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Influence of antioxidant on performance of CI engine using waste fried oil methyl ester

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Abstract. The future of biodiesel is bright. However, biodiesel is vulnerable to oxidative degradation due to autoxidation. Adding antioxidant is a probable answer to achieve clean burning and improved combustion. This paper addresses experimental study the influence of antioxidant with WFO biodiesel on diesel engine performance. WFOME was produced through transesterification process. BHA and BHT have been used as antioxidants. Increased oxidation stability of B40 (60% diesel + 40% Biodiesel) was observed with accumulation of antioxidants. A 5HP engine was preferred for this study. The outcomes illustrate that antioxidant-treated B40 produced 2.15% to 4.78% higher brake thermal efficiency and BSFC by 2.08% to 4.74% compared to untreated B40. Reduction in nitrogen emissions in tune of 4 ppm to 8 ppm was observed during this research. Increased CO in tune of 8.54 to 17.08% has been pointed out. HC emissions were higher by 7.73 to 14.95%.

1. Introduction

So as encounter the forthcoming energy a crisis there is needed to discover the biode-gradable and environmental friendly alternate fuel. Several methodologies and regulations were followed to reduce NOx emission and soot particles because of use of biodiesel. Compression Ignition engines are a major source NOx and particulate matter. Many investigations have been carried out over past few years to achieve standard emission norms. To reduce the NOx emission effectively, Anti-Oxidants (AO) were preferred [1-2]. Additionally, a carbon dioxide emission from diesel combustion is responsible for damage of environment [3]. Antioxidants decelerate the biodiesel squalor process considerably.

Fattah et al. tested antioxidants and observed reduction of NOx emission accompanied by higher emission of CO and unburned HC [4]. Sajith et al. investigated with cerium oxide nanoparticle at 20, 40 and 60 ppm addition in jatropha biodiesel and observed significant reduction of NOx and HC [5-6]. Selvan et al. mixed cerium oxide nanoparticle of 25 ppm in diesel-biodiesel-ethanol blends and observed improved BSFC with reduction in HC, CO, NOx [7]. Hess et al. observed drop in NOx emissions because of substitution of antioxidants [8].

In the present study, the effect of antioxidant additives BHA and BHT on CI engine with B40 blends was analyzed.

2. Methodology

The biodiesel produced through transesterification process from WFO was blended with diesel. Oxidation stability was measured with help of Biodiesel Rancimat. To confirm uniform mixture 40% WFOME is mixed with 60 % diesel (B40) at the beginning of testing. The accumulation of antioxidant to B40 increased viscosity by 0.18% (Table 1).

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Table 1 Fuel characterization.

Properties	B100	B40	B40+BHT	B40+BHA	Diesel	Method
Viscosity at 40°C (cSt)	6.8	5.56	5.57	5.57	4.320	ASTM D445
Specific Gravity	0.87	0.846	0.850	0.850	0.830	ASTM D941
Calorific Value (kJ/kg)	39000	41400	41250	41380	43000	ASTM D240
Oxidation stability(h)	7.4	15	24	25	59	ASTM D675
Flash Point (°C)	140	120	122	122	70	ASTM D93
Cetane Number	55	-	-	-	-	-

A typical 3.8 kW (5HP) diesel engine with a bore of 85 mm and 110 mm stroke length was used for test. Engine setup (figure 1) consists of Engine (1), Alternator (2), Electrical load bank (3), Fuel tank (4), Burette (5), Two way control valve (6), Air box (7), Orifice plate (8), U tube manometer (9), Exhaust gas analyser (10) and Exhaust gas thermocouple (11). The exhaust emissions were measured using AVL 444 Di-gas analyser. All the tests are carried out for three times under steady state condition. Table 2 presents error analysis of equipment.

