Phd Offer – 3-year fellowship – LEGI, Grenoble

Atomization of a liquid jet by a turbulent swirled gas co-flow: experimental characterization, mechanism and modeling

Lab : Laboratoire des Ecoulements Géophysiques et Industriels (LEGI), Grenoble
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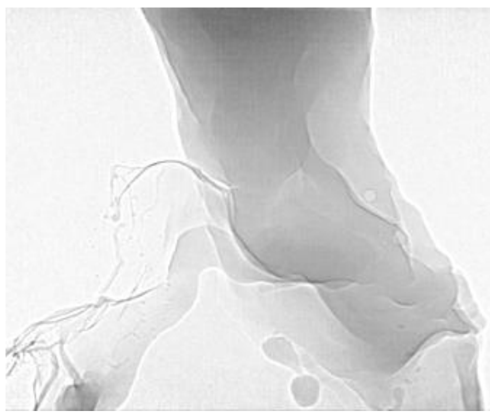
Topic: Assisted atomization is a widely used process used in industry (manufacturing, pharmaceutical, agricultural…) to produce a high-quality spray. A high-speed gas surrounds a low-momentum liquid jet, accelerating it and making it unstable, to successively break it into a cloud of fine droplets, namely a spray. In the context of propulsion application, the gas enters the nozzle goes through the jet engine turbines and becomes highly turbulent, with large velocity fluctuations as well as angular momentum, referred to as swirl. Despite their widespread use in industry, the modeling of such coaxial atomizer remains unsatisfactory due to the lack of a complete mechanistical understanding of the underlying physical phenomena describing the interfacial instabilities and the break-up processes. The design and exploitation of these systems rely on empirical approaches, extracted on uncomplete parameter range with respect to the wide nature of the applications, and with no thorough description of the effect of swirl and turbulence in the gas co-flow.



Left: High-speed back-lit imaging of the spray near-field, for a coaxial atomizer with laminar liquid injection and slightly turbulent gas co-flow.
Right: High spatial and temporal resolution X-ray radiography for the same condition.
The liquid jet diameter is 2.5 mm for both pictures.

The goal is to improve our understanding of this turbulent multiphase flow, suing a multiscale experimental approach, studying the spray from the near-field of the atomizer, where interfacial instabilities form on the liquid jet, to the far-field, where droplets are dispersed by the turbulent phase. This will require the combination of a set of available measurements techniques and the development of analysis tools. Different advances can be achieved:

- Characterize the gas co-flow of a coaxial atomizer with tunable swirl and turbulent fluctuation levels
- Measure the metrics of the near-field using visible light high-speed imaging, combined in real-time with gas phase particle image velocimetry measurements when necessary
- In identified regions of the parameter space, characterize the liquid jet and primary inclusions populations using high-speed Synchrotron X-ray absorption. If no beam time is obtained at ESRF, the characterization will be made using high-magnification visible light imaging.
- Analyze the droplets size and spatiotemporal distribution as well as extract the cloud of droplets spatial and temporal characteristic scales, using laser interferometry and planar particle detection.
- Test and develop new modeling approaches in agreement with the result obtained.

Requirements: The PhD candidate needs a strong background in fluid mechanics and a high interest in experimental research. The different imaging techniques require fine optical setup alignment, as well as the development of images analysis tools. The data throughput is high, making data processing skills appreciated.

Please contact Nathanael Machicoane (Nathanael.Machicoane@univ-grenoble-alpes.fr) and Alain Cartellier (Alain.Cartellier@univ-grenoble-alpes.fr) to apply for this position or with any questions.