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The Influence of Multi-Walled Carbon Nanotubes Additives into Non-Edible Biodiesel-Diesel Fuel Blend on Diesel Engine Performance and Emissions

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Abstract

This paper reports on an experimental investigation that was conducted to recommend the most suitable dose level of multi-walled carbon nanotubes (MWCNT) into biodiesel-diesel fuel blend at which the optimum diesel engine performance is attained. In this study, nano-particles of size from 10 to 15 nm with tube length 1-10 microns, the dose level is varied from 10 to 50 mg/l by step of 10 mg/l was mixed into the biodiesel-diesel fuel blend with the help of ultrasonicator. A single cylinder diesel engine test facility was used to study the effect of nanoparticles dose level on engine combustion and environmental performance parameters with a constant speed of 2000 RPM and different engine torque. The results of the present study showed that the biodiesel-diesel fuel blend slightly decreases the mechanical engine performance and increases its emission characteristics at all tested engine operating conditions. The use of MWCNTs is found to improve all engine performance parameters no matter the studied dose level. However, the best emission characteristics are obtained at a dose level of 30 mg/l (where remarkable emission reduction is observed; NO_x by 45 %, CO by 50 %, and UHC by 60 %). While the best of engine combustion characteristics are achieved at a dose level of 50 mg/l (the increase in the in-cylinder peak pressure - $P_{max,}$ is about 7 %). Finally, it valuable to recommend the dose level of 40 mg/l where reasonable improvement in engine performance is achieved.

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Keywords: Jojoba Methyl Ester; Multi-walled Carbon Nanotubes; Diesel Engine; Engine Performance; Emission Characteristics.

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1. Introduction

The diesel engines are the major engine type for heavy duty applications in transportation and power generation sectors. Nevertheless, diesel engines are considered one of the primary sources of many toxic emissions, in particular, the particulate matter (PM), and nitrogen oxides (NO_x) which have hazardous environmental impacts. These toxic compounds cause the formation of acidic rains, the depletion of ozone layer, the increase of greenhouse phenomena, the formation of smog, and undesirable climatic changes. There are major approaches to reduce diesel emissions; including the engine design modifications, the engine combustion enhancement, and the use of exhaust gas treatment technique [1, 2]. The modification of engine combustion seems to be the most recommended given it may need only minor modifications to engine systems rather than the use of new designs or the use of additional systems.

This approach is realized by regulating the fuel properties, modifying fuel injection, and/or use of fuel additives [2]. In this regard, the use of oxygenated fuels as biodiesel is found to be a promising alternative substitute for the conventional diesel fuel. Jojoba plant is one of the promising non-edible plants growing in desert lands, and its seed has more than 50% of its weight as raw oil [3] and [4]. So raw jojoba oil would be a suitable feedstock for biodiesel production. The raw jojoba oil is converted into biodiesel via transesterification process to obtain Jojoba Methyl Ester (JME). A few researchers have investigated the utilization of Jojoba oil as an alternative engine fuel. Radwan et al.[4], Selim et al.[5], and Al-widyan & Al-muhtaseb [6] emphasized the suitability of such promising fuel for diesel engines. However, as reported by many researchers, the use of Jojoba oil in the diesel engine decreases the engine thermal efficiency, increases the specific fuel consumption and increases the engine emissions especially the NO_x emissions [7] and [8].

Recently, there is a considerable attention to using nanoparticle additives to enhance the combustion quality of the burned fuel. Using the nanoparticles in the form of oxides as aluminum oxide, cerium oxide, and others in the combustion zone act as a catalyst [9]. These additives enhanced the radiative-mass transfer properties, reduce ignition delay and enhance the ignition temperature characteristics of the fuel within the combustion zone [10]. For engine applications, there are many investigations to study the effect of nanoparticle additives on engine performance. Correspondingly, a number of experimental investigations were conducted with the use of nano-additives blends with biodiesel and diesel fuel to improve the fuel properties and engine performance, as well as to reduce the engine emissions [9 -12].

Prajwal et al. [12], studied the performance of a single cylinder diesel engine using multiwall carbon nanotube blended biodiesel fuels. It was found that the brake thermal efficiency for biodiesel-multi walled carbon nanotubes blended fuel were relatively better as compared to that of biodiesel only. This could probably be attributed to the better combustion characteristics of multi-walled carbon nanotubes, due to high surface area and reactive surfaces that contribute to higher chemical reactivity to act as a potential catalyst. Also, the CO, HC, and smoke emissions were lower for biodiesel multi-walled carbon nanotubes blended fuel as compared to that pure biodiesel fuel. This could be due to catalytic activity and improved combustion characteristics of multi-walled carbon nanotubes, which leads to improved combustion characteristics. Furthermore, the NOx emission was relatively less for biodiesel-multi-walled carbon nanotubes blended fuel as compared to that of the diesel oil. This is because of reduced ignition delay that resulted in higher premixed combustion fraction and higher peak temperatures.

According to the previous researches and ASTM standard, the most recommended blending ratio of the biodiesel is B20 [8]. Therefore, the current study will be performed based on this blending ratio with different nano-additives dose levels. Therefore, the present work objectives to investigate the effect of the nano-additives on the performance of a diesel engine fuelled by JME-diesel blended fuel.

2. Nomenclature

ASTM:	American Society for Testing and Materials	JB20D20MWCNT:	JB20D+ 20 mg MWCNT
CA:	Crank angle, degree	JB20D30MWCNT:	JB20D+30 mg of MWCNT
CO:	Carbon monoxide, ppm	JB20D40MWCNT:	JB20D+40 mg of MWCNT
D100:	Neat diesel oil	JB20D50MWCNT:	JB20D+50 mg of MWCNT
EGT:	Exhaust gas temperature, °C	MWCNT:	Multi-walled Carbon Nanotubes
JME:	Jojoba methyl ester	UHC:	Unburned hydrocarbons, %Vol.