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Exhaust Emissions Reduction in Calophyllum Biodiesel Operated Diesel Engine through Antioxidant Additive

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ABSTRACT

The effect of antioxidant additive on engine performance, combustion and emission of a diesel engine fuelled with methyl ester of calophyllum biodiesel is studied. The antioxidant is mixed in various proportions from 50 mg to 200 mg with methyl esters of calophyllum biodiesel. It has been observed that the anti-oxidant mixture at 200 mg proportion is effective in controlling NO_x and HC emission without any modification in the engine. Further there is a reduction in other emission such as CO and smoke of about 48% and 28.57 % respectively at full load condition when compared to the diesel fuel.

1.Introduction

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 [1-2]. The result shows that when direct injection diesel engine run neat vegetable oil, injectors get choked up and loads 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 [1]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 NOx 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 NOxand HC emissions of methyl ester of cotton seed oil fueled diesel engines [15].

2. Transesterification

Transesterification is the process of using 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 increases the volatility and cetane number to levels comparable to that of diesel fuel. Conversion does not greatly affect the gross heat of combustion.

Property	Unit	Calophyllum Inophyllum
Colour	-	Greenish yellow
Density at 15°C	kg/m^3	910
Kinematic Viscosity at 40°C	Cst	38.17
Saponification Value	-	203
Calorific Value	MJ/kg	32.50
Specific Gravity	-	0.908
Flash Point	°C	224
Fire Point	°C	253

3. Result and discussion

3.1 Brake thermal efficiency

Figure 1 shows the variation of brake thermal efficiency with brake power for CAI biodiesel with four different proportions of L-ascorbic acid. It is found from the figure that the brake thermal efficiency is slightly higher for CAI biodiesel with L-ascorbic acid 200 mg at all loads when compared with other proportions and this is due to its lower viscosity and better mixture formation in the biodiesel. Further, it is also found that the increase in antioxidant proportions in biodiesel slightly increases the brake thermal efficiency. This may be due to the complete combustion resulting from antioxidant additive. It is also observed that the BTE is in the order of 200 mg, 150 mg, 100 mg and 50 mg at full load.

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The BTE for 200 mg for proportion of L-ascorbic additive is 25.5 %, which is 1.75 % higher than that of 50 mg proportion.

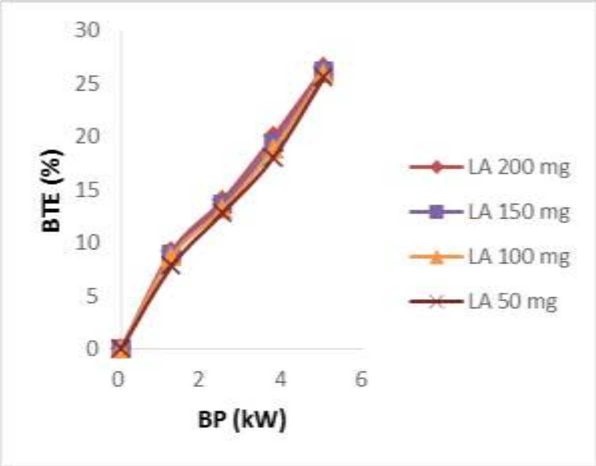

Figure 1.Variation of brake thermal efficiency with brake power for different proportions of L-ascorbic acid with CAI biodiesel.

3.2 Brake specific fuel consumption

The variation of brake-specific fuel consumption with brake power for CAI biodiesel with four different proportions of L-ascorbic acid is shown in Figure 5.23.It is observed that the brake-specific fuel consumption for CAI biodiesel with LA 200 mg is less than that of other three concentrations of L-ascorbic acid. The addition of antioxidant mixture slightly decreases the brake specific fuel consumption. This may be due to a little more fuel supplied to the engine to compensate the slight power loss due to the incomplete combustion resulting from antioxidant additive addition. It is seen from the graph that the BSFC is less for 200 mg proportion and more for 50mg. At 100% load, the BSFC for 200mg is 0.348 kg/kW-hr which is 0.033 kg/kW-hr lower than that of 50 mg proportion. This is because of higher proportion leading to the complete combustion at all loads.

