

## Experimental Study Of Vegetable Oil -Diesel Blends On The performance Of Compression Ignition Engine

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### ABSTRACT.

The aim of the study is to investigate the effects oils vegetable blends on the performance of single cylinder compression ignition Engine. The three types of vegetable oil appeared to affect the engine performance in a similar way and compared well with diesel fuel, this paper included prepared four samples fuels . They include (10% sunflower oil- 90% diesel blends) , (10% olive oil – 90% diesel blends), (10% corn oil- 90% diesel blends) and pure diesel . The testing achieved between different fuel samples by using the engine four stroke type (TD111) with a single-cylinder and compression ratio (21:1) .

The results show that there is decreasing in parameters performance of engine with using vegetable fuel blends , the brake power decrease as (7.4% ),(5.2%) and ( 1.3%) with using the samples (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively compared with pure diesel fuel for the engine speed of 2000 r.p.m. .While at same engine speed the  $\eta_{bth}$  showed a decrease as (10.9 %),(7.5%) and ( 5.8%) with using the (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively compared with pure diesel fuel . At the same time , it can be found that  $bsfc$  also increases as (7.9% ) , (5.7%) and ( 2.4%) with using (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) compared to pure diesel fuel . The exhaust gas temperature decrease as ( 7 °C),( 5 °C)& ( 3 °C) with using the samples (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively compared with pure diesel fuel for the engine speed of 2000 r.p.m. .

**Keywords : performance , blends , vegetable oil , alternative fuels, compression ignition engine .**

### 1- INTRODUCTION.

Diesel engines are the major sources of transportation power generation , marine application etc . Although more fuel efficient than their spark ignited counterpart , they have relatively higher emissions and noise level . hence , diesel is being used extensively , but due to gradual depletion of fossil fuel reserves and the impact of environmental pollution of increasing exhaust emissions there is an urgent need for suitable alternative fuels for use in C.I. engines. Vegetable oil is one obvious fuel particularly because their fuel properties are closer to diesel fuel. Two important properties, the cetane number and the calorific value are similar to diesel. Hence diesel engines can be operated on vegetable oil without modification[1].

The use of vegetable oils as a source of energy has been known for a long time since the very first creation of the Diesel engine. Vegetable oils are biodegradable and nontoxic. have low emission profiles, are made from renewable resources and so are environmentally beneficial. various oils like jatropa , methyl esters of palm oil , sunflower , cotton seed in

coconut mahura oil , deccan hemp oil are considered as alternate fuels to diesel which are promising alternates because they have the advantage they are renewable environmentally friendly and produced . vegetable oil esters are receiving increasing attention as a non-toxic, biodegradable, and renewable alternative diesel fuel<sup>[2]</sup> . These esters have become known as “biodiesel.” Since biodiesel is produced from vegetable oils and animal fats, the properties of finished biodiesel depend mainly on the feedstock It offers many advantages such as it is renewable, energy efficient, nontoxic, sulfur free and biodegradable, and also it usually takes cleaner combustion and reduces global warming gas emissions from the diesel engines. Biodiesel is also called as Fatty acid Methyl ester. Most vegetable oils can be converted into biodiesel but the cost of the vegetable oil feedstock is now a key factor in the least cost production of biodiesel for blending with fossil fuel diesel [2] .

from pervious studies it is evident that are various problems associated with vegetable oils being used in compression ignition C.I. engines mainly caused by their high viscosity volatility , ring sticking and gum deposits . The viscosity is due to the large molecular mass and chemical structure of vegetable oils which in turn lead to problems in pumping , combustion and atomization in the injector systems of diesel engine , Therefore reduction in viscosity is of prime importance to make vegetable oils suitable alternate fuel for diesel engines [3] . The problem of high viscosity of vegetable oils has been approached in several ways , such as preheating the oils , blends or dilution and with other fuels Therefore the paper study of vegetable oil -diesel blends on the performance of compression ignition engines [3].

