AL09 - Comparative Study of Alumina Dissolution in Complex Aluminum Electrolytes

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Abstract

In northern Chinese aluminum smelters, the electrolyte has high content of lithium fluoride and low content of potassium fluoride. In southern Chinese aluminum smelters, the electrolyte has high content of potassium fluoride and low content of lithium fluoride. In this paper, alumina dissolution behavior in three kinds of electrolytes, including simple electrolyte, high lithium low potassium electrolyte and high potassium low lithium electrolyte, was studied. The effect of bath superheat on alumina dissolution was also discussed.

Keywords: Alumina dissolution, aluminum electrolysis, complex electrolyte.

1. Introduction

Since 2001, China has been the largest primary aluminum producer in the world. In 2019, China produced 35.044 million tonnes of primary aluminum and 72.4742 million tonnes of smelter grade alumina and imported 1.65 million tonnes of alumina [1]. Even though the portion of imported bauxite for alumina refining is continually increasing in recent years, at least 40 % alumina was produced from domestic bauxite, which mainly mined in Shanxi province, Henan province, Guizhou province and Guangxi province in China. Table 1 lists the contents of impurities, mainly oxides of alkali metals in domestic alumina. Compared to imported alumina, all domestic alumina contains high content of lithium oxide and potassium oxide. Domestic alumina A and Domestic alumina B are produced by alumina refining plants located in southern part of China. Domestic alumina C and Domestic alumina D are produced by some northern refining plants in China.

Table 1. Concentration of alkali oxides in domestic alumina and imported alumina [2].

Alkali oxides	Domestic A	Domestic B	Domestic C	Domestic D	Imported
K_2O, wt.%	0.048	0.016	0.029	0.027	0.002
Li_2O, wt.%	0.017	0.006	0.058	0.044	0.001

When domestic alumina is fed to the reduction cell, the concentration of lithium and potassium will gradually increase to some levels in the cryolite-based electrolyte. Many Chinese smelters do not have long-term alumina supplier. They usually feed cells with alumina from different sources, which always results in complex situation for engineers to control their cells. In China, there are several types of electrolytes according to lithium and potassium concentration in the bath:

- Simple electrolyte without lithium and potassium, referred to as SE;

- High lithium and low potassium electrolyte, typically, 5-8 % LiF and 2-3 % KF, referred to as HLE;
- High potassium and low lithium electrolyte, typically, 5-6 % KF and 1-2 % LiF, referred to as HPE;
- High lithium and high potassium electrolyte, typically, 4-5 % KF and 5-6 % LiF, referred to as HLPE

Many papers have discussed the poor performance of the cells operated with complex electrolyte. Table 2 lists some performance indicators of Chinese smelters using complex electrolytes. Even though some smelters claimed lower energy consumption, their cells are operated with low current efficiency.

Table 2. The key performance indicators of 500 kA reduction cells using complex electrolytes in China.

Smelters	**A**	**B**	**C**	**D**	**E**	**F**
kA	500	510	500	505	500	500
AL/cm	32-37	29-32	30-32	23-25	28-30	29-31
BL/cm	15-18	17-20	14-16	16-18	18-20	16-18
T/°C	900-915	905-915	945-955	955-965	945-955	950-965
CR	2.7-3.1	2.5-2.7	2.5-2.7	2.5-2.7	2.3-2.5	2.4-2.6
Al_2O_3%	2-3	2-3	2-3	2-3	2-3	2-3
KF%	2.7	3.2	4.5	1.4	-	-
LiF%	8.4	8.6	2.78	1.1	-	-
MgF_2%	0.3	0.5	0.42	0.3	5.0	0.3
CaF_2%	4.2	4.2	4.07	3.8	3.0	5.5
CV/V	4.09	3.97	3.93	3.91	4.00	4.00
CE/%	**88**	**91.5**	**91.7**	**89.5**	**92**	**91**
EC/kWh/kgAl	13.9	13.0	12.8	13.0	13.0	13.1

Note：AL-metal level；BL-bath level；T-bath temperature；CR-molar ratio of NaF/AlF_3；CV-cell voltage；CE-current efficiency；EC-DC energy consumption。

Many factors give their contributions to current efficiency, such as superheat control, anodic current distribution, MHD stability, and alumina dissolution behavior. In this paper, alumina dissolution behavior in various types of electrolytes was compared, and the effect of the superheat of bath on alumina dissolution behavior was also discussed.

2. Experimental

2.1 Chemicals

Analytical reagents, calcium fluoride, lithium fluoride, potassium fluoride and chemical pure reagent cryolite were dried for 2 h at 400 °C. Anhydrous aluminum fluoride was obtained by the following treatment of aluminum fluoride trihydrate: chemical pure reagent aluminum fluoride floated on the melt surface for over twenty minutes and did not sink to the crucible bottom until stirred with a metal rod, which was quite different from that of clean melt.

4. Conclusions

The dissolution behavior of the secondary alumina was investigated in three types of aluminum electrolytes. These aluminum electrolytes are widely used in Chinese aluminum smelters. Comparative study confirmed that electrolyte containing high content of lithium fluoride exhibited the poorest dissolution ability of alumina because of its lowest liquidus temperature and lowest alumina saturation concentration. Electrolyte containing high content of potassium fluoride exhibited similar dissolution behavior of alumina with that of simple electrolyte. However, heavy carbon dust has great impact on alumina dissolution and deteriorate the alumina dissolution by forming agglomerates. Superheat of bath lower than 5 °C has negative impact on alumina dissolution.

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6. References

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