**Evaluation of a Motor Generator Adapted to Biogas**

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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 1.97m³ 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.

# 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 (Colen, 2003).

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;Nascimento; Alves, 2017) (Malinowsky, 2016).

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 (Mariani, 2018).

It can be used as fuel in internal combustion engines, turbines, stoves and ovens, boilers, dryers and in vehicle fleets (Albarracin, 2016).

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; Silva; Bastos, 2010).

For better engine performance, it is necessary that the biogas be filtered, as the absence of filtering processes over time damages the equipment in which biogas without purification is used (Canever, 2017).

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.

# 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 m³ h-1, maximum flow of 2.5 m³ h-1 and maximum working pressure of 50kPa.

To measure the engine speed, a Minipa brand tachometer, model MDT-2238ª 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:

ρgn = (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:

ρg = [ρgn. (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 = pCH4. 50,000 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;

pCH4 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).

# RESULTS AND DISCUSSION

In table 1 below, it is possible to verify the following data obtained in the tests: time (hr) of 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

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **hr** | **C°** | **Gas** | **rpm** | | | **Voltage (V)** | | **Current (A)** | | **accumulated** |
| **(m³ h-¹)** | **Min** | **Max** | **average** | **ammeter** | **panel** | **ammeter** | **panel** | **(kWh)** |
| 09:25 | 27.1 | 0.00 | 4200 | 4300 | 4250 | 106.6 | 106.8 | 4.7 | 4.8 | 0 |
| 09:35 | 27.5 | 1.97 | 4340 | 4400 | 4370 | 107.3 | 106.3 | 4.1 | 4.86 | 0.084 |
| 09:45 | 27.7 | 1.98 | 4250 | 4493 | 4372 | 106.7 | 106.9 | 4.6 | 4.87 | 0.158 |
| 09:55 | 27.8 | 1.97 | 4360 | 4505 | 4433 | 106.4 | 106.3 | 4.6 | 4.88 | 0.244 |
| 10:05 | 28.1 | 1.98 | 4382 | 4495 | 4439 | 106.2 | 106.2 | 4.7 | 4.87 | 0.329 |
| 10:15 | 28.4 | 1.98 | 4420 | 4520 | 4470 | 106.6 | 106.2 | 4.7 | 4.87 | 0.415 |
| 10:25 | 28.6 | 1.96 | 4460 | 4504 | 4482 | 106.2 | 106.3 | 4.8 | 4.87 | 0.501 |

# 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 1.97m³h-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).

# CONCLUSIONS

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

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