Modernization of gas treatment equipment from pollutants in alumina production

I I Shepelev, E V Kiryushin, O V Pilyaeva and E N Eskova

1 JSC "ECO-Engineering", 662150, Achinsk, South industrial zone, block XII, building 1
2 Krasnoyarsk state agrarian university, 660049, Krasnoyarsk, Mira Ave., 90
3 Achinsk branch of Krasnoyarsk state agrarian university 662150, Achinsk, Kommunisticheskaya str., 49
4 E-mail: Ekoing@mail.ru

Abstract. In this paper, it is the previous system of gas treatment on sintering furnaces used at JSC "RUSAL Achinsk", consisting of a dust chamber and electro filters, did not provide the necessary treatment degree. Old four-field electro filters were not effective and required constant replacement and adjustment of electrode systems and shaking mechanisms. Shown that the modernization of gas treatment equipment in alumina production reduces the emissions of polluted substances into the air. The introduction of technical solutions for modernization of obsolete and worn-out electric filters to more modern and efficient five-layer electro filters increases the degree of gas treatment from sintering furnaces from inorganic dust. The introduction of an additional stage of "wet" gas treatment on sintering furnaces in scrubbers has been confirmed by industrial tests, while ensuring high efficiency of gas treatment from fine-disperse dust. When using sub-sludge water as an irrigation liquid at the stage of "wet" gas treatment, it was not necessary to build additional treatment facilities, since the modernization project provides for its subsequent return to the hydrochemistry shop for technological needs.

1. Introduction

The technology for producing alumina from nephelines has demonstrated its advantages and ability to compete with the technology for producing marketable products from high-quality bauxites [1]. According to the applied sintering technology, JSC "RUSAL Achinsk" produces a number of related products (soda ash, potassium sulfate), which provides a comprehensive use of nepheline raw materials, a relatively low cost of production and high profitability [2]. However, gas treatment systems in heat and power facilities used in alumina production are not always effective due to the high temperature process of sintering obtaining, as well as presence in the emissions of furnaces significant quantities of fine-disperse dust [3]. The introduction of environmental engineering measures with the modernization of the gas treatment system of sintering furnaces can solve the problem of air treatment from fine-disperse dust [4].

2. Purpose of research

The purpose of this work was to carry out the modernization of gas treatment equipment and technological measures of environmental engineering, which provide an increase in the efficiency of
air treatment from fine-disperse inorganic dust in order to achieve the established standards of maximum permissible emissions of pollutants.

3. The obtained research results
The process of sintering an alumina-containing charge in rotating furnaces is accompanied by significant dust emission. The main part of the dust is removed from the furnace along with the waste gases. Dust formation in the furnace zones is different. From the sintering and heating zones of the charge, the dust loss is insignificant. The main amount of dust, which is from 25 to 40 % of the amount of charge loaded into the furnace, is removed from the dry part of the chain zone and the decarbonation zone. To ensure sanitary and hygienic standards for the quality of atmospheric air, as well as the return of dust to the process in order to reduce the loss of useful components, the waste gases of sintering furnaces are subjected to sequential treatment in dust-collecting facilities.

Recently, gas treatment from sintering furnaces was carried out sequentially in a dust chamber, electro filters, followed by the discharge of dust-free gases into the atmospheric air through a chimney. The existing scheme for gas treatment from sintering furnaces of JSC "RUSAL Achinsk" is shown in figure 1.

![Figure 1. Scheme for gas treatment in sintering furnaces: 1-sintering furnace; 2-dust chamber; 3-flues; 4-electric filters; 5-smoke pump; 6-chimney.](image)

All furnaces have a dust chamber at the cold end of the sintering furnace. The dust chamber serves as a connecting link between the furnace and the gas treatment system of the furnace, and is designed for rough treatment of the exhaust gases in sintering furnaces from large dust fractions (more than 50 microns). The gas stream passing through the dust chamber, due to a sudden increase in the cross-section area, loses speed, and dust particles are deposited in the silos of the dust chambers (from 8 to 15 % of the dust). The captured dust is returned to the process using augers and pneumatic chamber pumps.
Due to the fact that electro filters have been in operation for decades, it is natural for such a period to change both the operating mode of this technological unit and the sanitary requirements for the amount of pollutants emissions into the atmosphere. A radical means of ensuring the required sanitary standards is the modernization of equipment with the installation of new effective electro filters. Analysis of the previously performed reconstruction of electro filters showed that most of the work on the reconstruction of this equipment is carried out in the following areas: replacing the electrode system, increasing the deposition area and replacing power units [5]. Old electro filters work inefficiently and need to be replaced with more modern ones. Previously, four-field electro filters were used in the gas treatment processes of sintering furnaces, which did not withstand the warranty period of operation and the removal of fine-disperse dust particles into the atmosphere was observed. Increasing the number of fields with a constant total length of the electro filter active zone creates the following advantages for increasing the degree of gas emissions treatment:

- increasing the specific current of the crowning discharge;
- increasing breakdown voltages;
- reduction of dust entrainment during shaking and dust deposition;
- improving dust removal.

On the other hand, an increase in the number of fields leads to an increase in the number of power units for electro filters, dust shaking mechanisms, and the number of crowning electrodes. However, the use of the five-field is justified from the point of ecology view. Thus, the installation of an additional fifth field in a four-field electro filter allows reducing dust emissions by half at the initial treatment level [6].

