Methanol blends as motor fuels

CHARALAMPOS I. ARAPATSAKOS, ANASTASIOS N. KARKANIS, PANAGIOTIS D. SPARIS
Department of Production and Management Engineering
Democritus University of Thrace
V. Sofias Street, 67100, Xanthi
GREECE
xarapat@agro.duth.gr

Abstract: - In this paper will be examined the use of gasoline-methanol mixtures in a four-stroke engine, which is used for the move of an alternative generator. In the tests the gas emissions and the fuel consumption, where examined at idle and under full load(1KW) conditions. Specifically, the mixtures: gasoline, gasoline-10%methanol 20%methanol, gasoline-30%methanol, gasoline-40%methanol, gasoline-50%methanol, gasoline-60%methanol, and gasoline-70%methanol where tested, without any regulation of the engine relatively to the air/fuel ratio, maintaining the original adjustment that concerned gasoline was maintained. An important reduction of emissions was noted while the percentage of the methanol was increased. During the tests the fuel consumption was recorded for every mixture separately and for every load condition. It was observed a small increase of consumption when the percentage of methanol in the fuel was increased.

Key-Words: - Gas emissions, Methanol, Biofuels

1 Introduction

One of the most important problems that face the humanity in nowadays is the environmental problem and specifically the atmospheric pollution that leads to greenhouse effect, ozone formation and to many health problems to human beings. Automobile's exhaust emission is one of the many sources that lead to atmospheric pollution. Also the petroleum-based products that have been used as fuels produce dangerous gas emissions as well. By taking into consideration firstly the need of a clean atmosphere and secondly the fact that many countries around the world face the problem of energy shortage, the use of renewable fuels are necessary. Many scientists and many governments turned their attention to renewable fuels as alternatives to conventional fossil fuels and as oxygenates[1], in order to decrease the environmental impacts. Methanol is one of the alternative fuels. Moreover methanol (CH_3OH) is an alcohol that is produced from natural gas, biomass, coal and also municipal solid wastes and sewage. It is quite corrosive and poisonous and has lower volatility compared to gasoline, which means that is not instantly flammable. Usually methanol is used as a gasoline-blending compound, but it can be used directly as an automobile fuel with some modifications of the automobile engine.

Although there are many feed stocks that are being used for the production of methanol, natural gas is more economic. Methanol is produced from natural gas with a technology of steam reforming. By this method natural gas is transformed to a synthesis gas that is fed to a reactor vessel to produce methanol and water at the presence of a catalyst. The reactions that represent methanol production are the following[2,3]:

$$2CH_4 + 3H_2O \rightarrow CO + CO_2 + 7H_2 \text{ (Synthesis gas)}$$

$$CO + CO_2 + 7H_2 \rightarrow 2CH_3OH + 2H_2 + H_2O$$

The use of methanol as fuel has many advantages. Concretely the main advantage is that methanol is being produced from materials such as natural gas or biomass, which are renewable and can be found globally. In contrast, a large percentage of petroleum is located in Middle East. This means that methanol can also be cheaper and more economically attractive than gasoline. When fossil fuels are used in automobiles, produce exhaust emissions of hydrocarbons, carbon dioxide and other gases that contribute to the greenhouse effect. Methanol can give lower HC and CO emissions and besides that the vehicles that use methanol emit minimum particulate matter compared to gasoline, which usually has damaging effect to humans. In

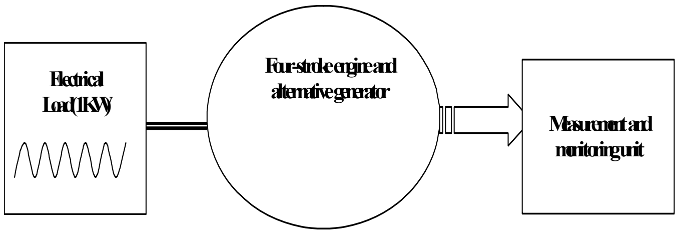
addition, methanol has high-octane content that promotes better the process of combustion. Another advantage of methanol is that if it does ignite can cause less severe fires to the vehicle because is less flammable than gasoline[4,5].
Apart from the advantages there are some disadvantages as well. Moreover, methanol has lower energy content compared to gasoline, the fact that is not volatile enough for easy cold starting and can damage plastic and rubber fuel system components. Also the vehicle that will use the methanol as fuel need to have a large storage tank as pure methanol burns faster than gasoline, and corrosion resistant, materials must be used for the storage equipment[6,7,8,9,10].
Considering the fact that petroleum-based products are not sufficient enough to last many years, it can be said that the use of methanol as fuel will probably replace it in the near future. Also, the severe environmental problems around the world will eventually lead to the use of more environmentally friendly technologies. The question that is examined in this paper is how the mixtures of gasoline-methanol behave in a four-stroke engine from the aspect of emissions 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 123cm3 displacement that is connected with a phase single alternative generator (230V/50Hz) with maximum electrical load approximately 1KW(picture 1). The engine according to the manufacturer uses as fuel gasoline. The engine functioned without load and under full load conditions (1KW) using different fuel mixtures: gasoline, gasoline-10%methanol, gasoline-20%methanol, gasoline-30%methanol, gasoline-40%methanol, gasoline-50%methanol, gasoline-60%methanol, and gasoline-70% methanol. During the tests, exhaust gases measurements, were also monitored for every fuel mixture 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

