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ISSN 0543-5846
METABK 62(2) 293-295 (2023)
UDC – UDK 669.71:66.067:542.6:669.2/8:669.781=111

COMPLEX PROCESSING OF PRIMARY ALUMINUM TO REMOVE IMPURITIES OF NON-FERROUS METALS

Received – Primljeno: 2022-09-15
Accepted – Prihvaćeno: 2022-12-08
Preliminary Note – Prethodno priopćenje

The paper presents researches on the complex processing of primary aluminum produced by electrolysis with flux treatment with boron-containing materials and further filtration refining through granular filters. The research methods and applied instruments used for the analysis of the chemical composition and electron microscopy are described. The results are presented before and after the complex treatment of primary aluminum, showing a significant reduction in non-ferrous metal impurities (vanadium, titanium, etc.) and other undesirable impurities.

Keywords: aluminum, flux refining, filtration refining, non-ferrous metal impurities, boron

INTRODUCTION

In recent years, there has been a tendency to involve in the electrolysis production of aluminum lower quality sources of raw materials for the production of anodes [1].

This is mainly due to the production of heavy oil (which includes asphaltene compounds). In asphaltenes, metal impurities (Fe, Si, V, Ni, etc.) are concentrated, which, during coking, turn into coke, and then into aluminum. Vanadium is one of the impurities in primary aluminum that reduces the electrical conductivity of the metal at a concentration of about 2 ppm [1–3].

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 based on cryolite, sodium chloride, aluminum fluoride used by Kazakhstan Electrolysis Plant JSC for refining primary aluminum do not remove non-ferrous metal impurities [1].

ANALYSIS OF ACHIEVEMENTS AND PUBLICATIONS

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

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

- decrease in the content of vanadium by an average of 78 % in the bulk of the metal, with an increase in its content in the lower part of the ladle (volume up to 5-10 % of the ladle capacity);
- conversion of a significant amount of vanadium into an intermetallic compound;
- difficulty in separating vanadium and refined aluminum intermetallic compounds in a ladle using traditional methods (settling for 4-7 hours did not give a positive result)

METHODS AND MATERIALS

In the work, experimental studies were carried out on the complex treatment of primary aluminum by flux treatment with boric acid (H_3BO_3) and further filtration refining of the melt through granular filters.

Table 1 shows the chemical composition of primary aluminum before refining, which was selected 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.

Experimental studies were carried out as follows. At the first stage, primary aluminum was melted in a laboratory induction furnace, H_3BO_3 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 the chemical composition of refined primary aluminum

Table 1 **Chemical composition of primary aluminum before refining /wt.%**

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

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was determined on a DFS optical emission spectrometer 500.

At the second stage, filtration refining of primary aluminum treated with boric acid through a granular filter was carried out. When choosing the parameters of granular filters, the recommendations of the following works [8 – 10] were taken into account.

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

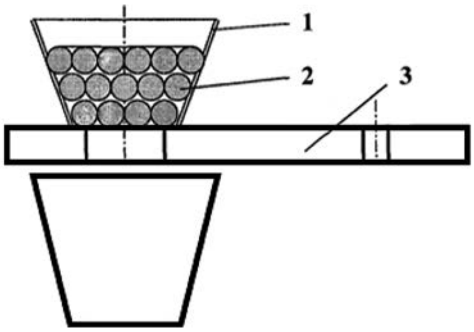

Figure 1 Scheme of the experimental setup

Ash from Ekibastuz coal, consisting mainly of SiO_2 and Al_2O_3, was used as a material for the manufacture of filter grains.

As a result of the experiments, filtered aluminum samples were obtained, which were further analyzed on a JEOL scanning electron microscope (SEM) with an INCA Energy microanalysis system.

Figure 2 Samples of filtered primary aluminum

RESULTS AND DISCUSSION

Determination of the chemical composition of primary aluminum after H_3BO_3 flux treatment on an optical emission spectrometer DFS-500 showed a decrease in the content of impurities. The degree of removal of impurities is given in Table 2.

