Numerical Studies on the Deposition and Transport of Water Mist Normal to a Horizontal Plate

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The deposition and transport of fine droplets in a water mist flowing downwards onto a horizontal plate are modeled numerically in this study. It reveals the aerodynamic process of droplets impacting to the top of a compartment or an object. The nature of the droplets transport phenomenon in the wake region behind an object is also investigated.

The computation is conducted in a 2-D flow field. The turbulent gas flow is modeled using the two-equation k-ε method in an Eulerian coordinate; however, the droplets are traced stochastically in a Lagrangian coordinate. Droplet dispersion is obtained by considering the interaction (2-way coupling) between the gas turbulent eddies and droplet trajectories.

The plate, where deposition occurs, is positioned horizontally with the gas streams coming from the top. In this study, the length of the plate is 0.75 m and the incoming gas velocity is 1 m/s. Droplets are introduced at the top of the flow field, which is primarily a stagnation-point flow. Both 50 μm and 200 μm droplets are studied for comparison.

In stagnant air, the terminal velocities for both the 50 μm and 200 μm droplets are found to be 0.075 m/s and 0.579 m/s, respectively, due to their difference in mass (inertia). Even though droplets are injected at the same rate, 200 μm droplets would move faster across the flow field.

Figure 1 shows a typical result of the deposition pattern of 50 μm droplets on the horizontal plate. It indicates higher mass flux depositions at both edges. It is also found that the deposition near the edges of the plate are mostly in the form of tangential impactions.

Below the plate, a flow recirculation zone appears with its size comparable to the plate. Figure 2 shows the gas flow streamlines together with the instantaneous distribution of the droplets in the field. Right below the plate, very little number of droplets can be swept into the recirculation zone due to their inertia effects.

The flow wake also shows oscillatory motion in time. In the wake, turbulent diffusion shall allow droplets to migrate toward the centerline and eventually may merge together to close the spray wake. However, the droplets in the spray may not follow the flow wake closely depending upon the size of the droplets and the flow condition. As shown in Figure 2, small droplets of 50 μm tend to follow the gas streams closely behind the wake than the large droplets of 200 μm. This is because when the droplet size is increased, its inertia effect becomes important that they do not follow closely to the gas streamlines. It can also be found that the number of 200 μm droplets in the flow field is considerably less than that for the 50 μm droplets because of the effect of terminal velocity.

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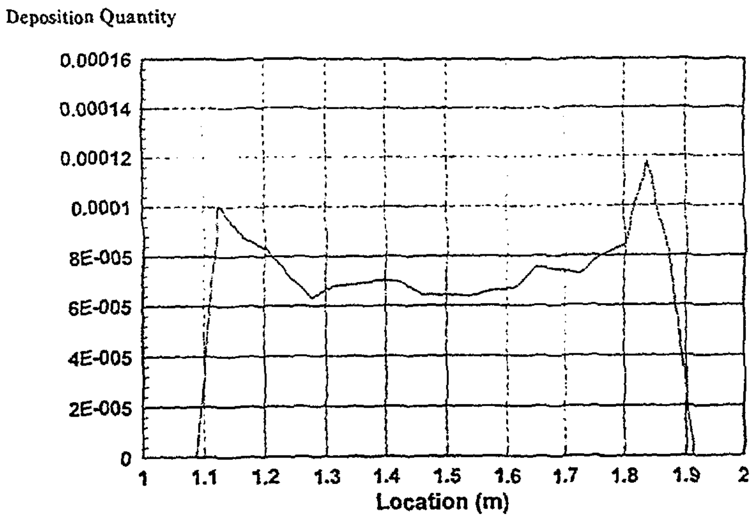

Figure 1 Deposition pattern of droplets onto a horizontal plate

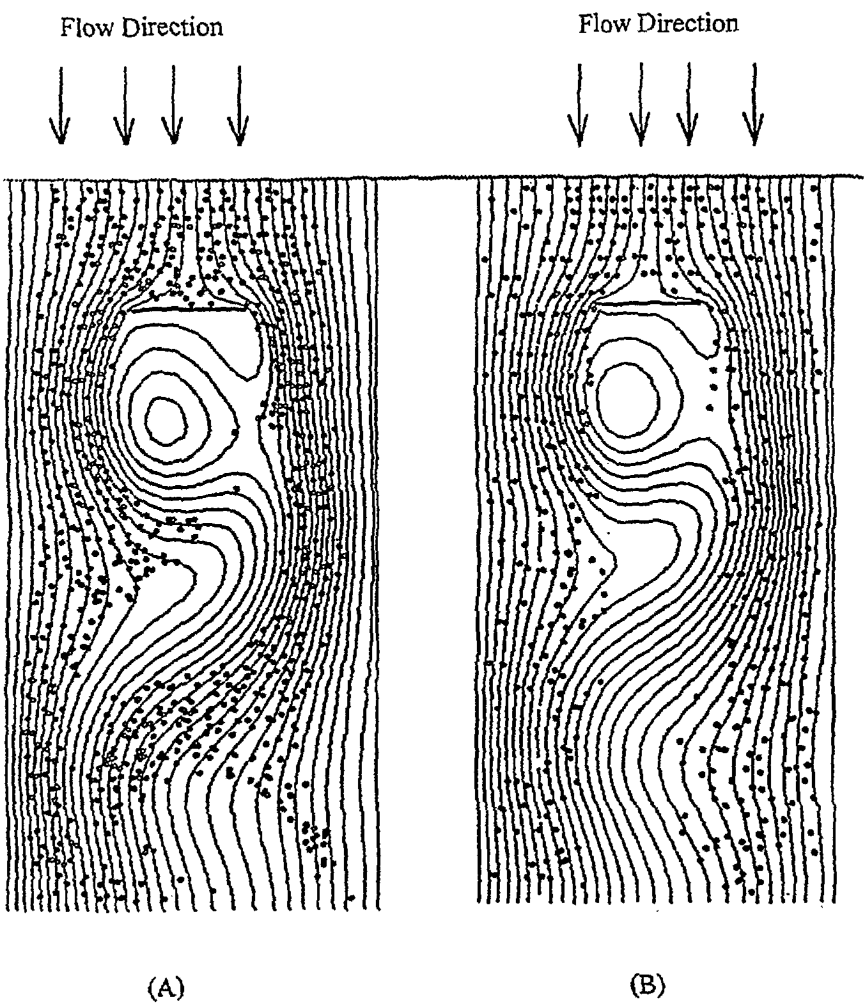

Figure 2 Effect of droplet size in the wake zone behind the plate
(A) 50 μm (B) 200 μm