AL15 - Simulation Optimization and Industrial Test of Fume Ductwork on Aluminum Reduction Cell

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Abstract

In a 400 kA smelter, there are some problems of the fume ductwork on the cells, such as serious alumina accumulation in the fume collecting duct, and large difference of fume volume collected between the duct end and the tap end. Even the fume escaped from the pot hood, which leads to random emission of the fumes to the potroom. In this paper, the existing structure of the fume ductwork of the reduction cells is studied by the simulation. The effects of the key factors are studied, and the design of an appropriate structure of the fume ductwork is optimized. The simulation results are verified by the industrial test on reduction cells. Test results show that the optimized fume ductwork exhausts fumes balanced between the duct end and the tap end, avoiding the fume escape from the pot hood of the tap end, and reduces the dust accumulation in the duct and the consumption of aluminum fluoride per ton of aluminum.

Keywords: Simulation optimization, fume ductwork, aluminum reduction cells.

1. Introduction

In a 400 kA smelter, there were some problems of the fume ductwork on the cells, such as a serious alumina accumulation in the fume collecting duct (shown in Figure 3), and large difference of fume volume collected between the duct end and the tap end. Even the fume escaped from the pot hood, which leads to the unorganized emission of the fume. In order solve these problems, the structure of the fume ductwork was improved, but the effect is not obvious. The original fume ductwork is shown in Figure 1, the improved and existing fume ductwork are shown in picture 2. Therefore, we need to re-simulate and optimize the design of the fume ductwork to reduce alumina accumulation and to improve the effect of the collected fume.

2. Simulation and Optimization of the Design of the Fume Ductwork

2.1. Modeling

2.1.1. Physical Model

According to the physical structure of the original design and existing design of the fume ductwork in the smelter, two physical models are established according to the design drawings. The original design is shown in Figure 1. The original design of the duct is divided into upper and lower parts. From the center of a cell to the tap end, the fume is collected from the round holes of the same size through the upper part. From the center of the cell to the duct end, the fume is

collected from the round holes of the same size through the lower part. All round, holes are evenly distributed in the same height of duct. The fume collecting duct has a semicircular bottom.
Figure 2 shows the new design of fume collecting duct with improvements based on the original design. The outlet of the upper duct is closed, as shown in Figure 4. The partition between upper and lower parts is opened, and all the fume goes through lower duct. The round holes from the center of the cell to the duct end are changed to square holes, and six discharge holes are added at the bottom of the duct pipe.

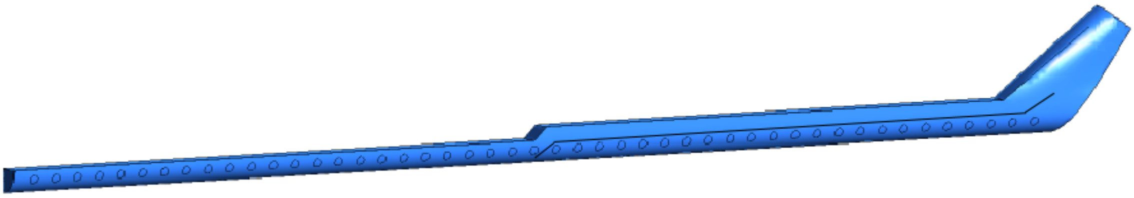

Figure 1. The original fume ductwork.

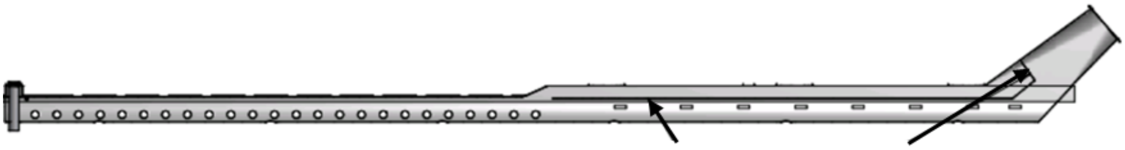

Figure 2. The new fume ductwork.

Figure 3. Accumulation of alumina in the duct.

Figure 4. The outlet of the upper duct is closed.

2.1.2. Governing Equations

As mentioned above, the dust accumulation in the duct is mainly caused by the insufficient discharge capability of the fume duct, which has few or no discharge holes or they are in unreasonable locations, and the difference in fume collection volume between tap end and duct end. The difference in fume collection volume between tap end and duct end is caused by the uneven fume collection between the two ends, and is not related to the temperature gradient. Therefore, the influence of temperature gradient is not considered in the simplified modeling, and the Fume Phase Turbulence Model is used in the simulation. The continuity and momentum governing equations are shown below.

Mass Conservation Equation
The equation for conservation of mass, or continuity equation, can be written as follows:

3.3. Comparison of Fluoride Consumption

Since September 2017, the fluoride consumption of each cell has been statistically compared. The consumption of fluorine salt per ton of aluminum decreased by 2.4 kg as shown in Table 6. It also shows that the amount of alumina powder taken away is also reduced, and it can be seen that the alumina powder is constantly flowing from the discharge holes.

Table 7. Comparison of fluoride consumption.

Fluoride consumption	**Sept. 2017 – March 2018**	**April 2018 – October 2018**	**Sept. 2017 – October 2018**
49 original cells（kg/t Al）	23.4	26.8	25.1
61 test cells（kg/t Al）	20.9	24.6	22.7
Difference（kg/t Al）	2.5	2.2	2.4

4. Conclusions

Through the simulation and optimization research on the fume collecting duct of aluminium reduction cells, the industrial test verification and application on more than 100 electrolytic cells, the simulation data, operation test data and user experience, all show that the positive effect of the duct modification is remarkable. Balanced fume collection of the cell is achieved, the seriously uneven exhaust fume collection between tap end and duct end of the original design is improved, the random emissions into the potroom are reduced and the environmental pollution is reduced. Equally, the alumina accumulation in the duct is reduced to ensure the fume collection efficiency in continuously during cell operation. The fume resistance of the duct is reduced and the fan energy consumption is reduced. The consumption of aluminum fluoride per ton of aluminum is also reduced by 2.4 kg.