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EXPERIMENTAL STADY OF USING OLIVE OIL AND BIO-DIESEL ON POLLUTANTS EMISSIONS IN THE CONTINUOUS COMBUSTION CHAMBER

Dr. Abdul Kadhim M. Hasan[1], Dr. Abdul Sattar Jawad M.[1], * Noora Saleh Ekaab[3]

1) Assist Prof., Mechanical Engineering Department, University of technology/Baghdad.
2) Assist Lect., Mechanical Engineering Department, University of technology/Baghdad.

Abstract: This study investigates the effect of using olive oil on the pollutants emissions in the continuous combustion chamber. The bio-fuels used are mixtures of olive oil with two types of hydrocarbon fuels (gas oil and kerosene). The pollutants measured include carbon monoxide CO, unburned hydrocarbon UHC, soot and nitrogen oxide NO_x .It is found that all pollutants have less percent emissions when using olive oil blended with percent addition of 5%, 10%, and 15%. The reduction in emission with olive oil blends is due to the existence of oxygen O_2 in the chemical structure of the olive oil which is sufficient to achieve the complete combustion. The test was conducted through the range of equivalence ratio between (0.85-1.7). Results showed that olive oil blends with gas oil brings about 45.63% reduction in UHC and 36.48% soot, while CO 32.24% and NO_x showed only about 39.54% reduction from that of pure gas oil. Whilst, blends with kerosene, showed a reduction of about 48.92% in UHC and 42.13% soot, while for CO and NO_x the reduction was 37.41% and 42.85% respectively compared with those of pure kerosene emission.

Key word: *Vegetable oils, Pollution, Emissions, Continuous Combustion Chamber*.

تاثيراستخدام زيت الزيتون على انبعاث الملوثات في عملية الاحتراق المستمر

الخلاصة: تقدم هذه الدراسة استقصاء لتاثيراستخدام زيت الزيتون على انبعاث الملوثات من غرفة احتراق مستمر. الوقود العضوي المستخدم هو عبارة عن خليط من زيت الزيتون مع نوعين من الوقود الهيدروكربوني (زيت الغاز والكيروسين). الملوثات المقاسة تتضمن (اول اوكسيد الكربون ، الهيدروكربونات غير المحترقة ، السخام واكاسيد النتروجين). لقد وجد ان كل الملوثات قد انخفضت انبعاثاتها مع استخدام زيت الزيتون مخلوطا بنسب مختلفة وهي 5% ، 10% ، و15% . الانبعاث الاوطئ مع خلائط زيت الزيتون تعود الى وجود الاوكسجين في البنية الكيمياوية لزيت الزيتون وبكمية كافية سعيا الى الاحتراق التام. تم اجراء الاختبارات ضمن حدود نسبة مكافئة تتراوح بين 0,85 الى 1,7 . اظهرت النتائج ان خلط زيت الزيتون مع زيت الغاز يحقق خفضا بالانبعاث بحدود 45.63% لكل من الهيدروكربون غير المحترق 36.48% والسخام ، بينما يصل الانخفاض الى حدود 32.24% فقط لاول اوكسيد الكربون و 39.54% اكاسيد النتروجين مقارنة مع انبعاث زيت الغاز النقي .بينما الخلائط مع الكيروسين تظهر خفضا بحدود 48.92% لكل من الهيدروكربون غير المحترق و 42.13% السخام ،في حين كان الانخفاض بحدود37.41% و 42.85 % لكل من اول اوكسيد الكربون واكاسيد النتروجين على التوالي مقارنة مع انبعاث الكيروسين النقي.

*Corresponding Author noora.saleh2015@gmail.com

1.Introduction

In the last years (30 years ago) strong efforts has been done to reduce the impact of combustion on their effects the environment. At the beginning، development of new combustion systems and much work has been done to reduce the production of pollutant emissions due to their role in ozone depletion and the creation of photochemical smog [1].The major disadvantage of the use of various petroleum products results from their pollutants emissions, such as carbon dioxide (CO_2), nitrogen oxides (NO_x), carbon monoxide (CO), unburned hydrocarbons (UHC), particulate matter (PM) and other harmful compounds. The above furnishes some of the reasons why alternative fuels are required. The “right” alternative fuels must be inexpensive, abundant, and their combustion product must be environmentally friendly. Also, they must be used in existing engines without any or with minor modifications replacing fossil fuels with bio fuels could reduce the world dependence of fossil fuel [2,3,8].

Bio-diesel is an environmental friendly since there is no aromatics contained in its chemical structure and has about 10% built-in oxygen, which helps it to burn completely [1]. Its blend with diesel fuel can be utilized to increase the flash point of diesel particularly where flash point is 44°C well below the world average of 55°C . This is important from the safety point of view .Cetane number (CN) of the bio-diesel is in the range of 48–60, this leads to combustion more efficient than hydrocarbon-based diesel fuels, also higher cetin number improves the ignition quality even when blended in the petroleum diesel. This type of vegetable oil (olive oil) contain 10–11% oxygen by weight, which may encourage lower volumetric heating values (about 12%) than diesel fuel which has lower volatility characteristics. In addition, they are biodegradable, non-toxic, and have a potential to significantly reduce pollution.[4].

Many workers have studied the effects of bio-fuel of pollutant emissions of combustion systems John, 2003[5], studied the most important reason for using vegetable oil and they found that the emissions are very low and his tests shows that biodiesel emissions are substantially lower in carbon dioxide, carbon monoxide, sulfur dioxide, and a host of other emissions than petroleum diesel emissions. In fact, the amount of carbon dioxide emitted in to the air by burning, is the same amount that is theoretically absorbed by growing the next crop of soybeans or corn.

