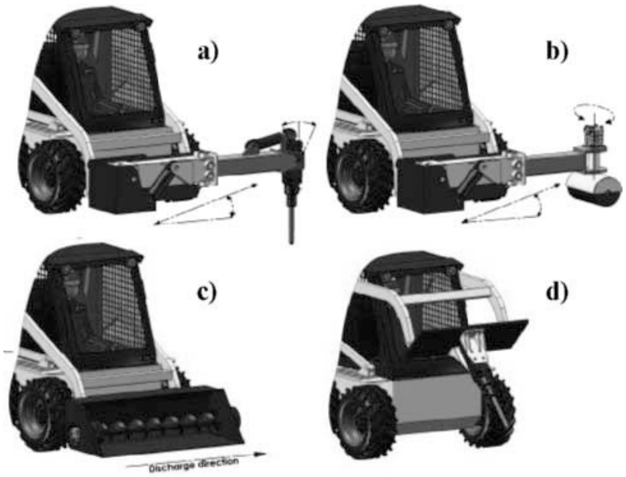

Figure 4. Tending vehicles:

a) Telescopic hydraulic breaker
b) Vehicle for adding raw materials & cleaning raw material spills
c) Feed bin
d) Front hydraulic breaker

Cathode Design

In the process of developing a new cathode design (Figure 5), the experience gained during the development of the RA-300 and RA-400 technologies was used:
- SiC side lining glued to the shell.
- Monolithic cathode blocks ('monoblocks').
- A dismountable deck plate (40 mm thick) with holes for aeration.

Figure 5. EcoSøderberg's cathode

Automatic raw material feeding system

At present, the automated raw material feeding system is being implemented at the Bratsk and Volgograd aluminum smelters (see Figure 6 and Fig.7).

It has the following benefits in comparison with the conventional alumina feeding system used at the Krasnoyarsk aluminum smelter:

- More space (by 25%) under the skirt in the point feeder area for better gas removal;
- Less material loss occurring during material loading into the bin for better environmental indicators: fewer fluoride and dust emissions;
- The possibility to use the system during cell start-ups and AEs;
- Longer cell service life due to lower vibration loads on the cathode and on the floor of the potroom by using the tending vehicles;
- Lower load on the floor for lower expenses for the scheduled (routine) maintenance and unscheduled maintenance of the potroom floor.
- Fewer steel constructions;

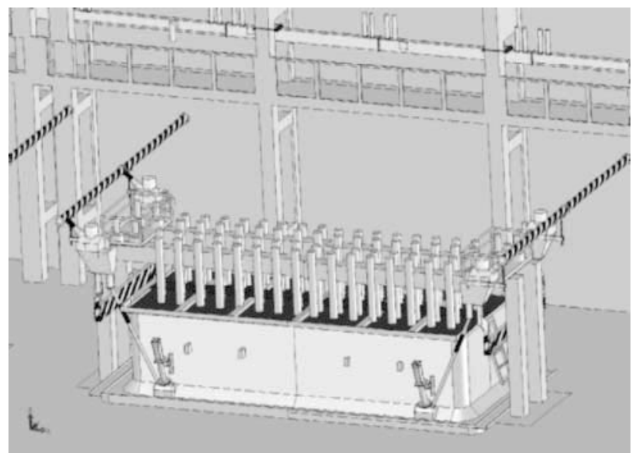

Figure 6. Scheme of new raw material feeding system

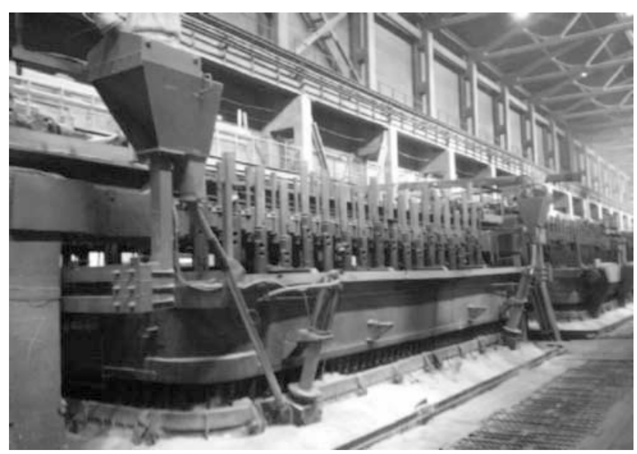

Figure 7. View of new raw material feeding system

The operational benefits are:

