The fuel temperature influence on gas emissions when it is used diesel-palm oil mixtures as fuel

Charalampos Arapatsakos, Dimitrios Christoforidis, Styliani Gkavaki

Abstract: - One of the main global problems is air pollution. The main sources of air pollution are transportation and fuel combustion. Therefore, there is a big need to produce appropriate fuels, which will have minimal environmental and social degradation. The main aim of this work is to examine the effect of fuel temperature in gas emissions that is used in a four-stroke diesel engine. The fuel temperatures that have been used are 20°C, 30°C, 40°C, 50°C, 60°C, 70°C and 80°C. The engine was functioned on 1000rpm, 1500rpm, 2000rpm, 2500rpm, 2000rpm, 1500rpm, 1000rpm(pyramid of rpm) when it has been used different mixtures of diesel-palm oil as fuel. For those fuel temperatures the gas emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen monoxide (NO) and smoke have been examined.

Key-Words: - Gas emissions, Fuel temperature, Palm oil

I. INTRODUCTION

Nowadays humanity faces many critical challenges. One of those challenges is the environmental degradation. Scientists express concern about risks associated with the environmental problems such as hazardous pollutants and global warming. Many countries around the world face the problem of energy shortage. Almost every human activity requires an important amount of energy. At the same time we must not forget the need for clean air, clean water, clean fuel and biodegradable, renewable materials.
By taken into consideration the damaging effects of air pollution to the environment and human health, there is a big need to use other energy sources that can be used with the same efficiency but they will be friendly to the environment and consequently to human health. The increased number of vehicles which mainly run on gasoline or diesel fuel has as a result the production of dangerous emissions such as carbon monoxide (CO), carbon dioxide (CO2), hydrocarbons (HC), nitrogen oxides (NOx) 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]. Ethanol and methanol are alcohols that can be used as fuels instead of gasoline in automobile engines. For better understanding of the use of these two alcohols we must examine them separately. 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 (CO2) 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 CO2 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. 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. Methanol 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.

In the past few years it has been observed an increased worldwide interest in biofuel as an alternative source of energy. Biofuels are fuels that derived from biomass. Biomass is the biodegradable part of products, waste or residues from agricultural, forestry and related industries as well as the biodegradable part of industrial and municipal wastewater. Energy crops are a type of biomass used for energy production. In the category of biofuels are bioethanol, biodiesel or methyl of fatty acids, biogas, biomethanol, synthetic biofuels, i.e. synthetic hydrocarbons or mixtures of synthetic hydrocarbons produced from biomass, biohydrogen, pure vegetable oils and more.

The most popular liquid biofuels in market are biodiesel and bioethanol, which they have replaced partially or whole diesel and petrol [13,14].In Europe biofuels become to claim the biggest part of fuel market and this is mainly due to the following reasons: Reducing the gas emissions of greenhouse (mainly CO_2) in the transport sector.

In the contribution of achievement the national targets of Kyoto protocol regarding to climate changes and the expected restrictions of emissions of pollutants from the exhaust of car engines[13,14,15].

To ensure fuel supply and reducing imports and dependence on oil producing countries, as the raw materials for biofuels are more evenly distributed, but vary in cost and quality from country to country.

In the creation of new fields of business and commercial activity in an area with large turnover, as it is the fuel sector and their growth in countries and regions that up to today are not related with oil extraction. The rising price of oil makes alternatives economically viable. Finally the uses of biofuels have the potential for a new rural policy and provide new agricultural activities creating new jobs.

The intensification of energy crops that lead to degradation of habitat and biodiversity. An example of biodiesel is palm oil. Palm oil is produced from palm tree Elaeis Guineensis**.** The fruit of the palm is the only one that can lead the preparation of two types of oils – oil from the flesh of the fruit and oil from the fruit kernels. Virgin palm oil is rich in carotenoids (provitamin A) and contains no trans fatty acids. Palm oil is often confused with oil that it is produced from the core of the fruit of the palm, but in reality it composition differs. The color of palm oil is reddish because it contains high percentage of beta carotene. It is used as cooking oil and in the manufacture of margarine as well. It is also used as an ingredient in many processed formulations. After a few minutes of boiling the carotene oils of palm oil are destroyed and its color become white. Palm oil contains high percentage of saturated fat and thus is semi-solid at room temperature[13,14,15,16,17].

In Malaysia at 2008, was cultivated 4.49 million hectares of which produced 17.73 million tons of palm oil and 2.13 million tons of palm kernels, offering in Malaysia 65.19 billion Ringgit (Malaysian currency is 1 Ringgit (RM) = 0,22 €) income from exports. The relevant industry provides direct and indirect employment to around 860,000 people. The same year Malaysia made 27.75 million tons palm oil exports and related products including 182.108 tons of biodiesel to: USA (71.224 tons), EU (65.681 tons), Singapore (29.485 tons), Romania (3.500 tons), Taiwan (3.000 tons) and Australia (1.200 tons)[16,17,18].

The question that arises is how a four-stroke diesel engine behaves on the side of pollutants and operation, when it uses as fuel mixtures diesel-palm oil in different temperatures, functioning the engine in different rounds: 1000 rpm, 1500 rpm, 2000 rpm, 2500 rpm, 2000 rpm, 1500 rpm, 1000 rpm (pyramid of rpm).

II. INSTRUMENTATION AND EXPERIMENTAL RESULTS

Specifically it has been used as fuel mixtures of diesel-palm oil (finikelaio) at different temperatures: 10^oC, 20^oC, 30^oC, 40^oC, 50^oC, 60^oC, 70^oC, 80 ^oC in a four-stroke air cooled diesel engine, named Ruggerini type RD-80, volume 377cc with one cylinder and power 8.2hp/3000rpm. The engine was connected with a centrifugal water pump. The fuel diesel that was used had the following characteristics:

Attributes	**Min**	**Max**
Density (15^{o}C), kg/m^3	-	845
Point of ignition, ^{o}C	55	
CFPP, ^{o}C		
From 1/10 until 31/3		-5
From 1/4 until 30/9		5
Water, ppm		200
Hovering particles, mg/kg		24
Anthracites remains, % vol(in remains 10%)		0,30
Ash % vol		0,01
Elements of distillation, % vol		
Distillation in the 250 ^{o}C		65
Distillation in the 350 ^{o}C	85	
The 95% it has distillated in their ^{o}C		360
Viscosity on 40^{o}C, cst	2	4,5
Sulphur, mg/kg		50
Lubrification, diameter of deterioration of spherule (wsd) on 60^{o}C, μm		460
Corrosion of cupreous lamina,	1	

group		
Cetane number	51	
Indicator of ketene	46	
Resistance in the oxidation, gr/m^3		25
Polycyclic aromatic hydrocarbons, % vol		11

Table 1. The diesel attributes

The engine was functioned on 1000 rpm, 1500 rpm, 2000 rpm, 2500 rpm, 2000 rpm, 1500 rpm, 1000 rpm (pyramid of rpm). In every category of rounds the engine remained 60sec, according to the figure below:

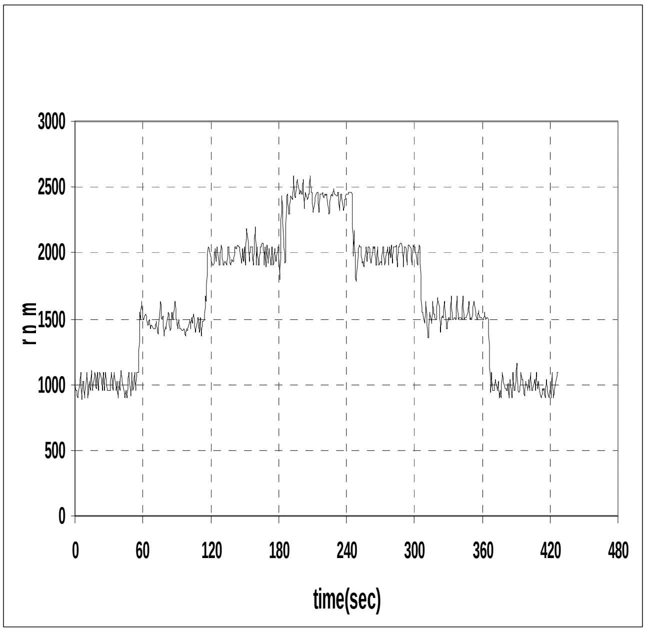


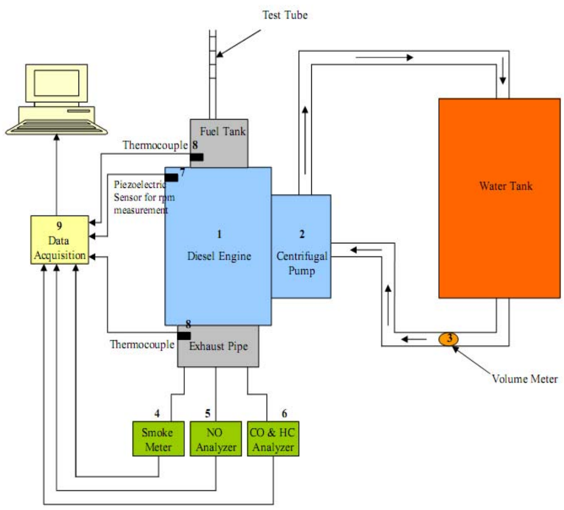
Figure 1. The ´´pyramid´´ rpm

Experimental measurements:

During the experiments, it has been measurement:

The CO %, the HC(ppm), the NO(ppm) and the % smoke.