The figures of CO and HC emissions, for every fuel and for every load conditions, are represented below:

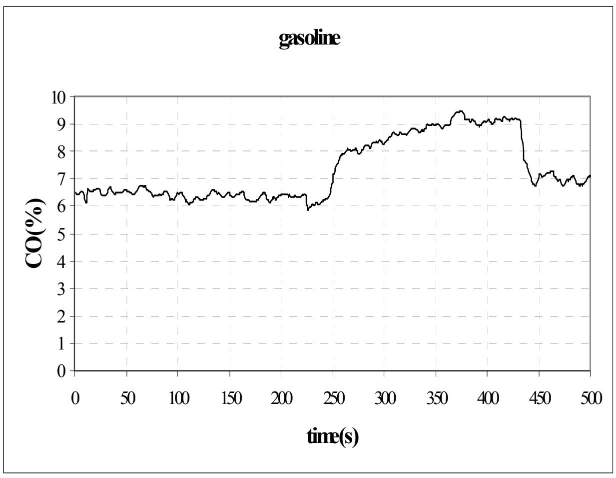


Figure 1. The CO variation when gasoline is used as fuel.

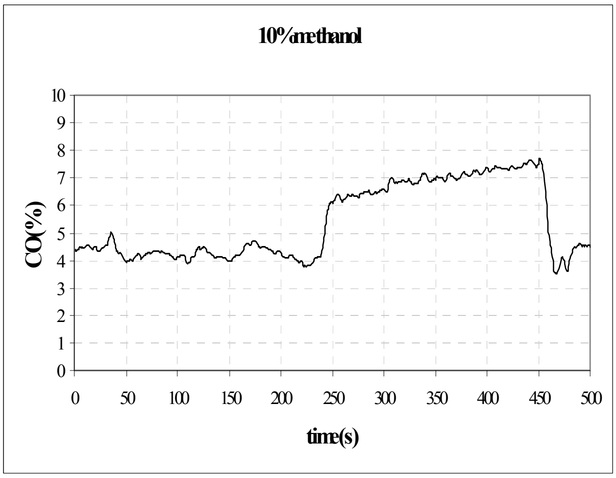


Figure 2.The CO variation when mixture of gasoline-10%methanol is used as fuel.

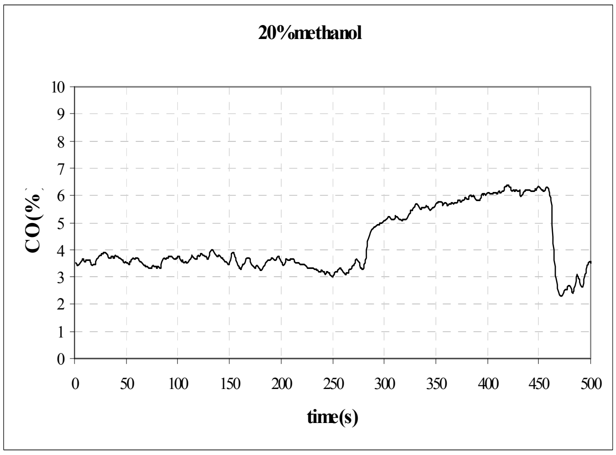


Figure 3. The CO variation when mixture of gasoline-20%methanol is used as fuel.

