Two-Stage Pot Gas Treatment Technology Allowing the Production of Sodium Sulfate

Viktor Mann[1] , Vitaly Pingin[2], Aleksey Zherdev[3], Sergey Pavlov[4] and Yuri Bogdanov[5]
1. Position of Mann, RUSAL Global Management B.V., Moscow, Russian Federation
2. Position of Pingin
3. Position of Zherdev
4. Position of Pavlov
5. Position of Bogdanov
RUSAL, ETC, Krasnoyarsk, Russian Fderation
Corresponding author: yuriy.bogdanov@rusal.com

Abstract

The key task of any socially responsible entity is to protect the environment from harmful effects of plant operation. UC RUSAL has developed and implemented at RUSAL Krasnoyarsk a two-stage pot gas treatment technology allowing the production of sodium sulfate, ensuring maximum efficiency in entrapping pollutants (dust, fluorides, and sulfur dioxide) and eliminating the need to build new landfills. Therefore, the important environmental task facing the plant has been solved. This paper describes the key process and technical aspects of the above technology. The first step includes the process of adsorbing fluorides and dust from the gas. The second step includes the process of adsorbing sulfur dioxide and the additional removal of the remaining fluorides and dust; and the third step includes the removal of sulfur, in the form of sodium sulfate, from the closed wet scrubber (WS) liquor circulation loop to increase the efficiency of the second gas treating step and eliminate the need to build new landfills. The resulting sodium sulfate can be used as a commercial product in paper pulp production.

Keywords: Pot gas treatment, dry scrubber, wet scrubber, sodium sulfate.

1. Introduction

Modern history of Krasnoyarsk Aluminum Smelter (KrAZ) includes a series of milestones to improve environmental situation, rationalize and upgrade existing environmental protection technologies. To improve systems cleaning cell off gases is among such significant milestones. Traditionally, smelters in the Soviet Union were equipped with two-stage gas treatment systems: Stage 1 – electrical filter to clean dust and tars, Stage 2 – wet scrubbing to remove fluorine, sulfur compounds, additional cleaning from dust and tars and discharge of saturated solutions to the settling ponds. Under modern conditions such a scrubbing system fails to meet treatment efficiency requirements.

The first stage of upgrading KrAZ gas scrubbing equipment was to completely replace all electric filters for up-to-date dry gas scrubbers with the operating principle based on screening the pollutants by alumina adsorption. Dry gas scrubbers reduced emissions of gaseous and solid fluorides, inorganic dust by 40 %, benz(a)pyrene and tars – by 15 %.

The second stage of wet gas scrubbing is to capture sulfur dioxide. Until recently the essential fault of the existing two-stage gas scrubbing at Krasnoyarsk Aluminum Smelter was the necessity to use settling ponds to discharge solutions saturated with sodium sulfate and, as a consequence – closed water turnover – accumulation of sodium sulfate. High concentrations of crystallizable sodium sulfate reduce efficiency of gas scrubbing equipment and necessitate its frequent maintenance and cleaning. Among possible solutions of this problem is to dilute

sodium sulfate with industrial water to reduce its concentration; this, however turns up another ecological challenge – restricted volume of existing ponds and the need to build new ones.

For the period of 2015 - 2017 specialists of RUSAL ETC LLC improved the existing two-stage gas scrubbing process. Up-to-date process meeting requirements of environmental laws and regulations, ensuring maximum achievable at the current technological horizon efficiency of gas treatment with closed solution turnover and production of dry sodium sulfate in demand in the market has been developed and implemented.

2. State-of-the art Gas Scrubbing Processes in Aluminum Production

All currently known methods of arranging fume gas treatment processes can be divided into cyclic and noncyclic; the cleaning process as it is classified as follows: adsorption, absorption and chemisorption (Figure 1).

