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TREATMENT OF GAS EMISSIONS IN POTROOMS

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Abstract

Today, pot gas emissions are well treated by modern Gas Treatment Centers (GTC), with efficiency rates close to 99.8%.
However, stack emissions only represent a very small amount of the total HF emitted by smelters. Indeed, HF is mostly originated from potrooms where in most smelters no specific treatment is provided to limit pollutants.
This paper presents several solutions from Fives to eliminate two of the main sources of HF emissions in potrooms:

- Emissions from opened pots. The normal draft cannot maintain a negative pressure in pots, which results in fumes emission. Fives developed boosted suction systems installed in the latest smelters.
- Emissions from butts stored in potrooms, before being transferred to the rodding shop. Fives developed a solution to confine butts, until being treated at the rodding shop.

A test campaign has been performed in the ALRO smelter in Slatina, Romania. Presented are the achieved HF reductions and a CAPEX and OPEX case study.

Introduction

Today, modern GTCs emit around 0.04 kg of hydrogen fluoride per ton of aluminum (kg_{HF}/t_{AL}) at stack outlet. For smelters without boosted suction capability it is commonly observed that 0.4 to 0.5 kg_{HF}/t_{AL} is emitted through the roof of potroom buildings. This depends on operating practices and conditions of electrolysis pots hood sealing and gas collection efficiencies. Most of these emissions occur during operation on pots, especially during anode changes when some pot hoods are removed, and when spent anodes and spent bath material are stored next to the pots inside the potroom.

Fives Solios? has developed several patented systems to reduce these roof emissions that are up to 10 times higher than stack emissions.

Lowering pots emissions during hoods opening

It has been proven [1] that by doubling pot extraction flow rate during these relatively short periods (about 3% of overall time), roof emissions can drop down to 0.25 - 0.35 kg_{HF}/t_{AL}. This represents a 30% to 40% improvement.

Two patented and industrialized systems have been designed by Fives to reduce fluoride fugitive emissions [2].

<u>Yprios, the optimum solution for the lowest potroom emissions</u>

A graphic representation of this dual duct pot suction system is displayed in Figure 1. An air-operated and patented [3] diverter valve is provided at each pot outlet to direct the flow either to the main pot collector duct that conveys gases to GTCs or to a constant-diameter duct located alongside the potroom building, next to the main duct. The extra energy required to handle the additional pot pressure drop when extraction flow is doubled is provided by centrifugal booster fans, which connect the forced flow duct to the main duct at the GTC inlet.

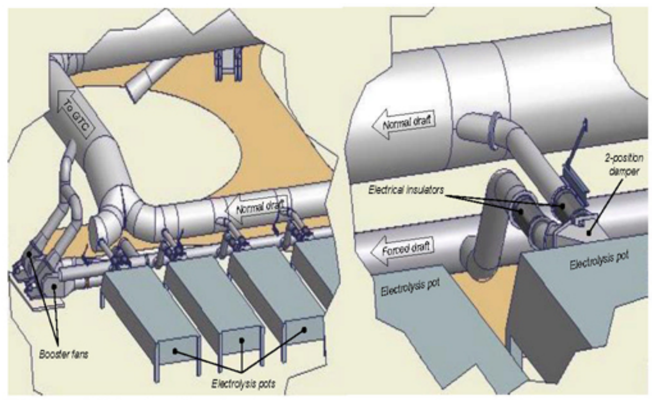

Figure 1. Yprios Dual suction system

The Yprios technology has been adopted and implemented by the largest primary aluminum producers, such as Alba (Line 5, Bahrain), Alcoa Fjarðaál (Iceland), Qatalum (Qatar) and most recently by Rusal in Taishet and Boguchany (Russia), and by Ma'aden Aluminium in Ras Az Zawr (Saudi Arabia).

It remains the most powerful boosted suction system available as it is suitable to any customer requirement and the boosted flow does not interfere with the normal draft duct.