In 2003 Khaled R. Asfar and etal [4] has An experimental study of using fuel blends, composed of diesel oil with olive oil and isobutanol alcohol as additives in various percentages, in compression ignition engines is presented. The engine used is a single-cylinder, four-stroke, water-cooled, variable compression ratio engine. The effect of various blends on the brake specific fuel consumption, exhaust soot mass concentration is investigated . They study shows, for blends of diesel and iso-butanol, a considerable drop in soot is obtained for a 5% and 10% pure iso-butanol with diesel . The brake specific fuel consumption increases with alcohol addition. Adding 5% to 10% iso-butanol to 10% olive oil-diesel mixtures as compared to pure diesel .

In 2003 M. Canakci and etal [5] expressed in their paper comparison of engine performance and emissions for petroleum diesel fuel, yellow grease biodiesel, and soybean oil biodiesel . The experiments were carried out on a single cylinder direct injection diesel engine by fuelling Five kinds of pure Fatty acid Methyl ester (FAME) are methyl laurate, methyl myristate, methyl palmitate, methyl separate and methyl oleate, the performance and emissions of diesel engine with the above fatty acids are studied. The conclusions of this study . Both of the methyl esters and their blends gave nearly identical thermal efficiencies with diesel fuel. The *bsfc* for the esters were higher than for diesel fuel . The higher *bsfc* for the net esters may be attributed to their lower heating values. The heating values of the methyl esters are about 12% less than for diesel fuel.

In 2008[6] P. Pavi. Kumar and etal studied performance of C.I. engine using blends of methyl esters of palm oil with diesel the study on the single cylinder 4- stroke naturally aspirated compression ignition engine using alternating fuel like methyl esters of palm oil . the compression of properties like viscosity , density , flash point , cloud point etc. of different mixture of diesel and methyl esters of palm oil etc . are been examined in the study . briefly the suitability of alternating fuels to diesel engine , the vegetable oil , methyl esters of palm oil is chosen as alternative to diesel , which is due to its agricultural origin is able to reduce net carbon dioxide emissions . the biggest hindrance to the easily adaptation of these vegetable oils is high viscosity and low volatility . In the performance analysis , the acquired

data will be useful to predict the thermal efficiency, brake specific fuel consumption, carbon dioxide, carbon monoxide and hydrocarbon.

In 2009 [7] Rehman, A.1, Pandey and et al expressed in their paper. performance and emission evaluation of diesel engine fueled with vegetable oil. To ascertain the possibility of use of modified karanja oil as fuel for compression ignition engine the performance test were conducted. The comparison of the test fuels made with diesel fuel. Test fuels' performance analyzed for esters of karanja oil, blends of karanja oil, and the diesel oil as baseline at varying loads performed at governor controlled speed. The variations in the injection parameters were analyzed to observe its influence on the engine performance with different fuels. results show that diesel engine gives poor performance at lower Injection Pressure than, esterified karanja oil and its blends with diesel. Specific energy consumption is a more reliable parameter for comparison. A comparison of physical and fuel properties of vegetable oils with those of diesel fuel indicates that the vegetable oil are quite similar in nature to diesel fuel. However, vegetable oils have exceptionally high viscosity. After esterification of karanja oil, the specific gravity reduced to 0.895 at 280°C and for diesel at the same temperature was 0.84. The calorific value of esterified karanja oil found to be 36.76 MJ/kg, which is 17.95% lower than that of diesel. The specific Energy consumption is higher for pure karanja methyl ester as well as for its blends with diesel.

In 2010 [8] T. Hari prasad and et al has investigate the effect of the biodiesel produced from high free fatty acid feed stocks on engine performance and emissions. Two different biodiesels were prepared from animal fat-based yellow grease with 9% free fatty acids and from soybean oil. The net fuels and their 20% blends with diesel fuel were studied at steady-state engine operating conditions in a four-cylinder turbocharged diesel engine. The brake thermal efficiencies of all Fatty acid Methyl ester (FAME) fuels are almost the same.

