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STUDY OF REFINING OF PRIMARY ALUMINUM FROM IMPURITIES OF NON-FERROUS METALS USING «ACTIVE» GRAIN FILTERS BASED ON BORIAN ACID

This article presents the results of comparative experimental studies on the complex two-stage processing of primary aluminum by flux treatment with boric acid (H_3BO_3) in a ladle with further filtration purification of the melt through granular filters and one-stage filtration purification of primary aluminum through active granular filters with boric acid additives.

The research was carried out within the framework of grant funding by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan under the Zhas Galym competition under the IRN AP19175493 project «Development of technology for refining primary aluminum with active surface filters».

The research results showed that a complex one-stage technology for cleaning raw aluminum from non-ferrous metal impurities using active filters reduces their content in primary aluminum. Laboratory studies showed a decrease in the content of vanadium by 53.3 %, copper by 19.8 %, magnesium by 49.6 %, manganese by 51.7 % and silicon by 97.1 % in primary aluminum when using the active filter cleaning method.

A comparative analysis of aluminum purification methods showed that the issue of using active filters needs further study in order to determine the degree of purification from non-ferrous metal impurities, depending on various parameters of the active filter.

Keywords: aluminum, non-ferrous metal impurities, filtration, boric acid, flux, active filter.

Introduction

The largest aluminum production enterprises operate in the Pavlodar region of the Republic of Kazakhstan. At present, world practice shows the use of lower quality raw materials for the production of anodes, which are so necessary for electrolysis enterprises [1].

The main source of pollution in this case are asphaltene compounds. Asphaltenes concentrate a high content of harmful impurities (V, Fe, Si, Ni, Ti, etc.), which are contained in anodes used in electrolysis plants. One of these impurities is vanadium, which significantly reduces the electrical conductivity of aluminum at a concentration of about 2 ppm [1, 2, 3].

In Kazakhstan, for the production of baked anodes of aluminum electrolyzers, local coke of UPNK-PV LLP (Pavlodar, Republic of Kazakhstan) with a high content of vanadium and other impurities is partially used.

Fluxes used at the enterprise JSC «Kazakhstan electrolysis plant» are made on the basis of cryolite, aluminum fluorides, sodium chloride and do not remove the above-mentioned hard-to-recover impurities, including vanadium [1].

In a number of works [4, 5, 6], methods for purifying primary aluminum from vanadium impurities are proposed, which have not found wide industrial application.

In [7], the technology of refining primary aluminum from vanadium impurities with a boron-containing Al-B alloy outside the electrolysis bath was studied. Studies have shown [7]:

– decrease in the content of vanadium by an average of 78 % in the mass of metal, with an increase in its content in the lower part of the ladle (volume up to 5 – 10 % of the ladle capacity);

– the transition of a significant amount of vanadium to the intermetallic compound;

– the complexity of the separation of intermetallic compounds of vanadium and refined aluminum in the ladle by traditional methods (settling for 4 - 7 hours did not give a positive result).

For further development of methods for removing non-ferrous metal impurities from primary aluminum, it is necessary to study the separation of the resulting aluminum from the intermetallic compounds formed during refining. The literature review shows that the most promising method of purification of aluminum from the formed precipitated intermetallic compounds is filtration by various methods. Currently, in most cases, smelters do not have a filtration step that can ensure the removal of heavy metal impurities.

Materials and methods

In this work, comparative experimental studies were carried out on the complex two-stage processing of primary aluminum by flux treatment with boric acid (H_3BO_3) in a ladle with further filtration purification of the melt through granular filters and one-stage filtration purification of primary aluminum through active granular filters with boric acid additives.

Table 1 shows the chemical composition of primary aluminum before refining, taken from the electrolyzers of Kazakhstan Electrolysis Plant JSC with installed anodes, obtained using calcined coke of UPNK-PV LLP (Pavlodar, Republic of Kazakhstan) with a high content of vanadium impurities.

Table 1 – Chemical composition of primary aluminum before refining, %

Al	Si	Fe	Cu	Mn	Mg	Ni	Cr	Ti	V
96,1299	3,2557	0,4105	0,0071	0,0032	0,0239	0,0115	0,001	0,0323	0,0132

Two series of experimental purification of molten aluminum were carried out.

