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Analysis of pneumatic atomizer spray profiles

Walter Schäfer[a,*], Simon Rosenkranz[a,c,d], Felix Brinckmann[b], Cameron Tropea[c]

[a] AOM-Systems GmbH, Flughafenstrasse 15, 64347 Griesheim, Germany
[b] LacTec GmbH, Otto-Hahn-Strasse 6-8, 63110 Rodgau, Germany
[c] Institute of Fluid Mechanics and Aerodynamics, Technische Universität Darmstadt, Alarich-Weiss-Strasse 10, 64287 Darmstadt, Germany
[d] Graduate School of Computational Engineering, Technische Universität Darmstadt, Dolivostrasse 15, 64287 Darmstadt, Germany

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ABSTRACT

Our objective is to analyze the atomization processes of a pneumatic atomizer by measuring the size and velocity distributions of droplets in a liquid paint spray. The droplet size and velocity distributions have been determined at different axial positions in the spray; a mathematical description of how these quantities vary throughout the spray is then proposed. Additionally, the relative number density of droplets and the relative local mass flux are estimated.

Introduction

The characterization of spray nozzles is an important step in the development of many industrial processes like car painting, spray drying, and pharmaceutical coating. One way to characterize the spray nozzles is to analyze systematically droplet size and velocity distributions at different position in such sprays as proposed in DIN Spec 91325 (2015). For measuring the size and velocity of the droplets there are numerous methods and techniques; a good summary can be found in Tropea (2011). In the present study the time-shift technique has been chosen, because it is capable of measuring not only transparent but also non-transparent, suspension/emulsion particles/droplets, which often occur in industrial applications. In addition, this technique does not require post-factory alignment and it can be operated in backscatter.

The measurement data presented in this study have been acquired using this time-shift technique (Albrecht, Damaschke, Borys, & Tropea, 2003; Damaschke, Nobach, Semidetnov, & Tropea, 2002; Schäfer, 2013; Schäfer & Tropea, 2014). This technique is a known measurement technique which was first introduced by Semidetnov (1985) and was further developed by Albrecht et al. (2003) and Damaschke et al. (2002). The time-shift technique has also been called the pulse displacement technique and several variations have been discussed (Hess & Wood, 1994; Lin, Waterman, & Lettington, 2000). It is based on light scattering of a shaped light beam from a single droplet/particle, and the instrument can be operated in backscatter, meaning that the detectors and light sources can be placed on one side of the measurement position, making the technique more attractive for applications presented in this study. Moreover, the water spray created by the pneumatic atomizer and operated at different pressures for shaping air has been characterized by measuring the droplet size and velocity distributions of this spray at different positions. The new developments and validation of this technique can be found in Schäfer (2013), Schäfer and Tropea (2014), and Schäfer, Rosenkranz, and Tropea (2015).

Using the time-shift technique, the light scattered from a single spherical particle can be interpreted as the superposition of all scattering orders present at the detector location. The intensity of the scattering orders is described by the Debye series (1909) expansion of the Mie (1908) scattering functions, or using a geometric optics approach (Van de Hulst, 1957; Van de Hulst & Wang, 1991) to compute the scattered field. When a particle/droplet passes through the focused light beam, the scattered light is detected by photodetectors focused on the scattering center. Each photodetector provides a time signal known as a time-shift signal (see Fig. 1). Depending on the scattering angle and relative refractive index, different scattering orders and their modes can appear at any one scattering

* Corresponding author. Tel.:+49 1738313120.
E-mail addresses: WS@AOM-Systems.com (W. Schäfer), SR@AOM-Systems.com (S. Rosenkranz), Felix.Brinckmann@lactec.com (F. Brinckmann), CTropea@sla.tu-darmstadt.de (C. Tropea).

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