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MOBILE MONITORING SYSTEM FOR POTROOM ROOF HF EMISSIONS

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Abstract

Presented is a solution of advanced measurement equipment for fugitive emissions through roof vents. Developed is an innovative mobile roof monitoring system that is tested for two years in several potrooms and presents many opportunities in terms of technical advancement as well as operation improvement. The system comprises of a climate controlled shuttle that is mounted on a rail track. It fundamentally complies with government rules for HF emissions and complies with both Alcan method 3010-09 and US EPA method 14/14A. The system eliminates safety risks associated with a hot and contaminated atmosphere and with the extreme working height. It has absolutely no co-activity with the process and costs less than a catwalk. The complete rail system and climate controlled shuttle are easy to maintain. The advanced features are: a multi-axis air speed profiling with real time recording (useful for sampling point selection that can be modified considering either seasonal change for collection efficiency or changes in regulations , and used even for building design validation), isokinetic sampling, concentration profiling and integrated reporting with active diagnostic. The platform is adaptable to integration of other pollutants such as SO_2, PM2.5 or others, for multiple sensors and with on-board IR instruments.

Introduction

By law, many countries are demanding that fluoride emissions from aluminum smelters are monitored. Several national methods have been documented like the US EPA 14/14A [1] and some companies even have developed their own methods (for example, the Alcan method 3010-09) that are accepted by the authorities.

Through the years two main technologies have been implemented to monitor HF emissions at the potroom roofline: a direct measure, usually done by laser and a sampling method of the potroom air using cassettes.

The laser-type instrument is used to measure fluorides present in the atmosphere above the cells in order to detect any potential malfunction and monitor working practices. However, while the law in many cases requires the measure of the total fluoride content, lasers only evaluate the gaseous fluoride. They are not suited for the particulate phase of fluoride. The ratio of gaseous to particulate fluoride is roughly 1.5 to 2.5 [2], meaning that a substantial part of the total fluoride content is then missing from the data. Lasers also need frequent calibrations [3] and are prone to errors in the measurement as a result of misalignment. That is why to Total Fluorides sampling is usually the best approach to meet the regulations.

However, up to now, this sampling has been performed using equipment placed in a fixed location near the roofline and accessible only through a catwalk built especially for that purpose. It often requires that an employee climbs up and down each time it is necessary to collect the sample, a situation that present health and safety issues.

Figure 1: Example of a catwalk under the roofline

The laser and the sampling technology also both require a measure of the air speed, usually done with an anemometer. This equipment also has to be located near the roofline and accessed each time it needs to be calibrated.

The concentrations estimated by the sampling equipment is then multiplied by the mean air speed to obtain the mean quantity of HF that went through the events of the roof during a specific period of time at this fixed location in the potroom.

The sampling period depends on the analytic method that is used. For example, US EPA 14A asks for three periods of 24 hours each month following a predetermined calendar issued by the local authorities. The Alcan method, for its part, requests a continuous sampling for 15 days in a row. The precise location for the fixed sampling equipment is usually listed in the technology provider instructions. RTA for example, for its AP technology, requires a specific ratio of sampler per cell.

Overcoming fixed HF sampling limitations

Because all the equipment (sampler and anemometer) is in a fixed location, it does not necessarily provide exactly the representative value of the fluoride emissions in the entire potroom. The sample, at any given time, is only an estimate of the quantity of total HF that has been emitted to the roof events and this evaluation can be over or under valued.

To address this problem, a new device called SHERPA (SHuttle for Environmental Roof vent Polluants Analysis) has been designed, whereby the sampler and the anemometer is combined in a box that is mobile along a rail going from the floor to the roof (see Figure 2). It is operated from the work floor which eliminates the need to construct a very costly dedicated catwalk and eliminates a number of safety issues related to reaching the sampling equipment, as the employees no longer have to work directly above the cells.

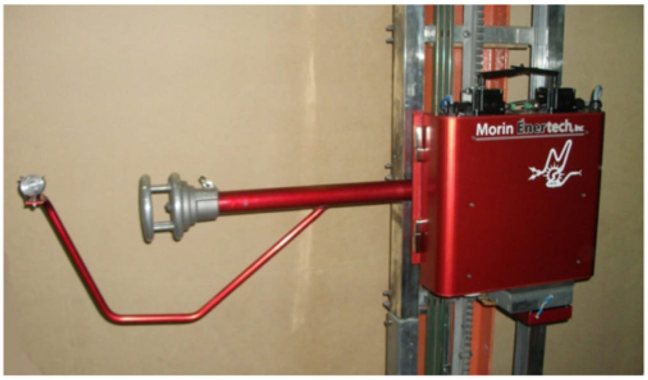

Figure 2: The mobile SHERPA box on its rail

Since the rail track covers the entire width and height of the potroom it can be placed at various locations along its full path. It thereby allows for a more precise estimate of the average values for flow and concentrations. A typical greenfield smelter can be entirely covered by about 30 SHERPA units. Each unit is interchangeable.

