論 文 の 要 旨

題 目　EXPERIMENTAL STUDY ON WALL HEAT TRANSFER OF DIESEL SPRAY FLAME IN TWO-DIMENSIONAL COMBUSTION CHAMBER OPERATED WITH RAPID COMPRESSION AND EXPANSION MACHINE

（急速圧縮膨張装置を用いた二次元燃焼室内ディーゼル噴霧火炎の壁面熱伝達に関する実験的研究）

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Reducing heat transfer during the spray combustion of diesel engines remains a challenging task. The thermal efficiency can be enhanced by minimizing heat transfer in the combustion chamber. Increasing common rail pressure can improve lean mixture formation before combustion. Additionally, a lean mixture can be achieved using a split injection strategy.

This study investigated the effect of number of holes injector on spray flame behavior, wall heat flux, soot emissions, and heat transfer phenomena of diesel engines at varying common rail pressures. A rapid compression and expansion machine (RCEM) was employed to simulate a single cycle of diesel spray combustion using split injection sprays. The two-dimensional (2D) stepped piston cavity is a uniquely shaped model used to describe the spray flame behavior in the combustion chamber. To investigate the heat transfer phenomena, a local wall heat flux sensor was installed in the cylinder (head and liner) and piston cavity (upper lip, lip, and bottom) to measure the heat flux distribution, and a diffused backlight illumination method was used to visualize the spray and flame behavior in the combustion chamber and 2D piston cavity.

The results indicated that, for both two-hole and six-hole injectors, the impingement flame surrounding the cylinder head contributed to the highest magnitude and longest duration of heat flux on the cylinder side due to the spray flame velocity, impingement, and residence time. Additionally, the higher temperature difference at the cavity bottom resulted in greater heat flux on the cavity side compared to the squish side. Higher injection pressure increased spray momentum and spray tip penetration, which led to a better air-fuel mixture, improved evaporation rate, and reduced flame residence time, thereby decreasing accumulated heat loss in the combustion chamber. Furthermore, lower common rail pressure induced a greater difference in the accumulated heat flux ratio than higher common rail pressure, attributed to the longer flame residence time in the combustion chamber. The results also showed that higher common rail pressures reduced combustion duration and soot emissions. Higher common rail pressure increased spray velocity, enhancing turbulence levels and resulting in higher peak values of wall heat flux. The highest peak value of wall heat flux was observed at the cylinder head due to the intense combustion region, followed by the cavity bottom due to the highest flame temperature occurring around this location. Additionally, the effect of the number of injector holes was examined in this study. The findings revealed that luminous flame appeared only at the cavity side wall with a two-hole injector, while with a six-hole injector, it was observed at the cavity side wall and near the injector holes. In the main result, common rail pressures 125 MPa and 120 MPa becomes the optimum for reducing the heat transfer which contributes to the increase the thermal efficiency for two-holes and six-holes injector, respectively. Moreover, the heat transfer phenomena in diesel engines were effectively represented by local Nu-Re correlations to confirm the heat transfer phenomena in diesel combustion chamber using RCEM. These results contribute to the increase the thermal efficiency of diesel combustion engines.