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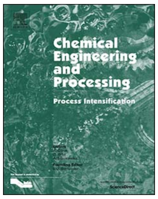

The concept design and study of twin-fluid effervescent atomizer with air stone aerator

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ABSTRACT

The work presents effervescent atomizer with air stone aerator. The aerator used air stone AS30 by Tetratec. porous stone with fine pores gives small resistance and allow to use the full power of the aerator. Measurements of the pressure drop and droplets sizes and spray angle produced by an effervescent twin-fluid atomizer with air stone aerator were carried out using the microphotography method. The tests were conducted from 0.05 to 0.3 (m3/h) and for liquid of 10 to 50 (l/h). The results showed that the drop of pressure increases with the rise of the gas flow rate and liquid flow rate. The discharge coefficient depends on the relation of the mass gas flow rate and the mass liquid flow rate. The spray angle increased with an increase in gas Reynolds number and with a decrease in liquid Reynolds number. Dimensionless equations were proposed that described the discharge coefficient and the spray angle. The obtained data is very important for atomizers designing, especially including some of twin-fluid atomizers.

1. Introduction

Spraying consists in transformation of a certain volume of the liquid into a set of fine droplets. The way of this transformation consists in disintegration of a stream of liquid into fragments that are further fragmented into droplets. Liquid atomization is one of the basic processes of chemical engineering and is used in various areas such as: construction, metallurgy, agriculture, technology, chemical engineering and environmental protection. Atomization is used to treat liquids, emulsions, suspensions and melted or powdered materials [1–7].

Most atomizers with air flow are atomizers with external mixing in which the liquid is transformed into a stream or a film before being in contact with the gas flowing at high rate. In atomizers with internal mixing, contact between the gas and the atomized liquid takes place inside the atomizer [1,2]. In pneumatic atomizers (air-blast and air-assist), the gas energy is used to disintegrate the liquid. In contrast to all other types of two-phase atomizers, in effervescent atomizers belonging to the group of atomizers with internal mixing, the dispersed gas is introduced to the liquid at a relatively low rate and ultimately forms a two-phase mixture flowing out from the outlet hole. The gas is partially dissolved in the liquid and is present in a form of bubbles [6–8]. Due to the relatively low density, the gas occupies a considerable part of the atomizer's cross-section. The atomization is improved by reducing the density and viscosity of the mixture and additionally, due to the fast increase of gas bubbles surrounded by the liquid at the outlet, which then are disintegrated, as a result of which the liquid is disintegrated into streams and droplets [8].

The analysis of scientific articles on two-phase atomization showed that the tests are carried out mainly with experimental methods. The main reason for this approach is a complex nature of the flow, interactions between the liquid phase and the gas phase and a complicated course of this phenomenon. Most works are fragmentary and cover only specific geometric solutions of atomizing systems and fail to thoroughly define the issue. The results of the tests shown in the literature were carried out for a wide range of varying operation and measurement characteristics. They indicate that the use of effervescent atomizers brings the following benefits in contrast to the conventional pressure, rotary and pneumatic atomizers [1,2]:

- gas flow rate in comparison to other two-phase atomizing systems [1,2] is very low;
- effervescent atomizers have a simple structure, require no maintenance, are durable, reliable and inexpensive [1,2];
- liquid flow rate from the outlet hole of the effervescent atomizer is

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relatively low when compared to the conventional atomizer (since the two-phase stream is compressed in the outlet hole more than the one-phase stream), which contributes to the lower erosion of the outlet hole and is important while atomizing a liquid having solids [1].

The greatest disadvantage of the effervescent atomization is the need to feed the atomizing system with a gas having a higher pressure.

Flow of the liquid from the atomizer hole and the shape of droplets formed are closely connected with the nature of the two-phase flow. The most typical flow in the two-phase atomization is a bubble flow. The structure in the two-phase flow [9] is shaped by forces acting on each phase, mainly by the forces of inertia and gravity, buoyant force, pressure, viscosity and surface tension. The spray angle of a stream of droplets of solutions with low viscosity such as water, is high. The impact of the flow structure inside the atomizer on the spray is shown in the work by Rahman et al. [10]. The work confirms the previous study by Huang et al. [11] and by Gadgil and Raghunandan [12]. They also determined the effect of the flow structure on the quality of sprayed liquid stream showing that the small gas bubbles present in the mixture contribute to better quality of the spray.

2. The aim of the study

The goal of this work is to analyse the flow resistances and liquid spray cone angles for the designed and constructed modified effervescent atomizer fitted with air stone aerator, achieved at variable values of gas and liquid flow rates and propose correlation equations describing the liquid discharge coefficient in *GLR* function and spray angle in the function of Reynolds number for the gas and liquid with dimensionless form.

