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Original Research Article

The Effect on Performance and Exhaust Emissions of Adding Cotton Oil Methyl Ester to Diesel Fuel

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Abstract

In the study, engine performance and exhaust emissions of diesel fuel and cotton oil methyl ester (COME) blends at proportions of 2%, %5 and 10% (v/v) have been investigated. The engine was fuelled with COME–diesel blends and pure diesel when running the engine at six different engine speed (1000, 1200, 1400, 1600, 1800, 2000 rpm) and at full load. Test results are presented engine torque and specific fuel consumption (SCF) as engine performance, and Carbon monoxide (CO), Hydrocarbon (HC), smoke and nitrogen oxides (NOx) as exhaust emissions. As result, this study is show that although engine performance decreased with COME adding to diesel fuel, exhaust emissions was generally improved.

Keywords: Cotton oil methyl ester, engine performance, exhaust emissions, engine test, methyl ester-diesel blends.

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1. Introduction

Researchers focused on new alternative energy sources due to diminishing petroleum reserves and increasing air pollution. The most important alternative energy sources for researches are solar power, wind power and biomass technology. Renewable energy sources such as biodiesel, bioethanol and biogas can be produced by biomass technology.

Biodiesel is produced from virgin or used vegetable oil and animal fats with transesterification method. Biodiesel can be used as pure or blending with diesel fuel. Its fuel properties are very similar to diesel fuel. It must suitable to EN14214 standard for called as biodiesel of produced fuel, otherwise, it is called as oil acid methyl ester. Some actual studies about biodiesel are presented below;

Banikov and Chattha [1] used jatropha methyl ester as fuel for diesel engine, and investigated performance and emissions characteristic. From the results, SCF increased and thermal efficiency decreased on engine performance. Also, T_{ex} (exhaust gas temperature) and CO emissions increased, smoke and NO_X emissions decreased, even HC emission undecided on exhaust emission parameters. Balakrishnan et al. [2] analyzed to combustion and emissions of using biodiesel from used cooking oil as fuel for diesel engine. As the results, ignition delay generally decreased, and combustion duration decreased at low loads despite its increased at high and full loads. On exhaust emissions parameters, exhaust gas temperature increased at low loads despite its decreased high and full loads, and CO emission increased, and smoke emission decreased at low loads despite its increased high and full loads. Mageshwaran et al. [3] investigated the effect on emission of using mustard oil methyl ester as diesel fuel. The results showed, CO and HC emissions decreased, and NO_X emission increased. Mattarelli at al. [4] explored to effects on the engine performance and exhaust emissions of using raw rape-seed biodiesel and biodiesel-diesel blends such as 20% and 50% as fuel. As results, engine torque decreased, SFC increased on performance, and CO_2 emission increased, soot concentration decreased with using biodiesel. Hassan et al. [5] studied to effects on performance and emission parameters of using biodiesel produced from Australian Beauty Leaf Tree as diesel fuel. They were exhibited that engine torque and power values decreased with using biodiesel. Besides, while CO and NO_X emissions decreased, CO_2 emission values increased by biodiesel. Abu-Hamdeh and Alnefaie [6] investigated to effects on engine performance and emissions of biodiesel fuels produced from almond and palm oils. According to obtained results, SFC is higher than diesel fuel, thermal efficiency, T_{ex}, CO, CO_2, NO_X, HC and particulate emissions are lower than diesel fuel for both fuels. Sajjad et al. [7] compared to performance and emissions of Calophyllum Inophyllum oil biodiesel with diesel fuel's. From results, maximum cylinder pressure and thermal efficiency decreased, SFC increased. CO, HC and smoke emissions decreased while NO_X emission increased with using biodiesel. Behcet et al. [8] investigated effects on performance and exhaust emissions of biodiesels produced from animal fats (fish and chicken). The results that SFC, torque and power as engine performance adversely affected with using both fuel. CO, CO_2 and HC emissions improved while NO_X emission increased with using biodiesels. Vedharaj et al. [9] used cashew nut shell liquid biodiesel as diesel fuel. Accordig to the results, maximum cylinder pressure and heat release rate decreased, SFC increased and thermal efficiency decreased with using biodiesel. HC, CO, T_{ex} and soot emissions increased and NO_X emission values decreased. Al-lwayzy et al. [16] presented that biodiesel decreased engine torque and engine power values, increased SFC values. Besides, it decreased exhaust gas temperature, CO emission, NO_X emission. According to study of Cardenas et al. [17], exhaust gas temperature, smoke opacity were decreased by used pure biodiesel, although it increased

