EFFECT OF NANO ADDITIVES ON PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE FUELLED WITH EDIBLE-NON-EDIBLE BIODIESEL FUELS

By

Mostafa Mohamed Abd-Elaziz Mahmoud

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

Mechanical Power Engineering

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Title of Thesis:

Effect of Nano Additives on Performance and Emission Characteristics of Diesel Engine Fueled with Edible-Non-Edible Biodiesel fuels.

Key Words:
Biodiesel – Nano-additives – Performance – Emission.

Summary:

The presented work introduces a performed study into the effect of adding nano particles to a various biodiesel fuels on performance and emission characteristics. The characteristics experimentally investigated on a single cylinder diesel engine test-bed at a speed of 1500 rpm and different engine load conditions. Diesel and biodiesel blends were prepared in volume percentage of 20% as (80% diesel+20% biodiesel) this blend investigated without additives and with different nano additives at different concentrations for a various types of biodiesel fuels.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and cited them in the references section.

Name: Date:

Signature:

Acknowledgments

First and above, all my thanks and my great acknowledgement to **Allah** for helping me in all my life. Praise is to **Allah,** who empowered me to complete my research and for guidance to bring it to light in such intended form.

I would like to express my grateful thanks and appreciation to **Prof. Dr. Mohamed Mahmoud Ali Hassan,** Professor of Mechanical Engineering Department, Faculty of Engineering, Cairo University, for suggesting the research point, direct supervision and assisting, helping, advising and supervising me during all the stages of this thesis. I am proud to work under such a distinguished scientist and teacher with whom I published the first paper in my career in an International Journal and registered patent from this thesis.

I would like to express my grateful thanks and appreciation to **Dr. Eslam Said Abd-Elghani,** Ass. Prof. of Mechanical Power Engineering Department, Institute of Aviation Engineering and Technology, for direct supervision, providing all financial facilities, helping, advising and gave me the opportunity to work with him.

I would like to express my grateful thanks and appreciation to **Dr. Mohammed Saber Mohamed Gad,** Researcher of Combustion, Mechanical Engineering Department, Engineering Research Division, National Research Centre, for direct supervision, providing all financial facilities, helping, advising and give me big experiences in Experimental work.

Also, my sincere thanks to all staff member of **Mechanical Engineering Department, Institute of Aviation Engineering and Technology** for supporting me during this work.

All my thanks are to **my father, mother, brothers, wife, son** and all **my family** for helping me and standing up behind me all the time to finish this work in a suitable form.

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Nomenclature

Symbol	Meaning	Units
A/F	Air/fuel mass ratio	
BSFC	Brake specific fuel consumption	kg/kW h
BTE	Brake thermal efficiency	%
CO	Carbon monoxide	%
CO_2	Carbon dioxide	%
EGT	Exhaust gas temperature	K
HC	Hydrocarbons	ppm
NO_X	Nitric oxide and nitrogen dioxide	ppm
RPM	Revolution per minute	rpm
D100	pure diesel oil	
JME	Jatropha methyl ester	
CME	Corn methyl Easter	
WME	Waste cooking oil methyl Easter	
J20	mixture fuel containing 20% JME + 80% D100	
J100	mixture fuel containing 100% JME + 0% D100	
C20	mixture fuel containing 20% CME + 80% D100	
C100	mixture fuel containing 100% CME + 0% D100	
W20	mixture fuel containing 20% WME + 80% D100	
W100	mixture fuel containing 100% WME + 0% D100	
CNTs	Multi walled carbon nano tubes	
TiO_2	Titanium oxide nano particle	
Al_2O_3	Aluminum oxide nano particle	
J20C25,50,100	CNTs with mass fraction 25, 50, 100 ppm mixed with J20	
J20T25,50,100	TiO_2 with mass fraction 25, 50, 100 ppm mixed with J20	
J20A25,50,100	Al_2O_3 with mass fraction 25, 50, 100 ppm mixed with J20	
C20C25,50,100	CNTs with mass fraction 25, 50, 100 ppm mixed with C20	
C20T25,50,100	TiO_2 with mass fraction 25, 50, 100 ppm mixed with C20	
C20A25,50,100	Al_2O_3 with mass fraction 25, 50, 100 ppm mixed with C20	
W20C25,50,100	CNTs with mass fraction 25, 50, 100 ppm mixed with W20	
W20T25,50,100	TiO_2 with mass fraction 25, 50, 100 ppm mixed with W20	
W20A25,50,100	Al_2O_3 with mass fraction 25, 50, 100 ppm mixed with W20	
SEM	Scanning Electron Microscopy	
TEM	Transmission Electron Microscope	
ASTM	American Society for Testing and Materials	

