DIMENTIONING OF ATMOSPHERIC EMISSIONS CONTROL SYSTEM

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1. INTRODUCTION

One of the industry's main challenges is control fugitive emissions. Those can be defined as emissions that are not released by stacks, ducts or vents. Fugitive emissions generation is intrinsic to the processes of steel plants and can be understood as a sequence of events, starting with feedstock preparation, transport and final product until its storage. Sinter plants and coal yard, for example, are areas that requires attention.

There are a few alternatives that might be used to mitigate dust emissions in steel plants different areas. One of the most recent technology that is calling attention are the fog canyons. Those can spread a fine mist of water on the interest source, increasing the particles density and consequently its sedimentation on the ground.

This mechanism is called wet deposition and it acts similar to rain, whereby particulate matter mix with water and wash out through atmosphere, minimizing pollutant dispersion.

This study's main objectives were determinate control systems (fog canyons) efficiency and criteria of its position in order to optimize the particulate matter control in critical areas of a steel plant.

2. MATERIALS AND METHODOLOGY

The analysis of atmospheric emissions requires a reasonable knowledge of micro-scale meteorological conditions that occurs on the influence area of the emission sources. The figure below shows the wind rose for the period of 2016-2020 at Timoteo Station (A511) – INMET.

Therefore, the region's wind roses showed north to northeast wind predominance and large presence of winds in the first quadrant (north-east). On the other hand, the winds of lower speeds pointed to the third quadrant (south-west).

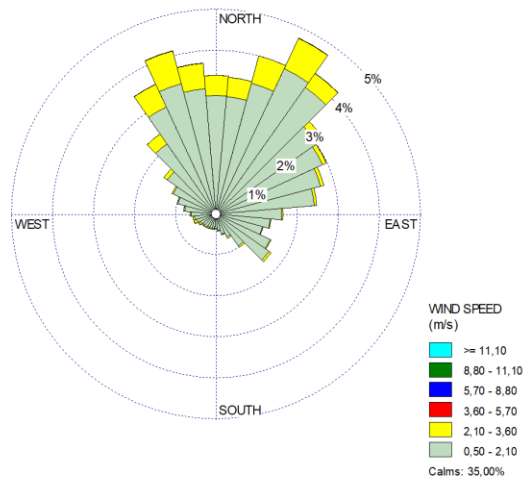

Fig. 1. Wind Roses for the period 2016-2020 in Timoteo Station - A511 – INMET

In order to characterize the seasonality of the wind behavior, Figure 2 shows the monthly wind roses of A511 station for the period of 2016-2021. When analyzed, is possible to observe that from July to January the winds come mainly from the first quadrant (north-east) and forth quadrant (west-north). From February to June is observed an increase in the frequency of the wind coming from the second quadrant (east-south).

