学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Study on Influence of Fuel Properties on Premixed Diesel Combustion
(予混合化ディーゼル燃焼の燃料性状依存性に関する研究)

Premixed diesel combustion, as a promising combustion concept to achieve low NOx and smoke emissions as well as high thermal efficiency, is paid much attention. Sufficiently long ignition delay is required for pre-mixture preparation to avoid over-rich mixture taking part in the combustion while the maximum pressure rise rate is suppressed to a tolerance level. Therefore, the operational load range of premixed diesel combustion with diesel fuel is limited at low and medium loads by the high pressure rise rate when increasing the fuelling rate per cycle. The results in recent researches indicate,by late injection strategy, with sufficiently low ignitability and high volatility fuel like gasoline, almost full operational load and speed ranges can be established in diesel engines with higher thermal efficiency and low emission levels. In this study, the influence of fuel properties including fuel ignitability, compositions and volatility on premixed diesel combustion is systematically investigated by experiments conducted on a single-cylinder, supercharged, four-stroke cycle, direct injection diesel engine with low pressure loop cooled EGR and common-rail fuel injection systems to obtain the optimal fuel properties for premixed diesel combustion.

Secondly, the stable premixed diesel operational range of intake oxygen concentrations for various indicated mean effective pressures (IMEP) was constraints of knocking (maximum pressure rise rate lower than 1.0 MPa/° CA), unstable combustion (the coefficient of variance (COV) in IMEP below 5

Influence of ignitability on premixed diesel combustion is firstly discussed with four primary reference fuels (PRFs) with octane numbers from 0 to 60. With increasing octane number, the combustion phasing is retarded and higher intake oxygen concentration can be used resulting in higher indicated thermal efficiencies due to the higher combustion efficiency and the larger maximum IMEP of the premixed diesel combustion. Silent, low NOx, and smokeless operation with a high thermal efficiency is possible up to 1.0 MPa IMEP using PRF with a research octane number of 40 when the intake oxygen concentration was optimized corresponding to IMEP.

Next, influence of the fuel compositions on premixed diesel combustion is investigated with the difference between PRF and normal heptane and toluene blend fuel (NTF) with the same research octane number as the PRF. Compared with PRFs, the stable operational ranges and optimum intake oxygen concentrations of premixed diesel combustion with NTFs with the same research octane numbers shift to the higher intake oxygen concentration side, showing lower ignition characteristics than PRFs. Slightly higher maximum IMEP can be achieved with NTF with premixed diesel combustion, compared with PRF of the same research octane number.

Influence of fuel volatility on operational range and combustion characteristics of premixed diesel combustion is investigated with normal heptane, PRF20 and an ordinary diesel fuel. The results show

the fuel volatility has little effect on the stable operational range and combustion characteristics of premixed diesel combustion. However, the best indicated thermal efficiency with the ordinary diesel fuel was lower than with PRF20 at the optimum intake oxygen concentration in a wide IMEP range, mainly due to the higher unknown loss. The unknown loss defined here includes the cooling loss (main component), the losses from unburned fuel entering the crank case and also the oxidized fuel after the apparent heat release in the cylinder during the expansion and exhaust strokes as well as in the exhaust manifold before the exhaust gas sampling. The deterioration of indicated thermal efficiency with the ordinary diesel fuel here is mainly due to the increased quantity of fuel which doesn ' t contribute to the effective combustion, as the high distillation components in diesel fuel adhere to the wall of the combustion chamber without evaporating.

Influence of fuel volatility on the thermal efficiency of premixed diesel combustion is investigated with three ordinary diesel fuels with different distillation temperature distributions and PRF20 as a high volatility fuel. With the premixed diesel combustion mode, regardless of injection timings, the indicated thermal efficiencies with the ordinary diesel fuels are lower than with PRF20 due to the higher unknown losses. With the conventional diesel combustion mode, the indicated thermal efficiencies with the ordinary diesel fuels and PRF20 are similar. These results suggest that the deterioration in the thermal efficiency in the premixed diesel combustion mode with the ordinary diesel fuel is mainly due to the adhesion of high distillation temperature components on the walls of the combustion chamber, and occurs mainly during the premixing period (between the end of fuel injection and the ignition); the larger amount of unburned fuel enters the crank case and the fuel oxidized after the apparent heat release in the cylinder do not contribute to the effective heat release.