REVISTA CONTRIBUCIONES A LAS CIENCIAS SOCIALES

Evaluation of a motor generator adapted to biogas

Avaliação de um gerador motorizado adaptado para biogas

Evaluación de un motogenerador adaptado al biogás

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ABSTRACT
With the need to reduce the environmental impacts caused by fossil fuels and minimize the problems caused by a possible crisis arising from price increases or even energy shortages, alternative and renewable ways to replace such non-renewable sources are sought. them. Among the various forms, there is biogas, which can be used as fuel in internal combustion engines. In this context, the present work aimed to evaluate a motor generator adapted to biogas. A 4-stroke, single-cylinder, gasoline-powered motor generator was used, with a nominal power of 6.5 HP. The tests were carried out, taking 6 times with an interval of 10 minutes each, where the rotations and energy consumption of the motor were measured, in addition to the voltage and electric current generated to supply the resistive load. The resistive load used in the motor generator was provided by lighting seven incandescent lamps of 100W nominal each, resulting in a verified measurement of 510W, which was maintained throughout the test. The motor-generator set consumed an average volumetric flow of 1.97m^3 h^{-1} and an average mass flow of 1.228 kg h^{-1} for a generator power of 501 W and a set efficiency of 7.53%.

Keywords: methane, performance, generator, renewable.

RESUMO
Com a necessidade de reduzir os impactos ambientais causados pelos combustíveis fósseis e minimizar os problemas causados por uma possível crise decorrente do aumento de preços ou mesmo da escassez de energia, buscam-se formas alternativas e renováveis para substituir essas fontes não renováveis. Dentre as diversas formas, destaca-se o biogás, que pode ser utilizado como combustível em motores de combustão interna. Nesse contexto, o presente trabalho teve como objetivo avaliar um motor gerador adaptado ao biogás. Foi utilizado um motor-gerador de 4 tempos, monocilíndrico, movido a gasolina, com potência nominal de 6,5 HP. Os testes foram realizados 6 vezes com intervalo de 10 minutos cada, onde foram medidas as rotações e o consumo de energia do motor, além da tensão e da corrente elétrica gerada para alimentar a carga resistiva. A carga resistiva utilizada no motor-gerador foi fornecida pelo acendimento de sete

lâmpadas incandescentes de 100W nominais cada, resultando em uma medição verificada de 510W, que foi mantida durante todo o teste. O conjunto motor-gerador consumiu um fluxo volumétrico médio de 1,97m³ h-¹ e um fluxo de massa médio de 1,228 kg h-¹ para uma potência de gerador de 501 W e uma eficiência de conjunto de 7,53%.

Palavras-chave: metano, desempenho, gerador, renovável.

RESUMEN
Ante la necesidad de reducir el impacto ambiental causado por los combustibles fósiles y minimizar los problemas derivados de una posible crisis derivada del aumento de los precios o incluso de la escasez de energía, se buscan formas alternativas y renovables de sustituir dichas fuentes no renovables. ellos. Entre las diversas formas, se encuentra el biogás, que puede utilizarse como combustible en motores de combustión interna. En este contexto, el presente trabajo tenía por objeto evaluar un motogenerador adaptado al biogás. Se utilizó un motogenerador de gasolina, monocilíndrico, de 4 tiempos, con una potencia nominal de 6,5 CV. Las pruebas se realizaron, tomando 6 tiempos con un intervalo de 10 minutos cada uno, donde se midieron las rotaciones y el consumo de energía del motor, además de la tensión y la corriente eléctrica generada para alimentar la carga resistiva. La carga resistiva utilizada en el motor-generador se proporcionó encendiendo siete lámparas incandescentes de 100W nominales cada una, resultando una medida verificada de 510W, que se mantuvo durante toda la prueba. El grupo motor-generador consumió un caudal volumétrico medio de 1,97m³ h-¹ y un caudal másico medio de 1,228 kg h-¹ para una potencia del generador de 501 W y un rendimiento del grupo del 7,53%.

Palabras clave: metano, rendimiento, generador, renovable.

1 INTRODUCTION

With the need to reduce the environmental impacts caused by fossil fuels and minimize the problems caused by an eventual crisis arising from the price increase or even the scarcity in the supply of fuels, alternative and renewable ways to replace them are sought.

Among several forms, there is biogas, which is a by-product of biomass, from agricultural activities, where waste of animal origin is an important source (Calza et al., 2015).

Biogas is generated from biomass through biodigesters, it as a closed fermentation chamber, where the biomass is digested by anaerobic bacteria, producing at the end of the biofertilizer process and biogas (Santos et al., 2017).

However, there are several models of biodigesters, which are adapted according to the needs of each property, whether for the use of biogas or for the production of biofertilizer.

The biogas has in its composition gases such as methane (CH4), carbon dioxide (CO2), hydrogen sulfide (H2S), among others in small concentrations (Molino et al., 2018).

It can be used as fuel in internal combustion engines, turbines, stoves and ovens, boilers, dryers and in vehicle fleets.

Internal combustion engines are spark ignition equipment, being the most adaptable to use with biogas due to the existing units for natural gas. These can be coupled with electricity generators that can be deployed in rural properties and agro-industries that have biomass residues in their production process and biogas production for the generation of electricity (Souza et al., 2010).

The main sulfur-based compound in biogas is hydrogen sulfide, which is corrosive in the presence of water and needs to be removed before use in storage tanks, compressors or engines in order to avoid corrosion in equipment, since that its reactivity with metals increases with concentration, pressure, presence of water and high temperatures (Person et al., 2007).