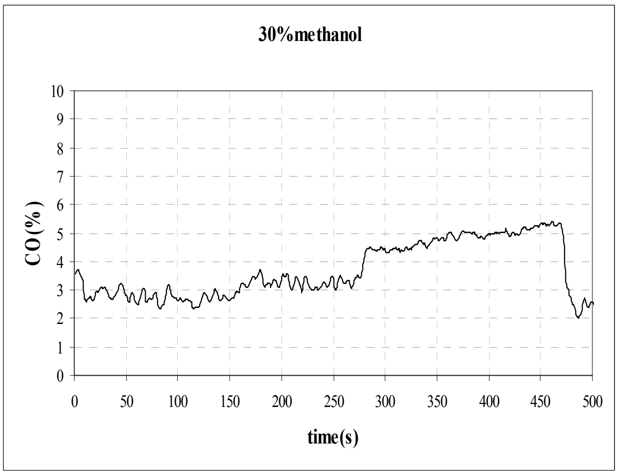


Figure 4.The CO variation when mixture of gasoline-40%methanol is used as fuel

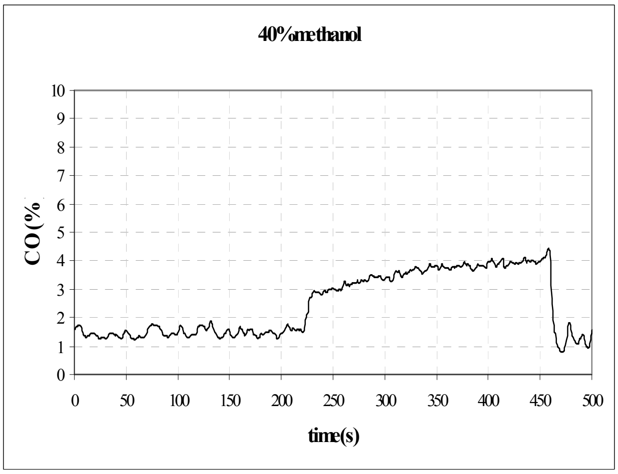


Figure 5.The CO variation when mixture of gasoline-40%methanol is used as fuel

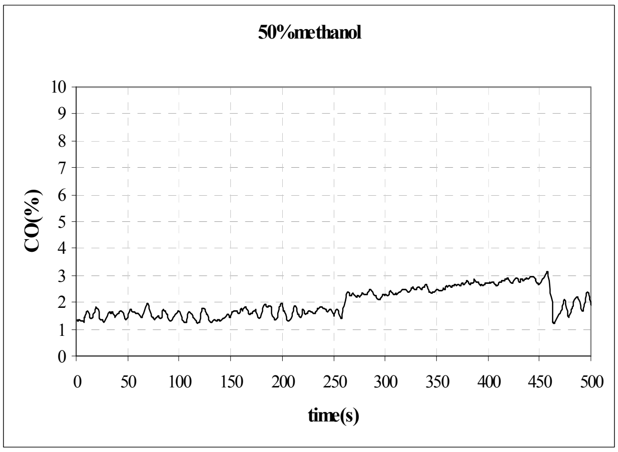


Figure 6. The CO variation when mixture of gasoline-50%methanol is used as fuel.

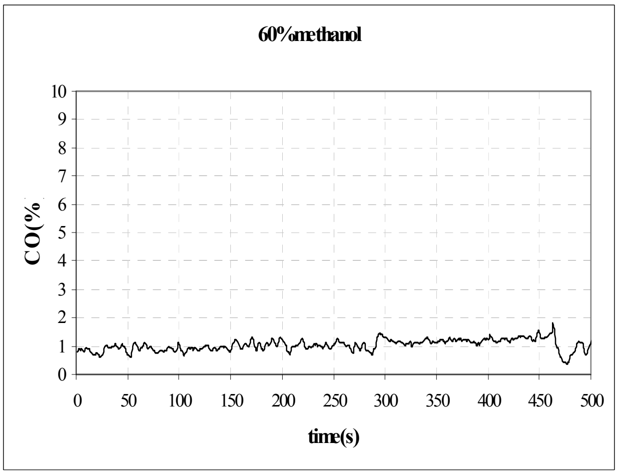


Figure 7. The CO variation when mixture of gasoline-60%methanol is used as fuel.

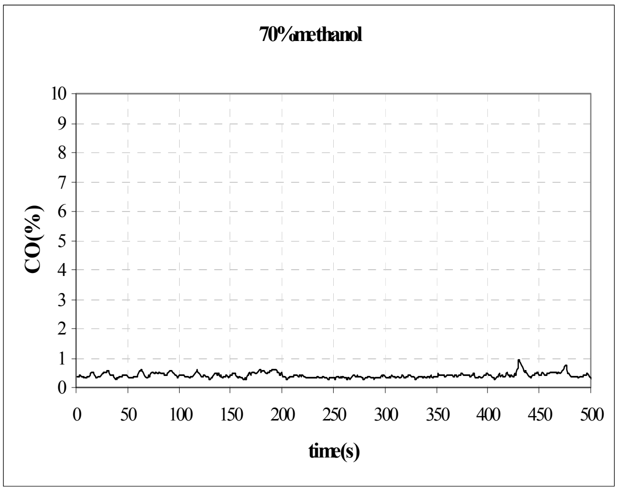


Figure 8. The CO variation when mixture of gasoline-70%methanol is used as fuel.

Figure 1 represents CO emissions when the fuel that is used is gasoline. The engine functions without load at first and then (after 250s) functions under full load conditions (1KW). The average value of CO emissions during the function of the engine without load is 6,41%, while at full load conditions the average value of CO emissions is 8,7%. Following, a mixture of gasoline with 10% methanol is used (fig. 2) and the same test is conducted with this mixture. From figure 2 it is being observed that the average value of CO emissions without load conditions of the engine is 4,87%, while at full load conditions the percentage of CO emissions is 6,9%. The same tests are conducted while increasing the percentage of the methanol in the fuel, using the mixtures: gasoline-20%methanol(fig. 3), gasoline-30%methanol(fig. 4), gasoline-40%methanol(fig. 5), gasoline-50%methanol(fig. 6), gasoline-60%methanol(fig. 7), and gasoline-70%methanol(fig. 8). The results of the %CO average values from the tests that were carried out are presented in the figure 9 below:

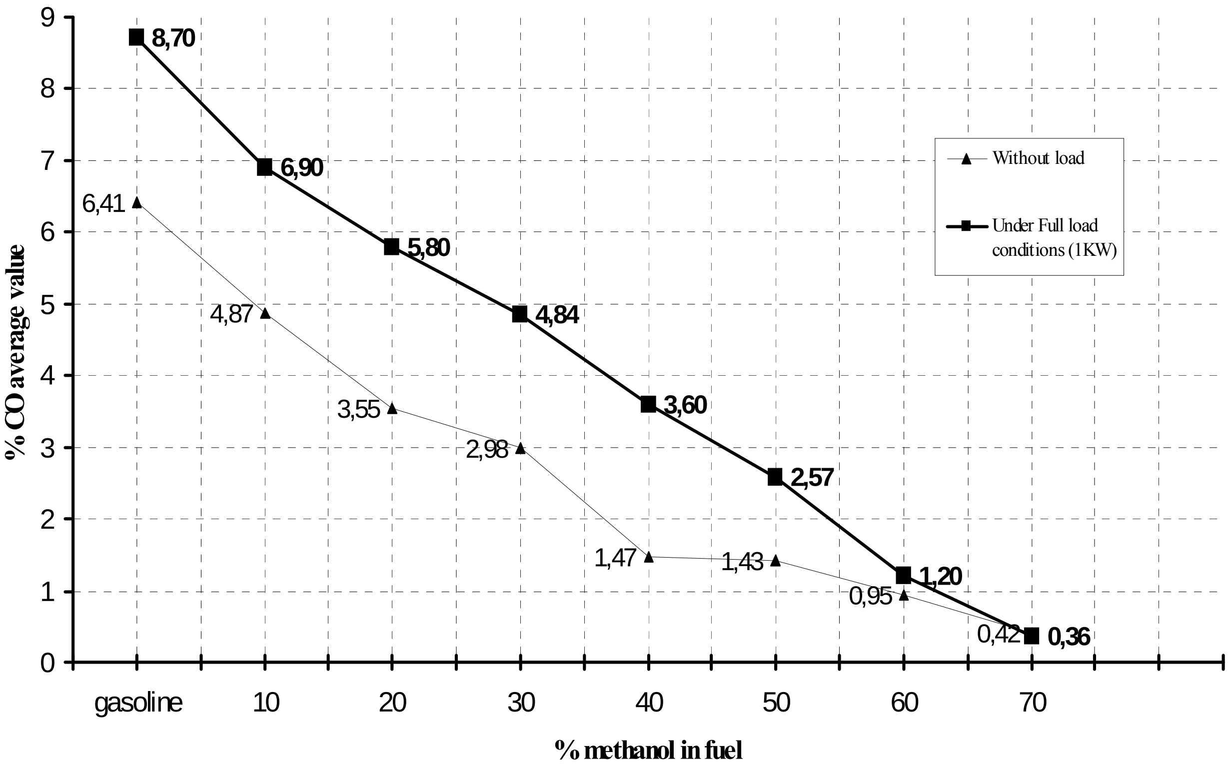


Figure 9. The CO emission average value for every mixture

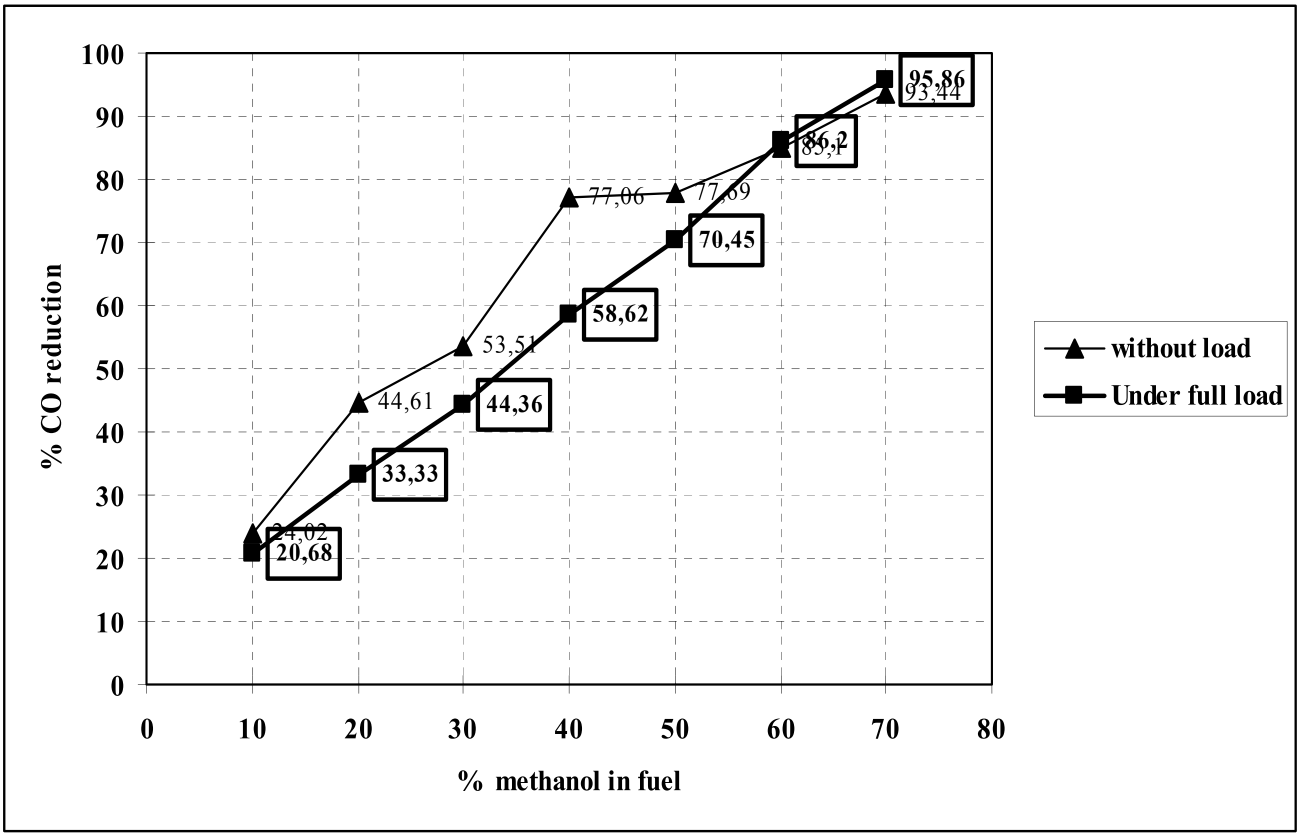


Figure 10. The % CO reduction for every fuel mixture in relation of gasoline

The Figure 9 shows the average values of CO emissions for every fuel mixture, without load and under full load conditions. It is being observed that as the percentage of methanol in the fuel increases, there is a considerable decrease of CO emissions. In figure 10 shows the % CO reduction for every fuel mixture in relation of gasoline. The