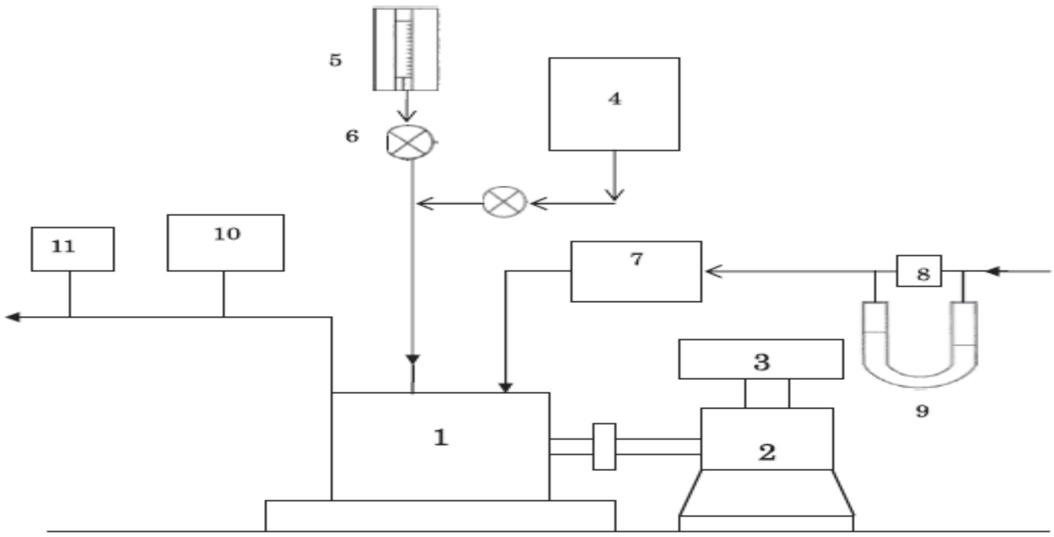

Fig. 1. Engine setup

Table 2 Error analysis

Instrument	Parameter	Accuracy	Parameter	Uncertainty
Dynamometer	Load	± 2.2 N	Torque	± 1.35 %
Digital counter	Speed	± 2 rpm	Power	± 1.35 %
Stop Watch	Time	± 0.5 %	BSEC	± 1.75 %
Temperature indicator	Temperature	± 1 °C	BTE	± 1.75 %
			NO_x	± 1 ppm
			HC	± 1 ppm
			CO Vol	±0.01 %

3. Results

3.1. Brake Thermal Efficiency (BTE)

The maximum values of BTE observed at 3.5 kW for B0, B40, B40 + BHA and B40 + BHT were 30.79%, 28.03%, 29.04% and 28.63% respectively. Antioxidants increased the mean BTE by 4.78% to 2.15% (Figure 2).

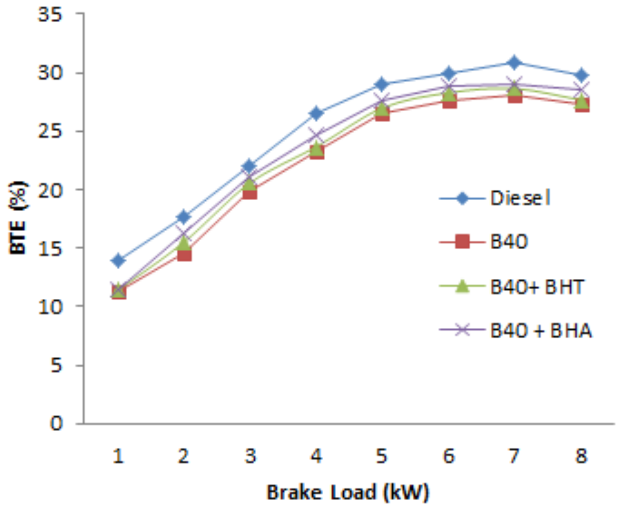

Fig. 2. BTE vs. Brake Load

3.2. Brake Specific Fuel Consumption (BSFC)

The maximum values of BSFC observed at 3.5 kW for B0, B40, B40 + BHA and B40 + BHT were 0.272, 0.310, 0.304 and 0.299 kg/kWh respectively. Antioxidants decreased the mean BSFC by 2.08 % to 4.74% (figure 3).

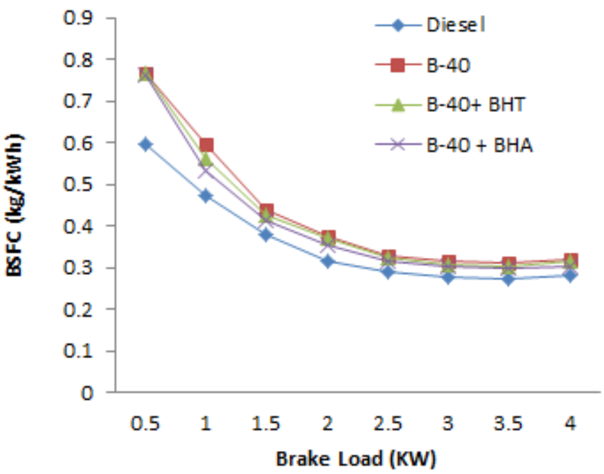

Fig. 3. BSFC vs Brake Load

3.3. Oxides of Nitrogen (NOx)

Accumulation of Antioxidant into the blends showed an encouraging impact on decreasing of emissions NOx [10]. BHA and BHT produced average decrease in NOx emission of 4 ppm to 8 ppm (figure 4). It could be due to the phenolic hydroxyl groups existent in these antioxidants interfere with the quick NOx mechanism [8].

