Application of diesel - ethanol mixtures in tractor engine

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Abstract: -The tractor has been developed in the first half of the twentieth century. A tractor is basically a machine that performs agricultural tasks, such as pulling or pushing agricultural machinery or trailers, planting cultivating, fertilizing and harvesting crops, with the purpose of a faster and more efficient production of rural products. Except of hauling materials tractor can be used for personal transportation as well. The tractor is a replacement of human effort and that of draft animals. The following essay investigates the behaviour of farm tractor engine under full and real load conditions, by using fuels as Diesel, Diesel-20% ethanol and Diesel-30% ethanol mixtures. Concretely, it examines the farm Tractor with Diesel engine from the viewpoint of power and gas emissions and consumption. A series of laboratory instruments were used for the realization of the experiments. The results of full load tests using Diesel and Diesel - ethanol mixtures in Diesel Tractor engine, indicate that the CO exhaust gas content tends to decrease in case of using ethanol as fuel. This is probably caused by the presence of oxygen in the ethanol that participates in the combustion process. In the case of full load tests the combustion temperatures are sufficient for efficient combustion in all the cases of engine rpm. Therefore, the reduction of exhaust emissions with the ethanol content is natural. However, the power decreases as far as the ethanol is increasing.

Keywords: Gasoline-ethanol mixtures, Gas emissions, Biofuels

I. INTRODUCTION

Tractor is one of the most important working tools of a farmer, the correct operation of which has as result the more efficient production. Most of the rural work is realized with the use of tractor. In the cost of utilisation of tractor is included the cost of fuels. This is important because this cost goes to the cost of rural products. Also the frequent use of tractor has as consequence the environmental deterioration from gas emissions[1,2,3,4].

Fuel quality affects diesel engine emissions even more strongly than emissions of spark-ignition engines. HC, CO and particulate emissions are the main pollutants affected by the fuel quality. The effect on nitrogen oxides is negligible[5,6,7].

Similar to gasoline for spark-ignition engines, diesel engine fuel is a mixture of hydrocarbons, although its boiling temperature is approximate 170 to 360^{o}C. Depending on diesel fuel composition and characteristics, the major differences on mixture formation and combustion and, hence, exhausts emissions. Major quality criteria are cetane rating, density, viscosity, boiling characteristics, aromatics content and sulphur content. With regard to environmental compatibility, the following requirements have to be met: low density, low content of aromatic compounds, low sulphur content, high ketene rating.

To a certain degree, the above requirements contrast with the demands for engine power and fuel economy. This becomes evident when the relationship between parameters such as density, content of aromatic substances and ignition quality (readiness to ignite) is considered: "High density = high content of aromatic substances = low ignition quality". All of the petroleum-based fuels are fossil fuels that have been stored in the earth for many centuries. They are nonrenewable and will be depleted at some future date. Production of crude oil in United States is already declining, and it is expected that world petroleum reserves will be depleted in the twenty-first century. Other sources of fuel energy for engines are being sought[8,9,10].

Solar energy is the most inexhaustible energy source, and it may be used directly or may be stored for later use. Petroleum is an extreme example of stored solar energy. The energy was trapped by plants growing thousands of years ago, and, these plants were eventually transformed into petroleum. In direct use, solar energy is used as soon as it is collected [11,12,13,14]. Direct use of solar energy to supply power to a farm tractor is impractical for two reasons. The energy is not concentrated enough to supply a tractor with a reasonably sized collector, and it is unavailable at night or on cloudy days. Coal, oil shale, and tar sands are fossil fuels that are available in much larger reserves than is petroleum. If these fossil fuels could be extracted from the earth and converted to petroleum-like liquids, the duration of the fossil-fuel era could be greatly extended. The extraction and conversion processes have been demonstrated on a pilot scale. The enormous capital costs of full-scale plants have delayed their construction in the United States, but South Africa produces large quantities of liquid fuel from coal. Engines can be operated on liquid fuels produced from biomass. Alcohol fermented from farm crops has been used as a fuel for spark-ignition engines. Soybean, sunflower, and other vegetable oils have been used as fuel for diesel engines. Such fuels might become available in sufficient quantities to supply the fuel needs of farm tractors, but not enough would be available to fulfill the needs of transportation, manufacturing, and other industries[15,16,17].