<u>S-Yprios, the cost-effective solution for lower potroom emissions</u>

In this dual position butterfly valve system, an air-operated butterfly valve is installed at each pot outlet to create or remove a pressure drop between the pot and the main pot collector. Under normal suction the large disc obstructs the pot outlet duct in order to create a pressure drop which, when removed by switching the valve, leads to a boosted flow rate (Figure 2). The novelty of this system consists in the dual position and the disc sizing that controls pots flow balancing for normal and boosted suction. This device replaces orifice plates and provides the desired boosted suction flow rate for all pots.

The S-Yprios technology has been patented [4] by Fives and supplied to Balco, India (Figure 3).

This solution is cost-effective and can be easily implemented and maintained. It is suitable for a flow rate increase up to 160% on boosted suction mode as it has low CAPEX and the OPEX depends on the exhaust fans consumption (from the created pressure drop).

It appears to be the optimal solution for brownfields and for plants that generally only need a slight flow rate increase in boosted suction mode.

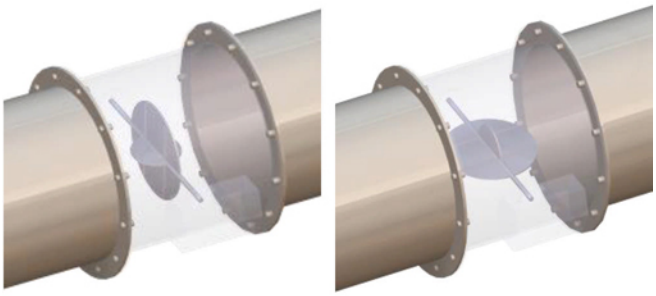

Figure 2. Valve at normal flow (left), at boosted flow (right)

Figure 3. S-Yprios

Treatment of emissions resulting from spent anode butts

HF is emitted by the reaction of the hot spent butt and the attached layer of hot bath crust when exposed to the humidity contained in the ambient air. A simple method to stop these emissions is to isolate the anode butt from ambient air.
In theory this is simple but the practical implementation is rather complex.Several systems have been developed and tested in various places.
One system, used by Alcoa in its Deschambault and Fjarðaál smelters [5] consists in placing the hot spent anodes into trays equipped with covers. This system is quite efficient in terms of HF limitation as long as the sealing around the anode rod is maintained. But this design requires significant maintenance costs as the seals are to be replaced on a regular basis; a consumption of 13 tons of seals per year has been reported.
Another system consists of placing the hot anode butts in confined rooms and to treat the gases emitted in the GTC. Again, this system is effective assuming the transfer of the spent butts is performed very quickly. However, it requires additional scrubbing capacity as well as an important storage hall and ductwork. Also, in most cases the transfer is not as quick.
Both systems described above are designed to keep the anode butts confined until their temperature lowers between 300 and 450°C [5]. This cool down lasts more or less three hours, and thus requires large storage capacities, and a huge trays inventory.
Another system developed by RTA [6] consisted in placing the spent anodes in trays and covering them with alumina: a relatively complex solution as the alumina distribution system is built in the walls.
The alumina is fed by gravity inside the tray, where it takes five minutes to cover the anode butt. In this configuration, alumina geysers have been observed due to its fluidizable property. After the anode butt has been transferred to the rodding shop, the alumina must be entirely evacuated before another spent butt can be loaded. The operation process is relatively long and requires handling important quantities of alumina.

Introduction to the Anode Inert Tray (AIT)

Taking the above described experiences into consideration, Fives has been striving to develop a system that isolates spent anode butts as fast as possible with handling operations reduced to the bare minimum. This system has to be easy to use, with a low CAPEX and virtually no maintenance cost.
The solution selected consists of sinking the hot spent anodes into a close fit fluidized alumina container as shown on Figure 4. As soon as it is submerged, fluidization is stopped. The butt is buried into alumina, thus totally isolated from ambient air. This process only takes a few seconds thereby minimizing emissions during handling.
In this configuration, trays do not require any lid, seal or moving part as alumina ensures tightness around the butt. It only requires a fluidization connection in the vicinity of the pots.