NO_X emission, HC emission and fuel consumption. Besides, Gharehghani et al. [18] investigated also using of biodiesel in CI engines. They presented exhaust emission parameters of a CI engine used biodiesel. According to their test results, biodiesel decreased exhaust gas temperature, CO emission and HC emission, and it increased CO_2 emission.

According to literature survey, engine performance parameters decreased with using biodiesel, and even exhaust emissions parameters generally positive effected or improved due to using biodiesel. In this study, we were investigated to effect on parameters of performance and exhaust emission of using fuel blends which mixing to diesel fuel with methyl ester produced from cotton seed oil.

2. Material and Methods

Test Fuels

Blends obtaining from volume basis (2%, 5%, and 10%) mixing of conventional Euro Diesel (cED) with methyl ester produced from cotton oil were used as test fuels. These fuels are called respectively cED, COME2, COME5 and COME10. Some physical and chemical properties of test fuels are showed in Table 1.

Table 1. Properties of Fuel

Properties	**cED**	**COME2**	**COME5**	**COME10**	**COME**
D (kg/m^3)	829	831	832	835	885
V (mm^2/s)	2.74	2.84	2.85	2.89	4.65
FP (^{o}C)	59	61	63	66	95
LHV (cal/g)	10994	10735	10645	10577	9389
CP (^{o}C)	-12	+6	+7	+7	+10
YP (^{o}C)	-19	-	-	-	+4
FRP (^{o}C)	-30<	-	-	-	+2
Copper cor.	1a	1a	1a	1a	1a
D: Density, V: Viscosity, FP: Flash Point, LHV: Low Heat Value CP: Clouding Point, YP: Yield Point, FRP: Freezing Point					

Test engine and equipment

The engine used in this study was a diesel engine with direct-injection, single cylinder and four-stroke. Specification of the engine is given in Table 2. Net Fren NF-150 hydraulic dynamometer and Bosch BEA 350 emission gas analyser were used in tests. Figure 1. shows that experimental setup prepared for tests.

Table 2. Technical Features of Test Engine

Model	Superstar
Stroke (mm)	100
Total cylinder volume (cm^3)	770
Injector opening pressure (MPa)	17.5
Compression ratio	17:1
Start of injection timing	28-35^o CA BTDC
Maximum Power (kW)	7.46 (10 HP) at 1800 rpm
Cooling system	Water cooling

Experimental procedure

Tests were performed at full load condition. Engine speed was changed from 1000 to 2000 rpm with an interval of 200 rpm. Before each test, the engine was warmed up with diesel fuel for about 15 min until the engine temperatures were stabilized.

3. Test Results

Engine Performance

It's analyzed to engine torque and specific fuel consumption from engine performance parameters. The measured engine torque values are effective torque values from engine shaft. Figure 2. shows engine torque results for each test fuels. Maximum torque values were obtained at 1600 rpm for all test fuels. Figure 2. shows that, torque values of cED are higher than COME5 and COME10 fuels at all engine speeds. Although maximum torque value of COME2 is lower than cED fuel, torque values of COME2 at low engine speed are higher than cED fuel's. Maximum torque values of cED, COME2, COME5 and COME10 fuels were obtained respectively as 33.84 Nm, 32.18 Nm, 30.75 Nm and 29.12 Nm.

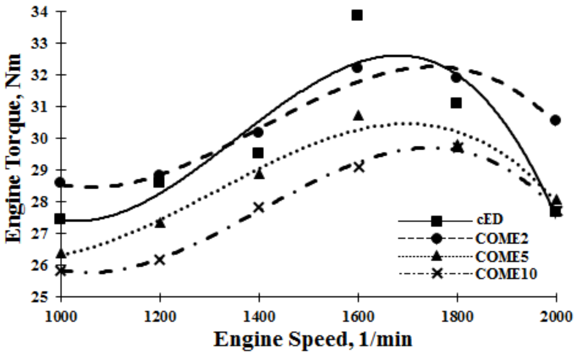

Fig 2. Change of engine torque values to speed for test fuels

To investigate SFC values, minimum values were obtained at 1600 rpm for cED, COME2 and COME5. Minimum SFC value of COME10 was obtained at 1800 rpm. Figure 3. shows that, SFC values obtained with other blend fuels, except COME2, are higher than cED. But SFC values of COME2 are generally lower than cED.

