Test of Powdery Bedding Materials for Use Underneath Cathode Blocks

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Abstract

Different bedding materials have been considered for use in aluminum electrolysis cells. A bedding material is the substance placed just below the cathode blocks, often serving as a leveling agent. However, the barrier properties of these materials have not always been thoroughly considered. In this study, we describe the development of a lab-scale test designed to evaluate various bedding materials with respect to their barrier properties. We have theoretically evaluated different powders and discussed their performance in the chemical tests conducted. This comprehensive approach aims to provide a deeper understanding of the suitability of different bedding materials in enhancing the efficiency and longevity of aluminum electrolysis cells

Keywords: Aluminium electrolysis, Lining materials, Powdery bedding materials.

1. Introduction

Today, alumina intended for electrolysis is used as bedding material underneath the cathode blocks. The bedding material is typically 20–40 mm thick and constitutes a significant part of the bottom lining. Different bedding materials have been utilized in Hydro. Initially chamotte powder and ramming paste was used in many plants, but the use was stopped due to unknown reason, and typically replaced by smelter grade alumina. The advantage of alumina is its availability in the plants and simplicity of the installation. However, smelter grade alumina has not the desired barrier properties, and a test program was carried out to evaluate different bedding materials with respect to their barrier properties.

A secondary objective with this work was to test AlF_3 as barrier material, an idea since it normally basic bath that is found underneath the cathode block in a cell after shut-down. The basic bath rich in NaF should then react with AlF_3 to form solid cryolite and thus form a solid material according to reaction (1).

$$NaF\ (l, bath) + AlF_3(s) \dashrightarrow Na_3AlF_6(s) \quad (1)$$

2. Experimental

2.1 Polarized Chemical Exposure

To simulate the conditions in an electrolysis cell and at the same time achieve reasonable reaction of the bedding material, a new test set-up was designed. The test set-up is shown in Figure 1 (left) and comprises of:

1) A graphite crucible which is also the working cathode in the experiment
2) A reference barrier brick (Alubar 1100) placed in the bottom of 1) of height 30 mm and diameter 100 mm
3) Crushed barrier brick (Alubar 1100) (< 1.18 mm) to fill the small gap between 1) and 2)
4) 20 mm of compacted test bedding material placed on top of 2) and 3)

5) A thin plate (~5 mm) of cathode block grade (N-4 from Energoprom) acting as a membrane. The plate was glued to the crucible with a carbon glue (AD20, Tokai COBEX)
6) 800 g of electrolyte: cryolite (CR = 3.4), 10 % Al_2O_3.
7) Anode (Ø30 mm) with a steel connection. The anode material was a graphitized cathode block carbon.

The tests were run at 970 °C with 10 A current for a duration of 25 hours.

