The variation of gas emissions in an Otto engine by using different gases as fuel

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Abstract: - Biofuels are fuels made from recently living organisms. They can be divided into three categories: 1) First-generation biofuels which are made largely from edible sugars and starches. 2) Second-generation biofuels, which are made from nonedible plant materials and 3) Third-generation biofuels, which are made from algae and other microbes. Biofuels are renewable, meaning their sources can be regrown. Advanced biofuels can offer environmental benefits such as lower carbon emissions and lower sulfur compared with conventional petroleum based fuels. The present paper examines the use of fuel gases (propane, 80%butane-20%propane, natural gas) in a small four-stroke engine of internal combustion, which it is used for the movement of a small alternative generator. The electrical generator functioned without load and under different loads (500, 1000, 1500 and 2000 W), using as fuels gasoline and fuel gases. During the tests, it has been observed the CO and HC emissions for every fuel and load condition. The use of natural gas as fuel has as a result the CO and HC emissions decrease under different load. The flow of fuel gases was regulated so that 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 the engine rpm was the same for every electrical load in both fuels gasoline and fuel gases. During the tests, the consumption of gasoline and fuel gases was recorded and it has been noticed that they were increased when the electrical load was increased too. As far as the consumption of fuel gases is concerned, it has been noticed that it gives the same engine behavior from the aspect of power and engine rpm that the manufacturer gives for the use of gasoline.

Key-Words: Gas emissions, propane, 80%butane-20%propane, natural gas

I. INTRODUCTION

Air pollution is made up of many kind of gases, droplets and particles that reduce the quality of the air. These substances have many consequences for the health of human being, plants and property. Damage to the ozone layer, the effects of greenhouse gases, the effect of ultraviolet light and increases in temperature are some of the results of air pollution. Large amounts of carbon dioxide and harmful molecules are released into the atmosphere, which affects ecosystems, plant life and wildlife. Pollutants can harm animals either directly or combine with other factors that change animals' water supplies through acid rain. Additionally, air pollution affects plant life, which in turn affects animals. Plants and insects are a food source for animals, so damage to either can harm wildlife. Besides plant life and wildlife, air pollution has major affects in human health as well. People can react very differently to air pollution. Some people may notice chest tightness or cough, while others may not notice any effects. People who have heart disease, such as angina or lung disease such as asthma or emphysema, may be very sensitive to air pollution exposure and may notice symptoms when others do not. Children also experience more illness, such as bronchitis and earaches in areas of high pollution than in areas with cleaner air. Moreover, human health can be affected from air pollution in many ways with both short term and long term effects. Examples of short term effects include irritation to the eyes, nose and throat and upper respiratory infections such as bronchitis and pneumonia[1]. Other symptoms can include headaches, nausea and allergic reactions. Long-term health effects can include chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys. Air pollution can also damage materials, the exterior surfaces of buildings, the paint of the cars and also the marble monuments [1]. 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 (NO_x) 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 (NO_2). Exposure to oxides of nitrogen includes human respiratory problems and damages to plants. Nitrogen dioxide takes part in photochemical smog reactions and when oxidized to nitric acid is 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]. 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].

