# PDPA MEASUREMENTS OF A COMMON RAIL DIESEL SPRAY

APPLICATION NOTE PDPA-008

In this time of unstable petroleum prices and concern for renewable energy and pollutant emissions, it is becoming more important than ever to achieve clean, efficient combustion in compression ignition engines. In the past, fuel injection systems were of the pump-line-nozzle type; a purely mechanical system. Injection pressures were generally under 100 Ma, and the fuel injectors were also predominately mechanical. A lot has changed in the past ten years. Fuel injection systems are now electronically controlled and pressures are approaching 200 MPa injection pressure. Piezo injectors are allowing multi-shot injections due to their fast response. All these changes are prompting many researchers to make a renewed effort at phase Doppler particle analyzer (PDPA) measurements of fuel sprays from modern fuel injection systems. Modeling efforts also need measured data to benchmark and tune the variables.

The Internal Combustion Engine Research Center of the Centro Motores Thermicos (CMT) at the Polytechnic University of Valencia in Spain utilizes a 1D PDPA, equipped with a 5W laser, XPD50-E beam expander, and FSA 4000-1P signal processor. Signals are captured by a RV1070 receiver and sent to a PDM1000-1P detector module. FLOWSIZER™ software is used to capture and analyze the data. These components provide high laser power, small measurement region, and high-speed measurement capability are required to make measurements in the highly dense and high speed fuel sprays generated by common rail systems. Key signal processor features, such as ***patented*** dynamic sampling rate selection, burst centering, SNR-based burst detection, and ***patented*** intensity validation enable the PDPA to make accurate and detailed measurements. The fact that intensity validation provides a totally independent measure of the droplet diameter means this validation technique results in more robust data in challenging diesel spray environments.

The FSA 4000's 800 MHz maximum sampling rate allows more accurate measurements on ultra-short Doppler bursts, even down to 50 ns!

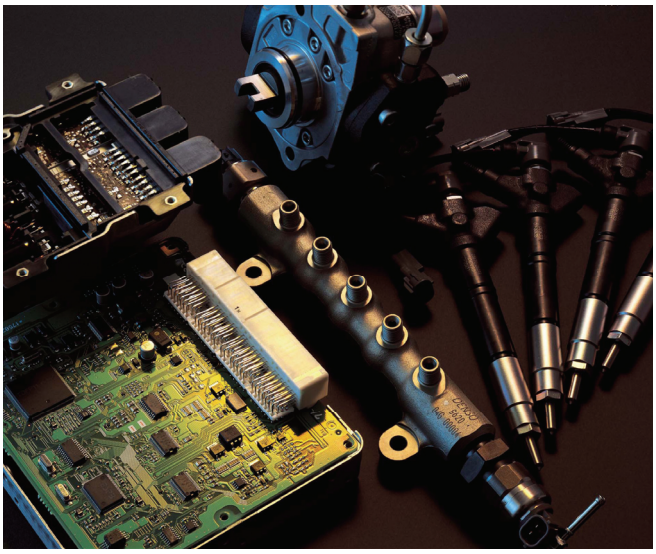

**Figure 1:** Common rail fuel injector system
*Courtesy Denso America Inc.*

The PDPA was designed to measure droplet size, velocity, concentration, flux, and a host of diameter statistics like the Sauter mean diameter and various volume mean diameters. Results from a fuel spray directed into a sulfur hexafluoride (SF6) high-density enclosure are shown in Figures 2 and 3. We notice that intensity validation results in a very smooth volume distribution, which indicates high data quality and reliability. These results illustrate some of the spray data one can obtain with a TSI PDPA for a common rail diesel fuel spray.

More results from CMT can be found at http://dx.doi.org/10.1115/1.2062767 and at www.upv.es/entidades/DMMT/.

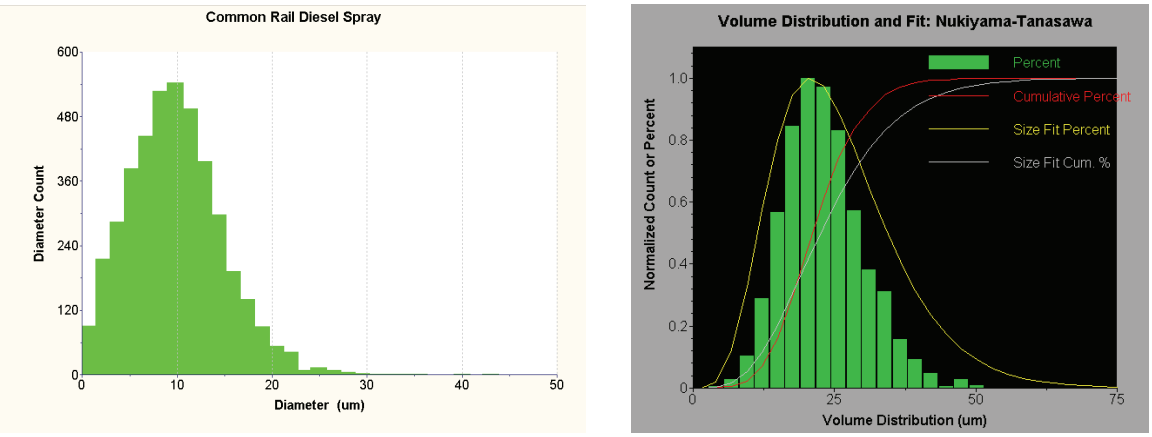


**Figure 2:** Measured diameter histogram (left) and volume distribution (right) for a common rail diesel fuel spray. *Courtesy CMT at Polytechnic Univ. Valencia.*

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|---|---|
| x | 23.64 |
| q | 3.95 |
| LWC (g/m3) | 31.0776 |
| Volume Flux X (cc/cm2 s) | 0.0586 |
| Volume Flux Y (cc/cm2 s) | 0.0000 |
| Volume Flux Z (cc/cm2 s) | 0.0000 |
| Volume 1 (%) | 7.39 |
| Volume 10 (%) | 13.37 |
| Volume 50 (%) | 21.54 |
| Volume 90 (%) | 29.19 |
| Volume 99 (%) | 34.79 |
| Total Particle Conc.(1/cc) | 9762.7988 |

**Figure 3:** Measured volume statistics for a common rail diesel fuel spray. *Courtesy CMT at Polytechnic Univ. Valencia.*