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# Ecological engineering in the process of gas treatment from dust and prospects for its use in agriculture

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**Abstract.** In this paper it is shown that the implementation of technological measures of ecological engineering in the sintering technology of alumina production allows reducing emissions of polluted gases into the atmosphere. The conducted industrial testing of the additional stage of wet gas treatment on sintering furnaces confirmed its high efficiency of gas treatment from fine-disperse dust. Physical chemical and morphological dust properties of gas treatment facilities of alumina production are investigated. The characteristic of the chemical dust composition of various technological equipment of gas treatment is given. The dust application of electrofilters in the alumina production as ameliorants for deoxidation of gray forest soils of the Western districts of the Krasnoyarsk territory. This will improve soil fertility and crop productivity through the absorption of soil cations calcium-containing waste and the sustainable functioning of the agrocenosis.

## 1. Introduction

The specific of the Russian aluminum industry is that all electrolysis plants are located in the center of Siberia. The only producer of alumina in this region is JSC “RUSAL Achinsk” on which the technology of complex processing of nepheline ores on a method of sintering is mastered on an industrial scale [1].The technology of producing alumina from nepheline has demonstrated its advantages and ability to compete with high-quality bauxite [2].At the same time, the gas treatment systems used in aluminum production are not always effective due to the high temperatures of the alumina production process, as well as the presence of a significant amount of fine-disperse dust in the emissions of furnace units [3-5].The introduction of ecological engineering measures with the modernization of the gas treatment system of sintering furnaces can solve the problem of air treatment from dust and its subsequent disposal [6-7]. The purpose of this work was to carry out technological measures of ecological engineering to improve the efficiency of air treatment from dust and the search for perspective technologies for its use.

## 2. The obtained research results

The main source of air pollution from alumina production at JSC "RUSAL Achinsk" are rotary sintering furnaces, which are designed for firing raw charge. Since the nepheline ore of the Kiya-

Shaltyr nepheline mine contains a significant amount of silicon dioxide (up to 42%), which can form insoluble compounds with aluminum oxide and lead to its losses, silicon dioxide must be removed from the process, which is carried out by binding it to a bicalcium silicate, which is slightly soluble in alkaline solutions. At the temperature of 1200-1280°C and the presence of a liquid phase that activates the diffusion of the raw charge components, all physical and chemical reactions are carried out [1].

The creation of the above temperatures in the sintering furnace area is provided by fuel combustion. Coal from the Kuznetsk Basin is used as fuel. The resulting sintering of the raw charge sintered enters the grate refrigerators, and the gases from the sintering furnace, containing mainly sintered dust, are sent to the gas treatment system, including a dust chamber, cyclones and electrofilters, where they are treated and discharged into the atmosphere through a pipeline. A part of the gases from the sintering furnaces after additional treatment is sent to the scrubber-electrofilters to the alumina department for carbonation of aluminate solutions. According to the technological requirements, the $CO_2$ content in these gases should be at least 16% vol. But due to the fact that the sintering process of alumina-containing charge in rotating sintering furnaces is accompanied by a significant dust release, the bulk of the dust is removed from the furnace along with the exhaust gases. To treat the gas emissions of sintering furnaces from the dust contained in them, dust collecting devices are installed to ensure the treatment of gas emissions into the atmosphere in accordance with the standards established by the enterprise. Pre-furnace gases in the dust chamber are treated from coarse fraction of dust (more than 50μm). In this case, the gas flow passing through the dust chamber loses speed and dust particles are deposited in the dust chamber bins. It is noted that in dust chambers on each sintering furnace from 8 to 15% of dust is deposited. Subsequent gas treatment of furnaces sintering occurs in the battery of cyclones where the deposited particles larger than 20μm. Dust particles are thrown by centrifugal force to the wall of the cylindrical part of the cyclone and move along it to the conical part, from which the dust is poured into the receiving hopper, and the treated gas, changing its direction, moves up, coming for further treatment to the electrofilters. Each oven has two groups of 8 cyclones each, in which 70-75% dust fraction 20-25μm are deposited. For the next stage of air treatment from dust in JSC "RUSAL Achinsk" there are five field electrofilters, SF SROGAS, the manufacturer JSC "Kondor-EKO" (village Semibratovo, Yaroslavl region) [8]. The process of dedusting gases in electrofilters occurs at a voltage of 80 kV, under the action of the electric field, the suspended dust particles are charged and move to the sedimentary electrodes on the surface of which they are deposited and discharged. Removal of dust from the electrodes is provided by shaking with special mechanisms. The degree of gas treatment after the electrofilters reaches 98-99%.

