X-ray particle tracking velocimetry in liquid foam flow

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ABSTRACT

We present the application of X-ray radiography to visualise the bulk flow of liquid foam by tracking custom-tailored tracer particles. In contrast to optical observations of quasi-two-dimensional foam in flat cells, X-ray PTV allows to investigate three-dimensional foam configurations with up to 100 mm thickness in X-ray beam direction. Light-weight steel tracers are additively manufactured by selective laser melting. Their tetrapod-inspired shape and millimetric size match with the foam structure and bubble size. Thus, these tracers adhere to the Plateau border junctions and follow the foam flow. Static tests have demonstrated that the tracer particles hardly alter the foam. The X-ray transmission images show the two-dimensional projections of the radiopaque tracers in the radiotransparent foam channel. Employing particle tracking algorithms, the tracer trajectories are measured with both high spatial (0.2 mm) and temporal resolution (25 fps). In a 180° bend channel with rectangular cross section, we have studied the flow of fine and coarse foam at different velocities. The simultaneous time-resolved measurement of the tracers' translational motion and their intrinsic rotation reveals both the local velocity and vorticity of the foam flow. In the bend channel section, we have investigated the rigid-body-like flow pattern. To sum up, X-ray radiographic particle tracking allows for measurement of three-dimensional foam flow at high spatial and temporal resolution. We believe that this technique is a promising initial step towards deeper understanding of turbulence and shear banding in foam flow.

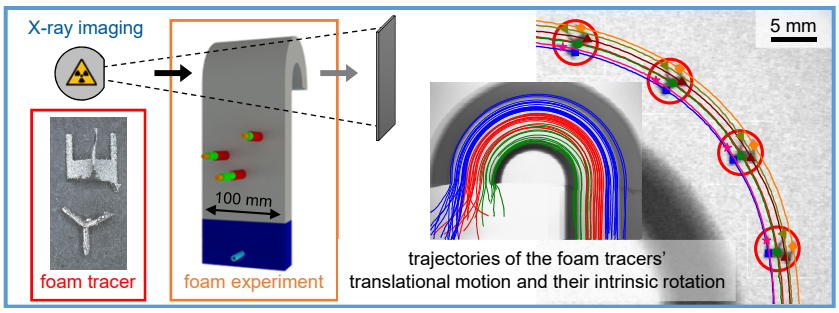

Figure 1: X-ray radiography gives insight into the bulk flow of liquid foam. To conclude on the local flow velocity and vorticity, purposely shaped 3D-printed steel tracers are tracked over time.