The possible increases of the price of crude oil, the abrupt oil market changes, the finite of reserves, as well as the environmental pollution led to the reevaluation of the importance of the rural and forestall factor as a renewable resources supplier.

Important quantities of ethanol are produced every year to be used as fuel [3]. Bioethanol has a high octane number, which means it can be used as an fuel additive, or as a substitute either as pure alcohol or as mixture of gasoline-alcohol[4].

Alcohol is produced in laboratories in many ways. Practical interest occurs in producing ethanol from the rich in sugar plants. ‘‘Alcoholic fragmentation’’ is the splitting of single sugars, type $C_6H_{12}O_6$, mainly glucose and fructose, to CO_2 which is catalysed by the zymasse enzyme. Raisins, molasses and starchy roots or fruits like potatoes, corn, barley and others are used for this purpose.

Nowadays mixtures of gasoline - alcohol are used in USA mainly as car fuel (gasohol), either to fight the energy crisis or to decrease environmental pollution, because of the limited CO, HC emissions. Compared to pure gasoline, the gasoline-alcohol mixtures produce smaller calorific output. This is why the use of these mixtures in petrol engines reduces the power of the engine[18,19,20]. The power decrease, in principle, increases in proportion to the alcohol percentage in gasoline. The question is how a diesel tractor engine behaves, from the viewpoint of pollution and power, when diesel-alcohol mixtures are used.

II. Instrumentation And Experimental Results

The experimental measurements were carried out on a model John Deere tractor engine. This is a four cylinder engine with an approximate 60 CV output at 2800 rpm. During the tests measurements, the engine rpm, exhaust gas composition (CO, HC), the gas temperature, the fuel consumption and the engine power, were also monitored. For this purpose, the HP 3497A Data Acquisition Unit was used with a HP 44422A multiplexer. For the rpm measurements an ignition pulse detector was used. The data acquisition unit was interfaced with an IBM-386AT via the HP-IB 82990A Command Library IEEE-488 interface card. This particular measuring system and software completed a scanning cycle per channel approximately every 0.1s. 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 infrared analyzer was used. This unit has the following ranges:

CO : 0-10% Volume
CO2: 0-20% Volume
HC : 0-10000 ppm.

The unit has a ±2% accuracy and ±2% repeatability. The operating principle for the CO_2, CO, HC measurements is Infrared Non Dispersive Spectrometry and the time response for the CO_2, CO, HC measurements is less than 10s. For the O_2 measurement a galvanic type cell is used with a time response of less than 25s. These delays are not caused only by the actual sensors, but also by the time required for the exhaust gas to reach the sensing area via the connecting tubes and filters. The analyzer was calibrated using a gas mixture provided by HORIBA. HC exhaust gas concentration calibration was based on n-hexane (n-$C6H_{14}$). The unit was considered adequate for the steady state operation measurements required. The tests were carried out on various engine speeds at full load conditions with different fuel mixtures[pure Diesel, Diesel - 20% ethanol mixture in volume and Diesel - 30% ethanol mixture in volume]. The engine speeds were 1000rpm, 1700rpm, 1900rpm and 2300rpm, without any adjustment in the fraction air/exhaust gas during the use of Diesel - ethanol mixtures in volume. The instrumentation included hydraulic power brake. During all tests the engine had a cold start in a temperature of (15-20^{o}C).

Table 1 shows the average values of CO and HC emissions, in relation to revolutions and the ethanol percentage in the fuel:

	DIESEL		DIESEL - 20%ETHANOL		DIESEL - 30%ETHANOL	
Rpm	CO%	HC(ppm)	CO%	HC(ppm)	CO%	HC(ppm)
1000	**2,5**	**155**	**1,8**	**129**	**1,6**	**120**
1700	**5,1**	**181**	**3,8**	**155**	**3,5**	**150**
1900	**5,8**	**194**	**4,5**	**149**	**4,1**	**141**
2300	**2.9**	**163**	**1,9**	**138**	**1,7**	**130**

Table 1. Average CO, HC under full load conditions

In the following figures 1, 2 the average values of CO, HC in the exhaust gas under full load conditions.