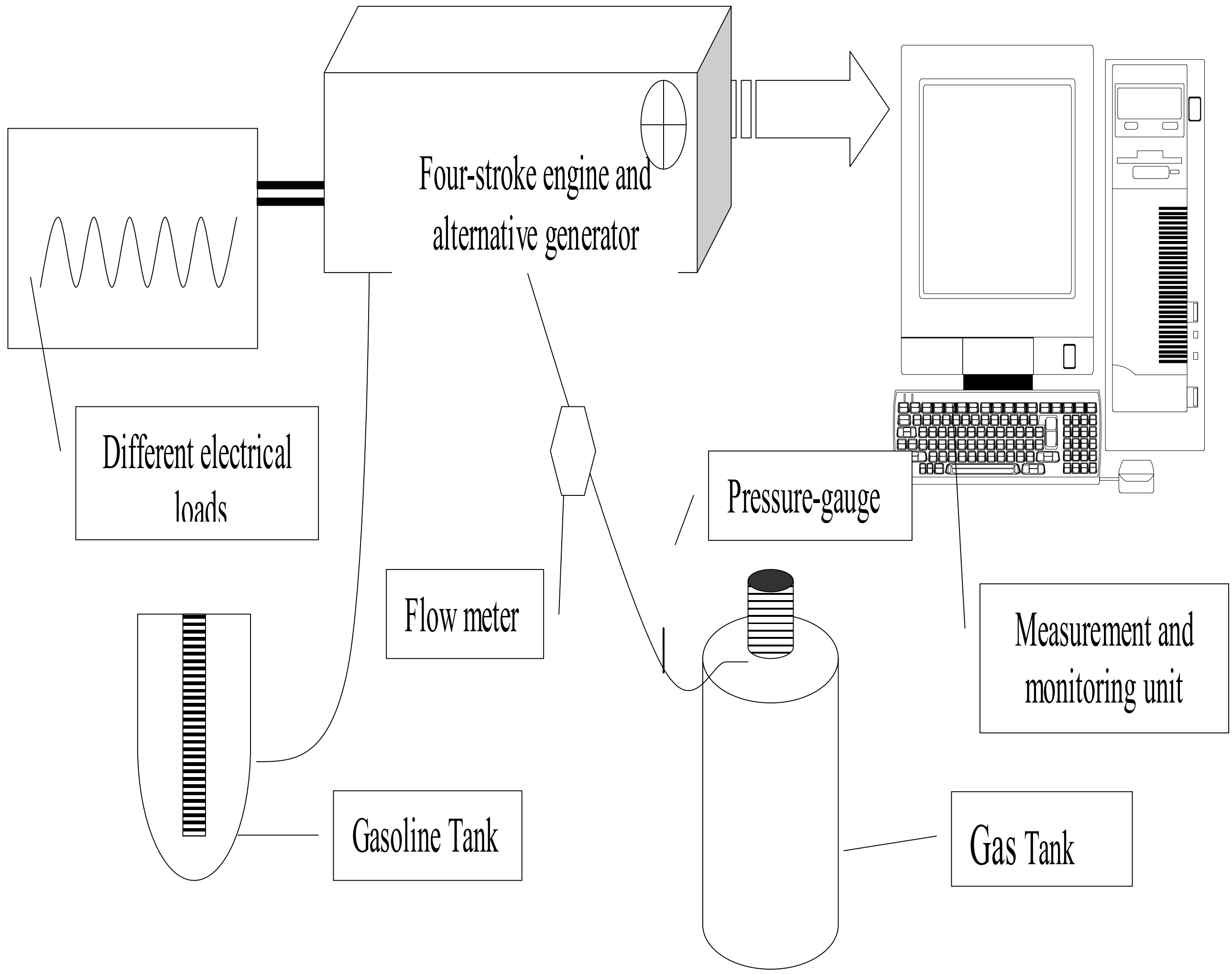
Propane and butane as blend is an alternative to gasoline and diesel and can be used in internal combustion engines as fuel. Propane-butane is a mixture of liquefied hydrocarbons and in liquid state is a colorless liquid that is volatilized easily. This liquefied gas can be derived during crude oil processing and the further processing of intermediate refinery products during petrol reforming, vacuum oil cracking, hydro cracking, soft asphalt desulfurization and pyrolisis of petrol and natural gas [5]. This mixture is stored and transported in pressurized tanks in liquid form but is used in its gaseous state. The use of propane-butane mixture has many advantages. Both propane and butane are alkenes with simple hydrocarbon structure and they are relatively uncreative, which means that are safe for use. The fact that they can be stored in pressure tanks means that they are portable and can be transported and stored where natural gas grid does not exist. Because propane and butane are gases that when they enter into the engine, they achieve better mix with air in the engine, which allows almost complete combustion. This also minimizes problems with starting the engine in cold weather. When the mixture of propane and butane is use as an alternative to gasoline, produces cleaner exhaust fumes [3,5]. Besides that, the amount of propane and butane 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. Generally the mixture of propane and butane has good combustible properties, high-energy value and perfect ecological and economical properties.