Gupta et .al ., 2010[4], studied the effect of viscosity ,flash point, cetane number and density of biodiesel on the pollutants emissions of a constant pressure burner , they found use vegetable oil lead to reduction in emission of sulfur oxides, carbon monoxide (CO),poly aromatic hydrocarbons (PAH), unburned hydrocarbons (UHC) , and particulate matter (PM).

Yong Fane et .al., 2013[6]studied, effect of the kinematic viscosity on liquid sprays injected by an air-assist pressure-swirl atomizer which has been investigated in a series of experiments employing pulse-laser backlight imaging and laser diffraction droplet size distribution measurements. In their test they used vegetable oil, because SVO (Straight Vegetable Oil) has much higher viscosity than the diesel fuel, providing a good atomization performance for clean and efficient combustion is an important issue and reduce the cost and CO_2 emission They found that atomization of the liquids was improved by introducing the assist air and leads to reduce pollutants.

The aim of the present work is studying the effect of using the olive oil along with conventional fuel (kerosene and gas oil) through different percents on the pollutant emissions of continuous combustion burner.

2. Experimental Work

locally and connect along with other devices such as measurement devices, air compressor, valves, and joins. The liquid fuel is stored in fuel tank and forced to flow through fuel injection system by compressed air generated by reciprocating air compressor, which is supplied compressed air also to atomize the liquid fuel in order to generate very small droplets size. The liquid fuel is directly sprayed into combustion chamber via the four-point air blast atomizer. The consumed fuel Figure (1) shows the test rig used in this study. The burner and ducts are manufactured is measured by using liquid flow meter. The main air flow from the blower is forced through nine holes surround the atomizer as show in figure(2) and measured by using differential pressure method (orifice plate).

In this work measurement of pollutants resulting from combustion in the continuous combustion chamber were done by smoke meter for measuring soot emission and gas analyzer for measuring (CO , UHC ,NO_x) as show in figure(3) . The range equivalence ratio used is (0.85-1.7) ,The drop sizes were measured with a system arranged for this purpose. Because of limitation of the drop size measurement instruments in our country, a simple method used by Abed AL-Khadhim [7], was applied here.

As shown in figure (4), the system consists of light source, lenses, and camera. The measuring of the droplet sizes (SMD) was achieved by rapid photographing of group droplets. The rapid photographing was done by a high speed camera type power shot from G_5 Canon Digital Camera. The exposure time of the camera ranges from 15 to 1/2000 s (15to2000 frame per second). The size of the droplets was made bigger by using lenses fixed to the camera. The group of the droplets was lighted by the high intensity light source. The two flashers work only during the short period of time needed to photographing. The picture was obtained, and the diameters of the droplets found in the picture were measured by comparing with the diameter of the wire that was also found in the same picture, as it is indicated in figure(5).

The concentrations of pollutants resulting from the combustion of biodiesel are compared with that obtained from combustion of each of pure gas oil and pure kerosene. The mixing ratios of olive oil with each of kerosene and gas oil to produce biodiesel are (5% ,10 % ,15%) olive oil mixed with ratios of gas oil and kerosene oil (95% ,90% ,85 %) each alone. When comparing the results all pollutants found to be less than that resulting when using biodiesel, but reduction rates are differs depending on the percent of olive oil in the mixture.

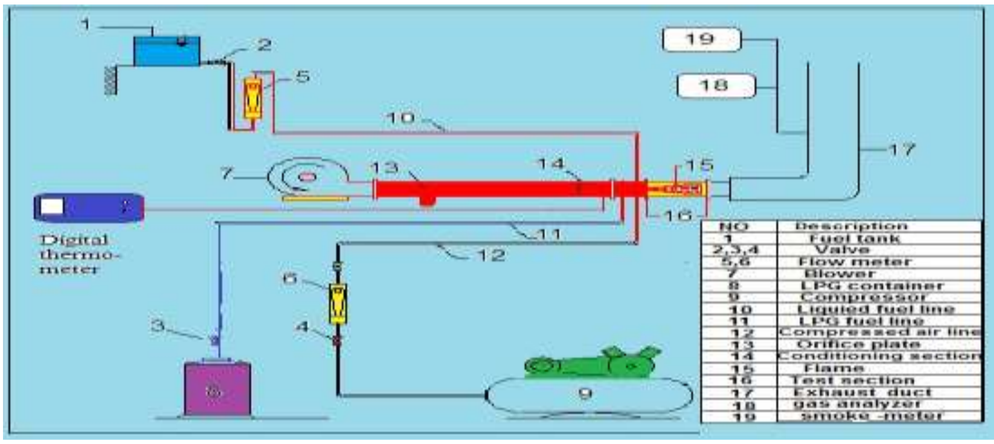

Figure (1): The test rig scheme

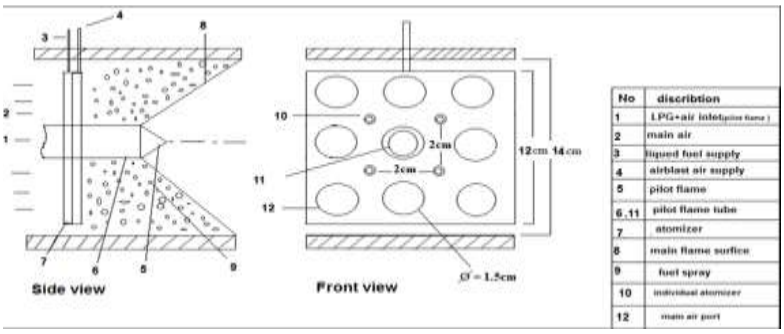

Figure (2) Schematic diagram of flame holder.

Figure (3) Gas analyser and Smoke meter devices.