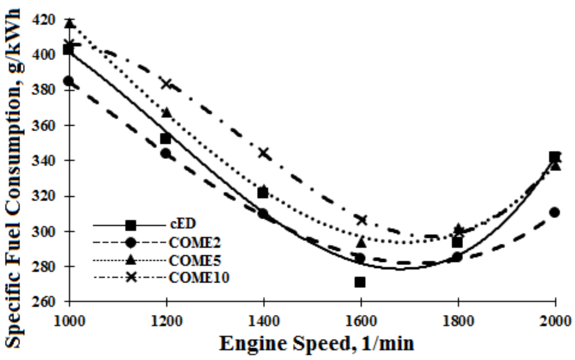

Fig 3. Change of SFC values to speed for test fuels

As test results, engine performance parameters with using COME effected as negative, although they usually improved with using COME2 at particularly low engine speed. Reasons of decreased at engine torque and increased at SFC with using COME can explain with low heat value of COME is lower than cED's as major reason. Besides, COME's flow problems such as higher density as viscosity were caused to bad atomize of fuel injection and thence combustion efficiency was decreased. Reason of improved on performance parameters with using COME2 can explain with decreased pumping losses due to increased fuel's density of adding about 2% COME to cED fuel. To exhibited results for performance parameters were similar with reported various studies by other researcher [1,4-15].

Exhaust Emissions

Figure 4. shows CO emission results for each test fuels. Usually, CO emission values from using COME are higher than cED's. There is increased approx. average 5.54% for COME2, approx. average 21% for COME10 according to cED. But, CO emission values of COME10 at especially high engine speeds are decreased approx. average 3.3% according to cED. Two major reasons of formed CO emission are low fuel flame temperature and inadequate oxygen during combustion in cylinder. Bad flow properties such as density and viscosity of COME were reduced flame temperature of blend fuels. Therefore CO emissions were increased by using COME. Reason of decreased on CO emission values with using COME5 can explain to oxygen content of COME. Namely, oxygen content of COME2 did not improve enough oxygen content of blend, also COME10 was worsen flow properties, CO emissions from using COME5 was reduced owing to oxygen content despite it ruined to flow properties. To exhibited results for CO emission parameters were similar with reported various studies by other researcher [1,2,9,11-12, 14].

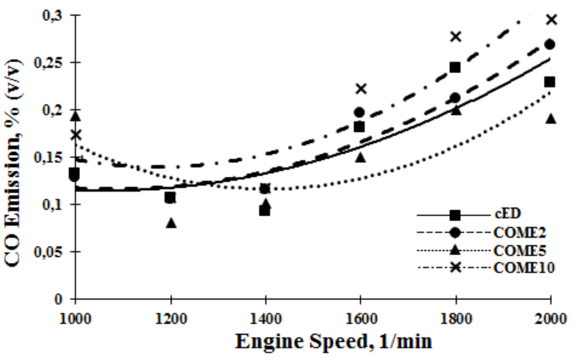

Fig 4. Change of CO emission values to speed for test fuels

Figure 5. shows that HC emission values obtained from test fuels. Generally, HC emissions with using COME are decreased, except for values from COME2 at low engine speed. Although HC emissions from COME2 are increased approx. average 22.22% at low speed, these values are decreased approx. average 48.1% at high speed. For other blend fuels, there is decreased approx. average 12.43% for COME5, approx. average 15.3% for COME10 according to cED. Reason of this decreasing is explainable that decreased

trend of HC emissions compared to diesel fuel might be presence of oxygen molecules in biodiesel helped for complete combustion. The oxygen content of biodiesel caused this type of result because the higher oxygen in the combustion region provides more complete combustion. To exhibited results for HC emission parameters were similar with reported various studies by other researcher [3,6-8,11-14].

