Lampiran 1

PGM-FI FUEL INJECTION **Specification**

Panjang x lebar X tinggi	1.881 x 706 x 1.081,5 mm.
Jarak sumbu roda	1.239 mm.
Jarak terendah ke tanah	130 mm.
Berat kosong	105.6 kg (tipe CW) 105.7 kg (tipe spoke)
Tipe rangka	Tulang punggung
Tipe suspensi depan	Teleskopik
Tipe suspensi belakang	Lengan ayun dengan pegas ganda
Ukuran ban depan	70/90 – 17 M/C 38P
Ukuran ban belakang	80/90 – 17 M/C 44P
Tipe Velg	Cast wheel Alumunium Alloy (tipe CW) Spoke / Jari-jari (tipe Spoke)
Rem Depan	Cakram Hidrolik dengan piston ganda
Rem Belakang	Tromol
Kapasitas tangki bahan bakar	3,7 liter.
Sistem bahan bakar	Fuel Injection (PGM-FI)
Tipe mesin	4 langkah, SOHC, pendinginan.
Diameter x langkah	52,4 x 57,9 mm.
Volume langkah	124,8 cc.
Perbandingan kompresi	9,0 : 1
Daya maksimum	9,18 PS/ 7.500 rpm.
Torsi maksimum	0,99 kgf.m/ 5.000 rpm.
Kapasitas minyak pelumas mesin	0,7 liter pada penggantian periodik.
Kopling	Ganda, otomatis, sentrifugal, tipe basah.
Gigi transmisi	4 kecepatan rotari / bertautan tetap.
Pola pengoperan gigi	N-1-2-3-4-N
Starter	Pedal dan elektrik.
Aki	MF 12 V – 3,5 Ah.
Busi	ND U20EPR9 / NGK CPR6EA-9
Sistem pengapian	Full transistorized

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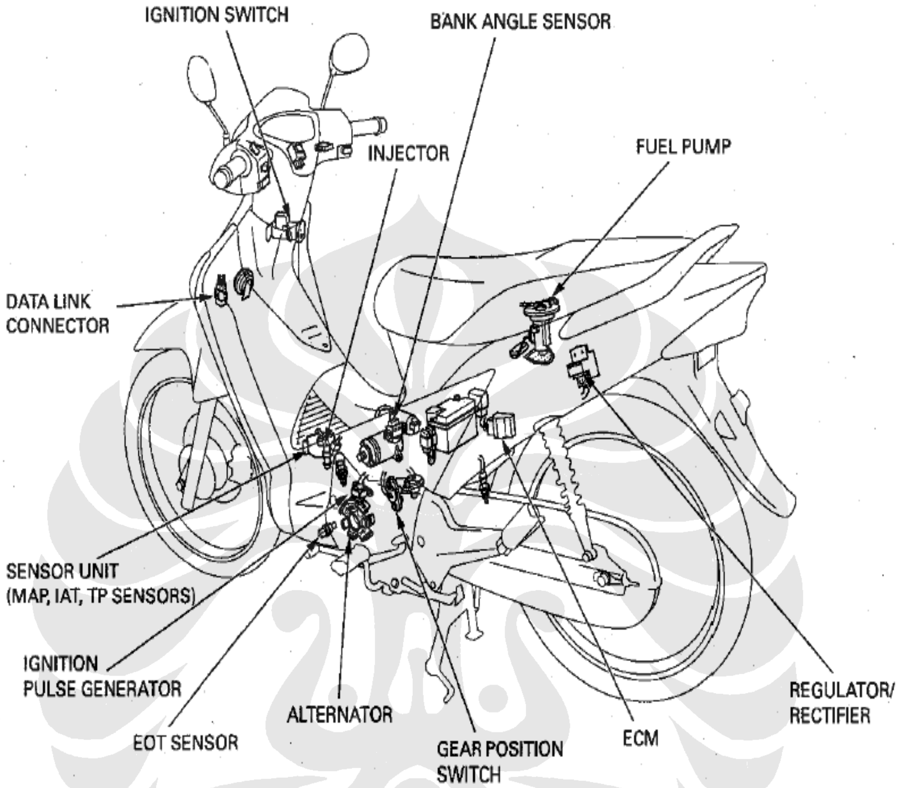
PGM-FI SYSTEM LOCATION



Lampiran 3

LEMBAR PENGAMBILAN DATA

Bahan Bakar : Premium Tanggal : 14 Desember 2008

Waktu pengapian : 10° BTDC

No	Putaran (rpm)	Daya (HP)	Konsumsi BB untuk setiap 10mL (s)	CO (%)	CO2 (%)	O2 (%)	HC (ppm)	NOx (ppm)	λ (Lamda)
1	3500	3,3	71	1,88	6,2	10,1	185	790	1,737
2	4000	4,05	66	2,44	6,4	9,3	145	712	1,594
3	4500	4,7	60	1,65	7,6	8,4	132	1263	1,535
4	5000	5,3	47	3,04	7,6	7	165	863	1,319
5	5500	6	42	3,58	8	5,9	185	907	1,225
6	6000	6,55	33	3,55	8,8	4,9	182	1029	1,139
7	6500	6,98	30	3,38	9,5	4,2	177	1317	1,077
8	7000	7,1	26	3,44	10,2	3,06	178	1429	1,034

