Local experimental study of microparticles resuspension mechanisms in ventilated duct under accelerated flow

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The risks associated with contamination by aerosols affect various industrial sectors such as the food industry, the semiconductor industry or the pharmaceutical industry. Thus we have to well understand the mechanisms behind the resuspension of aerosols to improve the control and management of risks related to the accumulation of particles in ventilated ducts.

The fan startup is inevitably accompanied by a transient acceleration period of the flow before reaching the steady state. Most of studies on microparticles resuspension consider only steady flows (Kassab *et al*., 2013). The acceleration period is not taken into account even if it might have a significant influence on the phenomenon. One of the fewer studies that explored this problematic is the one of Ibrahim *et al*. (2006). In this study, they measured the air velocity during the acceleration period and have observed its influence on the particles resuspension kinetics. However they did not explore the effect of the velocity close to the wall and the evolution of turbulence parameters during acceleration.

The objective of this study is to well describe the mechanisms involved in the resuspension of particles in ventilated duct by using an experimental methodology and taking into account the acceleration of the air flow which always precedes steady state. For that purpose we chose an optical method in order to investigate the initial movement of particles, and to quantify the resuspension kinetics. In parallel we collected local data of the flow during acceleration and steady state.

The experiments were carried in a ventilated duct of rectangular cross section (4X20 cm^2) of 2 meters in length, made of transparent antistatic polycarbonate material.

We used spherical bronze particles (CuSn) with a size range of 5 and 30µm, which have a density of around 8.0 g / cm^3. Their number size distribution was characterized by using laser diffraction and optical counting. A CCD camera (170 fps) was used to record the evolution of the number of particles remaining on the duct wall on a 1 cm^2 zone versus time. Five mean flow velocities at steady state (representative of those implemented in HVAC systems) between 3 and $9 m.s^{-1}$ were tested. The influence of the air flow acceleration (0.3 and 2.3 m/s^2) was also investigated.

Hot Wire Anemometry was used to characterize the air flow, at the center of the duct and close to the wall (up to 50 µm).

In steady flow the treatment of the data allowed to calculate the flow characteristics concerning the boundary layer (friction velocity, viscous sublayer thickness), i.e. at the wall duct distance concerned by particles resuspension. It enabled to validate that the particles are completely immerged in the viscous sublayer in the velocity range tested. We also calculated turbulence characteristics such as eddies diameter and power as well as flatness and skewness coefficients.

To characterize the accelerating flow we carried out simultaneous acquisition at the duct center and in the boundary layer. The treatments of the data enabled to calculate the evolution of the velocity and turbulent intensity close to the wall, as well as the number and power of eddies.

The figure 1 shows an example of resuspension kinetics (expressed in terms of remaining particles fraction versus time) superimposed to the evolution of the velocity close to the wall (137µm).

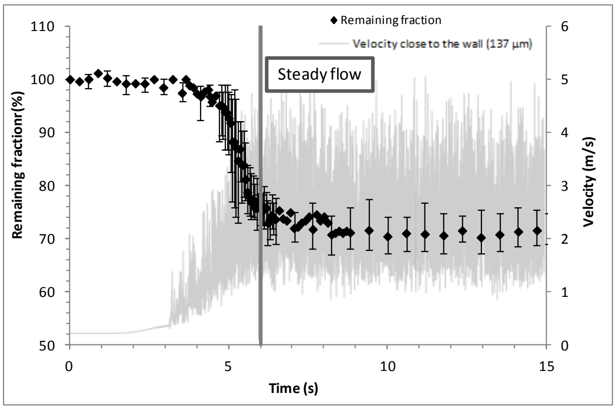

Figure 1 : Kinetics of resuspension for a steady velocity of 7.6 m/s and an acceleration of 2.3 m/s^2

We observed that the resuspension kinetics starts during the acceleration period and extends to steady state. We highlighted the relevant velocity characteristics (critical velocity at the center duct and close to the wall, critical turbulence intensity) to explain this phenomenon. We also used statistical data as the number and the power of coherent structures to understand the shape of the resuspension kinetics.

Kassab, A.S., Ugaz, V.M., King, M.D., and Hassan, Y.A. (2013) *Aerosol Sci. & Technol*. **47**, 351-360.

Ibrahim, A.H. and Dunn, PF. (2006) *Journal of Aerosol Sci* . **37**, 1258-1266.