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X-ray Tomography and 3D CFD Simulation of Fuel Mass Distribution in a GDI Spray

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The spray formation plays a fundamental role for the optimization of combustion efficiency and exhaust emissions of Gasoline Direct Injection (GDI) engines, allowing the control of the combustion process through the local equivalence ratio of air-fuel mixing. Non-intrusive diagnostics and three-dimensional (3D) Computational Fluid Dynamics (CFD) models provide a deep insight of fuel-air interaction. However, conventional optical techniques allow getting experimental data only in the less dense regions of the spray, while they miss to provide information about fuel distribution in the near-nozzle region, where liquid break-up effectively occurs. X-ray tomography can overcome these limitations making available quantitative measurements of fuel mass concentration in the high dense spray regions.
This paper reports the results of a numerical and experimental investigation of the inner structure of a high-pressure gasoline spray injected by a 6-hole GDI nozzle. A desktop facility based on polycapillary optics system, providing a high flux beam with low divergence, has been used to perform a spray micro-computed tomography (μCT) in the region immediately downstream of the nozzle.
The operative conditions considered are reproduced through the development of a 3D CFD model in the AVL FireTM environment, where the spray development in the near-nozzle region is investigated through a Reynolds Averaged Navier-Stokes (RANS) approach. The spray evolution is described through a Lagrangian Discrete Droplet Method (DDM), while the continuous gaseous phase is described by the standard Eulerian conservation equations.
This paper aims in comparing the results of x-ray based techniques with 3D CFD numerical model. The local mass distribution of a single jet at different distances from the nozzle was estimated through x-ray tomography and radiography. Experimental data were compared with numerical ones, enlightening the distribution of the liquid fuel concentration in a plane orthogonal to the axis of the spray injector.
The comparison demonstrates the accuracy of x-ray tomography desktop facility as a reliable diagnostic tool to get quantitative information about the local mass distribution and fuel flow.

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