Abstract

There is a heavy dependence on fossil fuels for energy production. This are not only depletable but also is the main cause of harmful emissions and global warming. Renewable energy and biofuels can play significant role in this concern. The increasing demand and consumption growth rates of diesel fuel together with environmental concerns, directed attention for use of non-edible oils such as jatropha oil and waste cooking oil as alternative biofuels in diesel engines.

Mechanical pressing was deployed to extract oil from jatropha seeds. Screw press extraction method was used to extract oil at extraction temperature of 100 °C and motor speed of 60 rpm. Screw press produces higher oil yield from the seeds of up to 20%.

A two-stage process is used for the esterification of the jatropha oil. The first is called esterification, and this is used to reduce the free fatty acid content in jatropha oil. The second stage called transesterification. On the other hand, only transesterification process is used for the esterification of the corn oil and waste cooking oil. Biodiesel from three different feed stocks (jatopha, corn and waste cooking oil) are mixed with diesel in different proportions to form different blends such as J20 (20% JME and 80% diesel), C20 (20% CME and 80% diesel) and W20 (20% WME and 80% diesel). The final biodiesel product properties were measured according to American Society for Testing and Materials (ASTM) standard in Central labs, Egyptian Petroleum Research Institute, Egypt.

Nanotech Egypt Company supplies three different nano additives (CNTs, TiO_2 and Al_2O_3) in the mass fractions of 25, 50 and 100 ppm which were mixed with produced biodiesel blends. Mechanical dispersion was used to prepare the homogeneous fuel mixture as well as to dismantle the agglomeration of nano particles. Then, biodiesel nano blends were kept in an ultrasonic bath set at a frequency of 24 kHz for 30 min to enhance the stability of the fuel blend. Scanning electron microscopy (SEM) provides direct examination of nano particles alignment and its size and also investigates the morphology of nano particles. Surface and morphological characterization of nano particles were carried out using Transmission Electron Microscope (TEM).

A single cylinder diesel engine (DEUTZ F1L511) has been employed as the test engine in the present work. The engine was equipped with all the necessary instruments to measure different engine parameters. AC generator of maximum electric power output of 4.5 kW has been coupled directly to the test engine. An external controllable electric load bank with variable loads is established for measurement of engine loads from 0 to full load. Engine performance and exhaust emissions were tested by burning diesel, biodiesel (J20, C20 and W20) and their nano blends with nano additives (CNTs, TiO_2 and Al_2O_3) at different concentrations of (25, 50 and 100 ppm).

The results of performance parameters and exhaust emission are based on the study are thermal efficiency, specific fuel consumption, exhaust gas temperature, air fuel ratio, CO, CO_2, HC, NO_x emissions and smoke opacity.

The W20T100 blended fuel attained a maximum increase of 14.4% in the brake thermal efficiency and a decrease of 11.6% in the brake specific fuel consumption at the dose level of 100 mg/l compared to D100. According to the measured emissions, a significant reduction of engine emissions was achieved at the dose level of 100 mg/l, where NOx, CO, and HC were reduced by 54.5%, 36.4%, and 11.1%, respectively for W20T100 compared to D100. According to the obtained results, the recommended concentration of TiO_2 in W20 was concluded to be 100 mg/l, which could give significant improvements in overall the parameters of engine performance and emissions with a good balance between them compared to D100.