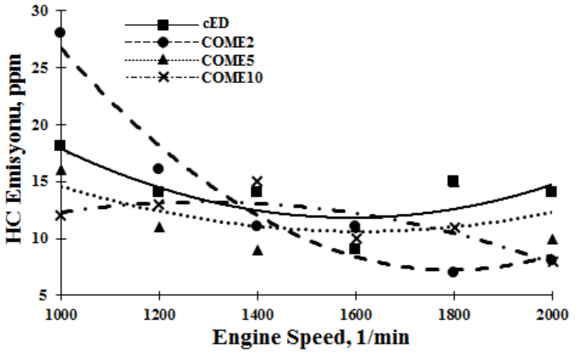

Fig 5. Change of HC emission values to speed for test fuels

Figure 6. shows smoke emission values of test fuels. Smoke emission measured as coefficient of k absorption which reducing luminous intensity of passing light through the gas of non-transparent particles in exhaust gas. Unit of k absorption coefficient is 1/m. Smoke emission values are increased with using COME. There is increased approx. average 74.95%-53.82%-65.47% respectively for COME2-COME5-COME10 according to cED. Reason of increased at smoke emission can explain lean combustion due to oxygen content of COME. To exhibited results for smoke emission parameters were similar with reported various studies by other researcher [9,11,13-15].

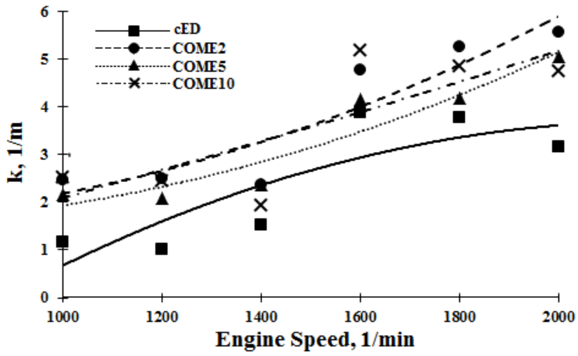

Fig 6. Change of smoke emission values to speed for test fuels

Figure 7. shows changing of NO_X emission values. Generally, NO_X emissions decreased with using COME. There is decreased approx. average 19.91% for COME2, approx. average 8.81% for COME5 and approx. average 14.63% for COME10 according to cED. NO_X emission is formed with chemical reaction of N and O atoms at very high temperature in cylinder. Worsen of combustion due to oxygen content of COME and poor of burning end temperature due to LHV of COME which it is lower than cED's are causes of decreasing NO_X emission. To exhibited results for NO_X emission parameters were similar with reported various studies by other researcher [5-6,9].

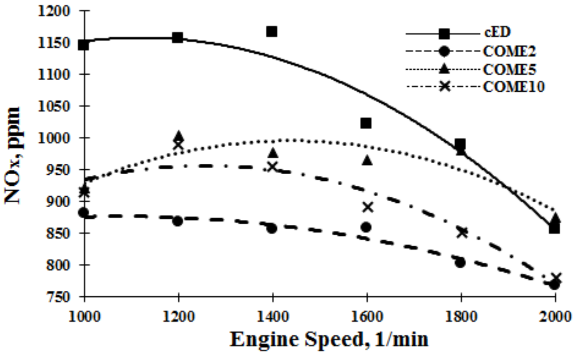

Fig 7. Change of NO_X emission values to speed for test fuels

4. Conclusion

In this study, the effects on engine performance and the exhaust emission characteristics of a diesel engine were experimentally investigated when the engine was fueled with COME – diesel blend. Based on the experimental results of this study, the following conclusions can be drawn:

- COME has similar physical and chemical properties with cED.
- Usually, cotton oil as raw material is cheaper than other vegetable oil and it is easily used in diesel engines.
- Compared to engine performance of cED and blend fuels, although engine performance values with adding COME to cED decreased as generally, adding about 2% COME to cED improved to engine performance according to cDE.
- To analysed for exhaust emissions, while HC and NO_X observed decrease, CO and smoke emission values were increased.

But CO emission values were decreased as noteworthy at high speed.

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