SUMMARY OF Ph.D. DISSERTATION

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Title

Influence of the Fuel Compositions on the Homogeneous Charge Compression Ignition Combustion

Abstract

In the homogeneous charge compression ignition (HCCI) engine, which is expected as next generation engine to realize high efficiency and low pollution, homogeneous and lean pre-mixture of fuel and air is supplied into the combustion chamber and occurs auto-ignition resulting from compression. However, controlling auto-ignition timing, emitting unburned HC and CO and limited operating region due to knocking are longstanding problems. In this study, the method of mixing fuels with different reactivity was adopted to solve these problems. The objective of this study was an investigation of the effect of the different fuel compositions on HCCI combustion, and a clarification of the fuel condition to realize the engine operation with high thermal efficiency and high power output by controlling the mixing ratio of fuels.

Chapter 1 summarizes characteristics and problems of HCCI engine and shows objectives.

Chapter 2 describes the method of combustion experiment, the analyzing method of its data and the method of the numerical calculation with elementary reactions. This chapter also describes the characteristics of the fuels treated in this study.

In chapter 3, describes the oxidation reaction processes of the HCCI combustion when using only DME as the single fuel and the condition in order to keep high combustion efficiency. From the results of numerical calculations and experiments, reaching more than 1500K of the maximum temperature in the cycle enabled to complete the HCCI combustion. However, in the case of the HCCI combustion using the single fuel, the combustion reaction speed increased to occur knocking as the increase of the maximum temperature.

In chapter 4, it was investigated the effect of the mixing ratio of double componential fuels, such as methane/DME, methane/*n*-butane and methane/hydrogen, on the oxidation reaction processes by the numerical calculations with elementary reactions. First, in the calculation of constant volume condition, the relationship between the mixing ratios of double componential fuels and ignition delays was researched. Next, the calculation of the adiabatic compression process like HCCI engine was carried out. As a result, with the increase of methane, it was possible to retard ignition timing, using any combination of fuels. Furthermore, to keep high combustion efficiency and suppress the combustion reaction speed, it was necessary to delay the timing of 50% heat release to the expansion process, and the fuel combinations of methane/DME and methane/*n*-butane were effective.

Chapter 5 shows the relationship between the HCCI operating region and reaction start temperatures, indicated thermal efficiency, IMEP (indicated mean effective pressure), combustion efficiency and the timing of 50% heat release, from the results of the experiments using methane/DME and methane/*n*-butane. Using any combination of fuels, reaction start temperatures mostly depend on the mixing ratios of fuels. Using any combination of fuels, under the conditions whose the timings of 50% heat release were within the expansion stroke by controlling the mixing ratios, with high combustion efficiencies due to inlet heat quantity, it was possible to keep high thermal efficiency and high IMEP.

Chapter 6 summarizes acquired knowledge and concludes the study.