Picture1. Photo of experimental layout



Picture2. 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 ANALYZER 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.

Experimental results:

The experimental results are shown at the following figures:

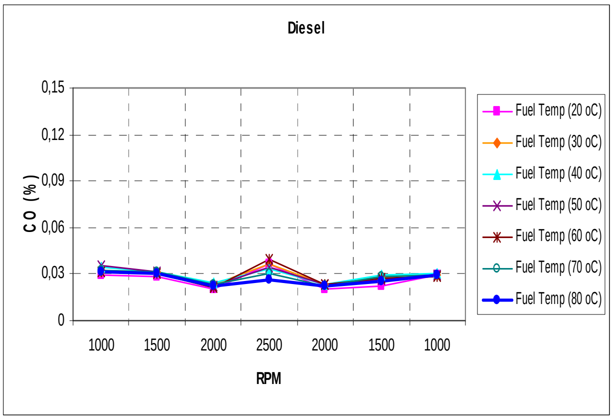


Figure 2. The CO variation used diesel as fuel on different rpm regarding to the fuel temperatures

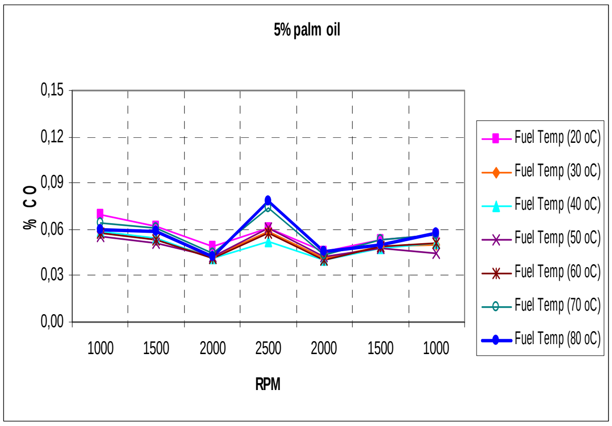


Figure 3. The CO variation used as fuel diesel-5%palm oil on different rpm regarding to the fuel temperatures

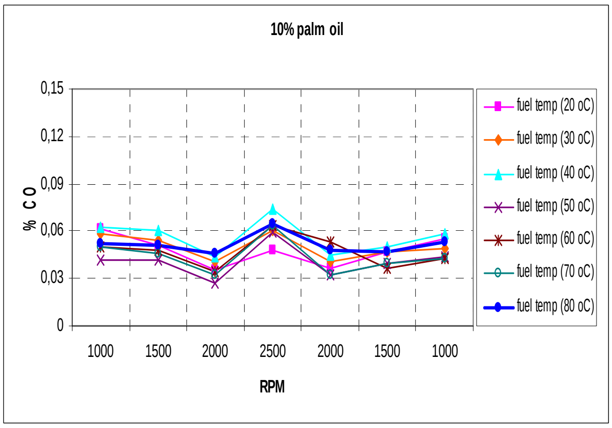


Figure 4. The CO variation used as fuel diesel-10%palm oil on different rpm regarding to the fuel temperatures

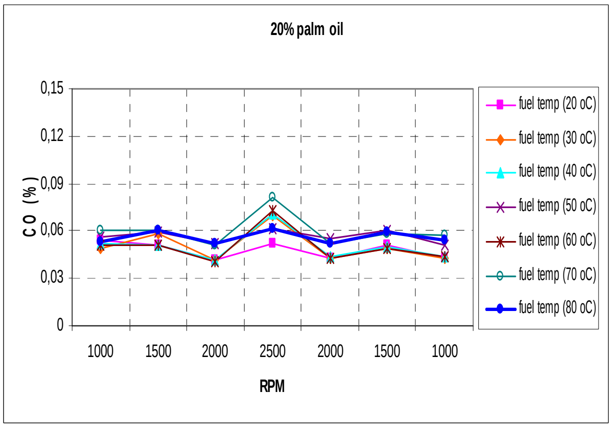


Figure 5. The CO variation used as fuel diesel-20%palm oil on different rpm regarding to the fuel temperatures

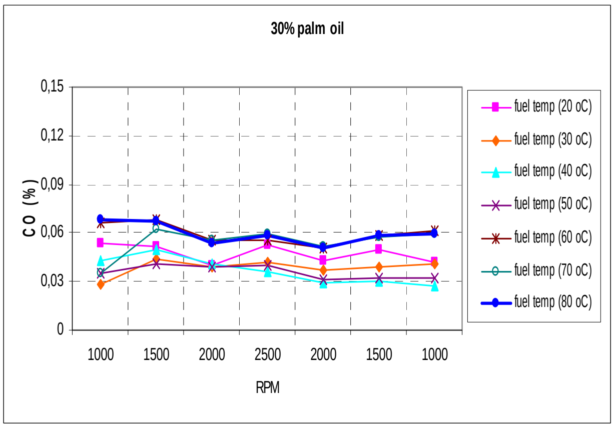


Figure 6. The CO variation used as fuel diesel-30%palm oil on different rpm regarding to the fuel temperatures

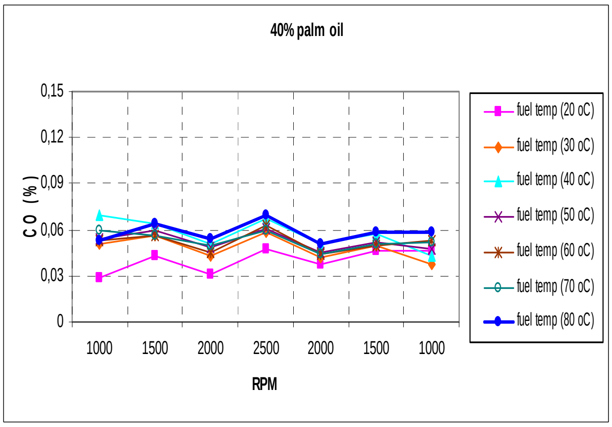


Figure 7. The CO variation used as fuel diesel-40%palm oil on different rpm regarding to the fuel temperatures

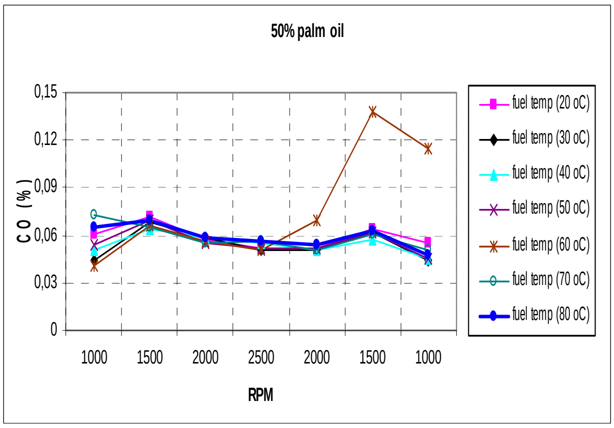


Figure 8. The CO variation used as fuel diesel-50%palm oil on different rpm regarding to the fuel temperatures

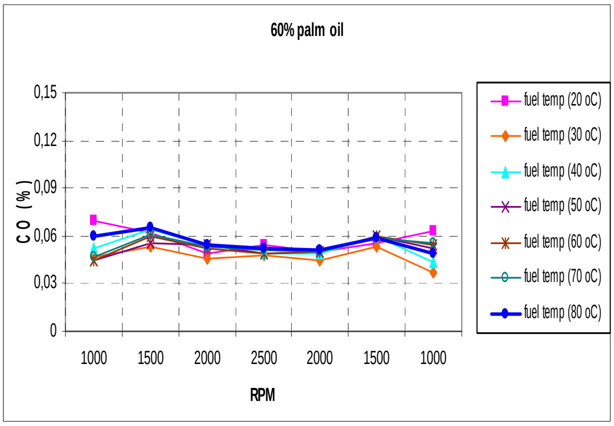


Figure 9. The CO variation used as fuel diesel-60%palm oil on different rpm regarding to the fuel temperatures

