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Emission and Performance Evaluation of a Diesel Engine Using Addition of Ethanol to Diesel/Biodiesel Fuel Blend

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Abstract: Many countries have adopted the addition of biodiesel to diesel as a way of inserting renewable content into mineral fuel and making a contribution to the environment. The addition of ethanol to the diesel/biodiesel blend to increase the renewable content of the added fuel blend and reduce the percentage of biodiesel could be a strategysince the demand for biodiesel production is high, and this fuel has a high production cost when compared to ethanol. Thus, this study evaluated the performance and the content of NO_x, CO and CO_2 exhaust gases from a diesel engine fueled with blends of diesel/biodiesel/ethanol: pure B7, B7E3 (B7 with 3% ethanol) and B7E10 (B7 with 10% ethanol). Emissions of fuel blends were evaluated using the engine speed variation and tested at a speed of 1500 rpm under constant load (185 Nm). Assays were performed at engine speeds of 1000, 1100, 1250, 1500 and 1750 rpm and with loads of 10, 25, 50, 75 and 100% of the maximum torque. Through the performance curves, the specific consumption and thermal efficiency were evaluated. The increase in speed and ethanol content in the diesel/biodiesel mixture increased approximately 5 to 7 and 1.4 times, respectively, in terms of the emission of exhaust gases. There was a 6% decrease in the maximum torque and power available at each speed with increasing ethanol content in the blend. However, in a vehicular application, this decrease would be perceived only at some points of the part-load regime, causing considerable reductions in thermal efficiency.

Keywords: diesel engine; ethanol; fuel blends

1. Introduction

Diesel oil is a widely used fuel to supply buses, trucks, machinery and industrial equipment and has been extensively researched in order to find a substitute renewable fuel that is less aggressive to the environment and the health of the population. Changes in fuel composition have been shown to be a more rapid and effective alternative to reduce problems such as pollution.

Among the renewable liquid fuels that can be used in the diesel engine, biodiesel from different origins can be highlighted [1–5]. This type of biofuel is miscible in diesel and does not require any mechanical modification in diesel engines for its use, as well as being considered an efficient, clean, and natural energy alternative to petroleum fuel [6]. In addition to the use of biodiesel added to diesel oil, many additives have been studied to improve both the performance of diesel engines and pollutant emissions such as: mono ethylene glycol [7], multi-wall carbon nanotube [8], glycerol derivatives [9,10], ethanol [11–16] and others.

The biofuel ethanol has been suggested to be added to diesel/biodiesel blends due to the fact that ethanol is miscible in diesel fuel only in small amounts and is commercially available at gas stations [12]. Ethanol is a renewable source of energy and has the advantages of being sulfur free, presenting a high amount of oxygen in its composition that can contribute to the reduction in emissions of particulate matter [17].

Mixtures of ethanol and diesel may present phase separation at low temperatures due to their miscibility and different chemical structure. This separation can be avoided with the use of biodiesel in the fuel composition [12]. Both biodiesel and ethanol molecules are polar, so the two have an affinity when mixing which generates a stability in the composition (diesel/biodiesel/ethanol), preventing the separation of ethanol with diesel oil [18].

Diesel, biodiesel, and ethanol fuel blends have a high oxygen content in their chemical composition and can contribute to the improvement of the combustion process in diesel engines. This fact could also improve performance and emission levels [11].

However, the operation of the diesel engine requires a number of essential properties, and the addition of ethanol to diesel fuel can certainly affect these properties, especially the fuel stability, viscosity, lubricity, power and cetane number [11,12,19,20]. Several investigations [10–22] have been carried out with blends containing diesel, biodiesel and ethanol for use in a diesel cycle engine with the objective of evaluating: performance (power, torque and fuel consumption) and the emission of pollutants (particulate matter, volatile organic compounds, metals and others). The ethanol content used in the blends studied ranged from 1% to 50%.

Labeckas et al. [23] reported that experiments on turbocharged four-cylinder diesel engines fueled with 10 and 15% ethanol in the diesel/ethanol blends can generate reductions of 12.5% in engine power and 20% in CO, sulfur dioxide (SO_2), and soot density due to the high oxygen mass and the low carbon/hydrogen ratio in the diesel/ethanol blend. However, due to the low cetane number and ignition delay, followed by the higher cylinder pressure and temperature, it was observed that the amount of NO_x emissions produced from the combustion of fuel blends E5 and E10 increased by 16.5% and 23.1% compared with ordinary diesel running on a lean air–fuel mixture at a 1400 rpm speed.

