Towards DPTV and IPI across Curved Displacement-Compressor Surfaces: Impact of Astigmatism on Particle-Image Characteristics of Bubbles and Tracers

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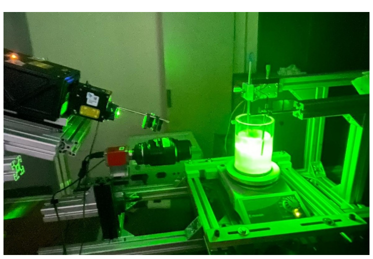
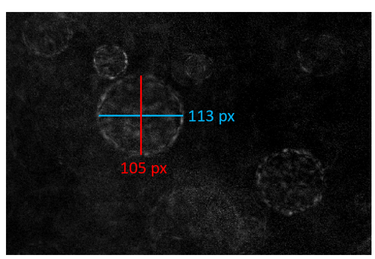
In order to increase the efficiency of oil-injected rotary positive displacement compressors (RPDCs), an in-depth knowledge of the two-phase surge and gap flow between two adjacent compressor chambers is crucial[1]. The accordingly required experimental investigations rely on the non-trivial flow measurement of both liquid and gas phases in the annular gap of the RPDCs. Recently, Leister *et al.*[2] successfully demonstrated the applicability of defocusing particle tracking velocimetry (DPTV) and interferometric particle imaging (IPI) for two-phase flow diagnostics in thin annular gaps. Sax *et al.*[3] furthermore identified the r-z-plane to be better suited for IPI measurements across a cylinder surface, compared to the r-φ-plane, as the scattering angle is independent from the depth and in-plane positions of the investigated bubbles. Such experimentation, however, requires particle imaging in back-scatter configuration. Leister *et al.*[4] successfully conducted back-scatter DPTV measurements through a transparent disc. More recently, Sax *et al.*[5] demonstrated the applicability of IPI in back-scatter orientation in a combined theoretical/experimental investigation. Both studies, as yet, considered planar surfaces for the optical access, which accordingly resulted in circular particle images (PI).

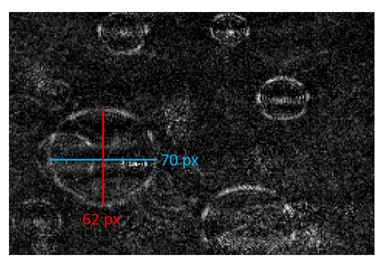
In continuation of the above studies the present investigation addresses the impact of the curved surfaces – as occur in RPDCs – and the corresponding influence of astigmatism on the resulting PI shape for both tracers and bubbles. The experimental setup is indicated in Figure 1(a), which consists of a laser and camera in back-scatter configuration in front of a circular beaker glass. The contained water is either supplied with tracer particles to evaluate the liquid phase with DPTV and/or a tip-to-rod electrolysis produces bubbles for the IPI diagnostics. Figure 1(b) and 1(c) present random raw images revealing DPTV and IPI patterns, respectively, where either set of PIs is already tagged with the semi-major (blue) and semi-minor (red) PI-axes. Even though conventional circle-detection algorithms lead to diminished diameter-estimation accuracy, if occurring astigmatism deforms the formerly circular PIs into ellipses, the combined evaluation of the semi-major and semi-minor PI-axes comprises information on the PI-distance to the curved surface. As such, the present evaluation strategy revolves around an advanced PI depth-localization method, which considers both diameter and shape of the recorded PIs. In addition to the PI-diameter based particle localization[4], the approach takes complementary advantage of the astigmatism particle tracking velocimetry (APTV, see e.g. Rossi & Kähler[6]), which interprets the particle-image shape rather than its diameter for depth codification.



(a) experimental setup



(b) preporcessed DPTV image



(c) preporcessed IPI image

Figure 1: Experimental approach and example results for the r-z-plane back-scatter experimentation of bubbles and tracers across a curved surface.

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[1]Nikolov & Brümmer, *Int. J. Refrig.* **148** (2023).
[2]Leister et al., *IOP Conf. Ser. Mater. Sci. Eng.* **1267** (2022).
[3]Sax et al., *11. Int. Conf. Multiph. Flow ICMF 2023* (2023).
[4]Leister et al., *Exp. Fluids* **64** (2023).
[5]Sax et al., *arXiv preprint arXiv:2303.16013* (2023).
[6]Rossi & Kähler, *Exp. Fluids* **1267** (2022).