One of the alternative fuels that can be used is natural gas. Natural gas is a mixture of hydrocarbon and non-hydrocarbon gases which occurs naturally and is found in porous geological formations that are called reservoirs, beneath the earth's surface. The chemical composition and the Btu content of natural gas varies with the reservoir source, processing / conditioning steps and the kind of pipeline used. Processed natural gas is primarily a mixture of paraffinic hydrocarbons with the following median composition: methane (93%), ethane (3,1%), propane (0,5%), isobutane (0,06), n-butane (0,05), isopentanes (0.02), n-pentane (0,02), hexanes (+ 0,04), along with N_2 (1,2%), and CO_2 (0,6%). Odorants (tert-butyl Mercaptan) are added for safety purposes. Low levels of H_2O vapor, H_2 CO, He, O_2 and C_6-C_{14} hydrocarbons are normally considered "negligible" constituents of most processed natural gas streams. In order to increase Btu content of processed natural gas it can be blended with reformed gas on a seasonal basis. Besides the use of natural gas as fuel, natural gas is a feedstock (hydrogen source) for ammonia production and a source of light hydrocarbons (ethane, propane, butane) for chemical synthesis or LG products. [5, 6]. Although in atmospheric natural gas is a gas, when it is used in internal combustion engines is in a liquid form and it is stored in cylinders and tanks.

The question that is examined in this paper is how the fuel gases(propane, 80%butane-20%propane, natural gas) behaves in a four-stroke engine from the aspect of emissions, function and fuel consumption.

II. INSTRUMENTATION AND EXPERIMENTAL RESULTS

The experimental measurements were carried out on a four-stroke, air-cooled engine. This is a one-cylinder engine with 162cm^3 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 gasoline as a fuel. The engine functioned without load and under different loads 500W, 1000W, 1500W and 2000W, using as fuels gasoline and natural gas. 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 a Pentium II PC at 266Mhz. 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

It must be mentioned that the regulation of the engine for the use of gasoline was the original, while for the use of natural gas was regulated in the quantity of gases in order not to have power decrease of the engine with load conditions. The power decrease is shown through 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. The engine rpm for the use of gasoline and gases for the cases without electrical load, for 500W, 1000W, 1500W and 2000W are represented in the figure below:

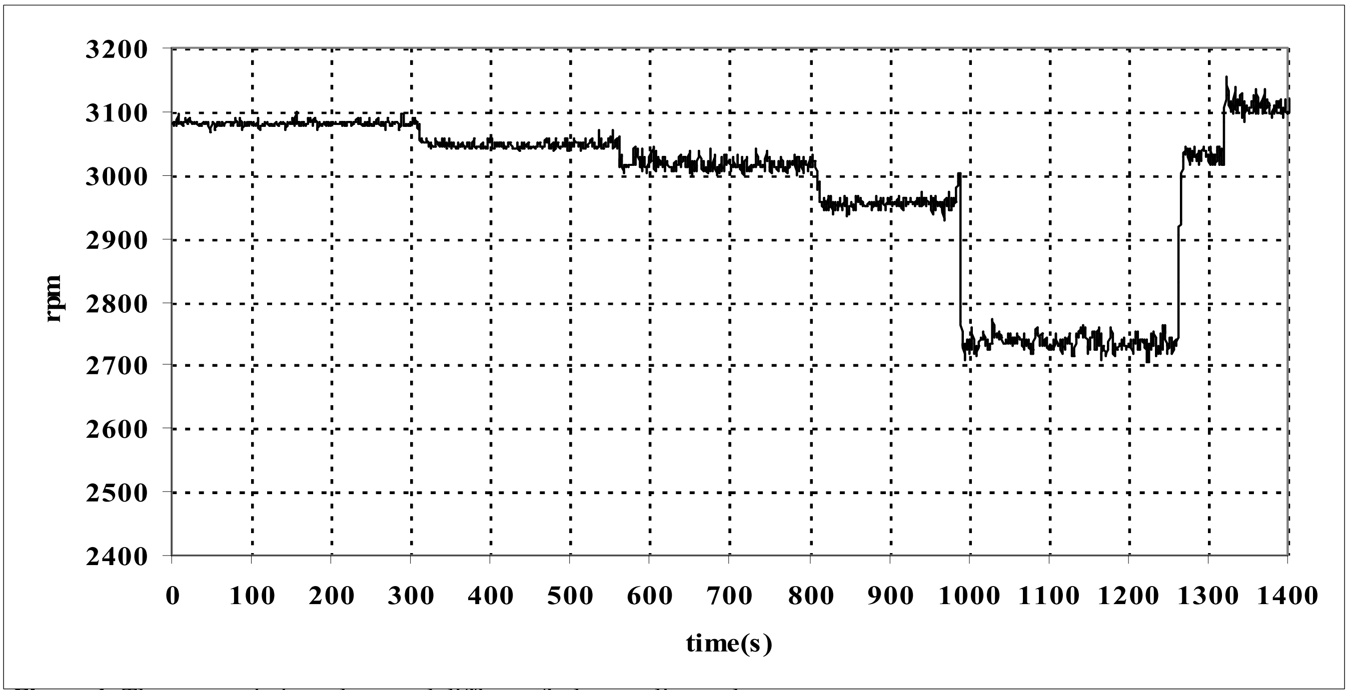


Figure 1. The rpm variation when used different fuels: gasoline and gases.

Figure 1 presents the engine rpm variation with gasoline or gases in relation to the electrical load. The time period of 0-300s approximately refers to the function of the engine with gasoline or natural gas 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. Figure 1 presents the 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:

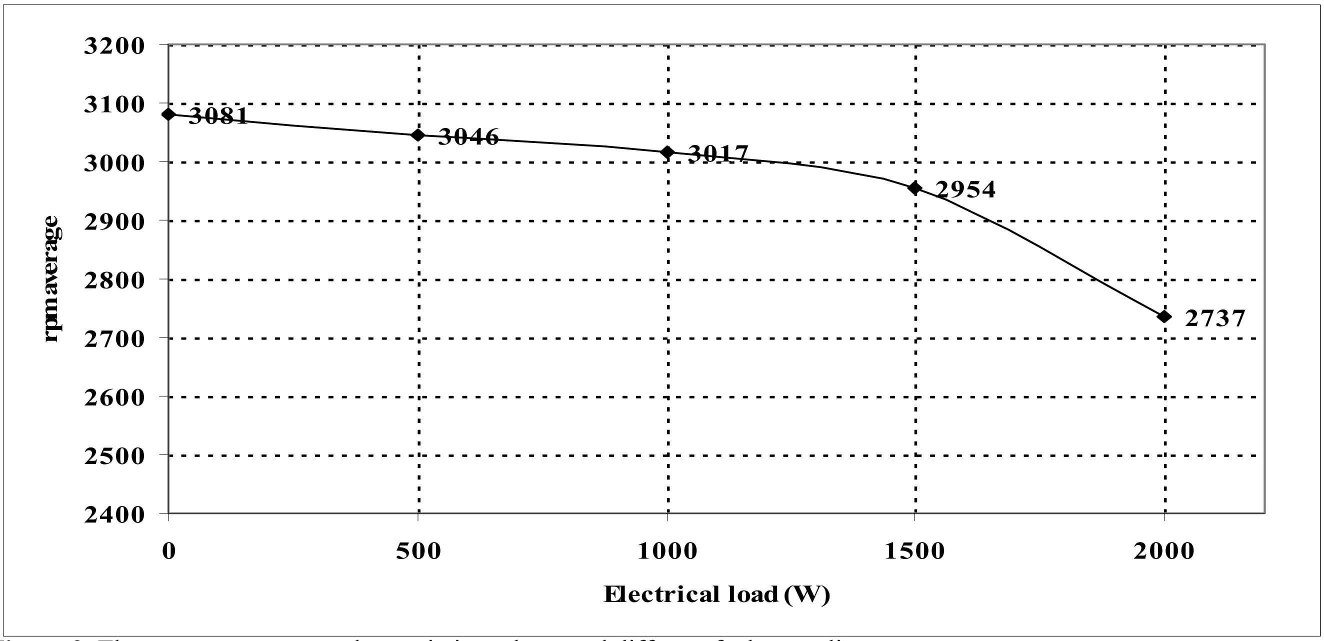


Figure 2. The test rpm average value variation when used different fuels: gasoline, gases.

The following figure presents the CO and HC emissions when is used as a fuel the gasoline and the gases for every load.