Measurement of the chemical composition of primary aluminum along the height of the ladle showed an

Table 2 **Degree of impurity removal from primary aluminum after H_3BO_3 flux treatment /wt.%**

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

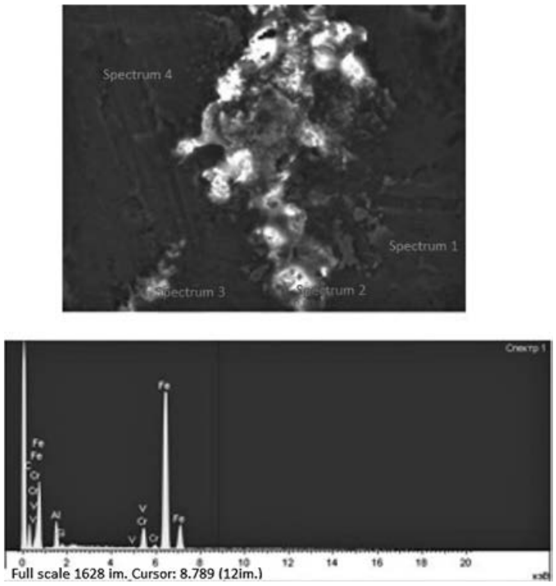

Figure 3 Results of SEM of the original sample of primary aluminum (before refining)

Table 3 **Characteristics of chemical elements based on the results of SEM of the initial sample of raw aluminum (before refining) /wt.%**

Spectrum	In stat.	O	Al	Si
Spectrum 1	Yes	-	5,71	0,63
Spectrum 2	Yes	21,03	78,97	-
Spectrum 3	Yes	15,28	84,72	-
Spectrum 4	Yes	30,74	69,26	-
Max.		30,74	84,72	0,63
Min.		15,28	5,71	0,63
Spectrum	V	Cr	Fe	Total
Spectrum 1	0,53	6,44	86,69	100,00
Spectrum 2	-	-	-	100,00
Spectrum 3	-	-	-	100,00
Spectrum 4	-	-	-	100,00
Max.	0,53	6,44	86,69	
Min.	0,53	6,44	86,69	

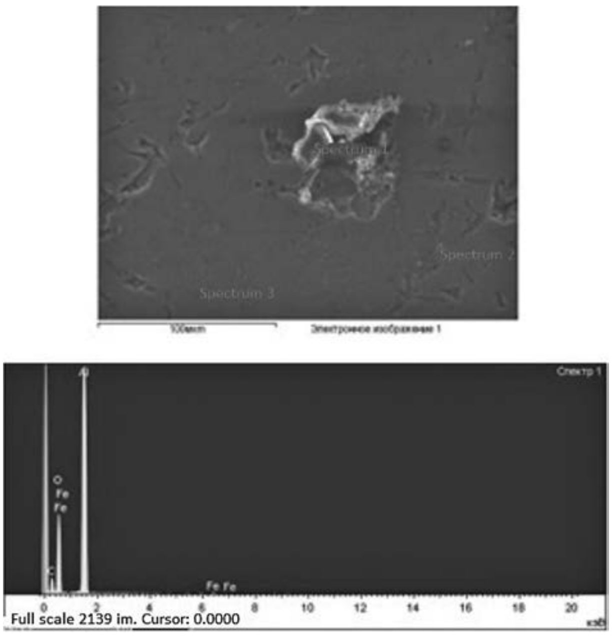

Figure 4 Results of SEM of raw aluminum sample after flux refining

Table 4 **Characteristics of chemical elements based on the results of SEM of a sample of raw aluminum after flux refining /wt.%**