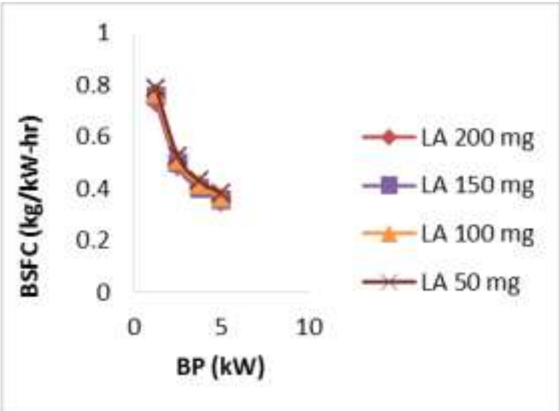

Figure 2 .Variation of brake specific fuel consumption with brake for different proportions of L-ascorbic acid with CAI biodiesel.

3.3.Exhaust gas temperature

Figure 3 shows the variations of exhaust gas temperatures with BP for CAI biodiesel with four different proportions of L-ascorbic acid. To indicate the cylinder combustion temperature, engine exhaust temperature is considered one of the important parameters. It is known that the higher ignition delay results in delayed combustion and higher EGT. Although CAI biodiesel with antioxidant mixture possess higher cetane number, poor atomization resulting from the higher viscosity of those biodiesel causes the presence of unburnt fuels in the premixed combustion phase.

Further, these unburnt portions continue to burn later in the diffusion combustion phase, leading to a higher exhaust temperature. This will give a loss of useful heat energy which affects thermal efficiency adversely. It is found from the figure that the EGT is high for 200 mg at all loads when compared to other proportions. At full load, 200 mg proportion has 270^{0}C of EGT which is 20^{0}C lower than that of 50mg proportion.

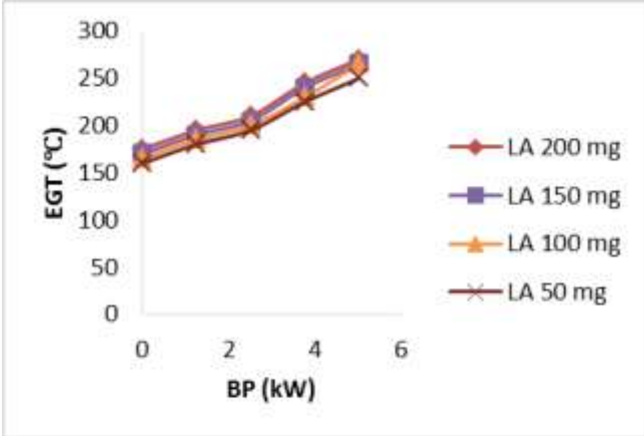

Figure 3.Variation of exhaust gas temperature with brake power for different proportions of L-ascorbic acid with CAI biodiesel

3.4 Hydrocarbon emission

Figure 4 shows the variation of HC emission with brake power for CAI biodiesel with four different proportions of L-ascorbic antioxidant additive. The HC emission is found to be higher with the increase in the antioxidant proportions in the blends. It is found from the figure that the 200 mg mixture reduces the HC emission by 18.75 % at full-load condition. In general, all antioxidant mixtures reduce HC since L-ascorbic acid is a reducing agent and reduces the functional groups present in the biodiesel. This leads to a significant reduction in HC emissions.

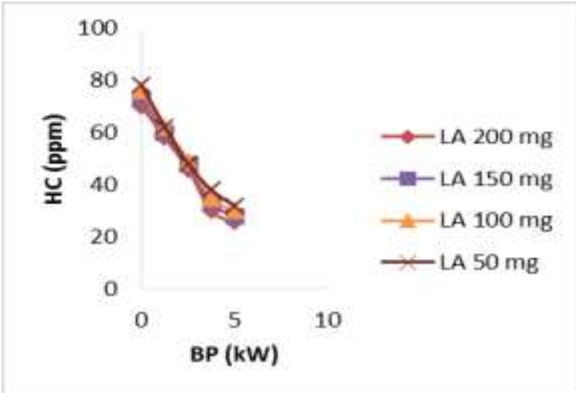

Figure 4.Variation of hydrocarbon with brake power for different proportions of L-ascorbic acid with CAI biodiesel