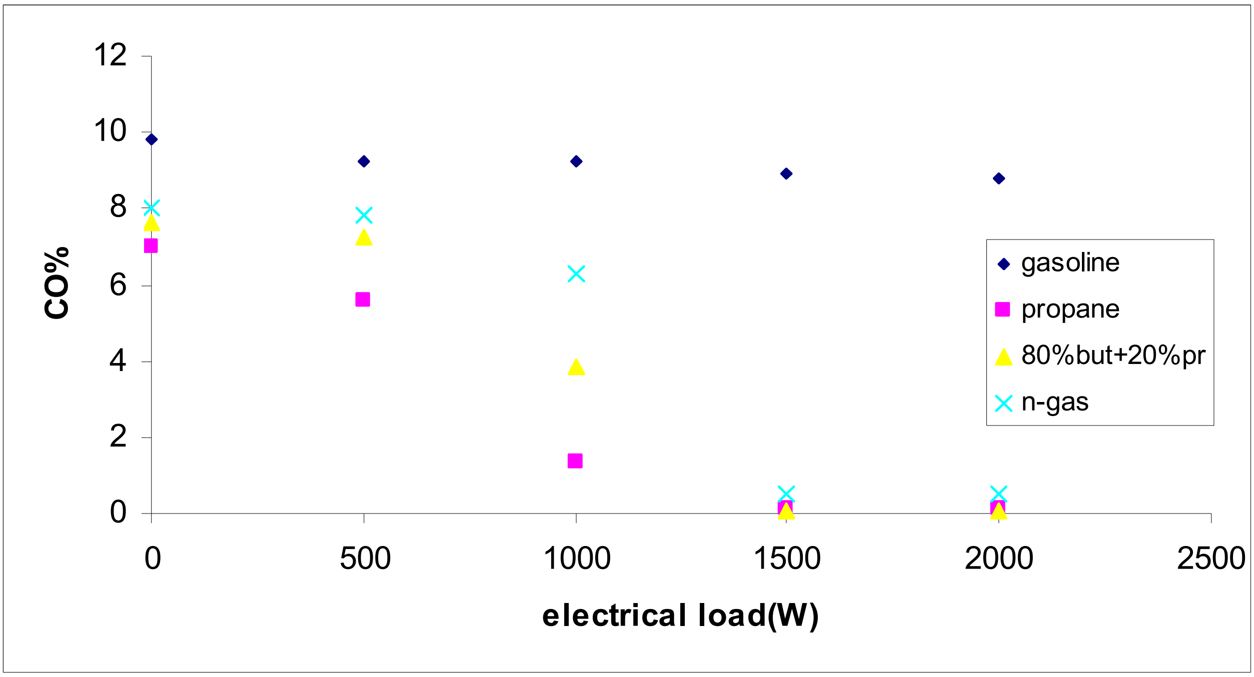


Figure 3. The CO average value about gasoline and gases during the tests

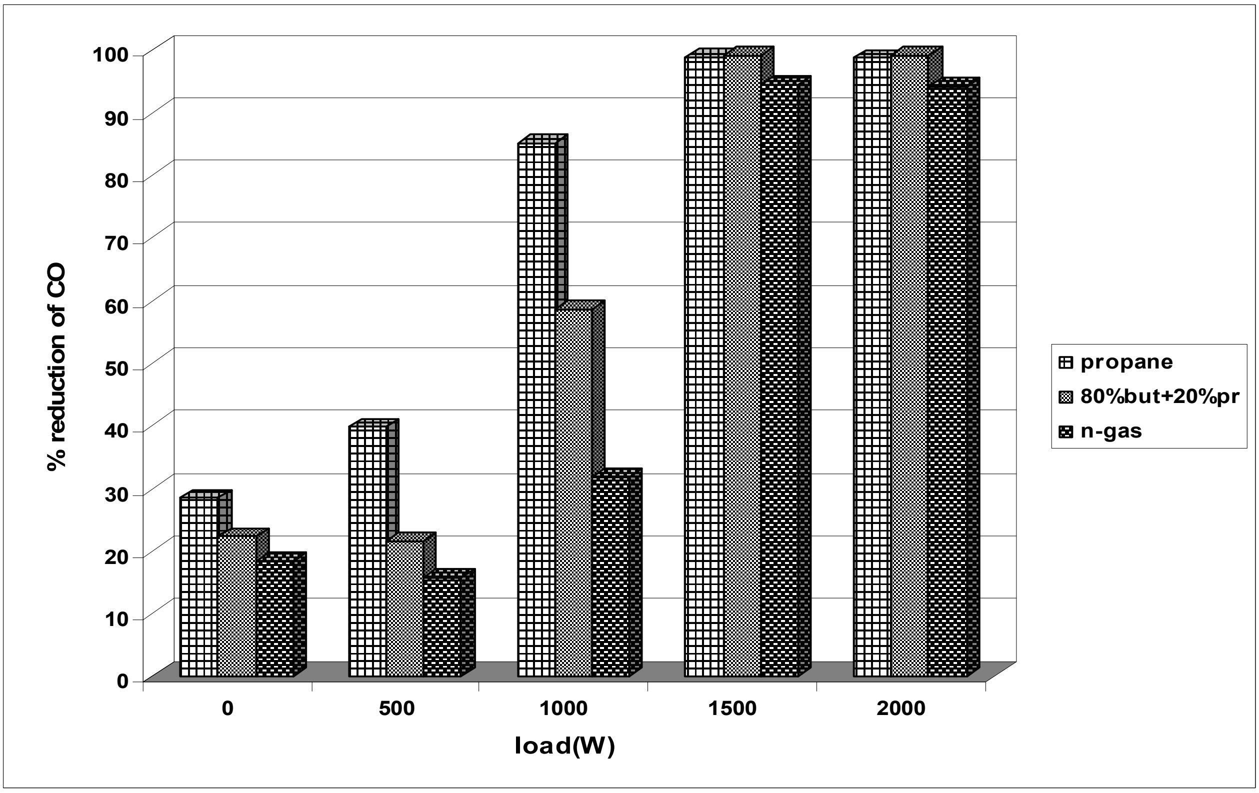


Figure 4. The % reduction of CO average value of gases fuels compared to gasoline

Figures 3 and 4 refer to the variation of CO emissions during the test for every electrical load and for every fuel separately (gasoline, gases). In this figure is observed significant highest decrease of CO emissions during the use of