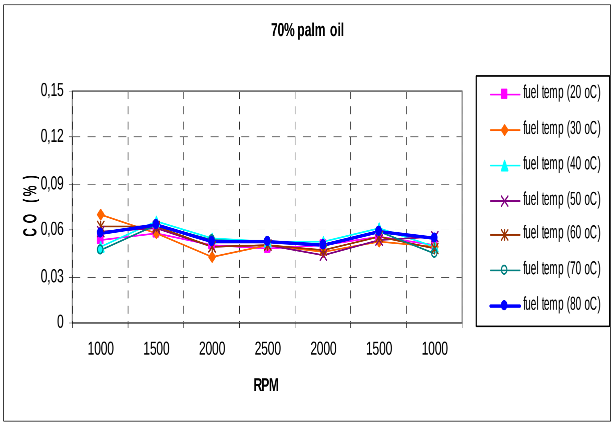


Figure 10. The CO variation used as fuel diesel-70%palm oil on different rpm regarding to the fuel temperatures

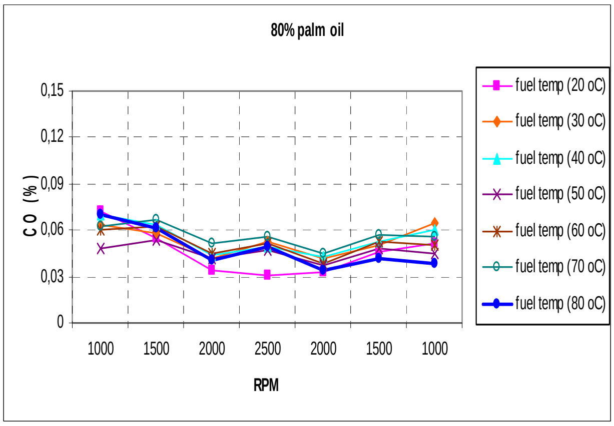


Figure 11. The CO variation used as fuel diesel-80%palm oil on different rpm regarding to the fuel temperatures

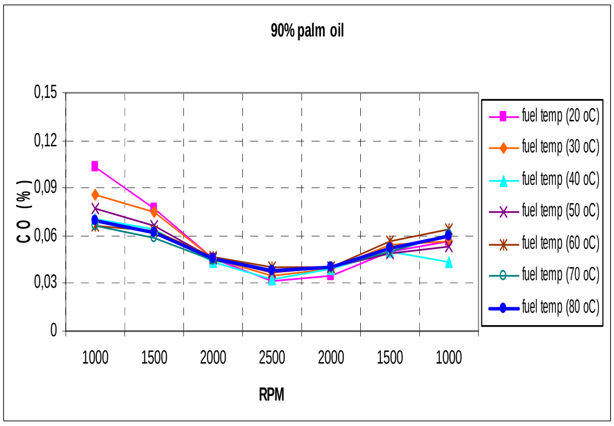


Figure 12. The CO variation used as fuel diesel-90%palm oil on different rpm regarding to the fuel temperatures

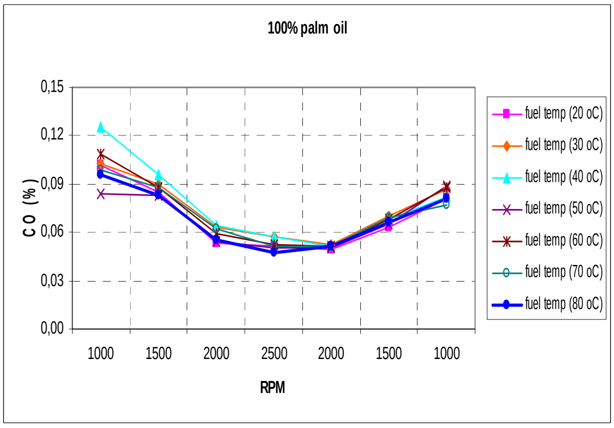


Figure 13. The CO variation used as fuel 100%palm oil on different rpm regarding to the fuel temperatures

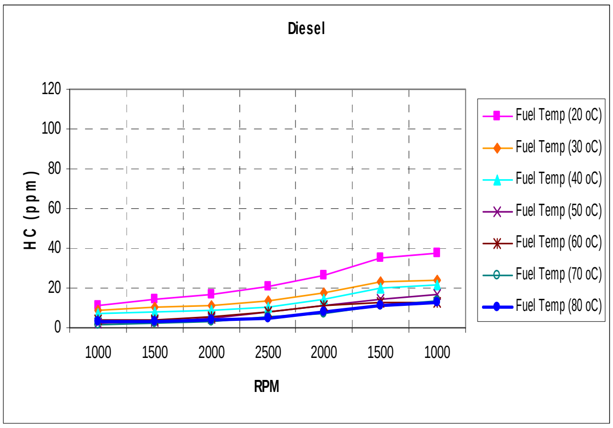


Figure 14. The HC variation used diesel as fuel on different rpm regarding to the fuel temperatures

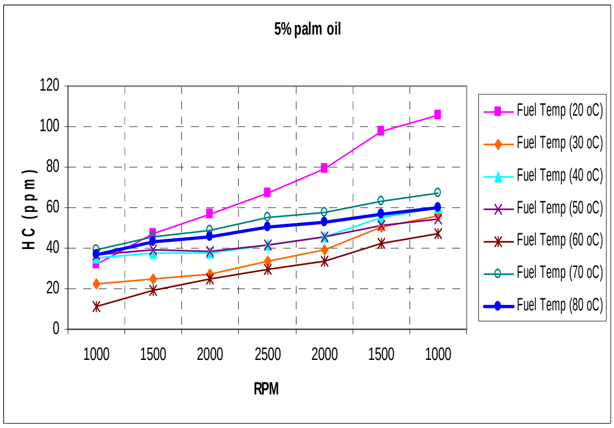


Figure 15. The HC variation used as fuel diesel-5%palm oil on different rpm regarding to the fuel temperatures

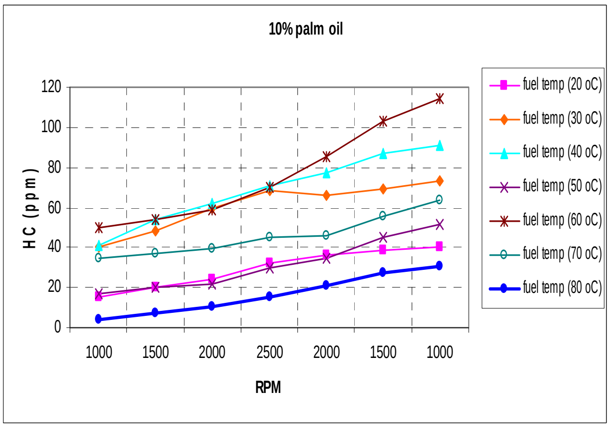


Figure 16. The HC variation used as fuel diesel-10%palm oil on different rpm regarding to the fuel temperatures

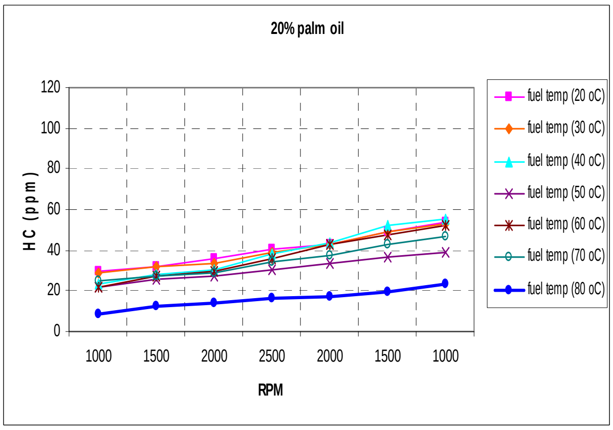


Figure 17. The HC variation used as fuel diesel-20%palm oil on different rpm regarding to the fuel temperatures