At the same time, the existing system of gas treatment on sintering furnaces does not provide enough complete treatment from dust. JSC "RUSAL Achinsk» is currently conducting industrial tests for the commissioning of an additional degree of wet gas treatment. The process of wet dust collection is based on the contact of the dusty gas flow with the liquid, which captures the suspended particles and takes them out of the apparatus in the form of sludge. The main advantage of wet gas treatment is the ability to catch particles of 3-5 microns in size. This method of treatment is based on the contact of dusty gas with the washing liquid (most often with water).

The experimental installation for the wet gas treatment is intended for treatment of exhaust gases from two sintering furnaces. The installation is an additional stage of treatment and is located at the cold end of the furnace after the smoke exhausters of electrofilters. The gas treatment installation consists of two parallel connected inertial scrubbers with a diameter of 4500 mm. The gas enters the apparatus tangentially, passes through the guide apparatus, which is also supplied with irrigation fluid (recycled sludge water), and it is sticking dust particles on the finely dispersed liquid. After that, under the action of centrifugal force, it is thrown to the walls of the scrubber, which flows into the conical part of the apparatus and is output. During the industrial testing, it was provided for the installation of shut-off valves with electric drives on the inlet and outlet flues to ensure the operation of the main process equipment when the gas treatment installation is being repaired. To ensure the circulation of the irrigation fluid, a pumping station consisting of three pumps, shut-off valves with electric drives was made and installed. To control the flow of the gas treatment process in the installation the sensors were provided to monitor the following parameters: the temperature of the gases at the inlet to the apparatus; the temperature of the gases at the outlet of the apparatus; the pressure in the scrubber; a liquid temperature before and after the scrubber; the flow rate before the scrubber; the liquid level in the scrubber.

In the process of wet treatment, waste water was formed, containing fine-disperse particles caught from the gas, which could cause environmental pollution. To exclude this, it was provided for the treatment of waste water coming from scrubbers in the sludge storage cards. Clarified sludge water was reused for wet treatment, which leads to the saving of fresh water. In the process of industrial testing of wet gas treatment, various expenses of irrigated liquid, volumes of treated gases, temperature of gas-dust flows was tested. The testing results showed a sufficiently high efficiency of the additional stage of wet gas treatment from residual fine-disperse dust particles. The measurements of dust content at the entrance to the wet treatment unit were 1.266 $g/m^3$, the residual dust content of the gases at the outlet of the unit was 0.04 $g/m^3$. At the same time, the volume of treated gas was 228 000 $m^3/h$, and the consumption of irrigated sludge water was 75 $m^3/h$.

Currently, the dust captured in the gas treatment system is transported by compressed air to the hopper of the process dust for its subsequent return to the process for use as an additive to the sinter and reduce the loss of useful components. At the same time, the return of the captured dust to the furnace in full volume under the conditions of the sintering process is not required and we conducted research on perspective ways of possible use of dust.

Agriculture can be one of the areas of possible dust use from gas treatment equipment of sintering furnaces. Development of technology for obtaining acid soil meliorant on the basis of waste gas treatment facilities of JSC "RUSAL Achinsk" can improve soil fertility and crop productivity by absorbing soil cations of calcium-containing waste [9]. To conduct the experiment, the dust of electrofilters from one of the sintering furnaces was taken from different fields of the electrofilter. The chemical analysis of the dust showed that in the fields of the electrofilter in its composition it contains a different amount of active calcium oxide in a fine-disperse form of fineness less than 20 microns, which was confirmed by the sieve dust analysis.

Chemical analysis of dust of all fields of the electrofilter of the sintering furnace No9 in JSC "RUSAL Achinsk" is shown in table1.

**Table 1** Results of the dust analysis of the electric filter of the sintering furnace of JSC RUSAL Achinsk».

| The name of the test object | Mass fraction of dust component, % | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $SiO_2$ | CaO | MgO | $Fe_2O_3$ | $Al_2O_3$ | $SO_3$ | Chlorides | Others |
| The dust from the electrofilter of sintering furnace No9 field No1 | 17.22 | 33.8 | 1.0 | 2.2 | 11.9 | 1.52 | 1.39 | 30.97 |
| The dust from the electrofilter of sintering furnace No9 field No2 | 16.76 | 32.8 | 1.0 | 2.2 | 11.6 | 2.04 | 1.99 | 31.61 |
| The dust from the electrofilter of sintering furnace No9 field No3 | 16.11 | 31.2 | 0.8 | 2.16 | 11.1 | 2.98 | 3.52 | 32.13 |
| The dust from the electrofilter of sintering furnace No9 field No4 | 3.9 | 8.96 | 0.6 | 0.65 | 3.06 | 11.26 | 27.5 | 44.07 |
| The dust from the electrofilter of sintering furnace No9 field No5 | 7.62 | 16.2 | 1.1 | 1.23 | 5.74 | 10.16 | 27.6 | 30.35 |

The largest mass fraction of calcium oxide required for use as a lime meliorant is observed in the dust taken from the fields No1,2 and 3 of the electrofilter, which is 33.8; 32.8 and 31.2% of the mass accordingly, (table 1). Dust from the fieldsNo4 and 5 of the electrofilter contains much less active calcium oxide, 8,96 and 16,2 % by weight accordingly. Therefore, as a meliorant, the dust of fields N 1-3 of electrofilters of sintering furnaces of JSC RUSAL Achinsk can be more effectively applied.