propane gas as fuel in every load conditions tested. As for hydrocarbons their variation is shown in figures 5,6:

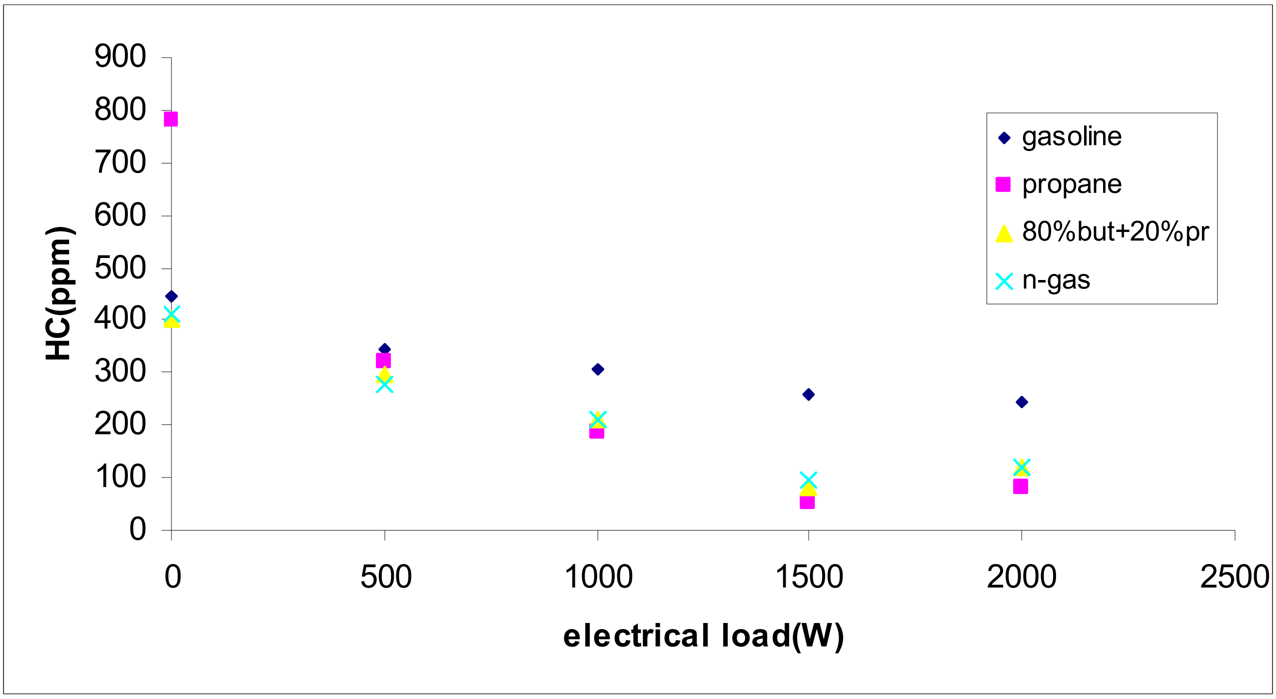


Figure 5. The HC average value about the gasoline and gases during the tests

It can be seen from figure 5 that HC emissions decrease when propane gas is used as a fuel for 1000-1500-2000W electrical load. The behavior of the engine from the aspect of rpm was the same for the use of gasoline and for the use of gases.