3. Experimental set-up

Fig. 1 shows the diagram of a testing station. The most important elements of the measurement system are: effervescent sprayer, pressure drop meter, liquid rotameters, gas rotameters, compressor, pump, camera.

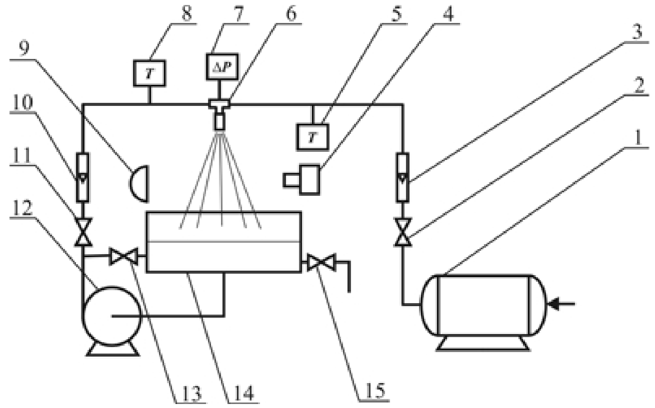

Fig. 1. Diagram of testing station: 1–compressor, 2–gas valve camera, 3–gas rotameter, 4–camera, 5–thermometer, 6–effervescent atomizer, 7–pressure drop meter, 8–thermometer, 9–stroboscopic lamp, 10–liquid rotameter, 11–liquid valve, 12–pump, 13–liquid valve, 14–tank, 15–outlet valve.

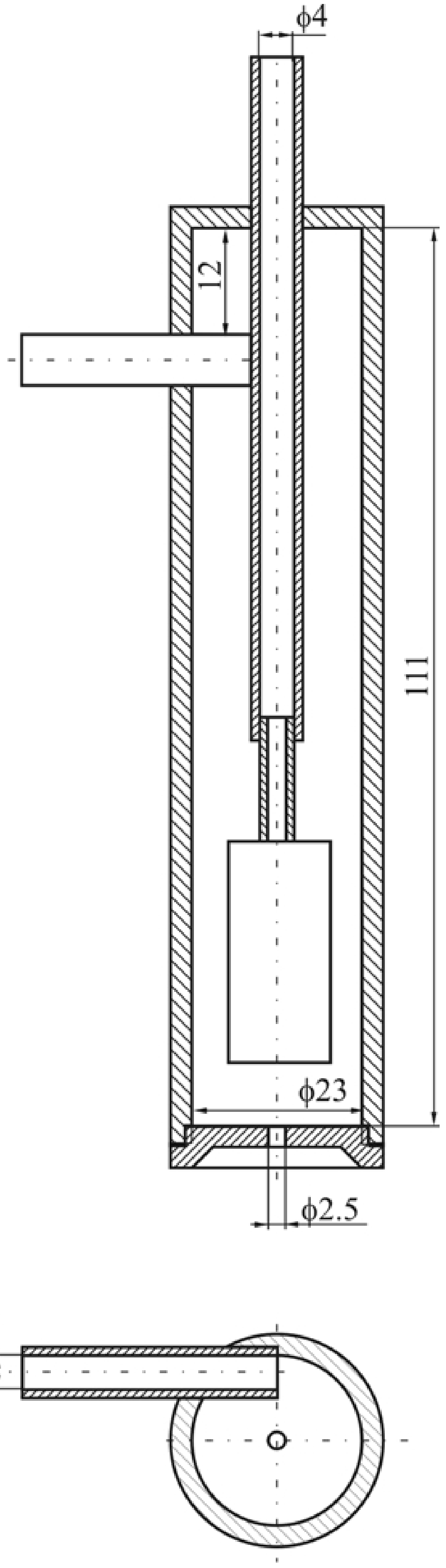

Fig. 2. Effervescent atomizer with air stone aerator.

Gas and liquid flow rates were determined using poppet valves. Gas and liquid was introduced through rotameters into the effervescent atomizer where the phases were mixed. The air was fed from Metabo 100L compressor to the VA-40 gas rotameters by Krohne Messtechnik GmbH&Co KG. Water was fed to two VA-40 liquid rotameters by Krohne using CHI 2–30 pump. The digital pressure meter DigiComb 1900 Tecsis GmbH was used to check the pressure drop values on the atomizer. Digital multichannel thermometer Center 309 delivered by Center was used to meter the temperature. Measurements were conducted at $T = 293 \pm 1$ K. Camera Canon EOS D1 Mark III was used to visualize the liquid stream from the analysed atomizer. The camera had Canon EF 28–135 mm f/3.5-5.6 EF IS USM lens. ISO was set to 1600 during the tests. Shutter opening time was 1/400 s. Light source used was a stroboscopic set DrelloScop 210 with LE 210-01 lamp with a flash