A Point Sink Superposition Method for Predicting Droplet Interaction Effects During Vapor-Diffusion-Driven Dropwise Condensation in Humid Air

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Objective

Develop a reduced-order analytical method to calculate the condensation rate of individual droplets within a group of droplets on a surface by resolving the vapor concentration field in the surrounding air.

Approach

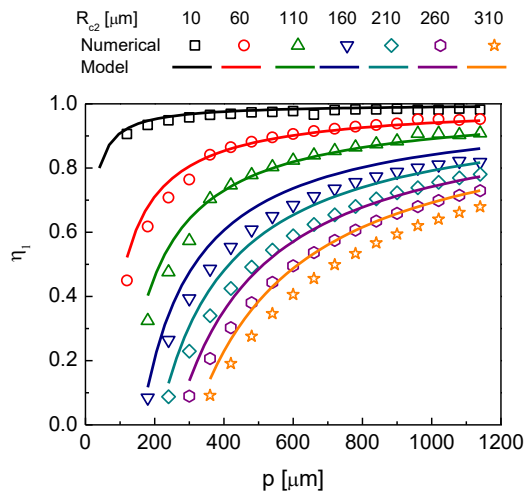
- Develop a superposition method for the solution of the diffusion equation for a single droplet
- Calculate the condensation rate of multiple droplets with varying size and pitch by using numerical simulation
- Compare condensation rates of individual droplets obtained from the numerical simulations and from the model

Results

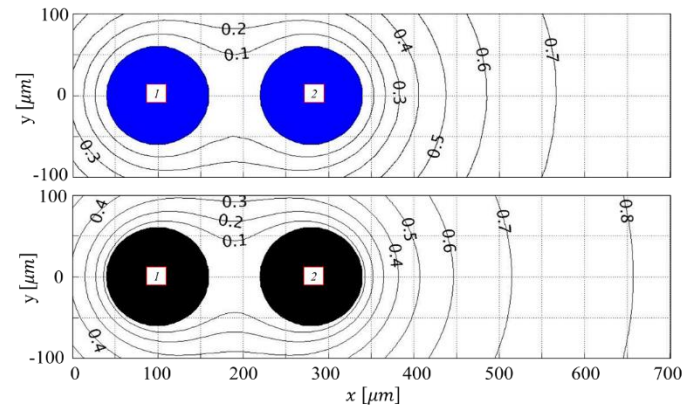
The condensation rate of the droplet within a system of multiple droplets can be obtained from:

$$\eta_i + \sum_{j=1, j\neq i}^{N} \eta_j \left(\frac{R_{cj}}{\left| \vec{r}_i - \vec{r}_j \right|} \right) = 1$$

where: $\eta = \dot{m}_{sys} / \dot{m}_{iso}$



Condensation rate correction factors for a small droplet in the vicinity of a the relatively larger neighbor droplet as function of the pitch.



Normalized vapor concentration field at the substrate plane for numerical simulations (top panel) and for the new point sink method-based prediction (bottom panel)

Impact

An accurate model for the time-evolution of dropwise condensation from humid air has can improve the design of industrial systems that involve condensation from humid air

Selected Publication

- J. E. Castillo and J. A. Weibel, International Journal of Heat and Mass Transfer, vol. 118, pp. 708–719, 2018.

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