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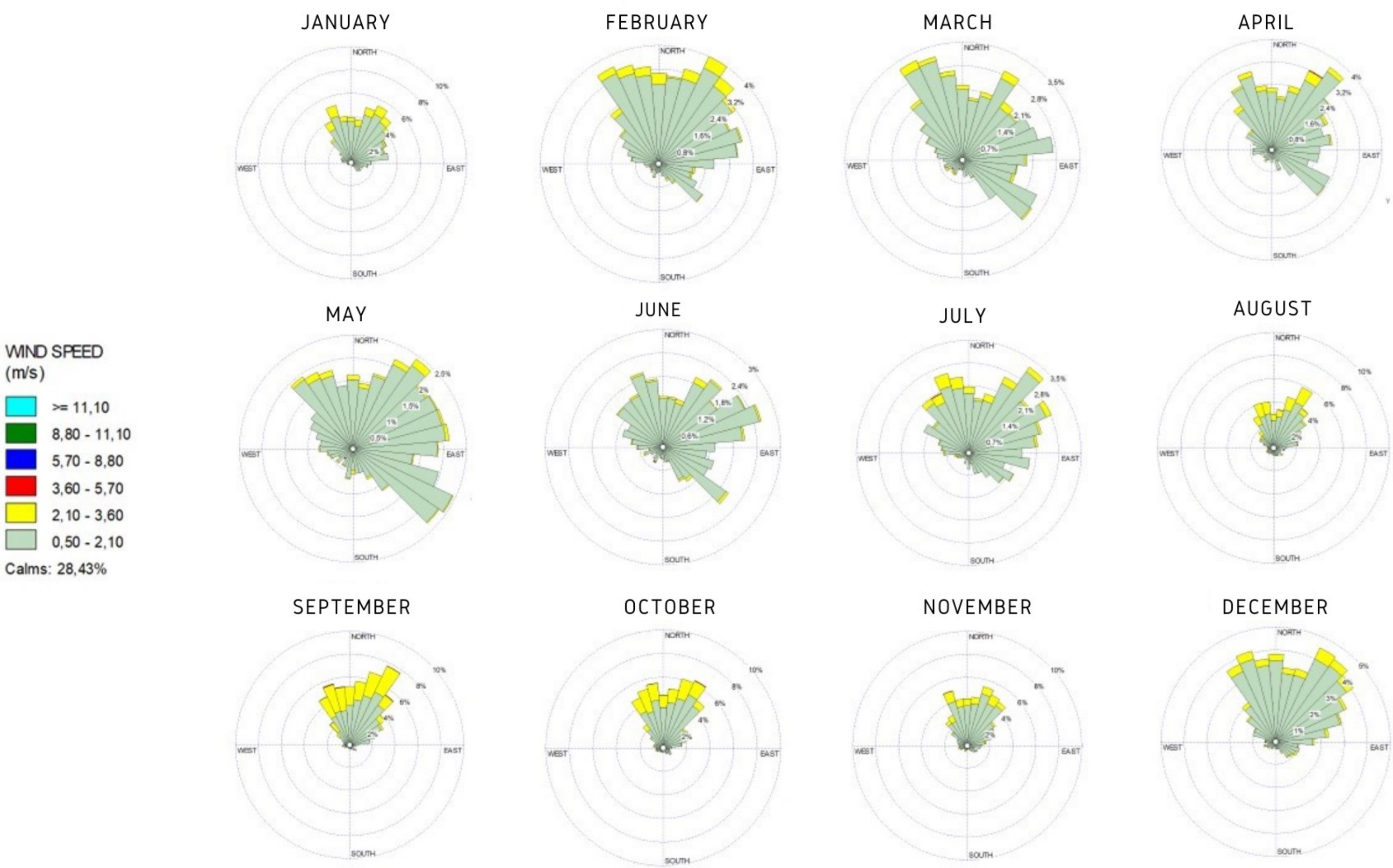

Fig. 2. Monthly Wind roses for the period of 2016-2020 from A511 Tiomótio Station,– INMET

The present study focused on monitoring particulate matter of a steel mill through the installation of two profilers.

Thus, the profilers were installed upstream and downstream of each evaluated source, considering two scenarios: one with the fog cannons application and other without any emission control equipment.

The methodology applied in the study was OTM 32 (US EPA) - Exposure Profiling Method. This method was published by US National Environmental Protection Agency (USEPA), is widely applied and one of the best methods to monitor fugitive emissions. This method was developed to measure open source emissions by plume profile.

The emission plume performs as a Gaussian model. Hence, this method quantifies particulate matter from open sources and it's based in the exposure profiling concept, with exposure defined as the time-integrated pollutants mass flux at a sampling point. The mass flux is the product of pollutant concentration and wind speed, which gives the pollutant mass at the sampling point per unit cross-section of the plume per unit time. The total emissions from the source during the sampling period is found by spatial integration of the exposure over the plume's cross-section, in the same manner as performed in standard emission testing of ducted sources based on the principle of mass conservation (USEPA 2013).

To consolidate the model, two vertical towers were placed downwind the source, in a sampling plane perpendicular oriented to the sampling time wind direction average, as shown in Figure 3.

