Emissions and fuel consumption when gas propane is used as fuel

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Abstract: - At the following essay it will be examined the use of gas propane in a small four-stroke engine of internal combustion that is used for the movement of a small alternative generator. The generator functioned at different electrical loads 500W, 1000W, 1500W and 2000W. During the use of propane was observed CO and HC emissions decrease under different load. The flow of propane was regulated so as until the load of 2000W the behavior of the engine from the aspect of efficiency to be the same with that of gasoline. This means that when gasoline was used and also when propane was used the engine rpm were the same for every electrical load. During the tests, the consumption of gasoline and propane was recorded and it was observed that it increased when the electrical load was increased. The gas propane consumption that was recorded was that which gives the same behavior of the engine from the aspect of power that the manufacturer gives for the use of gasoline.

Key-Words: - Gas emissions, Propane, Biofuels, Fuel consumption

1 Introduction

One of the major problems that face the humanity in nowadays is the pollution of the atmosphere. Moreover, the air pollution can cause many serious problems in the human health such as emphysema and asthma. Apart from the major problems in the human life, the atmospheric pollution causes damages to the plants, to the exterior surfaces of the buildings, to the paint of the cars and also to the marble monuments too [1,2,3]. The pollution of the atmosphere doesn't recognize country borders and it leads to many global problems such as the greenhouse effect and the protective ozone layer depletion in the stratosphere [2].

One of the major sources that cause air pollution in urban areas is road traffic. The main pollutants from car emissions are carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter. When carbon monoxide is present in the lungs, displaces oxygen from hemoglobin and reduces the amount of oxygen that can be delivered to the tissues [2]. Unburned hydrocarbons that are produced from incomplete combustion of the fuel can cause cancer to humans and they also have the role of precursors of photochemical ozone. The pollutants nitrogen oxides are nitrogen oxide (NO) and nitrogen dioxide (NO2). Exposure to oxides of nitrogen includes human respiratory problems and damages to plants. Nitrogen dioxide takes part in photochemical smog reactions and when is oxidized to nitric acid contributes to acid rain formation [3].

A number of parameters, such as the fuel and air mixing, the temperature of combustion, the time available for combustion in the engine, effect the vehicle exhaust emissions [3,4,5,6]. The fuel that is used to power the engine is a factor that also influences emissions. When alternative fuels are used instead of the usual petroleum-based fuels, the vehicular emissions are reduced [4].

Propane (C_3H_8) is one of the alternative fuels that can be used. It is in a gaseous state and can be easily liquefied. It doesn't have color or odor, and it has simple hydrocarbon structure and low reactivity. It can be produced by the process of separation from crude oil and from natural gas or by refining petroleum [5,6,7,8,9]. Although in atmospheric pressure propane is a gas, when it is used in internal combustion engines is in a liquid form and it is stored in cylinders and tanks.

Propane is friendlier to the environment compared to gasoline because it produces lower gas emissions [6,10,11,12]. Also it doesn't contain lead and has low sulphur content, which means that it doesn't contribute to acid rain formation. Furthermore, when propane is used in vehicles the emissions at cold-start are similar to those when the engine is worm, contrary to the high cold-start emissions from the use of gasoline. Because propane is in a gaseous state it mixes better with air which allows nearly

complete combustion [6,13,14,15]. At refueling points, the amount of propane that escape to the atmosphere is small and the vapors have low reactivity compared to gasoline, which means that they have lower ozone forming tendency[16,17,18]. Propane doesn't escape to the atmosphere because the fuel system of propane is effectively sealed. Generally propane is an economical and environmental friendly fuel.
The question that arises is how the gas propane behaves in a four-stroke engine from the aspect of emissions, function and fuel consumption.

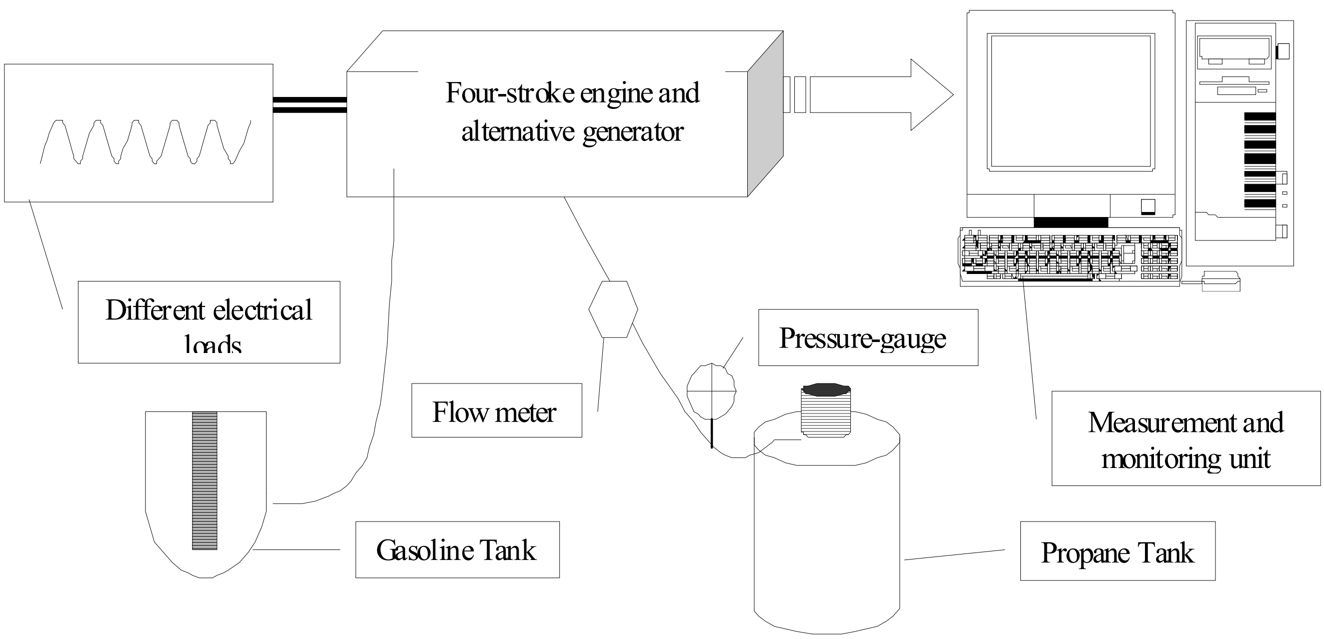
2 Instrumentation and Experimental results