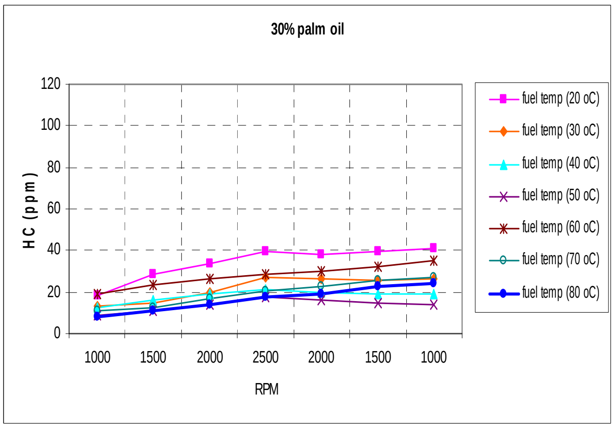


Figure 18. The HC variation used as fuel diesel-30%palm oil on different rpm regarding to the fuel temperatures

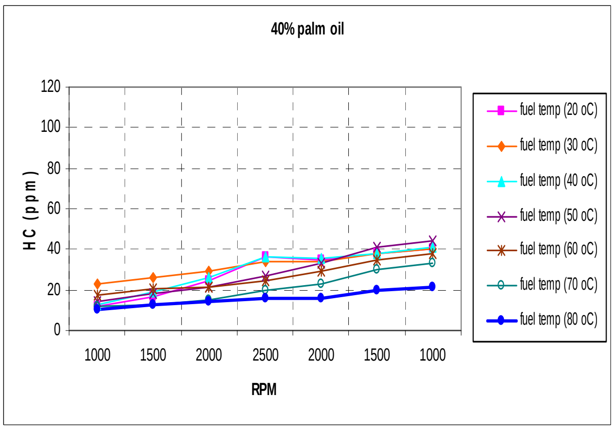


Figure 19. The HC variation used as fuel diesel-40%palm oil on different rpm regarding to the fuel temperatures

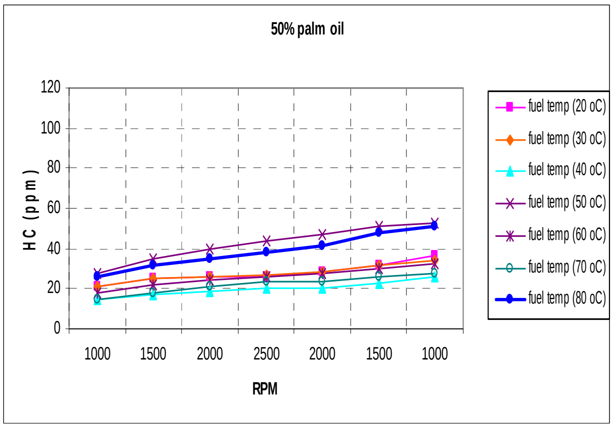


Figure 20. The HC variation used as fuel diesel-50%palm oil on different rpm regarding to the fuel temperatures

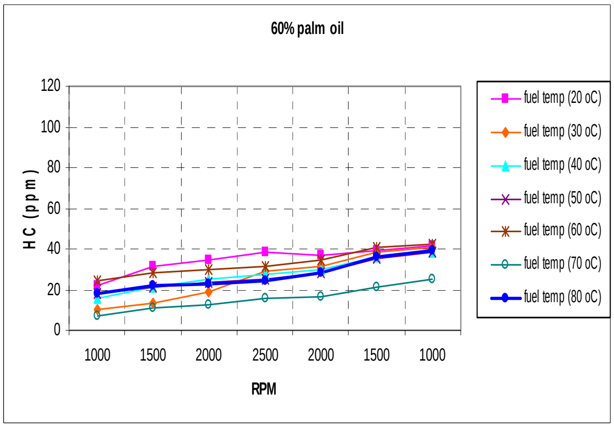


Figure 21. The HC variation used as fuel diesel-60%palm oil on different rpm regarding to the fuel temperatures

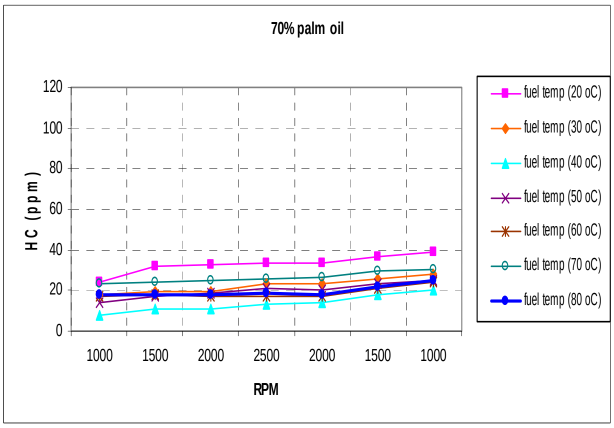


Figure 22. The HC variation used as fuel diesel-70%palm oil on different rpm regarding to the fuel temperatures

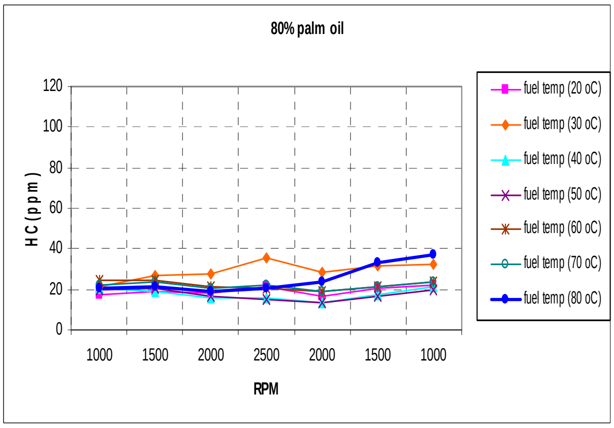


Figure 23. The HC variation used as fuel diesel-80%palm oil on different rpm regarding to the fuel temperatures

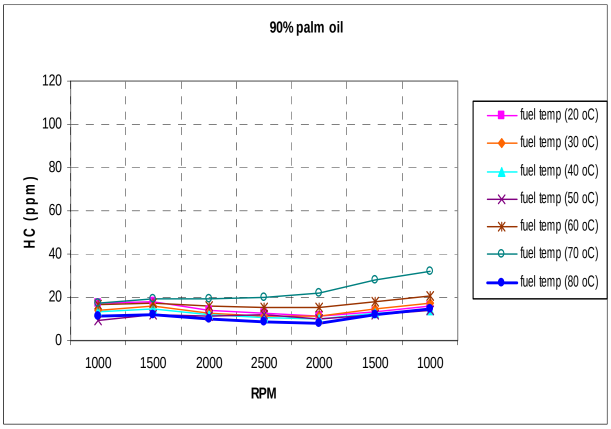


Figure 24. The HC variation used as fuel diesel-90%palm oil on different rpm regarding to the fuel temperatures

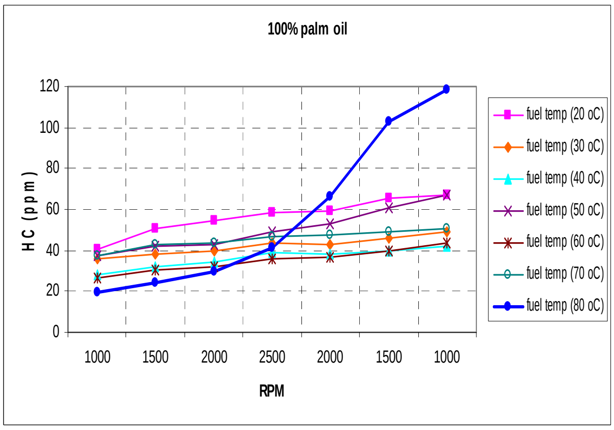


Figure 25. The HC variation used as fuel 100%palm oil on different rpm regarding to the fuel temperatures

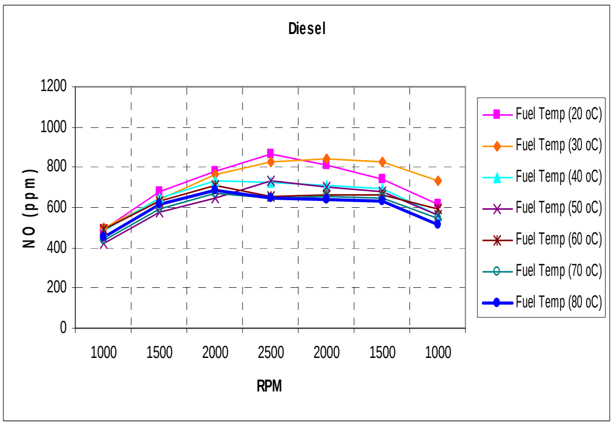


Figure 26. The NO variation used as fuel diesel on different rpm regarding to the fuel temperatures.