Bahan Bakar : E10 (90% premium + 10% etanol) Tanggal : 14 Desember 2008

Waktu pengapian : 10° BTDC

No	Putaran (rpm)	Daya (HP)	Konsumsi BB untuk setiap 10mL (s)	CO (%)	CO2 (%)	O2 (%)	HC (ppm)	NOx (ppm)	λ (Lamda)
1	3500	3,33	59	1,01	6,5	10,5	150	1161	1,87
2	4000	4,1	49	1,58	7	9,3	131	1088	1,664
3	4500	4,73	49	1,38	7,6	8,6	126	1346	1,597
4	5000	5,35	40	2,39	7,8	7,3	149	1093	1,384
5	5500	6,05	37	2,79	8,9	6,3	169	1122	1,28
6	6000	6,65	31	2,96	8,9	5,4	168	1093	1,196
7	6500	7,05	29	2,49	10,1	4,1	162	1459	1,141
8	7000	7,2	26	2,72	10,6	3,24	152	1473	1,070

(Lanjutan)

LEMBAR PENGAMBILAN DATA

Bahan Bakar : E20 (80% premium + 20% etanol)

Tanggal : 14 Desember 2008

Waktu pengapian : 10^o BTDC

No	Putaran (rpm)	Daya (HP)	Konsumsi BB untuk setiap 10mL (s)	CO (%)	CO2 (%)	O2 (%)	HC (ppm)	NOx (ppm)	λ (Lamda)
1	3500	3,25	51	0,89	6,8	10,1	138	1171	1,888
2	4000	4,05	47	0,85	7,1	9,6	135	1244	1,782
3	4500	4,8	44	0,28	8	9	120	1673	1,725
4	5000	5,45	38	1,3	8,2	7,7	137	1346	1,498
5	5500	6,1	33	2,19	8,7	6,1	164	1210	1,306
6	6000	6,75	29	1,85	9,5	5,9	156	1522	1,253
7	6500	7,13	26	1,7	10,7	3,92	162	1873	1,154
8	7000	7,3	24	1,70	11,2	3,16	163	2000	1,104

Bahan Bakar : E30 (70% premium + 30% etanol)

Tanggal : 14 Desember 2008

Waktu pengapian : 10^o BTDC

No	Putaran (rpm)	Daya (HP)	Konsumsi BB untuk setiap 10mL (s)	CO (%)	CO2 (%)	O2 (%)	HC (ppm)	NOx (ppm)	λ (Lamda)
1	3500	3,3	51	0,13	7,1	10,3	112	1595	1,973
2	4000	4,15	46	0,21	7,5	9,6	116	1527	1,848
3	4500	4,8	43	0,11	8,1	8,8	116	1781	1,788
4	5000	5,43	36	0,57	8,6	7,8	126	1639	1,554
5	5500	6,05	32	1,27	9,3	6,3	144	1605	1,363
6	6000	6,68	28	0,98	10,1	5,4	144	1981	1,298
7	6500	7,1	28	0,42	11,1	4,4	130	2000	1,242
8	7000	7,3	23	0,41	11,9	3,41	134	2000	1,172

Lampiran 4

Dyno Dynamics - AWD450DS Chassis Dynamometer

- Rear wheel drive
- Front wheel drive
- 4WD/AWD cars, recreational vehicles (with selectable single axle drive)
- 2WD/4WD race cars
- Sport utility vehicles
- Light commercial vehicles
- Motorcycles (with optional adapter)
- Front wheel drive
- Rear wheel drive
- All wheel drive
- Locked Front:Rear AWD
- Full time AWD
- Viscous coupled AWD
- Intelligent european AWD (Volvo dog clutch)
- Variable ratio Front:rear

Maximum vehicle weight 4,500 kg (9,900 lb) Maximum axle weight (per axle) 2,250 kg (4,450 lb)

Minimum wheelbase 2,250 mm (89") Maximum wheelbase 3, 500 mm (138")