De Oliveira et al. [19] investigated a diesel engine operating with diesel oil containing 7% biodiesel (B7) and hydrous ethanol with concentrations varying from 5 to 30% using a 49 kW diesel power generator, equipped with an electronic ethanol injection unit installed in the intake manifold. The results show a decrease in the in-cylinder pressure and a net heat release rate with the use of ethanol at low loads and an increase at high loads, in comparison with B7. Increasing the volume of the ethanol injection caused increased ignition delay and decreased combustion duration. The use of ethanol caused a reduction in nitric oxide (NO) and increased CO, total hydrocarbons (HC) and NO_X emissions.

It can be observed in the literature that post-treatment systems have been evaluated when using mixtures containing ethanol. The hydrocarbon selective catalyst reduction (HC-SCR) activities in terms of the effect of combustion using biodiesel–ethanol–diesel blends and the effect of adding hydrogen to the catalyst were studied by Sittichompoo et al. [21]. They observed that a lower level of NO_x was produced, while a greater concentration of carbon monoxide (CO) and THC was measured in the exhaust. Consequently, increasing the amount of THC/NO_x promoted the reduction in NO_x activity (up to 43%).

Recently, Shirneshan et al. [14] used a genetic algorithm to evaluate the effect of biodiesel/ethanol blends on the performance and emissions of a diesel engine and for the optimization of the parameters. They observed that the brake power and torque were decreased by approximately 30% with an increasing amount of ethanol in the fuel blend. The specific fuel blend consumption increased by approximately 16% with a higher percentage of ethanol as a result of the lower calorific value of ethanol compared with biodiesel. The higher percentage of ethanol resulted in lower levels of smoke and NO_x

emission approximately 38% and 17%, respectively, due to the high level of oxygen in the molecular structure of ethanol.

The performance, combustion and emission characteristics of ternary fuel (diesel–biodiesel–ethanol) blends have also been studied using Al_2O_3 nano additives [22]. An improved performance and lower levels of HC, CO and NO_x emissions and smoke were observed with the addition of 20 ppm alumina.

Recent research also shows that the use of unconventional techniques of biodiesel characterization using thermophysical and transport properties can indicate important properties on combustion [5,24,25]. Thus, this information can be very useful to simulate heat transfer in the resolution of heat transfer, chemical and bioenergetic characteristics of the combustion of biodiesel and its blends with diesel/biodiesel.

The amount of research published in the literature on the use of ethanol in diesel engines is still very small. Due to the diversity of types of biodiesel and diesel with different sulfur contents, it is of paramount importance that new research on diesel/biodiesel/ethanol blends be developed, so that regulatory agencies can implement measures for the use of this fuel based on scientific results.

Biodiesel production is not competitive when compared with the final cost of diesel fuel. In March 2022, the Agência Nacional de Petroleo Gás e Biocombustíveis do Brasil (ANP) recorded a difference of 61% in the cost of producing biodiesel when compared with the cost of producing S10 diesel [26]. Many countries have adopted the addition of biodiesel to diesel as a way of inserting renewable content into mineral fuel and making a contribution to the environment. In this sense, the present research proposes the addition of ethanol to the diesel/biodiesel mixture to increase the renewable content of the fuel mixture and reduce the percentage of biodiesel added, since the cost of producing ethanol [27] is lower (29 times) than that of biodiesel.

2. Materials and Methods

2.1. Experimental Setup

The fuel blends used during the tests were B7 (commercial diesel S10, with 7% biodiesel), B7E3 (3% ethanol in B7) and B7E10 (10% ethanol in B7). Biodiesel from soybean oil was used to standardize the biodiesel content (7%) after the addition of ethanol. The characteristics of the fuels are described in Table 1. Some properties of the test fuels were not measured, but some are described in Table 1, derived from other works by the research group, to compare the effects of the presence of ethanol in diesel. A 100% mechanical diesel engine (MWM MS 3.9T model, with a mechanical injection system) was used in this study, without an engine control unit (ECU) (Table 2). The engine was coupled with a bench dynamometer AVL DP 240 to control the speed and torque of the engine. The AVL Puma Open System was used for automatic dynamometer management, which allowed the monitoring of variables such as ambient temperature, air humidity and the temperature and pressure of process fluids, as well as fuel consumption. The air temperature during the test was 29 ± 2 °C, while the humidity was maintained at 46%. The correction factor was not applied in determining the effective net power in the studied process because the laboratory was located at sea level.