Figure 4. AIT prototype receiving spent anode in Alro

Test campaign in Alro smelter

In order to estimate the efficiency of this system, Fives has been working with Alro to measure the gaseous HF contribution of a spent anode in the potroom with or without the AIT. All HF concentration measurements have been performed in mg_{HF}/Nm^3 using a laser HF analyzer.
First, measurements have been performed on spent anodes in the potroom where they are usually cooled down before treatment in the rodding shop. The most typical measurement is shown on the Figure 5 below.

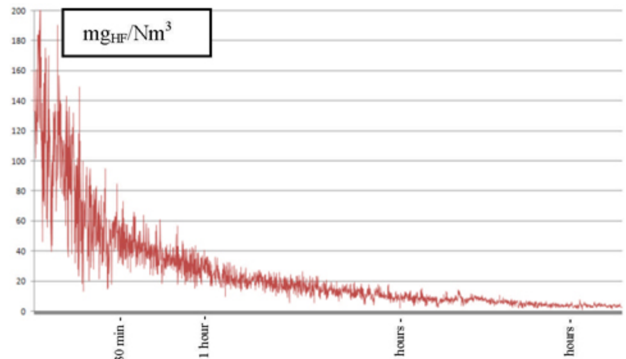

Figure 5. Evolution of HF concentration above a spent anode without AIT

Only less than 2 minutes separate the removal of the anode from the pots and the start of the measurement.
To estimate the quantity of gaseous HF emitted by a spent anode, the vertical velocity and flow rate of gas due to convection have been measured. As a result, the total contribution of spent anodes in a potroom at Alro smelter is estimated at 0.24 kg_{HF}/t_{AL}.
Afterwards, measurements have been performed on spent anodes buried in the alumina as shown on Figure 6. Wood boards have been placed around the box to avoid the wind above the box which could hinder the quality of the acquisition.

Figure 6. HF measurement on spent anode buried in alumina

Results are shown on Figure 7. The slight amount of emissions measured (between 0 and 6 mg_{HF}/Nm^3) during the first two hours was due to operations on pots next to the test; the spent anode contribution was under the detection limit. The AIT efficiency is then total.

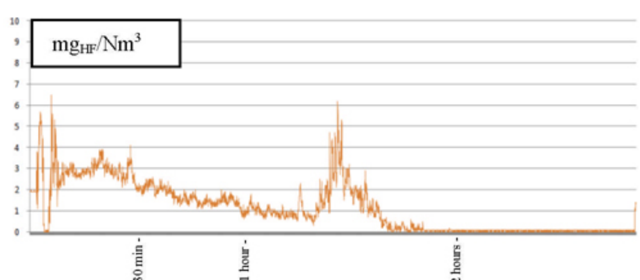

Figure 7. Evolution of HF concentration above a spent anode inside AIT

When the spent anode has been introduced in the AIT, a little bit of alumina was ejected vertically in little geysers (< 30cm height). These geysers stopped a few seconds after fluidization shutdown. This phenomenon depends on the quality of the fluidization and can be considerably reduced using an appropriate fabric and AIT design.
Finally, a 24-hour measurement has been achieved in the roofing of one quarter of potroom in a period which included an average amount of normal operations on pot (bath crushing, anode removing, tapping) that is found to be representative of global potroom emissions. The air flow rate going through the area has also been measured leading to an estimation of the total HF emission from the potrooms at 0.45 $kg_{HF}/t_{AL.}$
Considering the value provided earlier (cooling of spent anodes: 0.24 kg_{HF}/t_{AL}), the contribution of the anodes butts cooling in the potroom reaches about 50% of total HF emissions from electrolytic halls. As the AIT efficiency is virtually 100%, the HF abatement in the Alro plant equipped with an adequate number of AITs would be 50%.