Lampiran 5

Properties Bahan Bakar

TABLE A-2 Properties of Fuels

Fuel		Molecular Weight	Heating Value HHV (kJ/kg)	Heating Value LHV (kJ/kg)	Stoichiometric $(AF)_s$	Stoichiometric $(FA)_s$	Octane Number MON	Octane Number RON	Heat of Vaporization (kJ/kg)	Cetane Number
gasoline	C_8H_{15}	111	47300	43000	14.6	0.068	80–91	92–99	307	
light diesel	$C_{12.3}H_{22.2}$	170	44800	42500	14.5	0.069			270	40–55
heavy diesel	$C_{14.6}H_{24.8}$	200	43800	41400	14.5	0.069			230	35–50
isooctane	C_8H_{18}	114	47810	44300	15.1	0.066	100	100	290	
methanol	CH_3OH	32	22540	20050	6.5	0.155	92	106	1147	
ethanol	C_2H_5OH	46	29710	26950	9.0	0.111	89	107	873	
methane	CH_4	16	55260	49770	17.2	0.058	120	120	509	
propane	C_3H_8	44	50180	46190	15.7	0.064	97	112	426	
nitromethane	CH_3NO_2	61	12000	10920	1.7	0.588			623	
heptane	C_7H_{16}	100	48070	44560	15.2	0.066	0	0	316	
cetane	$C_{16}H_{34}$	226	47280	43980	15.0	0.066			292	100
heptamethylnonane	$C_{12}H_{34}$	178			15.9	0.063				15
α-methylnaphthalene	$C_{11}H_{10}$	142			13.1	0.076				0
carbon monoxide	CO	28	10100	10100	2.5	0.405				
coal (carbon)	C	12	33800	33800	11.5	0.087				
butene-1	C_4H_8	56	48210	45040	14.8	0.068	80	99	390	
triptane	C_7H_{16}	100	47950	44440	15.2	0.066	101	112	288	
isodecane	$C_{10}H_{22}$	142	47590	44220	15.1	0.066	92	113		
toluene	C_7H_8	92	42500	40600	13.5	0.074	109	120	412	
hydrogen	H_2	2	141800	120000	34.5	0.029		90		

Properties of some common fuels and hydrocarbons

Fuel (phase)	Formula	Molar mass, kg/kmol	Density[1], kg/L	Enthalpy of vaporization[2], kJ/kg	Specific heat[1], C_p kJ/kg · C	Higher heating value[3], kJ/kg	Lower heating value[3], kJ/kg
Carbon (s)	C	12.011	2	—	0.708	32,800	32,800
Hydrogen (g)	H_2	2.016		—	14.4	141,800	120,000
Carbon monoxide (g)	CO	28.013	—	—	1.05	10,100	10,100
Methane (g)	CH_4	16.043	—	509	2.20	55,530	50,050
Methanol (ℓ)	CH_4O	32.042	0.790	1168	2.53	22,660	19,920
Acetylene (g)	C_2H_2	26.038	—	—	1.69	49,970	48,280
Ethane (g)	C_2H_6	30.070	—	172	1.75	51,900	47,520
Ethanol (ℓ)	C_2H_6O	46.069	0.790	919	2.44	29,670	26,810
Propane (ℓ)	C_3H_8	44.097	0.500	420	2.77	50,330	46,340
Butane (ℓ)	C_4H_{10}	58.123	0.579	362	2.42	49,150	45,370
1-Pentene (ℓ)	C_5H_{10}	70.134	0.641	363	2.20	47,760	44,630
Isopentane (ℓ)	C_5H_{12}	72.150	0.626	—	2.32	48,570	44,910
Benzene (ℓ)	C_6H_6	78.114	0.877	433	1.72	41,800	40,100
Hexene (ℓ)	C_6H_{12}	84.161	0.673	392	1.84	47,500	44,400
Hexane (ℓ)	C_6H_{14}	86.177	0.660	366	2.27	48,310	44,740
Toluene (ℓ)	C_7H_8	92.141	0.867	412	1.71	42,400	40,500
Heptane (ℓ)	C_7H_{16}	100.204	0.684	365	2.24	48,100	44,600
Octane (ℓ)	C_8H_{18}	114.231	0.703	363	2.23	47,890	44,430
Decane (ℓ)	$C_{10}H_{22}$	142.285	0.730	361	2.21	47,640	44,240
Gasoline (ℓ)	$C_nH_{1.87n}$	100–110	0.72–0.78	350	2.4	47,300	44,000
Light diesel (ℓ)	$C_nH_{1.8n}$	170	0.78–0.84	270	2.2	46,100	43,200
Heavy diesel (ℓ)	$C_nH_{1.7n}$	200	0.82–0.88	230	1.9	45,500	42,800
Natural gas (g)	$C_nH_{3.8n}N_{0.1n}$	18	—	—	2	50,000	45,000

[1] At 1 atm and 20°C.

[2] At 25°C for liquid fuels, and 1 atm and normal boiling temperature for gaseous fuels.

[3] At 25°C. Multiply by molar mass to obtain heating values in kJ/kmol.

