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PERFORMANCE AND EMISSIONS CHARACTERISTICS OF A DIESEL ENGINE FUELLED WITH ETHANOL ADDITIVE IN DIESEL-SOYBEAN BIODIESEL FUEL BLEND

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Abstract

In this study, an experimental study was performed in order to examine the effect of ethanol additive in diesel-soybean biodiesel fuel blend. In experiments, 20% (by volume) soybean biodiesel was blended with low sulphur diesel fuel, and then 5%, 10%, and 15% ethanol was added in the blend. Experiments were conducted in a water cooled, four cylinder four stroke diesel engine. The results showed that, compared to diesel and biodiesel, ethanol addition improved carbon monoxide (CO), nitrogen oxide (NOx) and smoke opacity emissions, whereas engine power and torque values reduced while brake specific fuel consumption increased. Same trend observed with increasing ethanol content in the mixture.

Keywords: *Soybean biodiesel, Ethanol, Performance of Diesel engine, Exhaust Emissions*

1. INTRODUCTION

Fossil fuels face the threat of depletion in all over the world [1]. This scenario forces researchers to find out new alternative fuels. Biofuel is one of the most popular alternative fuels. Biodiesel and ethanol are two types of biofuels [2]. Biodiesel that derived from vegetable oil or animal fat, is renewable, non-toxic and biodegradable fuel [3]. Although using biodiesel-diesel blend in diesel engines has many advantages such as lowering the exhaust emission, it has disadvantages too, i.e. causes higher nitrogen oxide (NO_x) emissions [4]. Some researchers reported that NO_x emissions can be decrease by ethanol addition in diesel-biodiesel blend. [5-7]. However, in

literature, there is a little study about performance and emissions characteristic of a diesel engine fuelled with ethanol-soybean biodiesel-diesel blend. Therefore, in this study, effect of ethanol addition at different proportion (5%, 10%, 15% by volume) into diesel-soybean biodiesel fuel blend is investigated.

Many researchers are investigated effect of soybean biodiesel in a diesel engine. Al_DAwody and Bhatti experimentally and theoretically investigated combustion, performance and emission of a single cylinder direct injection diesel engine fuelled with different blends of soybean methyl ester (20%, and 40% by volume) with diesel and pure biodiesel [8]. Whereas Özener et al. compared diesel and soybean biodiesel fuel by using 10%, 20%, and %50 (by volume) blends [9].

Effect of ethanol addition in diesel fuel is also investigated by researchers, Britto Jr. and Martins injected ethanol with diesel fuel at different compression ratio and four different injection pressures [10]. Tutak introduced E85 into the intake manifold while diesel is injected directly to cylinders [11].

Some studies were presented about diesel engine fuelled with ethanol-biodiesel-diesel blend. Murcak et al. aimed to determine the effect of injection timing of a diesel engine. Fuels that are used in test engine contained 5%, 10%, and 20% ethanol by volume in HC based diesel fuel [12].

2. MATERIAL AND METHOD

Preparation of Test Fuels

Commercial castor bean oil was supplied from a local market and used without any further purification. Methanol (special grade, 96%) used for the alcoholysis, sodium hydroxide (NaOH, extra pure, 99.0%) was used as an alkaline catalyst. Test fuel were prepared as low sulphur diesel, 20% (by volume) soybean biodiesel blend with low sulphur diesel and 5%, 10% and 15% ethanol addition into the blend with 75:20:5, 70:20:10 and 65:20:15 ratios (named respectively as D75SB20E5, D70SB20E10, D65SB20E15).

Determination of Test Fuel Properties

Instruments that used for analysing the product; Zeltex ZX 440 NIR petroleum analyzer with an accuracy of ±0.5 for determining cetane number; Tanaka AKV 202 auto kinematic viscosity test for determining the viscosity; Kyoto electronics DA-130 for density measurement and IKA-Werke C2000 Bomb Calorimeter for gross heating value determination. Fuel properties of the test fuels are presented in table 1.

Table 1. Properties of fuel blends

Test Fuels	Density (kg/l)	Cetane Number	Kinematic Viscosity at 40^{o}C (mm^{2}/s)	Gross Heating Value (kj/kg)
Low Sulphur Diesel	0.837	59.57	3.43	45813
Soybean Biodiesel	0.938	98.23	20.5	43470
Ethanol	0.828	38.45	1.21	26781
D75SB20E5	0.852	72.74	4.18	41073
D70SB20E10	0.850	64.11	4.05	40454
D65SB20E15	0.848	61.26	3.67	38247

Experimental Set-up

In the experiments, a Mitsubishi Canter 4D34-2A, four stroke diesel engine with four cylinders which has a maximum torque 295 Nm at 1800 rpm was used. Properties of the engine are presented in Table 2. A hydraulic dynamometer which has torque range of 0–1700 Nm and speed range of 0–7500 rpm was used for measuring engine torque. Engine performance specifications were read by the help of a computer program of dynamometer control unit and exhaust emissions were acquired by the help of another computer program.

