Designing Thread forming Rotary Atomizers by Similarity Trials

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Abstract

Rotary atomizers operated in the regime of laminar thread disintegration can be used for the production of sprays with narrow distributed droplet sizes. The liquid threads formed are attenuated due to centrifugal acceleration and small drop sizes can be achieved, compared to the thread detachment diameter.

LAMROT can hold the desired break-up mode for an extensive range of liquid feed rates and revolution rates. This kind of rotary atomizer has a low plugging tendency and can be designed according to the principles described in [1]. For process design the mean drop size $d_{50,3}$ of the spray and the droplet *span*, representing the width of the droplet size distribution (DSD), have to be known.

The present work demonstrates how the operating parameters in spiraling thread atomization, i.e. volumetric flowrate and atomizer revolution rate, influence the drop size and size distribution. It is also demonstrated that similarity trials can be used for elaborating proper operating parameters.

In [2] we discussed the similarity of spiraling thread disintegration to the break-up of threads stretched in the field of gravity. As spiraling threads are subject to a gas-relative-velocity to the environmental gas, also in similarity trails a gas-crossflow to the threads must also be maintained. In [3] it was shown that thread break-up in the field of gravity is influenced by the non-dimensional volumetric flowrate $\dot{V}^*$, the non-dimensional viscosity μ^* and the gas-Weber-number We_g. $\dot{V}^*$ describes the influence of the flow momentum due to discharge and acceleration by gravity related to the capillary effect. The viscosity parameter μ^* represents the influence of viscous shear within the two-phase system. The gas-Weber-number We_g is defined as ratio of the dynamic gas pressure, caused by the gas-relative-velocity of the threads to the capillary pressure. For definition of the non-dimensional numbers, see Figure 1. The characteristic length of the system is given by the capillary length $L_c = (\sigma/\rho g)^{-0.5}$, scaling the equilibrium between hydrostatic pressure and capillary pressure. In [3] non-dimensional numbers were introduced and empirical correlations for non-dimensional thread break-up length, non-dimensional mean drop size d^* and droplet *span* were formulated.

In figure 1, experimental results from rotary atomization ($a = R\omega^2$) are shown and compared to the correlations formulated from the similarity experiments in the field of gravity ($a = g$). We_g is defined with the atomizer circumferential velocity $u = R\omega$ in order to describe the gas-relative-velocity of the spiraling threads. As figure 1 demonstrates a suitable coincidence of the data, the elaborated correlations can now be applied to the design of spray processes including spiraling thread disintegration. As an example the design of a spray drying process including a LAMROT atomizer for a given practical task will be discussed.

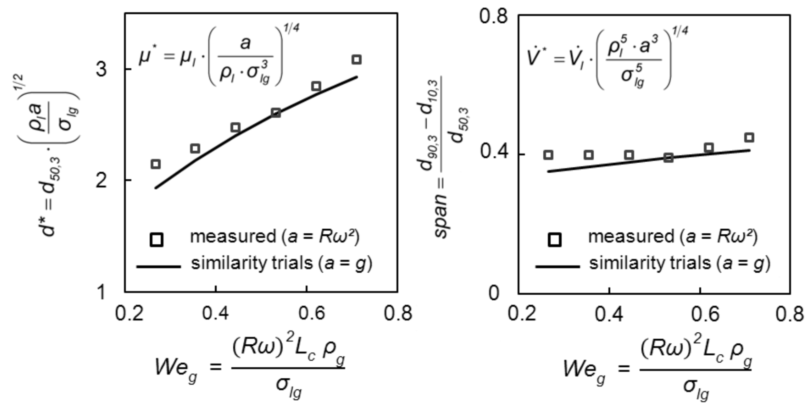

Figure 1: non-dimensional drop size d^* and droplet *span* for different gas-Weber-numbers We_g.
Comparison of rotary atomization experiments to calculated values. Experimental condition:
Glycerol/water-mixture, viscosity $\mu = 24$ mPas, atomizer diameter $D = 66{,}6$ mm, 40 threads per atomizer, liquid flowrate: 14,2 l/h, atomizer speed: $3000 < n < 8000$ rpm, Non-dimensional operating conditions: $0{,}24 < \mu^* < 0{,}4$ and $9{,}4 < \dot{V}^* < 42$.

[1] T. Schröder, P. Walzel, *Chem. Eng. Technol. 21-4*, 349-354, (1998).
[2] A. Mescher, P. Walzel, *ILASS - Europe 2010, 23rd Annual Conference on Liquid Atomization and Spray Systems*, Brno, Czech Republic, 5 - 8 September 2010.
[3] A. Mescher, A. Möller, P. Walzel, *ILASS - Europe 2011, 24rd Annual Conference on Liquid Atomization and Spray Systems*, Estoril (P), 05. – 07. September 2011.

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