Lampiran 6

Jurnal ilmiah mengenai campuran gasoline-ethanol

Judul	: ENVIRONMENTAL CONTRIBUTION OF GASOLINE-ETHANOL MIXTURE
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Sumber	: http://www.wseas.us/e-library/conferences/2006elounda2/papers/538-327.pdf

ENVIRONMENTAL CONTRIBUTION OF GASOLINE-ETHANOL MIXTURES

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Abstract: This paper deals with the use of gasoline-ethanol mixtures at a small four-stroke engine of internal combustion that is used for the movement of a small alternative generator. The mixtures that were used are: gasoline, gasoline-10%ethanol, gasoline-20%ethanol, gasoline-30%ethanol, gasoline-40%ethanol, gasoline-50%ethanol, gasoline-60%ethanol, gasoline-70%ethanol gasoline-80%ethanol gasoline-90%ethanol and 100% ethanol. During the use of these mixtures it was observed CO and HC emissions decrease when the percentage of ethanol in the fuel was increased, without any engine malfunction and under different load conditions (without load conditions and under full electrical load conditions). There was an exception with the mixtures: gasoline-90%ethanol and 100%ethanol for which the engine malfunctioned and the HC emissions were increased. It is important to mention that the ethanol that was used was 95^{o} alcoholic degrees and not 100% pure ethanol. Furthermore, during the use of the mixtures of gasoline-ethanol there was a small increase of fuel consumption when the percentage of the ethanol in the fuel was increased.

Key-Words: - **Ethanol mixtures, gas emissions**

1 Introduction

Today, one of the grater problems that humanity faces, is the environmental pollution. As humanity enters the new millennium, the interdependence of our world community is more comprehensible. Environmental pollution doesn't recognize country borders. Developed and also developing countries have increased industrial activity that rises the concentration of dangerous gases in the atmosphere that contribute to atmospheric pollution. Furthermore the increased vehicle number that usually uses petroleum-based fuels results to dangerous emissions production such as carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), nitrogen oxides (NO_x) and others. These emissions besides the fact that lead to environmental degradation they also constitute a threat for human health. People's concern about the risks associated with hazardous pollutants results to an increased demand for renewable fuels as alternatives to fossil fuels[1,2,3].

Fuel ethanol is an alternative fuel that is produced from biologically renewable resources that it can also be used as an octane enhancer and as oxygenate. Ethanol (ethyl alcohol, grain alcohol, ETOH) is a clear, colorless liquid alcohol with characteristic odor and as alcohol is a group of chemical compounds whose molecules contain a hydroxyl group, -OH, bonded to a carbon atom. Is produced with the process of fermentation of grains such as wheat, barley, corn, wood, or sugar cane. In the United States ethanol is made by the fermentation of corn [1]. By the reaction of fermentation simple sugars change into ethanol and carbon dioxide with the presence of zymase, an enzyme from yeast. Ethanol can also be made from cellulose that is obtained from agricultural residue and waste paper [1].

It is a high-octane fuel with high oxygen content (35% oxygen by weight) and when blended properly in gasoline produces a cleaner and more complete combustion. Ethanol is used as an automotive fuel either by itself or in blends with gasoline, such as mixtures of 10% ethanol and 90%gasoline, or 85% ethanol and 15% gasoline[3,4,5]. Many countries around the world use ethanol as fuel. For example, in Brazil ethanol is produced using as raw material sugarcane and many vehicles use ethanol as fuel. Also in Canada and in Sweden ethanol is highly promoted as fuel because of the many environmental benefits that ethanol has. When gasoline is used as fuel hydrocarbons (HC) escape to the atmosphere. Many hydrocarbons are toxic and some, such as benzene, cane cause cancer to humans. If ethanol is used as fuel hydrocarbons are not being produced because ethanol is an alcohol that does not produce HC when is burned. The reaction of hydrocarbons and nitrogen oxides that are produced from the gasoline burning, in the presence of sunlight leads to the formation of photochemical smog. The use of ethanol as fuel can contribute to the decrease of photochemical smog since it does not produces hydrocarbons[6,7,8].

Vehicles that burn petroleum fuels produce carbon monoxide (CO) because these fuels do not contain oxygen in their molecular structure. Carbon monoxide is a toxic gas that is formed by incomplete combustion. When ethanol, which contains oxygen, is mixed with gasoline the combustion of the engine is more complete and the result is CO reduction[9,10].

Using renewable fuels, such as ethanol, there is also a reduction of carbon dioxide (CO_2) in the atmosphere. Carbon dioxide is non-toxic but contributes to the greenhouse effect. Because of the fact that plants absorb carbon dioxide and give off oxygen, the amount of CO_2 that is formed during combustion is balanced by that absorbed by plants used to produce ethanol. That is why the use of ethanol will partially offset the greenhouse effect that is formed by carbon dioxide emissions of burning gasoline[11,12].