## **2- EXPERIMENTAL APPARATUS.**

### **2-1- Fuel Preparation.**

Three different types of vegetable oil diesel blends have been chosen for use in this paper. They include (10% sunflower oil- diesel blends), (10% olive oil - diesel blends), (10% corn oil- diesel blends) and pure diesel. The vegetable oils were obtained from commercial suppliers for all cases. Properties of the different blends oils along with commercially available diesel fuel are shown in **Table (1)**. The experimental research was performed on samples fuels prepared and tested in research laboratories and quality control of north refineries company. The research engine used in this paper was type (TD111) [9]. The engine is a 230cc, single cylinder type, and has a bore of 70 mm and a stroke of 60 mm. The combustion chamber is cylindrical in shape with a compression ratio of 21: 1. The 4-stroke, naturally aspirated, air-cooled, compression ignition engine is nominally rated at 3.5 kW at 3600 r.p.m. The engine is coupled to TD115 hydraulic dynamometer for measure the engine torque and load control. The main characteristics of the engine are listed in **table (2)**. TD114 instrumentation unit is designed to stand beside the engine under test. in addition to housing the instruments for measuring the engine performance, front view of the instrumentation unit is shown in **picture (1)**. the air consumption box viscous flow meter in TD114 instrumentation unit was used to measured the air flow of the engine. Engine speed was measured by movistrobe tachometer has range (150-4000) r.p.m., fuel mass flow rate was measured using stopwatch and calibrated glass tube divided into three 8,16,32 ml, in the TD114 instrumentation unit, the fuel consumption is determined by measuring the time taken for the engine consume given volume for fuel say 8ml. Type K (Ni-Cr)/(Ni-AL) thermocouples, connected to TD114 were installed to measure Exhaust gas temperatures at the outlet pipes. The schematic diagram of the experimental set up is shown in **Fig. (1)**.

## 2-2- TEST PROCEDURES.

Preliminary engine conditioning was necessary to prepare the engine at steady operating condition . Initially, the engine was run through a warm-up procedure on diesel fuel also the engine run on by handle . The procedure began with normal operation at idling speed . The engine performance carried out with fuel blends was accomplished under condition similar to those occurring if the fuel was substituted for diesel fuel without any modification to the engine . these tests were performed at engine speed ranges from 500 to 3000 r.p.m. with increment 500 r.p.m. . The required engine load was obtained thought the hydraulic a dynamometer . Before running the engine to a new fuel blend ,it was allowed to run for sufficient time to consume the left fuel from the previous experiment . Baseline tests were conducted with 100% diesel fuel .also (10% sunflower oil- diesel blends) , (10% olive oil - diesel blends), (10% corn oil- diesel blends) was used in the engine to compare with the baseline data at the same operating conditions . The experimental data measurements could then be performed for different fuel blends. The operating conditions were stabilized and the variables that were continuously measured were record . This included dynamometer speed ,torque , time required to consume 8 ml of fuels , pressure drop and the exhaust gas temperature.

The engine performance parameters such as brake power , brake specific fuel consumption and thermal brake efficiency were estimated using the following equation :-

$$BP = 2\pi N\tau \quad (1)$$

$$B.S.f.c = \frac{\dot{m}_f}{BP} \quad (2)$$

$$\eta_{bth} = \frac{BP}{\dot{m}_f \times Q_{HV} \times \eta_C} \quad (3)$$

Depending on the above equations the performance of engine is calculated and graph the parameter after assuming the combustion efficiency is 97% .

## 3- RESULTS AND DISCUSSIONS.

The experiments in the unmodified TD111 engine fueled with four types of fuels blends included the brake power , brake thermal efficiency , A/F , brake fuel consumption under various speeds , test runs were made on straight diesel fuel in order to make comparative assessments. Since a large amount of data was collected, only summary data is reported here in this paper as graphic . The properties of vegetable oil - diesel blends and pure diesel fuel blends are shown in **Table (1)**. The cetane number of vegetable oil-diesel blends is lower than that of pure diesel fuel. Cetane Number is a measure of the readiness of a fuel to auto-ignite when injected into a diesel engine. Cetane numbers are established by comparing the test fuel to two standard reference fuels. The fuel component n-cetane (hexadecane), C<sub>16</sub>H<sub>34</sub>, is given the cetane number value of 100, while heptamethylnonane (HMN), C<sub>12</sub>H<sub>34</sub>, is given the value of 15. To investigate the effect of cetane number on the performance , a mixture of materials normally found in vegetable oil was produced and blended with both diesel fuel. contained heptamethylnonane (HMN), C<sub>12</sub>H<sub>34</sub>, more than pure diesel. Therefore, the amount of vegetable oil - diesel fuel blends should be greater than that of diesel fuel to achieve the same energy output . The difference in viscosity between the vegetable oil-diesel blends and

