Industrial Ventilation Research in Argentina

Pocoví R, Villaflor G, Velasco J, Flores J, Bisonard E
INBEMI. Facultad de Ingeniería y Consejo de Investigación de la Universidad Nacional de Salta, Buenos Aires Salta, Argentina

Introduction

The INBEMI (Instituto de Beneficio de Minerales) is a Research Institute of the National University of Salta, working on the areas of mineral processing and extractive metallurgy. At present, the INBEMI is mainly working in the field of boron industry using borates as raw material. The main borate deposits in Argentina are in the north-western provinces, near the borders with Chile and Bolivia.

Among the research studies an important place is given to the industrial ventilation, including the control of the air quality that is discharged to the external atmosphere. This is particulary important for the boron industry, because several boric acid production plants are located in the Lerma Valley (where the Salta city is situated). This region is densely inhabited and an important agricultural area. Then, there is a risk of pollution with the borate and boric acid dust, containing boron oxide, arsenic (from the ore impurities) and other contaminants.

The research studies on industrial ventilation that we have done, and those we are carring out in the Institute can be divided into two groups: Basic Research and Applied Research.

Basic Research

Minimun Transport Velocity of Mineral Dust

Experimental studies related to the minimun transport velocities in exhaust ventilation systems have been performed (1). As it is well known, for exhaust systems handling dust, a minimun transport velocity is required to prevent settling and plugging of ductwork.

The work conclusion can be summmarized with the following experimental equation:

$$v_{min} = 5.2\ \rho_s^{0.37}\ d_p^{0.26}$$

where:

v_{min} : minimun transport velocity, m/s
ρ_s : solid particles density, g/cm^3
d_p: mean diameter of solid particlers, mm

The design velocity, which is the velocity used to operate the system, has to be higher than v_{min}, to protect the system against different practical contingencies: $v = f_s\ v_{min}$, where $f_s > 1$ is a safety factor.

With $f_s = 3$, the results obtained are in the order of the velocities given in the Industrial Ventilation Manual (2).

Exhaust Hoods Operation to Capture Dust

The velocity profiles in front of duct ends and tapered hoods (either square or circular) has been experimentally studied (3).

From the experimental results, it was concluded that the relation $Q = f(v,y,A)$ is:

$$Q = v\,(11.7\,y^2 + A)$$

where:

- Q: air flow into suction hood, m^3/s
- v: air velocity at distance y, m/s
- y: distance outward along axis,m
- $A = \pi D^2/4$: area of hood opening, m^2

This equation is very similar to the well known Dalla-Valle's equation (2), changing the numerical constant 10 by 11.7.

Capture Velocity Calculations

It is the velocity at any point in front of the hood opening necessary to overcome opposing air currents and to capture the contaminated air (2). Different cases have been studied.

Contaminant Released with Practically no Velocity into Calm Air

This is the case with less difficulties. If a particle of mass m situated in the dispersion point P is considered with $v_a = 0$ (v_a: air dispersion velocity), the capture velocity, v_c, can be calculated applying the Stokes' law. With a safety factor of 1.3, it is:

$$v_c = 1.3\frac{g\,d_p^{\,3}}{18\mu}\rho_s \quad \text{(homogeneus units)}$$

where μ is the air viscosity and g the gravity aceleration.

Contaminant Released at Low Velocity in Zone of Air Motion

This situation is considered when a transversal air flow exists with a velocity v_a = constant. In this case it is:

$$v = v(y) = \frac{Q}{K\,y^2 + A} \qquad \text{and:} \quad v(y) = \frac{dy}{dt}$$

K is a numerical constant; y: distance to the hood; x: hood diameter/2 = D/2

The dispersion path is $x = v_a\,t$, and the maximun admissible dispersion time is: $t_T = \frac{D/2}{v_a}$. Finally, the following equation for the capture velocity (v_c, y_c) is:

$$v_c = \frac{v_0\,A}{K\,y_c^{\,2} + A}$$

where v_0, air velocity at the hood opening (y = 0) can be calculated as:

$$v_0 = \frac{K\,y_c^{\,3}}{3\,A\,t_T} + \frac{y_c}{t_T}$$

Contaminant Released at High Initial Velocity into Zone of Air Movement (Most Difficult Case)

It is the case of grinding operations or abrasive blasting, where the particles are formed and released with high kinetic energy (dynamic proyection).

If the particle is produced with an initial velocity v_0, its energy is: $E_c = 1/2\ m\ v_0^2$. The movement of the particle is opposed by the friction resistent force, F_k. For a differential distance dL is: $F_k\ dL = -dE_c = -m\ v\ dv$, when particles are released at high velocity in the most favorable case: direction of v_a is towards the hood. The particles will have a velocity v = f(L), which is:

$$L = \frac{d_p^2 \rho_s}{18\mu}(v_0 - v) - v_a \ln\frac{v_o + v_a}{v + v_a}$$

The conclusion is that large particles (>20-40μm) cannot be captured unless an enclosing hood is used (those which complety or partially enclose the contaminant point).

Friction Losses in Exhaust Ventilation Systems

A theorical relationship has been developed to calculated the function n = f(v) for straight ducts, where:

v: mean air velocity in the duct, m/s

n: number of velocity pressure = $\frac{4f}{D}$, m^{-1}

f: friction factor, adim.

D: diameter duct, m.

From the Colebrook's (3) equation, it is obtained:

$$n = \frac{4}{D\left\{-4\log\frac{1}{3.7}\frac{k}{D} + \left(\frac{1.02}{10^4\ D\ v}\right)^{0.9}\right\}^2}$$

and the friction loss in a duct of lengh L (m) is:

$H_F = n\ L\ H_v$ (mm H_2O), where Hv is the velocity pressure, given by :

$H_v = 0.0612\ v^2$ (mm H_2O).

A graphical representation of this function n = f(v) has been done (3).

Applied Research

A computer program has been developed to design complex exhaust ventilation systems. It has been applied to solve ventilation problems in different local industries.

References

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