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MEASUREMENTS OF EXHAUST EMISSIONS AND ELECTRIC POWER IN A STATIONARY ENGINE USING BLENDS OF DIESEL AND AN ALTERNATIVE FUEL

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Abstract: The present work describes an experimental investigation concerning the exhaust emissions and the electric energy generation using blends of diesel and an alternative fuel obtained through the Low Temperature Conversion process applied to petrochemical residue. The alternative fuel (LTCF) was obtained in a Pilot Unit. The exhaust emissions (CO, CO_2, O_2, NO, NO_x and SO_2) were, also, studied. The results show that the use of diesel-LTCF blends in stationary engine is an alternative for the sustainable development. The mixture 10%vol. of LTCF and 90%vol. of diesel is the best one concerning the exhaust emissions.

Keywords: alternative fuel, electric power, environmental measurement

1. INTRODUCTION

Nowadays, the residues of the most varied economical activities become a great problem. Simultaneously, it happens an increase in the search for alternative sources of energy. The present work seeks to develop solutions for these two problems: the crescent increase of residues and the crescent disputes for alternative sources of energy.

The alternative proposal is the generation of electric power starting from biomasses and residues, using mainly the Low Temperature Conversion (LTC) process. This technology allows the integral use of biomasses and residues transforming them in oil (Low Temperature Conversion Fuel – LTCF), gas and char, for subsequent energy use.

With the application of the LTC process the residue becomes the matter of the process, it stops being a problem and to become an economical solution, eliminating possibilities of soil and water contaminations when disposition technologies are applied.

In that way, the central objective of the research is to study the use of blends of diesel and LTCF for the electric energy generation. For the accomplishment of this study a Pilot Unit is used in order to produce the oil (LTCF) from petrochemical residue and a stationary engine is used for the electric energy generation. The exhaust emissions are, also, analyzed.

1.1. Low Temperature Conversion process

The Low Temperature Conversion (LTC) process was developed starting from studies about the viability of the biodiesel production from mud of sewers treatment station's in Germany in the 80's. LTC is a thermochemical process, whose main objective is of encreasing the cycle of life of the residues. LTC has been applied to several residues and biomasses of urban, industrial and agricultural origin, being sought through the thermal conversion to transform them in products of potential commercial value. Depending on the biomass and residue type used in the process, oil and char are obtained in variable proportions, besides water and gas. The oil is sent to studies about the viability of its application as fuel or other possible commercial application (as greases, lubricants, resins etc) while the char is sent to studies of its activation so that it can be used as active char, besides the possible direct use as energy [1-2].

2. MATERIAL AND METHODS

2.1. Low Temperature Conversion process

A Pilot Unit was implanted that operates in continue way, with direct flow, electric heating and processed in inert atmosphere using the gas nitrogen. The Pilot Unit has capacity to process 50 kg/h of dehydrated sample (residue or biomass).

The Pilot Unit, for oil and char production, is constituted, basically, of the following components: conversion tube; unit of generation; condenser; tank to collect the condensed product (oil-LTCF); tank to collect the solid product (char); cylinder of nitrogen; compressor; heating system and control panels.

Samples of industrial residue (petrochemical mud of treatment station) were used in the Low Temperature Conversion process.

2.2. LTCF and diesel characterization

Elementary Analysis of the LTCF was done according to ASTM D 5291.

Physical and chemical analyses were accomplished in the LTCF and diesel, being used the following methods: ASTM 3286-6 (Heating Value); ASTM D 4052 (Density); ASTM D 4294 (Sulfur); ASTM D 93 (Flash Point); ASTM D 445 (Viscosiy); ASTM D 97 (Pour Point); ASTM D 86 (Distillation); ASTM D 976 (Cetane Index) and ASTM D 482 (Ash).

2.3. Blends of diesel and LTCF

The LTCF was mixed with diesel, for the accomplishment of tests with motor, in the following proportion in volume: 5%, 10% and 20%. These percentages were chosen tends in view the future tendency in Brazil of to allow mixing in the diesel, amounts of alternative fuel (biodiesel, biofuel) for commercialization.

The following nomenclature was used: AF = Alternative Fuel, being, AF5: 5%vol. of LTCF and 95%vol. of diesel; AF10: 10% vol. of LTCF and 90%vol. of diesel and AF20: 20% vol. of LTCF and 80%vol. of diesel.

2.4. Stationary engine

The diesel-LTCF blends were tested in a stationary engine whose characteristics are in Table 1.

Table 1. Stationary engine specifications

PARAMETERS	SPECIFICATIONS
Make	BD-2500
Speed	3600 rpm
Fuel	Diesel
Type	Four-stroke, direct injection
Number of cylinders	One
Cooling system	Air
Displacement volume	0.211 L
Maximum output	2.0 kW
Nominal power	1.8 kW
Fuel capacity	2.5 L
Weight	47 kg

2.5. Electric energy generation

It was used in the tests a load panel with the stationary engine. Every fuel was tested by 2.5 hours with 85% of the full load.

