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COMPARATIVE PERFORMANCE OF A DIESEL CYCLE ENGINE USING BLENDS OF DIESEL AND BIODIESEL

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Abstract. *Fossil fuels the main source of energy today, due to the possibility of storing large amounts of energy at a relatively low cost. Being a non renewable source, causing major environmental impacts, many countries seek alternatives to reduce the consumption of oil and other fossil fuels. Brazil is a country privileged to have numerous sources of biodegradable and renewable energy. Among them, the biodiesel, which appears as a strong candidate to reduce oil consumption by presenting excellent benefits, such as reducing air pollution, stimulate job creation and income, providing better living conditions in regions outside the centers urban areas, especially in remote areas, strengthening the local economy, especially in the stages of collection and processing raw materials in underdeveloped areas. This study evaluated the performance of the diesel cycle engine, running on different proportions of mineral diesel with biodiesel blends, we used the conventional engine MWM D_D229-4, 54 kW and 3,922 L, A 40kVA synchronous generators coupled to a load resistance Liquid one energy analyzer and gas using the ABNT NBR 5484 (1985) which_refers to a test engine dynamometer Otto and Diesel engines._The present study showed that the use of soybean oil mixed with regular diesel increased specific fuel consumption_the higher the concentration of biodiesel, diesel (B5) showed higher calorific value than biodiesel blends(B20, B50 and B100) . Emissions of NO_x, NO and CO_2 were higher when and uses biodiesel, but a load of about 40%, had the lowest rate of NO_x, NO and CO_2 compared to regular diesel.*

Keywords: *Biodiesel, environment solution, renewable energy, sustainable manner, diesel engine.*

1. INTRODUCTION

The objective of this work is to show the importance of encouraging the use of biofuels as an alternative for power generation for isolated communities with difficulties in having access to commercial diesel, evaluating the performance of a diesel cycle engine using blends of diesel with biodiesel.

Brazil is a country with almost 190 million inhabitants, with about 8.5 million km ^{2,} according to estimates by the Brazilian Institute of Geography and Statistics - IBGE, and stands as the fifth most populous nation in the world. According to data published in the Atlas Power Sector by the National Agency of Electric Energy (ANEEL, 2008), the country has more than 61.5 million consumer units in 99% of Brazilian municipalities. The exclusion of electricity in Brazil is being treated by public policies since the 90s, as the Light Programme Earth, Luz no Campo Program, Program for Energy Development of States and Municipalities - Prodeem and, more recently, the Light for everyone. Brazil started the Century with 12 million excluding electric, most of which lies in the northeast of Brazil, according to the 2002 Census pointed by IBGE. Although these data pointed to 96% of the population had electricity in their homes, in certain areas of the country (especially in the countryside of North and Northeast), the coverage of electricity was much lower, reaching less 50% of the population of certain micro-regions.

Biodiesel is a fuel made from vegetable oils or animal fats. The use of biomass for alternative fuel, including biodiesel, will lessen the attacks on the environment, as well as the use of oil and imports.

The renewable way makes the product an important source of energy in the long term, because it has a significantly reduction of greenhouse gas emissions, compared to the emissions caused by fossil fuels such as diesel, allowing to establish a closed loop of carbon in which CO_2 absorbed when the plant grows and is released when biodiesel fuel is burned in the engine.

According to Miguel Dabdoub (2000), the importance of using this fuel, is based in two aspects, environmental and economic. In environmental terms, the reduction of greenhouse gas emissions is significant, comparing the emissions caused by fossil fuels such as diesel. In economic terms is developing a production chain that generates jobs, increases agriculture, fixed man in the field, allows the production of a domestic fuel, without importing to produce diesel that drives 58% of our fleet of liquid fuels that the Brazil consumes.

This type of green economy serves as a means to achieve sustainable development, help to eradicate poverty and preserving natural resources, promotes standards of sustainable consumption and production, and lead the world toward the development of low-carbon (Conference of United Nations Conference on Sustainable Development Rio +20, 2012).

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Many of the plant species present in Brazil have been analyzed and used in biodiesel production, including soybean (Glycine max), oil palm (Elaeis guineensis), nuts and jatropha (Jatropha curcas), and waste cooking oil.