Ethanol, as an octane enhancer, can substitute benzene and other benzene-like compounds, which are powerful liver carcinogens, and reduce their emissions to the atmosphere. Besides the environmental benefits, production and use of ethanol, which is a renewable fuel, increases economic activity, creates job openings, stabilizes prices and can increase farm income. That is why ethanol as an automotive fuel has many advantages. Renewable fuels such as ethanol will probably replace petroleum-based fuels in the near future because petroleum reserves are not sufficient enough to last many years. 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-ethanol behave in a four-stroke engine from the aspect of emissions, function and fuel consumption.

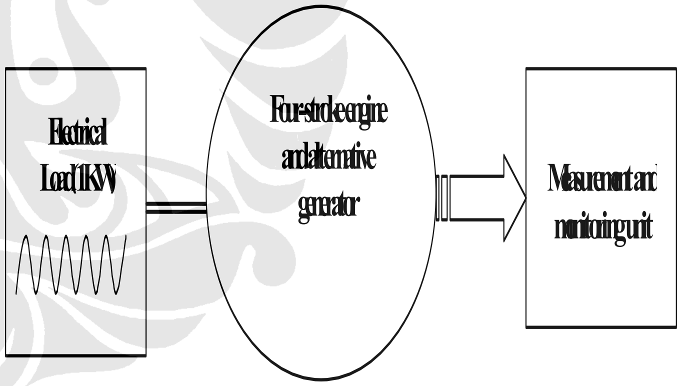
2 Problem Formulation - Problem Solution

The experimental measurements were carried out on a four-stroke, air-cooled engine. This is a one-cylinder engine with 123cm^3 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%ethanol, gasoline-20%ethanol, gasoline-30%ethanol, gasoline-40%ethanol, gasoline-50%ethanol, gasoline-60%ethanol, gasoline-70%ethanol gasoline-80%ethanol gasoline-90%ethanol and 100% ethanol. 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 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 gasmeasurements 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 CO and HC emissions, are represented in the figures below, for the mixtures: gasoline, gasoline-20%ethanol, gasoline-40%ethanol, gasoline-60%ethanol, gasoline-80%ethanol, gasoline-90%ethanol and 100% ethanol for every fuel and for every load conditions. For the mixtures gasoline-10%ethanol, gasoline-30%ethanol, gasoline-50%ethanol, gasoline-70%ethanol and only the average values of the emissions (CO, HC) are presented because from the average values, the variation of those emissions can be better understood.

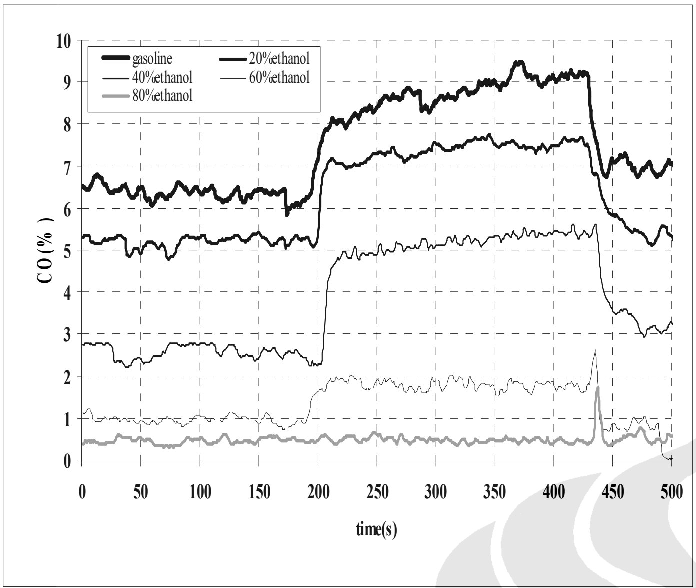


Figure 1. The CO variation about the mixtures, gasoline, gasoline-20% ethanol, gasoline-40% ethanol, gasoline-60% ethanol and gasoline- 80% ethanol

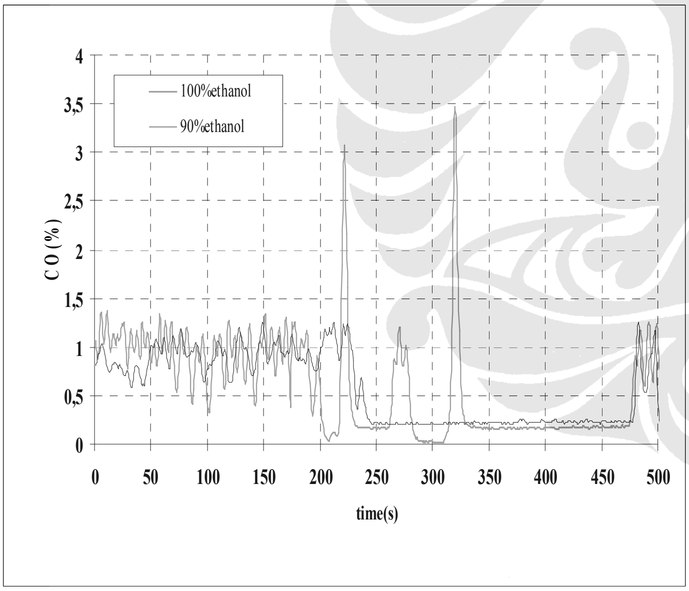


Figure 2. The CO variation about the mixtures, gasoline-90%ethanol and 100% ethanol

