

NO_x REDUCTION IN CI (COMPRESSION IGNITION) ENGINE FUELED WITH METHYL ESTER OF RAPESEED OIL USING ANTIOXIDANT ADDITIVES**Vetrivel Kumar K**

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ABSTRACT

The aim of the present study is to analyze the effect of antioxidant (L-ascorbic acid) on engine performance and emissions of a diesel engine fuelled with methyl ester of Rapeseed oil. The antioxidant is mixed in various concentrations (100-400mg) with methyl ester of Rapeseed oil. Result shows that antioxidant additive mixture (MERSO+LA300) is effective in control of NO_x and HC emission of methyl ester of Rapeseed oil fuelled engine without doing any engine modification.

Keywords: Rapeseed Methyl Ester, Transterification, L-ascorbic acid, performance, emissions, Diesel engine.

1. Introduction

Diesel engines are commonly used as prime movers in the transportation, industrial and agricultural sectors because of their high brake thermal efficiency and reliability. The increasing industrialization and motorization of the world has led to a steep rise in the demand of petroleum based fuels. Petroleum based fuels are obtained from limited reserves. These finite reserves are highly concentrated in certain regions of the world. Therefore, those countries not having these resources are facing energy/foreign exchange crisis, mainly due to the import of crude petroleum. Hence, it is necessary to look for alternative fuels which can be produced from resources available locally within the country such as alcohol, biodiesel, vegetable oils etc. The concept of using biodiesel in diesel engines was originated by the inventor “Rudolf Diesel” using peanut oil as a fuel at the World Exhibition in Paris in 1900[1]. Vegetable oil from crops such as soyabean, peanut, sunflower, Jatropha, mahua, neem, rape, coconut, karanja, cotton, mustard, linseed and castor have been tried in many parts of the world, which fulfill the present need [2]. The result shows that when

direct injection diesel engine run neat vegetable oil, injectors get choked up and leads to poor atomization and less efficient combustion [3]. One possible method to overcome the problem of higher viscosity is transesterification oils to produce Biodiesel. It was showed that the transesterification process is an effective means of biodiesel production and viscosity reduction of vegetable oils [4]. The purpose of the work is to examine the effects of Rape Seed Methyl Ester on engine performance and emissions. The result shows that methyl ester of rape seed oil improves the engine performance and reduced the emissions when compared to that of neat diesel fuel [5]. Studies on the deterioration of rape seed and frying oil at different storage conditions have been reported that increase of kinematic viscosity, peroxide value and acid value [6]. This study reported that the effects of different antioxidants on various biodiesels which enhances the oxidation stability and reduced the NO_x emissions [7-8]. The main disadvantage of the biodiesel/diesel blends is poor oxidative stability. The present work proves that it is possible to stabilize biodiesel/ diesel blends even the fatty components is aged for a period of three months [9]. This study reported that the use of antioxidant additives increases the oxidation stability of Croton oil Methyl Ester and utilized as a partial substitute of mineral diesel [10].

Antioxidants are hopeful additives for improving oxidation stability and decreasing NO_x emissions while using biodiesel [11-13]. It is reported that use of antioxidants increases to carbon monoxide emissions [14]. This paper shows that the antioxidant additive is effective method in controlling of NO_x and HC emissions of methyl ester of cotton seed oil fueled diesel engines [15]. This paper reported that the TBHQ antioxidant was optimal as BSFC and NO_x were reduced considerably [16]. Many researchers have reported that Addition of antioxidant to diesel fuel-vegetable oil blends leads to increase NO, NO_2 and CO formation and decrease CO_2 and HC emissions [17-18]. This paper reported that amount of antioxidant required for stabilizing the biodiesel [19]. This work deals with evaluation of oxidation stability of metal contaminated biodiesel/diesel blends. It is found that biodiesel blend with diesel shown the better oxidation stability [20]. The addition of n-butanol in vegetable oil-diesel blends improves the engine performance and reduced the engine emissions such as HC, CO and NO_x are lower than those of diesel [21]. Thus, 20% biodiesel blends added with antioxidant can be used in diesel engines without any modifications [22]. This paper shows that effect of antioxidant on the oxidation stability of the biodiesel fuel. It is found that addition of antioxidant improves the oxidation stability and few effects on the exhaust emission of a diesel engine [23]. The effect of low concentrations of methyl linoleate on the autoxidation have been investigated at different temperatures [24]. This paper reported that both types of antioxidant showed beneficial effects in inhibiting the oxidation of distilled palm oil methyl esters. Further, the synthetic antioxidants were found to be more effective than the natural antioxidants as lower dosage [25].