In 2004, a program was created by the Federal Government the National Program for Production and Use of Biodiesel (PNPB), which aims to make a sustainable either economically or technique, thus promoting social inclusion, in the production and use of biodiesel. Ensuring very competitive prices, product peculiarity and supplies. The PNPB is guided by an Executive Committee International (CEIB), which aims to formulate, implement and monitor the program. In 2005, it was approved the Law No. 11,097. Since then, the state now has goals of using biodiesel in National energy. From 2005 to 2007, the addition of 2% biodiesel to fossil diesel was optional, evolving to be mandatory, the same percentage, from 2008 to 2012. The percentage would rise to 5% from 2013. In 2008, it launched the diesel mixture with 2% biodiesel (B2). In July 2009, the country adopted the B4 (diesel with 4% Biodiesel), and in January 2010, entered the market B5, diesel with 5% biodiesel (NATIONAL PROGRAMME FOR PRODUCTION AND USE OF BIODISEL, 2012).

The biodiesel industry believes that the addition of renewable fuel in diesel will be increased from the current 5% to 7% in 2013. The new framework provides for the addition of biodiesel in diesel is expected to reach 10% in 2016, with gradual increases annually (Association of Producers of Biodiesel in Brazil - Aprobio).

Almeida et al. (2002), used a diesel engine MWM - 70 229 kW stocked with fresh palm oil and diesel oil. The study was conducted in order to verify the concentration of exhaust emissions and specific fuel consumption. The results showed that the specific consumption of palm oil is about 10% higher than the diesel oil. This is because the calorific value of palm oil to be smaller, requiring larger mass of fuel to accomplish the same task, the diesel showed lower CO concentration. As CO_2 emissions remained virtually the same. NO_x also increased with increasing load actually associated with increase in temperature in the combustion chamber.

Kanok-ON and Chinda (2004) used a single cylinder Yanmar diesel engine - TF 85 LM to check their performance, using as fuel oil diesel blends B10, B50, B90 and B100 palm biodiesel and blends B10, B50, B90 and B100 vegetable oil coconut fresh.After several experiments, they found that the power decreased when the engine was fueled with biodiesel blends palme and mixtures of vegetable oil coconut fresh. In contrast, the specific consumption increased as the percentage of diesel oil in the mixture decreased.

RAKOPOULOS et al. (2006) conducted an experimental study to evaluate the performance and emission of gases from an engine fueled with various fuels: B10 and B20 blends of biodiesel from cotton, soybean, sunflower, rapeseed and palm; blends of B10 and B20 fresh vegetable oils of soybean, corn, sunflower, olive seed oil, and diesel. Tests were performed using a single-cylinder diesel engine, working on angular velocity of 200 rpm and subjected to medium and high load. The results show that NO_x emissions were reduced using mild B10 and B20 blends of vegetable oil and blends of B10 and B20 biodiesel emissions compared to conventional diesel derived. For CO, we observed the same behavior with respect to mixtures B10 and B20 biodiesel, but exactly the opposite using B10 and B20 blends of vegetable oil. Already emissions of HC showed no significant changes. Regarding the specific consumption, the tests show a slight increase both the fuel mixes with the engine B10 and B20 vegetable oils as mixtures B10 and B20 biodiesel.

WANDER et al. (2007) analyzed on a dynamometer bench, performance and emissions of two stationary engines: one drum and the other with two cylinders, both manufactured by Agrale. Used as fuel type diesel blends B and B5, B30, B50, B75 and B100 diesel and biodiesel from soybean, castor and palm. Regarding performance, the average scores were: 2.5% reduction in power, a 2.0% decrease in torque and a 7.6% increase in the specific consumption in blends above B50. Regarding the emissions, it was observed that compared to pure diesel fuel, biodiesel (B100) has: decreased from 4.3 to 3.0 in the index of smoke Scale (Bosch); 45.0% reduction of CO and about , 8.7% decrease in CO2.