Table 2. Engine Properties

Brand	Mitsubishi Canter
Model	4D34-2A
Type	Direct Injection diesel with glow plug
Displacement	3907 cc
Bore	104 mm
Stroke	115 mm
Power	89 kW @ 3200 rpm
Torque	295 N m @ 1800 rpm

3. RESULT AND DISCUSSION

Engine Performance

With the use of test fuels, torque and power variation according to different engine speed is presented in figure 1 and 2 respectively. Compared to diesel fuel, average torque values reduced by 4,7% with B20. Furthermore, when ethanol was added in B20 test fuel with 5%, 10% and 15% volumetric ratios, reduction of values went up, 9.2%, 10,1% and 12,2 respectively. Reduction of power values are measured as 4,6% for B20, 8,6% for D75SB20E5, 9,6% for D70SB20E5, and 10,9% for D65SB20E15. Lower calorific value of biodiesel compared to diesel fuel may cause reduction of torque values. Since engine power is the multiplication of torque and engine speed, the same trend of torque value is observed at engine power too.

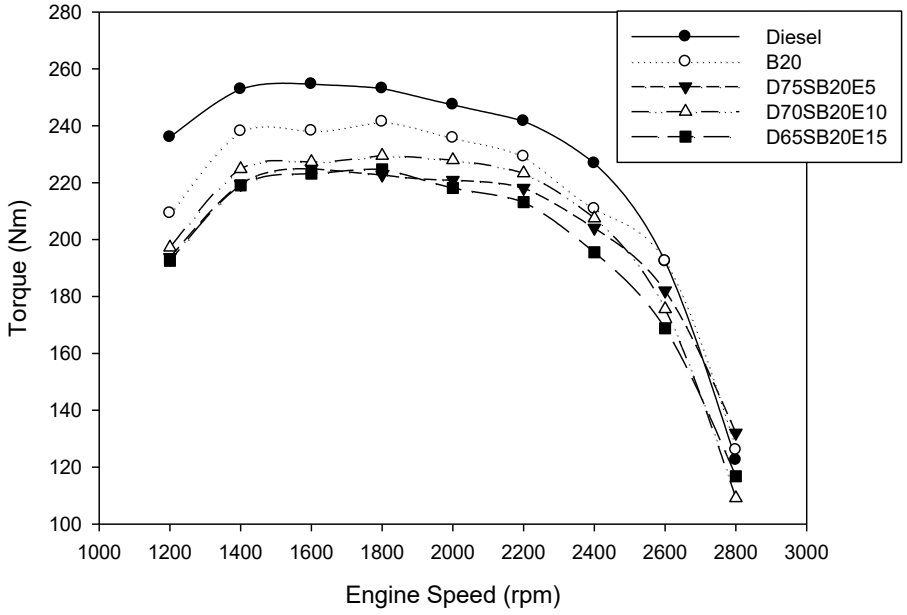

Figure 1. Torque output versus engine speed

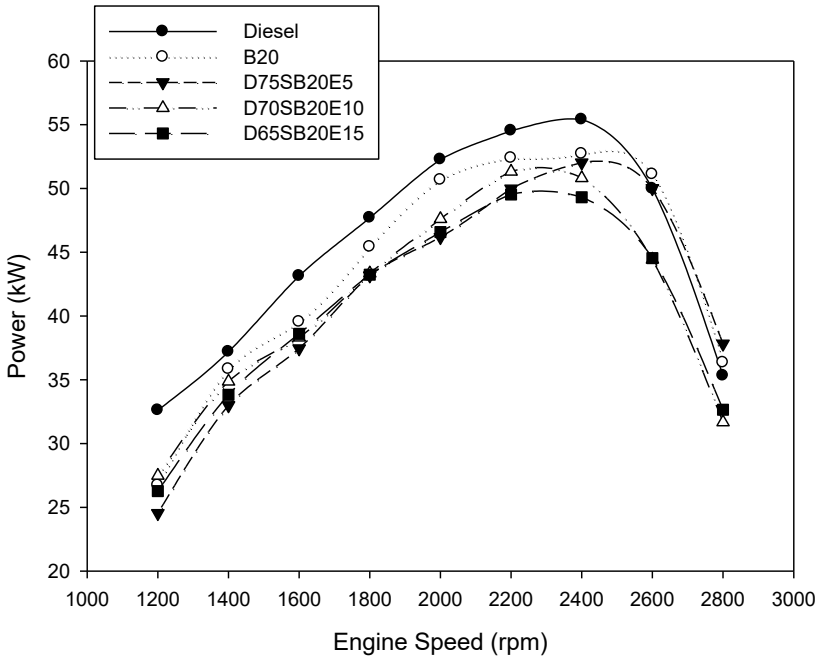

Figure 2. Power output versus engine speed