In this study, methyl ester of Rapeseed oil is used as a test fuel and L-ascorbic acid as antioxidant. The effect of antioxidant on performance and emissions along with methyl ester of Rapeseed oil operated direct injection diesel engine was studied.

2. Materials and methods

2.1. Test Fuels

Rapeseed oil is used as diesel fuel, either as biodiesel, straight in heated fuel systems, or blended with petroleum distillates for powering motor vehicles. Biodiesel may be used in pure form in newer engines without engine damage and is frequently combined with fossil-fuel diesel in ratios varying from 2% to 20% biodiesel.

2.2. Transesterification

Transesterification is the process of using an alcohol (e.g. methanol or ethanol) in the presence of catalyst such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), which chemically breaks the molecule of the raw oil into methyl or ethyl esters with glycerol as a by-product, which reduces the high viscosity of oils. This method also reduces the molecular weight of the oil to 1/3 of its original value, reduces the viscosity and increase the volatility and cetane number to levels comparable to diesel fuel.

2.3. Experimental setup

Experiments are carried out in a single-cylinder, water-cooled, naturally aspirated direct injection diesel engine coupled with an eddy current dynamometer. An eddy current dynamometer coupled to the engine is used as a loading device. The fuel flow rate, speed, loads, exhausts gas temperature and gas flow rate are measured through data acquisition system. AVL 444 Di-gas Analyzer is used to measure the CO, HC and NO_x emissions.

L-ascorbic acid is accurately weighted using a high precision electronic weighing balance and added to measured quantity of rapeseed biodiesel. To make 0.010%-m of antioxidant mixture, 100mg of antioxidant is added to 1kg of biodiesel. A 3000-rpm speed mixer was used to prepare a homogeneous mixture of antioxidant and fuel. The emissions from the engines were studied at different antioxidant concentrations such as 0.010%-m (LA100), 0.020%-m (LA200), 0.030%-m (LA300), 0.040%-m (LA400), with a constant engine speed of 1800 rpm. The antioxidants addition effect on emissions in a methyl ester of Rapeseed oil fuelled DI diesel engine at different loads have been studied in this investigation. The properties of methyl ester of Rapeseed oil, various antioxidant mixtures are compared with neat diesel fuel as shown in Table 1.

2.4. Specifications of the apparatus

The experiment was conducted in the following instruments/equipments and the details are given below.

I. Diesel Engine

- Manufacturer : Kirloskar oil engines limited
 - Type of Engine : Vertical, 4-Stroke Single cylinder
 - Model : SV1
 - Rated Output
- As per IS: 11170 : 8 HP (5.9kW)
- Speed : 1800 rpm
 - Compression Ratio : 17.5:1
 - Bore and stroke : 87.5 x 110 (mm)
 - Injection pressure : 200 bar

II. Exhaust gas analyzer

An AVL gas analyzer is used to measure the exhaust gas composition. The brief specification of exhaust gas analyzer is given below.