The electric properties (voltage, power and frequency) were measured and stored through a digital equipment, manufactured by CCK, model CCK 4300. The communication with this meter was made through Converter RS 485 supplied also by CCK.

2.6. Exhaust emissions

The engine emissions gas analyses were done in a GreenLine 8000 instrument using non-dispersive infrared (NDIR) analyzer for measurements of CO and CO_2 and electrochemical sensors for measurements of O_2, NO, NO_x and SO_2.

3. RESULTS AND DISCUSSION

3.1. LTCF and diesel characterization

It was made the Elementary Analysis of the LTCF as shown: nitrogen (3.7%); carbon (85.7%); hydrogen (9.3 %).

The Table 2 shows the results for the physical and chemical properties of LTCF and diesel. Each value represents a mean of at least 5 tests.

According to Table 2, the LTCF presented properties with close values to the properties of the diesel.

Table 2. Properties of LTCF and diesel

PROPERTIES	LTCF	Diesel
Density at 15ºC (kg/L)	0.8700	0.8448
Viscosity at 40ºC (mm^2/s)	4.6	3.6
Higher Heating Value (kJ/kg)	41000	45000
Distillation – 50% recovered (ºC)	300	270
Cetane Index	44.2	47.1
Flash Point (ºC)	75	76
Pour Point (ºC)	-12	-10
Sulfur (wt %)	0.17	0.3
Ash (wt %)	0.04	0.005

The LTCF also presented properties similar to other fuels reported in the literature (Tables 3 and 4).

Table 3: Properties of LTCF and other fuels

FUEL	Ash (wt %)	Higher Heating value or Lower Heating value (kJ/kg)
LTCF (present study)	0.04	41000 (HHV)
Diesel [3]	n.a .	42500 (LHV)
Diesel [4]	n.a .	45230 (HHV)
Diesel D2 [5]	< 0.01	42990 . (LHV)
Biodiesel [5]	< 0.01	36970 (LHV)
Peanut biodiesel [6]	n.a .	33600 (LHV)
Babassu biodiesel [6]	n.a.	31800 (LHV)
Sunflower biodiesel [6]	n.a.	33500 (LHV)
Diesel [6]	n.a.	43800 (LHV)
Marine diesel [7]	0.12	n.a.
Olive biodiesel [7]	0.0054	n.a.
Diesel [8]	n.a.	46450 (HHV)

n.a., not available

HHV, Higher Heating Value

LHV, Lower Heating Value

Table 4: Properties of LTCF and other fuels

FUEL	Density at 15ºC (kg/L)	Viscosity at 40ºC (mm^2/s)
LTCF (present study)	0.8700	4.6
Diesel D2 [5]	0.8290	2.40
Biodiesel [5]	0.8824	4.66
Peanut biodiesel [6]	0.883	4.9
Babassu biodiesel [6]	0.875	3.6
Sunflower biodiesel [6]	0.860	4.6
Diesel [6]	0.855	3.06
Marine diesel [7]	0.860	3.8.
Olive biodiesel [7]	0.880	4.7

3.2. Electric energy generation

Table 5 shows the properties (medium values of five measurements) obtained in the electric energy generation tests, using diesel and alternative fuels (diesel-LTCF blends).

Table 5. Medium values obtained in the electric energy generation tests

PARAMETERS	Diesel	AF5	AF10	AF20
Power (W)	1680	1688	1680	1680
Voltage (V)	103.2	104.0	104.0	105.0
Frequency (Hz)	59.8	60.0	59.8	60.0
Fuel consumption (L/h)	1.050	1.100	0.975	1.026

In agreement with the Table 5, it can be said that for all the mixtures the electric power generation happened without problems. With the mixture AF10, it was obtained the smallest consumption of fuel.

During the operation of the stationary engine with the alternative fuels there were not any type of breakdown occurrence or abnormal operation of the motor.

3.3. Exhaust emissions

The results (medium values of five measurements) of the emissions of gases are shown in Table 6.

The use of diesel-LTCF blends has some advantages concerning the exhaust emissions. The AF10 is the best blend, resulting in less emissions of CO, NO, NO_x and SO_2.

Table 6. Medium values of exhaust emissions

PARAMETERS	Diesel	AF5	AF10	AF20
O_2 (%)	20.0	18.8	19.7	18.7
CO_2 (%)	1.3	1.4	1.8	1.7
CO (ppm)	174	180	140	173
SO_2 (ppm)	9	7	7	9
NO (ppm)	446	n.m.	406	426
NO_x (ppm)	460	n.m.	419	439
Exhaust gas temperature (ºC)	165	158	158	159
Test room temperature (ºC)	34.3	32.4	30.4	34.1

n.m., not measured

4. CONCLUSIONS

The results of the tests show the viability of using diesel-LTCF blends in a stationary engine for the electric power generation, being an alternative for the sustainable development. The mixture 10%vol. of LTCF and 90%vol. of diesel is the best one concerning the exhaust emissions.

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