Correcting droplet–flame interactions in an artificially thickened turbulent lifted flame

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Supplementary material

Appendix A Non reactive flow

The non-reactive case is investigated to establish a reliable baseline prior to the inclusion of combustion effects. By removing chemical reactions and heat release, the analysis is concentrated on the fluid dynamic behavior, allowing a detailed assessment of the velocity field, turbulence structures, and recirculation zones that govern mixing and flame stabilization. This step validate the numerical setup, turbulence modeling, and boundary conditions independently of combustion-related complexities. Figure A1 and A2 show the profiles of the axial and radial velocity components, where the gray zone represents 1 rms.

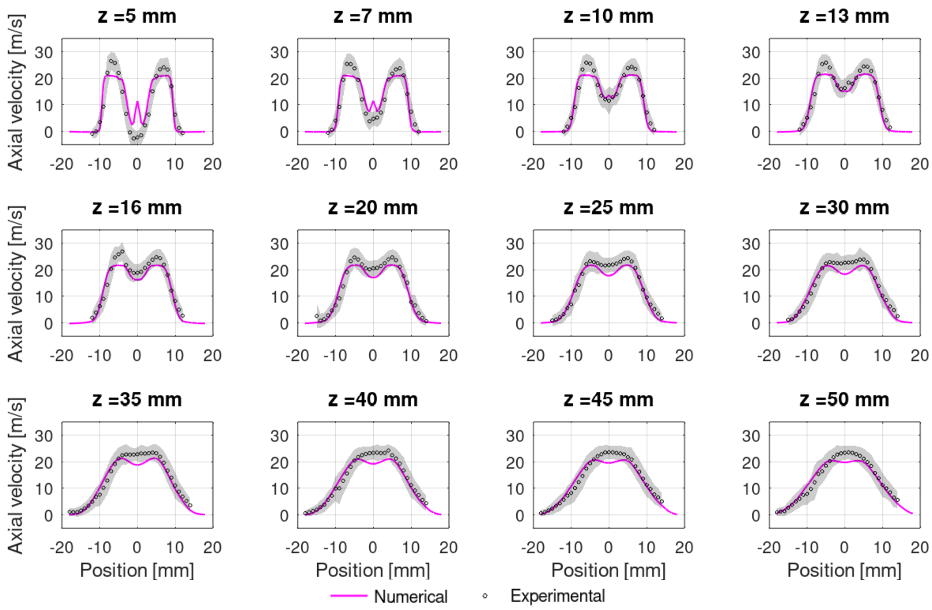

Fig. A1 Mean axial velocity of the carrier phase at different heights (5, 7, 10, 13, 16, 20, 25, 30 mm), evaluated in non reactive case. Grey zone represents 1 rms.

The turbulence, velocity field, and recirculation zones strongly influence the behavior of injected droplets, affecting their transport, dispersion, and evaporation. The mean velocity field determines droplet trajectories and penetration, while velocity gradients and shear layers promote radial spreading of the spray. Turbulence enhances droplet dispersion through fluctuating velocity components and increases interphase momentum, heat, and mass transfer, thereby accelerating evaporation rates.

A very good agreement can be observed between calculated and measured data for the axial and radial components of the carrier phase. Slightly deviations are limited to the inner core region of the jet flow (-5 mm $< r <$ 5 mm) for z $\leq$ 7 mm and z $\geq$ 25 mm. At the most downstream positions such deviations can be justified by the employed numerical injector.

