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Emissions of Diesel - Vegetable Oils Mixtures

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1. Introduction

The industrialization of society, the introduction of motorized vehicles and the explosion of the population are factors contributing toward the growing air pollution problem. Moreover, the exhaust from burning fuels in automobiles, homes and industries is a major source of pollution in the air. Apart from the anthropogenic sources of air pollution there are natural sources as well. Natural sources related to dust from natural source, usually large areas of land with little or no vegetation, the smoke and carbon monoxide from wildfires, volcanic activity etc. Air pollution not only affects the air we breathe, but it also impacts the land and the water. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. The human health effects caused by air pollution may range from subtle biochemical and physiological changes to difficulty breathing. It can also cause deaths, aggravated asthma, bronchitis, emphysema, lung and heart diseases to human beings. There are several many types of air pollutant [1,2]. These include smog, acid rain, the greenhouse effect and holes in the ozone layer. The atmospheric conditions such as the wind, rain, stability affect the transportation of the air pollutant [3,4]. Furthermore, depending on the geographical location temperature, wind and weather factors, pollution is dispersed differently [5,6]. For instance, the wind and rain may effectively dilute pollution to relatively safe concentrations despite a fairly high rate of emissions. In contrast when atmospheric conditions are stable relatively low emissions can cause buildup of pollution to hazardous levels.
The quality of fuel affects diesel engine emissions (HC, CO, NOx and particulate emissions) very strongly. The fuel that is used in diesel engines is a mixture of hydrocarbons and its boiling temperature is approximately 170^{o}C to 360^{o}C [4]. Diesel fuel emissions composition and characteristics depend on mixture formation and combustion. In order to compare the quality of fuels the following criteria are tested: ketene rating, density, viscosity, boiling characteristics, aromatics content and sylph content. For environmental compatibility, the fuel must have low density, low content of aromatic compounds, low sylph content and high ketene rating [6,7,8].
One of the most important and renewable sources of energy is biomass. Biomass as a renewable source of energy refers to living and recently dead biological material that can be used as fuel or for industrial production. Some examples of biomass fuels are wood, crops, manure and some garbage. Biomass is a renewable energy source due to photosynthesis. Concretely, with the photosynthesis is committed the solar energy and is changed in

chemical (energy). At the combustion of biomass the committed solar energy is changed in thermo while the dioxide of coal (CO_2) returns in the atmosphere, while the inorganic elements that are contained in the ash, enrich the soil with nutritious elements. Nowadays, the use of biomass, covers approximately 4% of the total energy which is consumed in USA and 45% of the renewable sources of energy [9,10,11]. The most common source of biomass is the wood. For thousands of years people have burned wood for heating and cooking. Another source of biomass is our garbage that comes from plant or animal products. Moreover, various materials of plant origin, as agricultural remains (e.g. straw), material of animal origin, remains from veterinary surgeon units as well as remains of fishery and their sub products, urban waste etc. Wood waste or garbage can be burned to produce steam for making electricity or to provide heat to industries and homes. Biomass can be used for the production of liquid fuel (called biofuel) which is used for the transportation to many countries of Europe, USA etc. [12,13,14]. Bio-diesel is also produced from oily plants (soya, sunflower) animal greases, products of carcasses, and used oils. Some of biomass advantages which make it an attractive source of energy are the following:

1. Reduction of air pollutants. The combustion of biomass has null balance of dioxide of coal ($CO_{2,}$) does not contribute in the phenomenon of green house, because the quantities of dioxide of coal ($CO_{2,}$) that are released at the combustion of biomass are committed again by the plants for the creation of biomass.
2. Zero existence of sulphur in biomass contributes considerably in the restriction of emissions of dioxide of sulphur ($SO_{2,}$) that is in charge of the acid rain.
3. Reduction of dependence from imported fuels, improvement of commercial balance, in the guaranty of energy supply and in the saving of exchange.
4. Sources are commonly available.
5. Sources are locally produced, consequently it increases the occupation to the agriculture places with the use of alternatives cultures (several kinds of cane, sorghum), as well as the creation of alternative markets for the traditional cultures (sunflower etc.) and withholding of population in their hearths.
6. Increase of Biomass production can often mean the restoration of waste land.

Biofuels are liquid or gas fuels which are produced from the biomass. Biomass can replace the conventional mineral fuels, totally or partial in the engines [15].

The major issue is how a four-stroke diesel engine behaves on the side of pollutants and operation, when it uses mixed fuel of diesel – vegetable oils.

2. Instrumentation and experimental results

In the experiment stage has been used directly used vegetable oil (used sunflower oil that emanated from cooking) in the mixture of diesel in to a four – stroke diesel engine. Specifically it has been used diesel, mixture diesel-5% used vegetable oil (u5), diesel-10 used vegetable oil (u10), diesel-20% used vegetable oil (u20), diesel-30% used vegetable oil (u30), diesel-40% used vegetable oil (u40), diesel-50% used vegetable oil (u50) in a four-stroke diesel air-cooled engine named Ruggerini type RD-80, volume 377cc, and power 8.2hp/3000rpm, who was connected with a pump of water centrifugal. Measurements were made when the engine was function on 1000, 1500, 2000 and 2500rpm.

During the experiments, it has been counted:

- The percent of CO
- The ppm of HC

- The ppm of NO
- The percent of smoke

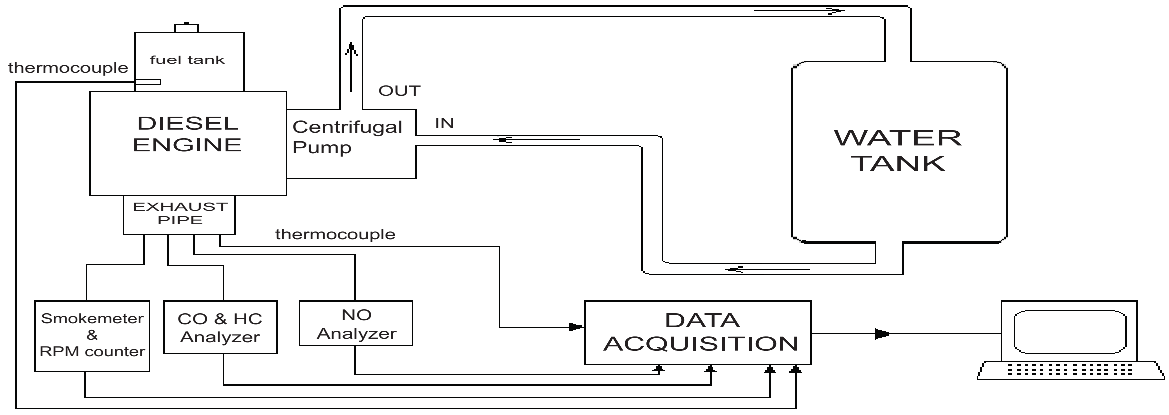

Fig. 1. Experimental Layout

The measurement of rounds/min of the engine was made by a portable tachometer (Digital photo/contact tachometer) named LTLutron DT-2236. Smoke was measured by a specifically measurement device named SMOKE MODULE EXHAUST GAS ANALYSER MOD 9010/M, which has been connected to a PC unit. The CO and HC emissions have been measured by HORIBA Analyzer MEXA-324 GE. The NO emissions were measured by a Single GAS Analyser SGA92-NO.

2.1 Used vegetable oil

The experimental results are shown at the following tables and figures [16]:

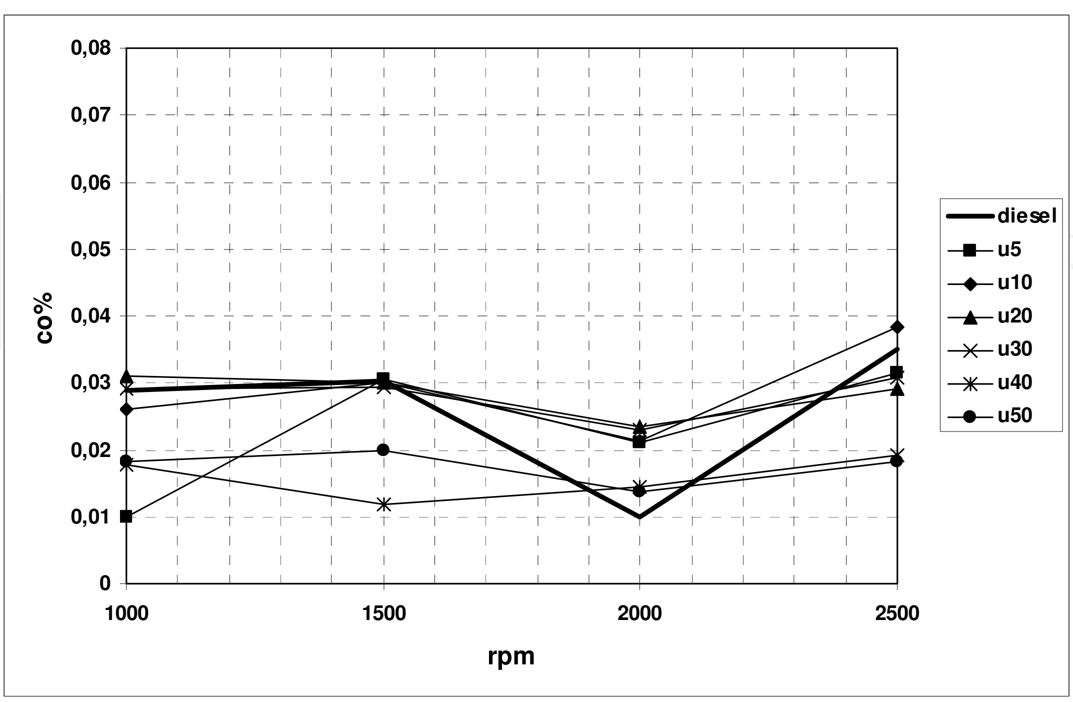

Fig. 2. The CO variation on different rpm regarding to the mixture

rpm	CO %						
	diesel	**u5**	**u10**	**u20**	**u30**	**u40**	**u50**
1000	0,02898	0,01000	0,026081	0,030985	0,029143	0,017823	0,018223
1500	0,03039	0,03059	0,030043	0,029979	0,029310	0,011818	0,019767
2000	0,01000	0,02108	0,021379	0,023500	0,023059	0,014483	0,013624
2500	0,03508	0,03145	0,038315	0,029120	0,030713	0,019111	0,018298

