RA-550 Cell Technology: UC RUSAL's New Stage of Technology Development

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Abstract

In 2016, five pilot cells were started up at UC RUSAL's Sayanogorsk Aluminum Smelter. The pilot cells use a completely new busbar design using two-side current feed anode risers, providing for efficient magnetic field compensation in aluminium metal pad and excellent MHD stability without using additional magnetic field compensation. The last seven months have validated the main calculated design parameters of the RA-550 cells and high level performance of main operational parameters, such as current efficiency and power consumption. The pilot cells are meeting or even exceeding the industry's benchmark environmental parameters. Today's key performance indicators confirm that UC RUSAL has developed a competitive, highly-efficient ultra-high-amperage cell technology that can be used both for greenfield and brownfield projects. Plans are to continue testing the RA-550 technology, including amperage increase up to 570 - 600 kA and optimizing energy efficiency over the next two years.

Keywords: Rusal RA-550 cells, two-side current feed anode risers, MHD stability, RA-550 cell key performance indicators, RA-550 environmental parameters.

1. Introduction

For the last 40 years, the main vector of development of the aluminum industry has been related to increasing the pre-baked (PB) cell amperage (Figure 1.)

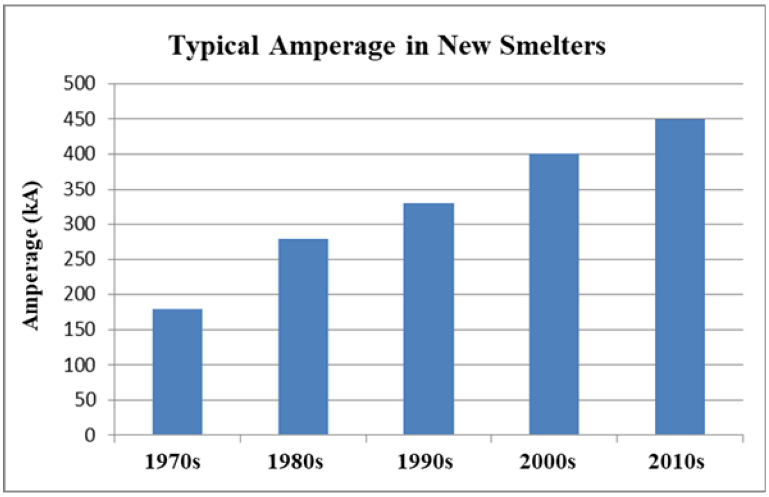

Figure 1. Cell amperage increase over decades.

Evidently, using more powerful cells makes it possible to reduce CAPEX for construction, to improve operational efficiency (or productivity) with retaining, or even improving, the Key Performance Indicators (KPI), which provide for a quicker return on investment and payback of greenfield projects. However, increasing amperage and cell dimensions may lead, at a certain stage, to serious technical limitations; such limitations make further development in this direction quite difficult.

Today, the main limitation, which challenges further cell amperage increase, is the difficulty with magnetic field compensation in the aluminium metal pad (especially the compensation of the vertical component of the magnetic field), which is the necessary condition for MHD stability that, in turn, determines the possibility of achieving the best operational results, such as high current efficiency and low specific energy consumption.

The attempts to create ultra-high-amperage cells operating at higher than 500 kA started back in the 1990s. By the year 2000, there were several operating 500-kA cell prototypes in the world. However, up till now, no operating smelter in the world has presented performance figures for 500-kA technologies that exceed those for 400 – 450 kA technologies, which lately have gained general acceptance for application in greenfield projects.

One of the main factors retarding the implementation of ultra-high-amperage cells, is less efficient magnetic field compensation in the liquid metal pad. As of today, technical and engineering solutions used in the all known 500-kA technologies have shortcomings reducing the economic efficiency and/or energy efficiency of such technologies:

- Additional compensation loop, providing for an acceptable magnetic field configuration in the metal pad but generating additional energy loss in the loop, as well as additional cost for the loop and equipment supplying power to the loop.
- High metal pad, providing for cell MHD stability but deteriorating alumina dissolution conditions and leading to an excessive ledge length on the cathode block, which ultimately reduces energy efficiency and productivity.

Considering the existing experience of operating ultra-high-amperage cells (500 - 600 kA), it is safe to conclude that this amperage level is critical, from the view point of ensuring good magnetic field compensation in the metal pad. This is largely due to the standard approach to developing the busbar design, which includes side-by-side cell arrangement and exclusively one-side current feed through anode risers, which are located along upstream side of the cell. It is obvious that such an asymmetric, one-side arrangement of current-feeding risers predetermines the asymmetry of the magnetic field in metal at the sides of the cell and, in turn, reduces cell MHD stability and which results in uneven metal pad heaving between the upstream and downstream sides of the cell.

2. Project Implementation

In November 2014, a decision was made to launch a project to develop a 500-kA+ technology, which is named ‘RA-550 Cell Technology’, and to construct a pilot area at UC RUSAL’s Sayanogorsk Aluminum Smelter to test such a technology. In December 2014, the new cell concept was defined as follows:

1. A totally new busbar configuration is to be used to ensure a symmetrical configuration of the magnetic field in metal at the sides of the cell, by means of using two-side current feeding.
2. No compensation loop is to be used to implement such a technology.
3. The so-called ‘modular approach’ is to be used to provide for the possibility of developing more powerful cells with 700 - 1000 kA.
4. The cell layout is to be as dense as possible to increase metal output per unit area.
5. The consumption of materials to manufacture each element of the cell is to be reduced (cathode shell, superstructure, lining, anode rod, etc.)
6. The gas exhaust rate is to be reduced and environmental performance is to be improved.

Table 1. Pilot RA-550 cell performance.

Parameter	Beginning (December 2016 to February 2017)	As of today (June 2017 to July 2017)
Amperage, kA	520	525
Current Efficiency, %	94.60	95.82
Cell Voltage (Gross), V	4.217	4.136
Total Power Consumption (DC), kWh/t	13 267	12 846
Carbon Consumption (net), kg/t	407	398
Average Noise Level, mV	14.3	9.8
AE frequency, AE/pot-day	0.32	0.015
AE duration, s	52.7	12.6
Total F Emissions, kg/t	0.24	0.21

5. Conclusions

UC RUSAL's engineers have developed a state-of-the-art, highly-efficient RA-550 technology, which, along with high amperage and high productivity, gives performance indicators conforming to the best industry standards and, in a longer run, exceeds the level achieved as of today.

The innovative solutions included in the busbar, such as two-side current feeding and modular design, eliminate the existing limitations on developing an ultra-high-amperage cell with excellent magnetic field compensation in metal and high operational performance without using a compensation loop.

Over the next two years, UC RUSAL plans to further increase the efficiency of the new RA-550 technology in terms of productivity, energy and environment.