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Original Research Article

Effect of cottonseed oil methyl ester on the performance and exhaust emissions of a vehicle

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ABSTRACT

The present work investigates the impact on vehicle performance and exhaust emissions from vehicle when using 100% diesel with petroleum origin (fossil diesel), compared to a mixture of 2-5-100% cottonseed oil methyl ester (COME) in fossil diesel fuel (B2, B5, B100). For the accomplishment of this work an assessment was made using some primary tests on a chassis dynamometer, measuring vehicle performance and emissions. The results demonstrate that the use of biodiesel has a negative effect on vehicle's performance. The increase in average fuel consumption was approximately 1.44 fold for usage of B2, B5 and B100 at forth gear. According to results of exhaust emissions from vehicle, the decrease in average CO emission was approx. 47.2% for usage of B100.

Keywords: Cottonseed oil methyl ester; Vehicle performance; Exhaust pollutant emissions.

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1. INTRODUCTION

Energy is very important for life quality, welfare level and social development of people as well as economic growth. Fossil fuels have been an important traditional energy source for years. Energy demand around the world is increasing rapidly as a result of on going trends in modernization and industrialization. Most of the developing countries import fossil fuels for satisfying their energy demand. Consequently, these countries have to spend their export income earned under severe conditions to buy petroleum products **[1]**. The scarcity of conventional fossil fuels, growing emissions of combustion-generated pollutants, and their increasing costs will make biomass sources more attractive. Petroleum-based fuels are limited reserves concentrated in certain regions of the world. These sources are on the verge of reaching their peak production. The fossil fuel resources are shortening day by day **[2,3]**.

Alternative fuels are becoming increasingly important due to environmental and energy concerns **[4]**. In regard to diesel engines, biodiesel represents a promising alternative to petroleum diesel fuel **[5]**. Diesel fuel is very important for countries' economy because it has wide area of usage such as long haul truck transportation, railroad, agricultural and construction equipment **[6,7]**. Biodiesel is a renewable, clean diesel fuel, which is made from fatty acid methyl or ethyl esters. These esters are made from vegetable oils, animal fats or waste oil used in cooking or industry **[8,9]**. Biodiesel may be produced from various seed oils. These include, but are not limited to, sunflower, canola, hemp, cotton, corn, safflower and coconut containing oil. Biodiesel is a fuel, which can be used directly in diesel engines without any modification or with a small modification **[10-13]**. Biodiesel can form blends with petroleum diesel fuel at any ratio and thus have the potential to partially, or even totally, replace diesel fuel in diesel engines **[5]**.

Many investigators have studied biodiesel fuels as an alternative energy source for internal combustion engines.

A slightly decrease in engine performance of biodiesel and its blends fuels when compared to petroleum diesel fuel **[14-16]**. Fuel consumption values of biodiesel and its blends fuels are higher than petroleum diesel fuel **[3,15-20]**. A decrease in CO emissions when substituting petroleum diesel fuel with biodiesel and its blends fuels could be considered to be a general finding of many studies **[15,17-19,21-23]**. Many studies have shown HC emissions of biodiesel and its blends fuels are lower than petroleum diesel fuel **[15,17,20,24-26]**. Many researchers have found that NOx emissions increase slightly when using biodiesel and its blends fuels compared to petroleum diesel fuel **[15,17-19,21,23,27,30]**. However, some studies have found a slight decrease in NOx emissions for diesel engines using biodiesel and its blends fuels compared to petroleum diesel **[28,29]**. In general, CO_2 emissions of biodiesel and its blends fuels are higher than petroleum diesel fuel **[19,20]**.

This study experimentally investigated the effects of biodiesel–diesel fuel blends on the vehicle performance and emission characteristics of a vehicle with DI and compared them with those of petroleum diesel fuel.

2. EXPERIMENTAL APPARATUS AND PROCEDURE

Vehicle specifications used in the study are given in Table 1. Controlling of tyre pressure and teeth, wheel balance and rod adjustment, engine controls performed before experiments.