In this context, the present work aims to evaluate a motor generator adapted to biogas, in terms of biogas consumption and electricity generation.

2 MATERIALS AND METHODS

The experimental tests were carried out at the Laboratory of Anaerobic Biodigestion of the Institute of Agricultural Sciences, Federal University of Minas Gerais, Campus Montes Claros. The laboratory has two digesters, an Indian model and another covered pond (also known as the Canadian model), which operate using swine manure. For the present study, only biogas from the Canadian model was used for the tests.

The motor-generator set used in the tests was of the Toyama brand, model TG2800MX, originally gasoline, four-stroke single-cylinder engine, with a rated power of 6.5HP, with a single-phase generator coupled from the factory, voltages 120/240, frequency of 60HZ, power maximum power of 2.5KW and rated power of 2.2KW.

The tests were carried out, taking 6 times with an interval of 10 minutes each, using a digital stopwatch, with a reading accuracy of tenths of a second, and a motor-generator set operating with the mixture of biogas and air inserted directly into the combustion chamber.

through a tube made with a low pressure flow valve, which made it possible to control the flow of biogas.

The resistive load used in the motor generator was provided by lighting seven incandescent lamps of 100W nominal each, resulting in a verified measurement of 510W, which remained constant throughout the test.

The biogas used in the test was purified in a filter basically composed of iron oxide as a filtering element, with the objective of eliminating hydrogen sulfide (H2S).

During the tests, were measured: Fuel consumption, engine speed, generated power, voltage and electric current. To measure the consumption of biogas by the motor-generator set, a volumetric gas meter of the LAO brand, model G1.6, minimum flow of 0.016 $m^3\ h^{-1}$, maximum flow of 2.5 $m^3\ h^{-1}$ and maximum working pressure of 50kPa.

To measure the engine speed, a Minipa brand tachometer, model MDT-2238[a] was used, and to measure the generated power, voltage and electric current, a Minipa ammeter clamp, model ET-4080 and also a digital indicator were used. of voltage and current.

The specific mass of biogas, which basically depends on its composition, is significantly influenced by the atmospheric conditions of the environment, such as pressure and temperature. Amestoy and Ferreyra (1987) demonstrate with the following calculation the ratio of the specific mass of methane gas as a function of the volumetric percentage of its components:

$$\rho gn = (0.72\%\ CH4 + 1.96\%\ CO2)/100$$

Mitzlaff (1988) reports on the influence of local atmospheric conditions on the specific mass of biogas, and presents the following relationship:

$$\rho g = [\rho gn.\ (288/101.33).\ Pa/\ (tg + 273)]/1000$$

Where:

ρg- real specific mass of the gas, kg m^{-3};
ρgn - normal specific mass of the gas, kg Nm^{-3};
pa - local ambient pressure, kPa, and
t - local ambient temperature, °C.

The lower calorific value of biogas (Hg) can be defined by the following expression:

$$Hg = pCH_4 . 50{,}000 \text{ kJ kg}^{-1}$$

Thus, for biogas with 65% methane and 23% carbon dioxide, with a pressure on the day of the test of 76.1 kPa at an average ambient temperature of 29.86ºC, we have:

Normal specific gravity: 0.9188 kg m^{-3};
Hg: lower calorific value (19,500 kJ kg^{-1});
Specific mass under ambient conditions (ρgn): 0.6222 kg m^{-3};
pCH_4 mass proportion of methane in biogas: 0.39 kg kg^{-1}.

To calculate the efficiency of the motor-generator set, the following equation was used:

$$n = [(P .1000^{-1}).3600]/ (mc. Hc)$$

Where:

P: Generated power (W);
mc: fuel mass flow ($kg.h^{-1}$);
Hc: calorific value of the fuel ($kJ.kg^{-1}$).

3 RESULTS AND DISCUSSION

In table 1 below, it is possible to verify the following data obtained in the tests: The biogas temperature (ºC), engine speed (rpm), voltage (V), Current (A) and consumption accumulated biogas in kWh.

Table 1: Data obtained in the test

C°	Gas	rpm			Voltage (V)		Current (A)		accumulated
	(m^3 h^{-1})	Min	Max	average	ammeter	panel	ammeter	panel	(kWh)
27.1	0.00	4200	4300	4250	106.6	106.8	4.7	4.8	0
27.5	1.97	4340	4400	4370	107.3	106.3	4.1	4.86	0.084
27.7	1.98	4250	4493	4372	106.7	106.9	4.6	4.87	0.158
27.8	1.97	4360	4505	4433	106.4	106.3	4.6	4.88	0.244
28.1	1.98	4382	4495	4439	106.2	106.2	4.7	4.87	0.329
28.4	1.98	4420	4520	4470	106.6	106.2	4.7	4.87	0.415
28.6	1.96	4460	4504	4482	106.2	106.3	4.8	4.87	0.501

Source: Authors (2024)

It was not possible to keep the rotations constant for the resistive powers tested, having varied between 4200 and 4520 rpm.

The voltage and current values of the motor-generator set measured with clamp meters were very close to the values shown on the digital indicator.

For the resistive power of 510 W, it was obtained an average volumetric flow of consumption of $1.97 m^3h^{-1}$ and an average mass flow of 1.228 kg h^{-1} for a power in the generator of 501 W and an active power also of 501 W with motor-generator power factor equal to 1 and set efficiency of 7.53%, which is very close to the value found by Souza, Silva and Bastos (2010).

4 CONCLUSION

The present study shows that the generation of electric energy is satisfactory for the conditions studied.

It was possible to operate the motor-generator set stably operating 100% with biogas, using the power system developed and adapted to the motor.

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