International Journal of Thermal Sciences 50 (2011) 1594–1603

Contents lists available at ScienceDirect

International Journal of Thermal Sciences

journal homepage: www.elsevier.com/locate/ijts

Thermodynamic, performance and emission investigation of a diesel engine running on dimethyl ether and diethyl ether

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ARTICLE INFO

Article history:
Received 12 August 2010
Received in revised form
24 March 2011
Accepted 26 March 2011
Available online 6 May 2011

Keywords:
Alternative renewable fuels
Dimethyl ether
Diethyl ether
Diesel engine
Engine performance
Fuel consumption
Exhaust emissions

ABSTRACT

This study investigates the use of dimethyl ether and diethyl ether in diesel engines as alternative fuels. A direct injection diesel engine was simulated via a thermodynamic cycle model for investigation. Thermodynamic and performance parameters besides emissions determined and compared for diesel, dimethyl ether and diethyl ether fuels at two different states. The results showed that dimethyl ether and diethyl ether presented a lower cylinder temperature and pressure, and thus a lower engine performance than diesel fuel for the equal injection conditions. The brake power declines about 32.1% and 19.4% at 4200 rpm while brake specific fuel consumption increases about 47.1% and 24.7% at 2200 rpm for dimethyl ether and diethyl ether, respectively. Engine performance for dimethyl ether and diethyl ether extensively improves for the same equivalence ratio condition, but a more amount of fuel is needed about 64% for dimethyl ether and 32% for diethyl ether. The gains in the brake power by dimethyl ether and diethyl are about 13.6% and 6% at 4200 rpm compared to diesel fuel. The brake specific fuel consumption is also higher about 43.5% for dimethyl ether and 23.6% for diethyl ether than diesel fuel. The brake thermal efficiency for dimethyl ether and diethyl is generally better than diesel fuel. The lower carbon dioxides are obtained by dimethyl and diethyl ethers at all conditions, while carbon monoxide and nitrogen oxide are slightly higher for dimethyl and diethyl ethers at equal equivalence ratio condition.

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1. Introduction

Diesel engines have been widely used in recent decades as an alternative power source for light-duty vehicles because of the economical and environmental reasons. Therefore, the global diesel fuel consumption has increased with the pollutions sourced from diesel engines [1,2]. The unburned or partially burned (total) hydrocarbon (THC) emissions, smoke (soot) or particulate matter (PM), nitrogen oxides (NO_x), sulfur oxides (SO_x) emitted from compression ignition (CI) engines and particularly carbon dioxide (CO_2) create severe environmental problems [2–4], which have been tried to be reduced by the stringent emission legislations. The different alternatives such as the investigation of viable alternative fuels and the reformulation of conventional fuels have been evaluated for meeting the emission standards and future energy demand [5,6]. The reformulation of diesel fuel contains the reduction of the sulfur and aromatic contents or the oxygen addition to diesel fuel [7]. A lot of works have been performed to show the effects of using alternative diesel fuels and additives including synthetic diesel fuels, biodiesels, alcohols and ethers.

The synthetic or gas-to-liquids (GTL) diesel fuels are very low sulfur and aromatic containing alternatives to conventional diesel fuel. The GTL diesel fuels are produced from wide variety of carbon-based feedstocks, including coal, natural gas, biomass and oil sands via a Fischer–Tropsch process [8]. The synthetic diesel fuels have also very high cetane number and excellent auto-ignition characteristics. These fuels offer significant reductions in PM and NO_x emissions [9,10]. The GTL fuels can be used neat [9] or blended in any proportions with conventional diesel fuel [10] without any engine modification. However, further research on synthetic fuel production technologies is essential for lower costs to make it more economically competitive with conventional fuels [11].

Biodiesels are one of the oxygen containing and sulfur free alternatives to petroleum-based diesel fuel, which are the fatty acids (or triglycerides) obtained from various straight vegetable oils [12–16] or the recycled waste oils [17–19] and animal fats [20–22]. Neat vegetable oils can be directly used in diesel engines because of a high cetane number and very close calorific value to diesel [5]. However, it was reported that they leaded to operational problems such as a lower engine power and efficiency, engine deposits under long-term use because of the high viscosity and low volatility [23,24]. Several methods to reduce the high viscosity of vegetable oils or

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doi:10.1016/j.ijthermalsci.2011.03.021