Measured Velocities and Pressure Profile inside a Twin-Fluid Atomizer

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Abstract

Twin-fluid atomizers with internal mixing features show low energy requirement and small drop sizes compared to internal or orifice flow cross-sections. If the upstream pressure exceeds the critical pressure the mass flow rate becomes independent on the backpressure. The critical mass flow rate and the pressure drop inside the nozzles are measured for different operating parameters, like the liquid to gas mass flow rate ratio, properties of the liquid phase (density, viscosity and surface tension), the nozzle geometry and the installation of different inserts. The resulting flow conditions and pressure profiles are compared with established models. Drop size data are recorded with a laser diffraction analyzer (LDA) and are also presented for selected geometries.

Introduction

For optimizing twin-fluid atomizers with respect to their special industrial use, it is necessary to predict the flow conditions and the pressure profile inside the nozzle. Often twin-fluid atomizers are used for high upstream pressure and high liquid loads and the critical pressure is reached in the chocked channel or orifice. This leads to a higher pressure at the outlet of the atomizer as the environment atmosphere. Modeling the critical mass flow rate for complex geometries is very demanding. The study of Lörcher [1] compares the results of different models for calculating the maximum mass flow rate with measured flow rates. The accuracy of the used models differs depending on the geometry. The model of Leung and Epstein and the model of Richter frequently but not always lead to good results. In the study of Moncalvo [6] the so-called “Omega Parameter” is introduced. The validation of their model results in a relatively good fit for different two-component flows. For spraying suspensions, in his study [7] and [8] F. Schmidt compares the models of Chawla and Böckh. The pressure course shows differences between the calculated and the measured data.

Materials and Methods

In the present work, liquid is sprayed by compressed air with a twin-fluid atomizer as shown in Figure 2. The gas enters through a side port into the mixing chamber. The liquid is introduced through a 2 mm capillary. The axial position of the capillary in the mixing chamber (with a diameter of 10 mm) is variable. The nozzle allows for a large variation of geometrical parameters as shape and distance of the liquid outlet to the chocked channel, nature and size of liquid outlet like frits or sharp capillary and duct or without flow restriction in front of the nozzle outlet.

The experimental setup is presented in Figure 1. The liquids, either water or a mixture of water and glycerin, are filled into the storage tank. The tank is pressurized and by opening the valve the liquid flows through the nozzle. The gas is supplied from gas cylinder. In both lines there are measurement points for the pressure and the volumetric flow rate. The observed operating parameters cover pressures up to 1.2 MPa and for the liquid volumetric flow rates up to 0.3 m^3/h. The self-adjusting volumetric flow rate of the gas would be recorded.

In order to obtain insight into the mixing and flow process inside the twin-fluid atomizer, five measurement points for pressures are installed. Observation of the flow is also possible with a high-speed camera as the nozzle housing is transparent and made of acrylic glass. Information on the pressure drop inside the nozzle is obtained and the influence of the inserts. The last measurement point close to the nozzle outlet indicates the critical pressure drop.

The measured volumetric flow rates of both phases are used to compare the existing models for the maximum mass flow rate through two-component nozzles. The expansion model of Leung and Epstein [3] describes the one-dimensional isentropic flow. The second model considered is the expanding flow with the “Omega Parameter” [6]. Other models compared are the model of Chawla [2], the model of Böckh [1] and the model of Muschelknautz and Herold [5].

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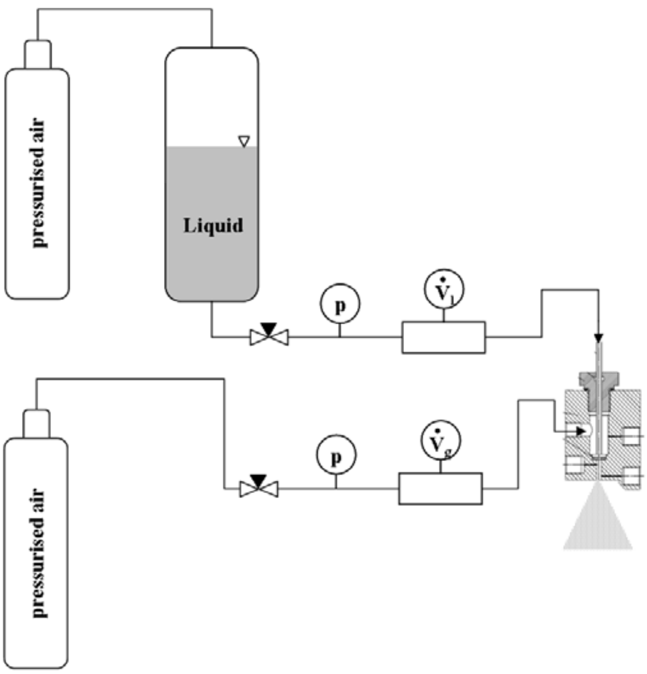

Figure 1. Experimental setup

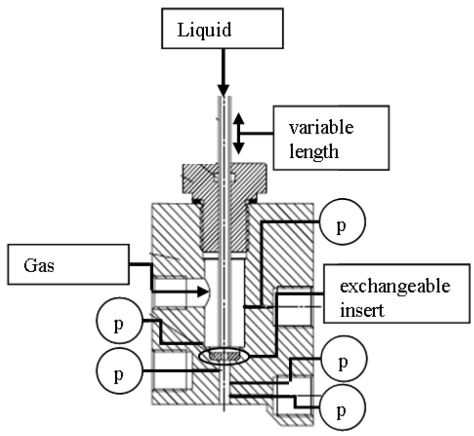

Figure 2. Model of the twin-fluid atomizer with the existing measurement points for pressure