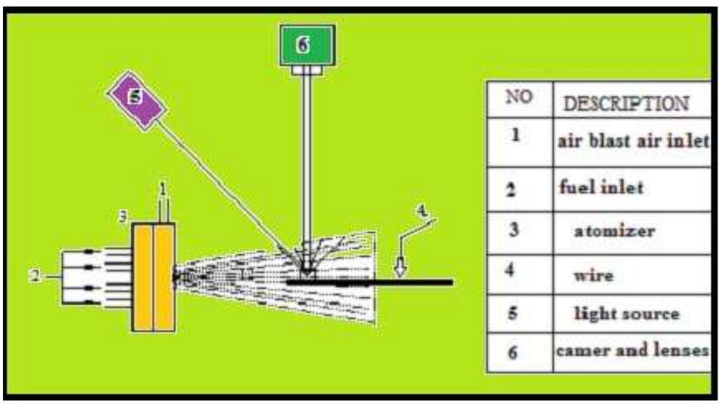

Figure (4): Droplet size measurement system.

Figure (5): Photography showing the fuel droplets size for comparison with the wire diameter.

3.Results and Discussion

The test in this study were conducted on bio-fuel mixtures prepared by blending olive oil with two conventional hydrocarbon fuels namely gasoil and kerosene. The pollutants detected were CO, UHC, NO_x, and soot. The burner was operated in a range of equivalent ratio between 0.85 and 1.7 while using blends of olive oil with ratios of 5%, 10%, and 15%.

Figure (6) and figure (7) show the results of pollutant emissions when mixing olive oil with gas oil fuel at different ranges and when fuel droplets size decreased from 160 µm to 80 µm with increasing atomization pressure, the corresponding decreasing in CO and UHC concentration is (31.62%, 41.55%), respectively, at Φ =1.0, But, for pure gas oil the decrease in CO and UHC emission is (28.39%, 33.99%), respectively.

Figure (8) and figure (9) show that for mixing olive oil with kerosene fuel, when fuel droplets size decreased from 140 µm to 60 µm, the corresponding decreasing in CO and UHC concentration is (42.27 %, 45.42%), respectively, at Φ=1.0. But, for pure kerosene fuel the decreasing in CO and UHC emissions is (32.81%, 34.98%), respectively.

This behavior is attributed to the increasing of atomization pressure which cause to reduce the droplets size and leads to decreased CO and UHC emissions, as a result of mixing improvement which produces more homogeneous mixture, as well as increasing burning rates.

The variation of NO_x emission with fuel droplets size figure (10) depicts that for mixing olive oil with gas oil fuel, when fuel droplets size decreased from 160 µm to 80 µm, the decrease in NO_x emission is (41.81%) at Φ=1.0. But, for pure gas oil, the decrease in NO_x concentration is (31.23 %).

Figure (11) clarifies that for mixing olive oil with kerosene fuel, when fuel droplets size decreased from 140 µm to 60 µm, the decrease in NO_x emission is (44.98%) at Φ=1.0. But, for pure kerosene, the decrease in NO_x concentration is (32.83%).

This NO_x behavior is associated with droplet interaction and the transitions from diffusive type of spray burning. Decreasing the droplet size results in increasing the droplet interactions; these suppressed the temperatures and reduce NOx.

The variation of soot emission with fuel droplets size figure (12) shows that for mixing olive oil with gas oil fuel, when fuel droplets size has decreased from 160 µm to 80 µm, the decrease in soot emission is (42.37%) at Φ=1.0. But, for pure gas oil, the decreasing in soot concentration is (33.33%).

Figure (13) manifests that for mixing olive oil with kerosene fuel, when fuel droplets size decreased from 140 µm to 60 µm, the decrease in soot emission is (49.5%). But, for pure kerosene, the decreased in soot concentration with the decrease of droplet size is (41.66%),at Φ=1.0.

This behavior may be attributed to the fact that at low atomization pressure, the droplet size of the fuel is large, and the total surface of droplet exposed to the hot air is small, that produced lower evaporation rate so that a large portion of fuel will burn in fuel-rich region therefore the soot emission will increase. Increasing the atomization pressure results in formation of a small droplet size with higher evaporation rate and offer larger surface area of droplet exposed to hot air. These droplets after evaporating and mixing with air will form more homogenous mixture flame. This type of flame has sufficient oxygen available for oxidation of soot, thus decreases soot emission.

As equivalence ratio is decreased, then CO and UHC emissions are decreased also, because the decrease of equivalence ratios makes the mixture lean with sufficient oxygen for oxidation of CO and UHC emissions.

Figure (14) and figure (15) show that for mixing olive oil with gas oil, when the equivalence ratio decreased from 1.7 to 0.85 at different values of fuel droplets size, the CO and UHC concentrations are generally decreased. The corresponding decrease in CO and UHC are (32.24%, 45.63%), respectively, at mix=10%, But, for pure gas oil, the decrease in CO and UHC emission is (26.92%, 30.45%), respectively, at fuel droplets size 100 µm.

Figure (16) and figure (17) show that for mixing olive oil with kerosene, when the equivalence ratio decreased from 1.7 to 0.85 at different values of fuel droplets size, the CO and UHC concentrations are decreased. The corresponding decrease in CO and UHC is (37.41%, 48.92%), respectively, at mix=10%, But, for pure kerosene, the decrease in CO and UHC is (28%, 34.95%), respectively, at fuel droplets size 100 µm.

The main reason of decreasing CO and UHC emissions with decreasing equivalence ratio is that the oxygen concentration in poor mixture is very high for the fuel droplets to complete the combustion process so, that the levels of CO and UHC will be decreased.

For mixing olive oil with gas oil fuel, figure (18) indicates the inverse proportionality of NO_x emissions with increasing equivalence ratio at different values of fuel droplets size. When the equivalence ratio increased from 1 to 1.7, the concentration of NO_x decreased by (39.54 %) at mix=10%. But, for pure gas oil, the decrease in $NO_x$is (33.5%), respectively, at fuel droplets size 100 µm.