The experimental measurements were carried out on a four-stroke, air-cooled engine. This is a one-cylinder engine with 162cm3 displacement that is connected with a phase single alternative generator (230V/50Hz) with maximum electrical load approximately 3,5KVA(picture 1). The engine according to the manufacturer uses as fuel gasoline. The engine functioned without load and under different loads 500W, 1000W, 1500W and 2000W, using different fuels: gasoline and gas propane.

During the tests, exhaust gases measurements, were also monitored for every fuel and for every load conditions. Also, during the function of the engine the consumption was recorded for every fuel. There was lack of engine regulation concerning the stable air/fuel ratio. For this purpose, the ADVANTECH PCI-1710HG Data Acquisition cart was used with the terminal wiring board PCLD-8710 with on-board Cold Junction The data acquisition card was installed at PC. This particular measuring system and software completed a scanning cycle per channel every 0.1 second approximately. This measuring speed was considered adequate for the purpose of the experiment and the sampling capabilities of the chemical sensors. For the exhaust gas measurements a HORIBA MEXA-574GE analyzer was used. This unit has the following ranges:

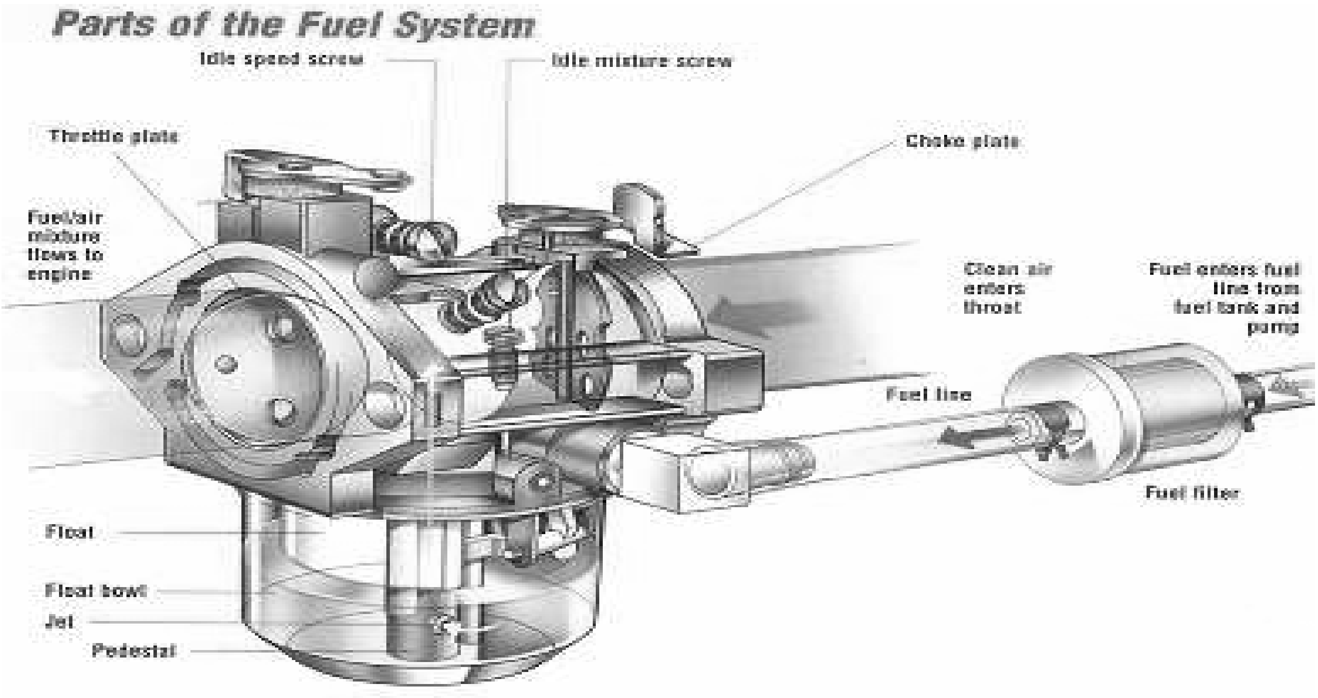
CO: 0-10% Volume
HC: 0-10000 ppm.

The operating principle of this unit for the CO, HC measurements is the Infrared Non Dispersive Spectrometry. The time response for the CO, HC measurements is <=10 s. This unit is adequate for the steady state operation measurements required. The unit has a ± 2% accuracy and a ± 2% repeatability.

