Simultaneous Measurement of Evaporating Droplet Diameter Using Phase Doppler Anemometry and High-speed Camera

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In order to understand the spray characteristics formed by PFI injector, many investigations of gasoline injection sprays using several measurement techniques like laser sheet method with high-speed camera, laser-induced (exciplex) fluorescence (LIF), laser and phase Doppler anemometor (LDV/PDA), particle image velocimetry (PIV) have been carried out for better control of spray and combustion characteristics. However, one of the key processes affecting spray behavior is the primary spray break-up, because it defines the starting conditions for the spray distribution, the evaporation process, and mixture formation. Liquid fuel forms the liquid column very close to the nozzle exit, and then makes liquid ligament and droplets due to the break-up of liquid ligament. Droplets, which were formed by the break-up of liquid ligament, were non-spherical shape. Therefore detection of non-spherical droplets was needed to understand break-up of liquid ligament. Some of the authors discussed primary fuel break-up very close to nozzle exit using high-speed video camera with long-distance microscope. Jet breakup and droplets breakup have been visualized using photographic method. Droplet stroboscope techniques, which are good for freezing the movement, have been usually used for droplet deformation process and droplet breakup. On the other hand, Dual-PDA system can measure the non-spherical droplets. Dual PDA system combines two-detector standard PDA and a planer PDA. In the standard PDA, the detectors are arranged at an off-axis angle perpendicular to the plane of the transmitting beams, on the other hand, in the planar PDA, the detectors are put in the same plane of transmitting beams. This combination allows us to measure the sphericity of droplets.

The purpose of this study is to investigate measurement accuracy of evaporating droplet (ethanol) diameter and sphericity measured by Dual PDA with comparing to visualization result using CCD camera with long-distance microscope. Measurement accuracy of PDA is not unclear in primary atomization region of PFI injector and non-spherical droplet. Dual PDA can measure droplet's vertical and horizontal sphericity. Simultaneous measurement of Dual PDA and visualization using CCD camera with long-distance microscope is necessary for understanding of measurement accuracy of Dual PDA. Single ethanol droplet is formed by ultrasonic levitator (vibrating frequency: 60 kHz). Levitated droplet is evaporated in time. Measurement accuracy of droplet diameter and sphericity of evaporating ethanol droplet using Dual PDA is discussed. Three main conclusions can be drawn in this research. Dual PDA can measure the droplet diameter of evaporating droplet avoiding 2π ambiguity. Measurement error due to 2π ambiguity in Dual PDA can be understood for larger droplet over maximum measurable droplet diameter. It is possible to measure droplet sphericity using Dual PDA. However, further consideration for more oblate droplet should be needed to discuss the measurement accuracy of droplet sphericity using Dual PDA precisely.

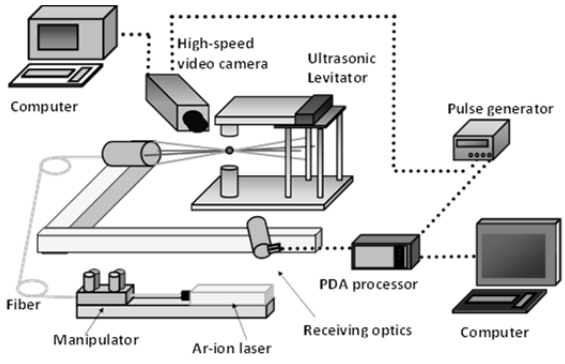

Fig.4 Experimental setup

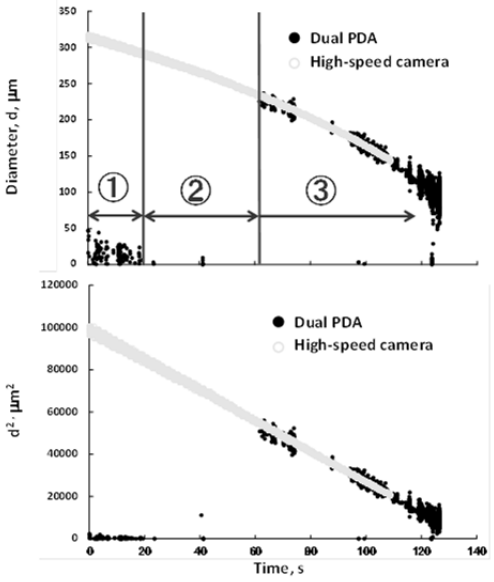

Fig.9 Time variation of droplet diameter under the condition #2

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