Figure (19) manifests that for mixing olive oil with kerosene fuel, when the equivalence ratio increased from 1 to 1.7, the concentration of NO_x decreased by

(42.85%) at mix=10%, But, for pure kerosene, the decrease in NO_x is(39.15%), respectively, at fuel droplets size 100 µm .

This behavior of NO_x attributed to the increase in equivalence ratio that causes a reduction in combustion temperature. This degradation in temperature ascribed to that the oxygen concentration in rich mixture is already low. So that the fuel droplets will not find the suitable amount of oxygen to complete the combustion process and release largest amount of heat. So, the combustion temperature will be reduced in this situation, and the NO_x level will also be reduced.

For mixing olive oil with gas oil fuel, figure (20) indicates the direct proportionality of soot emissions with equivalence ratio at different values of percentage added. When the equivalence ratio decreased from 1.7 to 0.85, the concentration of soot decreased by (36.48 %) at mix=10%, But for, pure gas oil, the decrease in soot is (31.67%), respectively, at fuel droplets size 100 µm and this may attribute to improvement in combustion resulted from decreasing of droplet size [9].

Figure (21) shows that for mixing olive oil with kerosene fuel, when the equivalence ratio decreased from 1.7 to 0.85, the concentration of soot decreased by (42.13%) at mix=10%. But, for pure kerosene, decrease in soot is (37.72%), respectively, at fuel droplets size100 µm.

This behavior may be ascribed to decreasing the equivalence ratio; this means less fuel that leads to poor flame with a higher flame temperature. A higher temperature and more insufficient oxygen available decrease the soot emission.

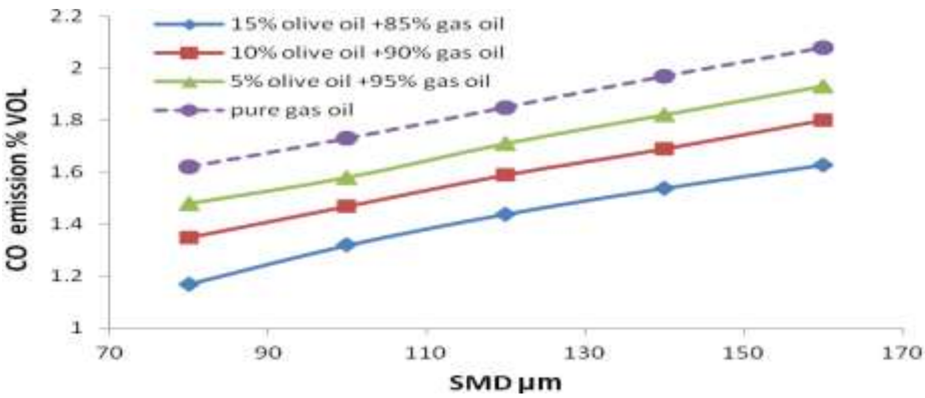

Figure (6):CO emissions from olive oil with gas oil fuel versus percent addat=1.0.

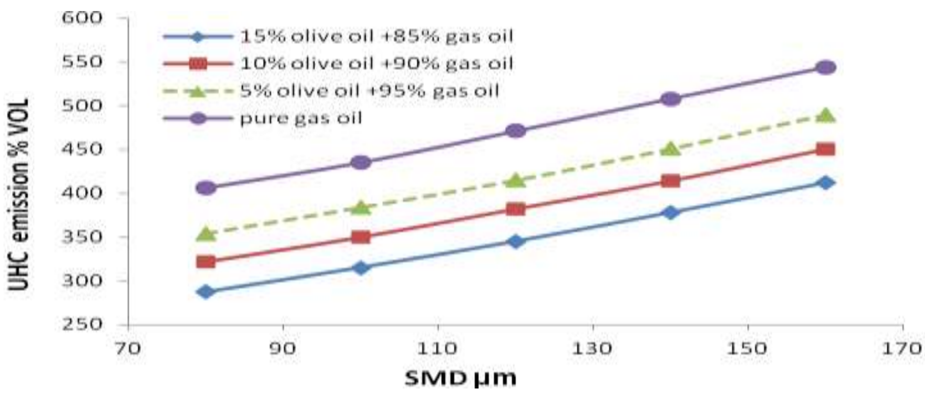

Figure (7) UHC emissions from olive oil with gas oil fuel versus percent add at=1.0.

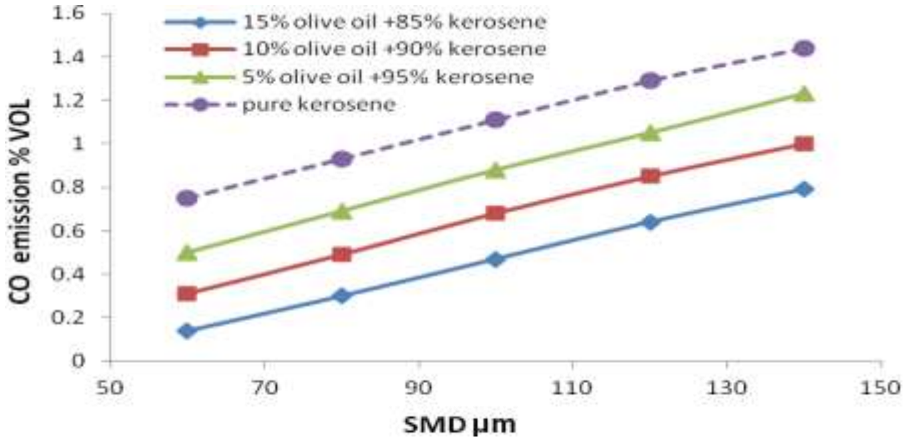

Figure (8):CO emissions from olive oil with kerosene oil fuel versus percent add at=1.0.