The vehicle was coupled to Delorenzo HPT 6100 type chassis dynamometer capable of measuring the wheel impulse power and vehicle speed. Fuel consumption was measured using fuel consumption measurement device which AIC-4004 type, digital displaying, average and can measure instantaneous consumption values, to sensibility 0.001. Vehicle exhaust emissions were measured using exhaust emission analyzer which Italo – Spin type, digital displaying, can measure CO (% vol) with 0.001 sensibility, CO_2 (% vol) with 0.001 sensibility, NOx (ppm) and HC (ppm) values. Fuels specifications used in the study are given in Table 2. The schematic layout of the experimental apparatus is shown in Figure 1.

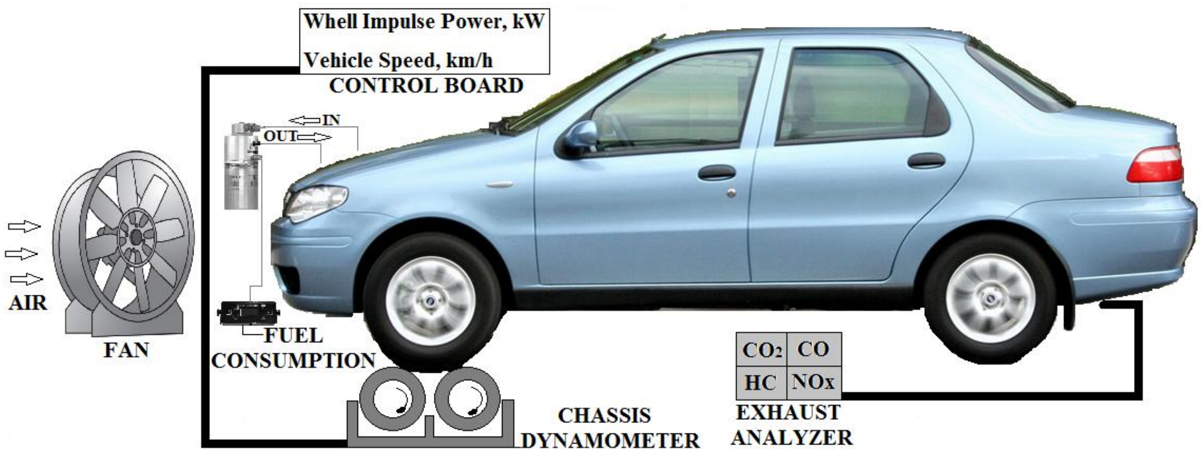

Fig. 1. Schematics of test setup

Table 1. Vehicle specifications used in the study

Make	FIAT
Model	Albea
Version	1.3 Multijet Active
Driving axle	Front wheel drive
Production year	2006
Min. vehicle weight (kg)	1055
Specifications of vehicle engine	
Total cylinder volume (cm^3)	1248
Valve number	16
Compression ratio	18:1
Fuel system	Common Rail
Max. engine power (kW– 1/min)	52.2 – 4000
Max.engine torque (Nm – 1/min)	180 – 1750

First, the vehicle was tested with B0 fuel. Then, the biodiesels were also tested B2, B5, B100, respectively. The tests were performed at second, third and forth gears for each fuel. Wheel impulse power and fuel consumption were measured at each gear and for each fuel. Exhaust emissions were measured at values of maximum wheel impulse power at each gear and for each fuel. The ambient air temperature, relative humidity, and atmospheric pressure were almost constant during the tests.

3. RESULTS

3.1. Vehicle Performance

Wheel power and fuel consumption were studied as vehicle performance.

3.1.1. Wheel power

The variations of wheel power with vehicle speed for the tested all fuels at each gear is depicted in Figure 2, 3, 4. Maximum wheel power was measured at 35 km/h as 28.2 kW for B0 at second gear. The least power was measured as 23.6 kW with B100 at same gear and speed.

Table 2. Fuels specifications used in the study

	B0	B2	B5	B100
Density (g/cm^3)	0,829	0,831	0,832	0,885
Viscosity to 40 C (mm^2/s)	2,74	2,84	2,85	4,65
Flashing point (^oC)	59	61	63	95
Low Heat. Value (cal/g)	10994	10735	10645	9389
Clouding point (^oC)	-12	+6 -7	+7	+10
Yield point (^oC)	-19	--	--	+4
Freezing point (^oC)	-30<	--	--	+2
Copper corrosion	1a	1a	1a	1a

Maximum wheel power was measured at 60 km/h as 31 kW for B0 at third gear. The least power was measured as 26.7 kW with B100 at same gear and speed.