In the first series, at the first stage, primary aluminum was smelted in a laboratory induction furnace, H3BO3 was introduced at a temperature of 850 °C at the rate of 1.2–2 kg/t of raw aluminum, then the melt was held for 15 minutes and chemical treatment was carried out. The composition of refined primary aluminum was determined on a DFS 500 optical emission spectrometer.

At the second stage, primary aluminum treated with boric acid was filtered through a granular filter. When choosing the parameters of granular filters, the recommendations of the following works [8 – 10] were considered.

The experimental setup (Figure 1) consisted of a filter block 1, a filter grain 2 and a mold 3, in the lower part of which there was an opening for the outflow of the filtered metal into the ladle, covered with a refractory mesh.

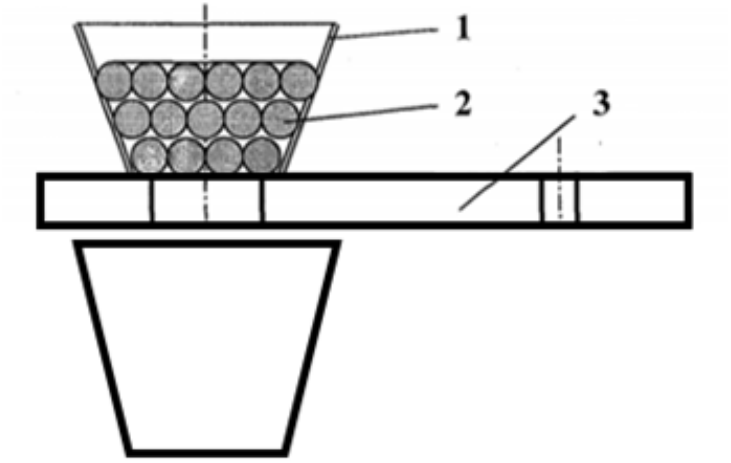

Figure 1 - Scheme of the experimental setup

As a result of the search for the optimal material for the purification of primary aluminum from heavy metal impurities, it was decided to use Ekibastuz coal ash (Figure 2), with an Al2O3 content of about 30 – 32 %. Aluminum oxide is the most preferred base for chemical reactions occurring in the Al-Ti-B system during the extraction of heavy metal impurities.

Figure 2 – Filter grains

Determination of the chemical composition of primary aluminum after treatment with H3BO3 flux and subsequent filtration through a granular filter on an optical emission spectrometer DFS-500 showed a decrease in the content of impurities. The degree of removal of impurities is shown in table 2.

Table 2 – The degree of removal of impurities from primary aluminum after treatment with H3BO3 flux with further filtration through conventional granular filters, %

V	Si	Cu	Mn	Mg
47,7	97,9	17,6	50,0	47,5

In the second series of experiments, primary aluminum was smelted in a laboratory induction furnace. Next, aluminum was filtered through an active filter with grains treated with boric acid (Figure 3). This step allows reducing the processing time of primary aluminum by combining the stages of refining and filtration, as well as removing hard-to-remove impurities of transition compounds in the Al-Ti-B-V-Fe-Zn system.

Figure 3 – Active filter grains

Determination of the chemical composition of primary aluminum after filtration treatment showed a decrease in the content of impurities. The degree of removal of impurities is shown in table 3.

Table 3 – The degree of removal of impurities from primary aluminum after applying an active filter, %

V	Si	Cu	Mn	Mg
53,3	97,1	19,8	51,7	49,6

Results and discussion

The research results showed that a complex one-stage technology for cleaning raw aluminum from non-ferrous metal impurities using active filters reduces their content in primary aluminum.

Laboratory studies showed a decrease in the content of vanadium by 53.3 %, copper by 19.8 %, magnesium by 49.6 %, manganese by 51.7 % and silicon by 97.1 % in primary aluminum when using the active filter cleaning method.

A comparative analysis of aluminum purification methods showed that the issue of using active filters needs further study in order to determine the degree of purification from non-ferrous metal impurities, depending on various parameters of the active filter.