Brake specific fuel consumption which is a measure of fuel efficiency is increased 6,1%, 7,4%, 8,3% and 9,5% for soybean biodiesel, D75SB20E5, D70SB20E10 and D65SB20E15, respectively (figure 3). The main reason for these trends may be the lower heating value of biodiesel compared to diesel and lower heating value of ethanol compared to biodiesel.

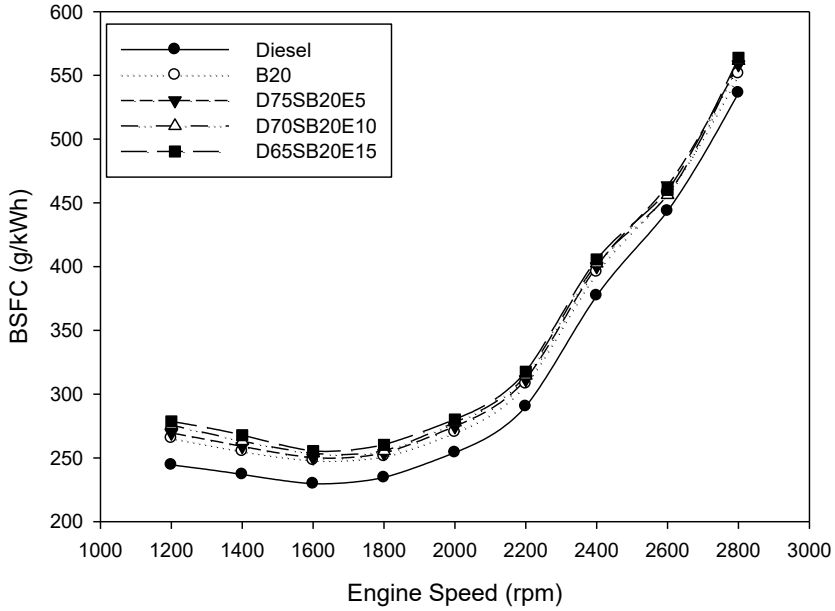

Figure 3. Brake specific fuel consumption versus engine speed

Emissions

The main reason of adding ethanol in biodiesel-diesel blend is to compensate NO_x increment of biodiesel fuel. The result showed that NO_x emission was increased by 6,3% with the use of 20% soybean biodiesel and with the introduce of 5%, 10% and 15% of ethanol in the fuel, the emission decreased by 2,6%, 8,0%, and 10,8% respectively with compare to diesel.

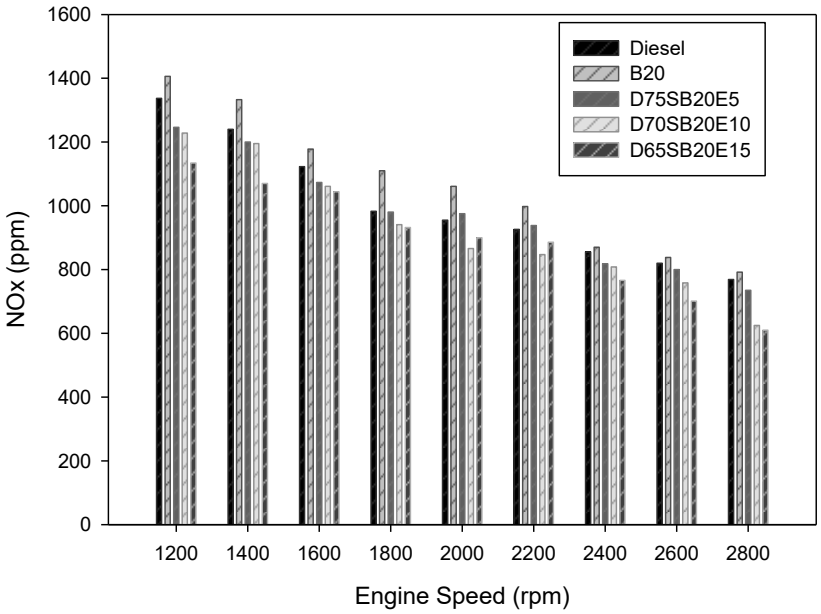

Figure 4. NO_x emission versus engine speed

Since biodiesel and ethanol contain additional oxygen, complete combustion enhanced; thus, CO and smoke opacity emissions values generally reduced with biodiesel and ethanol blend. Figure 5 and 6 demonstrate variation of CO and smoke opacity emissions with engine speed. Average reduction of CO emissions were 10,4% for soybean biodiesel, 13,7% for D75SB20E5, 16,1% for D70SB20E10, 18,2% for D65SB20E5 fuel, and smoke opacity emission reduced 1,4%, 3,7%, 5,9%, and 7,0% for soybean biodiesel, D75SB20E5, D70SB20E10 and D65SB20E15, respectively.

