**Evaluation of the Effect of UAV Rotor Wash on Atomization of Flat Fan Nozzles**

Brief Background

It is generally accepted that significant secondary breakup from air shear around a spray sheet occurs at airspeeds that exceed 40-50 mph. Recent publications examining UAV rotor wash have shown airspeeds lower than these thresholds, which can leave one to conclude that it has no significant impact on atomization. However, several recent field trials that examined deposits directly beneath UAVs found droplet sizes a size class finer than standard low-speed wind tunnel-based measurements would indicate. This begs the question then, does this rotor wash have an impact on the normal sheet breakup process because of the turbulent, often cyclonic air flows that surround the spray exiting the nozzle. Thus, this attempt to be understand these potential impacts.

This evaluation is complicated by the issue of measurement biases associated with laser diffraction-based systems and sprays where droplets of varying diameters have non-homogenous velocities. We leave it to the reader to read the numerous studies from the past several decades that discuss this issue in greater detail. It is of sufficient detail here to note that standard low speed wind tunnel methods use concurrent airflow parallel to the exiting spray sheet to attempt to maintain homogenous droplet velocities amongst the varying droplet sizes. This concurrent airflow is typically around 15-20 mph, though older work by the Spray Drift Task Force would suggest that even higher velocities, up to 40-50 mph, are needed to eliminate the spatial sampling bias, though that is not typically achievable in most existing facilities due to equipment limitations. Further complicating this issue, any testing done with a nozzle downstream of UAV rotor in operation will be subjected to any rotor induce airflow, which can range from 10-30 mph. The combination of these issues means any droplet size testing done to understand the UAV rotor affect will have to account for differences in sampling bias to compare the results as altering parameters like distance from rotor to nozzle, rotor RPM, and any potential concurrent airflow will directly impact the droplet diameter velocity distributions and thus the spatial sampling bias.

**Objective 1:** The initial phase of this project then is to develop a sampling and data analysis strategy that maximizes the measurement tools available to us to minimize spatial sampling bias to allow for discerning rotor wash impacts on breakup from flat fan nozzles.

Methods

Data was collected from a series of flat flan nozzles (the ASABE S572.3 nozzles) using both a laser diffraction and image-based system. Droplet size data was collected for each nozzle using both a full traverse of the spray plume through the measurement area and using a series of spot measurements along the full length of the spray fan. For the full traverse measurements, testing was done at 2 and 15 mph. For the spot measurements, all testing was done at 2 mph (This will likely need to also be done at 15 mph).

In addition to droplet sizing, each nozzle was tested on a patternator, which resulted in a physical measurement of the flowrate along the width of the spray pattern at the same distance from the nozzle as the droplet size data was collected. This data will be used to determine if the optical concentration data from the laser diffraction system and the flux data from the imaging system correlation to the measured flowrate. This data would then allow the spot data to be used to properly weight the spot data when calculating a conglomerate droplet size distribution representative of the entire spray sheet.

Steps:

* Input and preprocessing full traverse data from the LD (laser diffraction) and IM (image) based measurements for all nozzle and airspeed combinations.
* Develop diameter by velocity curves for each nozzle using the full traverse IM data.
* Apply a velocity weighted correction to the full traverse data from both the LD and IM systems for all nozzle/airspeed combinations.
* Input and preprocessing spot data from LD and IM based measurements for all nozzles (only on airspeed).
* Plot summary statistics for each nozzle as size by position from nozzle center.
* Plot patternator, LD optical concentration, and IM flux data and determine any correlations.
* Develop droplet diameter by velocity curves for each location (spot) data for each nozzle using the IM data.
* Determine full plume droplet size distribution by first applying a velocity weighting to each spot data, then average all spot data weighted by flowrates (optical concentration, flux) at each location.
* Compare all results and establish measurement protocol.
* NOTE: Additional data, particularly the spot data at the higher, 15 mph airspeed, will likely need to be collected to complete this data set and analysis.

Summary of data collected so far.

Sympatec data from a study comparing it to the Oxford Laser P15 data from the same study. The data is reference nozzle data evaluated in the low-speed wind tunnel. The following measurements and measurement conditions.

Sympatec:

All reference nozzles

- Full traverse at 1 and 2 in/s

- Every inch along the spray plume (Traverse Speed shown as 1 in/s should be 0)

Oxford Laser:

All reference nozzles

- Full traverse at 2 in/s

- Every inch along the spray plume (Traverse Speed shown as 1 in/s should be 0)

Patternator Data as done by UNL PAT Lab group.

Each reference nozzle was evaluated for spray deposit rate every inch along the spray plume at a height of 12 in. This data will be compared to the Sympatec optical concentration, and a flux value calculated from the Oxford Laser data.

Sympatec data diameter bins for the R7 lens (all in micrometers)

18, 22, 26, 30, 36, 44, 52, 62, 74, 86, 100, 120, 150, 180, 210, 250, 300, 360, 420, 500, 600, 720, 860, 1020, 1220, 1460, 1740, 2060, 2460, 2940, 3500