- better control of the alumina level in bins;
- easier quick measurements of the mass of alumina dump;

- being able to control the feeder and the crust breaker separately;
- decreasing the thermal load on the anode due to removal of conventional alumina bins (the bin type used for the automatic alumina feeding system.);
- easier servicing of the feeding position (visualization).

Results of the technology application

The parameters of EcoSøderberg technology in comparison with the conventional UC RUSAL Søderberg technology were published earlier [1].

The application of EcoSøderberg technology on an industrial scale shows the improvement of all the indicators in comparison with the conventional technology. But the indicators were a little lower than the results in the pilot cell testing (Table 1).

It should be noted that in those 5 potrooms with the EcoSøderbg cells there are also conventional Søderberg cells.

In order to increase the service life of the gas removal system, the team has improved the elements of the removal system by using different materials.

At present, the work aimed at improving the gas removal system for decreasing its price and weight, facilitating maintenance, optimizing the burning process under the skirt and the pipes of the gas removal system. This work has been done together with the Siberian Federal University.

The decision to use the bus bar with 3 raisers will help decrease the metal flow rate in the EcoSøderberg cell by 20-30%, increase the current efficiency (CE) by 0.5% and decrease the specific power consumption by 150 kWh/mt Al. The bus bar can be changed both during cell relining (during the conversion to EcoSøderberg) and when the EcoSøderberg cell is in operation.

The work aimed at decreasing the specific power consumption is ongoing by means of optimizing the control over the pre-set voltage and decreasing the voltage drop within the anode.

Table 1. Industrial performance by the different Søderberg technology

Parameters	S8BM	S8BM-E, July 2010 (pilot area)	EcoSøderberg (5 potrooms), September 2012
Amperage, kA	174.7	174.7	174.2
Current Efficiency, %	87.7	91.5	90.3
Power Consumption DC, kWh/t Al	16,102	15,500	15,966
Anode Paste Consumption, kg/t Al	520	490	510
Pitch Consumption, kg/t Anode Paste	297	246	263
Metal Height, cm	51	25	31.2
AlF_3 Consumption, kg/t Al	22	16	13.7

Due to the fact that the bus bar used for conventional Søderber g is different from the bus bar for EcoSøderberg, the technical a nd economic indicators of EcoSøderberg cells are affected.

The problems had to be solved

During the first stage to implement the EcoSøderberg technology (at the Krasnoyarsk aluminum smelter), the following problems occured:
- A high frequency of earlier shut-downs (some cells are less than 2 years old.)
- Short service life of the elements in the gas removal system (around 6 months.)

An ad hoc team was organized to increase the service life of the cell. The team performed several autopsies, analyzed the reasons for earlier shut-downs, built a math model of the process of cathode block corrosion. As a result, the following changes to the design for the EcoSøderberg technology improvement were proposed:
- to increase the metal pad by 5 cm (up to 30 cm) in order to decrease the metal flow rate;
- to change the lining of the cathode;
- to change the corner (end) walls of the cathode shell;
- to change the procedure for the baking, starting and initial operations of the cell;
- to use the bus bar with 3 raisers instead of 4 raisers.

Conclusions

An acceptable emission level, improving the cell technical and economic performance and reducing manual labor can be achieved by using the EcoSøderberg technology. The industrial application of the technology in 197 cells has proved its environmental and economic efficiency and the appropriateness of its use at other smelters.

Acknowledgement

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