JOVÍLSON et al. (2007) analyzed the concentration of CO_2, CO, SO_2 and NO_x existing in the exhaust gases from a diesel engine stationary Agrale-M85. The engine connected to a generator Kohlbach 4 kVA is supplied by four different fuels: diesel and blends concentration of 2%, 5% and 10% palm biodiesel. It is observed that in all fuels, emissions of CO_2 increases from the time that is required for 80% of the full load of the generator. The same applies to the emissions of SO_2 and CO, with the difference that the phenomenon occurs from 90% of full load. For NO_x and specific consumption, the opposite happens. From 29 to 50% of full load consumption and NO_x emissions decrease as specific the load increases.

Leal et al. (2007), totally replacing diesel with biodiesel from soybeans in electronically managed engine, Mercedes-Benz, Model OM-904 LA, cycle diesel direct injection, achieved a reduction of about 32% in CO, 18% in emissions HC and an increase of about 23% in NO_x emissions.

2. DIESEL ENGINES

The essential features of the compression-ignition or diesel engine combustion process can be summarized as follows. Fuel is injected by the fuel-injection system into the engine cylinder toward the end of the compression stroke, just before the desired start of combustion. The liquid fuel, usually injected at high velocity as one or more jets through small orifices or nozzles in the injector tip, atomizes into small drops and penetrates into the combustion chamber. The

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fuel vaporizes and mixes with the high-temperature high-pressure cylinder air. Since the air temperature and pressure are above the fuel's ignition point, spontaneous ignition of portions of the already-mixed fuel and air occurs after a delay period of a few crank angle degrees. The cylinder pressure increases as combustion of the fuel-air mixture occurs. The consequent compression of the unburned portion of the charge shortens the delay before ignition for the fuel and air which has mixed to within combustible limits, which then bums rapidly. It also reduces the evaporation time of the remaining liquid fuel. Injection continues until the desired amount of fuel has entered the cylinder. Atomization, vaporization, fuel-air mixing, and combustion continue until essentially all the fuel has passed through each process. In addition, mixing of the air remaining in the cylinder with burning and already burned gases continues throughout the combustion and expansion processes (Heywood, 1988). The figure 1 show diesel cycle.

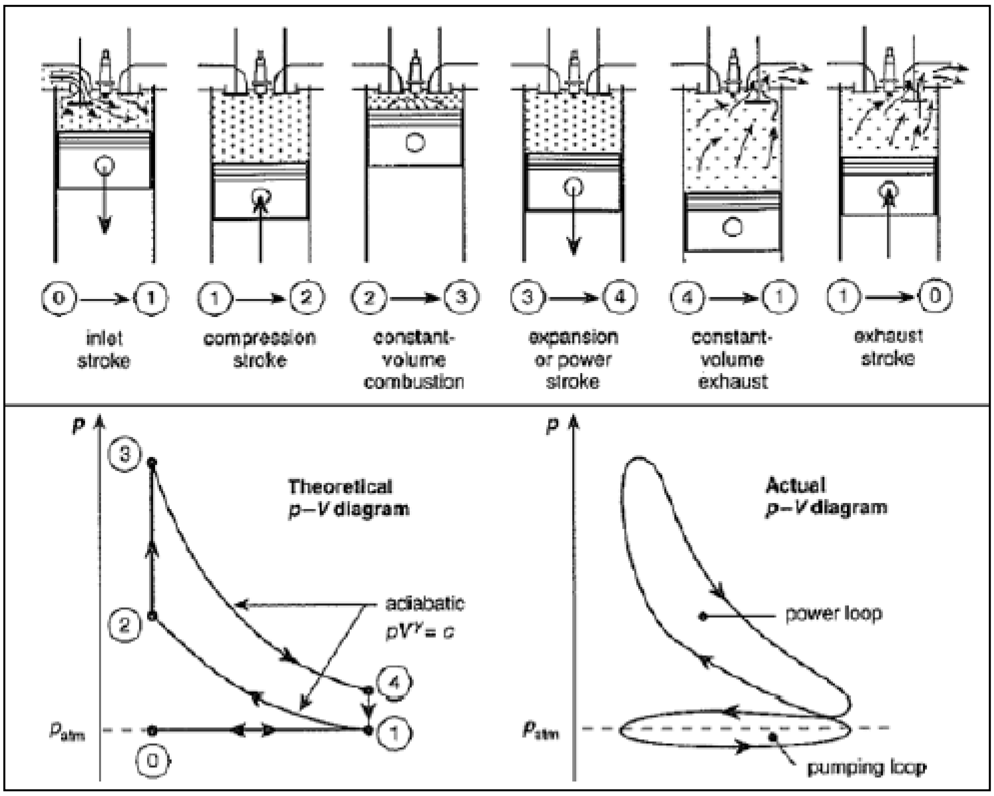

Figure 1. Diagram for a diesel cycle. Source: Heywood, 1988.