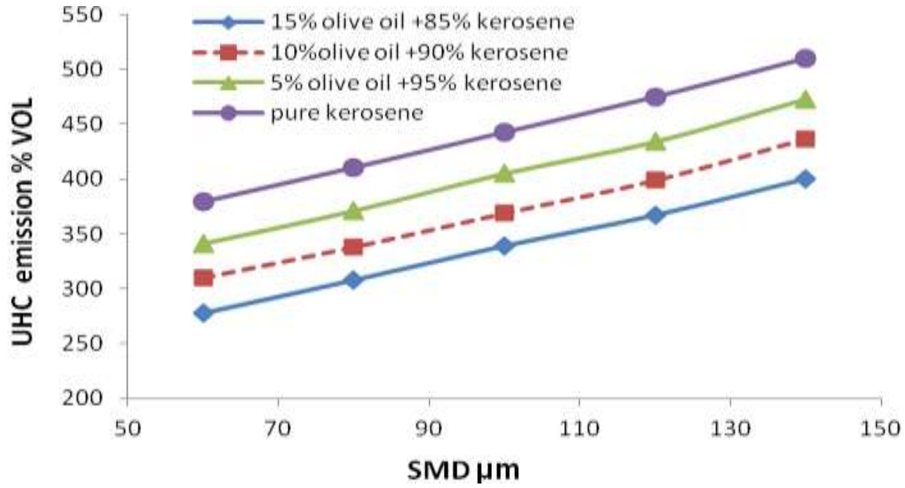

Figure (9):UHC emissions from olive oil with kerosene oil fuel versus percent add at=1.0.

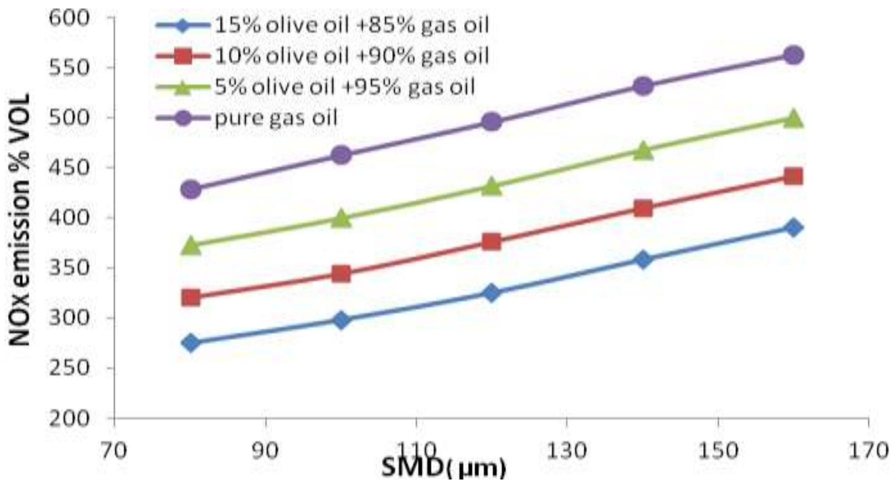

Figure (10):NO_X emissions from olive oil with gas oil fuel versus percent addat=1.0.

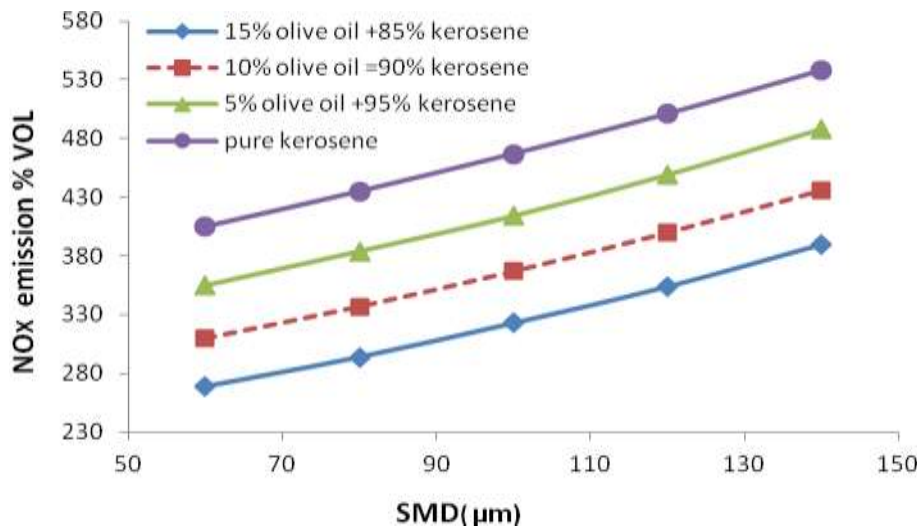

Figure (11):NO_X emissions from olive oil with keroseneoil fuel versus percent addat=1.0.