Figures 1 and 2 present the CO variation for the mixtures: gasoline, gasoline-20%ethanol, gasoline-40%ethanol, gasoline-60%ethanol, gasoline-80%ethanol, gasoline-90%ethanol and 100%ethanol, when the engine functions without load and under full electrical load conditions(1KW). The CO emissions are decreased during the tests while the percentage of ethanol in the fuel is increased. In figure 2 was presented the CO variation for the mixture gasoline-90%ethanol and 100%ethanol, because when these fuels are used there is a malfunction of the engine. The average values of CO emissions for every mixture separately and for every load conditions are presented in the figure 3 below:

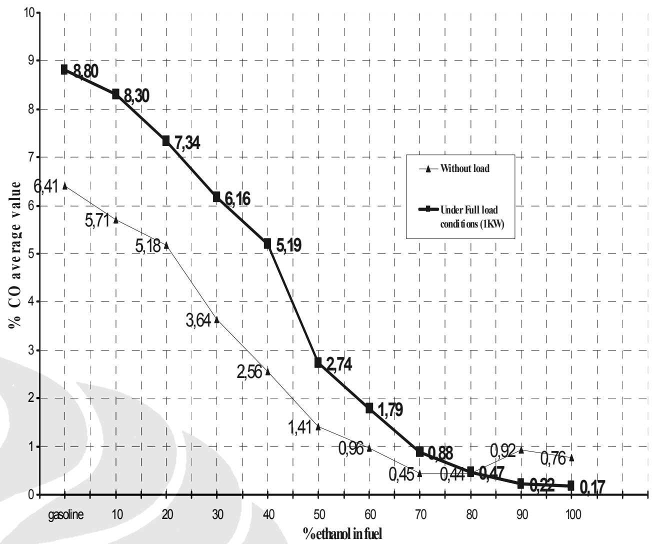


Figure 3. The CO average value variation.

Figure 3 presents CO emissions decrease when the percentage of the ethanol in the fuel is increased. Two conditions are presented: without load condition and full electrical load condition(1KW). At without load conditions CO emissions start with the value 6,41% that corresponds to gasoline, then the lower value is 0,44% that corresponds to gasoline-80%ethanol mixture and the final value is 0,70% that corresponds to 100% ethanol fuel. At full load conditions the average value of CO emissions starts with the value 8,80% that corresponds to gasoline and the lower value 0,17% is observed when 100% ethanol is used as fuel. Decrease of CO emissions is being observed at both load conditions.

The variation of HC emissions is presented in the figures below:

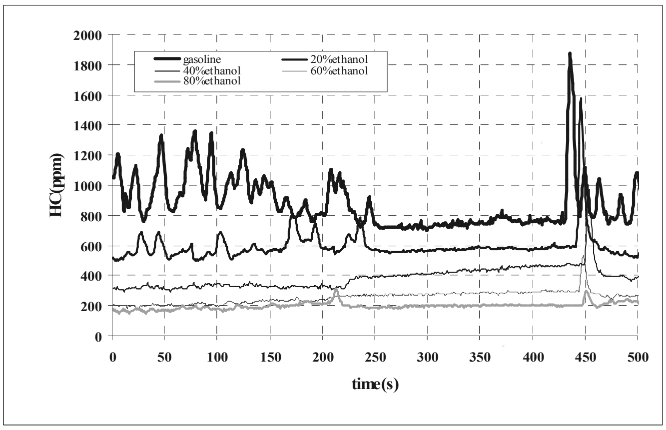


Figure 4. The HC variation about the mixtures, gasoline, gasoline-20% ethanol, gasoline-40% ethanol, gasoline-60% ethanol and gasoline- 80% ethanol

