Droplet Size Spectra and Atomization Properties of Tank Mixes: Measurements and Analysis

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Abstract. *Fluid properties of tank mixes affect the resulting droplet size from ag spray nozzles. Applicators often do not know how a particular tank mix will behave when applied. Spray droplet size models do not account for mixtures of products and the relationships between fluid properties and atomization are complex and not completely understood. This paper reports work on developing a tool that can assess tank mix properties and predict spray characteristics to assist applicators in choosing nozzles or making other application decisions. The tool will use measurements of vibration of the fluid as it flows through a nozzle. Preliminary experiments have established relationships between vibration measurements and spray droplet size spectra from commonly used nozzles.*

Keywords. Spray, atomization, droplet, vibration, viscosity, surface tension, nozzle

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Introduction:

In many pesticide applications, spray droplet size is the most important variable in spray management and product performance. Spray tank additives or adjuvants play a role in enhancing the effectiveness of some pesticides and have the potential to play a critical role in spray droplet spectra. Mixtures of chemical formulations and spray adjuvants can have complex physical properties that are not only difficult to measure but are also difficult to predict the effects of on the spray droplet size.

What is needed by applicators is a field device to provide insight into the atomization and deposition characteristic of a particular spray tank mix in the field. By knowing the characteristics of the mix they can then choose the best management method and/or equipment (proper nozzle and spray conditions) to meet the label requirements of droplet size, optimize deposition and efficacy.

This paper reports continuing work on a simple tool that applicators could use to estimate atomization characteristics by measuring the vibration produced by fluids as they pass through a fluid orifice.

Goal:

The goal of this work is to develop a vibration measurement system to provide field and on-board indications of the atomization of spray tank mixes.

Methods:

A hand-powered fluid extraction and sampling tool was fabricated. By adapting a handheld lubrication pump, a system was built that removes a sample of tank mix from a sprayer tank, pumps the fluid through a test nozzle with an industrial accelerometer and returns the fluid to the spray tank. The configuration of the system is shown in Figure 1.

An on-board fluid diagnostic system was developed for installation on a commercial agricultural aircraft (Figure 2). The system consisted of a sampling line plumbed from the aircraft delivery system. The spray from the delivery system is controlled by a three way valve, returning spray to the hopper or through the test system. The test system consists of a rugged industrial accelerometer coupled to an orifice measuring vibration of the fluid as it flows through the system. Currently the fluid discharged and collected in a small reservoir. The system will be further refined to include a small pump to empty the fluid from the reservoir back to the spray tank. The resulting vibration of the fluid flow, indicating the fluid tank mix properties, is displayed on the small, handheld computer and can be stored for subsequent analysis. The on-board system is the first implementation of its kind for real time, fluid properties

System performance was investigated by conducting droplet size measurements using two contrasting fluids selected due to their similarity in conventionally-measured physical properties. Fluids were a 10% solution of glycerin into water (surface tension = 71.6 mN/m; shear viscosity = 1.20 mPaS) and a 1% solution of a long chain polymer spray adjuvant (Mist Control™, Miller Chemical, Inc. with surface tension = 72.3 mN/m; shear viscosity = 1.01 mPaS) into water. Droplet size data were collected using a Sympatec Helio KF system. Vibration data were collected by coupling the accelerometer to the nozzle retaining ring. System pressures were 40 and 80 psi using a flat fan nozzle (XR11005, Spraying Systems, Inc.).