Table 1. The CO average value variation on different rpm regarding to the mixture

rpm	HC (ppm)						
	diesel	**u5**	**u10**	**u20**	**u30**	**u40**	**u50**
1000	2,535343	8,844156	5,653105	5,246253	5,124364	2,147903	2,974304
1500	13,31714	24,99127	12,87527	13,15385	9,358621	2,934461	6,714588
2000	7,131223	8,326797	12,67026	9,195652	13,79747	5,267241	4,936681
2500	10,96128	16,63420	17,30454	16,94635	6,706013	6,598698	6,759574

Table 2. The HC average value variation on different rpm regarding to the mixture

rpm	**NO (ppm)**						
	diesel	**u5**	**u10**	**u20**	**u30**	**u40**	**u50**
1000	518,210	771,001	696,827	495,603	380,361	349,140	207,760
1500	739,366	754,126	913,037	771,607	723,381	872,06	582,908
2000	762,155	834,334	520,485	760,936	839,268	928,337	720,505
2500	795,461	946,349	518,287	710,402	864,585	674,432	847,835

Table 3. The NO average value variation on different rpm regarding to the mixture

rpm	% smoke						
	diesel	**u5**	**u10**	**u20**	**u30**	**u40**	**u50**
1000	3,262370	4,870779	5,966167	16,43362	12,26745	15,7298	11,32741
1500	7,100651	8,174236	5,768602	7,652778	5,56423	9,206977	13,05011
2000	5,688865	7,619826	4,704957	6,151304	4,948101	4,351724	9,59869
2500	29,00617	23,21970	25,67279	16,86674	14,59399	17,48286	15,87915

Table 4. The % smoke average value variation on different rpm regarding to the mixture

From figure 2 it is clear that the more constant behaviour appears in the mixture u40, while the best behaviour is appears in the case diesel/1500rpm. From figure 3 it can be noticed the biggest reduction of HC regarding to diesel in case of mixture u40. From figure 4 it can be noticed the biggest reduction of NO regarding to diesel in the case of mixture u40. From figure 5 it can be seen the biggest reduction for u40 until the case u40/1000rpm. From the above figures it is clear that the use of different mixtures can constitute changes to CO, HC, NO and smoke too. It is also important the fact that there was no changes in the rounds of the engine, as well as in the supply of water at the use of mixtures. Finally as far as the consumption is concerned, did not observed changes with the use of different mixtures.

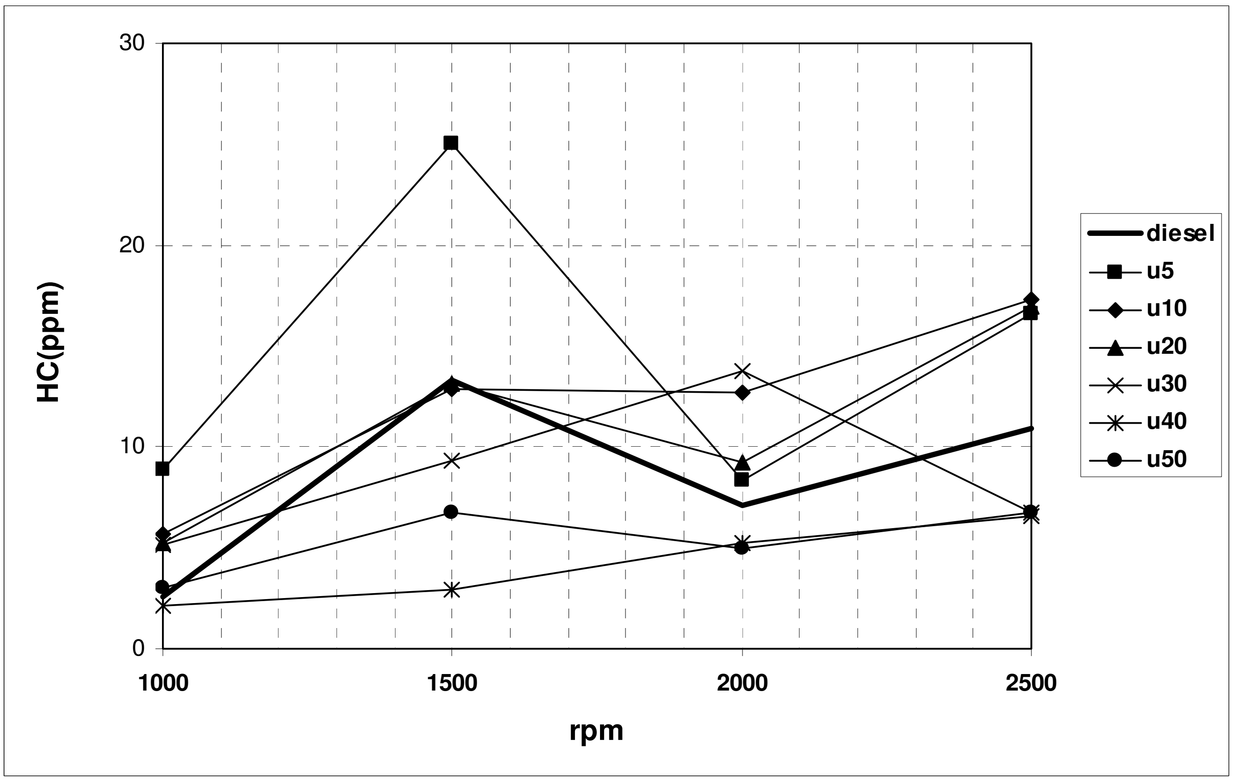

Fig. 3. The HC variation on different rpm regarding to the mixture

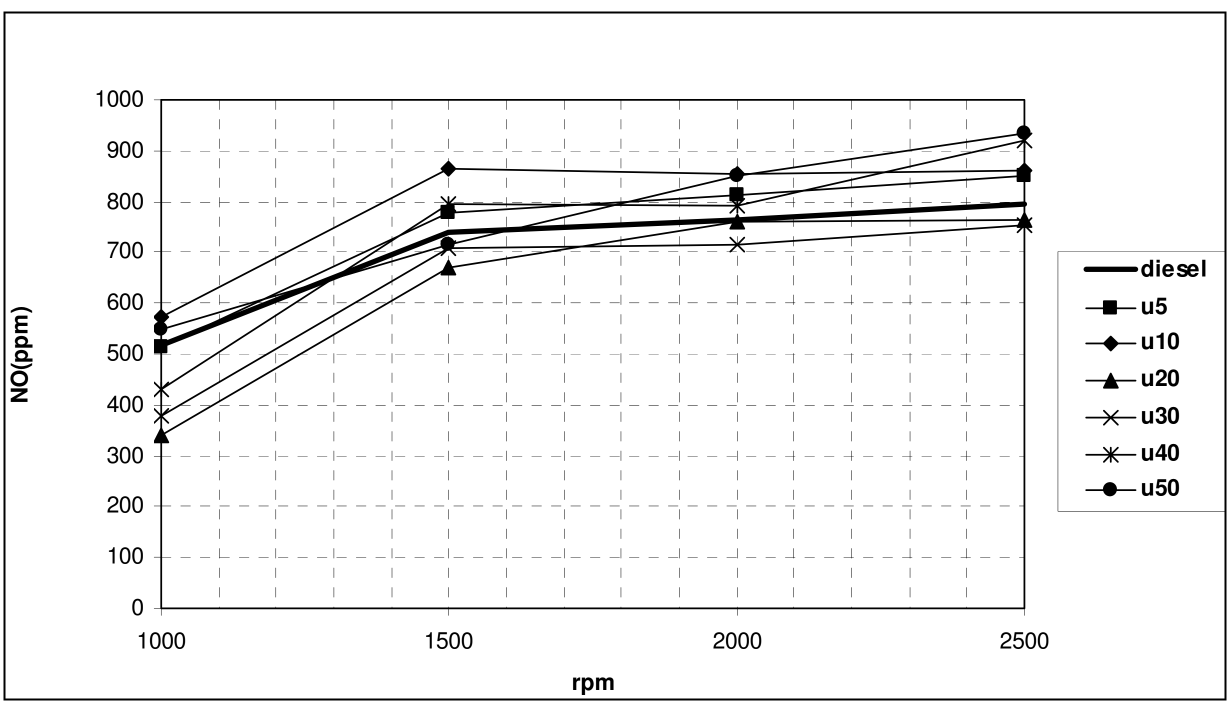

Fig. 4. The NO variation on different rpm regarding to the mixture

The use of mixtures of diesel-vegetable oil has as result change of gas emissions with better behaviour in the mixture u40. It is important, that is not presented reduction of power of engine from the combustion of the mixtures.

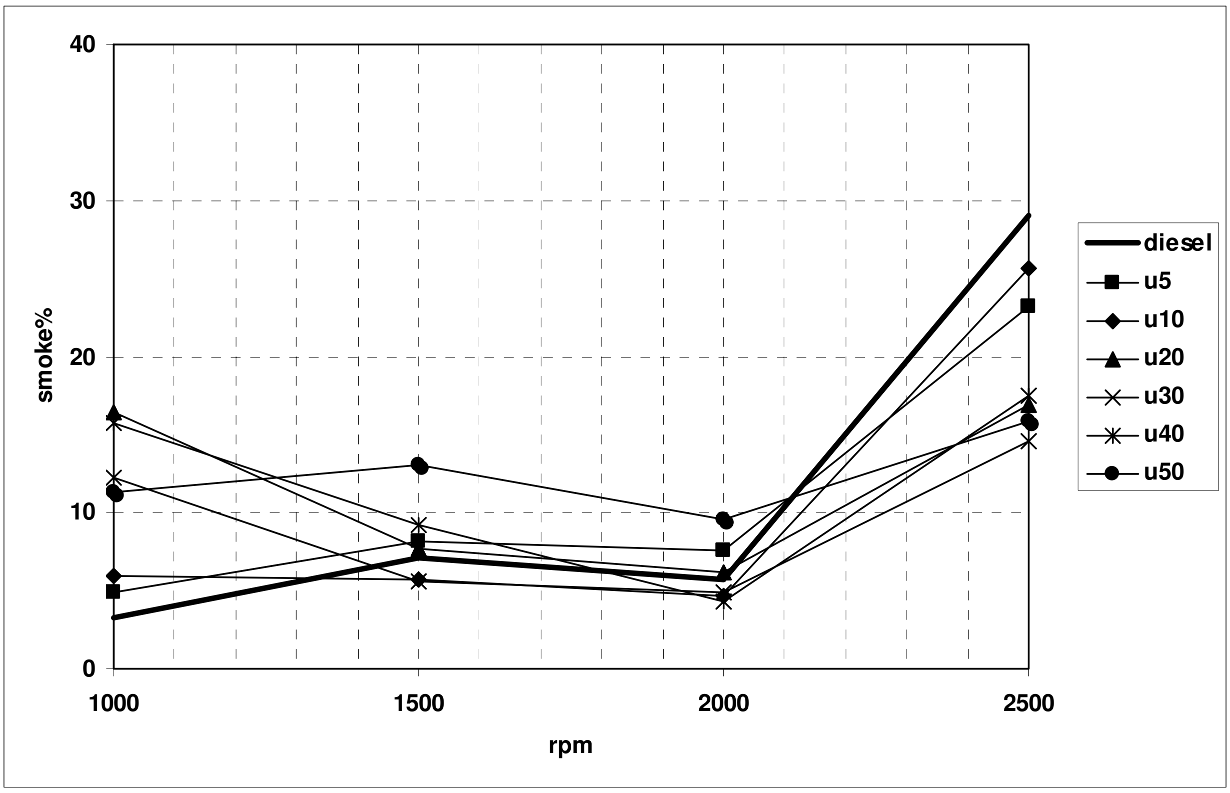

Fig. 5. The smoke variation on different rpm regarding to the mixture

2.2 Maize oil

In the experiment stage has been used directly maize oil in the mixture of diesel in to a four – stroke diesel engine. Specifically it has been used diesel, mixture diesel-5% maize oil (k5), diesel-10% maize oil (k10), diesel-20% maize oil (k20), diesel-30% maize oil (k30), diesel-40% maize oil (k40), diesel-50% maize oil (k50) in a four-stroke diesel engine [17]:

rpm	CO %						
	diesel	k5	k10	k20	k30	k40	k50
1000	0,0289	0,0310	0,0309	0,0309	0,0319	0,0397	0,0345
1500	0,0303	0,0302	0,0304	0,0311	0,0345	0,0211	0,0288
2000	0,01	0,0280	0,0232	0,0284	0,0274	0,0281	0,0219
2500	0,0350	0,0244	0,0317	0,0296	0,0324	0,0305	0,0292

Table 5. The CO average value variation on different rpm regarding to the mixture

rpm	HC (ppm)						
	diesel	k5	k10	k20	k30	k40	k50
1000	2,535	14,937	6,244	10,326	3,406	5,358	9,167
1500	13,31	21,485	9,236	17,997	14,718	0,449	17,197
2000	7,131	3,184	13,970	15,965	8,402	8,502	12,913
2500	10,961	16,347	18,884	23,556	30,551	7,451	17,712

Table 6. The HC average value variation on different rpm regarding to the mixture

rpm	NO (ppm)						
	diesel	**k5**	**k10**	**k20**	**k30**	**k40**	**k50**
1000	518,210	771,001	696,827	495,603	380,361	349,140	207,760
1500	739,366	754,126	913,037	771,607	723,381	872,06	582,908
2000	762,155	834,334	520,485	760,936	839,268	928,337	720,505
2500	795,461	946,349	518,287	710,402	864,585	674,432	847,835

Table 7. The NO average value variation on different rpm regarding to the mixture

rpm	% smoke						
	diesel	**k5**	**k10**	**k20**	**k30**	**k40**	**k50**
1000	3,262	12,722	7,301	7,488	16,623	7,200	26,232
1500	7,100	10,924	5,487	6,547	14,850	12,141	24,035
2000	5,688	18,679	4,001	6,588	9,936	14,071	18,884
2500	29,006	28,282	21,848	15,730	17,579	13,438	14,265

Table 8. The % smoke average value variation on different rpm regarding to the mixture