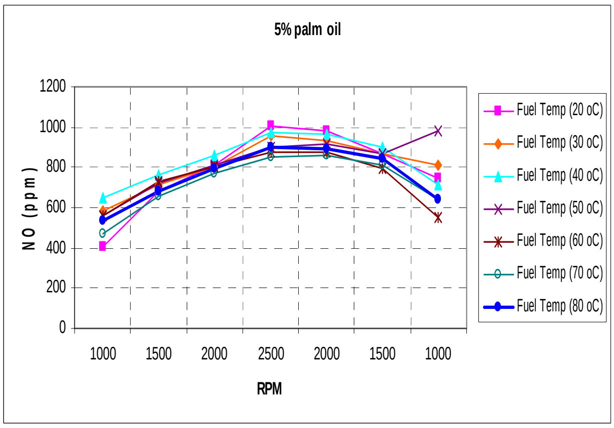


Figure 27. The NO variation used as fuel diesel-5%palm oil on different rpm regarding to the fuel temperatures

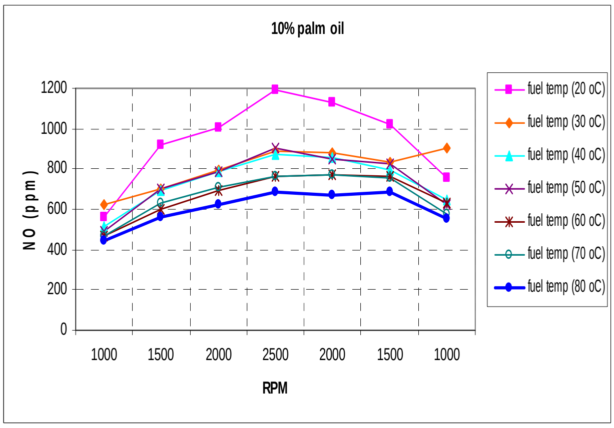


Figure 28. The NO variation used as fuel diesel-10%palm oil on different rpm regarding to the fuel temperatures

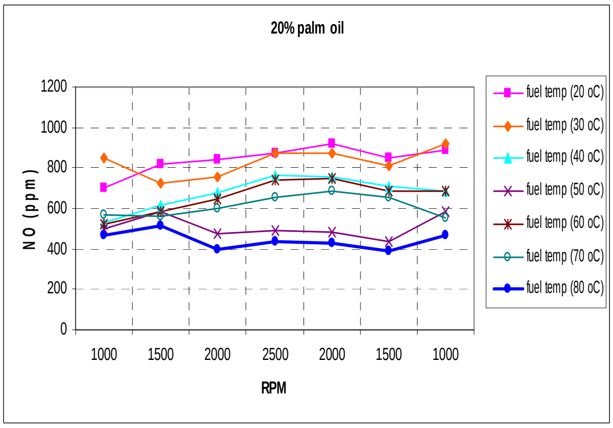


Figure 29. The NO variation used as fuel diesel-20%palm oil on different rpm regarding to the fuel temperatures

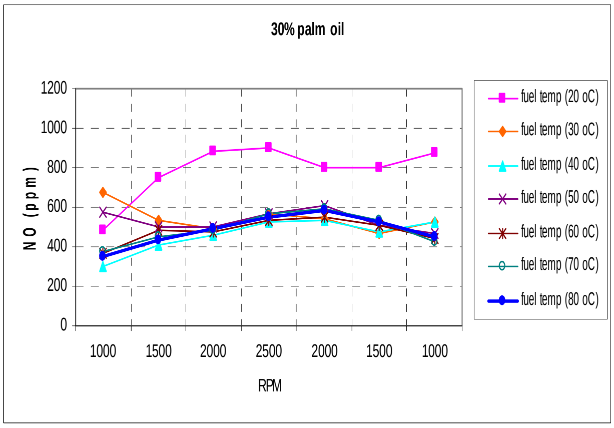


Figure 30. The NO variation used as fuel diesel-30%palm oil on different rpm regarding to the fuel temperatures

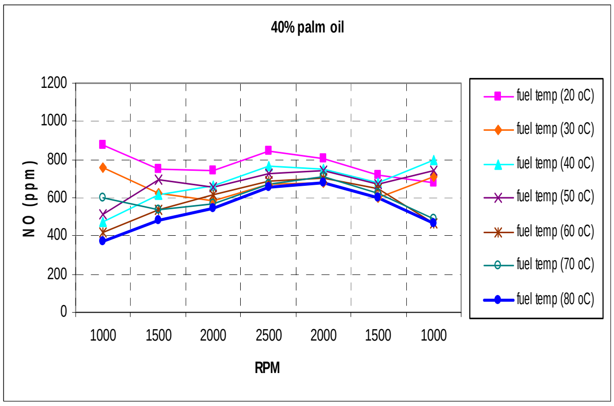


Figure 31. The NO variation used as fuel diesel-40%palm oil on different rpm regarding to the fuel temperatures

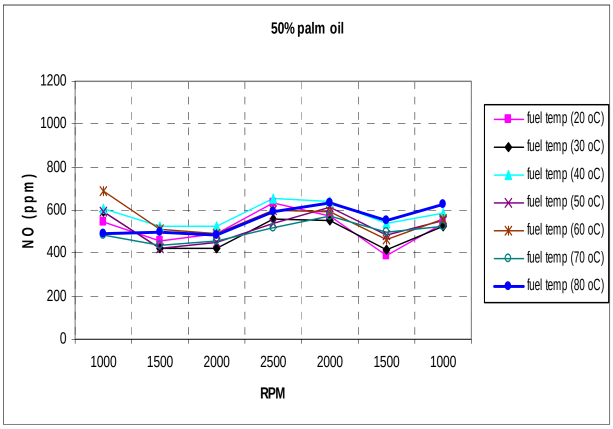


Figure 32. The NO variation used as fuel diesel-50%palm oil on different rpm regarding to the fuel temperatures

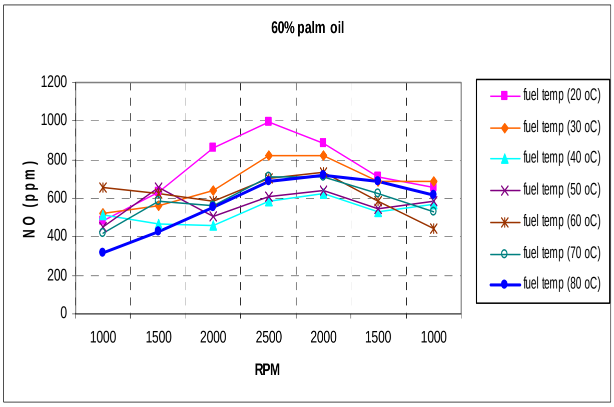


Figure 33. The NO variation used as fuel diesel-60%palm oil on different rpm regarding to the fuel temperatures

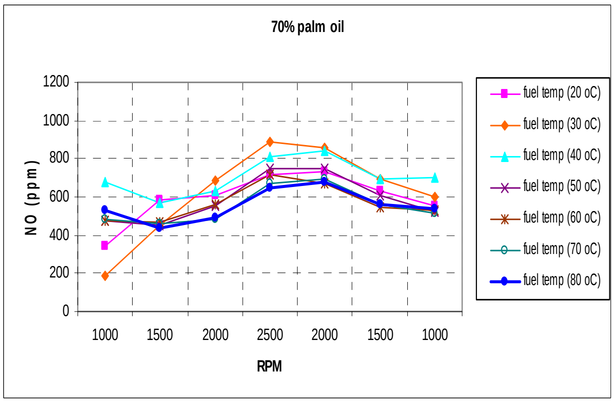


Figure 34. The NO variation used as fuel diesel-70%palm oil on different rpm regarding to the fuel temperatures

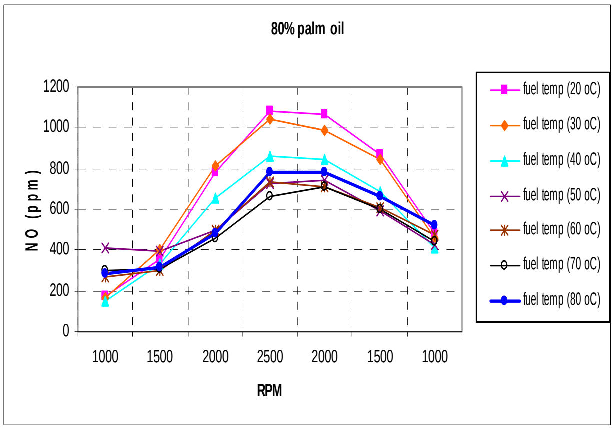


Figure 35. The NO variation used as fuel diesel-80%palm oil on different rpm regarding to the fuel temperatures

