Multi-camera PIV imaging in two-phase flow for improved dispersed-phase concentration and velocity calculation

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HIGHLIGHTS

• Use thin light-sheet combined with multi-camera imaging to accurately measure dispersed phase volume fraction.
• Multi-camera single-plane method provides 1) well-defined measurement volume through 3-D position of dispersed phase particles, 2) increased robustness in identifying particles at higher concentrations
• Provided accuracy of 2% for volume fractions approaching 0.01, improving the accuracy and increasing the volume fraction limit of prior single-camera methods.

ABSTRACT

We present a multi-camera thin light sheet imaging method to accurately measure dispersed phase concentration up to optical densities of close to O[1]. The work is an extension of prior single camera methods that utilize particle image characteristics to identify particles and, when appropriately calibrated, provide a measure of the effective measurement volume thickness. By introducing multiple camera perspectives, stereo photogrammetry methods can be combined with the redundancy of information available in the images to provide 1) increased accuracy in determining individual particle locations, and 2) increased reliability in identifying all of the dispersed phase objects in the face of increasing probability of obscuration by surrounding particles. The method is calibrated through the use of a fixed solid/gel suspension test cell that mimics the optical properties of a solid/water suspension. The new method is then tested against reference cell sets of different volume fractions ranging from \( C = 1 \times 10^{-4} \) to \( C = 1.2 \times 10^{-3} \) for a fixed particle size of \( D = 240 \, \mu m \). The new method is able to provide an accuracy of 2% up to a volume fraction of \( C = 8 \times 10^{-3} \), which is an order of magnitude greater than prior single-camera methods.

Fig. 1 Schematic of multi-camera configuration and resulting particle images from different scanning planes (left). Results of method showing valid measurement volume depth between 0.5 to 1 mm depending on volume fraction (right).