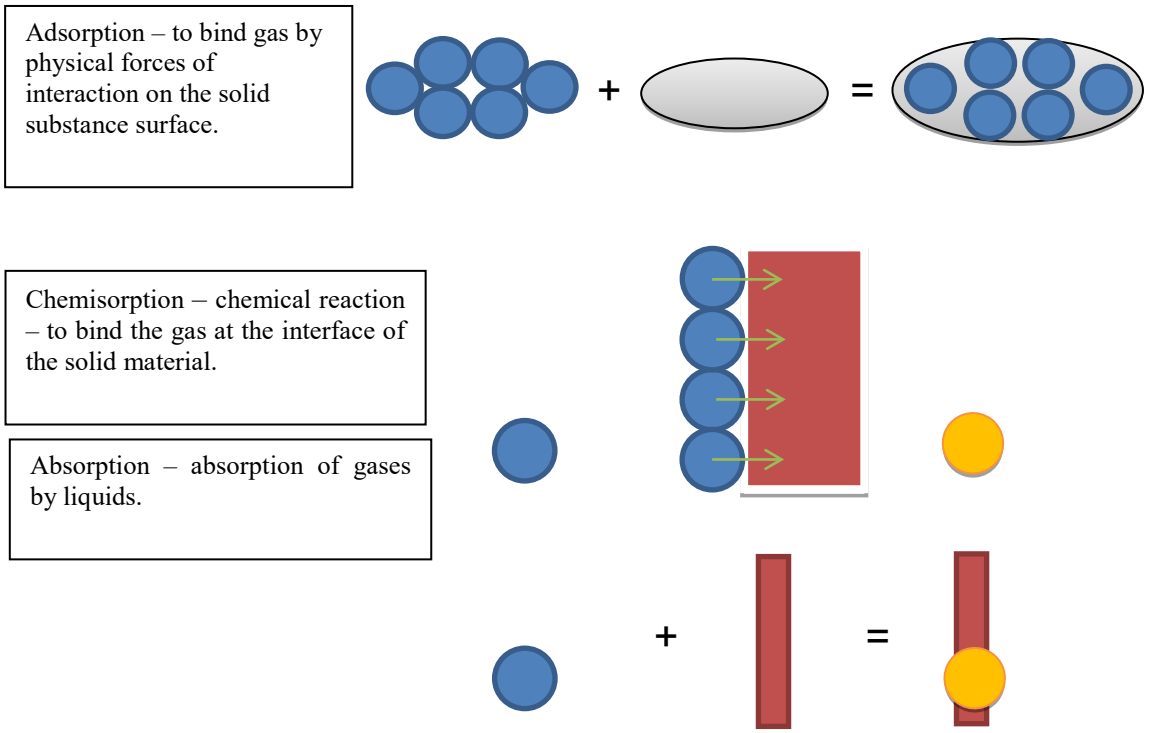

Figure 1. Methods of gas treatment.

In industrial enterprises gas treatment is broken up into 3 main groups by pollutant capturing method: Gas phase (dry) method, Liquid phase (wet) and Combined (wet-dry method).

2.1. International Practices

In actual practice most widespread are combined gas scrubbing units employing «dry» + «wet» or «dry» + «wet-dry» methods at different treatment stages. For the aluminum industry two stages of gas treatment in addition to industrial gas cleaning make possible to achieve savings on expendable materials, as after the 1st treatment stage expensive fluorine compounds are again delivered to the electrolysis process. The cell gases are, at that, successfully, cleaned from fluorine compounds and solids – dust particles - up to 99.9 %. The second treatment stage is to remove residual fluorine compounds and capture gaseous sulphurous (sulfur) anhydride followed by discharge of sulfate compounds to the settling ponds or by production of commercial gypsum.

4.1. Technology Performance Data of Evaporator

The evaporator was put into continuous operation in May 2017. Up to date all process procedures providing for its stable operation have been fine tuned. More than 50 tons of dry sodium sulfate has been produced. Basic performance data of the evaporator are presented in Table 3.

Table 3. Basic performance data of the evaporator.

Index	Units of measurement	Value
Productivity: - initial solution - evaporated water	 m^3/hour kg/h	 20 - 25 10 000 - 12 000
Heating team mass flow	kg/h	5000 - 6000
Heating steam pressure in the evaporator (absolute)	MPa	0.12 – 0.23
Heating steam temperature	°C	250 - 270
Input temperature at the evaporator	°C	100 - 101
Output temperature at the evaporator	°C	105 - 106
Evaporated solution density	kg/m^3	1260 - 1380
Volume consumption of cooling overslurry water	m^3/h	100 - 120
Rated output power of the pump	kW	150,5
Operation mode – continuous	Hours per day	24
Number of working days per year		300
Number of shifts per day		2

5. Conclusions

Removal of removing sodium sulfate accumulated in gas scrubbing solutions by evaporator was improved specifically: Dehydration is performed by centrifugation, ready product is dried in rack driers. The produced sodium sulfate contains 85 - 87 % of sodium sulfate, 8 – 10 % of sodium fluoride and some amount of soda and sodium bicarbonate.

As the demand for this product by main consumers – producers of cellulose, detergents, binding additive for production of copper, mud additives fluorine increases – the removal process has been developed and implemented.

As of today the scrubbing process is undergoing pilot tests. Pilot lot of 60 t of purified sodium sulfate is built up to conduct tests at Bratsk pulp-and-mill combine. After removal of fluorine the sodium sulfate will contain more than 95 - 97 % of primary product.

Thus, a serious ecological problem, associated with the necessity of building new settling ponds, has been solved, operation efficiency of gas scrubbing equipment has been increased, expenses to maintain it have been decreased.

6. Acknowledgement

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7. References

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