Reducing emissions of resinous substances in the electrolytic production of aluminum

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Abstract. The analysis of the influence of new technical solutions in the technologies of electrolytic production of aluminum on the quantitative indicators of pollutants in the emissions of anode gases is presented. Describes methods to reduce emissions of resinous substances, including 3,4-benz (a) pyrene. The problem of emission capture during cooling of the pins extracted from the anode is considered in detail. For the first time in the Russian Federation, it was proposed to use environmentally friendly oil pitch, in which 3,4-benz (a) pyrene is practically absent. A variant of collecting tar contaminants by cooling anode pins in an aspirated cartridge is proposed. The new solution reduces tar emissions by an average of 5%.

1. Introduction

The production of aluminum in electrolyzers with a self-baking anode and top current lead is accompanied by the formation of a significant amount of pollutants. In particular, during the production of each ton of aluminum, 9.3 to 19.8 kg of resinous substances are emitted into the environment (table) [1].

Table 1. The amount of tarry emissions generated in electrolyzers with top current lead.

| Source of emissions                        | Emissions         | %       |
|-------------------------------------------|-------------------|---------|
| Anode surface                             | 0.03 ± 0.035      | 0.3 ± 0.35 |
| From under the bell gas collector         | 6.0 ± 16.7        | 64.5 ± 84.3 |
| When moving the pins,                      | 2.0 ± 3.0         | 21.5 ± 32.2 |
| including due to the mass adhered to the hot part of the pins | 9.3 ± 19.8        | 100     |

The greatest danger in these emissions is benzo (a) pyrene, the specific emissions of which are 0.015 ÷ 0.032 kg / t Al.

The increase in the current strength of the electrolysis process, actively conducted over the past 10-15 years, allowed to increase the productivity of electrolyzers by an average of 20%. This is achieved through the development and implementation of qualitatively new technical solutions for the production of anode and cathode materials, the current supply to the electrolyzer, and also the increase in the diameter of the cylindrical part of the anode current-supply pin 1.1-1.5 times, on average from 138 mm
to 170 mm, which made it possible to achieve a current efficiency of 88–90% [2]. However, the latest technical solution led to an increase in the release of resinous substances during rearrangement of the pins, both directly from the hole of the anode and from the surface of the pin.

The amount of resinous substances released into the atmosphere when the pins are rearranged $P_{pr\,rs}$ can be determined from the expression:

$$P_{pr\,rs} = 0.785 \cdot d_h^2 \cdot h \cdot g \cdot c \cdot \rho_{lam} \cdot (1 - k) \cdot n_p$$

where:
- $d_h^2$ - the diameter of the hole, can be arbitrarily taken equal to the average diameter of the pin baked in the body of the anode, $dm$;
- $h$ - the average height of the hole in the cell (the height of the pin in the baked part of the anode), $dm$;
- $g$ - degree of filling of the hole, fraction of units;
- $c$ - the content of the pitch in the anode mass loaded before rearranging the pins, fraction of units;
- $\rho_{lam}$ - density of the liquid anode mass, kg / dm$^3$;
- $k$ - coke yield during rapid coking pitch, share units;
- $n_p$ - the number of rearranged pins per 1 t Al, pcs.

2. Materials and research methods

The calculation results show that when the pins are rearranged, emissions increased by 1.5–1.6 times and amounted to 3.0–4.8 kg / t Al, reaching a total value of 10.3–21.6 kg / t Al. Total increase in emissions of resinous substances amounted, on average, 10 - 20%.

The reduction in the intensity of emissions from the anode surface is currently provided by the use (as a binder in the production of the anode mass) of the pitches with a high softening temperature, and the reduction of emissions from the hole of the anode by the use of a pin anode mass loaded directly after removing the pin, and by reducing the time between operations "removing the used pin - installing a new pin."

However, the problem of capturing emissions from the pins removed from the anode at the time of their cooling remains unresolved. At present, the pins are cooled in open-type cassettes (Fig. 1). The cassette is an open "basket" with cells securing the pins in an upright position.