diesel was about tenfold, the viscosity of vegetable oil-diesel blends is higher than that of pure diesel fuel. The engine performance parameters obtained from the analysis of the experimental data are demonstrated in **Figs. (2 to 6)** and expressed in terms of the volume percentage of vegetable oil-diesel fuel blends in order to quantify the effect of vegetable oil blends addition in diesel fuel on engine performance.

**Fig. (2)** shows brake power as function of speed for four samples fuels (10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends), (10% corn oil- 90% diesel blends) and pure diesel. This figure clearly indicates that brake power increases as the engine speed increases for all fuels. Also, the figure presents that brake power decreases as (7.4%), (5.2%) and (1.3%) with using the samples (10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends) and (10% corn oil- 90% diesel blends) respectively compared with pure diesel fuel for the engine speed of 2000 r.p.m. due to the decrease in air-fuel mixture temperature at the beginning of the combustion stroke resulted from the decreases in the lower heating value of the vegetable oil - diesel blends. Consequently, combustion temperature decreases and also one possible reason for this may be the viscosity of the oils diesel blends as this property alters spray characteristics at the time of injection and can delay the combustion process in the engine. The lower cetane number also has the effect of increasing the ignition delay, thus brake power decreases for all the vegetable oil - diesel blends.

The effect of four samples fuels (10% olive oil - 90% diesel blends), (10% sunflower oil - 90% diesel blends), (10% corn oil- 90% diesel blends) and pure diesel fuel on engine brake thermal efficiency ( $\eta_{bth}$ ) at different engine speed is shown in **Fig. (3)**. It is clear that  $\eta_{bth}$  increases as the engine speed increases for all fuels. Also, contrary to the behavior of  $\eta_{bth}$  showed a decrease as (10.9%), (7.5%) and (5.8%) with using the samples (10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends) and (10% corn oil- diesel blends) respectively compared with pure diesel fuel for the engine speed of 2500 r.p.m., the explanation for this behavior lies in the lower brake power of the vegetable oil - diesel blends. This can be attributed to slight increase in  $bsfc$ , a slight decrease in the exhaust temperature and A/F at this speed comparing to diesel fuel.

While **fig. (4)** shows  $bsfc$  as function of speed for four samples fuels (10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends), (10% corn oil- 90% diesel blends) and pure diesel fuel. As shown in the figure,  $bsfc$  increases as the engine speed decreases and reach minimum speed value at (2000) r.p.m. and then increasing with increase the speed for all fuel blends. At the same time, it can be found that  $bsfc$  also increases as (7.9%), (5.7%) and (2.4%) with using ((10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends) and (10% corn oil- 90% diesel blends) respectively compared to pure diesel fuel. This behavior was reasonable in view of the fact that the engine would consume more fuel with fuel blends than with pure diesel fuel to generate the same power output, due to the decrease in the lower heating value of fuel blends, hence the increase  $bsfc$ . At these corresponding conditions the difference in viscosity between the vegetable oil-diesel blends and diesel was about tenfold the viscosity of vegetable oil-diesel blends is higher than that of pure diesel fuel. It can be seen that diesel had  $bsfc$  lower than the row vegetable oil-diesel blends. The results obtained implied that the overall combustion rate for the vegetable oils was somewhat slower than that for the diesel fuel.