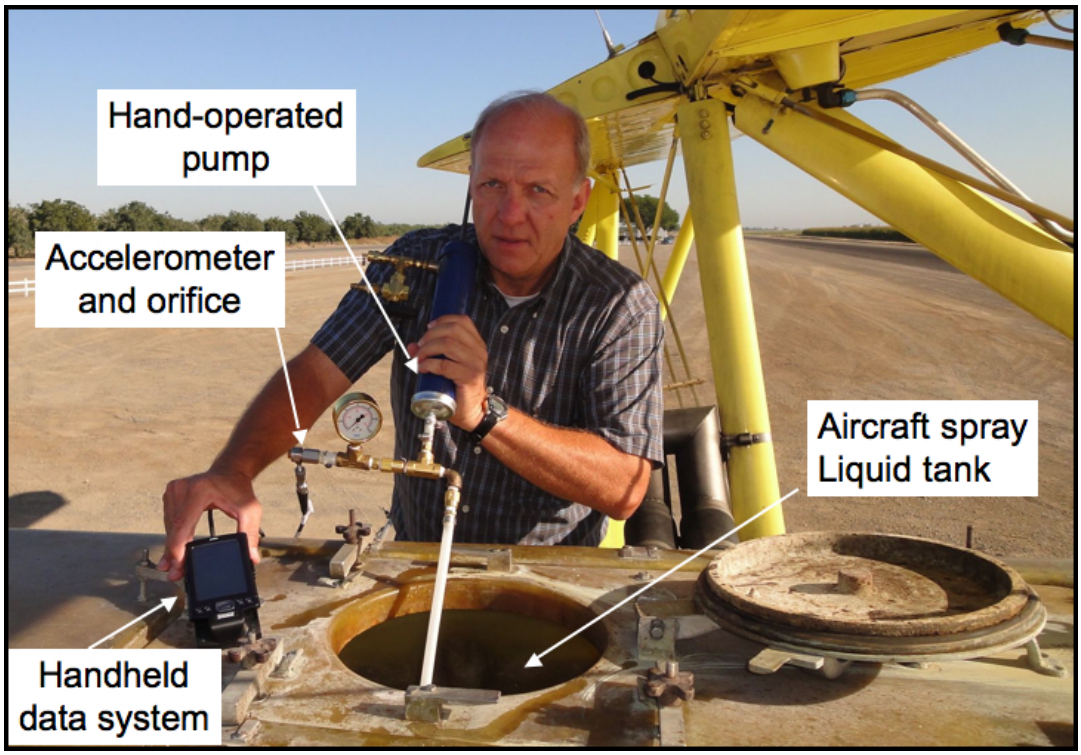

Figure 1. The field worthy fluid property diagnostic system as could be used to sample and characterize a mixed tank of spray fluid on an aircraft prior to application.

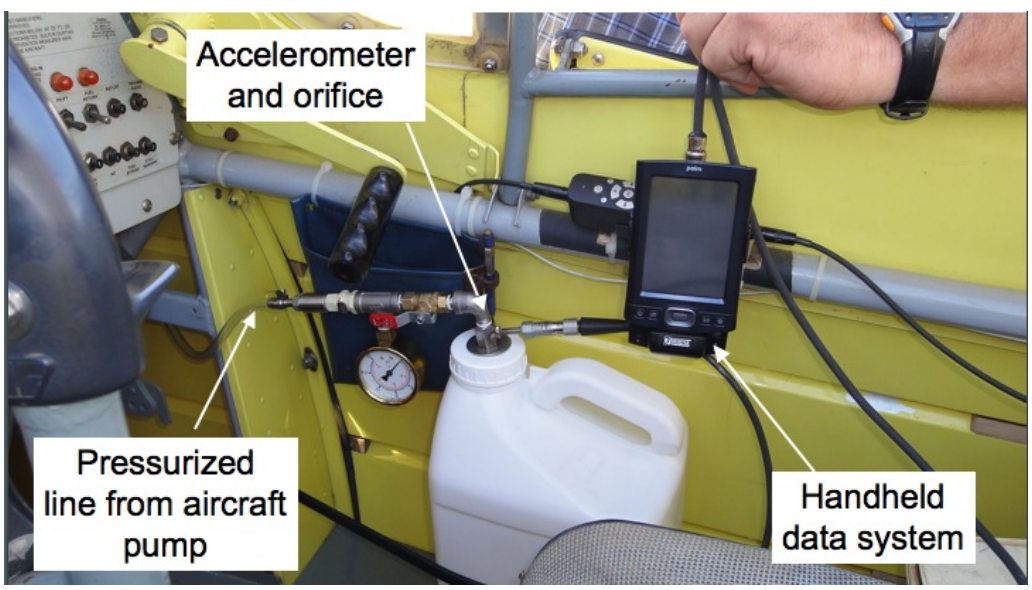

Figure 2. On-board, real-time fluid property monitoring system installed on an agricultural aircraft. Prototype system uses a small pilot line that supplies a sample flow of spray mix from the spray pump. The liquid is pumped through a test orifice and collected in a small reservoir for return to the spray tank.