A GA-21plus multifunctional gas analyzer from Madur Electronics was used to measure the concentration of the exhaust gases (CO_2, CO, NO, and NO_2). The gas analyzer probe was coupled to the end of the CVS, thus allowing the measurement of the concentration of pollutants present in the air/exhaust mixture (exhaust gases + dilution air).

Table 1. Fuel specifications. Please confirm if the italics should be retained.

Characteristics	B7 [a]	B7E3	B7E10	*Standard*
Density (20 °C kg/m^3)	836.7	835.7	830.9	815.0 to 850.0 *
Viscosity (40 °C mm^2/s)	2.70	2.47	2.30	2.0 to 4.5 **
Cetane number [11]	~48	~41	-	45 [a]
Latent heat of vaporization (kJ·kg^{-1}) [11]	~270	~350	-	250 [a]
Lower calorific value (kJ·kg^{-1}) [11]	~42.82	~41.73	-	43 [a]
Renewable fuel content (%)	7	10	17	-

[a] ANP Resolution N° 50 of 12/23/2013; * ASTM D4052 *; ** ASTM D445.

Table 2. Diesel engine features.

Features	Engine
Power (Stand-by—1500 rpm—cv/kW/kVA)	80/60/66
Total displacement (L)	3.87
Number of cylinders	four, in line
Combustion system	four-strokes, direct-injection
Induction system	Turbocharged
Compression ratio	15:1
Engine cooling	Liquid
Operation temperature (°C)	77/95

Source: Engine manufacturer manual.

A Constant Volume Sampler (CVS) was connected to the engine exhaust, collecting part of the exhaust gases and diluting the sample collection by approximately 1/30 (exhaust/dilution air) with ambient air (Figure 1).

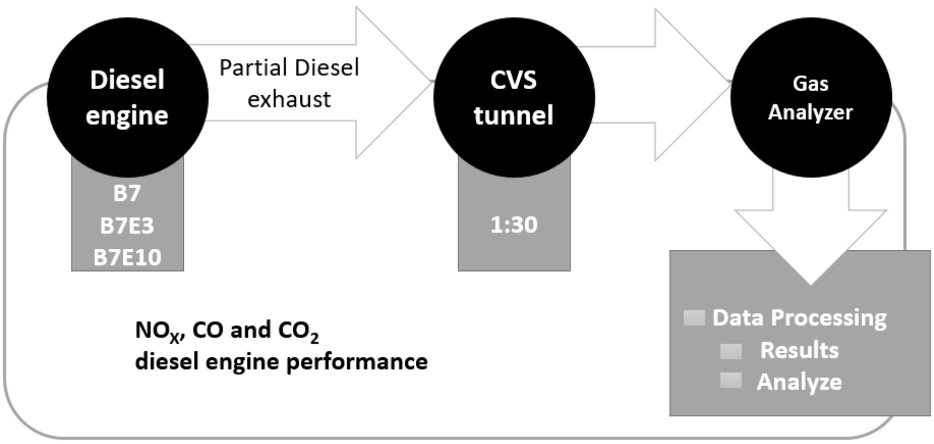

Figure 1. Schematic of experimental setup.

2.2. Experimental Procedure

Brake Specific Fuel Consumption (BSFC), power and torque were evaluated for each fuel blend (B7, B7E3 and B7E10) at five speeds (1000, 1100, 1250, 1500 and 1750 rpm) by varying the load (10, 25, 50, 75 and 100% of maximum torque at each speed when the engine was fueled with B7). All data were obtained through the data acquisition program of the dynamometer, the AVL PUMA Open. No changes were made to the engine parameters for comparative purposes between fuels blends and tests were started after the engine achieved the operating temperature (80 °C/176 °F). The BSFC was measured on the dynamometer brake and calculated for each fuel blend.

The comparison between fuel blends with different heating values required a parameter that included, not only fuel consumption, but also energy content. The thermal efficiency relates the measured power (with the dynamometer) to the calorific energy released (fuel energy content) and was calculated for a more complete comparison between the fuel blends

$$\eta = \frac{\text{P effective}}{\text{P fuel energy content l}} \quad (1)$$

$$\eta = \frac{\text{P effective}}{\text{Fuel Consumption} \, * \text{LHV}} \quad (2)$$

where η = thermal efficiency; $P_{effective}$ = measured power; LHV = Lower Heating Value.