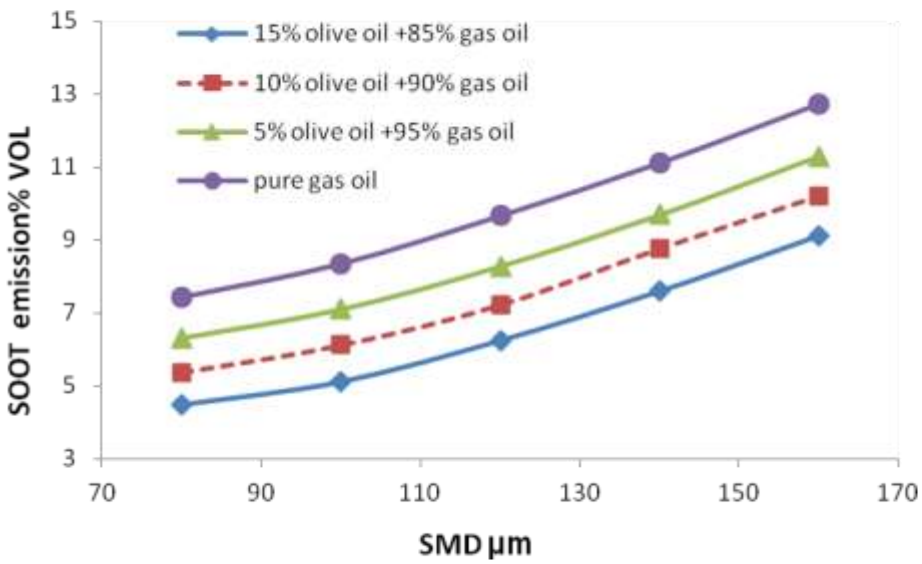

Figure (12):SOOTemissions from olive oil with gas oil fuel versus percent addat=1.0.

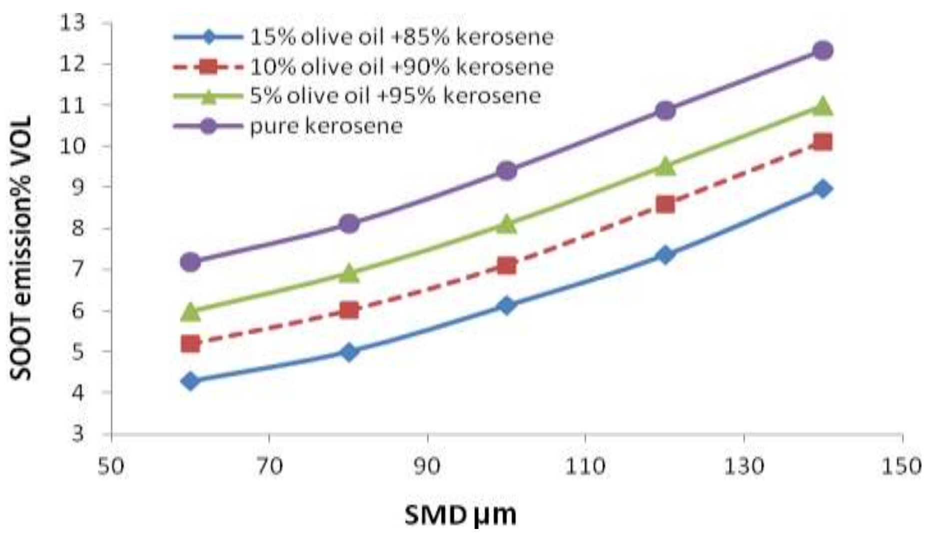

Figure (13):SOOTemissions from olive oil with kerosene oil fuel versus percent add at=1.0.

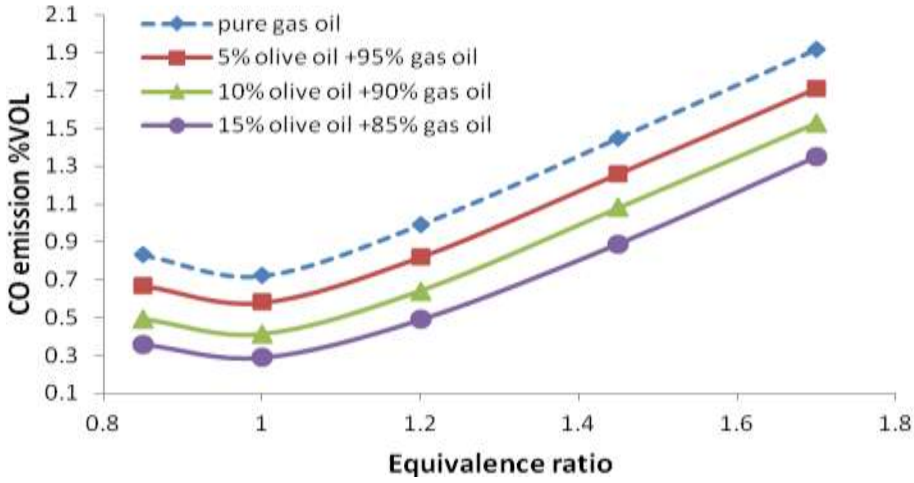

Figure (14):CO emissions from olive oil with gas oil fuel versus equivalence ratio

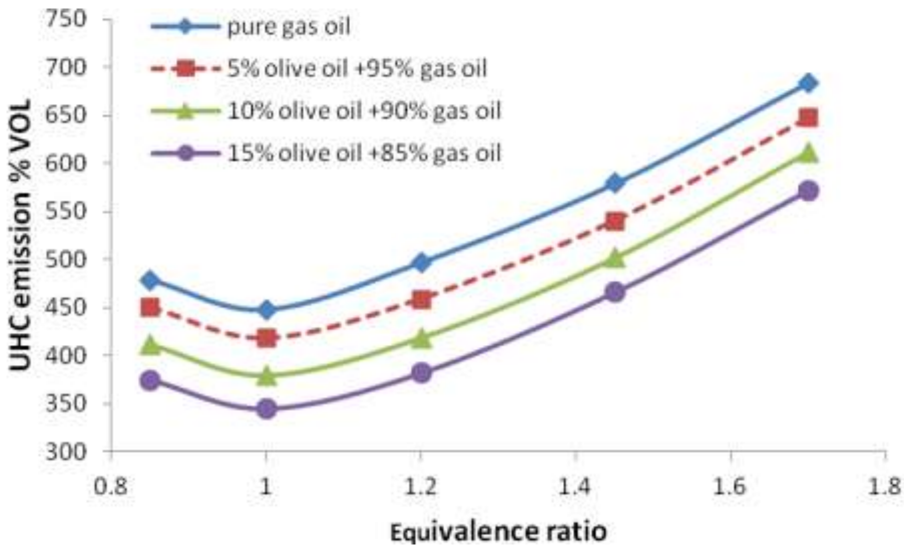

Figure (15):UHC emissions from olive oil with gas oil fuel versus equivalence ratio

