AL10 - State and Development Prospects of Technologies for the Use of Unshaped Lining Materials in Aluminum Reduction Cells

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Abstract

The paper elaborates on the use of unshaped lining materials in modern aluminum cells and lists the technical parameters of the main types of unshaped materials. It demonstrates the main elements of an up-to-date cell lining technology that uses un-shaped materials. The paper also compares conventional cells using bricks with cells using unshaped materials and lists several process and economic advantages of unshaped materials over conventional bricks. Moreover, it has been proved that such parameters as service life, power consumption, current efficiency, amount of waste and lining duration tend to remain stable with an increase in the number of cells. Autopsy results for cells older than 2 200 days are given. Furthermore, the paper provides information on material transformations during cell life and in case of abnormalities. In conclusion, it is demonstrated how said cell lining technology and equipment can be further enhanced, including technical solutions regarding developing cathode designs ensuring minimum waste.

Keywords: Aluminium electrolysis cells, unshaped lining materials, cell design and performance, equipment for installation and compaction lining materials, autopsy.

1. Introduction

The cost of aluminium production is one of the main factors to determine the competitiveness of companies in the aluminium industry. The reduction of cost of overhauls, storage or disposal of waste generated helps to lower the cost of aluminium production. This is why the search for new, more efficient, lining materials for cathodes in electrolysis cells and their application technologies continues in the countries with primary aluminium production.

Traditionally, shaped products in the form of bricks of various sizes, mainly aluminosilicate, are used as barrier materials to protect lower-lying thermal insulation materials in the design of cathode electrolysis cells [1]. This is primarily due to the properties of the resulting products of interaction with fluorides and sodium vapours. Advanced high-quality barrier bricks for aluminium electrolysis cell cathodes have low apparent porosity (up to 13 %) and small pore sizes to reduce the penetration of aggressive gaseous and liquid components into the thermal insulation layers. However, the gas permeability of the barrier brickwork is generally determined not by the properties of the shaped products, but mainly by the condition of the joints [2] between them.

The refractory mortar used to seal the joints is the material used to make masonry mortar and although it has a material composition close to the bricks, it is vulnerable to fluorides and aggressive gases, such as sodium vapours and sodium tetrafluoroaluminate. This is primarily due to the fact that it is not as dense as fired bricks. Cryolite-resistance tests have shown that the joint material has a resistance of no more than 50 % in relation to brick resistance [3].

In addition to shaped refractory materials, significant experience has now been gained in the use of unshaped lining materials of various particle size and mineral content, which allow producing seamless layers. As compared to shaped products, the technology for producing such materials requires 2–3 times less space of production facilities and is characterised by higher productivity (4–5 times) and 5–6 times lower energy costs [4].

In the previous development stages of the aluminium industry, alumina was widely used as a lining material [5]. There was the possibility of recycling it in the electrolysis cells or reusing it as lining materials, which reduced the amount of waste. However, as electricity costs rose and the composition of the electrolyte changed, alumina was replaced by insulating materials, diatomite and vermiculite, which were protected from above by an aluminosilicate-based unshaped refractory material with specially selected chemical and mineral and disperse compositions. Several types of such materials are currently known: a mixture of aluminosilicate [6], anorthite [7], and olivinic [8] compositions. Laboratory and industrial tests show that dry barrier mixes (DBM) based on aluminosilicates with a carefully selected particle size distribution have an advantage over others due to the ability to make viscous glass barriers [9]. At the same time, the performance of electrolysis cells with unshaped materials is generally close to that of electrolysis cells with brickwork. The successful DBM use is supported by data on the international practice [10]. Thus, the average service life of 300 kA electrolysis cells installed in China using the DBM is 2 200 days [10].

The subsequent compaction of unshaped lining materials (USLM) is an essential element of their application technology when assembling aluminium electrolysis cell cathodes. The easiest way of compacting the USLM is by using ordinary rollers [11]. However, the structure of the lining material did not have the required low porosity and small pore sizes. Although increasing the density of compacting (up to 25 %), the rollers fitted with a vibratory mechanism caused a wave-shaped defect in the surface. The method of lining the cathode device of the aluminium electrolysis cell is known to include filling the powdered material into the cathode cover of the electrolysis cell and levelling it with a straight edge. The lining was compacted by pneumatic tamping from above through a hot rammed carbon mass [12]. However, there has been a reduction in the service life of the electrolysis cells. When compacting the material by the dynamic method using a slide with a vibrator, both compaction and decompaction processes took place at the same time, resulting in dusting of the material being compacted [13]. Compaction of unshaped materials is most often performed using vibratory plates, which are used in construction technologies. The main disadvantage of this method of lining is the need for vibratory plates to pass through the surface of the barrier material multiple times in the cathode unit due to the small size of the plate. The parameters of the resulting barrier layer depend on the qualifications and conscientiousness of the operator. However, the most significant disadvantage is that the operation of the vibratory plate is mainly based on a dynamic shaping method with sub-optimal amplitude frequency and weight characteristics. With a low bulk density of the lining material, this results in both compaction and decompaction processes occurring at the same time. This results in dusting of the material being compacted.

In general, it can be noted that the use of unshaped materials in the installation of electrolysis cell cathode devices differs favourably from the use of the bricklaying technology due to the absence of joints, reduced installation time for lining materials, and lower labour costs [14]. The reduced installation time is particularly beneficial for production facilities repairing electrolysis cells in potrooms. However, these technologies have been generally implemented only for upper, refractory, lining layers, which are placed on thermal insulating bricks or vermiculite slabs. With

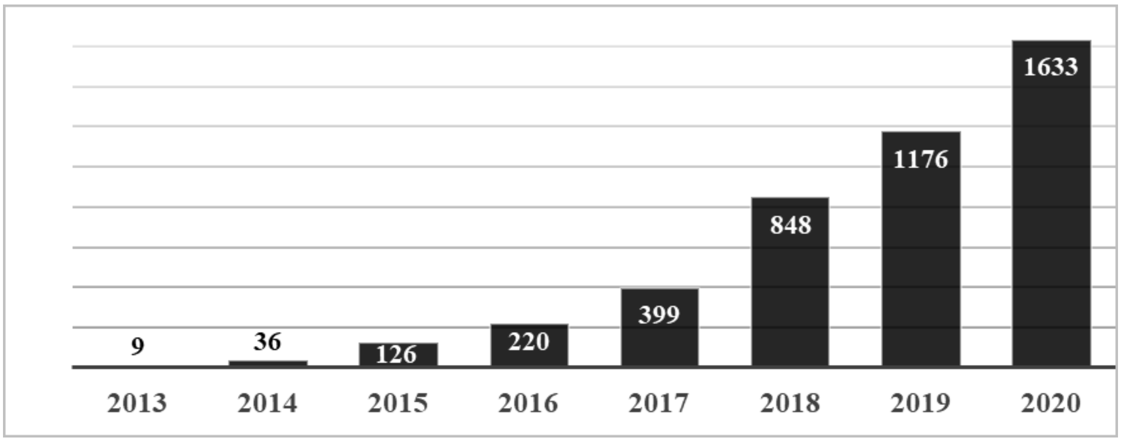

Figure 7. Number of cells of the RUSAL company lined with USLM.

4. Conclusions

The developed resource-saving technology for lining the sub-cathode zone of the aluminum reduction cell with new un-shaped lining materials, based on pyrolysis products from carbon raw materials and the developed lining equipment help reduce the amount of lining materials to be used (due to re-cycling), reduce financial and labour costs for lining, and reduce the amount of SPL-2.

The developed cell lining generates no cyanides, high cell KPIs, and stable thermal and physical parameters.

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