Maximum wheel power was measured at 90 km/h as 31.7 kW for B0 at forth gear. The least power was measured as 26.4 kW with B100 at same gear and speed.

In general, although maximum power values of B2 and B5 are close to B0, B100's power value was very lower than B0. The decrease in average power was 29.56% for usage of B100. The lower wheel power obtained for B100. The reason for this could be due to fuel flow problems, as higher density and higher viscosity, and decreasing combustion efficiency as bad fuel atomization of injection and lower thermal efficiency than B0.

3.1.2. Fuel consumption

The variations of fuel consumption with vehicle speed for the tested all fuels at each gear are depicted in Figure 2, 3, 4. In general, fuel consumption values of B2, B5 and B100 were higher than B0. Although fuel consumption values of all fuels are close at second and third gears, fuel consumption values of B2, B5 and B100 were rather higher than B0 at forth gear. The increase in average fuel consumption was approximately 1.44 fold for usage of B2, B5 and B100 at forth gear.

One possible explanation for this increase could be due to lower heating value and higher density compared to B0 (Table 2). Therefore, thermal efficiency of B0 is higher than thermal efficiency of B2, B5 and B100, and fuel consumption value of B0 is lower than fuel consumption of other fuels.

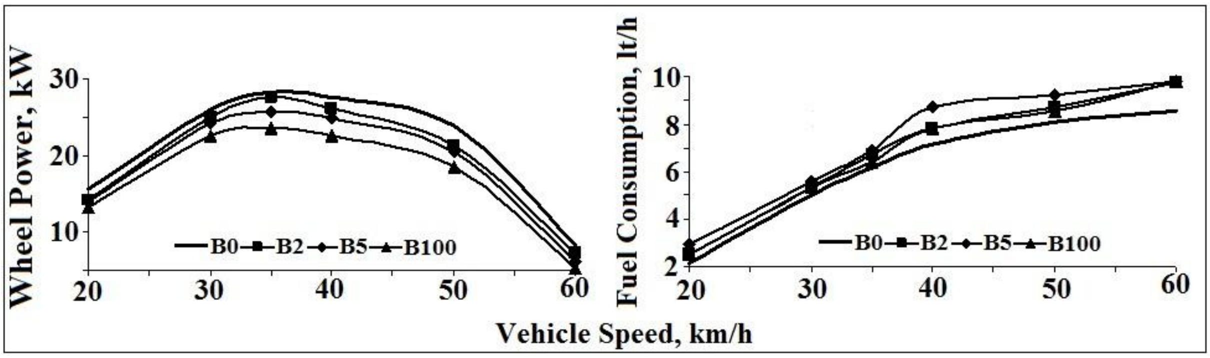

