Experimental investigation of the effects of different injection parameters on a direct injection HCCI engine fueled with alcohol–gasoline fuel blends

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1. Introduction

The HCCI engines have advantages such as lower NOx emissions and higher thermal efficiency compared to conventional compression ignition (CI) and spark ignition (SI) engines. Because of these main advantages, researchers have significantly considered HCCI engines as an alternative engine to SI and CI engines. However, there are some obstacles to use HCCI engines in the practical applications, especially to control the start of combustion. Therefore, the operating range of HCCI engines cannot be extended over a range of engine load and speed.

HCCI combustion is an auto-ignition combustion process which is governed by chemical kinetics of the air–fuel mixture. For this reason, there is not a direct control mechanism in HCCI combustion. Two main parameters play an important role in the control of auto-ignition timing and combustion rate in HCCI combustion. One of which is time–temperature history and the other is the auto-ignition characteristic of fuel [1]. Time–temperature history can be controlled by the methods such as intake temperature [2–4], intake pressure [5,6], variable compression ratio [7,8] and exhaust gas recirculation (EGR) [9–11]. After the intake valve closed, time–temperature history and fuel concentration can only be controlled by split and direct injection (DI) technique [12]. It is well known that using gasoline direct injection concept in SI engines produces high NOx and PM emissions due to high local temperature and equivalence ratio when compared to port fuel injection (PFI) technique. However, two stage direct injection technique can be used in the engines with high compression ratio since it has lower fuel consumption and higher volumetric efficiency compared with PFI technique [13, 14]. In order to form desired mixture in a HCCI engine, two stage direct injection technique is also preferred to adjust flexible injection timings and flexible fuel quantity. Wang et al. [15] simulated injection