

Measurement of a Large Scale Spray

Application Note PDPA-001

Sprays are an important part of our everyday lives, from the morning shower to the fuel injectors in our car's engine. But for fire suppression, having the right spray apparatus with the right suppressant liquid can mean the difference between life and death. Recent advances in manufacturing technology have made it possible to generate high-pressure sprays with compact and portable hardware, known as UHPS (Ultra-High Pressure System). This new type of fire suppression spray may be able to put out fires using less water in less time. In foam generation mode these new high-pressure devices can quickly create a layer of smothering foam, for putting out flammable liquid fires. Figure 1 shows a UHPS mounted on an all terrain vehicle (ATV), a completely self-contained system for response to remote and inaccessible areas. This UHPS had a variable atomizer nozzle, which allowed infinite adjustment from a narrow stream to a conical spray.



Figure 1: UHPS mounted to an ATV (courtesy of Rosenbauer America Inc.)

A TSI PDPA (Phase Doppler Particle Analyzer) system was used to analyze the water and foaming sprays from a UHPS unit. A two-component PDPA system was set up using a FSA4000-2P with a PDM 1000-2P detector module. Optics consisted of a TR260 transceiver probe and RV2070 receiver probe with 25 μm slit. Due to the large physical size of the sprays, a multi-Watt laser is required for illumination. A model LA6000 and FBL-2 multi-color beam generator were used as the light source. FLOWSIZER™ software was used to capture and analyze the data. Droplet diameter and 2 components (axial and radial) of velocity were measured. Satisfactory results were obtained at all measurement locations.



Figure 2: UHPS fire suppression spray (water) being measured by a TSI PDPA system

The UHPS sprays tested here used 11 MPa supply pressure, which resulted in a flow rate of approximately 40 L/min. Tap water and a variable amount of foaming agent (up to 3%) could be supplied to the atomizer nozzle. Measurements were done on pure water and 3% foaming agent sprays. The atomizer was set at both extremes, where measurements were made at various distances from the orifice ranging from about 1 cm to 1.3 m downstream. The transceiver and receiver probes were fastened to a rail and mounted in a vertical plane, to allow a horizontal spray direction, as shown in Fig. 2. The spray plume was about 6 m long.

Figure 3 shows a plot of axial (streamwise) spray droplet velocity as the measuring point was scanned across the spray plume. Measurements were acquired at about 4000 samples/sec. Velocities exceeding 130 m/s were measured in the center region, and the Sauter mean diameter (D32) was 58.2 μm for this scan. A wide range of diameter were found at the edge regions, but a rather narrower range of smaller droplets were measured in the center region. Note that ligaments and irregular shaped parcels of liquid are not measured by the PDPA, while the presence of >120 m/s velocities suggests that the potential core persists at 60 cm downstream. We would expect droplets to be shed from the outer “layers” of this liquid core. Measurements were also performed on the wide-cone spray with and without foaming agent. Figures 4 and 5 show the diameter histograms for this comparison. The water spray showed larger diameters, DV50 of 77.1 μm compared to 54.4 μm for the 3% foaming agent spray. D32 was 13 μm higher for the water spray as well. These results show that a PDPA can be used to make successful measurements of a large-scale high pressure spray of water and foaming agent.

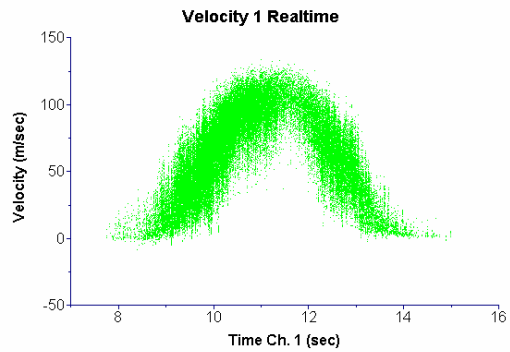


Figure 3: Centerline axial velocity scan of narrow cone spray, 60 cm downstream, as measured by a TSI PDPA system

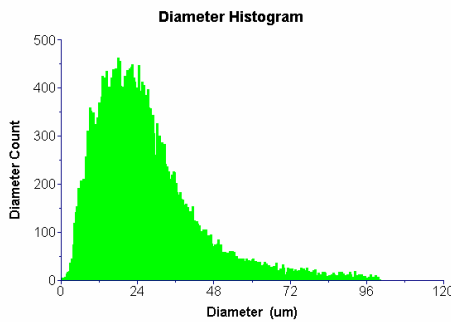


Figure 4: Diameter histogram for full-cone water spray taken at 30 cm downstream

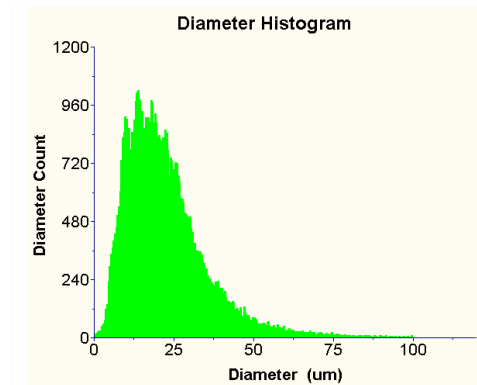


Figure 5: Diameter histogram for full-cone 3% foaming agent spray taken at 30 cm downstream

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