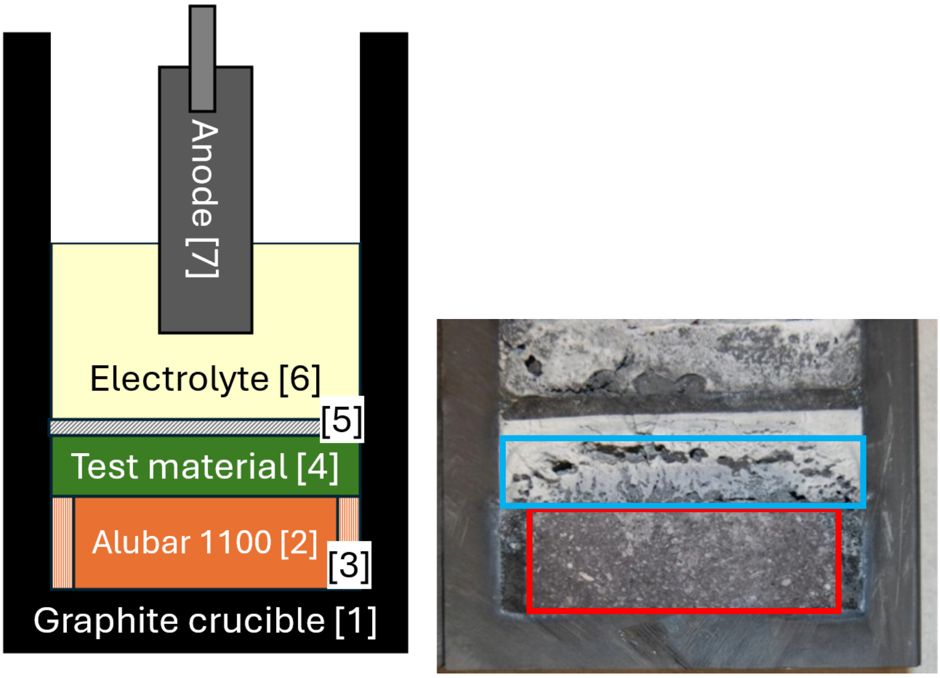

Figure 1. Left: Sketch of test set-up, Right: Example of cross-section after test. Blue frame indicates original bedding material. Red frame indicates original barrier brick, and the height of the red frame after the test is compared with the initial height of the brick.

The tests are listed 1–12 in chronological order. After the tests, the crucibles were cut in two parts with a diamond saw. The extent of reaction in the bedding material was assessed visually, an example is shown in Figure 1 (right). The height to unreacted (visually assessed) material of the Alubar 1100 reference brick was measured with a caliper.

The current and voltage were recorded for each experiment. There was some short-circuiting during the tests, and the electrolysis time varied from 16 to 24 hours.

2.2 Materials

The materials used in the tests are given in Table 1. The composition is taken from the supplier specification. The spent refractory brick was not analyzed but consisted of glassy lens material of black color.

should have the adverse effect on the viscosity of the protective layer formed [1]. However, the mineralogy and the grain size distribution will also influence the result.

Olivine powder, Olibar, also stops the bath penetration, but not as efficiently as the chamotte based powders. The Olibar bedding material gets infiltrated/reacted with bath, but there is no bath attack on the brick underneath. When using alumina as bedding material, the barrier brick reacts and dissolves in the upper area. This is also predictable as no viscous layer is formed nor reaction is expected to take place in the alumina layer. The same applies to ramming paste, but the extent of reaction is cluttered by infiltration of binder into the brick.

The result with spent refractory bricks shows some reaction in the top of the barrier brick. This is probably a reaction between the bedding material and the brick, and not the penetration bath. It is therefore difficult to fully verify the ability of spent refractory bricks to stop bath penetration. Further testing is needed, and the grain size distribution should be varied to assess the suitability of crushed SPL. Furthermore, due to the hazardousness of SPL (spent potlining), HSE considerations must also be considered in this context.

Finally, AlF_3 is not suitable as bedding material. Exposed directly to the refractory brick, SiF_4 gas is formed by the reaction below:

$$4AlF_3 + 3SiO_2 = 2Al_2O_3 + 3SiF_4 \quad (2)$$

Even if AlF_3 is separated from the SiO_2, the neutralization of the basic bath and solid cryolite formation is not efficient in stopping bath penetration.

5. Conclusions

Testing of different bedding materials in lab scale shows that chamotte based powders are considerably better than smelter grade alumina in stopping bath penetration. A chamotte based bedding material will slow down the reaction in the lining, and have a beneficial influence on thermal and dimensional stability of the lining. Use of smelter grade alumina or ramming paste does not stop bath and leads to a more rapid degradation of the barrier bricks.

Use of AlF_3 as bedding material is not recommended as AlF_3 does not react with the basic bath in a way that slows down bath penetration.

6. References

1. Christian Schøning, Tor Grande and Ole-Jacob Siljan, Cathode Refractory Materials for Aluminium Reduction Cells, *Light Metals* 1999, 231-239.