X-RAY MICRO-COMPUTED TOMOGRAPHY FOR LIQUID VOLUME FRACTION MEASUREMENTS AND CAVITATION EROSION INVESTIGATION

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ABSTRACT –
The flow inside a purpose build enlarged single-orifice nozzle replica is investigated both experimentally and computationally. The nozzle is part of a closed-loop flow circuit and it has been designed to replicate the main flow pattern observed in high pressure Diesel injector nozzles, with focus on cavitation structures, their interaction with turbulence and the induced material erosion. The highly transient flow features that are taking place, such as cavity shedding, collapse and vortex cavitation, have become evident from the high-speed shadowgraphy images. Moreover, the vapour volume fraction inside the orifice has been quantified using time-averaged X-ray micro-computed tomography (micro-CT), which provides three-dimensional slices of the object and are used (a) to identify internal geometric features of the object, and (b) to distinguish between media of different densities, i.e. liquid and air/vapour. Results have been obtained at Reynolds and cavitation numbers similar to those of real-size injectors, using a variety of normal and de-gassed Diesel fuels. Good agreement for the cavitation extend inside the orifice is found between the micro-CT and the corresponding temporal mean 2D cavitation images, as captured by the high-speed camera. However, the internal 3D structure of the developing cavitation cloud reveals a non-symmetric hollow vapour cloud ring formed at the hole entrance. Finally, micro-CT enabled the reconstruction of the orifice surface, which provided locations of cavitation erosion sites developed after sufficient operation time. Results appear promising and pose challenges in both, realisation of quantitative measurements of cavitation vapour fraction inside an injection hole and the relevant tools for meaningful results post-processing.