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The soil from Bolsheului district of Krasnoyarsk region with pH value of 4.5-4.9 units was chosen as the object of research, waste of the fieldsNo1,2, 3 and 4of electrofilter of gas treatment facilities of sintering furnace of JSC "RUSAL Achinsk" were tested as meliorants.

In the process of the work, the phyto-toxicity was evaluated according to the following indicators: seed germination energy, laboratory germination, morphometric parameters such as the length of seedlings, root length using Lepidiumsativum L. and Triticum vulgare L. as test plants.

It is established that to change the acidic reaction of the medium, a dosage of 0.1% of the dust from the first field of the electrofilter of the sintering furnace N 9 is required. Significant improvement of sowing qualities and morphometric indicators in comparison with the control variant (soil with pH 4,4) was noted in testing crops grown on the soil with the dustaddition of gas treatment facilities, which indicates the effectiveness of the selected concentrations of meliorants.

When growing test crops on acidic soil with the dust addition of gas treatment facilities of furnace units, a significant increase in morphometric indicators of plant development was noted. Plants of the experimental groups, compared with the control variant, have a more powerful root system and a stronger shoot (figure1).

Control field soil

The soil with dust from the electrofilter of sintering furnace 9 field 4

The soil with dust from the electrofilter of sintering furnace 9 field 1

**Figure 1.** Samples of soft spring wheat (Triticumvulgare L.) of the sort Novosibirsk 29 grown in different soil conditions.

Preliminary laboratory testing has confirmed the ability of deoxidation of gray forest soil, taken from one of the areas fromthe experienced field inBolsheului district, using dust from the electrofilterof sintering furnace field No1-3. The initial pH of the soil from the control area of the experimental field was at the level of 4.6-4.8, after entering 0.1% of the dust of the electrofilter (field 1), the pH increased to 7.0-7.2. The most effective meliorant was shown by the dust of the first field of the electrofilter of the sintering furnace, which is due to the high content of fine particles of active calcium oxide in it. Plants of experimental groups in comparison with control variants have more powerful and developed root system, as well as high shoots.

## 3. Conclusion

In the present work it is shown that the perspective direction of the use of calcium-containing waste in alumina production can bethe use of such waste as a chemical meliorant. Given that the proposed

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meliorant is a waste product and accumulates in large quantities, it can be in demand for deoxidation of acidic soils throughout the Siberian region. Improvement of sowing qualities and growth characteristics of plants of test cultures which were grown up on the soil with the dust addition of gas treatment installations (dust of the electrofilter from the sintering furnace No. 9 field 1 and field 4) that is connected with improvement of indicators of the soil, specifically, transfer of soil acid reaction in neutral is established.

## References

[1] Arluk B I 1994 Complex processing of alkaline aluminum-containing raw material (*Moscow: Metallurgy*) p 384

[2] Sizyakov V M 2006 *Current state and problems of development of aluminum industry in Russia Notes of mining institute* **163** 163-70

[3] Fraser P 2013 Carbon dioxide emissions from an Australianaluminum smelter using time-integrated stack sampling and GC-MS, GC-FID Analysis *Light Metals* 871-6

[4] Neate M 2013 Latest filter developments increasing existing aluminium smelter gas treatment centre capacity and reducing emissions *Light metals* 799-804

[5] Martineau P 2015 Start-up of the ozeos gas treatment center (GTC) for RTA AP60 *Light metalls* pp 623–5

[6] Shepelev I I 2013Ways of solving problems of secondary waste use of Achinsk alumina plant *Collection of scientific articles V Intern. Congress "nonferrous metals-2013". Krasnoyarsk: Publishing house "Verso"* pp 395-402

[7] Gordon G M and Peisakhov I L 1977 Dedusting and gas treatment in nonferrous metallurgy (*Moscow: Metallurgy*) p 347

[8] Gusev V A 2011 Technical solutions to improve the efficiency and reliability of electrofilters, FINGO *Collection of reports of the IV International interindustry conference "dust and gas treatment -2011" Moscow, 27-28 September 2011 JSC "INTEKO"* pp 16-8

[9] Tandelov J P 1997 Efficiency of mineral fertilizers and meliorants on acid soils of the Krasnoyarsk territory *Chemistry in agriculture* **1** 8-11