The data acquisition system was programmed to collect data for 30 s of operation in each condition. Thus, the power and torque values represent the average of the data collected from that determined time interval, being provided directly by the data acquisition software. The measurement uncertainty calculation used all of the factors that could influence the final reading of each test condition. The standard deviation of the measurements and the uncertainties associated with the equipment's calibration system (mass, calibration arm and gravity) were used to obtain the torque. To obtain the power, the values of the uncertainty of the torque derived from the calibration of the dynamometer rotation reading system were considered. As the readings were taken in the laboratory at sea level, the measurement uncertainty associated with the correction factor was not used.

Simultaneously, the emission tests were carried out with the B7 fuel at speeds (rpm) of 1100, 1500 and 1750 and a torque of 185 Nm to evaluate the impact of increased engine speed on the amount of NO_X, CO and CO_2. These gases were analyzed using a calibrated multifunctional gas analyzer model GA-21plus from Madur Electronics. Collections were carried out in triplicate, for each type of fuel, with an average of 3 min for each collection (10 measurements). From the data obtained, the mean of the values was calculated, and the measurement error was obtained through the standard deviation.

In order to evaluate the impact of the use of fuel blends on the exhaust gas emissions, the constant engine speed and torque used were 1500 rpm and 185 Nm, respectively. The conditions for these tests were chosen based on the conditions adopted by many of the studies described and cited in this work. The fuel filters and engine oil were exchanged with each test.

Before the start of the collection, the engine ran for about 30 min with the fuel to be tested so that it reached the operating temperature and was stabilized under constant engine speed and torque. The dilution air from the CVS was measured by the gas analyzer, without interference from the engine exhaust to verify that it was free of pollutants.

The pollutant emissions were collected in triplicate for each kind of fuel blend, and the analysis of the data represents the average of 3 min of collection. The CVS was adjusted to dilute approximately 1 part of the engine exhaust to 30 parts of ambient air (dilution 1/30). This adjustment was made through the control of the valves and flow sensors present in the CVS.

3. Results

3.1. Evaluation of NO_X, CO and CO_2

In this work, stable fuel blends of diesel/biodiesel and ethanol for use in a diesel engine were proposed. The blends B7, B7E3 and B7E10 were stable because there was no phase separation during 3 months of storage (at 21 °C and 1014 hPa). The fuel properties directly affect the engine operating characteristics, including efficiency, combustion and power, among others. Adding ethanol to a fuel blend reduces the overall viscosity of the blend, ultimately producing a less viscous fuel. However, the presence of biodiesel provides an increase of blend viscosity, since this fuel has higher viscosity when purchased from diesel and ethanol, suggesting the composition of binary and/or ternary blends within the limits established for its use.

Figure 2 shows the significant increase in the studied gases with increased speed (from 1100 to 1750 rpm) for B7, which can be explained as a reflection of the greater amount of fuel blend and air injected in the combustion chamber for each speed.