Exhaust gas temperature against the engine speed for four samples fuels (10% olive oil - 90% diesel blends), (10% sunflower oil-90% diesel blends), (10% corn oil- 90% diesel blends) and pure diesel presented in **fig. (5)**. As shown in the figure the exhaust gas temperature increases as the engine speed increases for all fuels. On the other hand, it is found that exhaust gas temperature decrease about (7°C), (5°C), (3°C) for the oils diesel blends samples (10% olive oil -90% diesel blends), (10% sunflower oil- 90% diesel blends),

(10% corn oil- diesel blends) respectively compared to pure diesel fuel for the engine speed of 2500 r.p.m. . This behavior can be attributed to the following factors : exhaust gas temperature is an indication of combustion temperature which is a function of ignition time . Diesel fuel has smallest ignition time related to the fuel heat of vaporization and the heating value . therefore with vegetable oil-diesel blends combustion temperature and exhaust gas decreases according to the type of oil vegetable . furthermore , the decrease in exhaust gas temperature is more evident for olive in the blends . This behavior is expected because the amount of fuel consumed by the engine is higher than that of other fuel blends . consequently , the heat losses (i . e. the increase in ignition time ) and the decrease in the heating value increase , hence exhaust gas temperature decrease . Moreover, using the oils diesel blends samples (10% olive oil – 90% diesel blends) , (10% sunflower oil - 90% diesel blends) , and (10% corn oil - 90% diesel blends) decrease in the exhaust gas temperature . This confirms the behavior of exhaust gas temperature. This can be attributed to a slight decrease in *bsfc*, a slight increase in exhaust gas temperature .

#### **4- CONCLUSIONS.**

The effect of the vegetable oil to the diesel fuel on the performance of single cylinder compression ignition engine was investigated and compared to the base line diesel fuel . The main results obtained can be summarized as follows :

1. Exhaust temperature and brake power are decreased with using the oils diesel blends samples (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively due to the increase in the heat of vaporization fuel blends . Also , it should be noticed that (10% corn oil- 90% diesel blends) seemed to perform better than (10% sunflower oil - 90% diesel blends) while the (10% olive oil - 90% diesel blends) is smaller in term brake power and exhaust temperature . The lower cetane number also has the effect of increasing the ignition delay, thus brake power decreases for all the vegetable oil - diesel blends.
2. Brake specific fuel consumption increased for oils diesel blends samples (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil- 90% diesel blends) respectively due to the decrease in the lower heating value of fuel blends . Also , it should be noticed that (10% corn oil- 90% diesel blends) seemed to perform better than (10% sunflower oil - 90% diesel blends) while the (10% olive oil - 90% diesel blends) is smaller in term brake specific fuel consumption . This behavior was reasonable in view of the fact that the engine would consume more fuel with fuel blends than with pure diesel fuel to generate the same power output , due to the decrease in the lower heating value of fuel blends , hence the increase *bsfc*.
3. brake thermal efficiency decreased for oils diesel blends samples (10% olive oil – 90% diesel blends) , (10% sunflower oil- 90% diesel blends) , and (10% corn oil - 90% diesel blends) respectively due to the increase in brake specific fuel consumption and decrease in combustion temperature . Also it should be noticed that (10% corn oil - 90% diesel blends) seemed to perform better than (10% sunflower oil - 90% diesel blends) while the (10% olive oil - 90% diesel blends) is smaller in term brake thermal efficiency , the explanation for this behavior lies in the lower brake power of the vegetable oil - diesel blends . this can be attributed to slight increase in *bsfc*, a slight decrease in the exhaust temperature and A/F at this speed comparing to diesel fuel .
4. It should be noticed that (10% corn oil - 90% diesel blends) seemed to perform better than (10% sunflower oil - 90% diesel blends) while the (10% olive oil - 90% diesel blends) is smaller in terms of engine performance. Pure vegetable oils have been considered as alternatives for diesel fuel, but the high viscosity at room temperature made them unsuitable for diesel engines. Vegetable oil has potential as an alternative

energy source. However, vegetable oil alone will not solve our dependence on oil within any practical time frame. The economics of vegetable oil blends fuels compared to traditional petroleum resources are marginal. But much more will be required if vegetable oils are to achieve their potential in world.