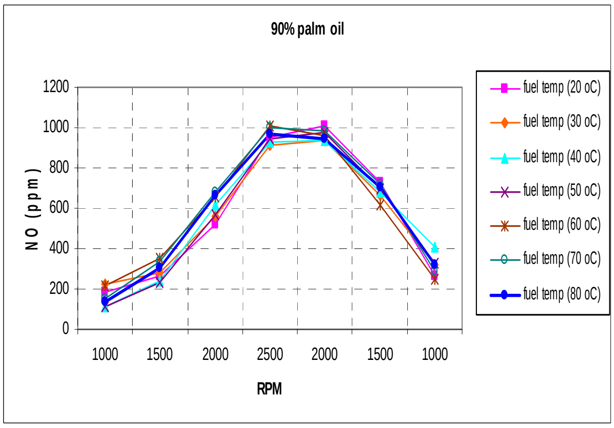


Figure 36. The NO variation used as fuel diesel-90%palm oil on different rpm regarding to the fuel temperatures

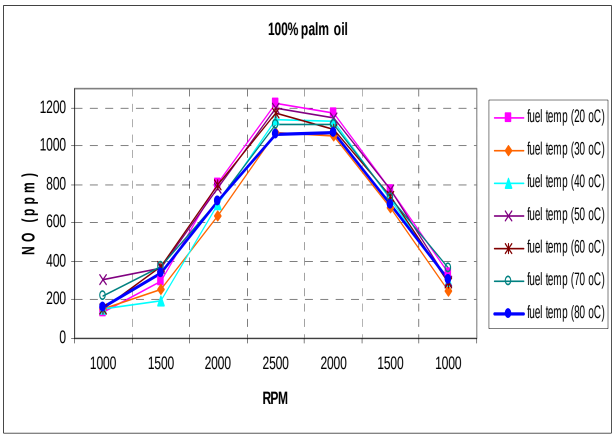


Figure 37. The NO variation used as fuel 100%palm oil on different rpm regarding to the fuel temperatures

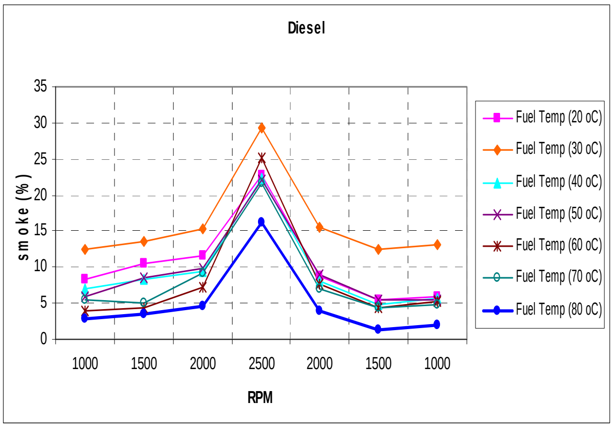


Figure 38. The smoke variation used as fuel diesel on different rpm regarding to the fuel temperatures

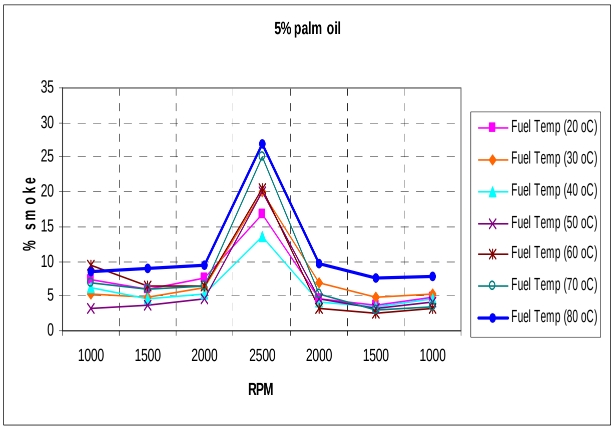


Figure 39. The smoke variation used as fuel diesel-5%palm oil on different rpm regarding to the fuel temperatures

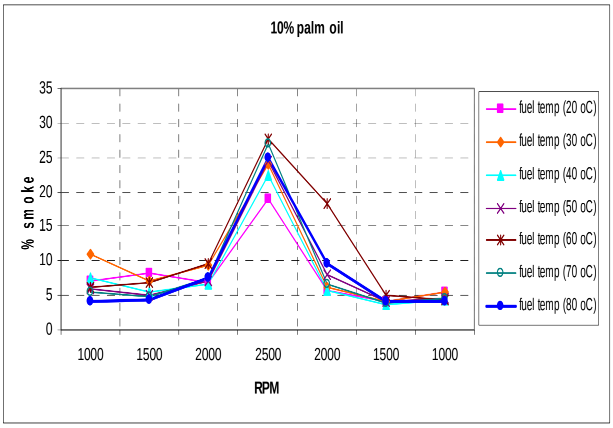


Figure 40. The smoke variation used as fuel diesel-10%palm oil on different rpm regarding to the fuel temperatures

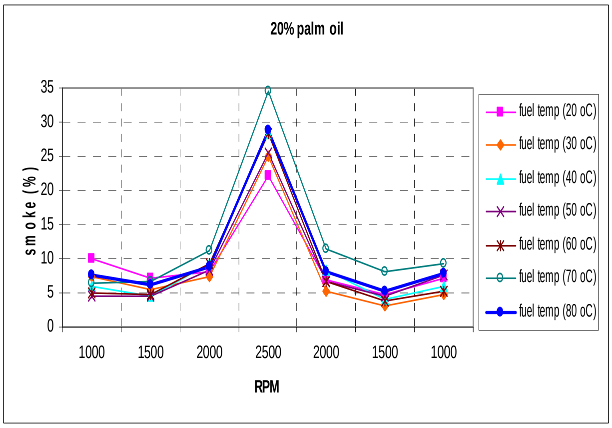


Figure 41. The smoke variation used as fuel diesel-20%palm oil on different rpm regarding to the fuel temperatures

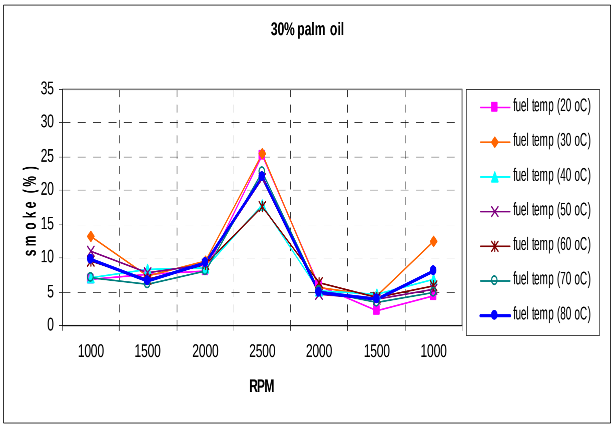


Figure 42. The smoke variation used as fuel diesel-30%palm oil on different rpm regarding to the fuel temperatures

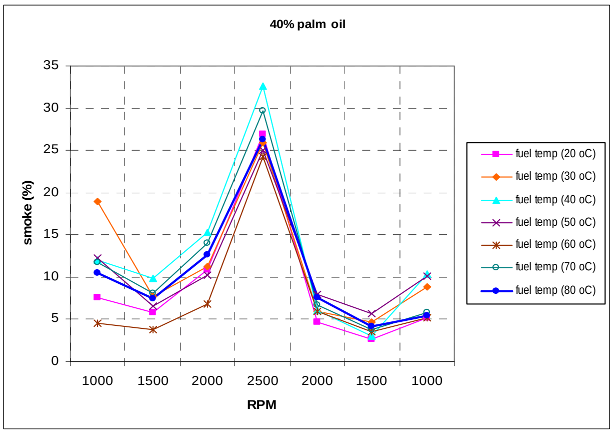


Figure 43. The smoke variation used as fuel diesel-40%palm oil on different rpm regarding to the fuel temperatures

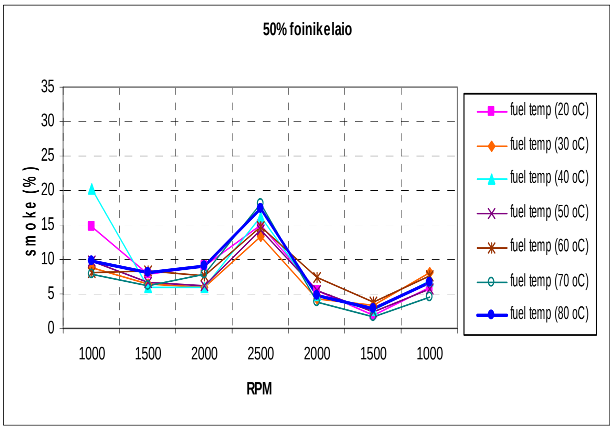


Figure 44. The smoke variation used as fuel diesel-50%palm oil on different rpm regarding to the fuel temperatures