Experimental data of the average diameter of the droplets are showed in Fig. A3. The gray region in the plots represents the 1 rms for the experimental data. The numerical droplet average diameter usually stay inside the 1 rms zone, except in the central region, mostly in the initial region of injection (lower heights), where droplets are predominantly advected out of the domain by the central primary airflow. The

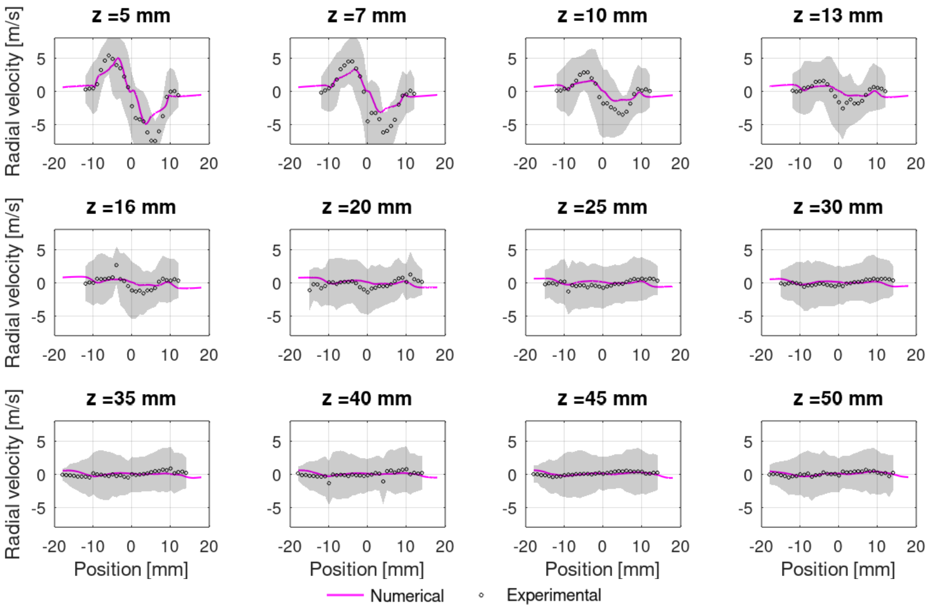

Fig. A2 Mean radial velocity of the carrier phase at different heights (5, 7, 10, 13, 16, 20, 25, 30 mm), evaluated in non reactive case. Grey zone represents 1 rms.

flame is situated in the region between 10 and 30 mm, where results tends to show good adherence between the numerical parcels and experimental diameter data.

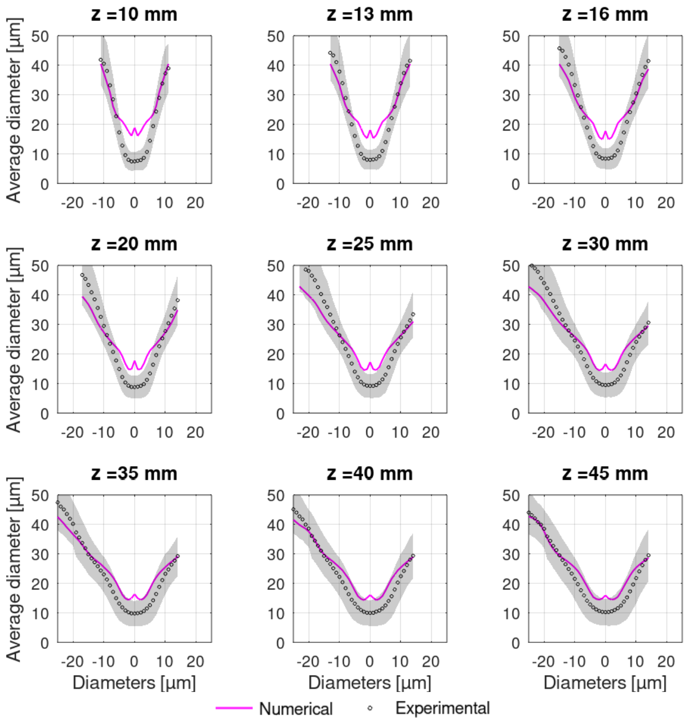

Fig. A3 Average diameters of droplets ($d10$) in the reactive flow, at heights 13, 20, 30 and 40 mm, with radial position of 0, 6 and 12 mm, evaluated in REF, STD and PRJ cases.