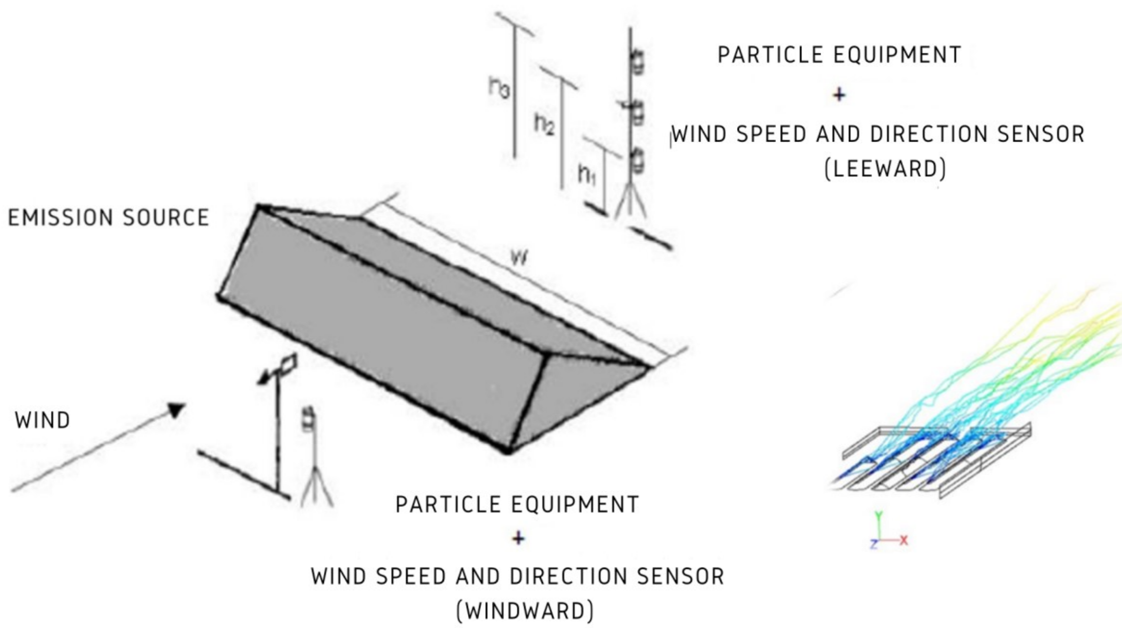

Fig. 3. Open source measurement scheme - Exposure profile method.

The particle emission rate was obtained by the spatial integration of the distributed exposure measurements (accumulated mass flow), which is mass concentration and wind speed product, according to the Equation 1 below:

$$R = \int_A C(h, w)\, u(h.w)\, dh\, dw$$

Where:
R = emission rate, µg/s
C = net particle concentration, µg/m^3
u = wind speed, m/s
h = vertical distance coordinate, m
w = lateral distance coordinate, m
A = effective cross-sectional area of the plume, m^2

Positioning the samplers across a vertical measurement plane downwind of the source requires plume's length preliminary knowledge. The equipment's positioning goal is to capture at least 80% of particulate material plume mass flux in the wind direction and remove the contribution of external sources. If there are any obstructions between the upwind sampling location and the downwind location, the accuracy of the measurements is decreased.

For the monitoring it was used the continuous particle and gas measurement equipment, GM-5000 of *Thermo Fisher Scientific*.

GM-5000 is a true compact air pollutant automatic monitoring station designed to provide different pollutants continuous measurements, including gases and particles.

In this study, the equipment was installed at three different heights and configured to measure particulate matter (TPM, PM_{10} and $PM_{2.5}$ fractions), according to Figure 4, in order to obtain the pollutant plume profile.

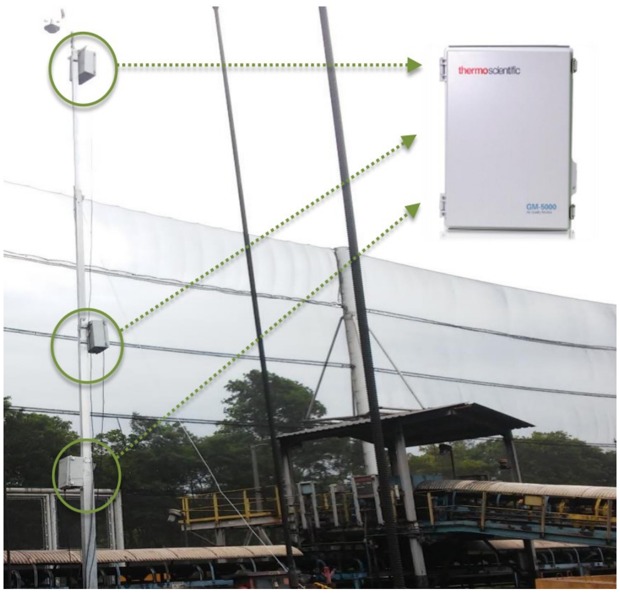

Fig. 4. GM-5000 installation in three different heights.

Particulate measurements are taken through an OPC (optical particle counter). The equipment samples the air through a heated vertical inlet tube, which allows gaseous pollutants and particulate matter smaller than 40 microns aerodynamic diameter to enter the analyzer, excluding larger debris and water droplets. The sampled air stream then enters a laser based Optical Particle Counter (OPC) that detects both number of particles and its size distribution.