In the diesel engine, air is compressed adiabatically with a compression ration typically between 15 and 20. This compression raises the temperature to the ignition temperature of the fuel mixture which is formed by injecting fuel once the air is compressed.

2.1 Combustion Efficiency

Air utilization in diesels is limited by the onset of black smoke in the exhaust. The smoke is soot particles which are mainly carbon. While smoke and other incomplete combustion products such as unburned hydrocarbons and carbon monoxide represent combustion inefficiency, the magnitude of that inefficiency is small. At full load conditions, if only 0.5 percent of the fuel supplied is present in the exhaust as black smoke, the result would be unacceptable. Hydrocarbon emissions are the order of or less than l percent of the fuel. The fuel energy corresponding to the exhausted carbon monoxide is about 0.5 percent. Thus, the combustion inefficiency is usually less than 2 percent. While these emissions are important in terms of their air-pollution impact, from the point of view of energy conversion it is a good approximation to regard combustion and heat release as essentially complete.

3. BIODIESEL

Biodiesel is a biodegradable fuel derived from renewable resources such as vegetable oils and animal fats that stimulated by a catalyst, react chemically with alcohol or methanol. There are different species of oilseeds in Brazil of which can produce biodiesel, including castor, palm, sunflower, babassu oil, soybean, cotton. The Brazilian production of soybean oil crop in 2013/2014 to reach 7.4 million tons, up 6.8 million tons produced in the previous period, according to forecasts by the Brazilian Association of Vegetable Oil Industries (Abiove). Soybean oil remains the most produced by the country, which consumes 5.7 million tonnes and exports the surplus. But the main focus of the sector in the coming years is palm oil. Over the past five years, the volume of palm oil imported by Brazil rose from 95,000 tons to 250,000 tons per year and palm kernel from 70,000 to 175,000 tons.

The shortage of electricity is a major reason for the low Human Development Index of isolated communities located in the Amazon basin. The biodiesel produced from vegetable oils extracted from oil seeds native species, in a sustainable way, is one of the best alternative energy for the region. The "tucumã of Amazonas" (Astrocaryum aculeatum), is an Amazon palm tree that produces a much appreciated fruit in the region, from which it obtains kernels that have high content in oil. Encourage the production of biodiesel can benefit isolated communities, with difficulties access to electricity (Barbosa, 2009)

The high energy demand in the industrialized world and the domestic sector, as well as pollution problems caused due to the use of these fuels, has resulted in a growing need to develop renewable energy sources, stimulating, and creating a recent interest in finding alternative sources for petroleum-based fuels. An alternative to replacing the fossil fuel is a biodiesel use (Meher, 2004). Chemically, oils and fats, animal and vegetable triglycerides consist of molecules which are composed of three long chain fatty acids in the form of esters linked to a glycerol molecule (Ma, 1999). However, the use of vegetable oil as an alternative fuel is also considered unsatisfactory by presenting a number of limiting factors, such as high viscosity, content of free fatty acids, and low volatility incomplete combustion which results in the formation of deposits on fuel injectors machine (Meher, 2004). To overcome them, the triglycerides should be derivatives to become compatible with existing machines (Ma, 1999). Several alternatives have been considered to reduce these problems, eg. Dilution, emulsification through formation of microemulsions using solvents such as methanol, ethanol or butanol, transesterification with ethanol or methanol (Ma, 1999). Of the various methods described in the literature for obtaining biodiesel transesterification of vegetable oils is currently the method of choice primarily because the physical characteristics of fatty acid esters are very close to those of diesel (Schuchardt, 1998).