![Figure 1. Cassette for cooling anode pins.](image)

The number of pins placed in a typical cassette is 20 - 24. The removed pins in the cassette are cooled and then either reinserted into the anode or transported to the area for cleaning scale and dirt from their surface. It should be noted that the methodology for calculating emissions directly from the surface of the hot pin assumes that an approximately 3 mm layer of anode mass adheres to the hot part of the pin. However, this assumption may be correct for anode pins not corroded (Fig. 2).
3. Results and Discussion

In fact, the thickness of the layer of adhering anode mass and, correspondingly, the level of emissions can significantly exceed the indicated values, both due to the high corrosion wear of the pins (Fig. 3) [3], the result of which is an increase in their roughness, and upon deformation of the pins as a result of exposure to high temperatures in the thickness of the anode [4] (Fig. 4).

Cooling the pin in a tank with a liquid cooling medium significantly reduces the operation time and allows you to catch almost all tarry emissions [5]. However, this technical solution has several disadvantages. The first should be attributed to the evaporation of the liquid when the anode pin is immersed in it.

![Figure 2. New current-carrying anode pins.](image1)

![Figure 3. Anode pins removed from the body of the anode.](image2)

![Figure 4. The nature of the deformation of the current-carrying pin in the body of the anode.](image3)

When water is used as a coolant, its vapors, when mixed with gaseous hydrogen fluoride and sulfur dioxide contained in the atmosphere of the body, form hydrofluoric and sulfuric acids, which are less volatile compared to their gaseous compounds, therefore, can form hazardous concentrations. If you use oils as a coolant, there is a risk of the formation of oil "mists" in the atmosphere of the electrolysis case. Coolants must be replaced periodically, used ones must be disposed of. In addition, it is dangerous to use water in the electrolysis vessels, since emergency situations are possible - it gets into the electrolyzer and the melt is released.
The solution to the problem of capturing the resinous emissions from the anode pins during their cooling is possible through the use of an aspirated cartridge for storing the anode pins during their cooling (Fig. 5) [6]. The cassette is a sealed container equipped with an exhaust fan and a filter, for example, granular, to capture resinous substances.

![Figure 5. Aspirated cartridge for storing anode pins during cooling.](image)

As a filtering material, it is possible to use coke grains that are returned, as they are worked out, to the production of the anode paste, or fibrous combustible material, the disposal of which is possible in coke calcination furnaces.

Another effective technological solution is the use of compounded oil pitch to obtain a pin and ordinary anode mass. This pitch has the same physicochemical and technological parameters as the medium-temperature coal tar pitch, but significantly exceeds it in the practically absent 3,4-benz (a) pyrene, as well as in the low content of polyaromatic hydrocarbons, phenols and resinous substances.

4. Conclusion
1. The introduction of anode current-conducting pins of a diameter increased to 170 mm led to an increase in the total emissions of resinous substances from the electrolyzer by an average of 10 - 20% and reached 10.3 - 21.6 kg / t Al.
2. At present, cooling of the anode current-carrying pins is carried out in open-type cassettes, as a result of which the resinous substances contained in the anode mass adhering to its surface enter the atmosphere of the electrolysis body in an amount of up to 0.48 kg / t Al, which is about 5 % of their total emissions.
3. The capture of emissions of resinous substances evaporating from the surface of the anode current-carrying pin at the time of its cooling is possible due to the introduction of an aspirated cartridge.
4. The introduction of aspirated cassettes will reduce resinous emissions by an average of 5%, which will be about 480 tons / year for aluminum smelters comparable in productivity to Krasnoyarsk and Bratsky; including benzo (a) pyrene - 0.76 - 0.77 t / year.
5. The use of oil pitch will reduce emissions of 3,4-benz (a) pyrene by 4-5 times, tarry substances by 20% and polycyclic aromatic substances by 12-15%.

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