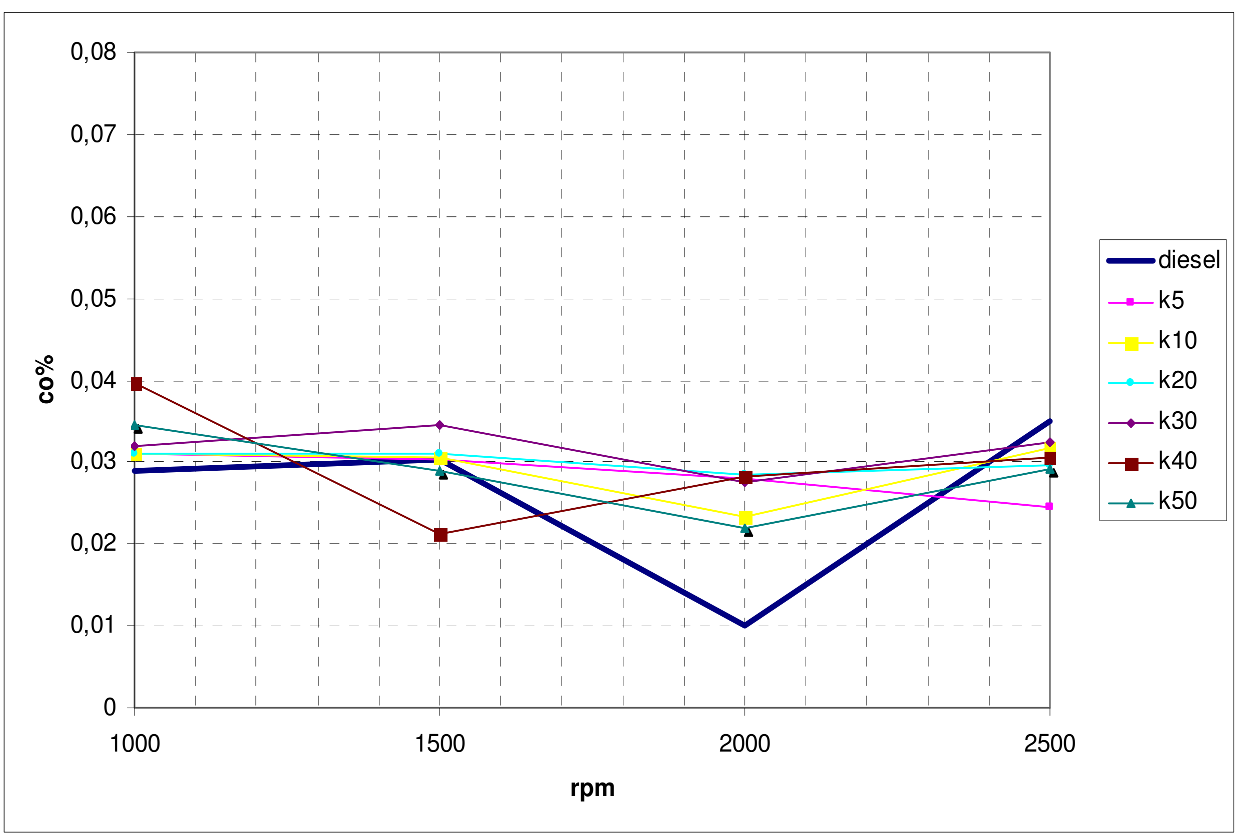

Fig. 6. The CO variation on different rpm regarding to the mixture

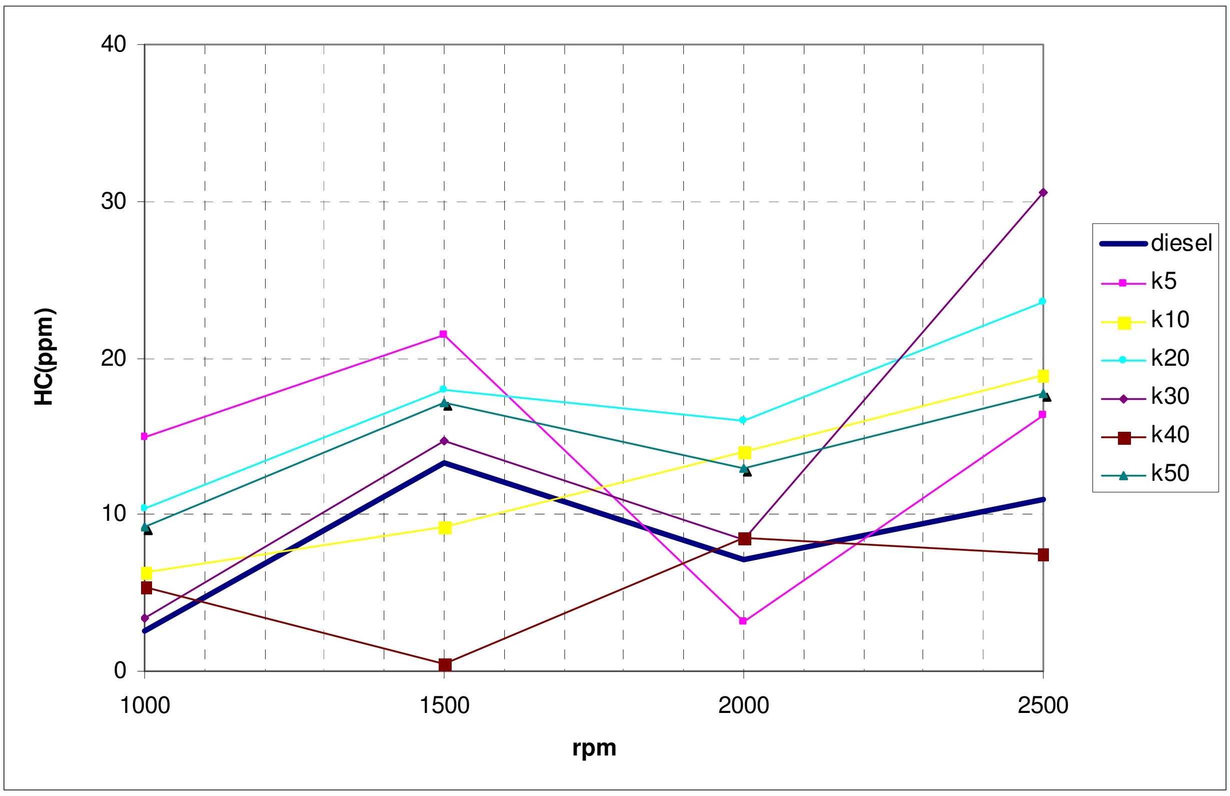

Fig. 7. The HC variation on different rpm regarding to the mixture

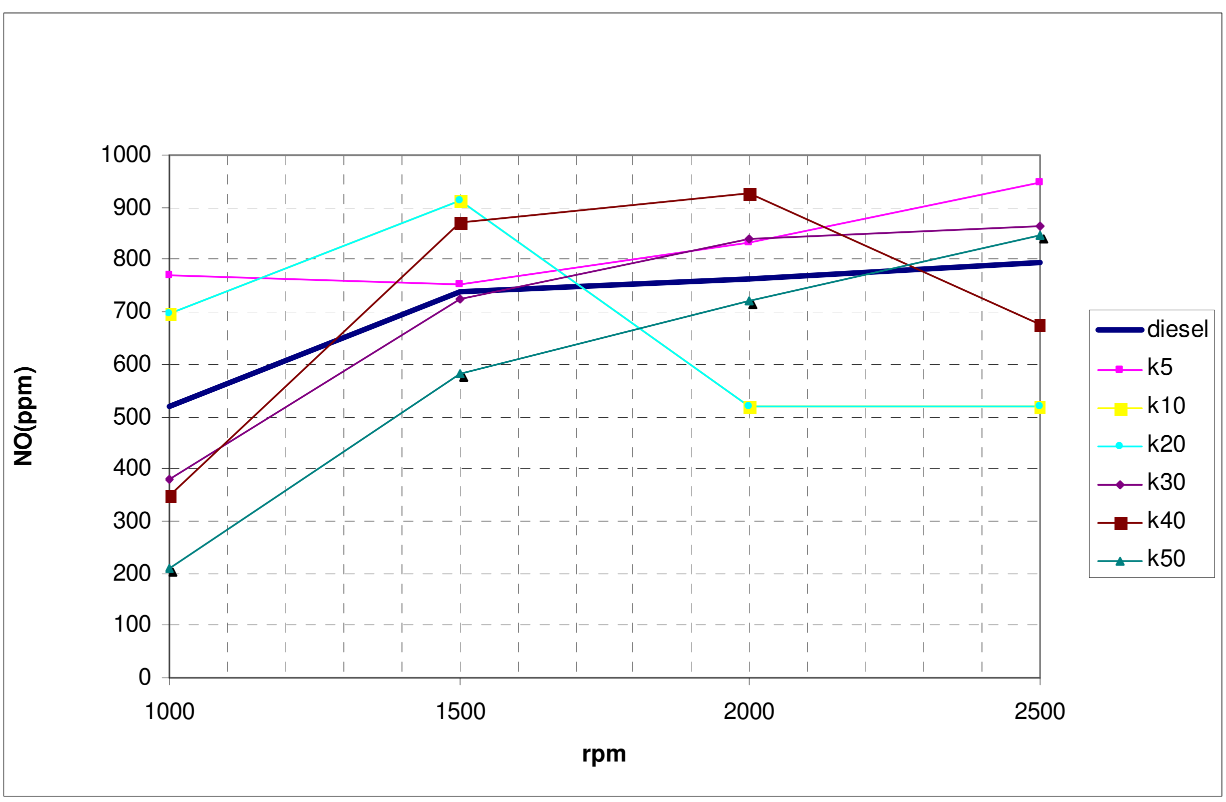

Fig. 8. The NO variation on different rpm regarding to the mixture

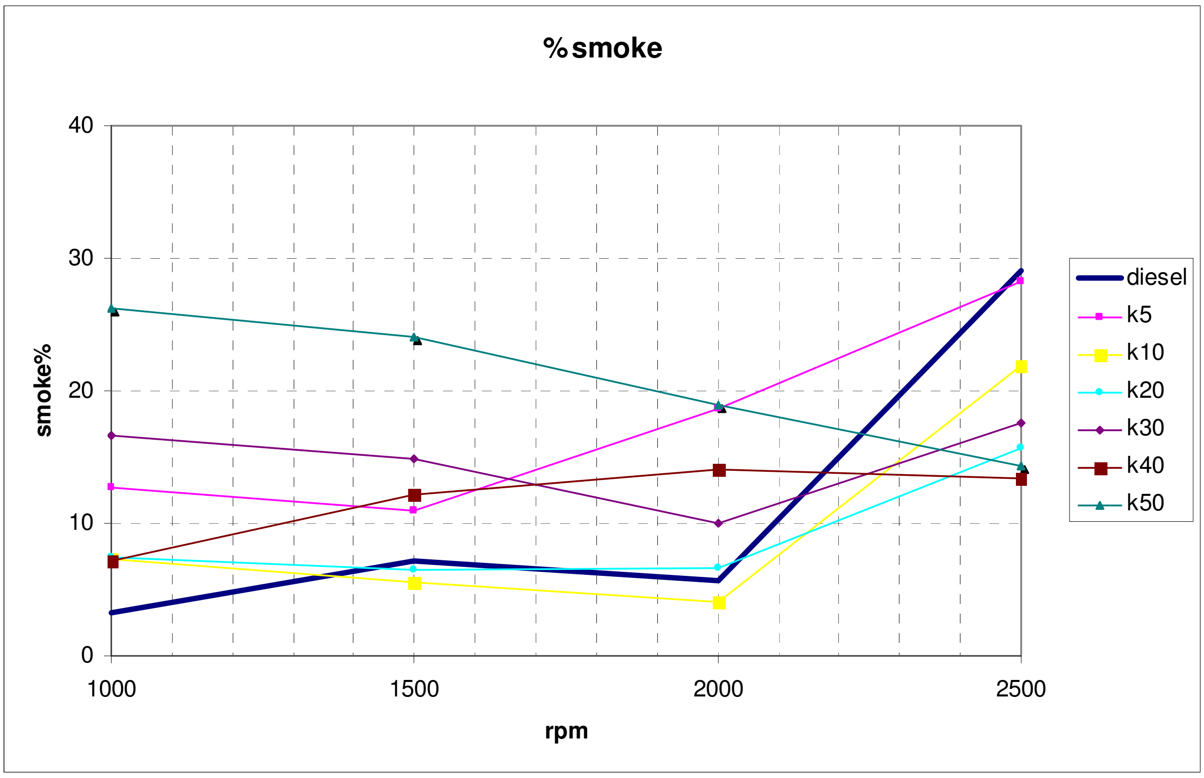

Fig. 9. The smoke variation on different rpm regarding to the mixture

From figure 6 it is clear that when the maize oil is increased on the fuel regarding to diesel, it appears an increase of CO, except in the case k40/1500rpm. From figure 7 it can be noticed the biggest reduction of HC regarding to diesel in case of k40/1500rpm. From figure 8 it can be noticed the biggest reduction of NO regarding to diesel in the case of k20/2000-2500rpm. From figure 9 it can be noticed the biggest reduction for k10/1500-2000rpm. From the above figures it is clear that the use of different mixtures can constitute changes to CO, HC, NO and smoke too. It is also important the fact that there was no changes in the rounds of the engine, as well as in the supply of water at the use of mixtures. Finally as far as the consumption is concerned, did not observed changes with the use of different mixtures. The use of mixture of diesel and maize oil has the following impacts:

- About CO it can be noticed that when the maize oil is increased on the fuel regarding to diesel, it appears a decrease of CO, except in the case k40/1500rpm.
- About HC it can be noticed the biggest reduction of HC regarding to diesel in case of k40/1500rpm
- The biggest reduction of NO regarding to Diesel is noticed in the case of k20/2000-2500rpm.
- The smoke it can be noticed the biggest reduction for k10/1500-2000rpm

2.3 Cotton oil

In the experiment stage has been used directly cotton oil in the mixture of diesel in to a four – stroke Diesel engine and not elaborated in the figure of bio-diesel. Specifically it has been used diesel, mixture diesel- 10% cotton oil(B10), diesel- 20% cotton oil(B20), diesel- 30% cotton oil (B30), diesel- 40% cotton oil (B40), diesel- 50% cotton oil (B50) in a four-stroke diesel engine [18]:

The experimental results are shown at the following tables and figures:

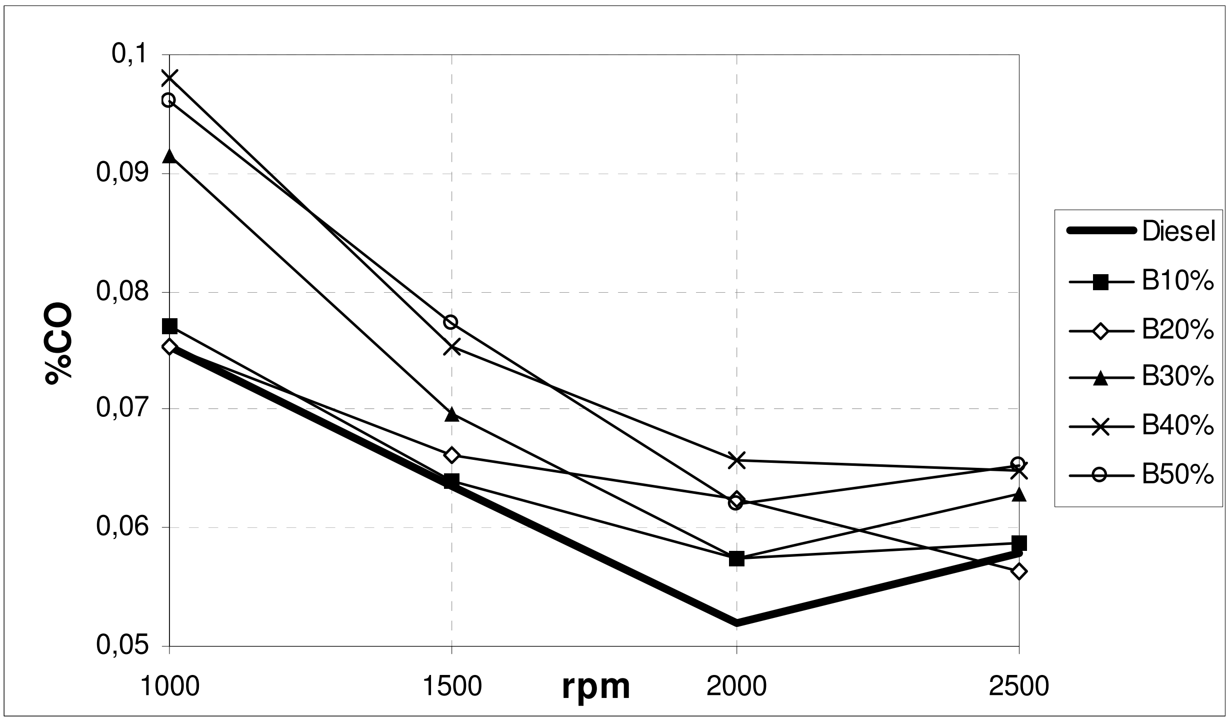

Fig. 10. The CO variation on different rpm regarding to the mixture

From figure 10 it is clear that when the cotton oil is increased on the fuel regarding to Diesel, it appears an increasement of CO.

