21st International Conference **ENGINEERING MECHANICS 2015**
Svratka, Czech Republic, May 11 –14, 2015
Paper **#110, pp. 204–205**

Influence of the Primary Breakup Conditions on the Droplet Size of the Spray Generated by Twin Fluid Atomizers

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Keywords: twin-fluid atomizers, Y-jet atomizer, effervescent atomizer, CFT atomizer, primary breakup, spray

Abstract: Main goal of this study is to relate the measured droplet sizes, characterized by the Sauter mean diameter (ID32), to the conditions of the primary breakup defined mainly by the Weber number (We). To compare different atomizing techniques, we investigated four twin-fluid atomizers with different mechanisms of internal mixing: Y-jet atomizer, outside in gas (OIG) and outside in liquid (OIL) effervescent atomizers and in-house invented CFT atomizer. Our results shows, that for the OIL, OIG and CFT atomizer a common relation between the working parameters (pressure drop- *Δp*, gas to liquid ratio- GLR) and measured droplets sizes, normalized regarding to the critical Weber Number (We_{crit}) in the primary breakup area, is found Increasing trend of the normalized droplet diameter with increasing GLR and *Δp* indicates the decreasing efficiency of atomization process, which is in accordance with current knowledge of energy conversion in twin fluid atomizers. The Y- jet atomizer shows a different trend which is related to the considerably lower We at primary breakup site.

Introduction

Atomization by twin fluid nozzles with internal mixing is a complex process which starts by injection of liquid and gas into a mixing chamber and finishes by ejection of the mixture and the formation of stable spherical droplets. This work describes the influence of primary breakup conditions on droplet size, which is a first approach in our effort to find a general link between the working parameters of selected atomizers and the quality of the spray (related to droplet size).

Experiment

Experiments were conducted on a cold test bench equipped with four twin fluid atomizers: Y-jet, OIL, OIG and CFT atomizer [Fig. 1]. The working parameters of the atomizers were defined by input pressure (Δp = 1.4 *MPa*) and gas to liquid ratio (GLR = 2.5, 5, 10 and 20 %). To investigate the effect of viscosity on the droplet size, two solutions of maltodextrin and de-ionized water (μ = 60 and 143 *mPa·s*) were used as the working liquids.

The primary breakup was investigated by the high-speed imagining. Captured images were processed to describe the breakup by dimensionless numbers [1]. Droplet size was measured by a laser diffraction system (Malvern Spraytec) at the distance 100 *mm* downstream to the discharge orifice. To find general relation for the droplet size, the measured Sauter mean diameter of the spray (ID32) was normalized by the value $d_{max} = We_{crit} \cdot \sigma / \rho \cdot \omega^2$, where σ denotes liquids surface tension, ρ denotes density of gas. Symbol ω is for liquid to gas velocity difference at the primary breakup site and the W_{ecrit} = 1.18 [2] denotes the critical Weber number of spherical droplets.

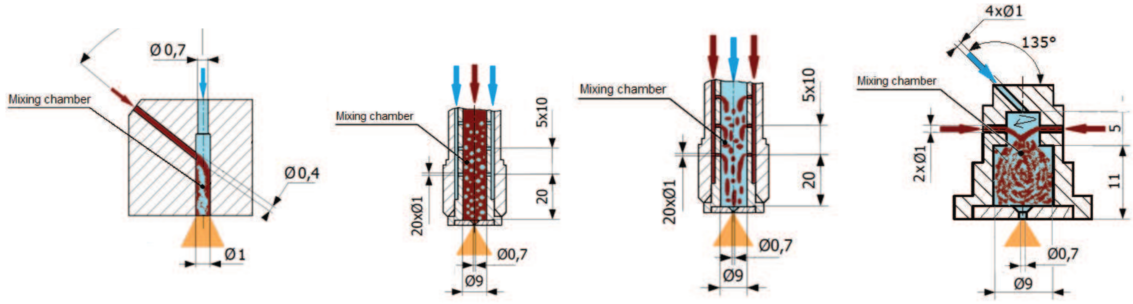

Fig. 1: Used atomizers, a) Y-jet atomizer, b) OIG atomizer, c) OIL atomizer, d) CFT atomizer

Results and discussion

Fig. 2 shows that for the OIG, OIL and the CFT atomizer a common relation between the working parameters of the atomizer (GLR, Δp) and the normalized spray drop size can be found for OIL, OIG and CFT atomizer. The Y-jet atomizer differs from the previous ones by design of the mixing chamber and internal flow, which leads to a different breakup mechanism from the other ones [1] and finally to a different relation of the normalized spray drop size on GLR.

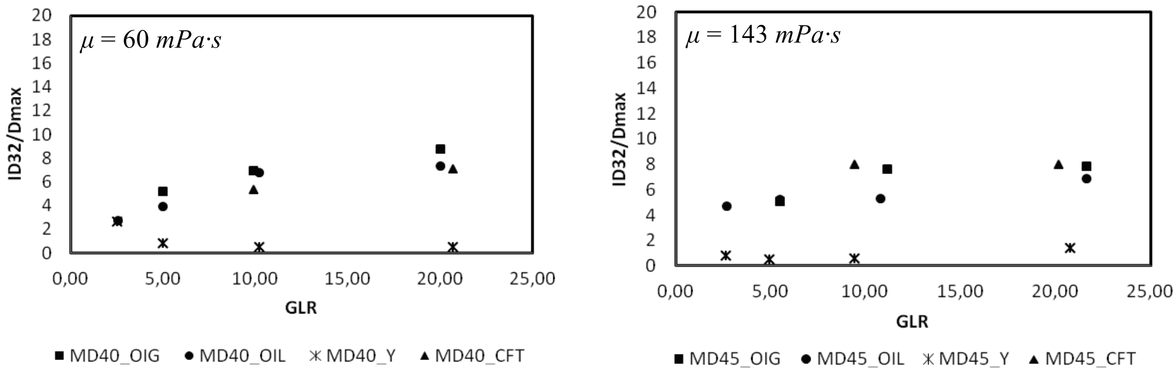

Fig. 2: Normalized droplet size for input pressure 0.14 *MPa*, $ID32/D_{max}$ [-], GLR [%]

Acknowledgement: Authors acknowledge financial support from project № 101/11/1264 funded by the Czech Grant Agency, from project NETME CENTRE PLUS (LO1202) co-funded by the Ministry of Education, Youth and Sports within the support programme „National Sustainability Programme I“ and project № CZ.1.07/2.3.00/30.0005 of Operational Program Education for Competitiveness of Ministry of Education, Youth and Sport of the Czech Republic.

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