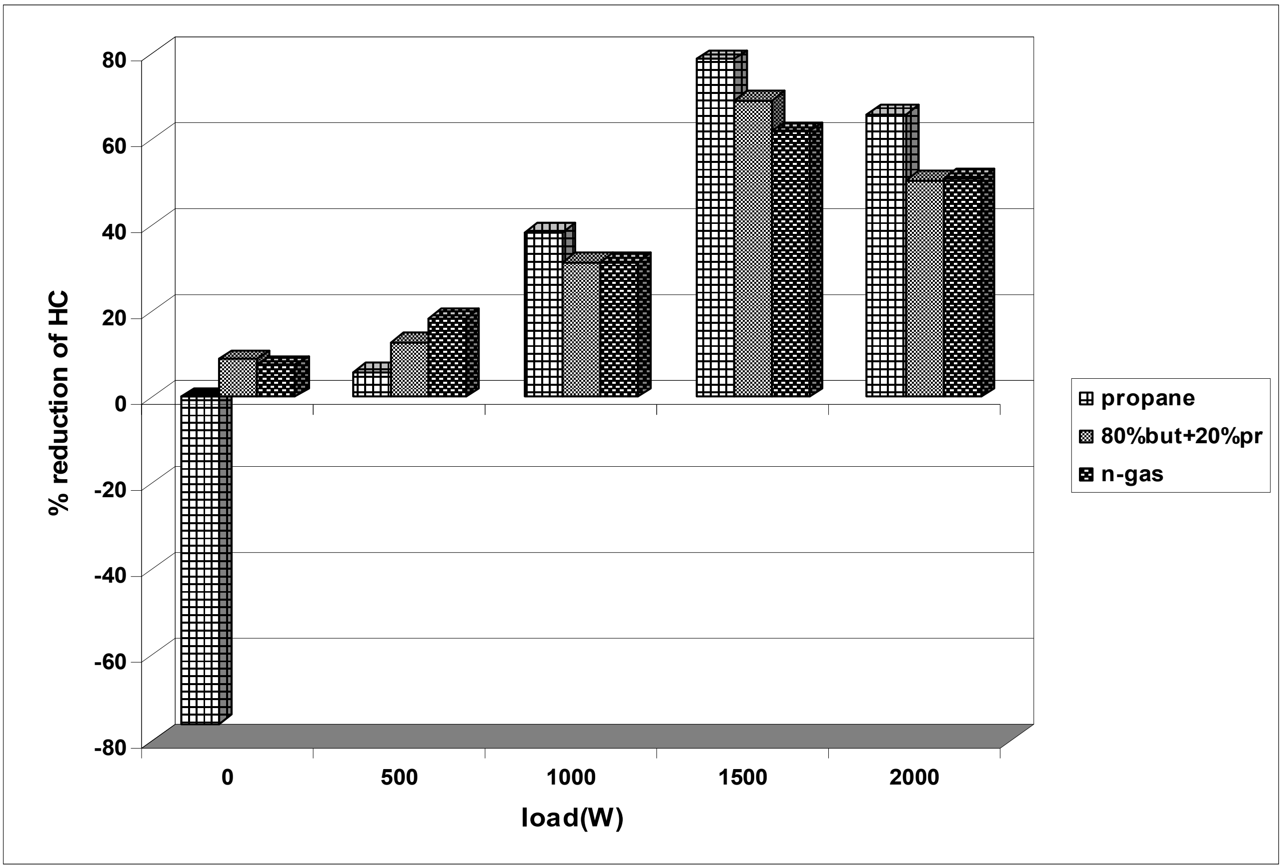


Figure 6. The % reduction of HC average value of gases fuels compared to gasoline.