➤ Manufacturer	:	AVL private limited
➤ Type	:	AVL 444 DI gas Analyzer
➤ Ranges	:	CO - 0 to 10 %
		HC - 0 to 10000 PPM
		NO _x - 0 to 5000 PPM

2.5. Testing Procedure

Engine was started and warmed up at low idle, long enough to establish the recommended oil pressure, and was checked for any fuel and oil leaks. The engine was run on no-load condition and speed was adjusted to 1800 rpm by adjusting fuel injection pump. Engine was run to gain uniform speed, after which it was gradually loaded. Experiments were conducted at different load levels. The engine was run for 10 minutes and data's were collected during last 4 minutes. The performance and emission tests were carried out at different antioxidant mixture concentrations. The exhaust gas is sampled from exhaust pipe line and passed through an exhaust gas analyzer for measurement of carbon monoxide, unburnt hydrocarbon, oxides of nitrogen present in exhaust gases. The experimental uncertainties are shown in Table 2.

3. Results and discussion

3.1. NO_x emission

Temperature plays a vital role in NO_x formation. It is also depends upon the compression ratio, equivalence ratio, geometry of the combustion chamber, fuel injection advance ,pressure and temperature of the inlet air. Fig 2 shows that variation of NO_x emission with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen from Fig 2that NO_x emissions increases with increase of engine load. The NO_x emission decreases with the percentage of antioxidant additives with the methyl ester of rapeseed oil, up to of 0.030%-m of antioxidant mixture after that it increases. Further it is also seen that NO_x emission of 0.020%-m of antioxidant mixture is decreased by 40.16% when compared to neat diesel fuel respectively. This is due to the reduction in the formation of free radicals by antioxidants. Free radicals play a key role in prompt NO formation during the combustion of biodiesel within the flame.

3.2. Hydro carbon emission (HC)

Fig 3 shows that variation for HC emission with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen that HC emissions decrease with increase of engine load. The HC emission decreases with the percentage of antioxidant additives along with the methyl ester of Rapeseed oil, up to of 0.030%-m of antioxidant mixture after that it increases. Further it is also seen from Fig 3 that HC emission of 0.030%-m of antioxidant mixture is decreased by 37.97% when compared to the neat diesel fuel at full load condition. This is due to fact that antioxidant (L-ascorbic acid) is a reducing agent and reduce functional groups present in the methyl ester of Rapeseed oil.

The oxygen content of biodiesel may have provided some better conditions particularly in the fuel rich region, which enhanced the oxidation of HC emissions. This leads to reduction in hydro carbon emission. This result is also reported in introduction section [17].

3.3. Carbon monoxide emission (CO)

Fig 4 shows that variation of CO emission with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen from the Fig 4 that CO emission increases with increase of engine load when compared to that of diesel at load conditions. This is due to incomplete combustion from the addition of antioxidant additives. The oxidation of CO is directly related to the OH radicals present in the reaction. This result is also reported in introduction section.

3.4 Smoke emission

Fig 5 shows that variation of smoke emission with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen from Fig 5 that smoke emission increases with increase of engine load when compared to that of neat diesel at load conditions. The smoke emission increases with the percentage of antioxidant additives with the methyl ester of Rapeseed oil. This is due to incomplete and improper combustion which results from the antioxidant formation.

3.5 Brake specific fuel consumption (BSFC)

Fig 6 shows that variation of brake specific fuel consumption with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen from Fig 6 that BSFC increases with increase of engine load. The BSFC increases with the percentage of antioxidant additives with the methyl ester of rapeseed oil. This is due to improper and incomplete combustion which results from antioxidant addition. Further it is also due to supply of little more fuel to compensate slight power loss.

3.6. Brake thermal efficiency (BTE)

Fig 7 shows that variation of brake thermal efficiency with brake power for diesel fuel, methyl ester of rapeseed oil and methyl ester of rapeseed oil-antioxidant mixtures. It can be seen from Fig 7 that BTE decreases with increase of engine load. The BTE decreases with the percentage of antioxidant additives with the methyl ester of rapeseed oil. This is due to more variation in the property of methyl ester of rapeseed oil-antioxidant mixture and incomplete combustion which results from antioxidant addition.