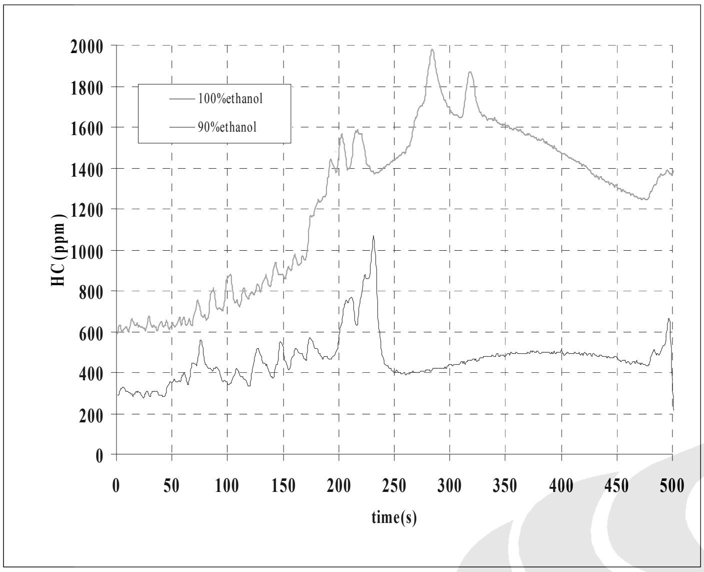


Figure 5. The HC variation about the mixtures, gasoline-90% ethanol and 100% ethanol

Figures 4 and 5 present the progress of HC emissions for every mixture and for every load conditions. As it was mentioned above for the mixtures gasoline-90%ethanol and 100%ethanol the engine malfunctioned. The average values of HC emissions for every mixture and for every load conditions are presented in the Figure 6 below:

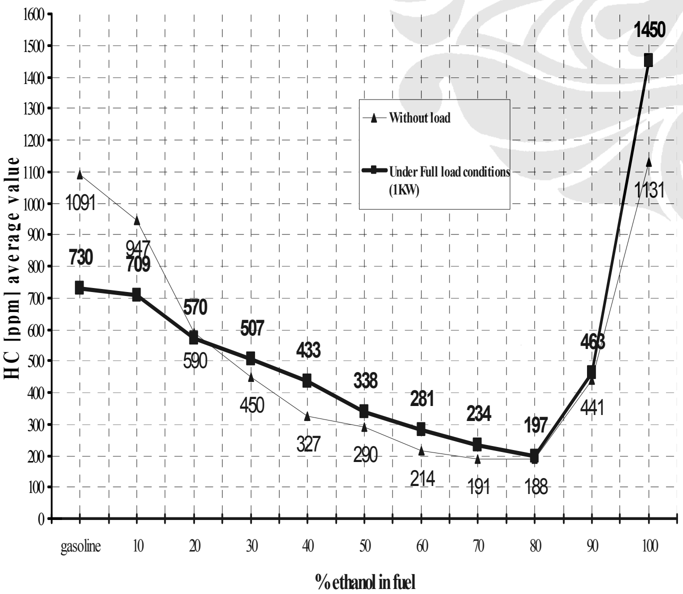


Figure 6. The HC average value variation

Figures 4, 5 and also figure 6 show HC emissions decrease while the percentage of ethanol in the fuel increases until the use of the fuel mixture gasoline-80%ethanol without load and under full electrical load conditions(1KW). At higher percentage of ethanol in the fuel 90%ethanol and 100%ethanol it is observed HC emissions increase, which is due to incomplete combustion. Indeed, during the tests of the mixtures: gasoline – 90%ethanol and 100%ethanol, there was an engine malfunction mostly at without electrical load. This malfunction is showed from the rounds per minute recording in the figures below:

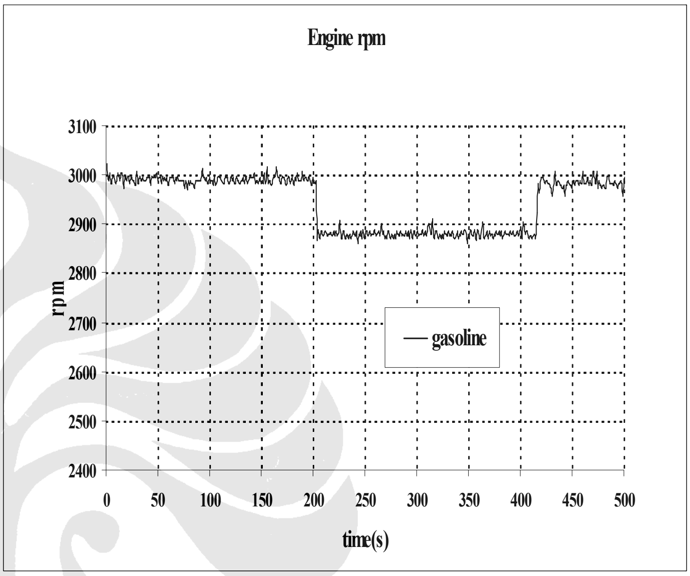


Figure 7. The rpm variation when used fuel gasoline

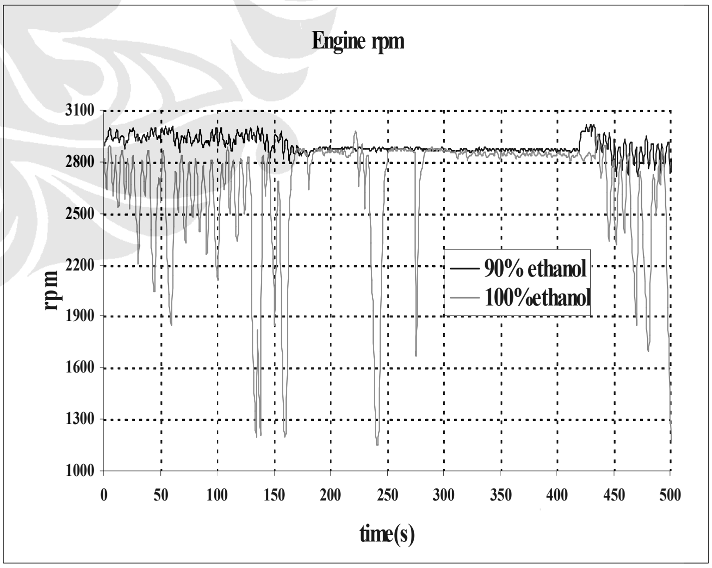


Figure 8. The rpm variation when used fuels gasoline – 90%ethanol and 100%ethanol

During the tests the rounds per minute of the engine were recorded as it was mentioned above. The normal variation of the engine rpm appears in figure 7. The same variation that is illustrated in this figure corresponds to the mixtures gasoline until the mixture gasoline-80% ethanol, without any change. As it is presented in figure 7, the average value of the engine rpm without load (0-200s and 420-500s) is approximately 2990rpm while at full load conditions (200-420s) the average value of the engine rpm is 2880rpm. It must be noted that the engine has a round stabilizer. In figure 8 the mixtures gasoline-90%ethanol and 100%ethanol are illustrated and irregular variation of the engine rpm is presented, which is caused from the engine malfunction. Higher irregular variation is observed at without load condition, and lower at full load conditions. This malfunction is due to the smaller calorific value of ethanol and to the fact that there is no adjustment of the air/fuel ratio during the use of gasoline-ethanol mixtures, but the initial adjustment (that corresponds to gasoline as fuel) is maintained[13,14].

Furthermore, during the tests the consumption of the fuel was recorded for every mixture separately and for every load conditions. The results of the consumption recording are illustrated in the figure below:

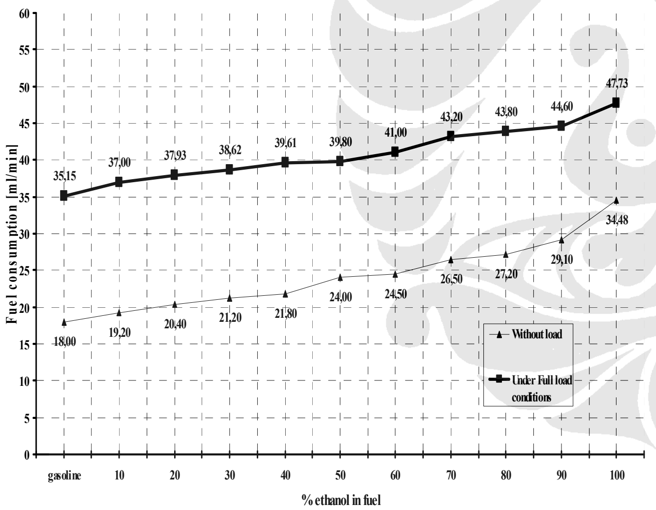


Figure 10.The fuel consumption

The figure 10 shows an increase of fuel consumption when the percentage of ethanol in the fuel increases. The smaller calorific value of ethanol compared to gasoline and also the lack of regulation (ratio air/fuel) of the engine, result to the consumption increase. This increase of consumption happens automatically for the rounds regulator that the engine has, for the maintaining of the rounds constant. It is important to mention that the ethanol that was used wasn't 100% pure but it was of 95^{o} alcoholic degrees.

3. Conclusions

From the observations above is appeared that ethanol as mixture with gasoline results in an emissions (CO and HC) decrease when the engine functions without load and under full load conditions. There is an exception in the use of the mixtures: gasoline –90% ethanol and 100%ethanol where there is observed an HC emissions increase because of the incomplete combustion and consequently due to engine malfunction. Also, it must be mentioned that the adjustment of the engine (air/fuel ratio) was that which referred to the use of gasoline as fuel. From the aspect of consumption, there was a consumption increase when the percentage of the ethanol in the fuel was increased in both load conditions. Finally, it is important the fact that ethanol is a renewable fuel, which presents emissions decrease when it is used, in a time period where petroleum reservations are depleted and the environmental pollution is one of the most important problems that humanity faces.

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