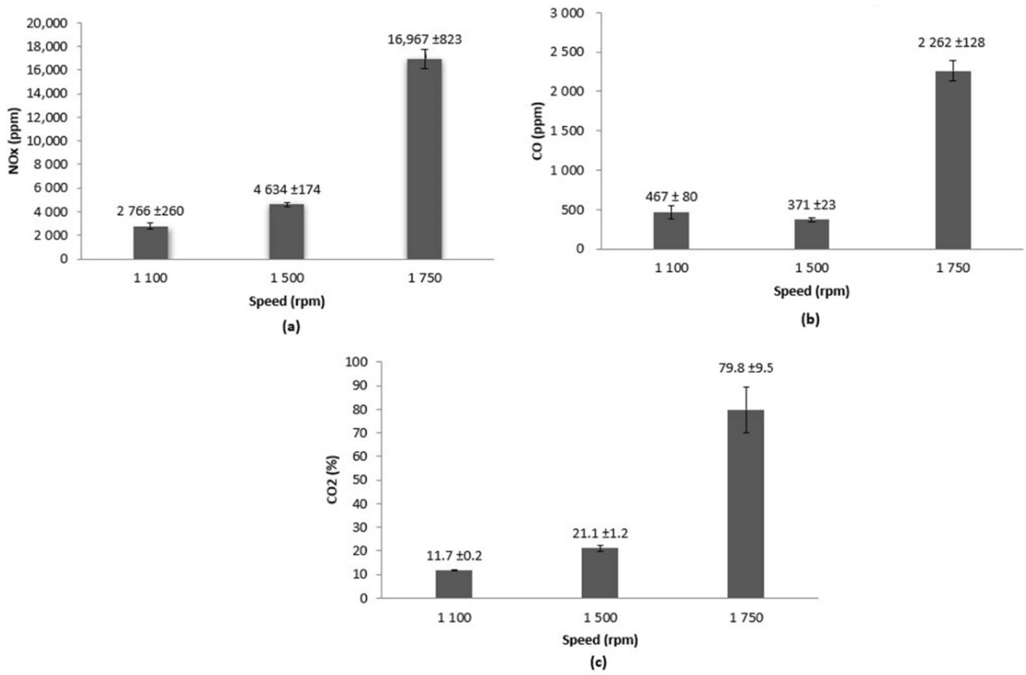

Figure 2. Exhaust gases by varying engine speed using B7: (**a**) NO_X; (**b**) CO; and (**c**) CO_2.

For speeds of 1100 and 1500 rpm, no significant difference was observed in CO emissions, which were considered statistically equal due to measurement error. CO emissions showed a marked increase at the maximum speed tested (Figure 2b). This growth was also found by Man et al. [28], which justifies the association between an increased fuel/air ratio and a reduction in volumetric efficiency and higher fuel consumption as a consequence of increased engine speed. Even though the boosting pressure was lower (about 390 mbar) at 1100 rev/min than pressure (about 410 mbar) at 1500 rev/min, the values did not vary by more than the margin of error.

For CO_2, it is known that complete combustion within the cylinder determines its formation. Although this reaction is impossible in an engine, almost complete combustion can be achieved, depending on the machine's operating conditions and the nature of the fuel [29]. The increase in CO_2 as a result of the increased speed points to a more complete combustion at higher speed, in addition to the fact that there is a greater fuel burn at such speeds, which would lead to the formation of higher concentrations of carbon.

The formation of NO_X is strongly influenced by the internal temperature of the cylinder, the oxygen concentration and the time it takes for the reaction to occur [11]. In addition, the cetane number of ethanol is lower than that of diesel, contributing to the ignition delay and increasing the cylinder temperature, which raises the cylinder pressure owing to the combustion of the fuel [30].

These factors may have influenced the increase in the amount of NO_X exhaust with the increase in motor speed (Figure 3a). However, Buyukkata [31] observed that the reaction time in each cycle was reduced, which led to a decrease in the residence time of the air–fuel blend under high temperatures and the consequent reduced formation of NO_X.

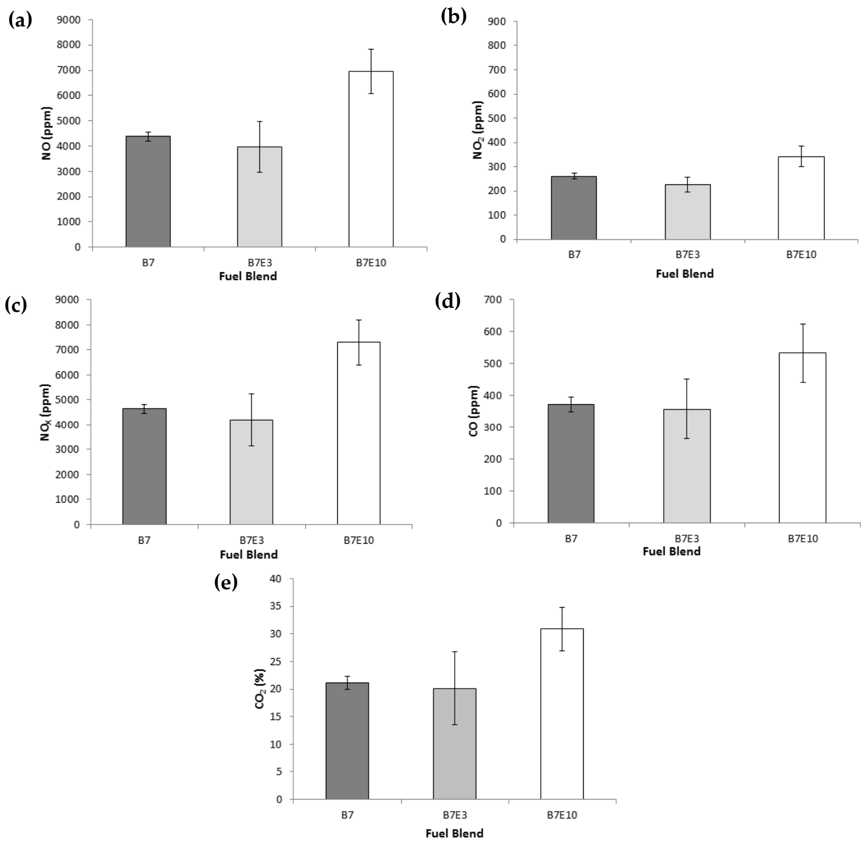

Figure 3. Exhaust gases from burning of each fuel blend: (**a**) NO; (**b**) NO_2; (**c**) NO_X; (**d**) CO; and (**e**) CO_2.

