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► **To cite this version:**

Xavier Nicolas, Syphax Ikardouchene, Stéphane Delaby. Interaction of micrometric droplets with a turbulent plane air jet impacting a wall. Turbulence and Interactions - TI2022, May 2022, Elba Island, Italy. hal-03808016

HAL Id: hal-03808016

<https://hal.science/hal-03808016v1>

Submitted on 10 Oct 2022

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Interaction of micrometric droplets with a turbulent plane air jet impacting a wall

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Experiments and Large Eddy Simulations are carried out to study the interaction of spherical particles (micrometric oil droplets) with a turbulent air jet impacting a wall. The context is that of the dynamical air curtains used to separate a contaminated atmosphere with passive particles from a clean atmosphere.

In the experiment, the impacting air jet configuration is similar to that of [1, 2]. The aspect ratio H/e of the jet is equal to ten (see Fig. 1). A spinning disk is used to produce oil droplets close to the air jet. The droplet diameter varies in the range $0.35 \mu\text{m} \leq d_p \leq 7 \mu\text{m}$. Measurements are based on particle image velocimetry and optical particle counting. The jet and particle Reynolds numbers and the jet and turbulence Stokes numbers are respectively equal to $Re_j = 13500$, $0.33 \leq Re_p \leq 3.5$, $0.02 \leq St_j \leq 0.35$ and $0.1 \leq St_t \leq 1$. The passing rate of the particles (PPR) that cross the air jet is analyzed according to the particle size distribution. Whatever the droplet size is, the PPR increases with time due to the presence of two large vortices on each side of the air jet. The time averaged PPR is shown to decrease with respect to the particle diameter.

Numerical simulations of the experimental configuration are carried out with the commercial code ANSYS/Fluent, with the LES Wale model for the air flow and a stochastic Lagrangian model for the particle transport (see Fig. 2). The droplet collision and coalescence are accounted for thanks to O'Rourke's model [3]. The LES solutions for the air jet are validated through comparisons with numerous literature results. The high frequencies due to the Kelvin-Helmholtz (KH) roll passing and the low frequencies of the oscillating jet are detected in the spectra. The PPR is analyzed according to the particle size and compares favorably with the experiments, only when the coalescence of the oil droplets and their deposit on the wall are accounted for. The vertical profiles of the PPR along the jet axis are also analyzed to detect the weak zones of the jet in its role of dynamical air curtain.

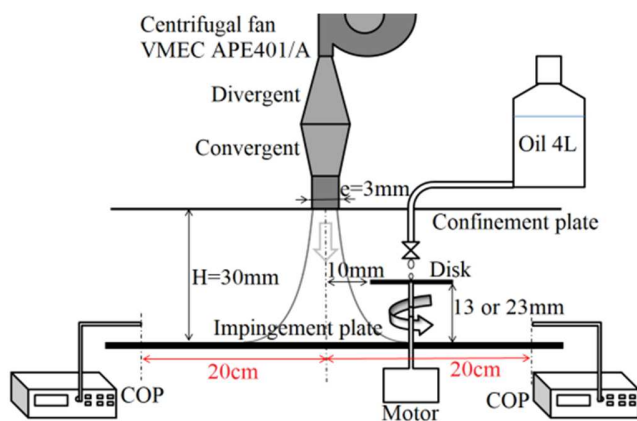


Fig. 1: Scheme of the experimental setup

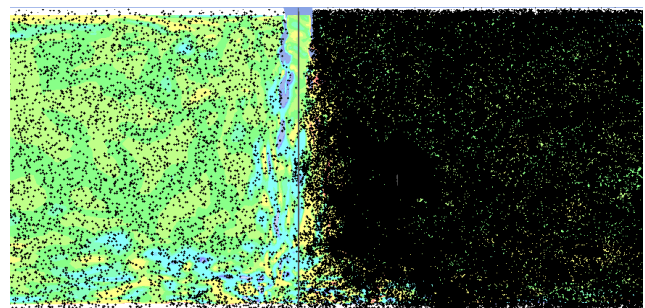


Fig. 2: Numerical simulation : vorticity and particle fields on both sides of the vertical air jet, at time $t=100$ ms. On the right : zone contaminated by particles. On the left : initially clean air zone.

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- [2] F. Beaubert, S. Viazzo, Large eddy simulations of plane turbulent impinging jets, *Int. J. Heat Fluid Flow*, 24 (2003) 512-519.
- [3] P. J. O'Rourke, Collective drop effects on vaporizing liquid sprays. PhD thesis, University of Princeton, 1981.