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Engine Performance of Dual Fuel Operation with In-cylinder Injected Diesel Fuels and In-Port Injected DME

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Abstract

The demand for new and alternative fuels such as biodiesel or synthetic fuels has seen sharp increase, however their composition and properties can affect significantly engine performance and emissions. The effects of the type of fuel on diesel engine performance have been revealed as very important in new engine. Dimethyl Ether (DME) is potential alternative option to further facilitate the limitations of fossil fuel source in a near future. The benefit of DME fuel properties, cetane number and heating value, is higher than the diesel fuel. In the present work was carried out to further the understanding into the engine performance and exhaust gas emission on single cylinder common rail. The engine fueled with diesel fuel and injecting additional DME fuel into the cylinder via intake manifold. The effect of DME additions, 0 - 90% of the total fuel, were demonstrated under different steady state operated conditions. The combustion of the DME port injection were improved thermal efficiency and reduced exhaust emission compared with the engine was operated with diesel fuel. The exhaust gas emission, i.e. nitrogen oxide and black smoke, was reduced from the engine operating at 30% DME concentration was used. In additions, diesel fuel consumption was reduced up to 22.36% lead to increase the brake thermal efficiency. Furthermore, the higher concentrations of DME are required to improve hydrocarbon and carbon monoxide emissions. However, optimised injection timing are very important in improving the engine performance under different engine operating conditions.

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Keywords: Common rail, Diesel engine; Dimethyl ether; HCCI; Port Fuel Injection

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1. Introduction

The demand for higher efficiency engine with lower fuel economy is growing continuously. This demand is being met with diesel engine in order to the lean burn combustion, the high durability, reliable characteristics and lower emissions compared with gasoline engines. However, the limits of fossil fuel source getting ever more concern in the near future. Therefore, the researcher have been challenge in developing the new renewable energy for the diesel engine in order to fulfill future fuel source limitations and future emission regulations. Dimethyl Ether (DME) is a key element as a fuel alternative which has been suggested as a replacement for fossil diesel fuel due to the fuel properties similar to diesel fuel. DME has low boiling point (-25 °C) at atmospheric conditions. In order to allow the liquid phase to be pressurized above 5.0 bar at atmospheric conditions also low viscosity [1,2]. The potential benefit of DME is due to it being a clean fuel with low emission especially [3], particulate matter (PM) and soot. In addition, the amount of hydrocarbons (HC) and carbon monoxide (CO) emissions are also low levels. DME is an alternative fuel that can be produced from natural gas, coal or biomass, whose properties are good enough to be used as an alternative fuel in diesel engines. The modification injection system of diesel engine are required when fuelled with DME. Therefore, the DME used in diesel engines by port fuel injection (PFI) is an interesting alternative method with small modification injection system.

Port fuel injection (PFI) in diesel engines runs is premixed charge compression ignition (PCCI) combustion mode. PCCI is broadly considered as a combined concept between homogeneous charge compression ignition (HCCI) type of combustion and direct injection compression ignition (DICI) type of combustion. HCCI mode is the low-temperature combustion (LTC), which reduce NOx emission and soot [4,5]. HCCI engines have control of ignition timing or combustion phasing controls difficult, limited load ranges as a result, the response was narrow [6]. Therefore, it has not popular in vehicles. Moreover, the conventional diesel fuel is unsuitable for HCCI engine in order to the diesel is require high heat of vaporisation. Thus, DME can operated under HCCI mode due to DME has gas phase at atmospheric conditions and has similar properties with diesel fuel [7,8].

In this work, the aimed to experimental study the effect of concentrations (0-90% of the total fuel) of DME intake charge with dual fuel mode on engine performance and emissions at different engine loads and constant engine speed operating conditions.

Nomenclature

BSEC	brake specific energy consumption
BTDC	before top dead centre
DICI	direct injection compression ignition
DME	dimethyl ether
HCCI	homogeneous charge compression ignition
HTC	high-temperature combustion
LTC	low-temperature combustion
PCCI	premixed charge compression ignition
PFI	port fuel injection

2. Experimental setup and procedure

2.1. Experimental setup

A schematic of the experimental apparatus is detailed and illustrated in Fig. 1. The experiments were performed on modified single cylinder compression ignition engine, which is a 406 cm^3, naturally aspirated, and common rail direct injection diesel engine. The engine is operating under dual fuel between diesel fuels and DME port fuel injection mode. A supplementary injection system was used for the diesel, with an injector just in the intake manifold to provide DME with the inlet charge. This injection system mainly comprised by a common rail direct injection which provides a constant flow of finely atomized and the injection timing was fixed at 20°CA BTDC. The engine was coupled to