Transesterification is a general term used to describe a class of important organic reactions in which an ester is transformed into another by exchange of the residue alkoxyl (Vollhardt, 2004). When the original ester reacts with an alcohol, the transesterification process is called alcoholysis**.** This reaction is reversible and continues essentially mixing the reagents. However, the presence of a catalyst (acid or base) greatly accelerates the conversion, but also contributes to increase the yield thereof (Schuchardt, 1998).

In the transesterification of vegetable oils, one triacilglicerídeo reacted with an alcohol in the presence of a base or strong acid to produce a mixture of esters of fatty acids and glycerol. The overall process is a sequence of three consecutive reactions, in which mono and diacilglicerídeos are formed as intermediates (Schuchardt, 1998). For a transesterification stoichiometrically complete a 3:1 molar ratio of alcohol per triacilglicerídeo is required (Schuchardt, 1998). However, due to the reversible nature of the reaction, the agent transesterificante (alcohol) is usually added in excess, thus contributing to increase the yield of the ester, as well as allowing their separation from the glycerol formed (Meher, 2004).

$$\begin{matrix}\textbf{\textit{Triacylglyceral}}\\(\textbf{\textit{Vegetable oil}})\end{matrix} + \textbf{\textit{Alcohol}} \xrightarrow{\textit{Catalyst}} \begin{matrix}\textbf{\textit{Alkyl ester}}\\(\textbf{\textit{Biodiesel}})\end{matrix} + \textbf{\textit{Glycerol}}$$

Figure 2. The transesterification reaction. The alcohol used for producing biodiesel is usually methanol.
Source: Knothe, et al.

The Transesterificante agent with respect to the reaction process preferably occurs with low molecular weight alcohols, eg. Methanol, ethanol, propanol, butanol and ethanol amílico15 but methanol and ethanol are most often empregados4. Methanol is the most widely used due to its low cost in most countries and its advantages on physical and chemical properties (polarity, alcohol shorter chain, rapidly reacts with and dissolves easily triacilglicerídeo basic catalyst) (Ma, 1999). Moreover, it allows the simultaneous separation of glycerol (Schuchardt, 1998). The same reaction using ethanol is more complicated because it requires anhydrous alcohol and oil with a low content of water to lead to separation of the glycerol (Schuchardt, 1998).

Most of works described in the literature employing basic catalysts such as KOH and NaOH were observed which increased yield and selectivity (Freddman, 1986). However, other basic catalysts nonionic surfactants can be used in the transesterification of triglycerides by preventing the formation of undesirable by-products such as soaps, including triethylamine, piperidine, guanidines (Schuchardt, 1998).

4. MATERIAL AND METHODS

The test was conducted at the experimental farm of the Federal University of Amazonas, research unit in science and technology, located at BR174, 38 km. We use a diesel engine MWM D229-4 according to the manufacturer

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nominal potential of 54 kW total of 3,922L cylinder compression ratio and 17:1 at 2500 rpm, connected to a three-phase synchronous generator KOHALBACH brand, model LA 180 40 kVA , 220/127 V, 1800 rpm, with a frequency of 60 Hz for the load simulation was performed using a copper electrode, connected to each phase of the generator tank 500 L with conductive solution of sodium chloride and water. The electrode contact with the conductive solution, was controlled via a pulley system figure 2, which was proportional to the load variation of electrode height. For measurement of charge, was used Minipa energy analyzer Model ET - 5051 C and for emissions analysis was performed using a gas analyzer model Testo 350.

