SUMMARY OF Ph.D. DISSERTATION

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Title

Autoignition and Combustion Mechanism of Natural Gas in a Homogeneous Charge Combustion Ignition Engine

Abstract

Homogeneous charge compression ignition (HCCI) engine is regarded as the next generation engine in terms of high thermal efficiency and low emissions of nitrogen oxide and particulate matter. However, it is difficult to control autoignition and combustion duration because they are controlled primarily by the chemical kinetics of air/fuel mixture. And also, it is problem of high unburnt hydrocarbon (HC) and CO emissions. To solve these problems, it is necessary to clear the control factors of autoignition and combustion duration and mechanism of oxidation reaction in an HCCI engine. Natural gas is supplied as city gas 13A in Japan. The composition of that varies production district of natural gas and manufacturing company. In this study, it is clarified that the control factors of autoignition and combustion duration, the operation condition to reduce the HC and CO emissions, the influence of natural gas composition variation on autoignition and combustion using experiment and elementary reactions calculation in a four-stroke HCCI engine.

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

Chapter 2 describes the experimental apparatus, fuel and analysis method.

Chapter 3 describes the control factors of autoignition and combustion duration, and the operation condition to reduce the HC and CO emission. When the in-cylinder gas temperature reaches 1080±15K, the autoignition of natural gas (13A) occur. To realize high thermal efficiency and low CO emission in an HCCI engine, it is necessary to prepare operation conditions that the maximum cycle temperature is over 1600K.

Chapter 4 describes the influence of natural gas composition variation on the characteristics of autoignition and combustion. It is investigated the influence of mole fractions of methane/ethane, methane/propane, methane/*iso*-butane and methane/*n*-butane air mixtures on autoignition temperature, autoignition timing and combustion duration. As the mole fraction of additive fuels increase, the autoignition temperature becomes lower, and the autoignition timing advances. This effect becomes smaller with increasing mole fraction of additive fuels.

Chapter 5 describes the chemical reaction mechanism of natural gas using zero dimensional elementary reaction. If the *n*-Butane adds to methane, the HCHO, H_2O_2 generated LTR of *n*-Butane accelerated the generation of OH radical, and initial reaction of methane is accelerated. The zero dimensional elementary reaction can estimate the characteristics of autoignition and combustion qualitatively in an HCCI engine.

Chapter 6 describes the influence of blend ratio on autoignition temperature, autoignition timing, combustion duration and operation region in Methane/Di-Methyl Ether (DME) air mixtures. DME has low temperature reaction (LTR) and much HCHO and H_2O_2 are produced in its oxidation process. If the blend ratio of DME control to occur the peak heat release of high temperature reaction (HTR) at expansion stroke, the operation region is expanded by the restraint of rapid heat release.

Chapter 7 summarizes the results of this study