Figure 3 presents the average NO_x, CO and CO_2 data from the burning of each fuel mixture studied. The presence of and increase in ethanol in the fuel mixture resulted in an increase in the emission of all gases studied.

NO_X is one of the most critical pollutants in emissions from diesel powered engines. The concentration of NO_X emissions (NO + NO_2) showed a tendency to increase with the increase in the ethanol percentage in the blend (Figure 3c). The addition of ethanol to diesel reduces the cetane number (Table 1), which increases the delay in fuel ignition, promoting the poor mixing of air and fuel and the consequent increase inNO_X emissions [32]. On the other hand, ethanol has a higher latent heat of vaporization and a lower calorific value, which leads to a reduction in the emissions of nitrogen oxide [33]. NO emissions (Figure 3a) were higher in relation to NO_2 emissions (Figure 3b) for all fuel mixtures studied. Previous research results point to inconclusive values for NO_X emissions (Figure 3c) in engines fueled with diesel/ethanol blends. Some studies observed an increase in NO_X emissions [30–34], although others observed a decrease in this pollutant [11,12,35] when adding ethanol to diesel/biodiesel blends. Other researchers found similar values of NO_X for ternary mixtures in relation to pure diesel [36]. It is important to note that such divergences in results may be associated with the ethanol concentrations used, as well as the characteristics and conditions of the diesel engine evaluated.

The CO emissions obtained in this study are presented in Figure 3d. Similar results in terms of the elevation of the CO emissions as a consequence of the addition of ethanol in the mixture were also found in previous studies [37]. With the addition of ethanol, the studied blends presented a low combustion temperature and burning speed due to the low calorific value and high latent heat of the ethanol, which causes the combustion to be more incomplete and higher carbon monoxide levels to consequently be emitted [38].

An increase in CO_2 levels was observed when increasing the amount of ethanol in the blends (Figure 3e). The burning of oxygenated fuels presents a slight reduction in

CO_2 emissions because biodiesel has less carbon in its molecules, and the product of the combustion of ethanol presents less CO_2 and more H_2O [39]. However, for engines with high power and speed, when the amount of fuel burned is higher without excess air, this effect is not noticed, resulting in high CO_2 emissions [40]. Some authors cited in the previous research observed the growth of CO_2 emissions as the percentage of ethanol/bioethanol was increased for blends of diesel–biodiesel, compared with pure diesel [2,32]. However, other researchers have found decreasing CO_2 values for ternary blends [11].

3.2. Evaluation of Diesel Engine Performance

The study of both the maximum torque and power available at each speed for the three fuels was conducted at full load operation. Figure 4 shows the power, torque and thermal efficiency for 100% load. The B7 fuel presented the highest values of torque and load at each speed (Figure 4a,b), and a reduction in these performance parameters was observed with the increase in the ethanol content in the blend. The thermal efficiency obtained in the tests indicated that the use of ethanol mixed with B7 did not cause energy losses, since the values of thermal efficiency for each fuel were very similar at all speeds under 100% load.