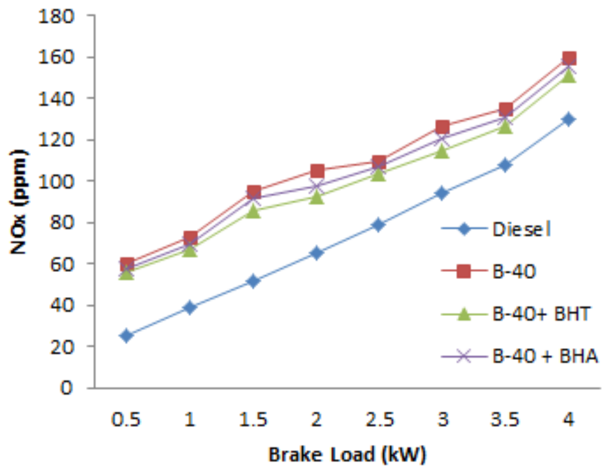

Fig. 4. NO_x Vs Brake Load

3.4. Carbon monoxide (CO)

The average CO emission reductions for were B40, B40 + BHA, B40 + BHT, 31.85%, 26.03% and 20.21%, respectively. Lesser CO emissions can be credited to higher cetane number [11]. Antioxidants increased CO emission by 8.54% and 17.08% (figure 5).

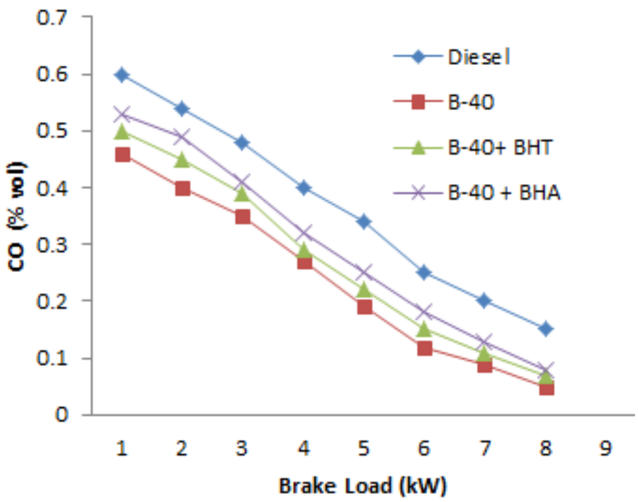

Fig. 5. CO Vs Brake Load

3.5. Hydrocarbon (HC)

Fuel spray characteristics and engine parameters setbacks HC emissions whereas improved oxygen content in the fuel can significantly reduce emissions of HC [12-13]. Decrease of oxidative free-essential materialization could be the cause of increase in HC in comparison with B40 with addition of AO [14]. B40 + BHA and B40 + BHT increased mean HC by 14.95% and 7.73%, respectively, compared to B40 (Figure 6).

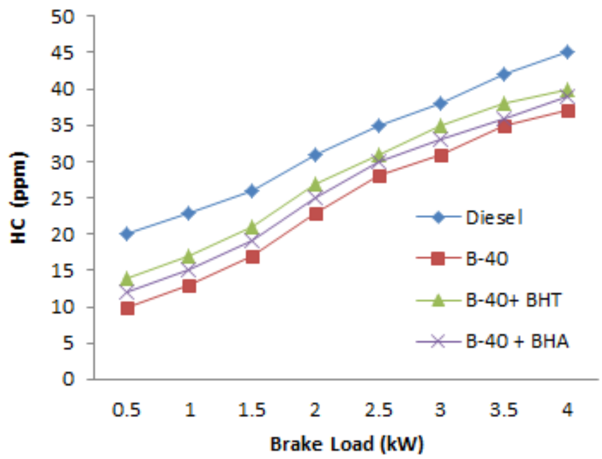

Fig. 6. HC Vs Brake Load

4. Conclusions

The following conclusions can be drawn based on the experimental investigations.

1. BHA produced better stabilization compared to BHT in B40.
2. The addition of antioxidants BHA and BHT to B40 increased the mean BTE by 4.78% and 2.15%, respectively compared to B40.
3. The accumulation of BHA and BHT to B40 decreased the mean BSFC by 2.08 % and 4.74%, respectively compared to B40.
4. Antioxidant-alleviated blends formed reductions in mean EGT of 3–8% com-pared to B40.
5. Accumulation of Antioxidant into the blends showed an encouraging impact on decreasing of emissions NOx. BHA and BHT producing a mean decrease in measured NOx emission of 4 ppm to 8 ppm in comparison to B40.
6. Mixing of BHA and BHT produced mean increases in CO emission of 8.54% and 17.08% compared to B40.
7. B40 + BHA and B40 + BHT produced mean HC reductions of 14.95% and 7.73%, respectively, compared to B40.

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