Spectrum	In stat.	O	Al	Si
Spectrum 1	Yes	51,77	47,50	-
Spectrum 2	Yes	52,21	47,79	-
Spectrum 3	Yes	11,59	77,31	0,83
Max.		52,21	77,31	0,83
Min.		11,59	47,50	0,83
Spectrum	V	Cr	Fe	Total
Spectrum 1	-	-	0,73	100,00
Spectrum 2	-	-	-	100,00
Spectrum 3	-	-	8,65	100,00
Max.	-	-	8,65	
Min.	-	-	0,73	

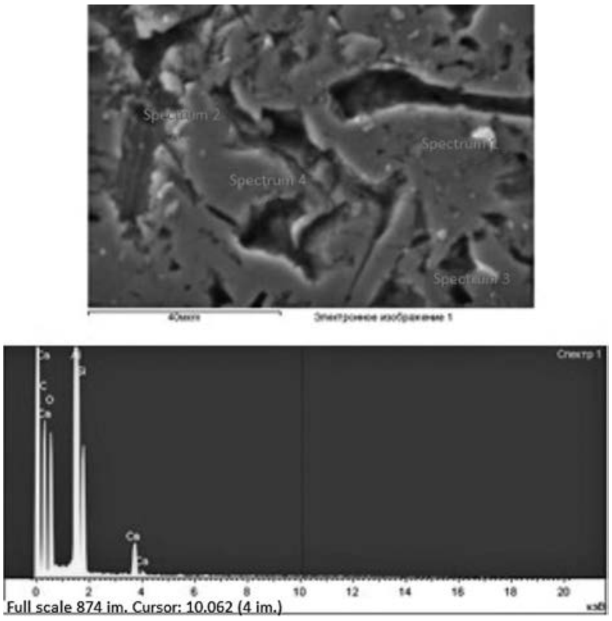

Figure 5 Results of SEM of raw aluminum sample after filtration refining

Table 5 **Characteristics of chemical elements based on the results of SEM of a sample of raw aluminum after filtration refining /wt.%**

Spectrum	In stat.	O	Al	Si
Spectrum 1	Yes	35,45	49,41	11,70
Spectrum 2	Yes	48,96	25,13	6,51
Spectrum 3	Yes	7,33	23,59	69,08
Spectrum 4	Yes	6,27	91,18	1,74
Max.		48,96	91,18	69,08
Min.		6,27	23,59	1,74
Spectrum	V	Ca	Fe	Итог
Spectrum 1	-	3,44	-	100,00
Spectrum 2	-	19,40	-	100,00
Spectrum 3	-	-	-	100,00
Spectrum 4	-	-	0,81	100,00
Max.	-	19,40	0,81	
Min.	-	3,44	0,81	

uneven distribution of vanadium in the volume of the ladle. An increase in the content of vanadium in the lower part of the ladle after settling was revealed.

On a JEOL scanning electron microscope with an INCA Energy microanalysis system, samples of primary aluminum were analyzed before refining (Figure 3, Table 3), after H_3BO_3 flux refining (Figure 4, Table 4) and after filtering through granular filters (Figure 5, Table 5).

Laboratory studies have shown a decrease in the content of vanadium, copper, magnesium, manganese and silicon in primary aluminum during flux refining and further almost complete removal of reaction products of non-ferrous metal impurities with boron according to the results of filtration.

Detailed studies on a JEOL scanning electron microscope with an INCA Energy microanalysis system showed the possibility of removing non-ferrous metal impurities, primarily vanadium, as can be seen from Figures 3, 4, 5 and Tables 3, 4, 5.

CONCLUSION

The research results show that the complex technology of refining raw aluminum from vanadium using boric acid (H_3BO_3) in a ladle with further filtration reduces the content of non-ferrous metal impurities from primary aluminum.

Laboratory researches have shown a decrease in the content of vanadium by 47,7 %, copper by 17,6 %, magnesium by 47,5 %, manganese by 50,0 % and silicon by 97,9 % in primary aluminum during H_3BO_3 flux refining and further almost complete removal reaction products of non-ferrous metal impurities with boron according to filtration results.

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Note: The responsible in English translate is Ibraieva Madina, Pavlodar, Kazakhstan.