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## **6 - NOMENCLATURE.**

A.P.I	American petrol instituting.
<i>BP</i>	brake power.
<i>bsfc</i>	brake specific fuel consumption.
E.B.P	end boiling point.
I.B.P	initial boiling point.
$m_f$	mass flow rate of fuel.
$Q_{HV}$	heating value.

## **GREEK LETTERS.**

$\tau$	torque.
$\eta_c$	combustion efficiency.
$\eta_{bth}$	brake thermal efficiency.

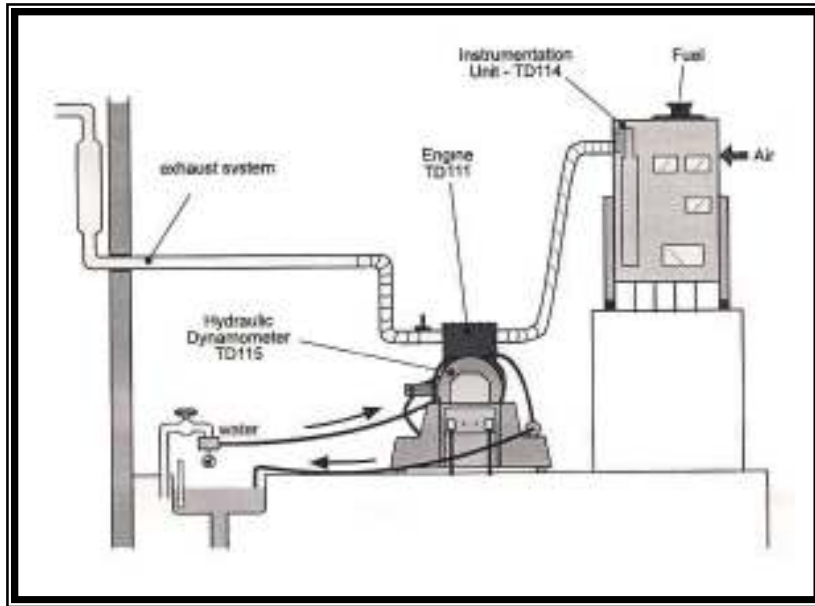
**Table (1):** the properties of fourth sample of diesel fuel.

Test	(10% corn oil - 90% diesel blends)	(10% olive oil – 90% diesel blends)	(10% sunflower oil - 90% diesel blends)	Pure diesel fuel
Specific gravity @ 15.6 °C	0.8417	0.8417	0.8417	0.8337
A.P.I	36.6	36.6	36.6	38.2
Colour	1.0	1.0	1.0	1.0
Flash point °C	60	65	67	61
Pour point	-3	-3	-3	-3
Viscosity (CST) @40 °C	3.7	3.7	3.6	3.4
Cetane	53.4	52.874	52.874	55.268
Distillation				
I.B.P	170	170	169	167
5%	195	196	194	195
10%	212	212	211	209
20%	233	232	232	230
30%	252	252	250	249
40%	270	271	270	265
50%	283	282	282	280
60%	300	300	300	294
70%	316	315	315	305
80%	342	341	341	320
85%	355	354	355	330
90%	360	360	360	342
95%	-	-	-	360
E.B.P	360	360	360	360
T.D	90%	91%	90%	95%
Res.	9	8	9	4
Loss.	1	1	1	1

**Table (2):** the specification of the used engine.

Type of engine	TD111 single cylinder
The No of stroke	4- stroke
bore	70mm
Stroke	60mm
Displacement volume	230 CC
Compression ratio	21:1
Mechanical efficiency	81%
Max. speed	3600 R.P.M
Max. power	3.5





**Figure (1):** show The schematic diagram of the experimental set up of engine (TD11) , instrument TD114 and hydraulic dynamometer TD115.