4. Conclusion

The effects of antioxidant addition on exhaust emission with methyl ester of Rapeseed oil have been studied at different fuel condition in this present work. The main conclusions of the present study are given below.

1. It was observed that L-ascorbic acid is an effective antioxidant for the addition of MERSO+L300, the NO_x emission reduced by 40.16% and also HC emission is reduced by 37.97% at full load conditions when compared to the neat diesel fuel.

2. CO and smoke emission for all concentrations found to be slightly increased when compared to that of neat diesel fuel. This is due to the disturbance during combustion.

3. It is concluded that NO_x emission and HC emission can be reduced considerably by using

antioxidant (L-ascorbic acid) along with the methyl ester of Rapeseed oil .It is simple and cost effective method without change in any engine modification.

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Figure caption

Figure 1 Experimental setup

Figure 2 Brake Power (BP) vs Oxides of Nitrogen emission (NOx)

Figure 3 Brake Power (BP) vs Hydro Carbon emission (HC)

Figure 4 Brake Power (BP) vs Carbon mono oxide emission (CO)



Figure 1 Experimental setup

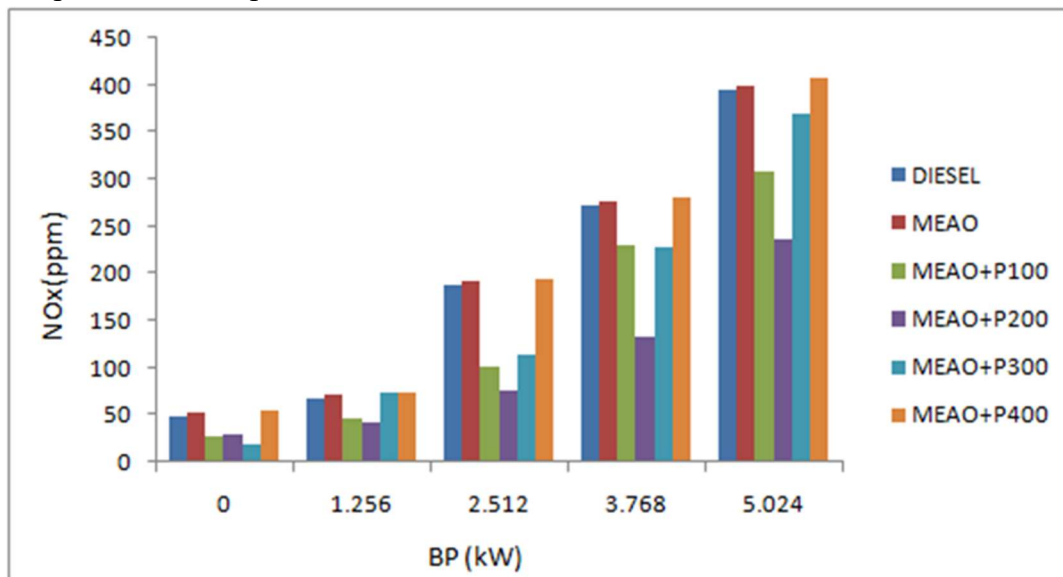


Figure 2 BP vs NOX

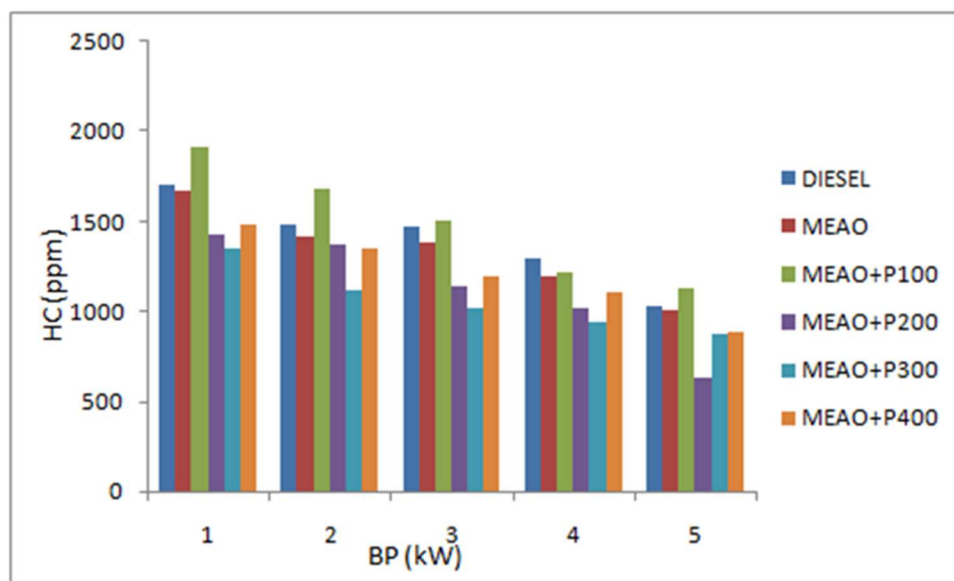


Figure 3 BP vs HC

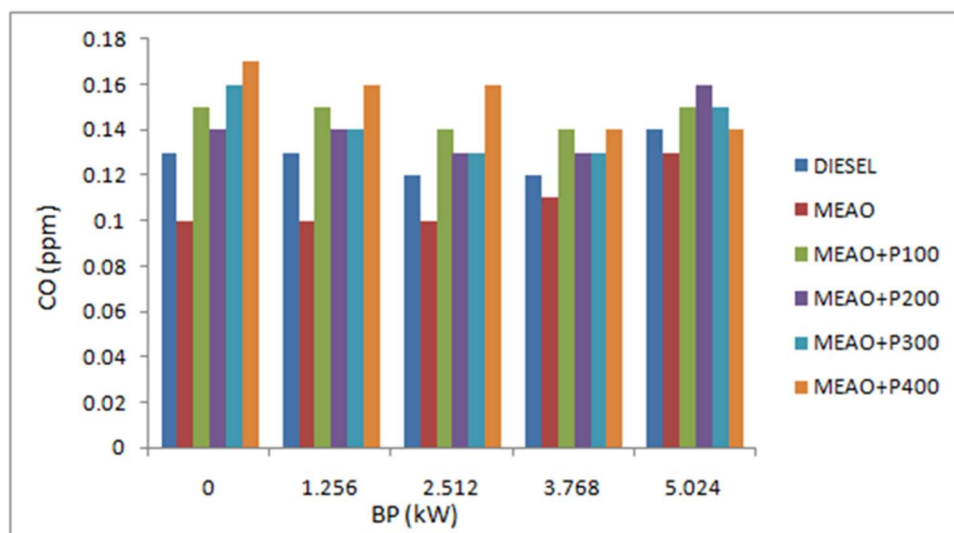


Figure 4 BP vs CO

List of Tables

PROPERTY	Diesel	MEAO	MEAO+P100	MEAO+P200	MEAO+P300	MEAO+P400
Kinematic viscosity in cst at 40 ⁰ C	3.1	5.18	5.18	5.18	5.16	5.16
Calorific value in Kj/kg	43200	39575	39572	39499	39496	39493

Density at 15 ⁰ C in kg/mm ³	830	880.2	878	876	874	872
Cetane no.	46.4	52	52	52	52	52
Flash point (°C)	56	76	76	76	76	76
Fire point (°C)	64	92	92	92	92	92

Table.2. Experiment uncertainties

Parameters	Systematic Errors (±)
Speed	1 ± rpm
Load	± 0.1 N
Time	± 0.1 s
Brake power	± 0.15 kW
Temperature	± 1°
Pressure	± 1 bar
NO _x	± 10 PPM
CO	± 0.03%
CO ₂	± 0.03%
HC	± 12 PPM
Smoke	± 1 HSU