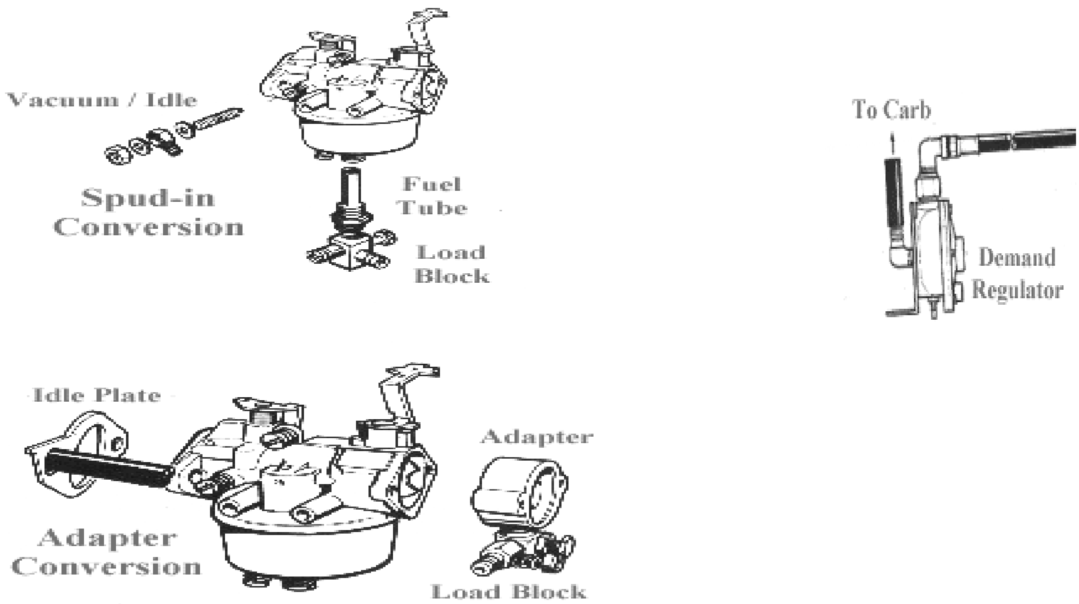


Picture 1. The illustration of the experimental unit.

For the function with gas the fuel alimentation system of the engine, that is the carburetor(picture 2), had some alterations that are presented in picture 3:



Picture 2. The existing fuel alimentation system of the four-stroke engine [6]



Picture 3. Alterations of the fuel alimentation system [6]

It must be mentioned that the regulation of the engine for the use of gasoline was the original, while for the use of propane the quantity of propane was regulated in order not to have power decrease of the engine with load conditions. The power decrease is shown though the rpm decrease.

Therefore, the regulation was made in order to maintain the engine rpm stable at 2000W load, as in the case of gasoline use. During the tests the pressure inside the propane tank was 6,5-7bar. The engine rpm for the use of gasoline and propane for the cases without electrical load, for 500W, 1000W, 1500W and 2000W are represented in the figure below:

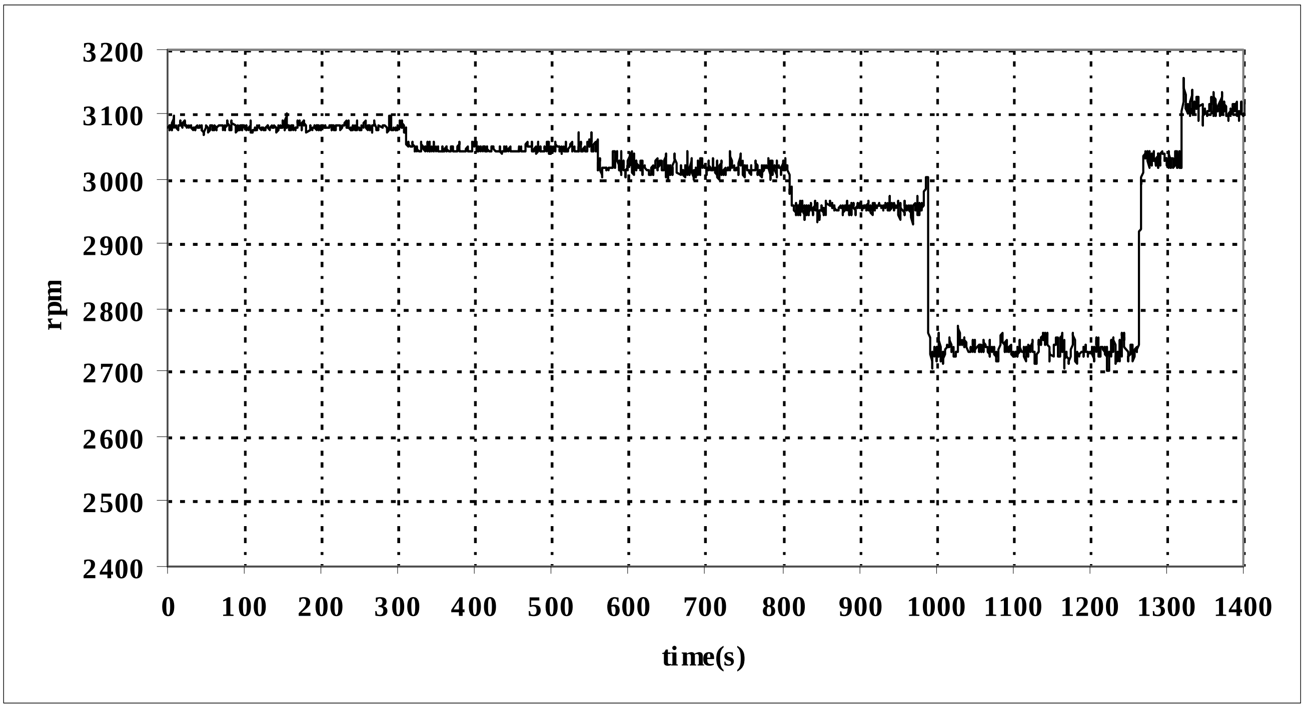


Figure 1. The rpm variation when used different fuels: gasoline, gas propane

Figure 1 presents the engine rpm variation with gasoline or propane in relation to the electrical load. The time period of 0-300s approximately refers to the function of the engine with gasoline or propane without load. The time period of 300-550s approximately refers to the function of the engine at 500W load. The time period of 550-800s approximately refers to the function of the engine at 1000W load. The time period of 800-1000s approximately refers to the function of the engine at 1500W load. From 1000s until 1250s the engine functions at 2000W electrical load. From 1250s until 1350s the engine functions at 1000W electrical load. Finally, from 1350s until 1400s approximately the engine functions at idle speed. In figure 1 is observed rpm decrease when load increases. This decrease is normal and is among the determined limits of normal function of the engine-generator. The average values of the engine rpm in relation to electrical load are presented in figure 2:

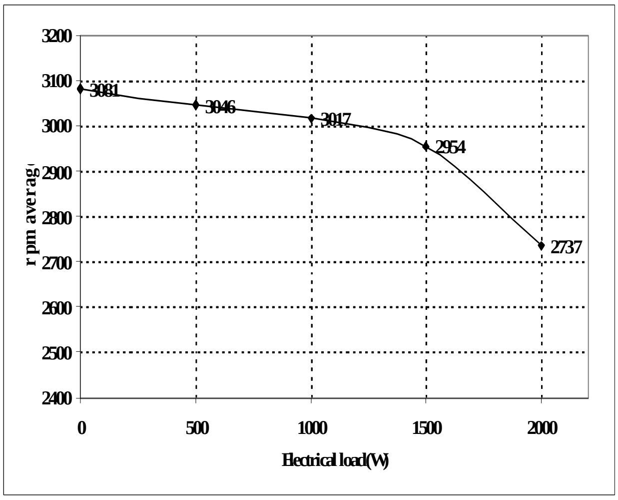


Figure 2. The test rpm average value variation when used different fuels: gasoline, gas propane

The CO and HC emissions using as fuel gasoline and then propane, for every load, are represented in the figures below:

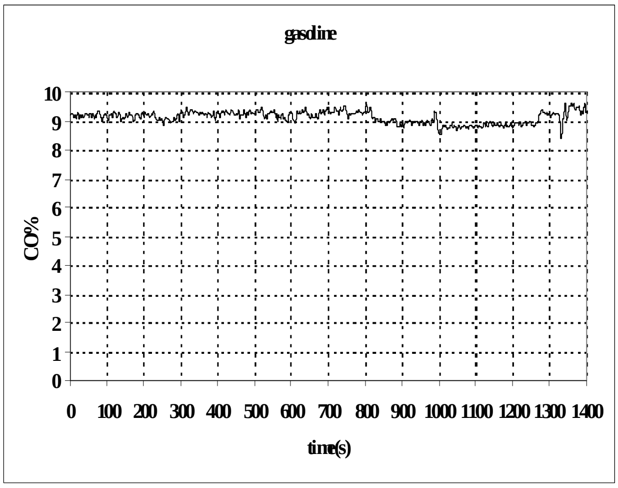


Figure 3. The CO variation about the gasoline fuel during the tests

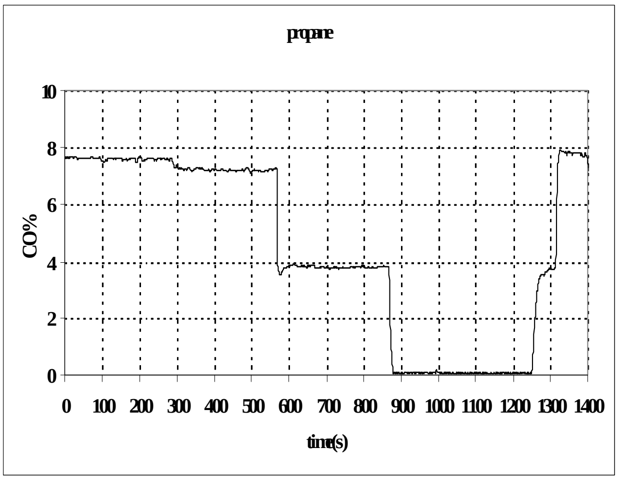


Figure 4. The CO variation about the propane fuel during the tests.

Figures 3 and 4 refer to the variation of CO emissions during the test for every electrical load and for every fuel separately (gasoline, propane). The average value of CO emissions is presented in figure 5 below:

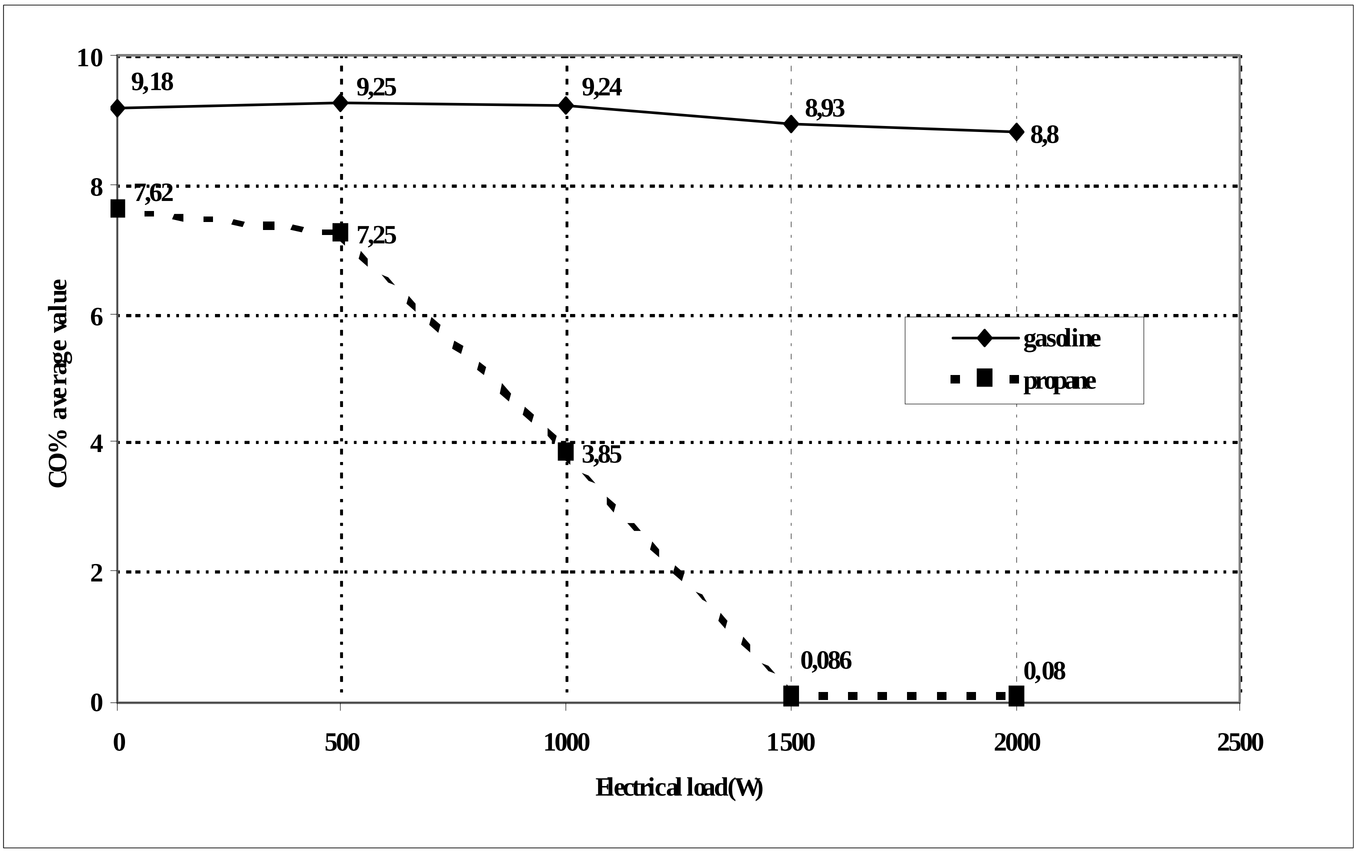


Figure 5. The CO average value variation about the gasoline and propane fuels in relation to electrical load.

In figures 5,6 is observed significant decrease of CO emissions during the use of propane as fuel in every load conditions tested. As for hydrocarbons their variation is shown in figures 7 and 8:

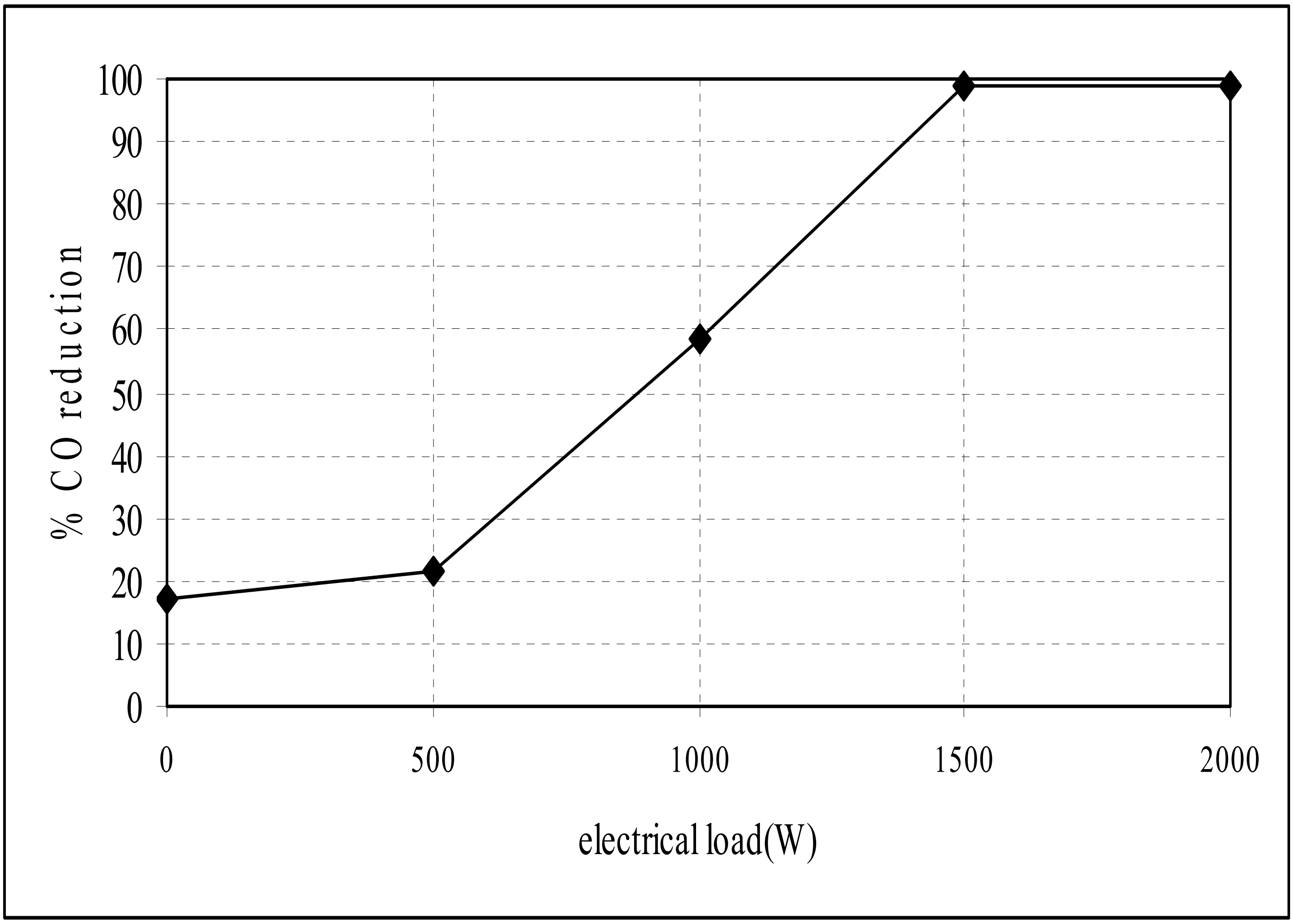


Figure 6. The % CO reduction in relation of electrical load

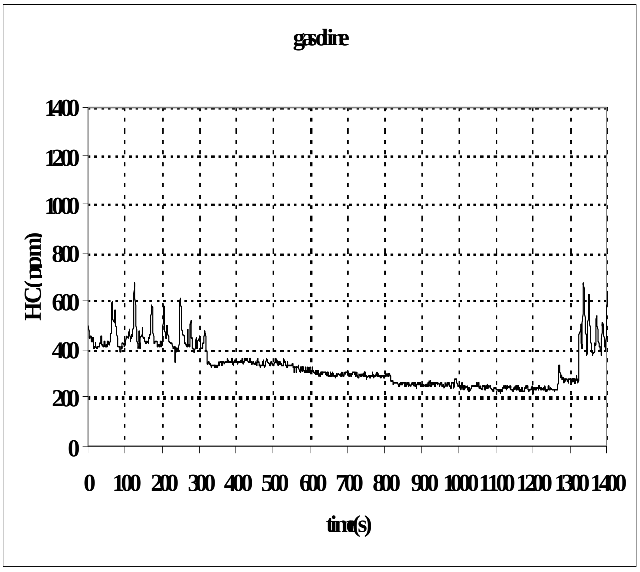


Figure 7. The HC variation about the gasoline fuel during the tests.

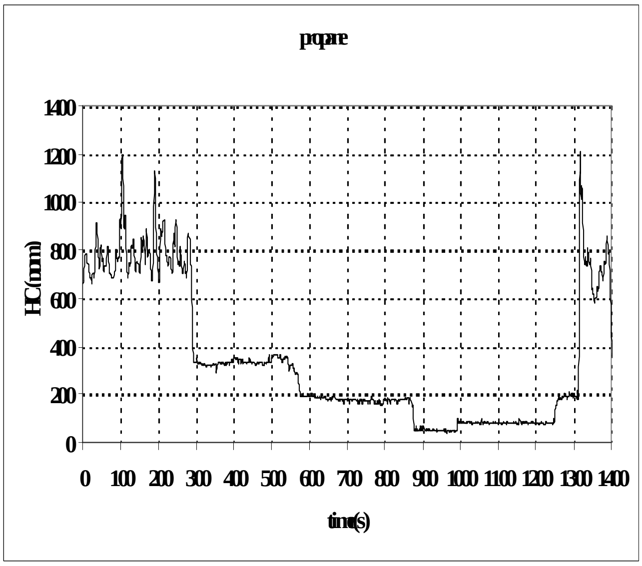


Figure 8. The HC variation about the propane fuel during the tests

In figures 7, 8and 9 is observed HC emissions decrease during the use of propane in every electrical load. There is an exception where, during the function of the engine without load, the value of HC emissions is higher than that of gasoline. This happens because the regulation of gas propane flow was based in 2000W load conditions. This means that the gas flow at 2000W load was that in order not to have engine power decrease, which is shown through the rpm decrease.

The behavior of the engine from the aspect of rpm was the same for the use of gasoline and for the use of propane. This has as result the gas propane flow increase at without load condition, which is the main reason of HC emissions increase during the use of propane. The variation of HC emissions is represented clearly in the figure below that refers to the average values of HC:

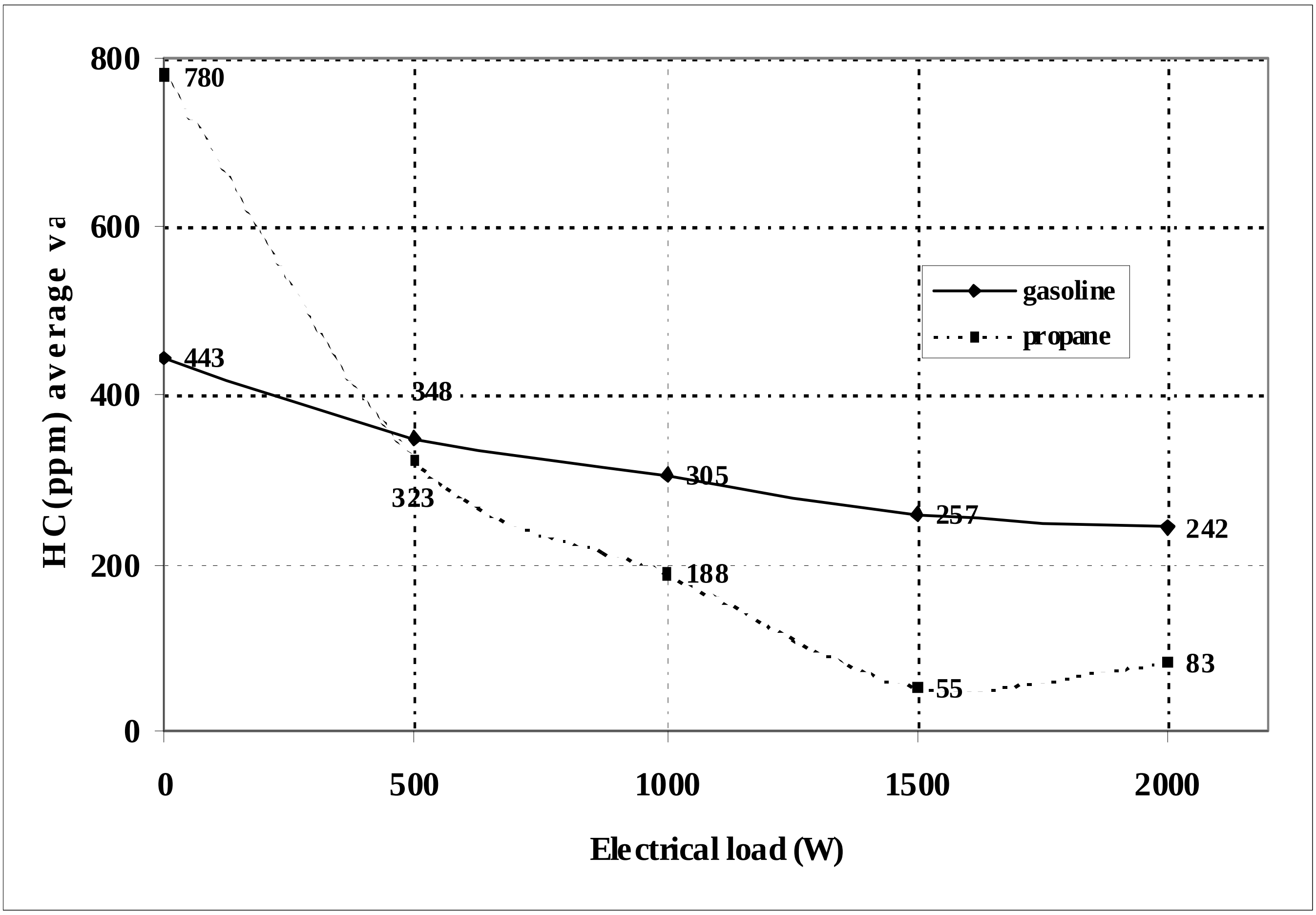


Figure 8. The HC average value variation.

In figure 8 the HC decrease is obvious at load conditions when propane is used as fuel, due to better combustion.