Figures 3 and 4 illustrate the type of rail that is used and a scheme of the position of the rails in a potroom section. It shows how the mobile sampling unit is guided along 30 meters on an industrial rail.

Figure 3: The mobile SHERPA box on the rail covering the width and the height of a potroom

The shuttle unit comprises of three main components: a control and transfer data centre (900 MHz), a rigid enclosure that provides for the right protection in the presence of dust and magnetic fields, and finally the rails and guides with the necessary electrical connections. In addition, probes are mounted to the shuttle box to provide for localized measurements wherever the shuttle box is placed.
Implemented units give data on air velocity, temperature and pressure, total fluorides content and the intensity of the emissions when correlated with the aluminum production as required by regulations. This enable this new technology to meet and even exceed the criteria of reference methods such as US EPA 14/14A.

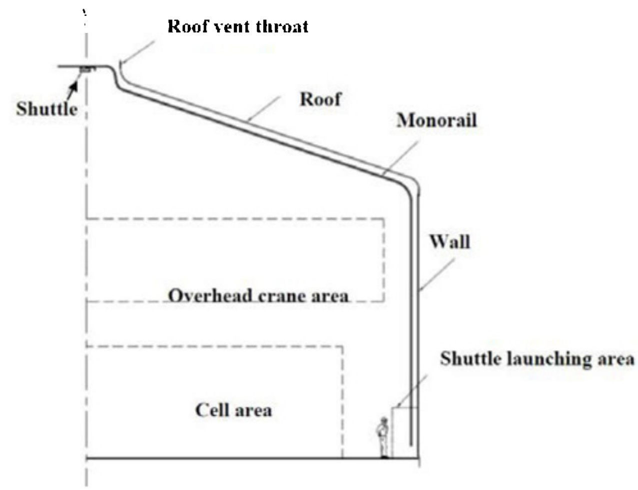

Figure 4: View of the mobile sampling installation in a potroom section

Operating the new technology

The shuttle, comprising of the anemometer with the temperature sensor, the radio transmitters, the sample pump with its flow control module and the sampling cassette, move on request both ways from the ground floor to the events and back while staying clear of the working zone at any given time.

Data is collected from the ambient air in the plant and the shuttle is activated by the operator using a control pad situated near the base of the rail.

It is possible to program the shuttle to lead it to a predetermined position; however, an important innovation is the introduction of a scanning mode. This feature can be used to obtain a velocity profile of the air flow or a concentration profile from the on board instruments. Normally the point of measurement is fixed but over time conditions change and the representative air velocity shifts. If this mode is used on a regular basis then the measurments are generally taken in the most representative location. This feature is an important improvement in the accuracy of these kind of measurements.

The shuttle contains all the instruments and electronics. Because it is located in the most difficult conditions in the potroom it has an on-board climate control unit that ensures that the inner parts are working at more acceptable temperatures.

The choice of aluminum and stainless steel for the construction of all the exposed elements of the shuttle ensures a safe operation and a long period without need for major maintenance.

Applications

This innovative design combined with a well-known technology for sampling fluorides opens the doors to a series of new applications. Three applications will be examined here: a greenfield (new smelter plant), a brownfield (existing aluminum plant) and the use as a research and development tool.

Greenfield application

Two major topics are to consider when facing the choice of a sampling technology for a greenfield smelter: the health and safety factors and the construction and operation costs.

Health and safety

With the traditional sampling technology, a catwalk was always required to give access to the filter cassettes. When the employees used this path to collect the results, they were exposed to the contaminants and heat generated by the cells under their feet.

The new mobile shuttle completely eliminates safety risks as it is simple to install and can be controlled entirely from the working floor.

For example, it has been built to be resistant to high temperatures (40 to 85°C) and to any obstruction by the dust present in the ambient air that can form deposits on the rails. If ever a loss in communication occurs, an additional electric line is available to return the shuttle to the floor to insure a safe and practical operation.

Maintenance is normally an issue with the traditional system: if not maintained in top shape then there is always a risk that the combined exposure to gases, heat, abrasive dust as well as the contamination of sliding surfaces could lead to the breakage of some pieces of the catwalk as somebody stands on it or under it.

Some traditional systems have been designed to pull out the filter cassettes from the catwalk by pushing them midair with the help of a pole with a motorized winch and a cable. This kind of cable proves to be very difficult to inspect through its service life, and is prone to break at any given time.

The new mobile shuttle technology offers no interference or co-activity with the smelter production. It translates in a reduction of the health and safety risks related to this hot working environment characterized by the presence of fine particles and gases released from electrolysis cells.

It also greatly reduces the risks associated with work at a height or co-activity for the main users or those working around on the premises.

Construction costs

In the past, catwalks had to be constructed to perform two main functions: to feed alumina to scrubbers (a feature that is no longer required in most plants) and to install and maintain the sampling equipment while collecting the samples.