**Picture (1):** (TD114) instrumentation unit.

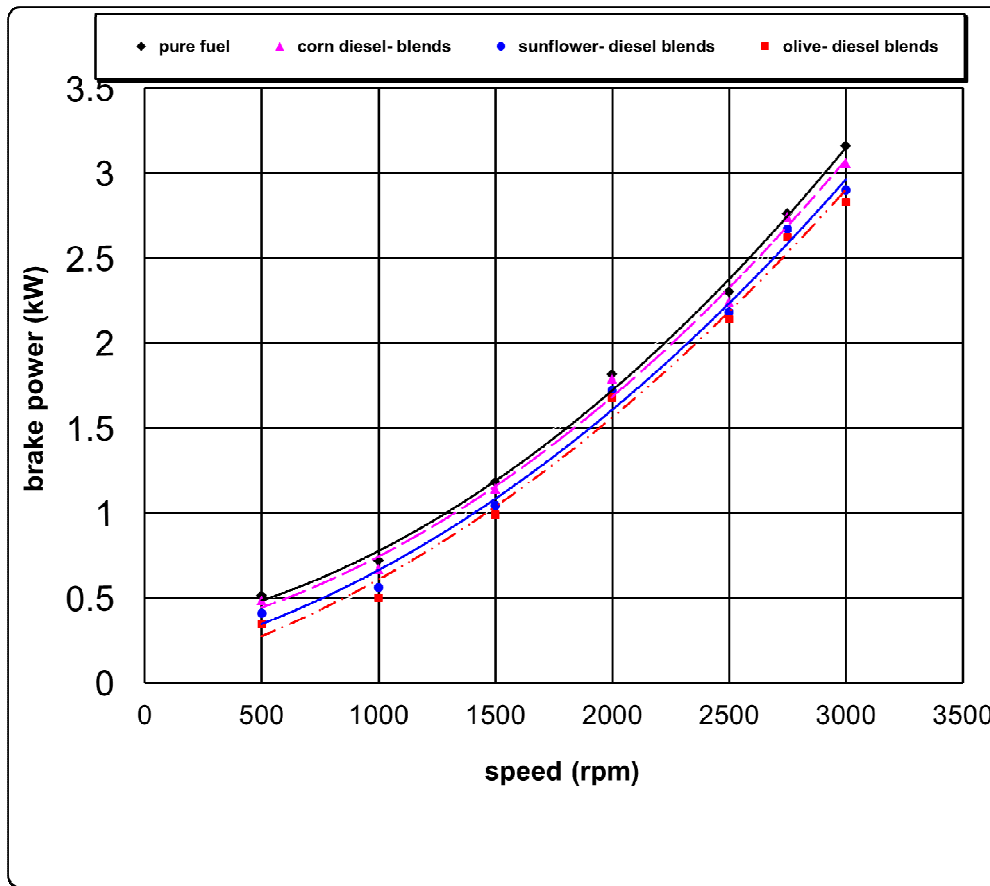


Figure (2): effect of fuel blends types on the *BP* at differences speeds .