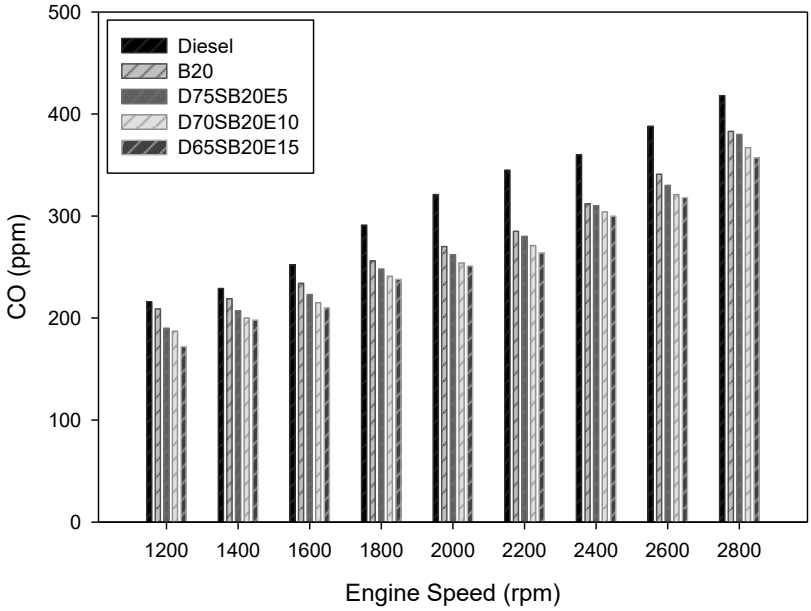

Figure 5. CO emission versus engine speed

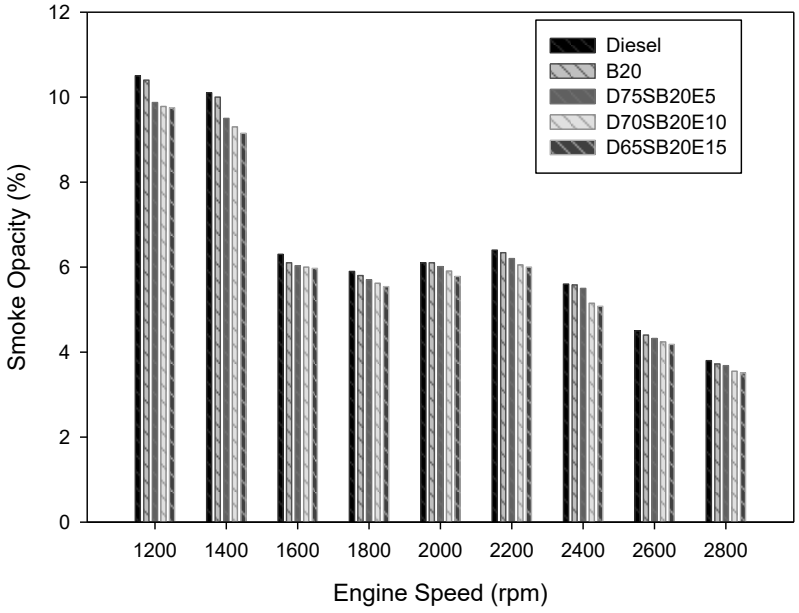

Figure 6. Smoke Opacity emission versus engine speed

4. CONCLUSIONS

Fuel properties of diesel fuel, soybean biodiesel and their blend with ethanol were determined. Furthermore, engine performance, nitric oxide, carbon monoxide and smoke opacity emission values were gathered. The following conclusions were drawn;

- From the result of fuel properties, it decided that any modification on diesel engine is unnecessary for running with test fuels.
- Engine performance parameters such as; engine torque, power and BSFC adversely affected by blending biodiesel and ethanol in diesel fuel.
- Increment of NO_x emission that caused by biodiesel introduction with diesel fuel was compensate with ethanol. Increasing ethanol ratio result that further decrement of NOx emissions.
- The exhaust emission tests revealed that, CO and smoke opacity values improved with ethanol addition.

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