3.5. Carbon monoxide emission

The variation of carbon monoxide with brake power for CAI biodiesel with four different proportion of L-ascorbic acid. The oxidation of CO is directly related to the amount of OH radicals present in the reaction. It is seen from the figure that the CO emission is lower for 200 mg and higher for 50 mg at all loads. This is due to the incomplete combustion of lower proportions of antioxidant additive. At higher proportions there is a possibility of complete combustion and reduction of CO emission in the exhaust. At 60% load the CO emission is 0.24 % for 200 mg proportion which is 5 % lesser than that of 50 mg proportion.

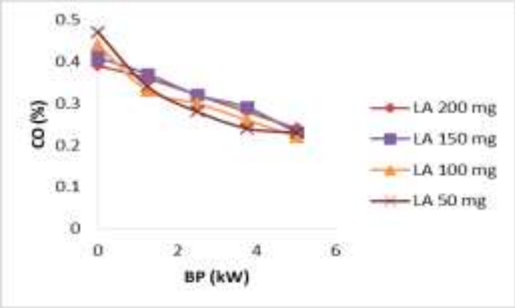

Figure 5. Variation of carbon monoxide with brake power for different proportions of L-ascorbic acid with CAI biodiesel

3.6 .Oxides of nitrogen emission

Figure 6 shows the variation of NO_x with brake power CAI biodiesel with four different proportions of L-ascorbic acid. The results show that NO_x emission increases with the increase in engine load. It is observed that the NO_x emission decreases with increasing antioxidant proportions. Further, it is also observed that LA 200 mg reduces NO_x emission by 2.6 % compared with 50 mg proportion at full load. This may be due to higher antioxidant proportion, which leads to formation of free radicals, which in turn reduces the NO_x emission significantly.

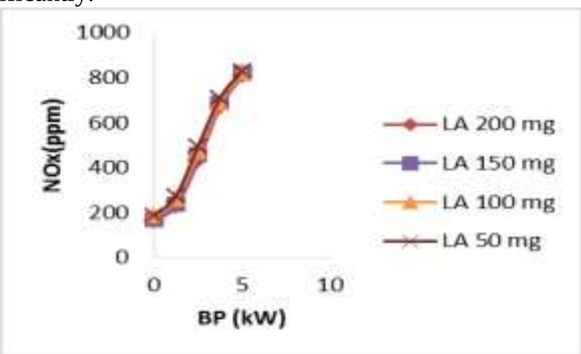

Figure 6.Variation of NO_x emission with brake power for different proportions of L-ascorbic acid with CAI biodiesel.

3.7 Smoke opacity

Figure 7 shows the variation of smoke intensity with brake power for CAI biodiesel with four different proportions of L-ascorbic acid. The results show that smoke intensity increases with the increase in engine load. It is found that LA 200 mg shows lower smoke emission than others. It is also found that the addition of antioxidant slightly decreases the smoke intensity at all load conditions. This may be due to the proper combustion resulting from antioxidant addition in fuel. It is observed that at 75% load the smoke emission for 200 mg proportion is 26 HSU, which is 5 HSU lower than that of 50mg proportion and this is due to the complete combustion when free radicals are present in the combustion chamber.

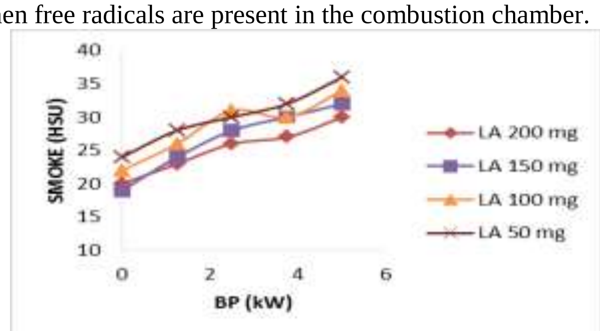

Figure 7.Variation of smoke opacity with brake power for different proportions of L-ascorbic acid with CAI biodiesel

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