Funding information

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БОР ҚЫШҚЫЛЫ НЕГІЗІНДЕГІ «БЕЛСЕНДІ» ТҮЙІРШІКТІ СҮЗГІЛЕРДІ ҚОЛДАНА ОТЫРЫП, ТҮСТІ МЕТАЛЛ ҚОСПАЛАРЫНАН БАСТАПҚЫ АЛЮМИНИЙДІ ТАЗАРТУДЫ ЗЕРТТЕУ

Бұл мақалада балқыманы түйіршікті сүзгілер арқылы одан әрі сүзу арқылы тазартумен және бор қышқылы қоспалары бар белсенді түйіршікті сүзгілер арқылы бастапқы алюминийді бір сатылы сүзу арқылы шөміштегі бор қышқылымен (H_3BO_3) флюсті өңдеумен бастапқы алюминийді кешенді екі сатылы өңдеу бойынша салыстырмалы эксперименттік зерттеулердің нәтижелері келтірілген.

Зерттеулер Қазақстан Республикасы Ғылым және жоғары білім министрлігі Ғылым комитетінің «Жас ғалым» конкурсы бойынша ИРН AP19175493 «Белсенді беті бар сүзгілермен бастапқы алюминийді тазарту технологиясын әзірлеу» жобасы бойынша гранттық қаржыландыру шеңберінде жүргізілді.

Зерттеу нәтижелері белсенді сүзгілерді пайдалана отырып, шикі алюминийді түсті металл қоспаларынан тазартудың кешенді бір сатылы технологиясы олардың бастапқы алюминийдегі құрамын төмендететінін көрсетті.

Зертханалық зерттеулер белсенді сүзгілермен тазарту әдісін қолданған кезде бастапқы алюминийде ванадий 53,3 %, мыс 19,8 %, магний 49,6 %, марганец 51,7 % және кремний 97,1 % құрамы төмендегенін көрсетті.

Алюминийді тазарту әдістерінің салыстырмалы талдауы белсенді сүзгілерді қолдану мәселесі белсенді сүзгінің әртүрлі параметрлеріне байланысты түсті металдардың қоспаларынан тазарту дәрежесін анықтау үшін одан әрі зерттеуді қажет ететіндігін көрсетті.

Кілтті сөздер: алюминий, түсті металл қоспалары, сүзу, бор қышқылы, флюс, белсенді сүзгі.

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ИССЛЕДОВАНИЕ РАФИНИРОВАНИЯ ПЕРВИЧНОГО АЛЮМИНИЯ ОТ ПРИМЕСЕЙ ЦВЕТНЫХ МЕТАЛЛОВ С ПРИМЕНЕНИЕМ «АКТИВНЫХ» ЗЕРНИСТЫХ ФИЛЬТРОВ НА ОСНОВЕ БОРНОЙ КИСЛОТЫ

В данной статье представлены результаты сравнительных экспериментальных исследований по комплексной двухэтапной обработке первичного алюминия флюсовой обработкой борной кислотой (H_3BO_3) в ковше с дальнейшей фильтрационной очисткой расплава через зернистые фильтры и одноэтапной фильтрационной очисткой первичного алюминия через активные зернистые фильтры с добавками борной кислоты.

Исследования проводились в рамках грантового финансирования Комитета науки Министерства науки и высшего образования Республики Казахстан по конкурсу «Жас Галым» по проекту ИРН AP19175493 «Разработка технологии рафинирования первичного алюминия фильтрами с активной поверхностью».

Результаты исследований показали, что комплексная одноэтапная технология очистки алюминия-сырца от примесей цветных металлов с использованием активных фильтров снижает их содержание в первичном алюминии.

Лабораторные исследования показали снижение содержания ванадия на 53,3 %, меди на 19,8 %, магния на 49,6 %, марганца на 51,7 % и кремния на 97,1 % в первичном алюминии при использовании метода очистки активными фильтрами.

Сравнительный анализ методов очистки алюминия показал, что вопрос применения активных фильтров нуждается в дальнейшем изучении с целью определения степени очистки от примесей цветных металлов в зависимости от различных параметров активного фильтра.

Ключевые слова: алюминий, примеси цветных металлов, фильтрация, борная кислота, флюс, активный фильтр.

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