From Figure 6, it can be noticed that the biggest decrease occurs in the mixture of 80% but+20%pr when the load is 1500W.

As far as the consumption is concerned, the results are presented in the following figure:

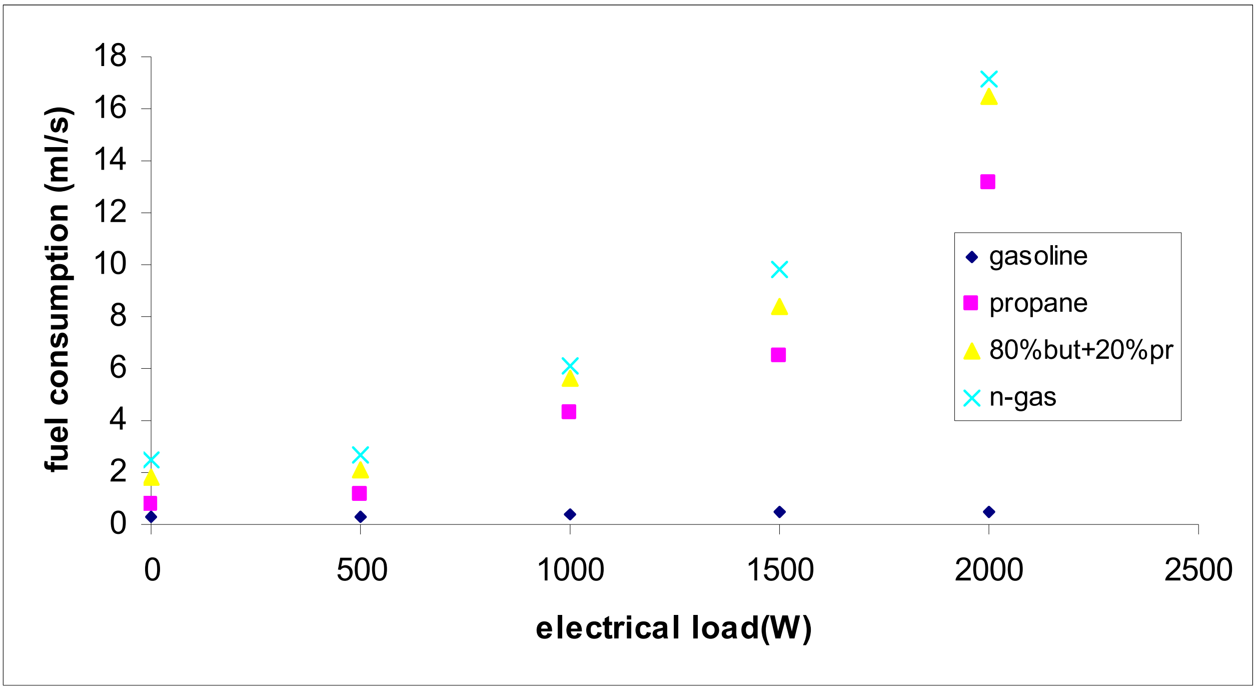


Figure 7. The fuel consumption

Figure 7 appears the consumption of the fuels used in relation to different load conditions. It can be noticed that the consumption increases in both cases of gasoline and gases usage when the electrical load of the generator increases. It is important the fact of small consumption in the case of propane gas, always in relation to its cost. Also it must be mentioned that the measurements of gases consumption was made after being regulated the engine power until 2000W load, in order to be the same with the one that corresponds to gasoline as fuel, without any decrease of engine rpm[7,8].

III.CONCLUSION

Alternative fuels produce less pollution than gasoline or diesel. The transportation fuels that are made from biomass through biochemical on thermo chemical processes are known as biofuels. The use of biofuels doesn't contribute to global warming, as the carbon dioxide they release when burnt is equal to the amount that the plants absorbed out of the atmosphere. It is a renewable source of energy and emits less particulate pollution than other fuels, especially diesel[9,10,11].

By taken into consideration all the above figures, it can be concluded that gases results in an (CO and HC) emissions decrease when the engine functions under different load conditions. The gases flow was regulated so that 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 gases the engine rpm for every electrical load conditions were the same[12]. From the aspect of consumption, there was a consumption increase when the electrical load increases in both cases of gasoline and gases use. Finally, from all gases fuels, the one that presented the lowest CO and HC emissions was gas propane. It was also the one that presented the lowest consumption too.

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