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THE SUMMARY OF Ph.D. DISSERTATION

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Title

Study on Auto-Ignition and Combustion Mechanism of The HCCI Engine

Abstract

In the HCCI (Homogeneous Charge Compression Ignition) engine, fuel and air mixture are supplied to the cylinder and occurs auto-ignition resulting from compression. This method can expand the lean flammability limit, realize smoke less combustion and has also potential for realizing low NOx and high efficiency. The optimal ignition timing is demanded to keep high thermal efficiency. The Ignition in the HCCI engine largely depends on the chemical reaction between the fuel and the oxidizer. Physical methods in conventional engines cannot control it, so chemical method is demanded. Combustion duration is kept properly to avoid knocking. In addition, the amount of HC and CO emissions must be reduced. In this study, objectives are to clarify followings by the calculation with detailed chemical reactions, the chemical reaction mechanism, control factors of ignition timing and combustion speed and HC and CO emission mechanisms. Ignition and Combustion mechanism and effect of pre-mixture inhomogeneity on ignition and combustion are also clarified by measuring the luminescence at auto-ignition and combustion process by using an optical access engine.

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

Chapter 2, zero dimensional elementary reaction model and n-Butane as a fuel were selected to analyze the chemical reaction mechanism of auto-ignition and combustion. Adaptabilities of selected model to analyze auto-ignition and combustion in an engine were judged by comparing ignition delays of the shock tube and heat release of an engine experiment.

Chapter 3 describes the chemical reaction mechanism of n-Butane at engine condition. n-Butane is consumed by O2 addition to half, HCHO, H_2O_2 and CO are generated and small heat release occurs. Large heat release occurs as HCHO and H_2O_2 decrease rapidly, chemical reaction is completed as CO oxidation. The chemical reaction mechanism at heat released by low temperature reaction followed by high temperature reaction was clarified.

Chapter 4 describes the control factors of the ignition timing and the combustion speed. Effects of equivalence ratio, initial temperature, initial pressure of pre-mixture and engine speed on auto-ignition and combustion were analyzed. It was clarified that heat release with high temperature reaction occurred at 900-950K constant and combustion speed depended on amount of fuel in the combustion chamber.

Chapter 5 describes HC and CO emission mechanisms. Maximum temperature of the cycle correlate with combustion efficiency, it was clarified that CO oxidation completed over 1500K. But the combustion speed increased to occur knocking and NOx was generated as increasing maximum temperature of the cycle, operation region was narrow in HCCI engine.

Chapter 6 describes prediction of luminescence of auto-ignition and combustion process of DME/air mixture and measurement of luminescence by using the optical access engine, photo multipliers, a spectroscopy and a framing camera. Chemical luminescence intensity increased at the heat release start and decreased at heat release end.

Chapter 7 describes the effect of pre-mixture inhomogeneity on auto-ignition and combustion. Inhomogeneity could change time variations of reactions spatially in the combustion chamber. It was indicted that it had potential to control the combustion duration.

Chapter 8 summarizes the results of this study.