Considering the current requirements for waste gas treatment of heat power facilities, JSC “RUSAL Achinsk” is gradually replacing four PGD 4×50-type field filters with more efficient five-field electric filters of the EGAV 1-25-12-7-5 type; EGBM 1-25-12-6-5; EGA 1-30-12-6-5 developed by SF NIOGAZ, the manufacturer of JSC “Condor-Eco” (Semibratovo village, Yaroslavl region) [6]. Currently, 10 of the 12 sintering furnaces have been replaced with five-field electro filters. On each furnace is equipped with two electro filters running at the same time. The process of de-dusting gases in the electro filter proceeds as follows: a constant current of high voltage (up to 80·10-3 V) of negative polarity is supplied to the crowning electrodes. When the voltage increases to a certain value, a crowning charge is formed between the electrodes, resulting in ionization of the gas molecules. Moving under the influence of electric field forces and participating in the random thermal movement of gas molecules, the ions collide with suspended dust particles, are adsorbed by them and transfer their charge to them. Charged dust particles move to the electro filters, are deposited on their surface, and are discharged. The degree of gas treatment in the electro filters is 98-99% [5,6]. The release of treated gases into the atmosphere is carried out through chimneys.

The process dust caught in the gas treatment system is fed to the bunker by the screw conveyor system and pumped by pneumatic chamber pumps to the bunker at the site of the furnace hot head. From the bunker, the process dust is fed by screw feeders to the pipe through which fan air is fed to the furnace in the fuel torch zone.

To increase the degree of gas treatment from pollutants, it was decided to further modernize the system for waste gas treatment from sintering furnaces. For this purpose, a project was developed and tested on a pilot scale for the introduction of an additional stage – "wet" gas treatment of sintering furnace after electro filters using sub-sludge water as an irrigation liquid, followed by its return to the hydrochemistry shop. The "wet" gas treatment method is based on absorption methods founded on the diffusion transition of the gaseous component to the liquid medium. The "wet" treatment facility developed by JSC "Feld-EM" consisted of two parallel connected inertia scrubbers with a diameter of 4500 mm. Gas is supplied tangentially, passes through a guide device (grid), which is also supplied irrigating fluid sub-sludge water. In scrubbers, dust particles adhere to the finely sprayed liquid, then under the action of centrifugal force it is thrown to the walls of the scrubber, along which it flows into
the conical part of the device and is brought out. The project solution for reducing the impact on the environment provides for the reconstruction of the dust treatment equipment production line for all 12 sintering furnaces, which will allow the company to reach the maximum permissible emissions into the atmosphere. According to the project, the technical modernization of the gas treatment system will not change the volume of water used, contaminated and heated waste water and will ensure their return to the circulating systems for technological needs. For these reasons, special measures for wastewater treatment are not required.

When evaluating the operation of the pilot facility for "wet" treatment of sintering furnaces No. 11, 12, it was found that the amount of inorganic dust emitted into the atmosphere with a content of up to 20% SiO₂ did not exceed the established maximum permissible emissions (19.25 g/s). The joint operation of five-field electro filters and the "wet" treatment unit mounted on sintering furnaces No.11, 12 consistently provided treatment of emissions below the level of maximum permissible emissions. Measuring performed during industrial tests showed that the dust content at the outlet of the electro filters was 1.266 g / m³, while the residual dust content of the gases at the outlet of the "wet" treatment unit was 0.04 g / m³. The dust caught in the gas treatment system was transported using compressed air to the recycling process dust bunker for its subsequent return to the process for use as an additive to the sinter and reducing the loss of useful components.

4. Conclusion
The previous system of gas treatment on sintering furnaces used at JSC "RUSAL Achinsk", consisting of a dust chamber and electro filters, did not provide the necessary treatment degree. Old four-field electro filters were not effective and required constant replacement and adjustment of electrode systems and shaking mechanisms. The modernization of gas treatment equipment at sintering furnaces by replacing four-field electro filters with five-field ones has made it possible to increase the efficiency of waste gas treatment from inorganic dust. Implementation of environmental engineering measures and installation of an additional stage of "wet" gas treatment on sintering furnaces in scrubbers confirmed the possibility of providing a high degree of gas treatment from fine-disperse dust. At the same time, gas emissions are treated below the maximum permissible emissions set by the company. As an irrigation liquid at the stage of "wet" gas treatmentsub-sludge water from the sludge storage is used. The use of lye-containing sub-sludge water in scrubbers will not disrupt the water balance of the enterprise due to its return to the revolving water supply system for technological needs.

References
[1] Sizyakov V M 2006 Current state and development problems of the aluminum industry in Russia Notes of the mining institute 163 163-70
[2] Arluk B I, Liner Yu A and Pivnev A I 1994 Complex processing of alkaline aluminum-containing raw materials (Moscow: Metallurgy) p 384
[3] Fraser P, Steele P and Cooksey M 2013 Carbon Dioxide Emissions from an Australian Aluminium Smelter Using Time-Integrated Stack Sampling and GC-MS, GC-FID Analysis Light Metals 871-6
[4] Gordon G M and Peisakhov I L 1977 Dust collection and gas treatment in non-ferrous metallurgy (Moscow: Metallurgy) p 347
[5] Guzeev V A and Troitsky A A 2011 Technical solutions for improving the efficiency and reliability of FINGO electro filters Collection of reports of the IV international conference Dust and gas treatment 16-8
[6] Chekalov L V 2004 Ekotehnika. The protection of atmospheric air from dust emissions of dust, aerosols and fogs (Yaroslavl: publishing house "Rus") p 424