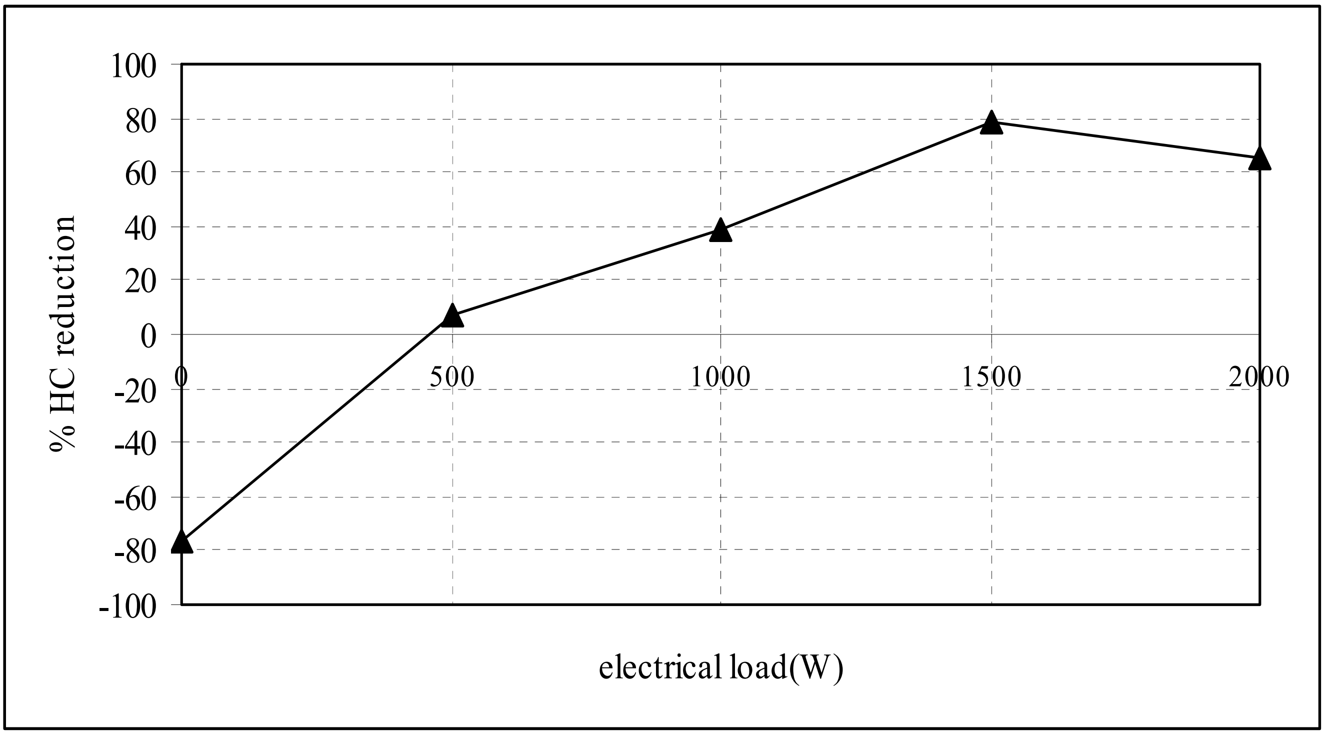


Figure 9. The % HC reduction in relation of electrical load

From the aspect of consumption the results are presented in the figure 10 below:

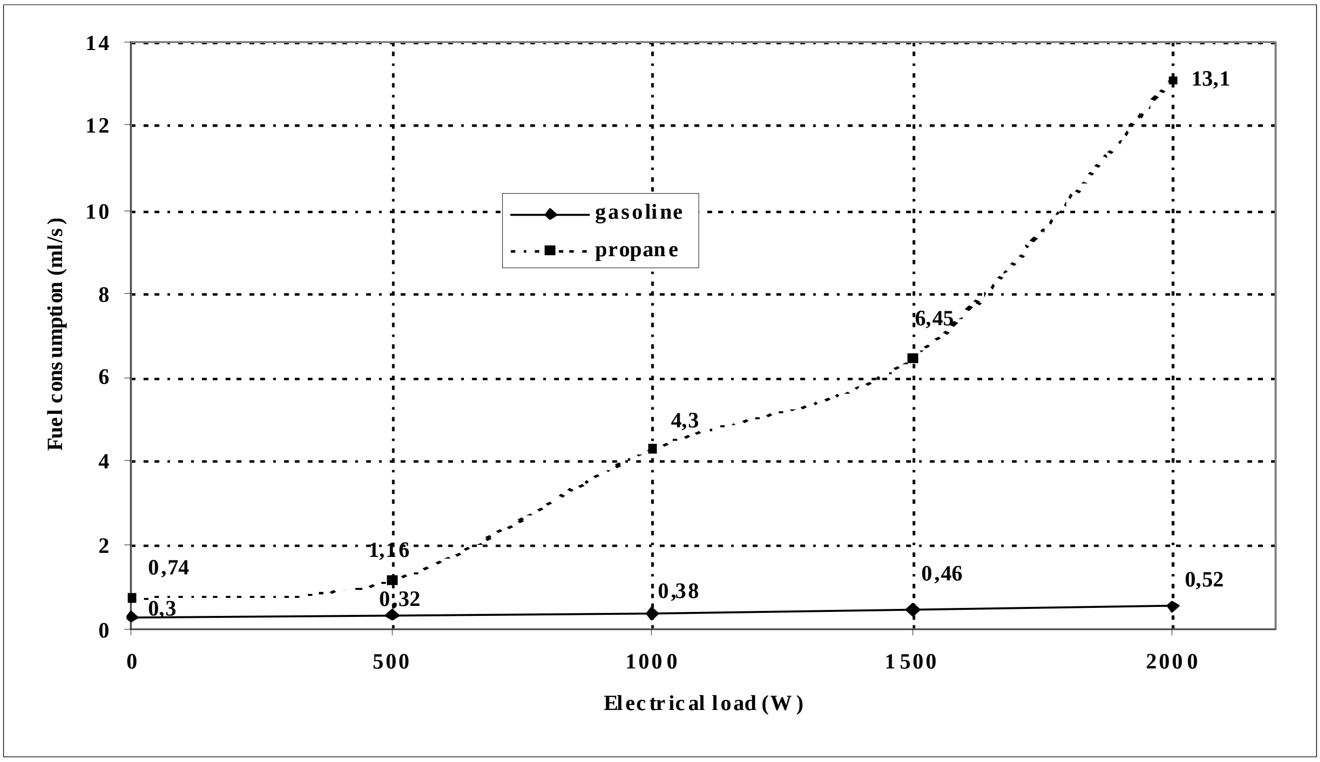


Figure 10. The fuel consumption

The figure 10 above shows the consumption of the two fuels used in relation to different load conditions. The consumption increases in both cases of gasoline and propane usage when the electrical load of the generator increases. It is important the fact of small consumption in the case of gas propane, always in relation to its cost. Also it must be mentioned that this consumption of propane (after the regulation) is that so as the engine power until the 2000W load is the same with that which corresponds to gasoline as fuel without any decrease of engine rpm.

3 Conclusion

From the observations above is appeared that gas propane results in an emissions (CO and HC) decrease when the engine functions under different load conditions. The gas propane flow was regulated in order the engine behavior from the efficiency aspect, until the 2000W load, is the same with that of gasoline. This means that during the use of gasoline and during the use of propane the engine rpm for every electrical load conditions were the same. From the aspect of consumption, there was a consumption increase when the electrical load increases in both cases of gasoline and propane use. Finally, it is important the fact that gas propane is a fuel, which presents emissions decrease and it has lower cost compared to gasoline.

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