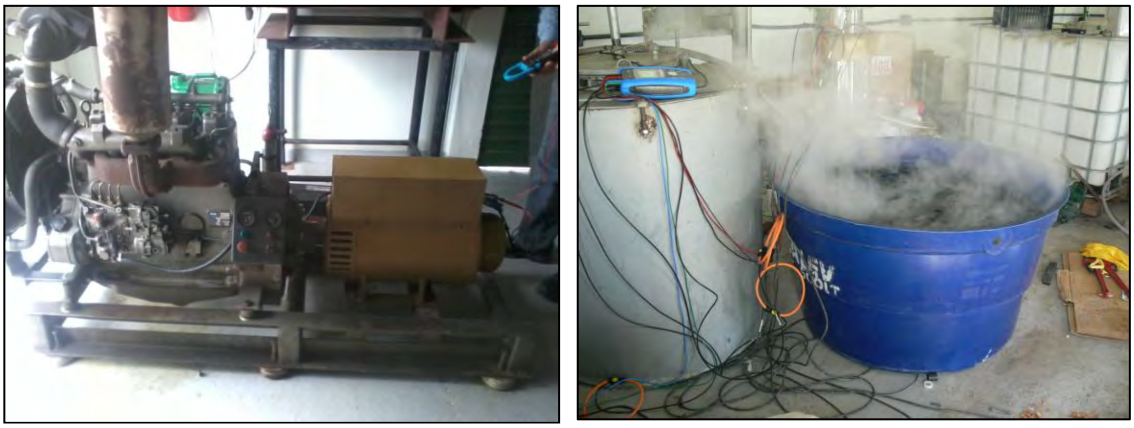

Figure 3. Diesel engine MWM D229-4, generator KOHALBACH and liquid resistance - Charge simulation

Figure 4. Diagram of NOx emissions (ppm) versus load (%)

The fuel used for the test was composed of a mixture between the volumetric biodiesel soybean oil and commercial diesel (B5). The proportions of biodiesel in the fuel composition were: 5% (B5), 20% (B20), 50% (B50), 100% (B100). We use a precision scale and a digital stopwatch to measure the mass of the fuel and the test time, obtaining the hourly fuel consumption during the tests.

To evaluate the performance of the motor-generator was used as a base specific fuel consumption (sfc) and conversion efficiency (η) into electrical energy.

$$sfc = \frac{\dot{m}}{P} \quad (1)$$

Where:

sfc: Specific Fuel Consumption ($gkWh^{-1}$)
$\dot{m}$: Hourly fuel consumption (gh^{-1})
P: applied load (kW)

The conversion of chemical energy of fuel into motor motion is given by:

$$\eta = \frac{1}{PCI \times sfc} \times 100 \qquad (2)$$

Where:

η: Collection efficiency (%)
PCI: lower calorific value ($kWh\ kg^{-1}$)
sfc: Specific Fuel Consumption ($kg\ kWh^{-1}$)

5. RESULTS AND DISCUSSION

5.1 Fuel

TRANSESTERIFICATION PROCESS

We used soy vegetable oil used for frying and a solution of potassium hydroxide dissolved in methanol.

This solution should be handled carefully, using protective equipment due to large capacity corrosive base and methanol toxicity.

Soybean oil was filtered with cotton cloth to remove the residue and heated, being regularly agitated to a temperature of 70 ° C. Then, to the solution was added potassium hydroxide and methanol, which remained under agitation for 15 minutes. The mixture was transferred to a separation funnel, which allowed the separation and decantation of the phases, containing biodiesel upper and lower composed of glycerol and other products.

The fuel samples B20, B50 and B100 were sent to the laboratory research and testing fuel LAPEC, Federal University of Amazonas, which was rated the cetane number and the specific mass of the fuel, as shown in Table 1.

Table 1. Characteristics of fuel

SAMPLE	B20	B50	B100
SPECIFIC MASS AT 15° C (kg/m^3)	853.6	861.4	884
SPECIFIC MASS AT 20° C (kg/m^3)	850	858.4	880.9
INDICATION CETANE	50.4	50.3	unvalued
LOWER CALORIFIC (kWh/kg)	12.19	11.73	10.96

The national oil agency ANP specifies the values of specific mass for commercial diesel S10 and S50 820-850 kg/m^3. The fuel mixture showed a value slightly above specifications. For the cetane index, ANP specifies the minimum cetane for diesel S10: 48, S50: 46 and S1800: 42, so all blends were higher than the specifications.

5.2 Emissions data

During the test, the CO (ppm), NO_x (ppm) NO (ppm), NO_2 (ppm) and CO_2 (%), were captured by the gas analyzer Testo model T350 with frequency measurement per second calibrated on 23/03/12, ISO / IEC 17025. The data for each sample were sent to the computer that processed and made the record. The assay was performed by varying the load on the engine by 20%, 40%, 60% and 80% in different proportions of diesel and biodiesel (B5, B20, B50 and B100).

The results of the engine relative to CO (ppm) emission is equal to 1 or 2 in the most of analysis, it means that the measurements were close to the accuracy of the equipment.