The AIT process

Three trays with a total capacity of six anodes can be installed on a trailer. When the trays are loaded with hot spent anodes the trailer can bring them to the rodding shop.
The unloading is easily performed by re-fluidizing the alumina during a few seconds. Anode butts can then be processed at the rodding shop, where emissions of HF are taken to the GTC.
The AIT can then go back to the potroom, after having been loaded with new anodes placed on the non-fluidized alumina bed.
The use of trailers is therefore optimized, limiting the number of trays needed for the smelter.

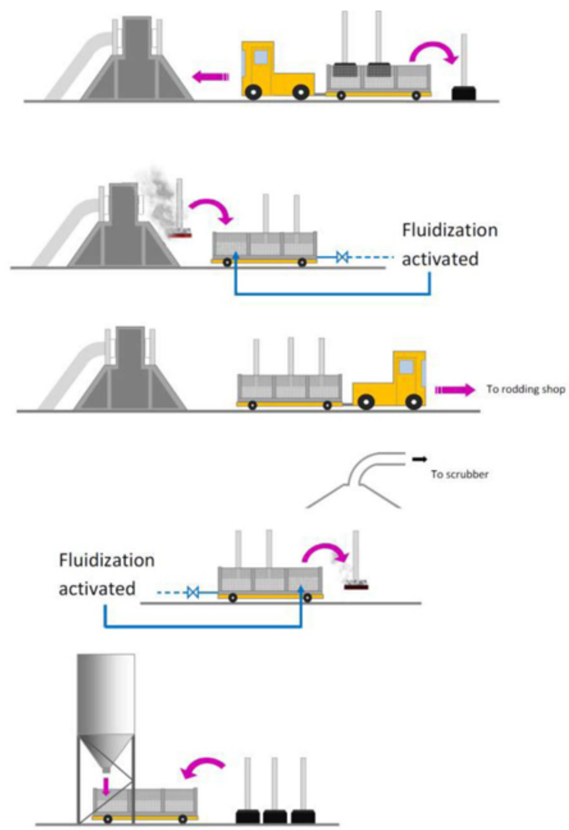

Figure 8. Sequence of loading & unloading of spent anodes

The alumina is kept in the trays and can be re-used. A partial refill might be necessary from time to time. The cleaning can also be performed without emptying the alumina, thanks to a movable grid located at the bottom of each tray, above the fluidizing media. By simply lifting this grid, fluidized alumina can be screened in order to recover the coarse grains of bath crust and carbon. The grid is then emptied on a dust bin and placed back at the bottom of the tray. Eventually, alumina can be easily replaced as each tray may be emptied by gravity after the alumina is fluidized.

Considering that one anode per pot is changed daily, with three AIT transfers per day, a smelter with 200 pots would require only 12 trailers, each equipped to carry six anodes. With a few spare units, 15 to 20 trailers would be enough for this type of smelter. Compressed air used for alumina fluidization can be taken from the plant air system via quick couplings.

The estimated cost for such solution is around 2 M USD, i.e. less than 1 M USD per 0.1 kg_{HF}/t_{AL} reduced

Conclusion

The reduction of fluorinated gases produced by smelters must remain a prime preoccupation.

Tremendous efforts have been done to improve the efficiency of Gas Treatment Centers and today, only minor improvements can still be expected on this technology with regards to the level of HF emissions.

Today, about 90% of HF emitted by a smelter is localized in the potrooms. Therefore, there is much room for improvement in this area.

Technologies dedicated to addressing emissions during pot openings such as dual suction systems are becoming more and more widespread and are now regularly implemented in modern smelters.

Now, the treatment of hot spent anode butts that are often left untreated in most smelters offers here again an opportunity to tackle at potroom emissions. The Anode Inert Tray (AIT) offers a cost-effective and easy-to-use solution to address this matter. It can be implemented in most existing smelters without difficulty and the size and number of trailers can be easily customized to the need of every smelter. In this context, the AIT system will offer an immediate significant reduction of the smelter's fugitive emissions.

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