LIF를 이용한 DISI-엔진 내부의 분사연료의 정량적 분석

Laser Induced Exciplex Fluorescence (LIEF) Measurement for the Quantitative Analysis of Fuel Spray in a Direct-Injection Spark-Ignition (DISI) Gasoline Engine

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Two-dimensional slices of the cross-sectional distributions of fuel images in the combustion chamber of the Direct-Injection Spark-Ignition (DISI) gasoline engine were visualized quantitatively using a laser-induced exciplex (excited state complex) fluorescence technique. A new exciplex visualization system consisting of 5%DMA (N,N-dimethylaniline) and 5%1,4,6-TMN (trimethylnaphthalene) in 90%isooctane (2,2,4-trimethylpentane) fuel was employed.(1) In this method, the vapor phase was tagged by the monomer fluorescence while the liquid phase was tracked by the exciplex fluorescence with good spectral and spatial resolution. The direct calibration of the fluorescence intensity as a function of the fluorescing dopant concentrations then permitted the determination of quantitative concentration maps of liquid and vapor phases in the fuel. The 308 *nm* (XeCl) line of the Excimer laser was used to excite the doped molecules in the fuel and the resulting fluorescence images were obtained with an ICCD detector as a function of crank-angle degree (CAD).

Figure 1 shows the experimental schematic of an in-cylinder fuel calibration at a motored engine condition. The same experimental setup was used in the actual engine measurements. A pulsed Excimer laser, 308 *nm* (XeCl), was used as the excitation source, with a maximum power of 150 *mJ* per pulse at a maximum repetition rate of 250 *Hz*. The laser beam is formed by two pairs of cylindrical fused silica lenses into a sheet of light approximately 800 *um* thick by 50 *mm* wide, directed into the quartz cylinder. The final beam steering mirror (M3) moves the laser sheet through the quartz cylinder. All mirrors and lenses were anti-reflection coated. The sheet of light passes through the center of the fuel injector, which is located at the center of the cylinder axis. The fluorescence from the vapor or liquid was imaged by a quartz camera lens (Nikkor UV lens, 50 *mm*, f/11) onto a digital computer-controlled image acquisition system (Princeton Instruments CCD-576x384) equipped with a gated image intensifier. For the vapor phase, a band-pass filter (CVI Laser Model F35-355-4), centered at 339 *nm* with 12 *nm* FWHM, was used and for the liquid phase, a long-pass filter (Corion LL-400-S), which has cutoff wavelength around 400 *nm*, was employed. Therefore, the cross-talk effect existing on both the vapor and liquid phase fluorescence can be minimized. With this configuration, an area of the fluorescent image approximately 39 *um* (wide) x 39 *um* (long) was focused onto a single pixel (23 *um* x 23 *um*) of the ICCD detector. Fluorescence quenching by oxygen can be a serious problem, especially for the vapor phase. The quenching of the liquid phase fluorescence is much less of a problem since the dissolved oxygen can be purged from the fuel prior to the experiment and any atmospheric oxygen will not have sufficient time to diffuse into the drop during the short droplet lifetime,(2) Therefore, nitrogen environment was provided in the quartz cylinder throughout the experiment.

Figure 2 shows typical images of vapor and liquid phase fuel distribution taken at 300 Crank Angle Degrees (CAD) after the start of fuel injection. The in-cylinder measurements revealed that both the liquid and vapor phases showed cycle-to-cycle variations. However, the liquid phase showed much more cyclic variation. The life span of most of the liquid phase was relatively short, i.e., during the intake stroke most of the liquid was vaporized. This is believed to be due to convectional heat transfer, which results in rapid evaporation of the liquid fuel resulting from the turbulent airflow. In the early stage of the compression, the liquid phase was enhanced abruptly probably due to the liquefaction. Near the end of the intake stroke, most of the liquid phase fuel was vaporized; however, a very small mass of liquid still remained in the central part of the combustion chamber. The fuel distribution of the vapor phase differed from the liquid phase. As time proceeded, more vapor phase developed in the central part of the cylinder and eventually a very intense stratified charge developed near the injector. Although the stratification of vapor phase fuel as the piston approaches TDC is not well understood, a rich charge mixture near the spark plug can prevent the misfire. With a lean mixture, the stratification of charge around the spark plug is an important factor in the direct injection engine in improving fuel efficiency and reducing raw NOx emissions. The results demonstrated that at the end of the compression stroke, the liquid fuel was almost vaporized and the intense-stratified vapor phase charge was developed near the two spark plugs.

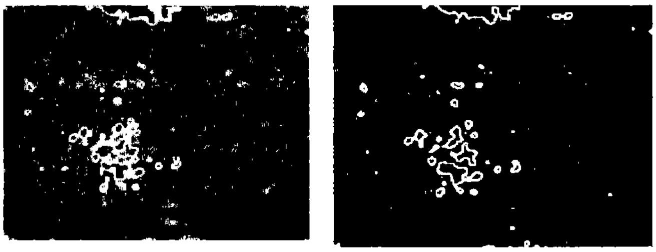

Fig. 2. Liquid Phase Fuel Distribution @300 CAD

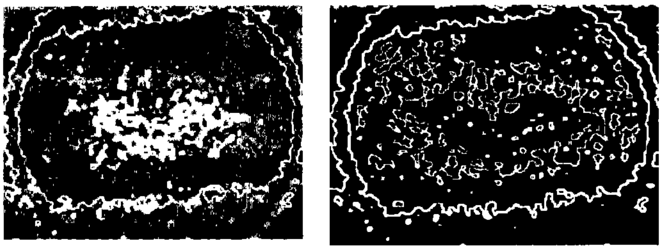

Fig. 2. Vapor Phase Fuel Distribution @300 CAD

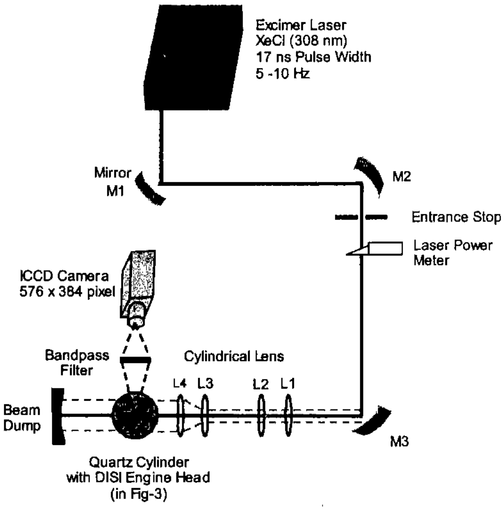

Fig. 1. Experimental Schematics

[References]

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