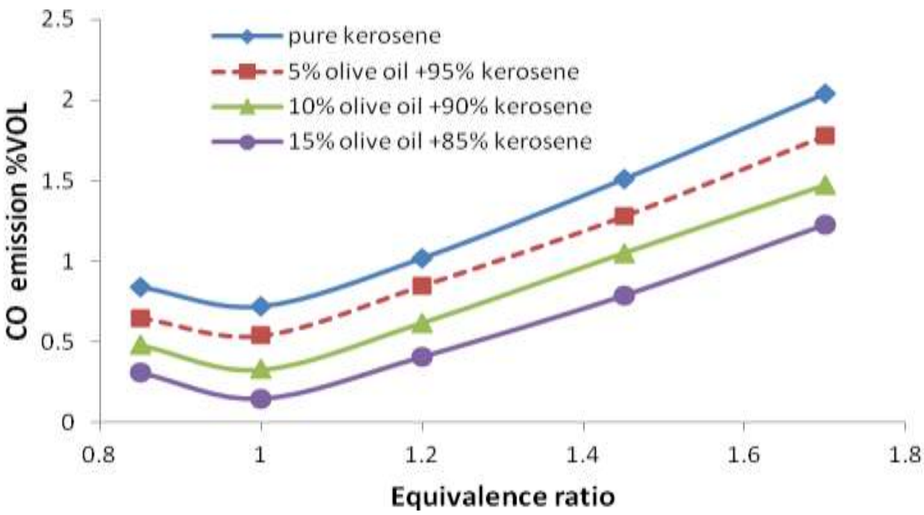

Figure (16):CO emissions from olive oil with kerosene oil fuel versus equivalence ratio

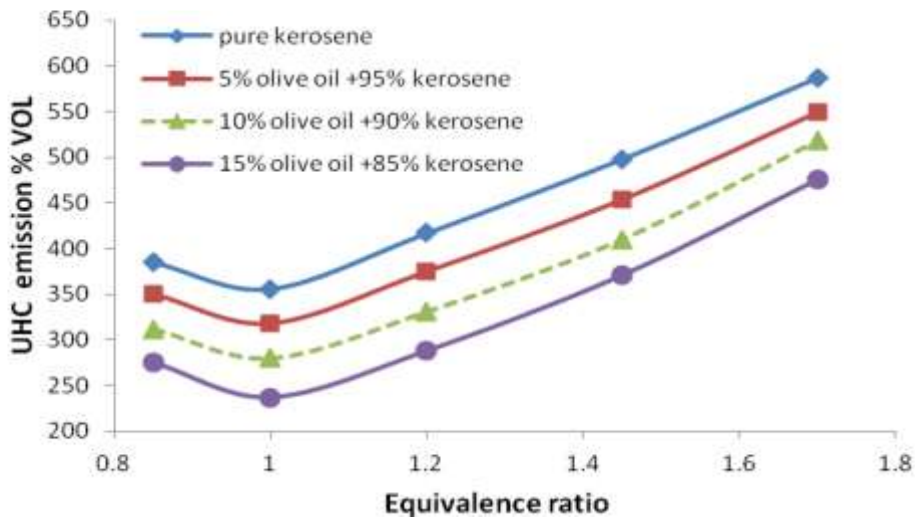

Figure (17):UHC emissions from olive oil with kerosene oil fuel versus equivalence ratio

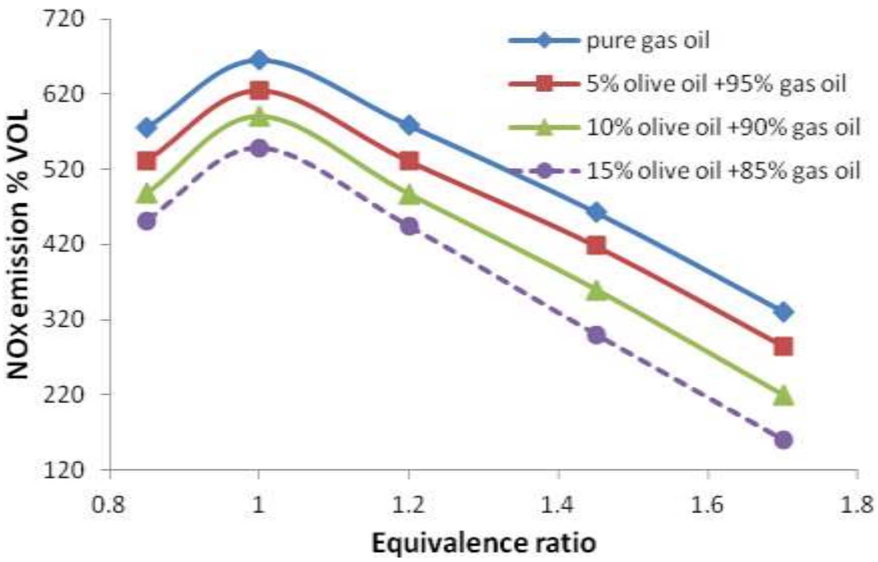

Figure (18):NO_X emissions from olive oil with gas oil fuel versus equivalence ratio

