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HCCI COMBUSTION CHARACTERISTICS DURING OPERATION ON DME AND METHANE FUELS

Y. TSUTSUMI[1)*], A. IIJIMA[1)], K. YOSHIDA[1)], H. SHOJI[1)] and J. T. LEE[2)]

[1)]Department of Mechanical Engineering, College of Science and Technology, Nihon University, 1-8-14 Kanda-Surugadai, Chiyoda-gu, Tokyo 101-8308, Japan
[2)]School of Mechanical Engineering, Sungkyunkwan University, Gyeonggi 440-746, Korea

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ABSTRACT−The Homogeneous Charge Compression Ignition (HCCI) engine has attracted much interest because it can simultaneously achieve high efficiency and low emissions. However, the ignition timing is difficult to control because this engine has no physical ignition mechanism. In addition, combustion proceeds very rapidly because the premixed mixture ignites simultaneously at multiple locations in the cylinder, making it difficult to increase the operating load. In this study, an HCCI engine was operated using blended test fuels comprised of dimethyl ether (DME) and methane, each of which have different ignition characteristics. The effects of mixing ratios and absolute quantities of the two types of fuel on the ignition timing and rapidity of combustion were investigated. Cool flame reaction behavior, which significantly influences the ignition, was also analyzed in detail on the basis of in-cylinder spectroscopic measurements. The experimental results revealed that within the range of the experimental conditions used in this study, the quantity of DME supplied substantially influenced the ignition timing, whereas there was little observed effect from the quantity of methane supplied. Spectroscopic measurements of the behavior of a substance corresponding to HCHO also indicated that the quantity of DME supplied significantly influenced the cool flame behavior. However, the rapidity of combustion could not be controlled even by varying the mixing ratios of DME and methane. It was made clear that changes in the ignition timing substantially influence the rapidity of combustion.

KEY WORDS : Internal combustion engine, Combustion, HCCI, DME, Methane, Spectroscopic measurement

1. INTRODUCTION

The Homogeneous Charge Compression Ignition (HCCI) engine (Thring, 1989) can simultaneously reduce nitrogen oxide (NOx) and particulate matter (PM) emissions (Aoyama *et al*., 1996) because, among other factors, the air and fuel are premixed homogeneously and operation is possible in the lean mixture region. Another reason for the increased interest the HCCI combustion process is that it achieves thermal efficiency on par with that of diesel engines. However, it is difficult to control the ignition timing of HCCI combustion because the fuel is ignited by the temperature rise resulting from compression. Furthermore, the fact that combustion occurs simultaneously throughout the combustion chamber causes the pressure to rise too quickly.

Various methods of controlling HCCI combustion have been proposed, including varying the compression ratio (Hyvonen, 2005), varying the intake air temperature (Yoshida *et al*., 2005), applying exhaust gas recirculation (EGR) (Urushihara *et al*., 2003; Urata *et al*., 2004; Persson *et al*., 2004; Iijima *et al*., 2007), and using two types of fuel having significantly different ignition characteristics (Ozaki *et al*., 2006; Sato *et al*., 2006). This study examined the method of using a blend of two types of fuel. The test fuels used were dimethyl ether (DME), which tends to autoignite easily because of its active low-temperature oxidation reactions, and methane, which does not autoignite readily, as it has no low-temperature oxidation reaction mechanism. The heat release rate was analyzed to investigate the influence of each type of test fuel on combustion behavior when the fuel mixing ratios were varied. Spectroscopic techniques (Shoji *et al*., 1994, 1996) were used to measure the light emission intensity and absorbance of HCHO, which is rapidly produced in cool flame reactions.

**Corresponding author.* e-mail: shoji@mech.cst.nihon-u.ac.jp

2. TEST FUELS

2.1. Characteristics of DME and Methane

The properties of DME and methane are shown in Table 1 (Glassman, 1996). DME has drawn interest as an alternative fuel for compression ignition engines because its high cetane number allows for compression ignition. It also has a negative temperature coefficient region in which the ignition delay is not shortened even though the mixture reaches a higher temperature due to compression. For that reason, it displays a multi-stage heat release pattern attribut-