Figure 5 shows data NO_x increases it rate when increase the charge, but can be observed at 40% load the emissions are more expressive to diesel fuel as biodiesel.

Figure 6 shows the NO emissions data for a load of the engine. Note that up to 40% is observed a small decrease in emissions of NO, as the load increases, diesel oil showed the lowest rate of emission the biodiesel blends.

Figure 7 shows the data for emissions of NO_2 were observed a decreasing emission of NO_2 as it increases the value of the load, the diesel with biodiesel blends showed higher emission index in all load ranges.

Figure 8 shows the data of CO_2 (%), for a load of 20% no significant changes in emissions, while in 40%, emissions decreased with increasing the percentage of biodiesel in the blend, while loads of 60% to 80% the emission values were higher as the engine operates biodiesel and mixtures thereof.

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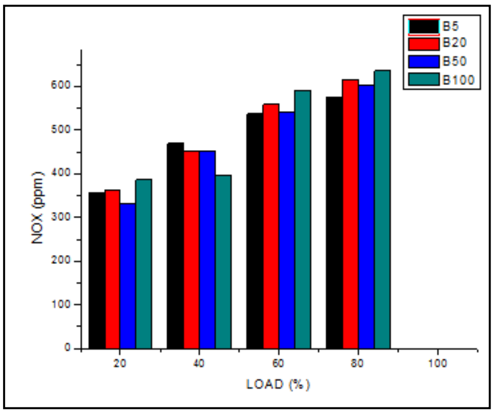

Figure 5. Diagram of NO_x emissions (ppm) versus load (%)

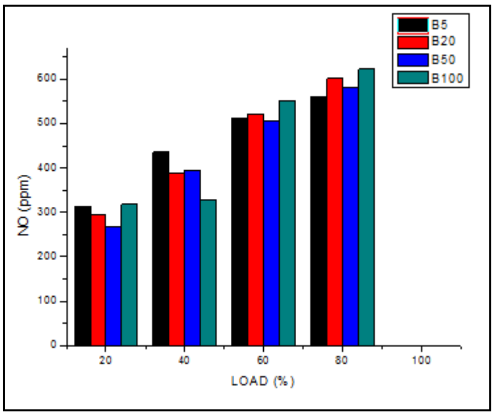

Figure 6. Diagram of NO emissions (ppm) versus load (%)

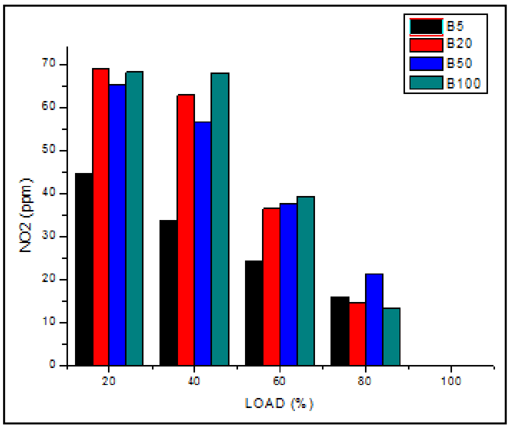

Figure 7. Diagram of NO_2 emissions (ppm) versus load (%)

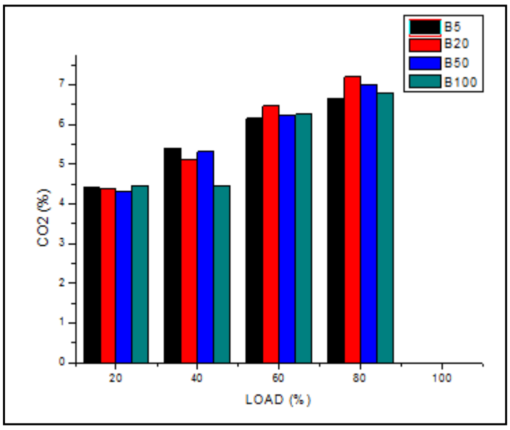

Figure 8. Diagram of CO_2 emissions (%) vs. load (%)

5.3 Performance

The specific consumption (sfc) is related to the calorific value of a fuel, the higher the calorific value the lower the specific fuel consumption. However, these data are not sufficient to assess what type of fuel has the best behavior in relation to energy production.

