学 位 論 文 要 旨

題　目：

Characterization of Internal Flow, Spray Evolution and Mixture Formation of Multi-Hole Nozzle for Diesel Engine

（ディーゼル機関用多噴孔ノズルの内部流れ，噴霧挙動，混合気形成に関する研究）

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The combustion process, emission formation, and the resulting engine performance in Diesel engines are well known to be governed mainly by the spray behaviors and the consequent mixture formation quality，in terms of the breakup, atomization, air entrainment, and mixture formation processes. One of the most determining factors that affect the spray development is the nozzle configuration, which can generate the absolutely different internal flow inside the nozzles. Originally, the single-hole Diesel injector was usually applied in fundamental research to provide insights into the spray characteristics. However, Multi-hole nozzles are used for actual Diesel engines to deliver the well atomized and adequate fuel under high injection pressure conditions. Therefore, the spray emerging from a realistic multi-hole nozzle approaches the practical engine operation situation better, and the spray behaviors injected by the practical multi-hole nozzle is worthwhile to be investigated.

This study focuses on the clarification of the characteristics of internal flow, spray break up and mixture formation of multi-hole nozzles (10 holes). The differences in the internal flow and spray evolution between the realistic multi-hole diesel injector and the traditional single-hole nozzle injector were confirmed firstly. Thereafter, various multi-hole nozzle geometrical design concept was evaluated under a series of engine dynamic operation conditions, which were set to reproduce the typical thermodynamic environment of near top dead center (TDC) in diesel engines. Specifically, the effect of rail pressure (80, 120, 180 MPa) and injection quantity (0.3, 2.0mm^3/hole) were paid attention to firstly, and then the multi-hole nozzles with different orifice diameter (0.07, 0.10, 0.133 mm), and different hole length (0.4, 0.6, 0.8 mm) were selected to acquire a better understanding about the nozzle geometrical design effect on spray behaviors. Additionally, the effect of multiple fuel injection, nozzle hole inlet roundness (0, 8, 16, 32 um), and K factor of the hole (-0.13, 0, 0.15) on the multi-hole nozzle internal flow properties was discussed numerically as well.

The BOSCH long tube method was applied to measurement the fuel injection rate under different conditions. Mie Scattering technique was implemented to obtain the information of Diesel spray emerging from different kinds of nozzles under the non-evaporation conditions. In addition, the dual-wavelength ultraviolet-visible Laser Absorption-Scattering (LAS) technique was adopted to analyze the mixture formation process of Diesel spray qualitatively and quantitatively under the evaporation condition. Moreover, the nozzle internal flow and spray were reproduced by the CFD simulation method under the corresponding conditions with the aim of providing integrated explanations and speculations for the mechanism behind the phenomenon observed in the experiments.

Finally, the nozzle geometrical design was correlated with the numerical and experimental results under aforementioned conditions. The result presented in this study was able to make contribution to improve the geometrical design and spray modeling accuracy of diesel multi-hole nozzles.