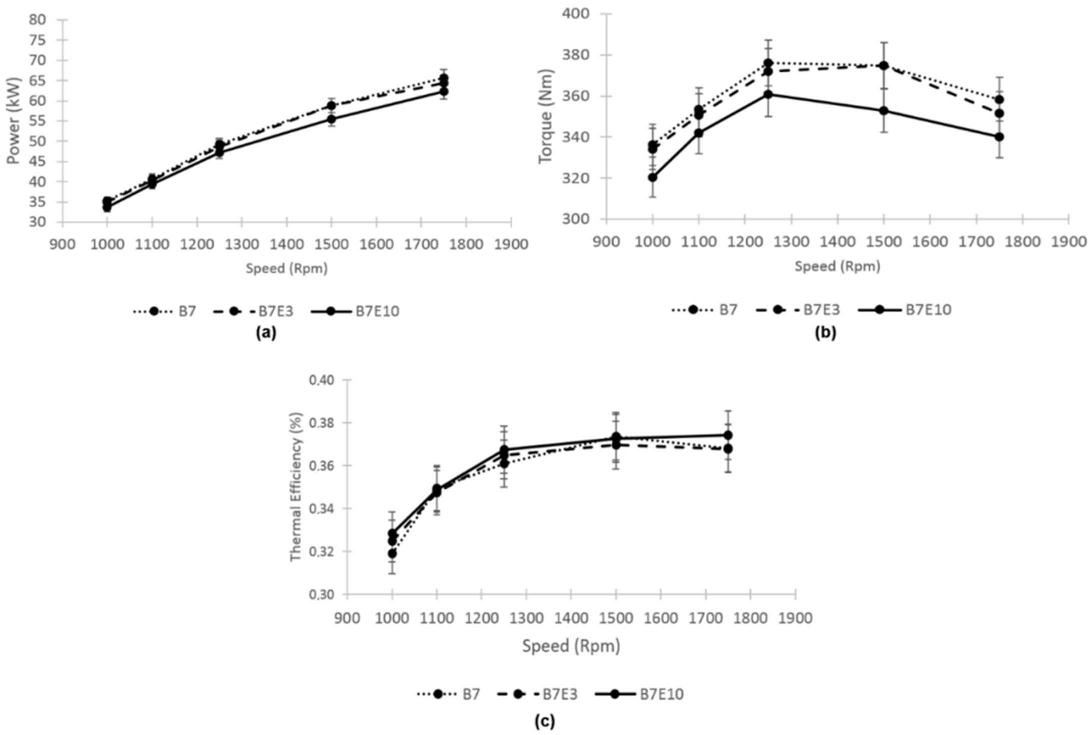

Figure 4. Diesel engine dynamometer performance results for each fuel blend: (**a**) power at 100% load for each speed; (**b**) torque at 100% load for each speed; and (**c**) thermal efficiency at 100% load for each speed.

The torque available at each speed decreased with increasing ethanol content in the blend by up to 2% with B7E3 and by up to 6% with B7E10. The maximum torque and power conditions were reduced by 4% (from 376.1 Nm to 360.7 Nm at 1250 rpm) and 5% (from 65.7 kW to 62.3 kW at 1750 rpm), respectively, with the use of B7E10. This is because the cetane number of ethanol is lower than that of diesel. The increase in the blend ratio of ethanol reduces the cetane number of the fuel blend, which reduces the combustion performance of the fuel blend and reduces the energy released per unit volume of fuel, thereby reducing the brake power at high torque [41].

For vehicular application, this decrease would not be perceived either in the capacity of transport or in the agility in traffic.

Figure 5 shows the fuel blend values used in speed and power sampling. The BSFC was calculated to compare the power conversions of the masses consumed of each fuel. At full load, the specific consumption did not vary much between fuel blends; however, by analyzing the three mixtures at each speed, it was possible to verify variation in the BSFC. In general, with the increase in the speed, there was no great differentiation between the BSFCs, with the results practically maintaining a standard profile.

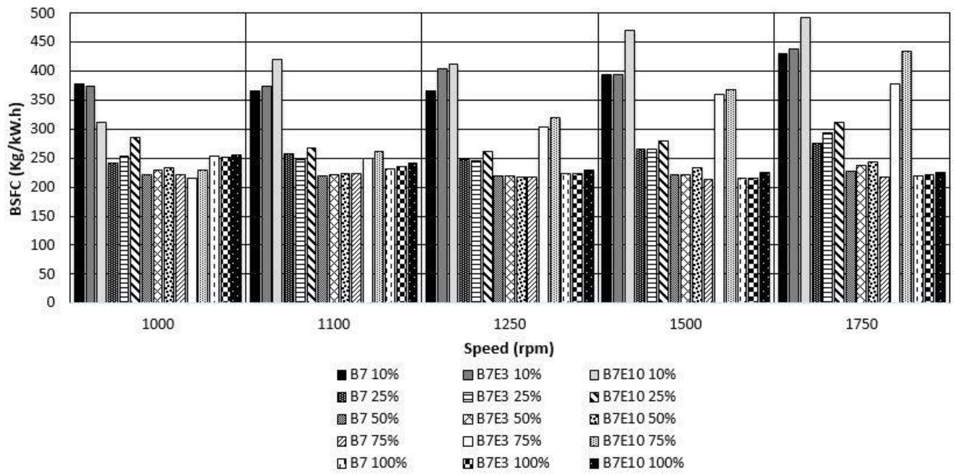

Figure 5. BSFC of the fuel blends for each operation condition in the diesel engine.