The innovation introduced here with the SHERPA eliminates the need to build a catwalk (walkway and safeguard) in each potroom thereby saving potentially 1 to 3 million dollar in capital costs. That figure does not include all the other expenses for the installation of sampling tubes or electrical conducts to feed equipment and transmit data.

The rail can be adapted to any type of configuration either for the building or the roof and by-pass any obstacle.

Further savings can be achieved regarding the time dedicated to the collect and replacement of the filter cassettes. The new technology enables the personnel to perform the equivalent of their actual fluoride sampling tasks in 50% less time as there is no need to obtain a work authorization, to delineate a working area, access the equipment, etc.

The same can be said for the maintenance of the equipment, which is done at a minimal cost: this compact unit does not require that the critical instruments in it should be dismantled each time they need to be calibrated. This can be restricted only to the time when major maintenance is needed.

If environmental standards should change eventually and require new instruments, it will be easy to modify the interior of the mobile shuttle without any major investment other than for the new type of instruments.

Morin Enertech is providing several units of the SHERPA technology to Rio Tinto Alcan for the new Kitimat smelter in British Columbia.

Figure 5: The mobile shuttle can take different positions along the rail.

Brownfield application

Two scenarios need a special mention when a brownfield project is concerned.

First, the case where more sampling points have to be added to an existing potroom. The new mobile shuttle concept allows that at a minimum cost.

Second, the case of a major retrofit project, where the HF profile in the potroom happens to be completely modified. In this situation, the fixed locations chosen previously to sample representative HF points are no longer relevant.

In any case, all the considerations already mentioned for the greenfield projects in terms of savings on construction costs (catwalk, conducts, etc.), on workforce costs (time reduced by half for sampling, no work authorization necessary, etc.) and maintenance costs (easy changes and calibration) are still pertinent.

Examples of Brownfield projects are found in Alcoa's Baie-Comeau and Alma smelters.

Research and development

Monitoring emission is a key component of assessing pollution prevention performance for the smelters.

As mentioned in the technical literature, emissions from aluminum reduction processes are primarily gaseous hydrogen fluoride and particulate fluorides, alumina, carbon monoxide (CO), carbon dioxide (CO_2), volatile organics, and sulfur dioxide (SO_2) from the reduction cells. The source of fluoride emissions from reduction cells is the fluoride electrolyte, which contains cryolite, aluminum fluoride (AlF_3), and fluorospar (CaF_2). [4, 5]

The fact that the new technology presented in this paper introduces the mobility of the sampling point, opens the door to a whole new world of experimentation from the R&D point of view.

With a mobile equipment, sampling of different pollutants are easy to perform with minor changes in the shuttle box: fluorides can be evaluated as well as sulfur dioxide (SO_2) or fine particulate matter (PM 2.5) for example.

Profiles can be determined for air speed or temperature. Ventilation patterns can be established and data compared with simulation to ensure optimum working conditions on the ground as well as minimal emissions at the roof events [6, 7].

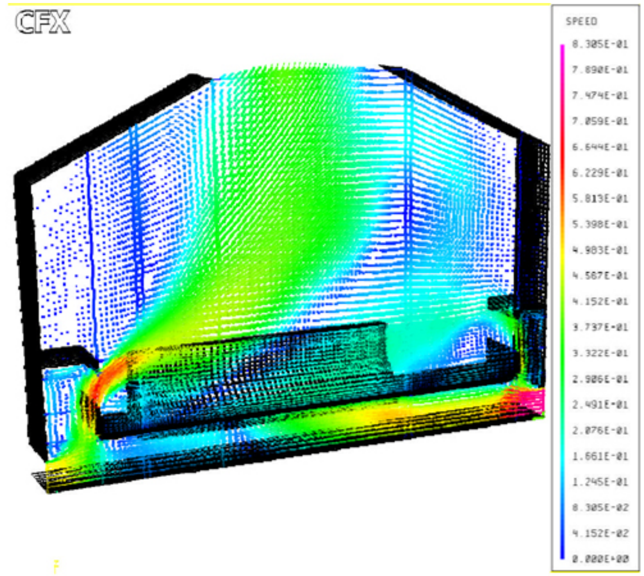

Figure 6: Example of the simulation of the air flow in a potroom [6]

Zones can be predefined in the potroom and analyses of the pollutants performed for each of them.

Shuttles can also provide easy access to locations difficult to reach.

In any case, more sampling points will always translate into less uncertainties on the data [8].

Conclusions

The SHERPA technology developed by Morin Enertech is an innovative solution to improve the sampling of total HF emissions at various locations along the width, height and length of a potroom. It can be used in greenfields, brownfields or as a R&D tool. It can be considered a step change in accuracy of these kind of measurements.

It eliminates the need to build a catwalk (walkway and safeguard) in each potroom of a Greenfield smelter thereby potentiall saving $1-$3 million in capital costs.

More savings can be achieved regarding the time dedicated to the collect and replacement of the filter cassettes. The new technology enables the personnel to perform the equivalent of their actual fluoride sampling tasks in 50% less time.

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