figures below represent the HC emissions for every fuel and for every load conditions:

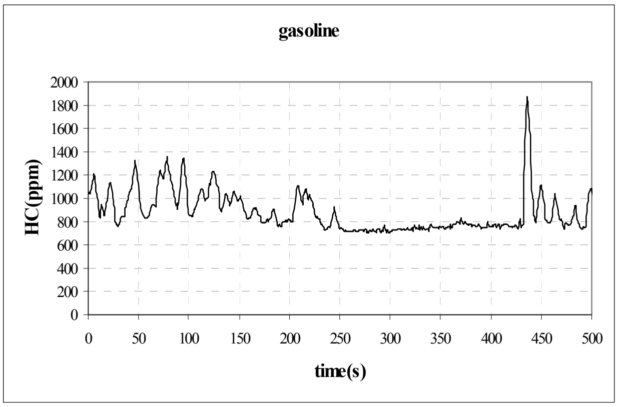


Figure 11. The HC variation when gasoline is used as fuel.

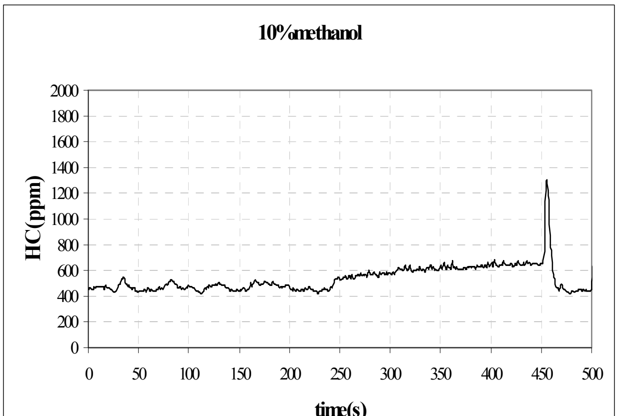


Figure 12. The HC variation when mixture of gasoline-10%methanol is used as fuel.

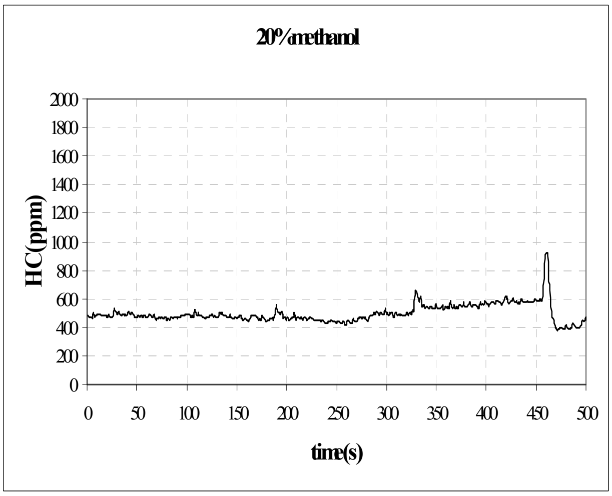


Figure 13.The HC variation when mixture of gasoline-20%methanol is used as fuel.

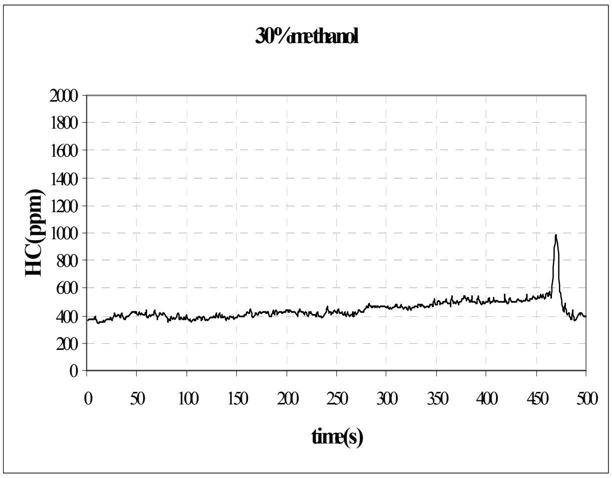


Figure 14.The HC variation when mixture of gasoline-30%methanol is used as fuel.

