Determination of performance and combustion characteristics of a diesel engine fueled with canola and waste palm oil methyl esters

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In this study, the performance, combustion and injection characteristics of a direct injection diesel engine have been investigated experimentally when it was fueled with canola oil methyl ester (COME) and waste (frying) palm oil methyl ester (WPOME). In order to determine the performance and combustion characteristics, the experiments were conducted at constant engine speeds under the full load condition of the engine. The results indicated that when the test engine was fueled with WPOME or COME instead of petroleum based diesel fuel (PBDF), the brake power reduced by 4–5%, while the brake specific fuel consumption increased by 9–10%. On the other hand, methyl esters caused reductions in carbon monoxide (CO) by 59–67%, in unburned hydrocarbon (HC) by 17–26%, in carbon dioxide (CO2) by 5–8%, and smoke opacity by 56–63%. However, both methyl esters produced more nitrogen oxides (NOx) emissions by 11–22% compared with those of the PBDF over the speed range.

1. Introduction

In today’s world, in order to meet the growing energy needs as a consequence of spiraling demand and diminishing supply, alternative energy sources mostly biofuels are receiving more attention. Indeed, the petroleum crisis exploded in the late 1970s and early 1980s, petroleum products became very scarce and expensive. Besides, because of the environmental pollution from internal combustion engines, the increasing global concern has caused to focus on the oxygenated diesel fuels. These issues have triggered various research studies to replace petroleum based diesel fuel with the vegetable oils or their derivations [1].

Biodiesel can be produced from various vegetable oils, waste cooking oils or animal fats. The fuel properties of biodiesel may be changed when different feedstocks are used. If the fuel properties of biodiesel are compared to petroleum diesel fuel, it can be seen that biodiesel has higher viscosity, density, pour point, flash point and cetane number, near-zero aromatic compound, and no sulphur link [2,3]. Also the energy content or net calorific value of biodiesel is about 10–12% less than that of conventional diesel fuels on the mass basis. Biodiesels consist of mixture of mono-alkyl ester of saturated and unsaturated long chain fatty acid which determines chemical structure of biodiesels. The chemical structures of biodiesels contain approximately 76–77% carbon, 11–12% hydrogen and 10–12% oxygen by weight. The hydrogen–carbon ratio of biodiesel is affected by its fatty acids content which causes differences in the injection, combustion, performance and emissions characteristics of the engine [4].

In the last three decades, the impacts of biodiesel produced from different feedstocks have intensively investigated on the performance and emission characteristics of diesel engines by many researchers. These studies point out that biodiesel from different feedstocks exhibits similar results [5,6] or very little performance differences [7–9]. It enhances fuel lubricity [10,11] and causes reductions on regulated emissions when compared PBDF. Therefore, it may not require any significant modifications on diesel engines to use biodiesel.

There is a general agreement on the biodiesel fuel which provides a substantial reduction in HC, CO, and smoke emissions, but it increases the NOx emissions compared to PBDF [12–16]. Therefore, some researchers have tried to explain the effect of fuel properties on the NOx formation. Signer et al. [17] expressed that an increase occurred in the NOx emissions for a 3.5% increase in the fuel density. Peterson et al. [18] and McCormick et al. [19] found that the number of double bonds, quantified as iodine number, correlated with the NOx emissions. It should be noted that biodiesel’s chain structure and fuel properties such as density, cetane number, bulk module, and freezing point are correlated with iodine number.

Wang et al. [20] showed that methyl esters from high oleic (>85%) soy oil have a measurable reduction (5%) in NOx emissions compared to normal soy methyl ester which contains 25% oleic...