EHD sprays as a seeding agens for PIV system measurements

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Abstract

Reported here is an application of polyvinylalcohol particles generated by electro hydrodynamic atomization (EHDA) as a seeding medium for visualization of flows in gases using PIV and LDA methods. Modified multi-hole electro spray device and the simple droplet atomizer were integrated with compressed air and used as a seeding system for applications where the submicron droplet size is required.

Introduction

In recent years the Particle Image Velocimetry (PIV) method is utilized in many challenging applications that require specific parameters of seeding particles. For PIV and LDA investigation measurements the presence of seeding particles in gaseous fluid is essential. The particles suitable for these techniques have to pass a couple of conditions such as light scattering, fluid dynamic consideration and sufficient quantity of population for analysis. [1, 2]

LDA and PIV methods generally indicate a particle diameter above 1μm, but also when the smaller range size is needed, application of smaller particle in conjunction with higher light intensity is possible. Liquid drops are the most satisfactory form of seeding being non-abrasive, non-contaminating and with suitable liquids, non - corrosive and non-toxic. The example of the application where the smaller diameter is necessary can be increasing interest of aerosols and particles effects on human lungs of many scientific groups, including flows studying specialists, aimed their goal research on the alveolus system in recent years. The particle size distribution of the simple droplet atomizer is not very dependent on flow rate or properties of the liquid and the size distribution of aerosol production can be hardly markedly affected. With a well designed nozzle, drops of mean diameter 1μm can be produced with distribution from about 0.1 - 30μm. For novel system models this diameter is not suitable. Here came up the idea of using external electrostatic force to secondary disintegrate raising droplets from the main jet stream to achieve demanded spray characteristic and distribution.

The standard aerosols atomizers (SAFEX, oil generator or ultrasonic atomizer) product usually average size of droplet diameter in ranges 0.1 - 10 microns with the diameter peak of 0.8μm. Those equipments usually work with highly specific liquids that can not be changed or modified. As a suitable solution for this problem occurred the usage of electro hydrodynamic atomizers (EHDA). By setting regulative and solution parameters (voltage, gap, conductivity or surface tension of solution) could be easily set the droplet diameter in a narrow range distribution in a submicron size.

Materials and Methods

A multi-hole electro spray atomizer and a simple droplet atomizer were directly connected to a compresed air [3, 4]. The multi-hole setup produces higher particle concentration then single jet needle one. The same effect was reached by charging sprayed solution in a pneumatic nozzle atomizer. [5]

In both cases as a sprayed solution was used 4% Poly vinyl alcohol. This substance is convenient for its dissolving ability in water and alcohols so the chemical and physical properties can be easily influenced.

Here was tested three nozzle sizes in a range 14, 20, 27 gage and feed rate of 2 - 10ml/h for EHDA and pressure 0.01 and 0.02MPa for pneumatic nozzle. The voltage 15kV was applied to Multi-hole electro spray as well as pneumatic atomizer.

The droplet size distribution was measured at a fixed position 15 cm from the nozzle on the centerline and the results were calculated using Interferometric Particle Sizing Method and compared to image analyzed optical microscope samples. The changes in spray characteristic under applied voltage were visualized and calculated using Particle Tracking Method.

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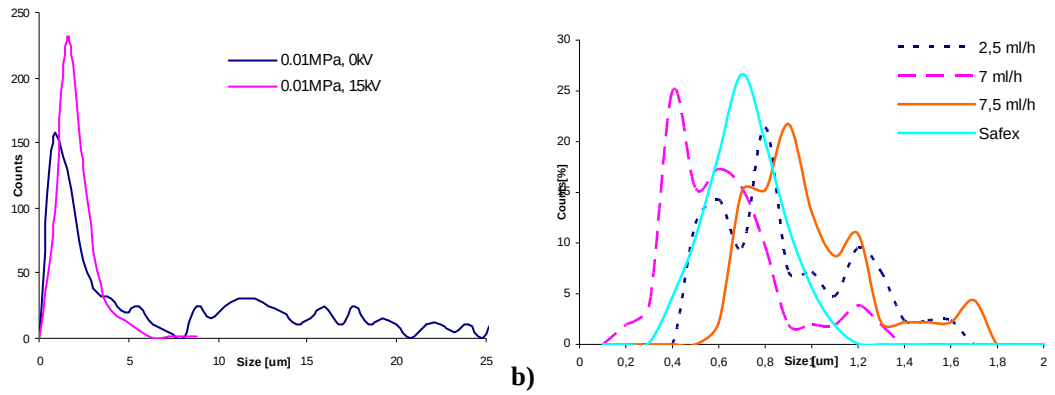
Results and Discussion

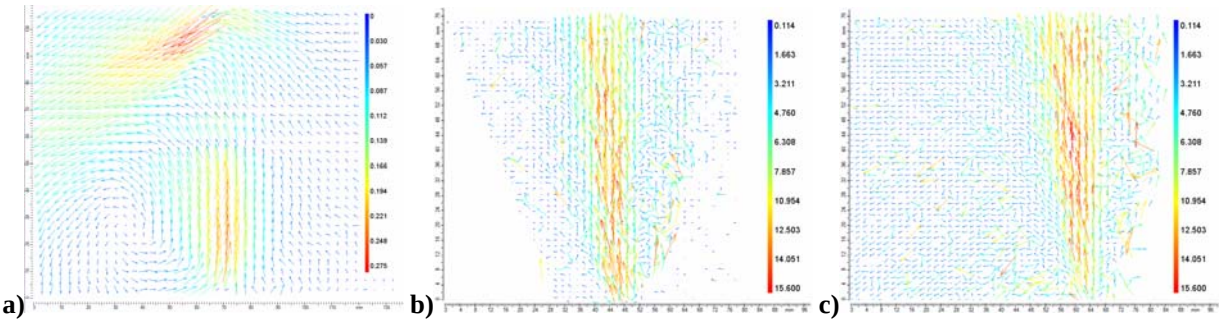
Here was confirmed practicability of the electrostatic field to the pneumatic nozzle that tent to a narow size distribution for the paralel or serial spray dispensing into the flow for PIV measurements. The Multi-hole EHDA was studied under certain parameters and the results were interpreted. The spray production characteristics and size distributions were compared to SAFEX atomizer. Using the suitable solvent to PVA we can affect the vaporization rate, droplets or particles stability and the rate of solidification, if it is necessary. Set against the comertial equipment, here specific liquids enrich for additives such as fluorescence substances or color pigments can be used. The figure 1 a) shows the droplet size distributions of the SAFEX generator, pneumatic nozzle without and with applied voltage. The second part of this figure compares the size distribution between various feed rates of Multi-hole EHDA.

The spray characteristics and their influencing with electrostatic field is seen on figure 2. As the high voltage is connected to the nozzle the spray becomes wide spread and the size distribution straiten as the droplets are more disintegrated.



a) b)

Figure 1. 4% PVA Droplet Size Distributions: a) Comparison of Pneumatic Nozzle Atomizer under Pressure 0.01MPa with applied Voltage 15kV, b) Multi-hole EHDA under Voltage 15kV, Needle Gage 14, Electrode Distance 105mm according to various Feed Rate compared to SAFEX generator.



a) b) c)

Figure 2. 4% PVA Spray Characteristics: a) under Optimal Voltage Setup 15kV for Multi-Hole EHDA, visualization of the flow between two electrodes - here the ionic wind effect occurs, b) Simple Jet Atomizer with applied Pressure 0.01MPa, c) Simple Jet Atomizer 0.01MPa and 15kV.

Acknowledgement

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