Fig. 2. The variations of wheel power and fuel consumption at second gear

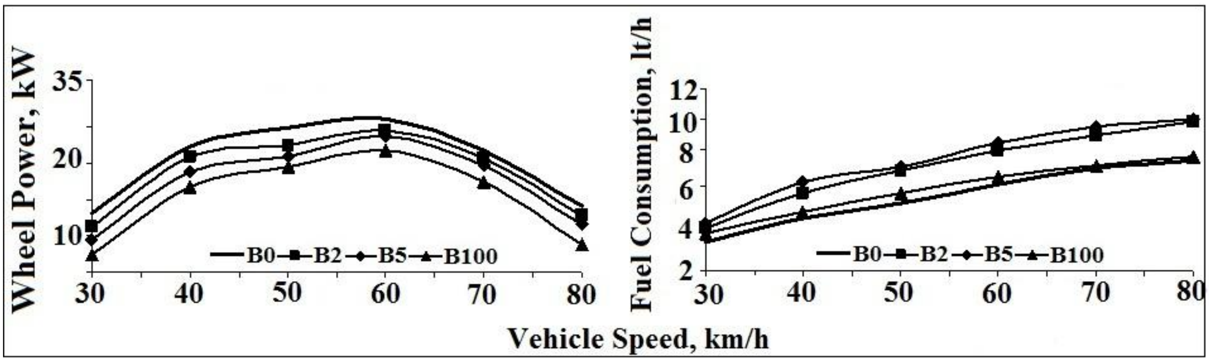

Fig. 3. The variations of wheel power and fuel consumption at third gear

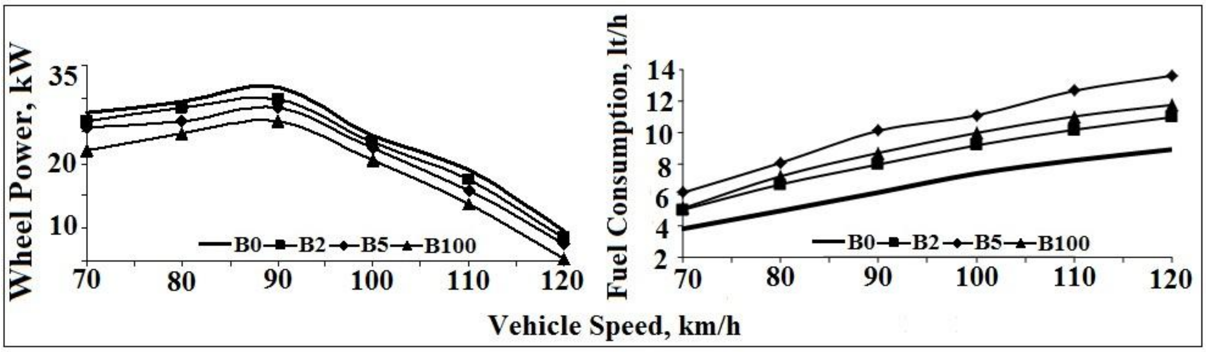

Fig. 4. The variations of wheel power fuel consumption at forth gear

3.2. Exhaust Emissions

3.2.1. CO emission

The variations of CO produced by running the vehicle using B0, B2, B5 and B100 fuels is shown in Figure 5. In general, CO emissions of other fuels are equal or higher than B0. Particularly, CO emission of B100 is rather lower than CO emission of B0. The decrease in average CO emission was approx. 47.2% for usage of B100. It is known the decrease in O_2 content means incomplete combustion which results in CO increase. The decreasing in CO emissions may explain with content O_2 of biodiesel.

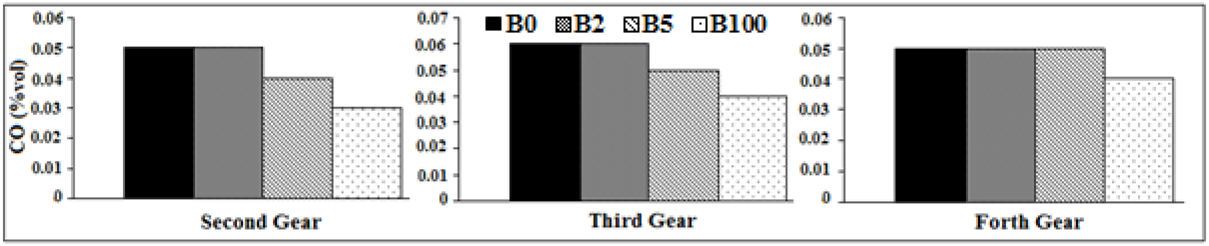

Fig. 5. The variations of CO emission

3.2.2. CO_2 emission

The variations of CO_2 produced by running the vehicle using B0, B2, B5 and B100 fuels is shown in Figure 6. CO_2 emissions of poor biodiesel rate fuels are higher than CO_2 emission of B0. But CO_2 emission of B100 is lower than CO_2 emission of B0. CO_2 emissions depend on combustion of fuel and amount of C atoms. If combustion is bad, CO_2 emission will decrease. Therefore, CO_2 emission values of B100 fuel are lower than B0. Rising on CO_2 emission values of blended fuels may explain with more contain C atoms of biodiesel.

