Study of the resuspension phenomenon during airflow acceleration using Eulerian and Lagrangian approaches

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Particle detachment from a surface and its subsequent entrainment within the flow describes the resuspension process. Understanding the phenomenon is essential in industrial applications: predicting airborne particulate contamination in HVAC systems (D'Alicandro *et al.*, 2021). This study involves monolayer deposits of isolated microparticles on a surface in a ventilation duct. It aims at studying the influence of the airflow pattern (an acceleration stage followed by a short steady-state period) properties on microparticle behaviour. For that purpose, the mean velocity and acceleration roles are investigated, and the evolution of the particle fraction remaining on the duct wall $F_{\mathrm{rem}}(t) = N_{\mathrm{p}}(t)/N_p(t_0)$ (with N_{p} the particle number) is analysed as a function of time. The experimental procedure involves filming microparticle deposits and monitoring airflow characteristics using constant temperature anemometry (Theron *et al.*, 2022). Centre and near-wall velocities and wall shear stress are monitored using hot-wire and glue-on hot-film probes, respectively.

Bronze particles were used for their spherical morphology. Two particle fractions with narrow size distributions characterised by d_{50} of 23.3 and 31.3 µm were tested to investigate the influence of the particle size on resuspension. The open return wind tunnel was 200 cm long with a rectangular section (w x h = 20 x 4 cm²). The test area, located 130 cm downstream of the entrance to ensure fully developed flow, was made of glass of low mean roughness. A CCD camera coupled with an x12 zoom lens composed the optical set-up. The window length was 2.0 x 1.5 mm², corresponding to a 0.86 µm/pixel resolution. The airflow properties were the final velocity $\overline{u_{0,\mathrm{eq}}}$ = 7.6-11.0 m.s^{-1} and the acceleration α = 0.3-2.1 m.s^{-2}, representing ventilation systems operating conditions. The deposit frames were processed using an *in-house* particle detection algorithm (Cazes *et al.*, 2022), which gave deposit properties and particle numbers. Thus, one can compute the remaining particle fraction F_{rem} over time.

Another experimental rig was used, resembling the one described hereinabove to ensure flow similarity, to perform Particle Tracking Velocimetry (PTV), *i.e.*, measure particle trajectories and their velocity and acceleration. It used a Phantom VEO 440L camera and a 10 mm lens (Laowa) with a 2.8 opening. The frequency rate was 1.1 kHz with a 2560 x 1600 pixels² resolution.

Results showed that most particles resuspended during the acceleration regime for all temporal airflow patterns. It emphasises that the phenomenon must be studied through time-resolved approaches. Based on a model fitting (Theron *et al.*, 2022), one can define a virtual start velocity $U_{0,s}$ which is the instantaneous mean centre velocity at the virtual start of the resuspension. Figure 1 shows the influence of $\overline{u_{0,\mathrm{eq}}}$ and α on F_{rem} (t). The particle fraction remaining and the virtual start velocity appear independent of the final velocity but increased with the acceleration parameters. The same tendency was seen for friction and near-wall velocities.

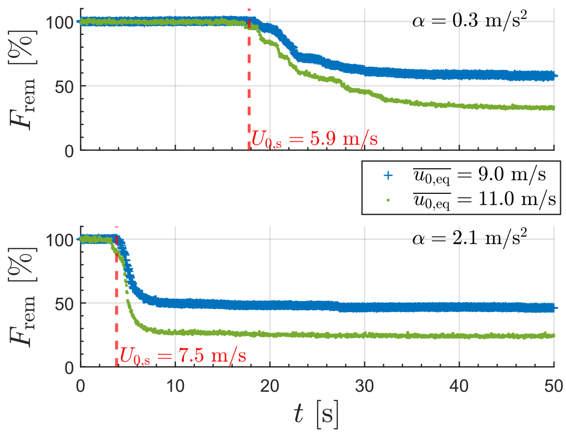

Figure 1. Remaining fraction F_{rem} as a function of time.

Finally, we investigated the particle trajectories at the resuspension start and their velocities using PTV. As a result, we propose to link the physical phenomena responsible for the resuspension with the appearance of turbulence in the near-wall region.

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