Results and Conclusions:

The results of the droplet size measurements are shown in Figures 3 and 4. The effect of the polymer addition on the droplet size spectrum is clearly apparent with a significant increase in the droplet size. Vibration data are shown in Figure 5. The relationship between higher vibration and smaller droplet size was clearly observed.

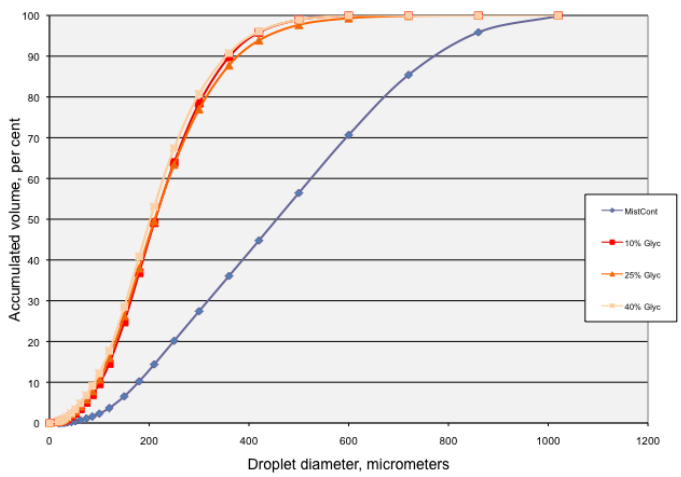

Figure 3. Droplet size spectra at 40 psi.

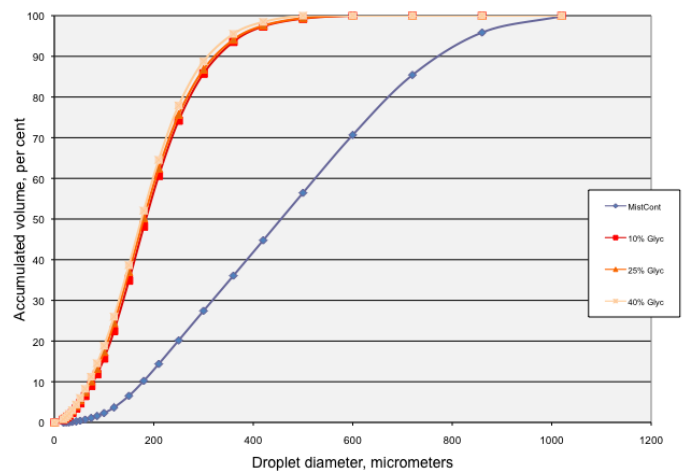

Figure 4. Droplet size spectra at 80 psi.

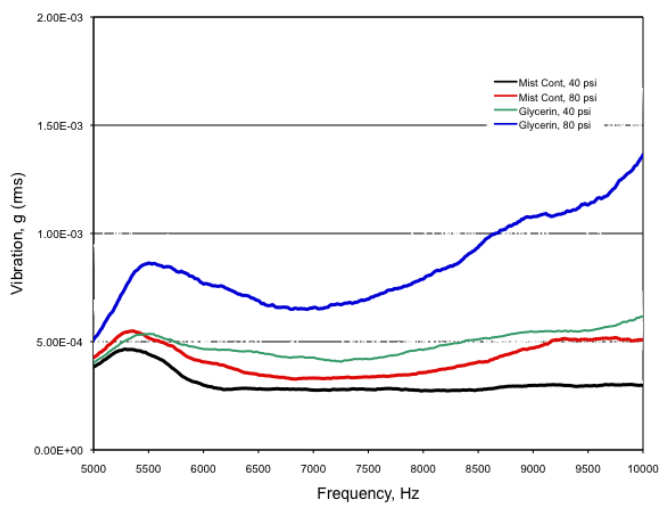

Figure 5. Vibration test data for test fluids and pressures.

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