From the calculation efficiency is possible to point out that the fuel had better efficiency. During the test, we kept the rotation of the engine around 1800 rpm and power of 25 kW. Although the B100 have higher specific consumption of fuel in the tests carried out, it showed the highest index of efficiency, while mixtures B20 and B50 showed values almost identical, but lower than the diesel sold (B5).

Table 2. Performance data for rotation of 1800 rpm and Power of 25 kW

SAMPLE	CONSUMPTION (kg/h)	SPECIFIC FUEL CONSUMPTION (kg/kWh)	EFFICIENCY (%)
B5	7.13	0.285	28.48
B20	7.36	0.294	27.91
B50	7.62	0.305	27.95
B100	7.80	0.312	29.26

In Table 2 are collected the values of consumption and thermal efficiency, these data show that the fuel that showed the best thermal efficiency was the B100 fuel, with gains of 2.67%, a similar result presented by Barboza et al. (2008), and there was an increase of 8.65% of the specific consumption in relation to biodiesel, in agreement with other literature.

Under some studies on the performance of diesel engines using biodiesel blends.

Das & Agarwal (2003) conducted tests on an internal combustion engine using eleven proportions of diesel oil and biodiesel (B0, B5, B10, B15, B20, B25, B30, B40, B50, B75 and B100). In the study, we assessed the sfc and the thermal efficiency of the engine and the results compared with diesel (B0). The authors found that the best performances for fuel blends were obtained with 20% biodiesel, with gains of up to 2.5% in thermal efficiency.

Soranso et al. (2006) evaluated the dynamic performance of a 4 x 2 tractor ALL 100 hp with distilled biodiesel (50% + 50% ethyl ether) in mixtures of B0, B5, B15, B25, B50, B75 and B100, observed that the use of the motor with 100% biodiesel represented a 18% increase in specific fuel consumption compared to diesel (B0), the effective yield on the draw bar decreases 14% compared to diesel (B0).

Mazeiro et al. (2007) evaluated the performance of a diesel engine MWM D229.3, 46 kW at 2450 rpm, using diesel oil and crude oil from sunflower. Noted that, with the use of crude oil to replace diesel, markedly reduces the mechanical performance and detrimental changes arise in engine as formations inlay inside.

Barbosa et al. (2008) showed an average gain of 4% in the efficiency of the diesel engine of 58.2 kW (78 hp) of a tractor to use 100% biodiesel compared with petroleum diesel.

Reis et al. (2013) evaluated the performance of an engine diesel generator 5 hp 4-stroke, using concentrations of biodiesel (B5, B10, B20, B50, B75 and B100) found that emissions of gases O_2, CO, SO_2 and CO_2 are higher when used diesel (B5) compared to other fuels evaluated, and higher values of NO_x prevailed when the biodiesel in the blend. With the increase of concentration in the biodiesel blends, an increase in the efficiency of the combustion process.

6. CONCLUSION

The biodiesel is an important fuel and can be used to generate power without big losses of efficiency. It means that, in isolated regions, it became a good solution to solve power supplier problems. In the Amazon, some places suffer with shortages of diesel, the use of this fuel is a solution to avoid rationing, mainly in the dry season the rives. The present study showed that using a soya bean oil mixing with common diesel increased the specific fuel consumption, as the concentration of biodiesel, due the diesel (B5) presents higher calorific that biodiesel blands (B20, B50 and B100). The emissions of NO_x, NO and CO_2 were greater when using when using biodiesel, but a load of around 40%, had the lowest rate issued NO_x, NO and CO_2 in relation to common diesel. Within an environmental thinking, encouraging the use of biodiesel reduces global warming, the CO_2 released is absorbed by oilseeds during growth, which balances the emissions into the atmosphere. In this tests, using 100% biodiesel, the thermal efficiency was 2.7% higher than diesel (B5), for a rotation of 1800 rpm and 25 kW load, it means the better use of energy of fuel. The use of biofuel promotes the generation of agro-industrial cooperative in small and medium businesses, outside urban centers, pinning people in their regions and valuing local raw materials.

7. ACKNOWLEDGEMENTS

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