Figure 1 shows the CO variation in relation to revolution and the fuel. The CO emission reduction when using mixture of Diesel-ethanol:

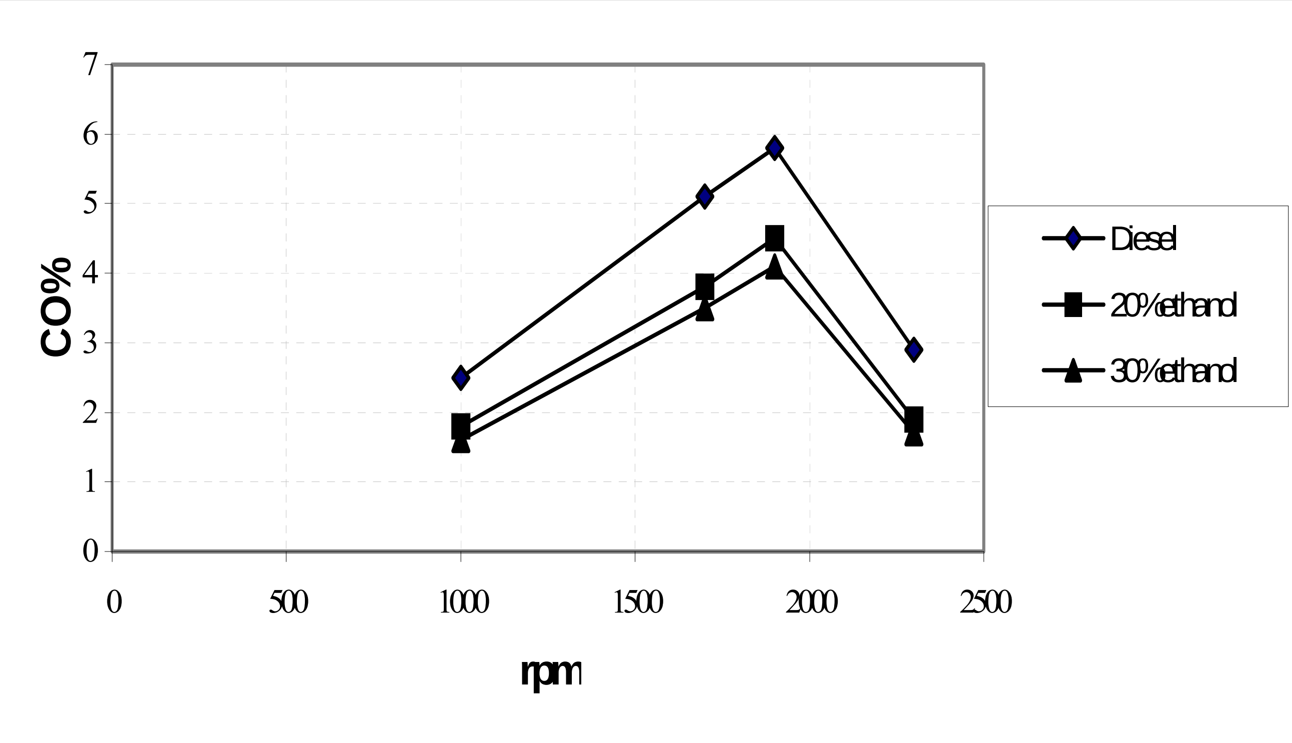

Figure 1. Average CO variation under full load conditions.