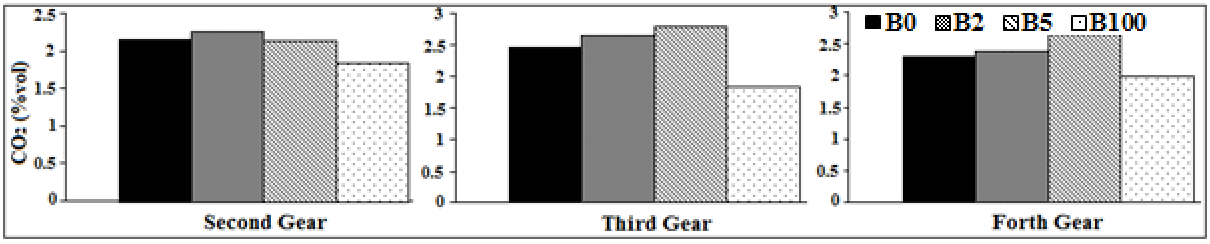

Fig. 6. The variations of CO_2 emission

3.2.3 HC emission

The variations of HC produced by running the vehicle using B0, B2, B5 and B100 fuels is shown in Figure 7. In general, HC emissions of poor biodiesel rate fuels are lower than HC emission of B0. But HC emission of B100 is higher than HC emission of B0. Cause of this is bad burning with B100. However, O_2 in poor biodiesel rate fuels is improved to burning, and HC emission of B100 is increased due to lower heating value of B100.

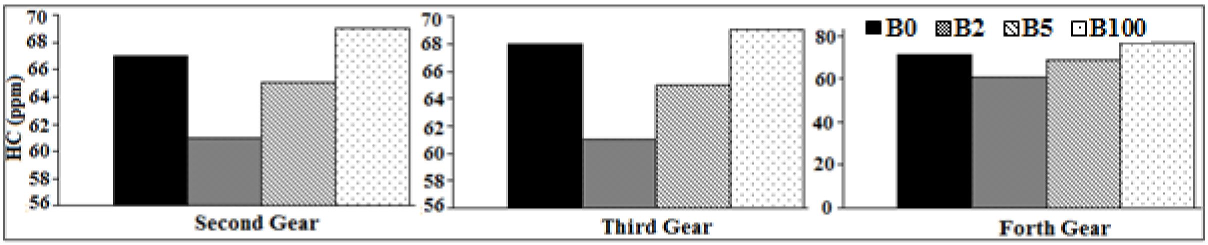

Fig. 7. The variations of HC emission

3.2.4. NOx emission

The variations of NOx produced by running the vehicle using B0, B2, B5 and B100 fuels is shown in Figure 8. In general, NOx emissions of poor biodiesel rate fuels are higher than NOx emission of B0. But NOx emission of B100 is lower than NOx emission of B0. Cause of the decrease is low of lower heating value of B100, and thus, temperature at burning end is decreased.

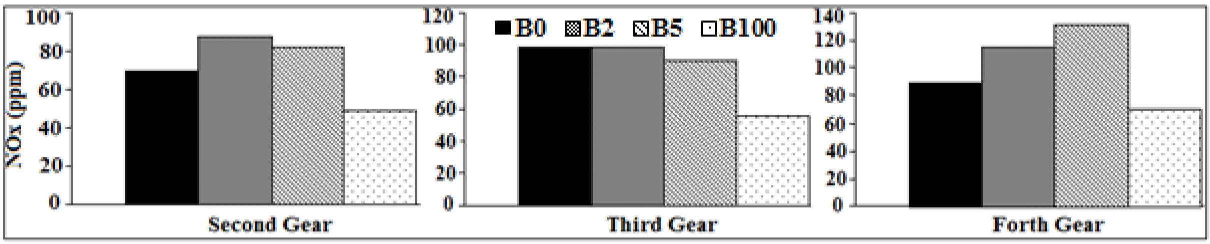

Fig. 8. The variations of NOx emission

4. CONCULSION

In this study, it is shown that COME as alternative diesel engine fuel can be used successfully to operate a common rail diesel engine without modifications to engine or injection system.

The following conclusion may be drawn from the result of the present study:

• COME is a renewable energy resource.

• Diesel fuel and COME are similar in their chemical and physical properties.

• COME can be used cheaply and as an alternative fuel in a diesel engine instead of diesel fuel.

• Although wheel power values of COME and COME blends fuels are lower than diesel fuel, exhaust emissions of COME and COME blends fuels were better than diesel fuel.

Result of performance and emission tested wheel power, emission and fuel consumption values of COME are optimistic.

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