rpm	% CO					
	Diesel	**B10**	**B20**	**B30**	**B40**	**B50**
1000	0,075	0,076	0,075	0,091	0,098	0,095
1500	0,063	0,064	0,066	0,069	0,075	0,077
2000	0,052	0,057	0,062	0,057	0,065	0,061
2500	0,057	0,058	0,056	0,062	0,064	0,065

Table 9. The CO average value variation on different rpm regarding to the mixture

rpm	HC (ppm)					
	Diesel	**B10**	**B20**	**B30**	**B40**	**B50**
1000	30,78	35,86	39,04	39,05	14,86	46,64
1500	62,86	41,18	35,59	48,74	53,84	51,34
2000	125,52	83,84	101,38	109,07	76,42	142,94
2500	78,26	84,93	169,34	103,64	167,82	105,80

Table 10. The HC average value variation on different rpm regarding to the mixture

rpm	NO (ppm)					
	Diesel	**B10**	**B20**	**B30**	**B40**	**B50**
1000	439,67	471,17	464,34	361,59	318,85	320,47
1500	649,65	660,83	626,78	611,71	565,26	522,16
2000	710,41	688,75	679,64	687,06	710,18	798,96
2500	868,88	930,50	919,53	919,08	987,35	947,80

Table 11. The no average value variation on different rpm regarding to the mixture

rpm	%smoke					
	Diesel	**B10**	**B20**	**B30**	**B40**	**B50**
1000	7,72	5,76	6,36	13,89	12,88	13,35
1500	5,81	3,16	5,41	10,72	12,17	13,62
2000	5,24	3,62	4,45	7,59	7,28	7,70
2500	10,98	7,94	9,93	7,92	9,62	9,01

Table 12. The %smoke average value variation on different rpm regarding to the mixture

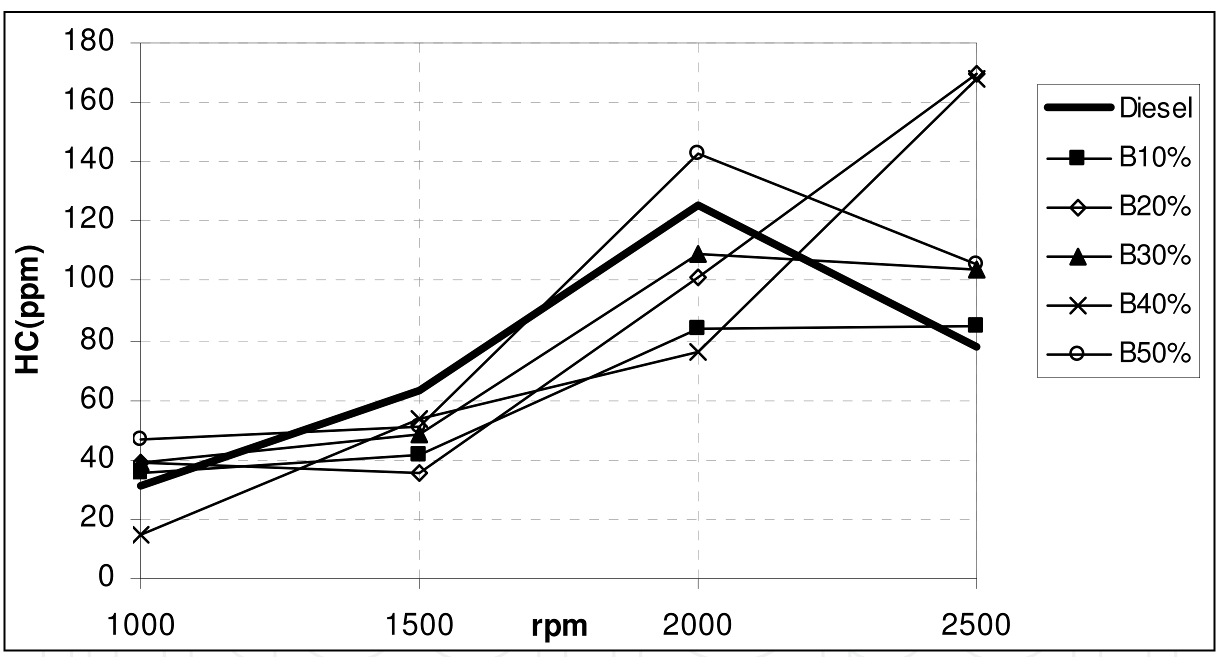

Fig. 11. The HC variation on different rpm regarding to the mixture

From figure 11 it can be noticed the biggest reduction of HC regarding to Diesel in case of the mixture B20/1500 rpm and in the case of the mixture B40/2000 rpm.
From figure 12 it can be noticed the biggest reduction of NO regarding to Diesel in the cases of the mixture B40/1000 rpm, B50/1000 rpm and B50/1500 rpm too.
From figure 13 it can be seen the reduction of smoke regarding to Diesel in case of the mixture B10 and B20 at all rounds per minute. It can also be noticed the reduction of smoke in the case of B30, B40, B50/2500 rpm. Finally it can be seen an increasement of the mixture B30, B40, B50 at all rounds regarding to Diesel. From the above figures it is clear that the use of different mixtures can constitute changes to CO, HC, NO and smoke too.

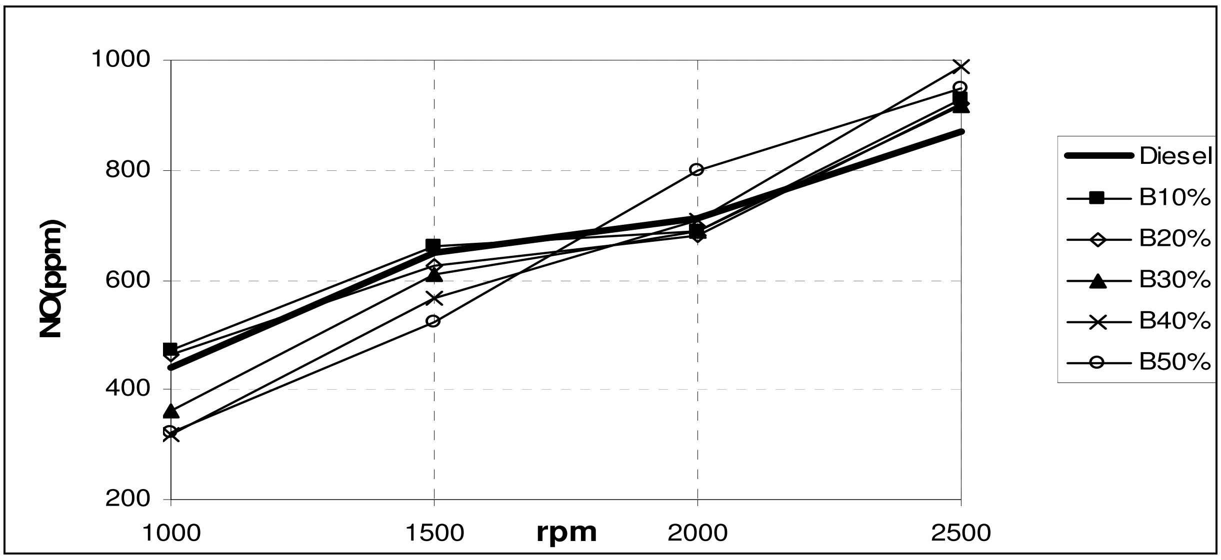

Fig. 12. The NO variation on different rpm regarding to the mixture

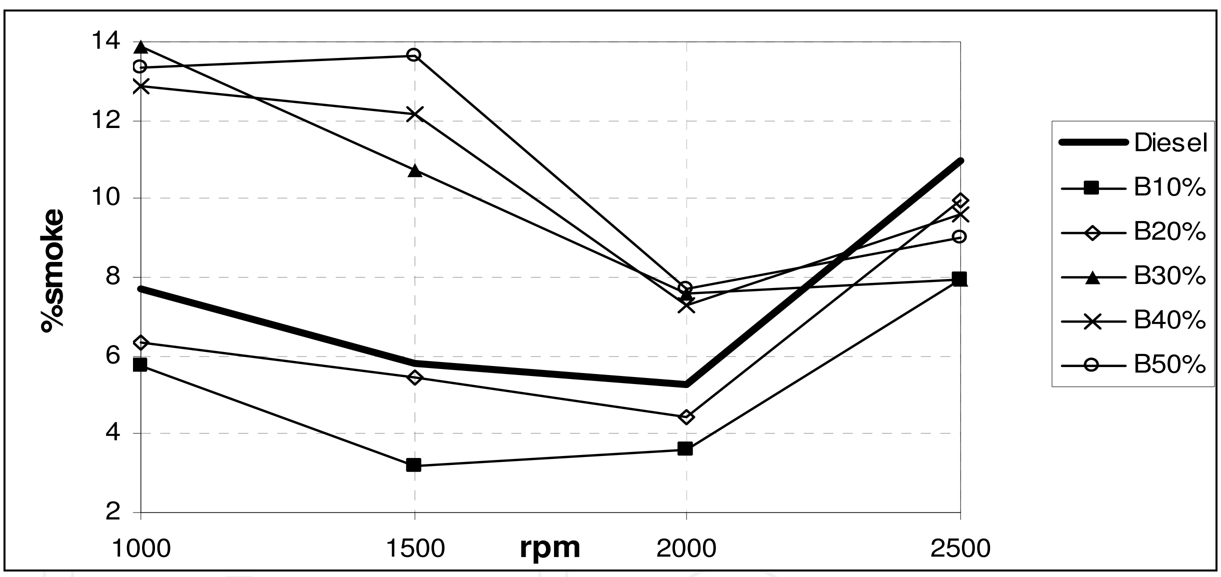

Fig. 13. The smoke variation on different rpm regarding to the mixture

It is also important the fact that there was no changes in the turns of engine, as well as in the supply of water at the use of mixtures. Finally as far as the consumption is concerned, did not exist changes with the use of different mixtures.The use of mixture of Diesel and Cotton Oil has the following impacts:

- About CO it can be noticed an increasement when the cotton oil is used as a fuel.
- About HC it can be noticed a reduction at 1500 rpm and particularly bigger reduction in the use of B20. It also appears reduction of the HC for all the mixture at 2000 rpm with the exception of B50. Finally about the HC, for all the mixture at 2500 rpm is observed increase of HC regarding to Diesel.
- About NO has been noticed a reduction at 1000 rpm and 1500 rpm for all the mixtures. A small reduction appeared for all the mixtures at 2500 rpm with the exception of B50, regarding to Diesel. Finally about the NO for all the mixtures appeared increase at 2500 rpm regarding to Diesel.