GM-5000 has an optical particle counter that detects the particles and its work principle is based on a laser incidence on the passing sample. The particles on the sample reflects the light received, which is measured by a highly sensitive optical sensor. Light scattering depends on particle diameter and shape. The signal generated by the light detector is sent to a microprocessor which interprets and calculates the amount and distribution of particles and its diameter contained in the air sample. Then, the air with suspended particles passes through a vacuum pump being again expelled, as shown in Figure 5.

3. RESULTS AND DISCUSSIONS

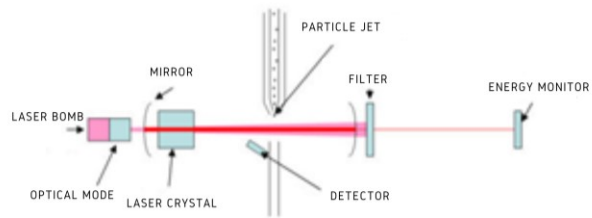

Fig. 5. OPC (Optical Particle Counter) Scheme.

The concentrations were analyzed along with wind direction and speed data. To apply conservation mass and obtain particles liquid concentrations, its necessary to filter the data based on wind direction which is favorable to the positioning of the equipment. Such methodology aims to isolate the emission source contribution at pollutant's downwind (background).

Figure 6 shows the performed monitoring.

Fig. 6. Fog's cannons in the mining field.

Figure 7 shows the pollutants average concentrations between the different heights monitored with and without the fog cannons control equipment application.

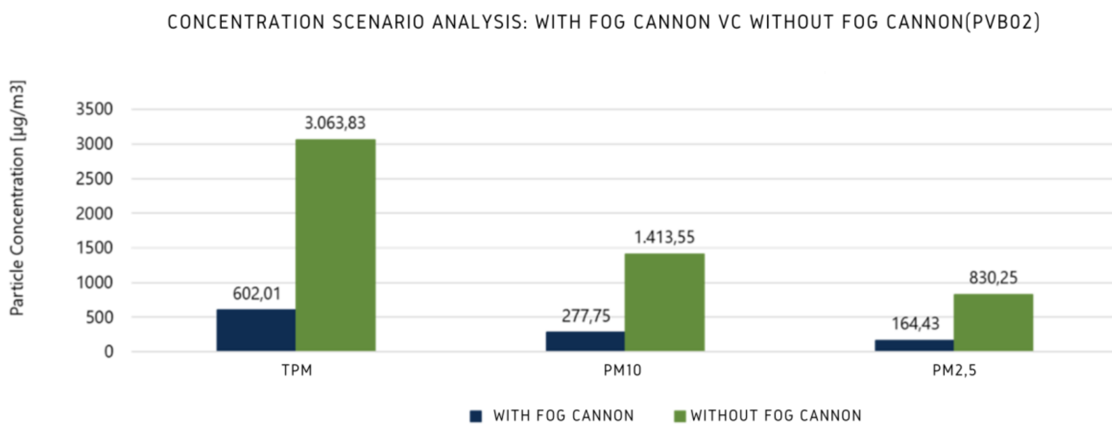

Fig. 7. Comparison of particle concentrations with and without fog cannons at one of the monitored sources.

Comparing the particulate matter concentrations fractions obtained with and without the application of the control equipment, it is possible to verify that the efficiencies obtained were 81% for TPM and PM_{10} and 80% for $PM_{2.5}$.

4. CONCLUSION

The efficiency of the control system performed depends of parameters such as wind speed, fog canyons height, angle and its position regarding the monitoring source of interest.

Through the obtained results and meteorological data evaluation, Aires performed a computational numerical simulation to visualize the cannon's ideal placing. With those results it was possible to elaborate some technical guidelines to adjust and optimize the cannons positioning on the areas of interest. Those are presented below:

- Minimum distance from the source: 15m, due to high turbulence zone and erosion potential;
- Application of cannons with 50° angle, in order to cover a larger influence area and less turbulent impact area;
- Application of cannons in "Parabola Effect": Cannon Direction positioning in order to allow the creation of a fog curtain in the local predominating wind direction;
- Maximum distance from the source: 60 to 70m;
- Cannons positioning above ground level, preferably equal or greater than source's heigh.

Regarding that the monitoring was taken according to the methodology and guidelines mentioned previously, the maximum efficiency obtained in the study using fog cannons control method was 81%.

5. REFERENCES

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