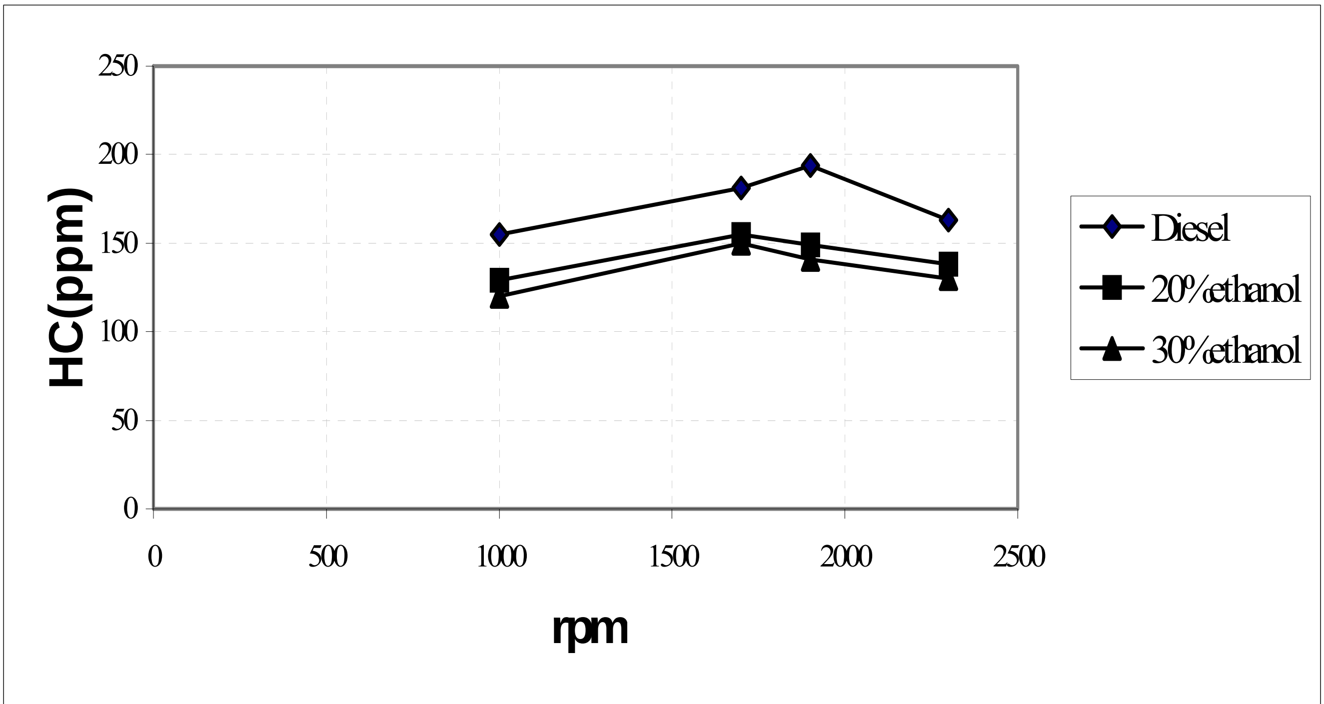

Figure 2. Average HC variation under full load conditions.

The variation of power between the two fuels is represented in the following table 2:

	DIESEL	20% ETHANOL	30% ETHANOL
rpm	Power(CV)	Power(CV)	Power(CV)
1000	**25**	**24**	**24**
1700	**42**	**39**	**38**
1900	**47**	**42**	**41**
2300	**56**	**52**	**51**
2800	**60**	**56**	**53**
3000	**57**	**54**	**52**

Table 2. The power variation

The results from the above table are shown in the figure 3:

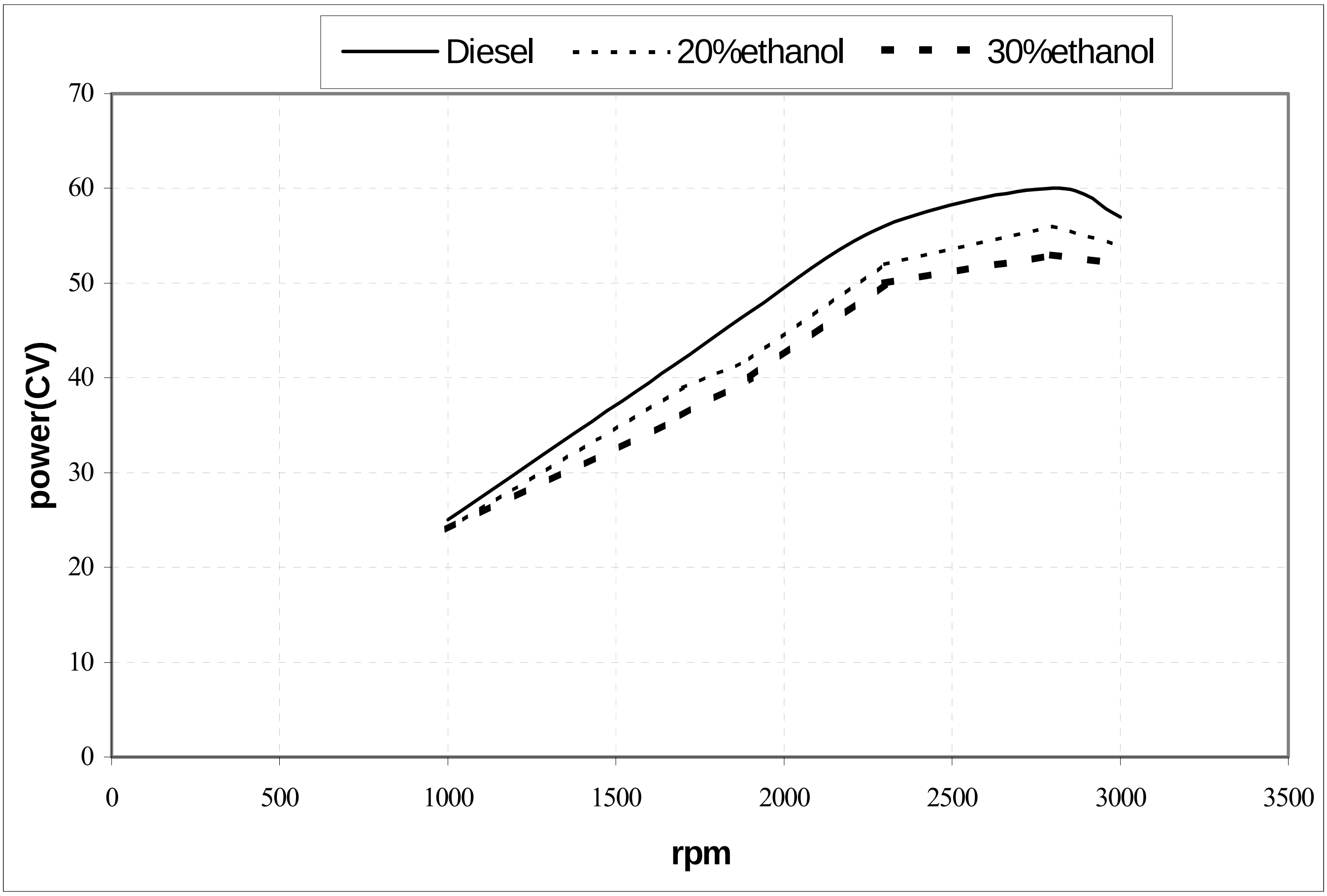

Figure 3. The power variation

Is been observed in figure 3 a small reduction of power in case Diesel-30%ethanol is used as fuel. But, the use of ethanol has as result the reduction of CO and HC emissions, as it is represented in figure 1 and 2.
The consumption was measured while the tractor was tilling:

The percentage of consumption increase in each case of fuel its represented in the following table 3:

	20% ETHANOL	30% ETHANOL
rpm	%	%
1000	**2**	**4**
1700	**3**	**4,5**
1900	**5**	**6,6**
2300	**3**	**4**
2800	**7**	**9,2**
3000	**8**	**10,6**

Table 3. Percentage of consumption increase

It is crucial to mention that the engine didn't present any malfunction after been working 2000 hours with various mixtures of ethanol-gasoline under full load conditions. After these hours of operation the engine was taking apart and no trace of damage was observed. The other factors of operation such as the pressure of oil and the temperature of water were not altered during the use of mixture of ethanol in the fuel.

