第５号様式

論文審査の要旨

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論　文　題　目

Characterization of Flat-Wall Impinging Fuel Spray under High-Pressure Cross-Flow Condition

(高圧横風気流中で平板に衝突する燃料噴霧の特性)

論文審査担当者

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〔論文審査の要旨〕

Owing to the advantages of good fuel economy and high thermal efficiency, direct injection (DI) gasoline engines have widely been applied in the automotive field. The DI gasoline engines include two combustion modes: stratified charge combustion and homogeneous combustion. In either mode, the air flow movement in the cylinder is strong enough to influence the fuel spray characteristics, such as spray profile, spray breakup, and fuel–air mixing. In addition, the fuel spray might impinge on the piston cavity wall before being fully vaporized due to the high injection pressure and small cylinder. Spray impingement usually influences fuel atomization and combustion, resulting in excessive hydrocarbon (HC) and soot emissions. To examine the effect of cross-flow on the impingement spray characteristics, such as the spray structure, droplet size and velocity distributions, a comprehensive experimental investigation was carried out in a high-pressure wind tunnel. The impingement spray images in a vertical plane and two horizontal planes were recorded by a high speed video camera and a laser sheet technology. By employing the particle image analysis (PIA) optical diagnostic method, the Sauter mean diameter (SMD) and the droplet velocity components were investigated. The detailed arrangement of this dissertation is summarized as following.

Chapter 1 is entitled "Introduction". Firstly, the background and motivation of this research was shown in this chapter. Then a review about the previous study was also introduced in this chapter.

Chapter 2 is entitled "Experimental Apparatus and Procedures". It presented the experimental setup applied in this study, such as cross-flow wind tunnel, fuel injection system, and the observation techniques for impingement spray.

Chapter 3 is entitled "Impingement Spray Structure in Vertical Plane". First of all, the effects of cross-flow velocity, ambient pressure and impingement distance on the spray structures in a vertical plane have been investigated by using VCO and Sac hole nozzles. And then, spray tip penetration and vortex height were obtained from the impingement spray images for quantitative analysis. A Contribution Index was utilized to evaluate the contribution of each condition to the effects on the spray tip penetration and vortex height.

Chapter 4 is entitled "Impingement Spray Structures in Horizontal Planes". The influences of the ambient pressure and cross-flow velocity on spray structure in horizontal planes have been experimentally investigated in this chapter by using a laser-sheet imaging technique. In the middle part of spray the images were taken in the horizontal plane of y = 25mm. And near the wall region the images were taken in 3 mm intervals (from y = 42 mm to y = 48 mm).

Chapter 5 is entitled "Droplet Size and Velocity Distribution of Impingement Spray". In this chapter, PIA optical diagnostic method was utilized to obtain the droplet images of local spray. The droplet size and velocity distribution of local spray were measured in various locations under cross-flow conditions. The droplets flow field distribution in the vertical plane were measured by PIV optical diagnostic method. The droplet velocity distribution in the wall-jet vortex was discussed in detail.

Chapter 6 is entitled "Near-Field Spray in Cross-Flow". The effects of cross-flow and ambient pressure on the near-field spray structure and droplet distribution were discussed in this chapter. The spray profiles at SOI, MOI and EOI under quiescent ambient and 5 m/s cross-flow with different ambient pressures have been descripted. Gray value distributions in the line of y = 3.75 mm under various cross-flow velocities and ambient pressures have been discussed. And the outlines of near-field spray in various cross-flow velocities plotted by colored curves are listed.

Chapter 7 is entitled "Numerical Simulation". The numerical simulations were conducted by the validated spray models based on the CONVERGE software. The simulation results about spray structures, spray tip penetration, vortex height and velocity distributions have been shown and compared with the experiment results.

Chapter 8 is entitled "Conclusions". The main findings of this work and general conclusions on the impingement spray characteristics are summarized, and several recommendation of future work was proposed in this chapter.

以上，審査の結果，本論文の著者は博士（工学）の学位を授与される十分な資格があるものと認められる。

備考：審査の要旨は，1,500 字以内とする。