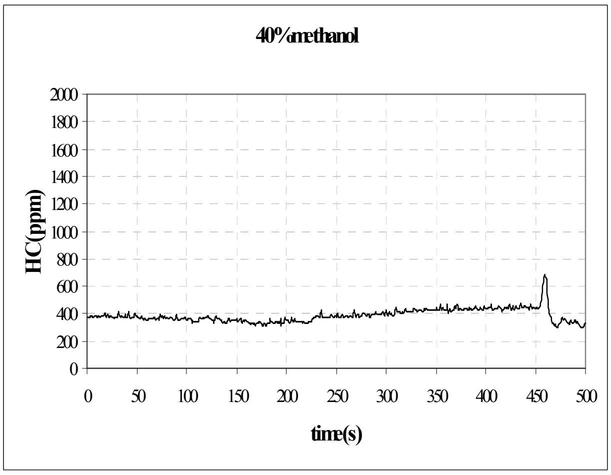


Figure 15. The HC variation when mixture of gasoline-40%methanol is used as fuel.

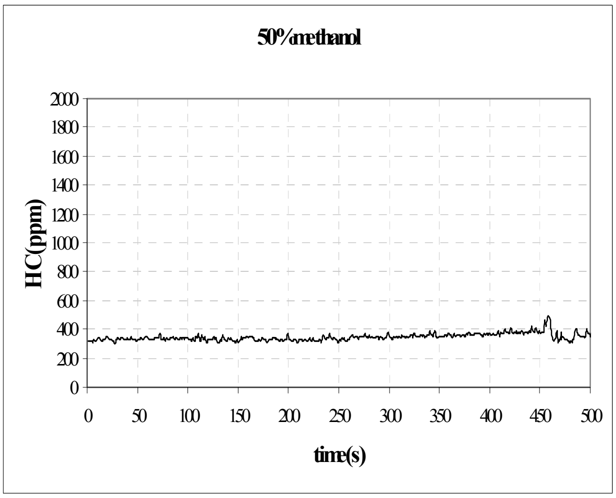


Figure 16. The HC variation when mixture of gasoline-50%methanol is used as fuel

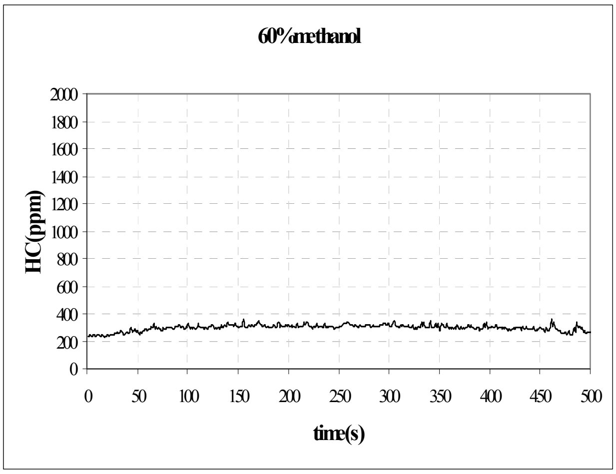


Figure 17.The HC variation when mixture of gasoline-60%methanol is used as fuel.

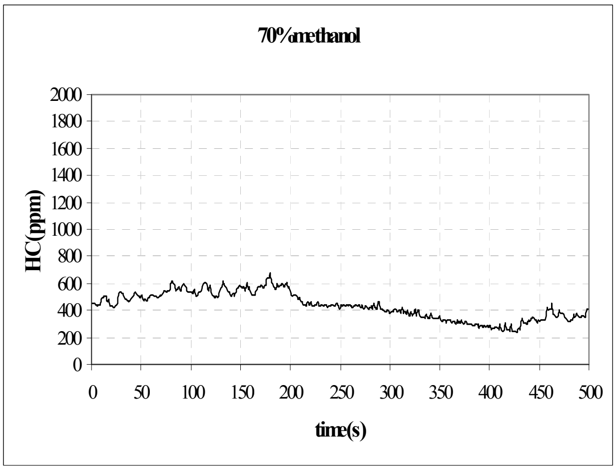


Figure 18.The CO variation when mixture of gasoline-70%methanol is used as fuel.

The HC emissions when the fuel that is used is gasoline are represented at figure 11. As it was mentioned above, the engine functioned without load at first and then (after 250s approximately) functioned under full load conditions (1KW). During the function of the engine without load the average value of HC emissions is 1091ppm, while at full load conditions the average value of HC emissions is 730ppm. The mixture of gasoline with 10% methanol is illustrated at figure 12.

At this figure is being observed that the average value of HC emissions without load conditions of the engine is 496ppm, while at full load conditions the HC emissions is 613ppm. When the percentage of the methanol in the fuel increases: gasoline-20%methanol(fig. 13), gasoline-30%methanol(fig. 14), gasoline-40%methanol(fig. 15), gasoline-50%methanol(fig. 16), gasoline-60%methanol(fig. 17), and gasoline-70%methanol(fig. 18), the results of the HC average value are presented in the figure 19 below:

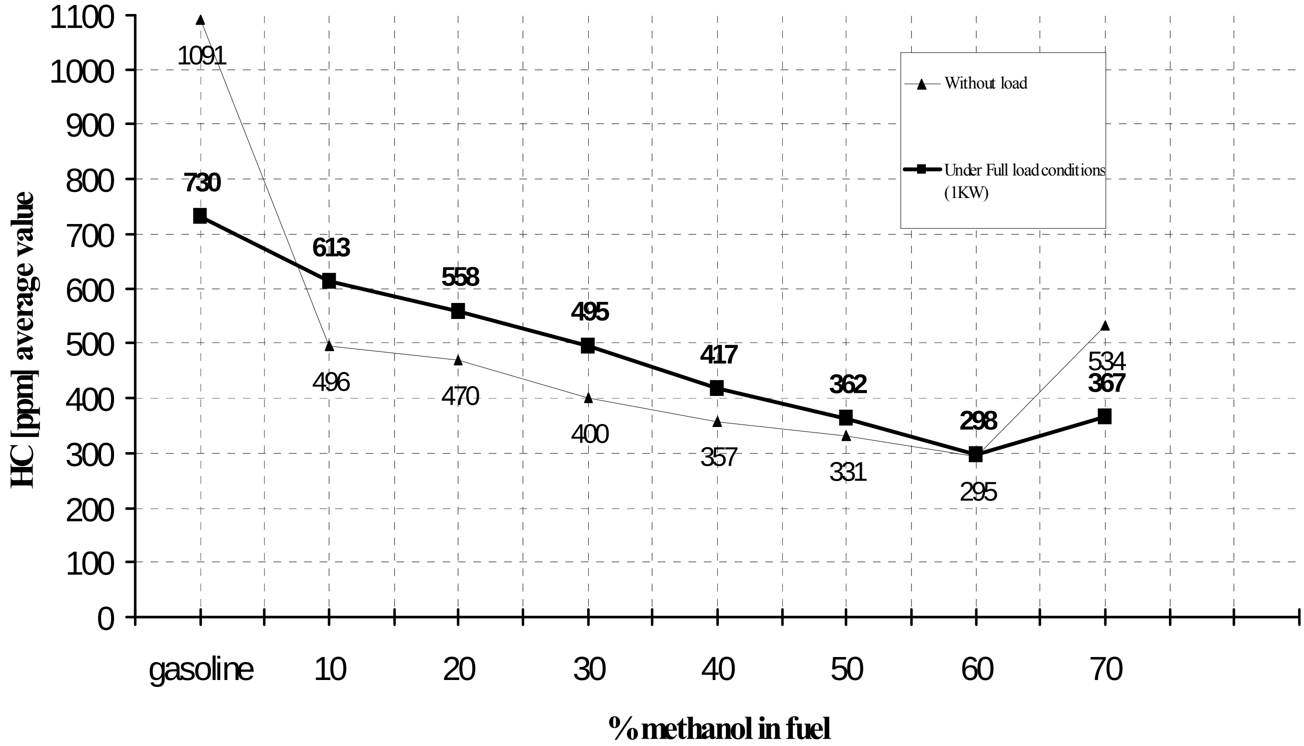


Figure 19. The HC emission average value for every mixture

In the case of HC emissions there is also a decrease of emissions when the percentage of methanol in the fuel increases at idle and under full load(fig.19) conditions. There is an exception at the mixture gasoline-70%methanol where the average value of HC without load is 534ppm and under full load is 367ppm. These values are higher than the values that correspond to the mixture of gasoline-60%methanol (295ppm, 298ppm). This is explained by mentioning the fact that during the use of the mixture gasoline-70%methanol there was a malfunction of the engine that was cause by the bad mixture of the air with the fuel(gasoline-70%methanol), since the engine was not regulated(ratio air/fuel) for every mixture maintaining the adjustments for gasoline. Also it must reported that the addition of methanol in the fuel led to HC decrease for the same mixture but for different load conditions. When gasoline was used HC emissions were higher at no load conditions than at full load conditions(1KW), while during the use of gasoline-methanol mixtures this was reversed. This is due to the better combustion under full load conditions because methanol has higher octane number than gasoline[9,10,11,12,15].

In figure 20 shows the % HC reduction for every fuel mixture in relation of gasoline:

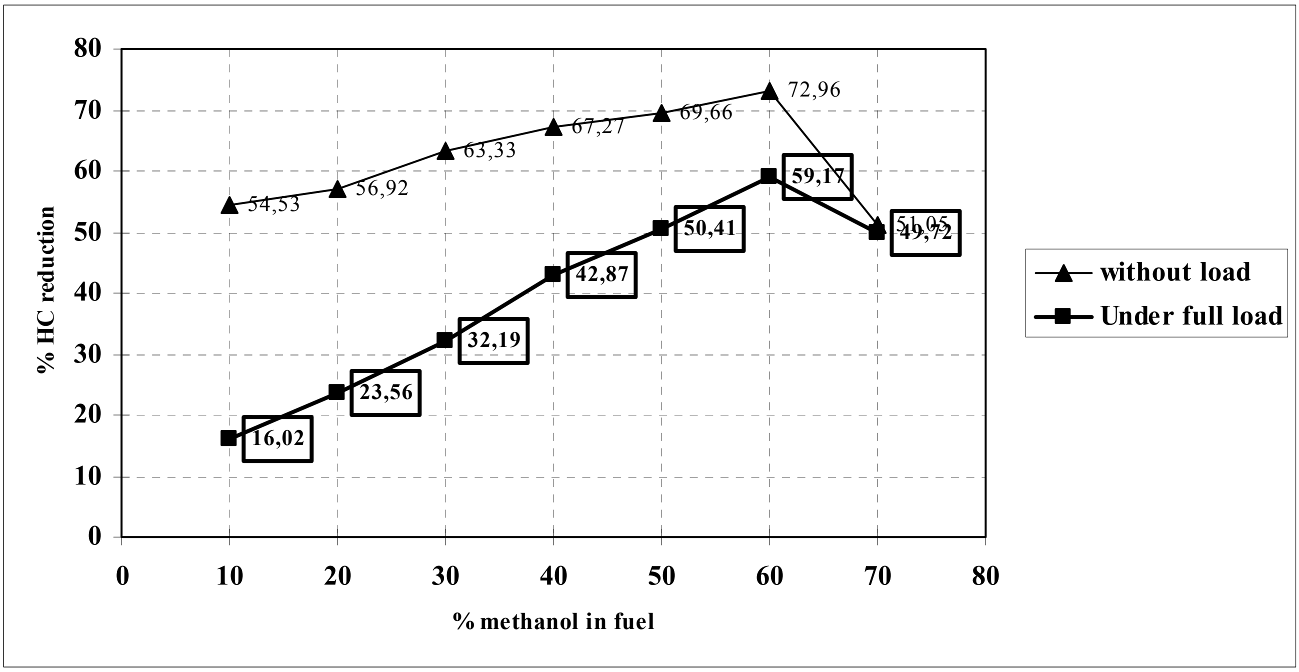


Figure 20. The % HC reduction for every fuel mixture in relation of gasoline

Furthermore, during the tests the consumption of the fuel was measured for every mixture and for every load conditions. The results are presented in the figure 21 below

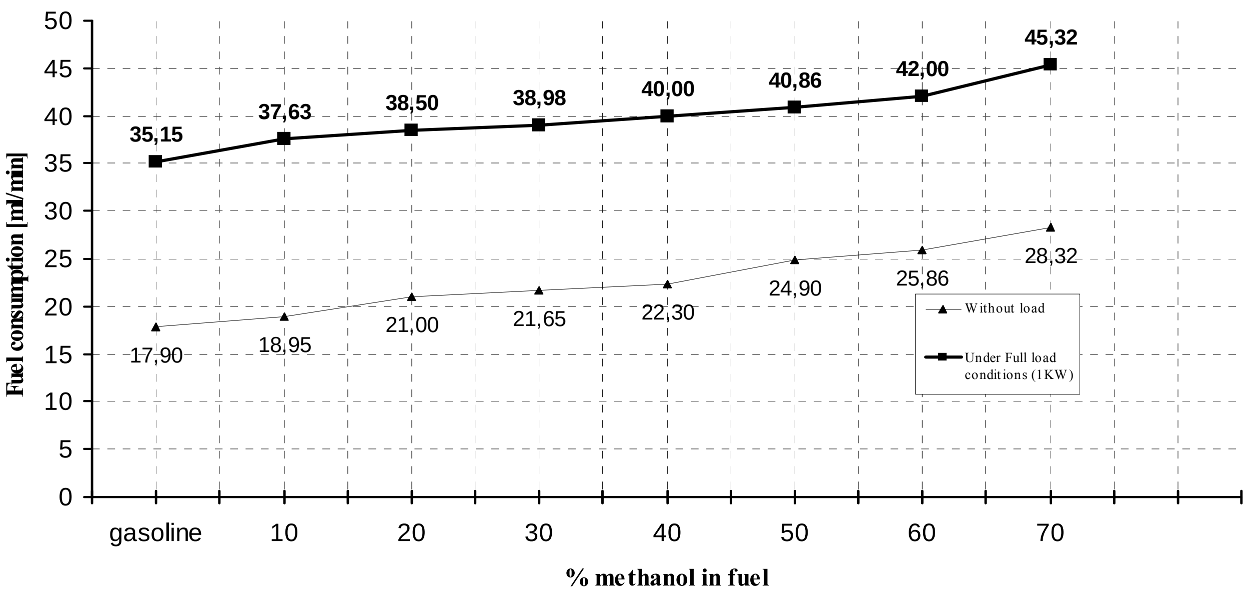


Figure 21. The variation of the fuel consumption

The figure 21 shows an increase of fuel consumption when the percentage of methanol in the fuel increases. The result of the smaller calorific value of methanol compared to gasoline and also the lack of regulation (ratio air/fuel) of the engine, result to the consumption increase[10,16,17,18]. This increase of consumption is caused due to the operation of the rpm regulator that the engine has, maintaining of the engines speed constant. It is important to mention that when mixture gasoline-80%methanol was tested the engine could not function properly.

3.Conclusion

The use of methanol in the internal combustion engine has as result the CO and HC emissions decrease in the case where the engine is without load but also in the case where the engine functions under full load(1KW) conditions. This is due to the better combustion because of the higher octane number of methanol. There is an exception at the fuel gasoline-70%methanol, where there is an increase of HC emissions due to the malfunction of the engine because there was lack of regulation. It must be noted that for all the mixtures that where used the engine maintained the initial regulation that concerned the gasoline fuel (relatively to the air/fuel ratio). Also from the aspect of consumption, at idle and under full load conditions, the increase of methanol percentage in the fuel caused consumption increase because of the small calorific value of methanol.

Finally, is important to note that the emissions decrease and the fact that methanol is a renewable fuel in an era where the needs for fuel increase while the reserves of petroleum are depleted.

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