- About the smoke it can be noticed a reduction of the mixture of B20 and B10, but it appears an increasement for all other mixture in any round regarding to Diesel, with the exception of 2500 rpm, in where all the mixture appear a reduction.

2.4 Olive seed oil

In the experiment stage has been used directly cotton oil in the mixture of diesel in to a four – stroke Diesel engine. Specifically it has been used diesel, mixture diesel-5% olive seed oil (Pyrin5%), diesel-10% olive seed oil (Pyrin10%), diesel-20% olive seed oil (Pyrin20%), diesel-30% olive seed oil (Pyrin30%), diesel-40% olive seed oil (Pyrin40%), diesel-50% olive seed oil (Pyrin50%) in a four-stroke diesel engine [19]:
The experimental results are shown at the following tables and figures:

rpm	CO %						
	diesel	Pyrin 5%	Pyrin 10%	Pyrin 20%	Pyrin 30%	Pyrin 40%	Pyrin 50%
1000	0,056	0,056	0,054	0,060	0,053	0,053	0,048
1500	0,055	0,044	0,038	0,055	0,040	0,041	0,036
2000	0,043	0,038	0,031	0,050	0,031	0,036	0,030

Table 13. The CO average value variation on different rpm regarding to the mixture

rpm	HC (ppm)						
	diesel	Pyrin 5%	Pyrin 10%	Pyrin 20%	Pyrin 30%	Pyrin 40%	Pyrin 50%
1000	31,783	35,237	77,922	152,830	13,023	16,799	12,508
1500	38,001	48,434	79,198	165,479	22,954	24,870	22,860
2000	38,338	71,585	97,513	208,166	60,209	37,725	47

Table 14. The HC average value variation on different rpm regarding to the mixture

	NO (ppm)						
rpm	diesel	Pyrin 5%	Pyrin 10%	Pyrin 20%	Pyrin 30%	Pyrin 40%	Pyrin 50%
1000	518,210	415,212	375,075	392,478	372,681	473,620	362,663
1500	739,366	730,361	677,793	703,549	673,198	729,462	758,413
2000	762,155	790,676	738,929	805,702	825,376	938,210	880,990

Table 15. The NO average value variation on different rpm regarding to the mixture

rpm	%smoke						
	diesel	Pyrin 5%	Pyrin 10%	Pyrin 20%	Pyrin 30%	Pyrin 40%	Pyrin 50%
1000	9,990	12,605	14,787	12,717	11,018	9,932	16,278
1500	7,363	11,967	10,594	13,715	12,575	13,285	19,673
2000	6,634	14,212	12,201	14,131	14,098	17,528	23,359

Table 16. The %smoke average value variation on different rpm regarding to the mixture