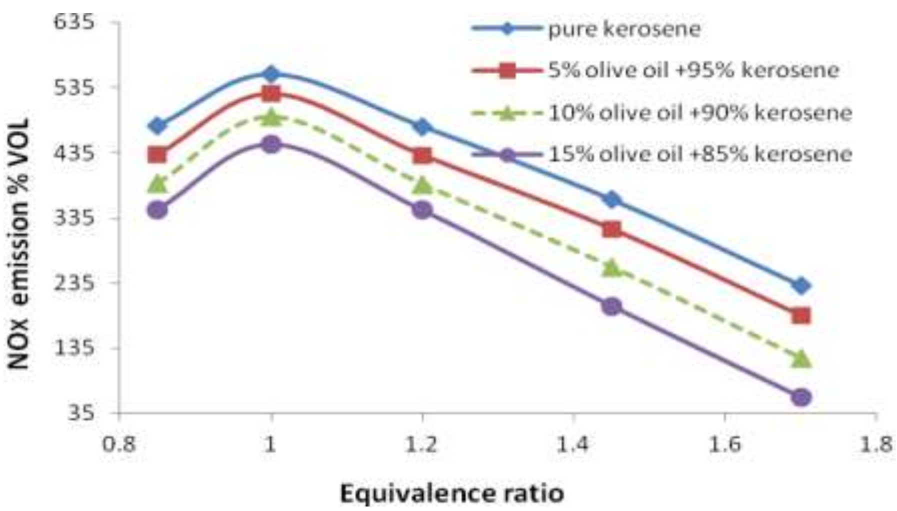

Figure (19):NO_Xemissions from olive oil with kerosene oil fuel versus equivalence ratio

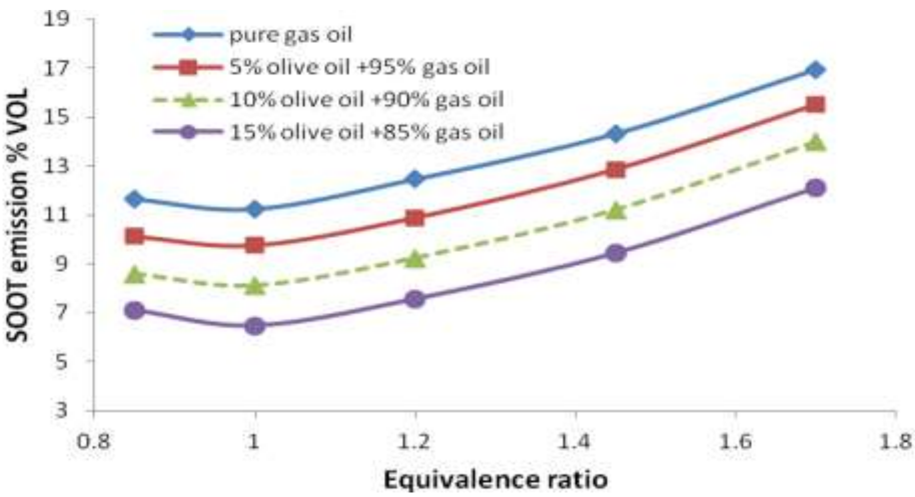

Figure (20):SOOT emissions from olive oil with gas oil fuel versus equivalence ratio

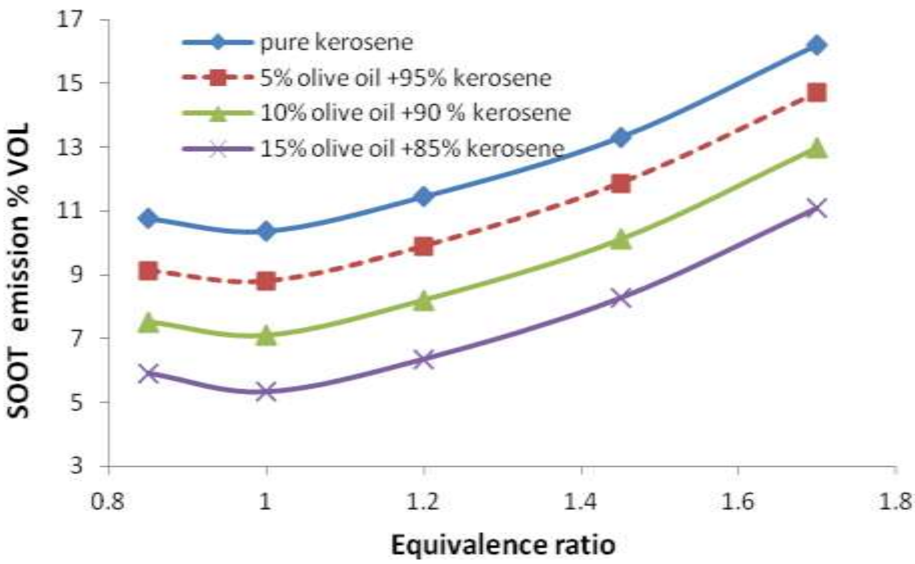

Figure (21):SOOT emissions from olive oil with kerosene oil fuel versus equivalence ratio

4. Conclusions

1. Decreasing the fuel droplet size generally decreases emissions of all kinds of pollutants. When emissions of CO, UHC, NO_x and soot is (42.27%, 45.42%, 44.98%, 49.5%), respectively, at mix=10% olive oil with kerosene fuel.
2. Increasing the equivalence ratio results in an increase in CO, UHC and soot emissions but decreases the NO_x emissions. When the equivalence ratio increases from 0.85 to 1.7, the corresponding rise in CO, UHC and soot emissions is (37. 41%, 48.92%, 42.13%), respectively, at fuel droplet size 100µm and mixing olive oil with kerosene fuel used as fuel. But, the corresponding decrease in NO_x emissions is (42.85 %).
3. The addition of olive oil with kerosene fuel leads to decrease the emission of (CO, UHC, soot and NO_x) by about (25%, 22%, 29.22%, 30.44%), respectively according to the percentage added.

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