SIMULTANEOUS DETERMINATION OF VELOCITY FIELD AND SIZE DISTRIBUTION OF A WATER SPRAY FROM IMAGE ANALYSIS

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ABSTRACT: Particle sizing techniques have been widely investigated and developed in a variety of industries and research laboratories, which aims at characterizing the form and the diameter distribution of the particles ranging from several nanometers to several millimeters in a targeted group. The past several decades has seen the advancement of optical methods attribute to the application of laser techniques. Optical methods evidently show their advantages by providing non-intrusive and real-time measurements as well as the possibility of combination with velocity measuring devices [1]. In this article, an optical particle sizing method based on the analysis of polarization status of light scattered by targeted particles will be introduced. The optical setup will be combined with PIV (Particle Image Velocimetry) for the simultaneous determination of particle velocity.

Theory of Lorenz-Mie provides the solution of Maxwell electromagnetic equations which elaborates the absorption and scattering of incident light by a sphere in a linear, isotropic and homogeneous medium [2]. The polarization status of scattered light is characterized by four experimental parameters including the incident wavelength (λ), the angle of observation (θ), the relative refraction index of the particle and the medium (m), and the particle diameter (d). Thus the particle diameter can be obtained from the analysis of polarization ratio (P) of scattered light which is acquired from experiments:

$$P(\lambda,\theta,m,d,) = \frac{i_{\perp}}{i_{//}}$$

Where $i_{\perp}$ is the scattered irradiance per unit incident irradiance given the incident light is polarized perpendicular to the scattering plane, while $i_{//}$ is its counterpart when the incident light is polarized parallel. The ratio of these two polarized components of scattered light is determined experimentally from the analysis of polarized particle images taken by a high resolution CCD camera. When a double-pulsed Nd:Yag laser is used as incident light source, the experimental setup becomes a PIV device which enables the simultaneous acquisition of velocity field. The theoretical calculation work and a detailed description of the experimental plan can be found in the authors' previous publication [3].

In the current presentation, the size distribution of a water spray will be determined by the method of polarization ratio, with the velocity profile of the spray obtained by PIV.

References

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