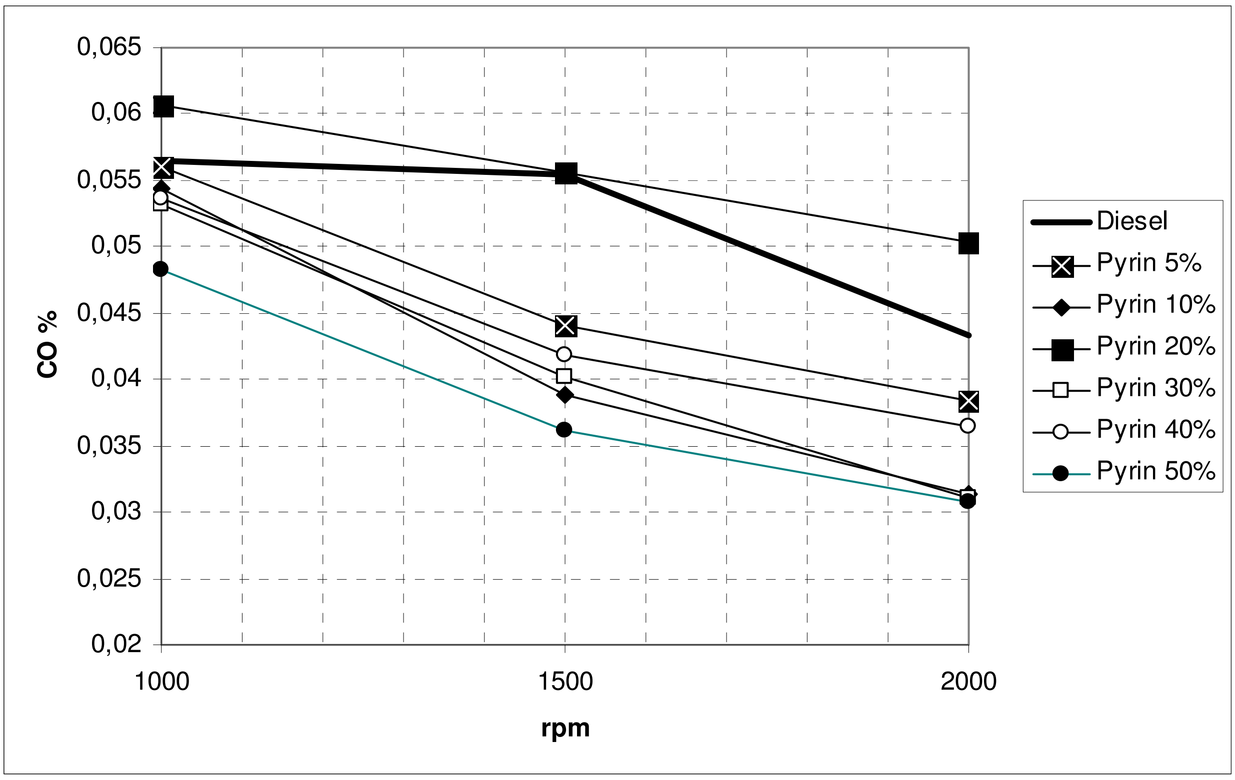

Fig. 14. The CO variation on different rpm regarding to the mixture

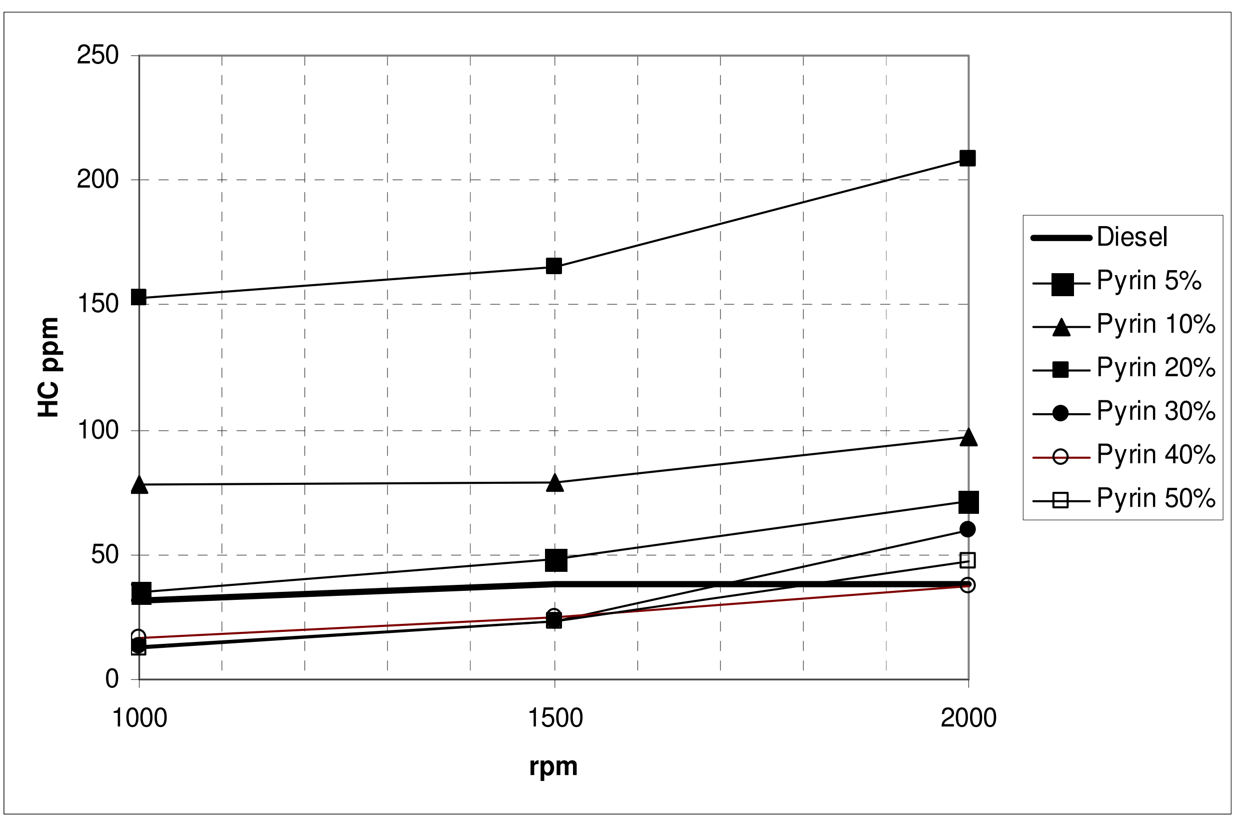

Fig. 15. The HC variation on different rpm regarding to the mixture

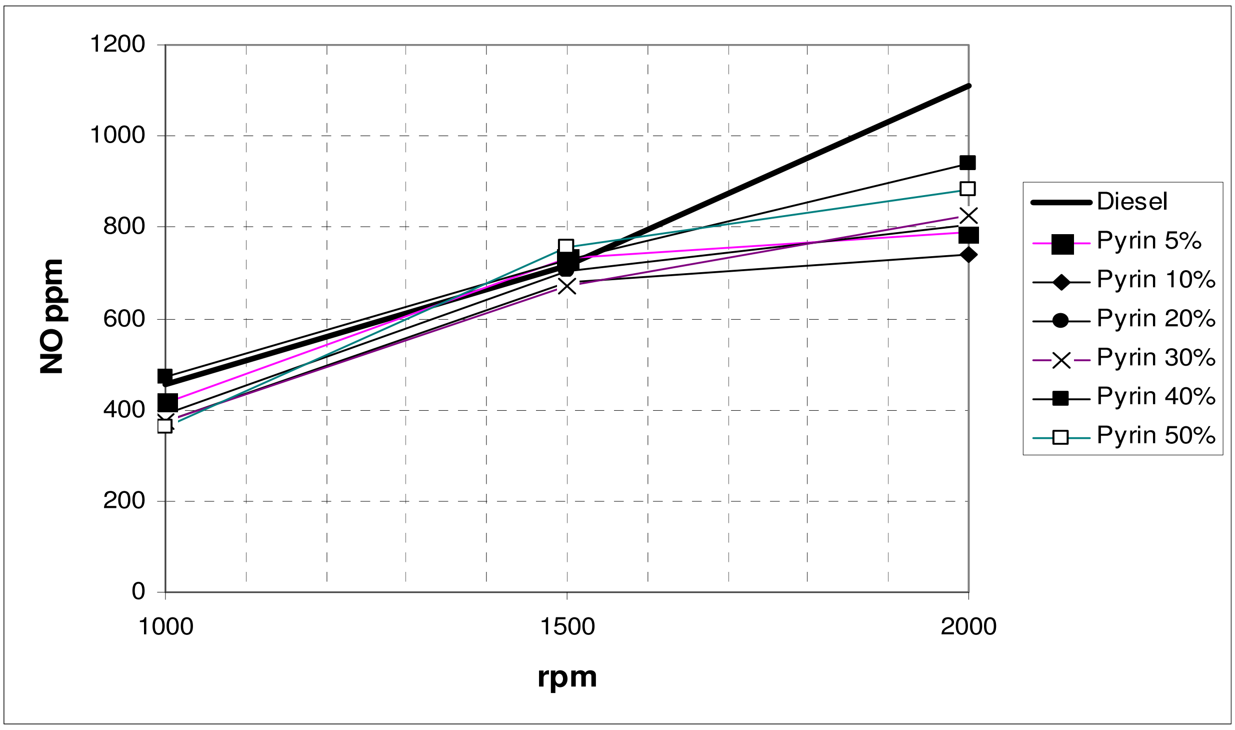

Fig. 16. The NO variation on different rpm regarding to the mixture

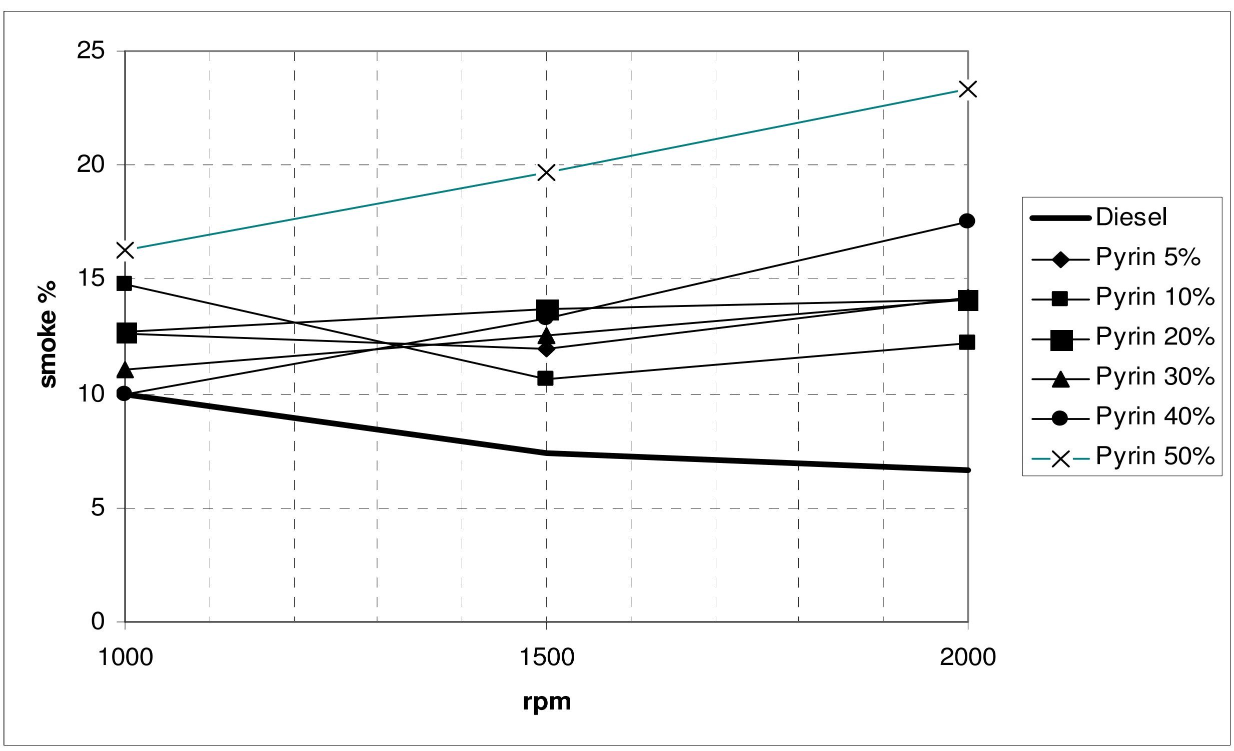

Fig. 17. The smoke variation on different rpm regarding to the mixture

From figure 14 it is clear that when the olive seed oil is increased on the fuel regarding to diesel, it appears a decrease of CO. From figure 15 it can be noticed the biggest reduction of HC regarding to diesel in case of pyrin50%. From figure 16 it can be noticed the biggest reduction of NO regarding to diesel in the case of pyrin10%/2000rpm. From figure 17 it can be noticed that the best behaviour appears on diesel. From the above figures it is clear that the use of different mixtures can constitute changes to CO, HC, NO and smoke too. It is also important the fact that there was no changes in the rounds of the engine, as well as in the supply of water at the use of mixtures. Finally as far as the consumption is concerned, did not observed changes with the use of different mixtures. The use of mixture of diesel and olive seed oil has the following impacts:

- About CO it can be noticed when the olive seed oil is increased on the fuel regarding to diesel, it appears a decrease of CO
- About HC it can be noticed the biggest reduction of HC regarding to diesel in case of pyrin50%
- The biggest reduction of NO regarding to diesel in the case of pyrin10%/2000rpm.
- The smoke it can be noticed that the best behaviour appears on diesel.

2.5 Soy oil

In the experiment stage has been used directly soy oil in the mixture of diesel in to a four – stroke Diesel engine. Specifically it has been used Diesel, mixture Diesel-5% soy oil (S5), Diesel-10% soy oil (S10), Diesel-20% soy oil (S20), Diesel-30% soy oil (S30), Diesel-40% soy oil (S40), Diesel-50% soy oil (S50) in a four-stroke diesel engine [20]:
The experimental results are shown at the following tables and figures:

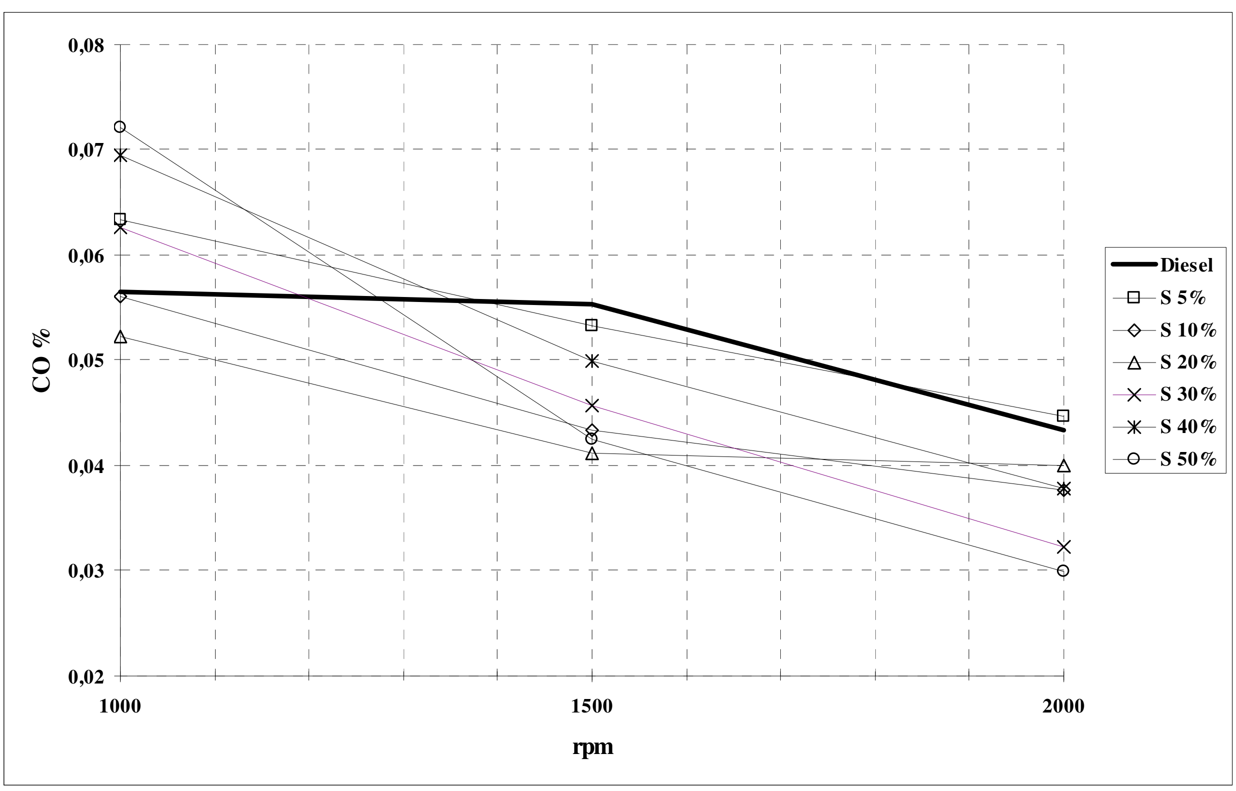

Fig. 18. The CO variation on different rpm regarding to the mixture

From figure 18 it is clear that when the soy oil is increased on the fuel regarding to diesel, it appears a decrease of CO, except in the cases S5,30,40,50/1000rpm.

rpm	HC (ppm)						
	Diesel	S5	S10	S20	S30	S40	S50
1000	31,78	21,15	21,88	8,28	5,76	54,61	28,01
1500	38,00	24,30	51,65	9,16	5,80	55,53	30,04
2000	38,33	23,70	89,90	28,68	22,34	84,88	67,47

Table 17. The CO average value variation on different rpm regarding to the mixture

rpm	NO (ppm)						
	Diesel	S5	S10	S20	S30	S40	S50
1000	454,2	387,6	397,5	416,1	414,8	341,0	277,9
1500	715,3	739,8	743,6	720,9	758,8	718,8	651,1
2000	1109,6	621,7	829,6	808,2	915,6	919,8	920,2