Among the fuels, the highest values of BSFC were obtained for the B7E10 blend at all speeds except 1000 rpm. The highest values of BSFC were observed for the load of 10% at each speed. At 25% load, B7E10 repeated the relative performance and presented the highest BSFC values among the fuels. Operating at 50%, the results in terms of the specific consumption with each mixture were very close. This changed in the 75% load test, and the blends made with ethanol showed a significant increase in BSFC compared with B7 at 1250 rpm, 1500 rpm and 1750 rpm at all speeds. This result can be justified by the increase in engine load, cylinder pressure and temperature improving the combustion process and resulting in a drop in BSFC. Thus, BSFC increases due to the reduced energy content with increasing alcohol, which is related to the lower calorific value of ethanol. When using less calorific fuels, it is necessary to inject more fuel to obtain comparatively higher energy efficiency [42].

The results of consumption reflected a thermal efficiency that was up to 40% lower with the use of B7E3 and almost 50% lower with the use of B7E10 when compared with B7 at 1750 rpm. This result is similar to the finding of Putrasaria et al. [43], who observed that BSFC decreased with increasing ethanol content. However, Hulwan [44] found a superior BSFC with higher thermal efficiency for blends with high ethanol content. Oliveira et al. [19] observed that the fuel conversion efficiency was reduced at low loads up to 6.6%, using 20% ethanol in the fuel, and increased up to 13% at high loads, for 30% ethanol. Redel-Macías et al. [45] observed that alcohol/diesel fuel blends exhibit a comparable reduction in particulate matter and unburnt hydrocarbon emissions, with a lower penalty in NO_x and CO emissions compared to diesel fuel combustion. However, according to Esawi et al., after carrying out tests with different mixtures of pure diesel, diesel/biodiesel and ethanol blends, it can be said that up to 15% biodiesel, 5% ethanol and 80% diesel can replace diesel fuel without any modification to the automotive system [46].

4. Conclusions

This study provided parameter analysis through an experiment with a generator turbocharged diesel engine fueled with three diesel/biodiesel/ethanol blends under 25 conditions, varying by load and speed, for a total of 75 operating conditions. The operating parameters at part load and full load were evaluated with different turbocharger pressures. B7 was used as the baseline for tests, and the additions of ethanol (3% and 10% in mass) were evaluated, focusing on the high oxygen content present in the composition of this molecule and the increased renewable content of the fuel mixture and the reduced percentage of biodiesel added. Considering the experimental results of the tests with different fuel blends (B7, B7E3 and B7E10), it was concluded that there was a small decrease (6%) in the maximum torque and power available at each speed with increasing ethanol content. However, in a vehicle application, this decrease would be more easily perceived only under some part-load conditions, causing considerable reductions in thermal efficiency. At full load, the values of thermal efficiency for each fuel were very similar. The results provide evidence that the use of diesel blended with small proportions of ethanol for a diesel engine generate neither significant energy nor malfunctions.

The speed and ethanol content in the diesel/biodiesel mixture increased by approximately 5 to 7 and 1.4 times the emission of exhaust gases, respectively. The NO_x emissions were greater with an increase in ethanol in the fuel blend, and the NO values were significantly higher than those of NO_2. The CO and CO_2 concentrations also showed growth with the increase in the ethanol content. The low heating value and high latent heat of ethanol allows for greater emissions of CO, whereas CO_2 concentration can vary according to amount of fuel burned. At close to the maximum engine speed, pollutant emissions increase significantly.

Although the results show small increases in the emission of the exhaust gases studied, with the addition of ethanol in the diesel/biodiesel mixture, the final cost of the fuel mixture may be reduced. The results obtained in this study demonstrate the possibility of increasing the renewable content of diesel oil without the need for modifications to the diesel engine. In addition, the use of ethanol does not result in significant losses in the thermal efficiency of the engine. Thus, new studies should be developed with the aim of verifying the contribution of exhaust gas after-treatment systems and with the addition of substances to improve cetane number when ethanol is added to the diesel/biodiesel mixture.

Author Contributions: Conceptualization; data curation; formal analysis; investigation; methodology; resources; validation; visualization; writing—original draft; writing—review and editing, E.S.d.C.F., L.L.N.G., K.K.d.S.A.; —formal analysis; investigation; methodology; supervision; validation; visualization; writing—original draft; writing—review and editing, E.A.T., B.A.S.M.; investigation; methodology; visualization; Writing—original draft, M.V.I.d.S., E.T.d.A.G., J.F.C.d.J. All authors have read and agreed to the published version of the manuscript.

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