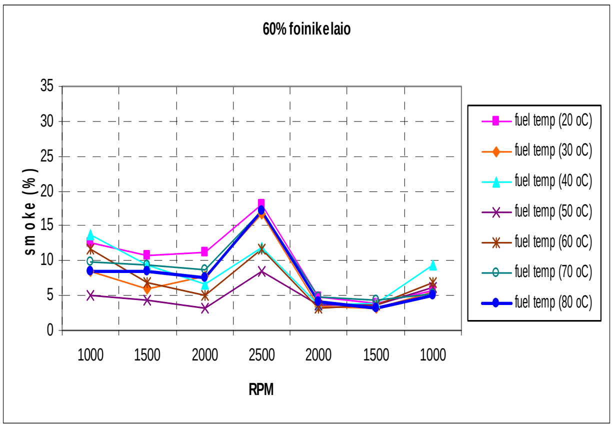


Figure 45. The smoke variation used as fuel diesel-60%palm oil on different rpm regarding to the fuel temperatures

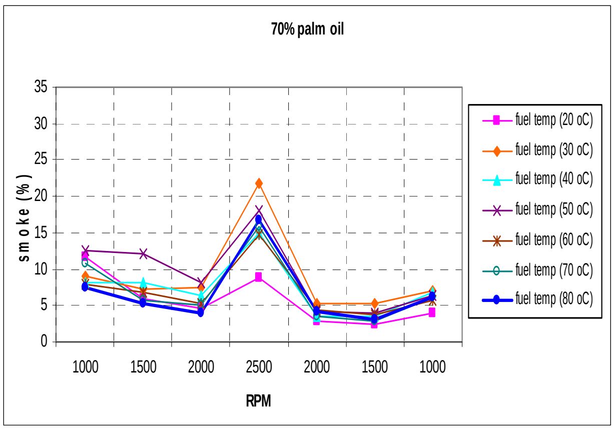


Figure 46. The smoke variation used as fuel diesel-70%palm oil on different rpm regarding to the fuel temperatures

The following table presents the fuel consumption regarding to the fuel and the fuel temperature:

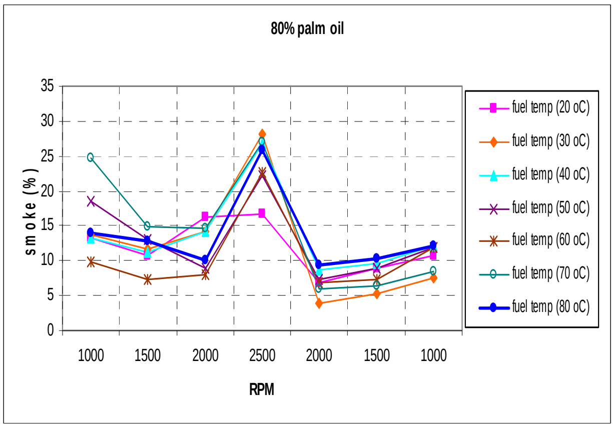


Figure 47. The smoke variation used as fuel diesel-80%palm oil on different rpm regarding to the fuel temperatures

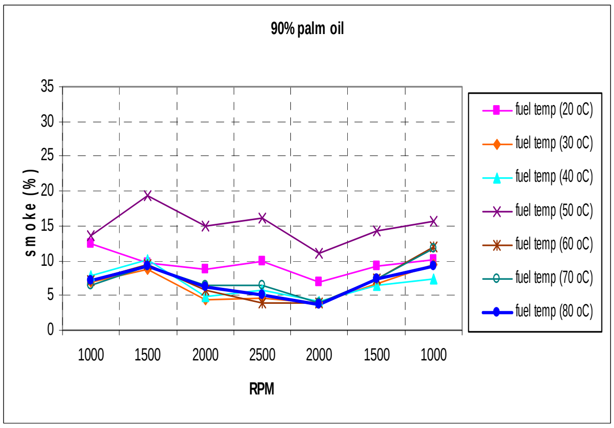


Figure 48. The smoke variation used as fuel diesel-90%palm oil on different rpm regarding to the fuel temperatures

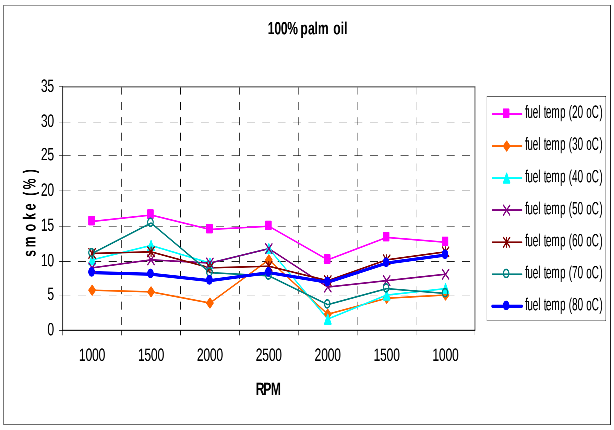


Figure 49. The smoke variation used as fuel 100%palm oil on different rpm regarding to the fuel temperatures

fuel temp	diesel (ml/min)	5% palmoil (ml/min)	10% palmoil (ml/min)	20% palmoil (ml/min)	30% palmoil (ml/min)	40% palmoil (ml/min)	50% palmoil (ml/min)	60% palmoil (ml/min)	70% palmoil (ml/min)	80% palmoil (ml/min)	90% palmoil (ml/min)	100% palmoil (ml/min)
20 °C	8,05	7,76	8,45	7,47	7,24	7,49	6,63	8,59	6,85	7,97	7,96	8,22
30 °C	8,38	7,45	7,47	7,2	6,61	8,1	7,1	7,1	8,45	7,7	7,84	8,05
40 °C	8,33	8,72	8,83	9,06	8,07	8,22	8,35	7,44	7,33	8,54	8,55	9,67
50 °C	10,46	8,85	10,06	7,84	8,94	9,58	7,96	8,19	8,94	8,38	9,29	9,05
60 °C	10,8	10,7	12,35	9,43	10,16	9,3	10,4	9,67	10,75	9,31	9,8	10,4
70 °C	11,95	12,15	12,2	11,63	11,88	11,78	10,18	10,16	10,04	9,29	9,18	11,1
80 °C	16,2	13,27	16,05	11,76	13,32	12,52	11,04	11,02	11,36	11,88	10,53	11,87

Table 2. The fuel consumption

The following diagram presents the fuel consumption regarding to the gas and the temperature:

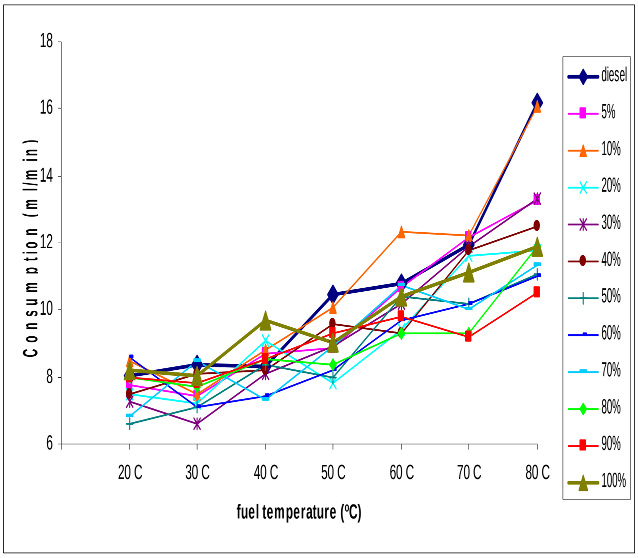


Figure 50. The fuel consumption in relation to the fuel temperature

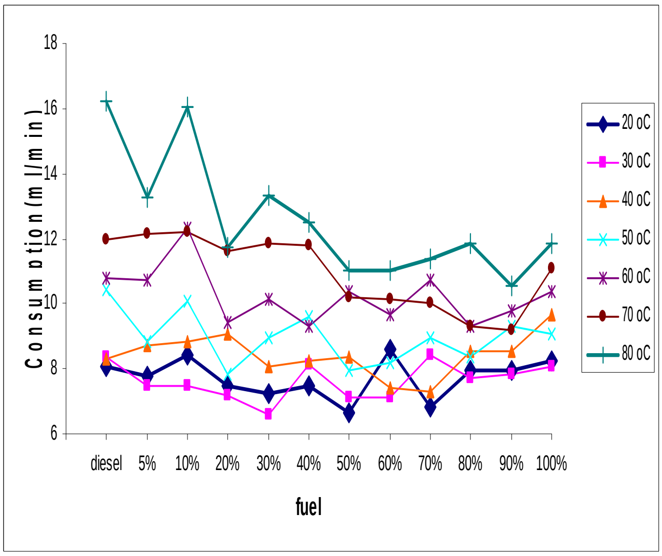


Figure 51. The fuel consumption in relation to the fuels

III.CONCLUSION

From figures 2 to 49 it can be concluded the followings:

- For the emissions of soot it was observed a sharp increase in emissions at 2500 rpm. Also the prices of soot in the staging of "pyramid" are lightly higher compared to the ones at the descent of "pyramid". In plain palm as well as in mixtures with high percentage of palm oil (80% and 90%), rates of soot had high fluctuations throughout the measurements, which justifies the low or negative correlation that it has been observed.
- Carbon monoxide emissions in diesel appears very low and often lower rates of carbon monoxide at all temperatures. Rounds seem to play a role in emissions at 2000 rpm, either uploading or downloading by giving the lowest emissions in general. In most fuel mixtures, there are slightly elevated values on emissions of carbon monoxide at 2500 rpm. In plain palm it has been observed elevated rates of emissions of carbon monoxide, in 2500 rpm, there was a fall in the percentage regarding to the lowest rounds with the 1000 rpm to present the highest percentage. The same thing happened with the fuel mixture of 90% palm oil, but in lower percentages of emissions.
- By taken into consideration all the figures relating to emissions of unburned hydrocarbons, it is obvious that the emission of unburned hydrocarbons does not seem to be influenced by rounds rotation. Unlike the majority of cases seem to increase during each measurement. Also it should be mentioned that the fuel mixtures with 80% and 90% of palm oil did not follow the above pattern as well as the fuel mixture with 30% of palm oil at 40°C and 50°C fuel temperature. Diesel has very low emissions of unburned hydrocarbons and very close to it was the fuel mixture with 90% of palm oil, which it has started with higher emissions than diesel, but during the measurement, was not growing particularly those emissions.

One main conclusion that comes from the overall study of figures related to emissions of nitrogen oxide is that the emissions are influenced by the number of rounds. It can be seen that the emission is at its highest point at 2500 rpm. Also, plain palm appears lower emissions of nitrogen oxide at lower rounds (1000 and 1500) and very high emissions at 2000 and 2500 rpm. It is observed that at 2000 rpm in downloading the emission level is approximately the same level as that of 2500 rpm. A similar pattern but without large deviations is observed in both fuel mixtures of 80% and 90% of palm oil. The remaining fuel mixtures have smoother rotation pattern of emissions depending on rpm. The emissions of diesel are shown in the middle figures[19]. There is a difference in the price of gas emissions by changing the fuel temperature.

- From figures 50, 51 and from table 2, it can be said that the mixture with the lowest consumption at 20^{o}C of fuel temperature is the one with 50% of palm oil and 6,63 ml/min, while the highest consumption presented in the mixture of 60% palm oil and 8,59 ml/min. At 30^{o}C of fuel temperature the mixture that presented the lowest consumption is the one with 30% palm oil with 6,61 ml/min, while the highest consumption appeared in the mixture of 70% palm oil with 8,54 ml/min. It doesn't seem great difference in the consumption between these two temperatures.

In 40^{o}C of fuel temperature, it has been observed sometimes less and sometimes greater increase in consumption of all mixtures of fuel, with the exception of 70% palm oil in where there was a decrease in the consumption (from 8,45 to 7,33 ml/min) and this was the lowest consumption for the particular temperature. The highest consumption appeared from the plain palm oil with 9,67 ml/min.

In 50^{o}C of fuel temperature, it has been observed an increase in consumption in most of the fuel mixtures, but there was a decrease in 4 mixtures (20%, 50% 80% and 100% palm oil). The lowest consumption (8,19 ml/min) was observed in the mixture of 60% palm oil, while the highest consumption (10,46 ml/min) appeared on diesel.

In 60^{o}C of fuel temperature, it has been observed an increase in consumption of all the fuel mixtures. The lowest consumption (9,3 ml/min) was appeared in the mixture of 40% palm oil while the highest (12,35 ml/min) appeared in the mixture of 10% palm oil.

In 70^{o}C of fuel temperature, it has been observed a small decrease in consumption in 5 fuel mixtures (10%, 50%, 70%, 80% and 90% palm oil). Lower consumption (9,18 ml/min) was appeared in the mixture of 90% palm oil and higher consumption (12,2 ml/min) had the mixture of 10% palm oil.

In 80^{o}C of fuel temperature, it has been observed an increase in consumption in all fuel mixtures. Lower consumption (11,2 ml/min) was appeared in the mixture of 60% palm oil while higher consumption (16,2 ml/min) appeared in diesel.

REFERENCES:

[1]. Timothy T. Maxwell and Jesse C. Jones "Alternative fuels: Emissions, Economics and Performance" Published by SAE, 1995.

[2]. Keith Owen and Trevor Coley "Automotive Fuels Reference Book" Second Edition, Published by SAE, 1995.

[3]. Fred Schafer and Richard van Basshuysen " Reduced Emissions and Fuel Consumption in Automobile Engines" Published by SAE, 1995.

[4]. Swedish Motor Fuel Technology Co., " Alcohols and alcohol blends as motor fuels" Vol. II B, p.8:39,STU information No 580,1986.

[5]. H. Menrad and M. Haselhorst, "Alcohol fuels", Monograph. Springer, New York, ISBN 3211816968,1981

[6]. Harrington, I.A.; Shishu, R.C.: A Single-Cylinder Engine Study of the Effects of Fuel Type, Fuel Stoichiometry and Hydrogen-to-Carbon Ratio on CO, NO and HC Exhaust Emissions, SAE-Paper 730476.

[7]. K. Taschner, " Who Needs Biofuels" European Environment Bureau Brussels 1993.

[8]. D.J Rickeard and N.D.Thompson. "A review of the potential for biofuels as transportation fuels" SAE paper No.932778, 1993.

[9]. U.E. Stumpf, "Brazilian Research on Ethyl Alcohol as an Automotive Fuel" Alcohols Fuels Conference, Inst. Chem. Eng., Sydney, 1978.

[10]. N.N.: U.S. EPA, Clean Air Facts, Nr. 3, 5, 9, 10, 15/1989, Washington, D.C.

[11]. N.N.: VDA-Jahresbeicht. Auto 89/90, Sept.1990

[12]. "The Clean Fuels Report" J.E. Sinor Consultants Inc., Niwot, Colorado, February 1991.

[13]. Abdullah A.Z., Salamatinia B., Mootabadi H., Bhatia S., Current status and policies on biodiesel industry in Malaysia as the world's leading producer in palm oil, Energy Policy 37 (2009) 5440-5448.

[14]. Worldwatch Institute, Biofuels for Transport, Global Potential and Implications for Sustainable Energy and Agriculture, Earthscan London, 2007.

[15] Pollution Science Edited by Ian L. Pepper, Charls P. Gerba, Mark L. Brusseau, 1996.

[16]. C. Arapatsakos, D. Christoforidis, S. Gkavaki ´´THE ATTITUDE OF CO, HC, NO AND SMOKE EMISSIONS ON DIFFERENT

TEMPERATURES´´ Proceedings of WSEAS International Urban Planning and Transportation Conference. Rodos 2009.

[17]. Charalampos Arapatsakos, Anastasios Karkanis, Panagiotis Sparis, ENVIRONMENTAL CONTRIBUTION OF GASOLINE – ETHANOL MIXTURES WSEAS Transactions on Environment and Development Vol. 2, Is. 7, 2006

[18]. C. Arapatsakos, D. Christoforidis, S. Gkavaki, THE FUEL TEMPERATURE EFFECT ON THE GAS EMISSIONS WHEN USE AS FUEL DIESEL-PALM & SUNFLOWER OIL MIXTURE, Proceedings of WSEAS International Urban Planning and Transportation Conference. Rodos 2009.

[19]. C. Arapatsakos, D. Christoforidis, S. Gkavaki, The gas emissions variation when it is used diesel-palm oil mixtures as fuel on different fuel temperatures ´´ Proceedings of WSEAS International Conference on HEAT TRANSFER, THERMAL ENGINEERING and ENVIRONMENT, Florence – Italy 2011