Table 18. The HC average value variation on different rpm regarding to the mixture

rpm	% smoke						
	Diesel	S5	S10	S20	S30	S40	S50
1000	9,99	8,72	9,41	11,61	14,26	18,32	24
1500	7,36	8,23	8,43	9,87	13,02	18,21	17,84
2000	6,63	6,25	7,70	8,08	11,27	17,21	20,5

Table 19. The NO average value variation on different rpm regarding to the mixture

rpm	CO %						
	Diesel	S5	S10	S20	S30	S40	S50
1000	0,056	0,063	0,056	0,052	0,062	0,069	0,072
1500	0,055	0,053	0,043	0,041	0,045	0,049	0,042
2000	0,043	0,044	0,037	0,04	0,032	0,037	0,029

Table 20. The %smoke average value variation on different rpm regarding to the mixture

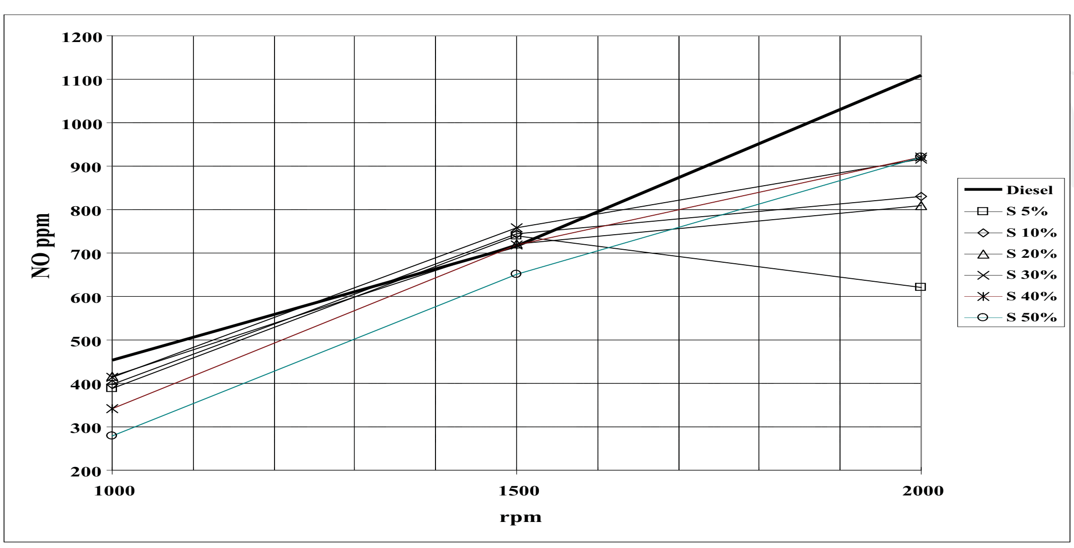

Fig. 19. The HC variation on different rpm regarding to the mixture

From figure 19 it can be noticed the biggest reduction of HC regarding to diesel in case of the mixtures S5, S20 and the mixture S40.

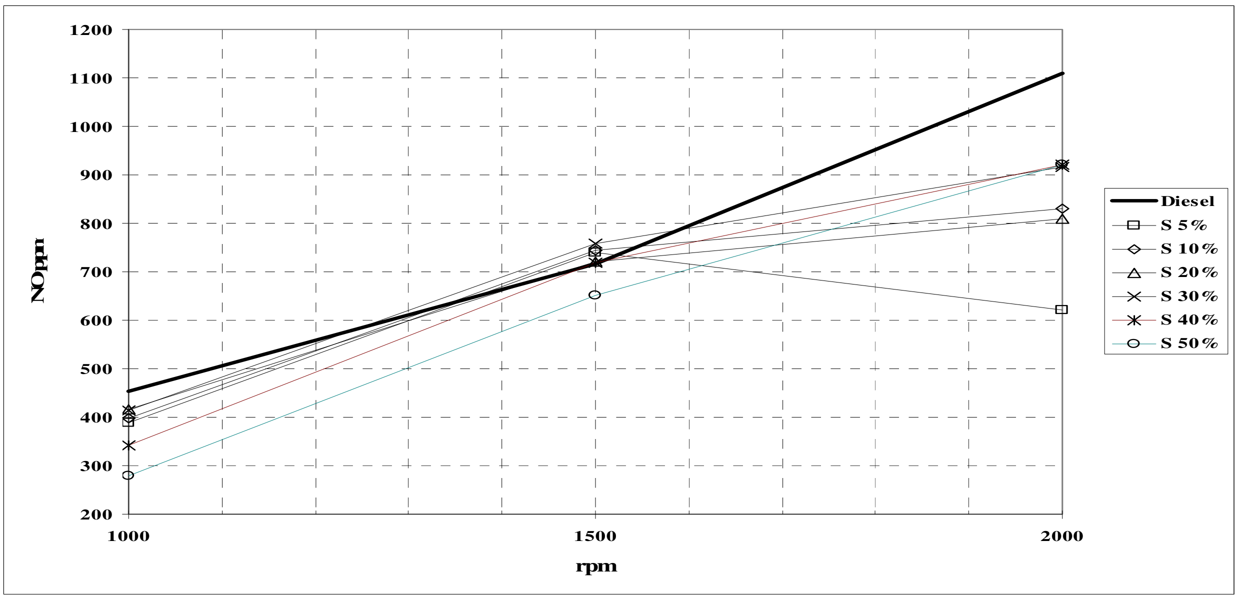

Fig. 20. The NO variation on different rpm regarding to the mixture

From figure 20 it can be noticed the biggest reduction of NO regarding to Diesel in the case of the mixture S50.

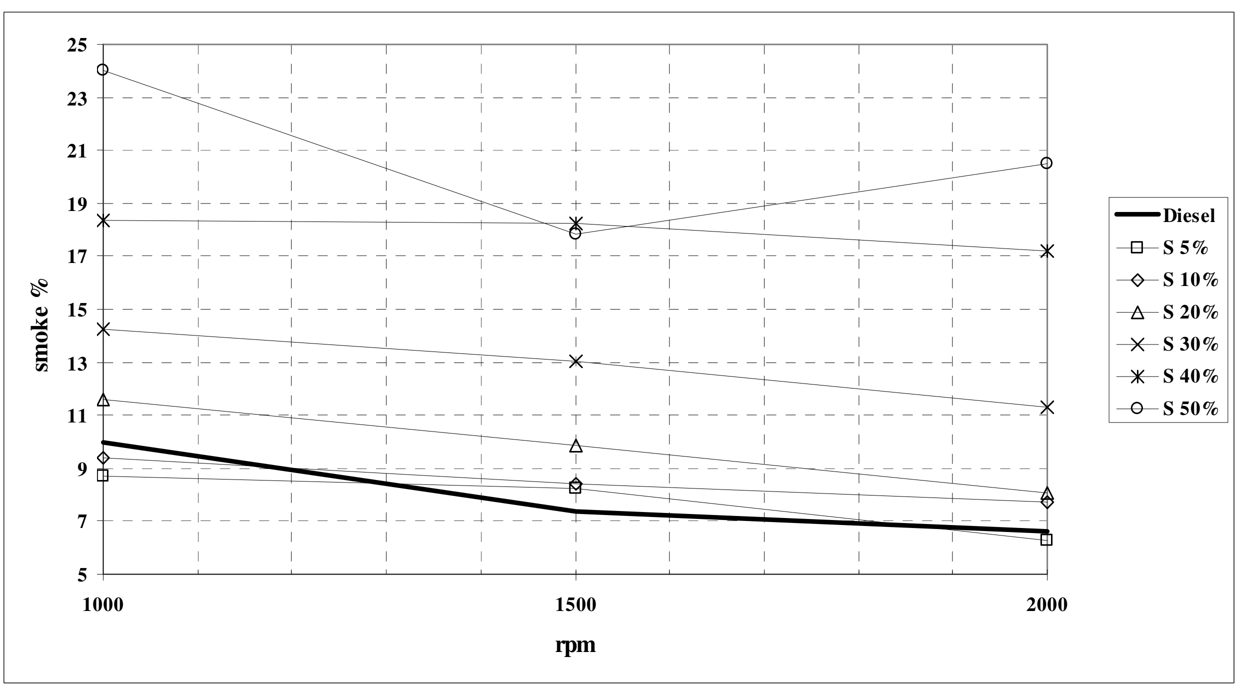

Fig. 21. The smoke variation on different rpm regarding to the mixture

From figure 21 it can be seen the increase of smoke regarding to diesel for all the mixtures. From the above figures it is clear that the use of different mixtures can constitute changes to CO, HC, NO and smoke too. It is also important the fact that there was no changes in the rounds of the engine, as well as in the supply of water at the use of mixtures. Finally as far as the consumption is concerned, did not observed changes with the use of different mixtures. The use of mixture of diesel and soy oil has the following impacts:

- About CO it can be noticed that when the soy oil is increased on the fuel regarding to diesel, it appears a decrease of CO, except in the cases S5,30,40,50/1000rpm.
- About HC it can be noticed the biggest reduction of HC regarding to diesel in case of the mixtures S5, S20 and the mixture S40.In the case of S30 appears the maximum increase of HC in relation to diesel.
- The biggest reduction of NO regarding to Diesel is noticed in the case of the mixture S50.
- The smoke is increased regarding to diesel for all the mixtures. Except the cases S5,50/1000rpm.

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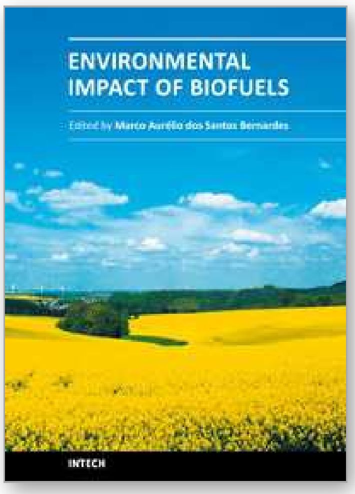

Environmental Impact of Biofuels

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This book aspires to be a comprehensive summary of current biofuels issues and thereby contribute to the understanding of this important topic. Readers will find themes including biofuels development efforts, their implications for the food industry, current and future biofuels crops, the successful Brazilian ethanol program, insights of the first, second, third and fourth biofuel generations, advanced biofuel production techniques, related waste treatment, emissions and environmental impacts, water consumption, produced allergens and toxins. Additionally, the biofuel policy discussion is expected to be continuing in the foreseeable future and the reading of the biofuels features dealt with in this book, are recommended for anyone interested in understanding this diverse and developing theme.

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