Improving Swirl Atomizer Performance with Coanda-Deflection Outlets

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Abstract

In the present work, the application of the Coanda-effect on the sheet atomization at swirl atomizers is described. It can be used to reduce the mean drop size by increasing the spray angle above its limitation given by the swirl paramter. With swirl atomizers liquids can be sprayed with fairly low pressures. Commonly, they operate in the regime of sheet formation, leading to relatively small drop sizes compared to the nozzle orifice diameter. Reasonably narrow drop size distribution can be achieved. The drop sizes strongly depend on the initial liquid sheet thickness at the nozzle outlet, the sheet velocity and the sheet thinning effect due to the divergent spray propagation. It generally known, see e.g. [1], that a reduction of the sheet thickness and a spray angle increase can be achieved through an intensified swirl flow by modifying the nozzle geometry. Unfortunately the higher tangential velocities within the nozzle lead to higher friction losses, especially for viscous liquids, reducing the sheet velocity and thus increasing the mean drop size. It can be shown, that for each liquid viscosity and pressure, an optimum for the swirl intensity exists where the mean drop size reaches its lowest value.

A deflection outlet mounted below the orifice allows for enlargement of the spray angle up to $\Theta = 180°$ by the Coanda-effect as explained in [2]. The Coanda-outlet is a trumpet shaped outlet, like illustrated in the figure below, deflecting the sheet on a smaller radius R_C compared to the natural hyperboloid osculation radius R_H. The sheet then detaches from the trumpet at a sharp detachment edge. The advantage of the Coanda-design over the conventional sharp edged orifice is the higher energy efficiency, which allows for generating the same mean drop size with noticeable smaller liquid pressures. Also, the swirl atomizer application area is extended toward higher liquid viscosities, which otherwise could only be sprayed with disproportional high atomization pressures or using alternative atomizer designs. When Coanda-deflection outlets are considered the sheet velocity slowing down due to the additional contact area to the nozzle wall has to be analyzed. Choosing smaller deflection radii can reduce the contact area. However, reducing the ratio of the deflection radius to the sheet thickness $\delta_{0,C}$ below a certain value may lead to a premature film detachment and disintegration, which is usually unwanted.

The aim of the present work is to identify optimized Coanda-deflection geometries depending on of the swirl flow intensity, the liquid properties and the atomization pressure. In addition the influence of the ambient gas pressure on the sheet detaching behavior, which is quite unexplored so far, is analyzed.

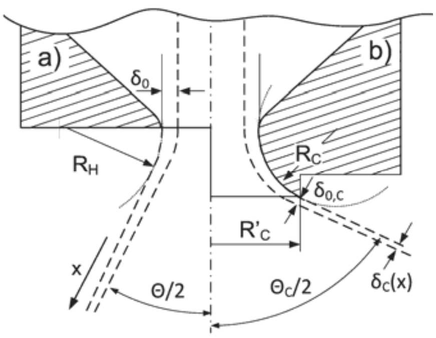

Figure:

Sheet detachment at the swirl atomizer orifice a) without - and b) with Coanda-deflection, R_H = hyperboloid osculation radius, R_C = Coanda-deflection radius, R'_C = Coanda detachment radius, Θ = Spray angle, Θ_C = Spray angle with Coanda-deflection, δ_0 = initial sheet thickness, $\delta_{0,C}$ = initial sheet thickness with Coanda-deflection, x = coordinate along the main sheet trajectory

[1] Lefebvre, A.H., *Atomization and Sprays*, Taylor & Francis, 1989

[2] Kistler, S.F., L.E. Scriven, The Teapot Effect: Sheet forming Flows with Deflection, Wetting and Hysteresis, *J. Fluid Mech.*, 263:19-62, 1994

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