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Visualization of optically opaque flow systems through lab-based, dynamic X-ray micro-CT

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Single and multi-phase flow are encountered almost everywhere, including biological and chemical processing, offshore applications, oil and gas recovery, corrosion and naval hydrodynamics. Extending the physical understanding of single and multi-phase flow is of key importance of many industrial applications. High-speed visualization, such as particle image velocimetry (PIV) has been successfully applied to capture flow processes in detail for many of these flows. However, for some set-ups, light might scatter between vapor and liquid phases or more severely, be completely blocked.

In Previous work, to overcome this limitation of PIV, a medical X-ray source coupled with a high-speed imager was used to study the void fractions in ventilated and cavitating flows (Mäkiharju et al., 2013). The system was capable of acquiring two-dimensional projections through an O(10 cm) water column at rate of 1kHz with spatial resolution below 1 mm. In general, when using experimental techniques to study the behavior of flow, they ideally should have both a high spatial and temporal resolution to resolve the dynamics of the flows. Because of their high fluxes, synchrotron facilities are well suited to perform those dynamic experiments (Duke et al., 2015). Imaging of dynamic processes is one of the key applications at synchrotron facilities, pushing the time resolution more and more down with quite some success. However, access to those facilities is often limited and operational cost are quite high.

The flows of industrial interest typically require imaging rates much higher than achievable with conventional micro-CT laboratory systems. If the acquisition time is slower than the flow speed relative to the resolution, temporally induced blurring is induced. However, recent developments at TESCAN XRE have made it possible to image, reconstruct, and inspect dynamic processes in the laboratory with a temporal resolution of a few seconds. These developments are not only enabling investigation of low Reynolds number opaque flows in great detail, but also clogging processes in porous media. For the latter, for example mobilization and clogging of clay can significantly change the transport properties in porous rock materials. Segmentation and analysis of the seeding particles was performed by using the Software GeoDict.

In this study, we demonstrate the capabilities of visualizing flows in 3D in optically opaque containers or materials by using in-lab X-ray micro-CT. The proof-of-concept experiments resulted in the visualization and analysis of particles in creeping flows. Silver coated hollow particles were used as flow tracers in a liquid (water-glycerol mixture). Hundred full rotation were acquired with a total scan time per rotation (0-360°) of 2.9 seconds. This resulted in both the visualization and analysis of the flow behaviour in opaque systems.

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Time Block Preference

Time Block B (14:00-17:00 CET)

References

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