The table 3 is represented in the following figure:

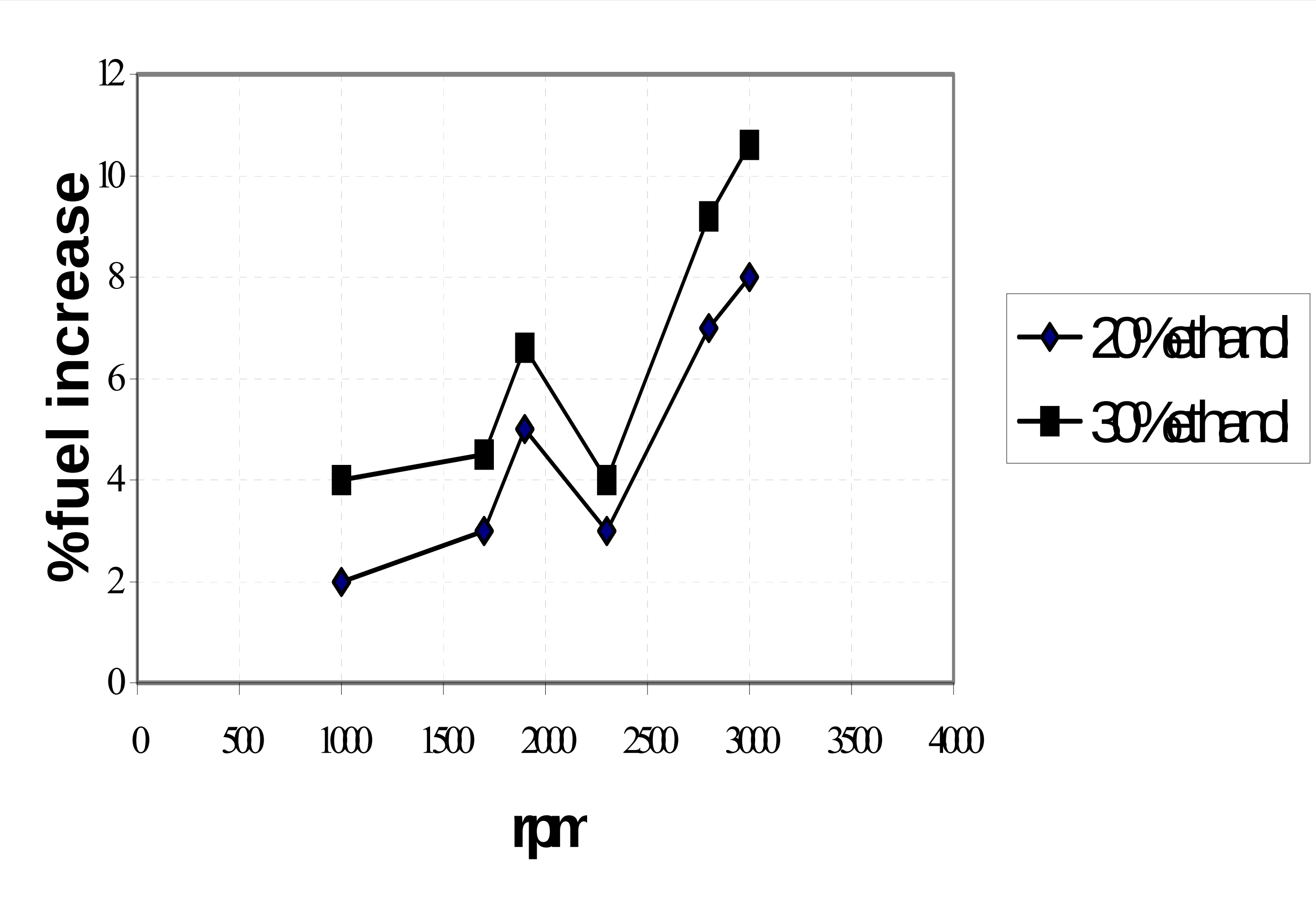

Figure 4. Percentage of consumption increase

Figure 4 shows as the percentage of ethanol in the fuel increases at the same time the consumption increases.

III.CONCLUSION

The results of full load tests using Diesel and Diesel - ethanol mixtures in Diesel Tractor engine, indicate that the CO, HC exhaust gas content tends to decrease in case ethanol is used as fuel. This is probably caused by the presence of oxygen in the ethanol that participates in the combustion process.
In the case of full load tests the combustion temperatures are sufficient for efficient combustion in all the cases of engine rpm. Therefore, the reduction of exhaust emissions with the ethanol content is natural.

When the percentage of ethanol increases, the power decreases. That happens due to the small calorific value of ethanol.

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