Microparticle resuspension under accelerated airflow: dimensional analysis to account for the airflow pattern properties

Corentin Cazes, Félicie Theron, Lionel Fiabane, Dominique Heitz, Laurence Le Coq

Microparticle resuspension under accelerated airflow: dimensional analysis to account for the airflow pattern properties

C. Cazes[1,2], F. Theron[1], L. Fiabane[2], L. Le Coq[1] and D. Heitz[2]

[1]GEPEA-CNRS UMR 6144, IMT Atlantique, Nantes, 44307, France
[2]INRAE, OPAALE, Rennes, 35044, France
Keywords: Microparticle resuspension, resuspension kinetics, accelerated airflow.
Presenting author email: corentin.cazes@imt-atlantique.fr

The process of resuspension is described as the detachment of a particle from a surface and its subsequent entrainment in the flow. By understanding this phenomenon, it is possible to predict airborne particulate contamination, including the transport of hazardous materials or dust in HVAC systems (Kottapalli and Novosselov, 2021).

This work aims to study the influence of the airflow pattern properties on the evolution of microparticles behaviour with respect to time for fan accelerations followed by a short period of steady state. For that purpose, the transient evolution of the fraction of particles remaining on the duct wall F_{res} is analysed as a function of time considering the instantaneous properties of the airflow.

To achieve this, the experimental methodology reported by Theron et al. (2020) was used and improved. It consists of filming the deposit during the airflow acceleration and the subsequent steady-state, and monitoring both centre and friction velocities using Constant Temperature Anemometry (CTA). Both air velocity (at the duct centre and in the viscous sublayer, *i.e.* where particles are initially deposited) and wall shear stress are monitored using miniature hot wire and glue-on hot film probe, respectively. The wall shear stress is proportional to the friction velocity, consequently giving insights on turbulence accountable for the resuspension (Guingo and Minier, 2008).

The particles are made of bronze and have been chosen for their spherical morphology. They have been sieved to conduct experiments with three narrow size distributions characterized by d_{50} of 11.7; 23.3 and 31.3 µm, respectively. The particles are deposited as mono-layer of isolated particles on a surface.

The open return windtunnel consists of a L200xl20xh4 cm^3 rectangular channel flow, made of antistatic Polymethyl methacrylate. The measurement section, located at 130 cm from the duct entrance to ensure fully developed flow, is made of glass for optical access. Temperature and relative humidity are monitored during experiments. The optical set-up is composed of a CCD camera and a ×12 zoom lens placed below the deposit. The window size is 2.0×1.5 mm^2 corresponding to a resolution of 0.86 µm/pixels.

The properties of the airflow pattern tested are representative of those encountered in real ventilation systems (mean velocity at steady state: V_0 = 7.6-11.0 $m.s^{-1}$ and mean acceleration: α = 0.3-2.1 $m.s^{-2}$).

The films are processed using a detection algorithm developed *in house*. It detects and counts the particles on each frame to obtain the resuspension kinetics. In addition, it gives parameters of the deposit such as the particle concentration and repartition on the plate, particle size distribution and the number of particle clusters that form during the deposition process or during the experiment.

A typical time evolution of the fraction of particles remaining on the duct wall is plotted on Figure 1. One must note that the beginning of the particle detachment occurs during the fan acceleration. This is the case for all the investigated conditions. Furthermore, longer experiments were conducted and point out that most of the resuspension takes place at the beginning of the process and on very short periods. One can conclude that the acceleration process plays a major role in the phenomenon and that resuspension must be looked over as a dynamical problem. Finally, the results are presented into a dimensionless form to show the physical phenomena responsible for the resuspension.

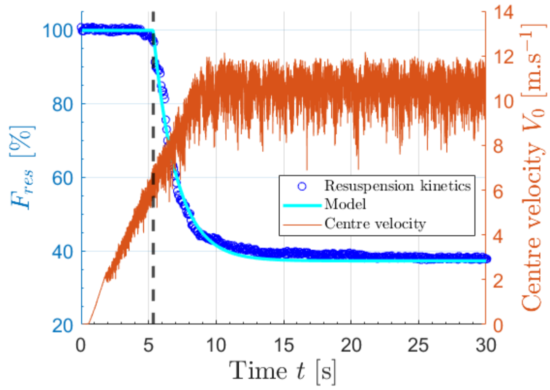

Figure 1 - Remaining fraction F_{res} (blue) and its model (cyan) along with centre velocity V_0 (orange) with respect to time t for the conditions V_0=10.0 $m.s^{-1}$ and α=1.0 $m.s^{-2}$. The dashed black line refers to the beginning of the resuspension.

This work is financially supported by the Ministry of the Armed Forces - Defence Innovation Agency.

Guingo, J. A., Minier, J.-P. (2008) *J. Aerosol Sci.* **39**(11), 957-973.
Kottapalli, K., Novosselov, I. V. (2021) *Talanta* **231**, 122356.
Theron, F., Debba, D. and Le Coq, L. (2020) *J. Aerosol Sci.* **140**, 105477.