論 文 の 要 旨

題目　Characterization of Mixture Formation and Combustion Processes of Diesel Spray of Multi-Hole Injector with Split Injection Strategy

（多噴孔ディーゼルインジェクタ噴霧の分割噴射時の混合気形成と燃焼過程の特性解析）

さみーる ちゃんどら れい
氏名　SAMIR CHANDRA RAY

The fundamental concept of the Laser Absorption Scattering (LAS) technique is to understand the fuel concentration by attenuation of both visible and ultraviolet light. The intensity of visible light is only attenuated by the scattering of droplets, while that of ultraviolet light is attenuated by the scattering of droplets and the absorption of vapors. The temperature dependence of the absorbance of the tracer fuel used in the dual-wavelength laser absorption and scattering method. The absorbance was measured in this study to acquire the molar absorption coefficient that was used to calculate the concentration of the air-fuel mixture using the tracer LAS method. Moreover, the effect of atmospheric temperature and pressure on absorbance was investigated. The effects of the split ratio and dwell times on the mixture formation and combustion process of a diesel spray in a constant-volume chamber were experimentally investigated. The effects of the mass-dependent split ratio and dwell time were observed when the total fuel injection was 5.0 mg/hole. Three split ratios were considered: 3:7, 5:5, and 7:3, while the dwell time of 120 μs was fixed for every condition. Again, three dwell times were selected, i.e. 0.12, 0.32, and 0.54 ms, with a split ratio of 7:3. A laser absorption-scattering technique was adopted to examine the formation of mixtures with regarding to the equivalence ratio. A high-speed video camera was used to observe natural flame luminosity, and a two-color pyrometer system was employed to evaluate the temperature and soot concentrations in the flame. In the experiment, a commercial seven-hole injector with a hole diameter of 0.123 mm allowing high injection pressure up to 100 MPa was used to avoid the potential inconsistencies with single-hole test injector. The diesel surrogate fuel which consists of 97.5 % n-tridecane and 2.5 % of volume-based 1-methylnaphthalene was used. Among the distribution ratios tested in this study, the 7:3 split ratio exhibited the best performance for the lean mixture formation considering the overall equivalence ratio distribution. In the shortest dwell time of 0.12 ms, the equivalence ratio distribution decreases uniformly from the rich mixture region to the lean mixture region. The result also revealed that for the 7:3 split ratio, accelerated the soot deduction rate to the cycle of soot oxidation during the combustion period. Consequently, 0.12 ms can be considered the optimal dwell time due to the ignition delay and relatively low soot emission afforded. The conventional LAS uses the ND: YAG pulse laser, CCD cameras and one shot for one spray, which takes time and effort. Moreover, temporal variation measurement of a single shot spray is not possible by the conventional LAS. To record the distribution of the whole vapor phase in an injection event and measure the liquid and vapor concentration inside the spray, a high-speed laser absorption scattering (HS-LAS) technique was developed applying continuous diode light source, high-speed video cameras, and image intensifier for UV light, which can provide the temporal variation of a single shot spray.

The dissertation is organized in the following way to present this work: A review of previous work on the multiple injection technique, mixture formation characteristics, D. I. Diesel spray combustion techniques and the optical diagnostic techniques for spray and combustion are given in Chapter 1.

Chapter 2 describes experimental apparatus such as the high-pressure high temperature constant volume chamber, fuel injection system, injection rate measurement system. The principle of Laser Absorption Scattering technique, optical arrangement of the conventional LAS and the HS-LAS system are presented in this chapter. Multi-hole injector adaptor, Image processing area and constant volume spray chamber, natural luminosity recording system, Two-color pyrometry method and calibration method are mentioned.

Chapter 3 illuminates the vapor phase absorption spectrum of 1-methylnaphtalene and tracer fuel. The correlation between absorbance and concentration was found in this study. The molar absorptivity was found to have a low temperature dependence.

Chapter 4 clarifies the effects of split ratio and dwell time of diesel spray injection on mixture formation and combustion process. A laser absorption-scattering technique was adopted to examine the formation of mixtures with regarding to the equivalence ratio. A high-speed video camera was used to observe natural flame luminosity, and a two-color pyrometer system was employed to evaluate the temperature and soot concentrations in the flame. The integrated KL factor was derived in this paper by integrating the pixel values across the image. The average temperature is calculated by dividing the number of valid pixels by the summation of the temperatures inside them. These results were averaged across three separate runs under the same experimental setting.

Chapter 5 irradiates the high-speed laser absorption scattering (HS-LAS) imaging of evaporating diesel spray and mixture formation process. The injection amounts were set as 2.5 and 5.0 mg/hole to observe the effect of the injection mass on the diesel spray characteristics and mixture formation process by using this technique.

In Chapter 6, general conclusions on the mixture formation and combustion processes of the diesel spray with the split injection strategy and their temporal development / shot to shot variations are given.