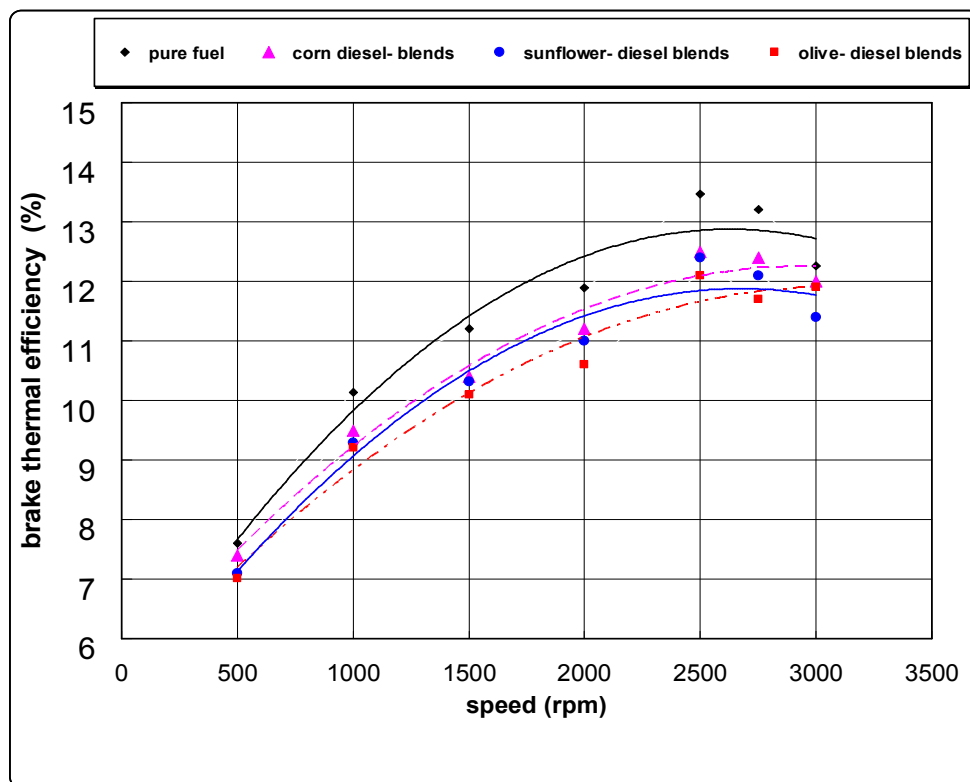


Figure (3): effect of fuel blends types on the brake thermal efficiency at difference speeds .

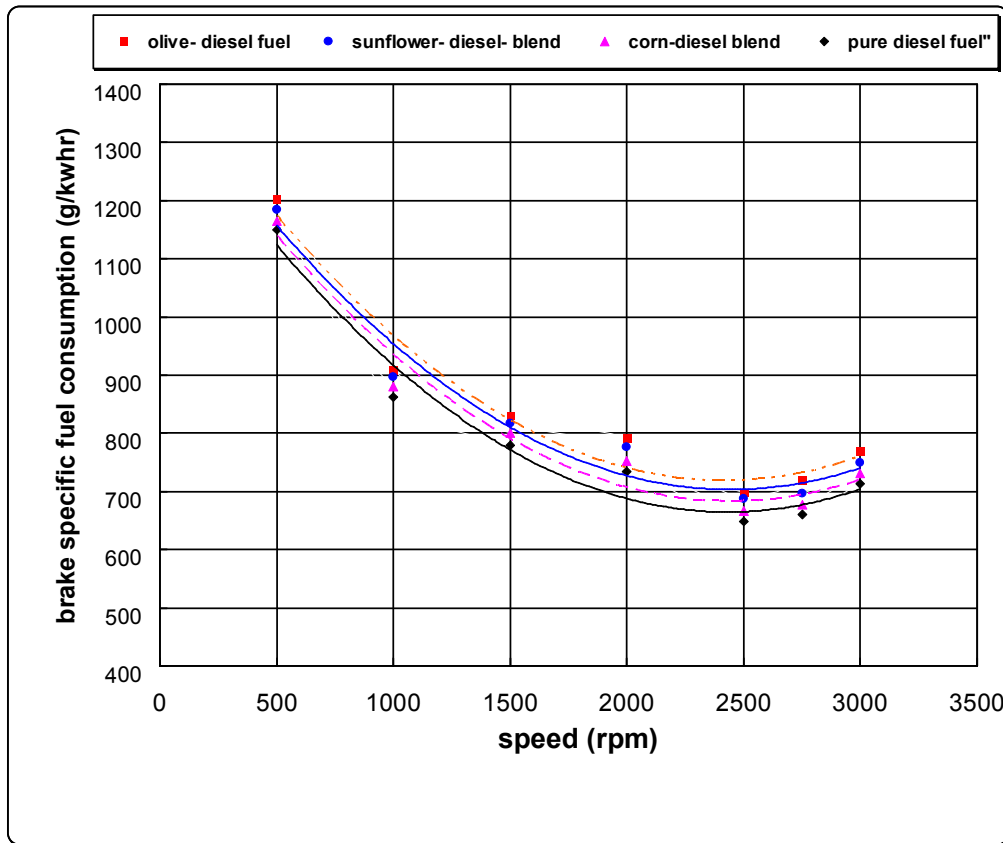


Figure (4): effect of fuel blends types on the *bsfc* at difference speeds .

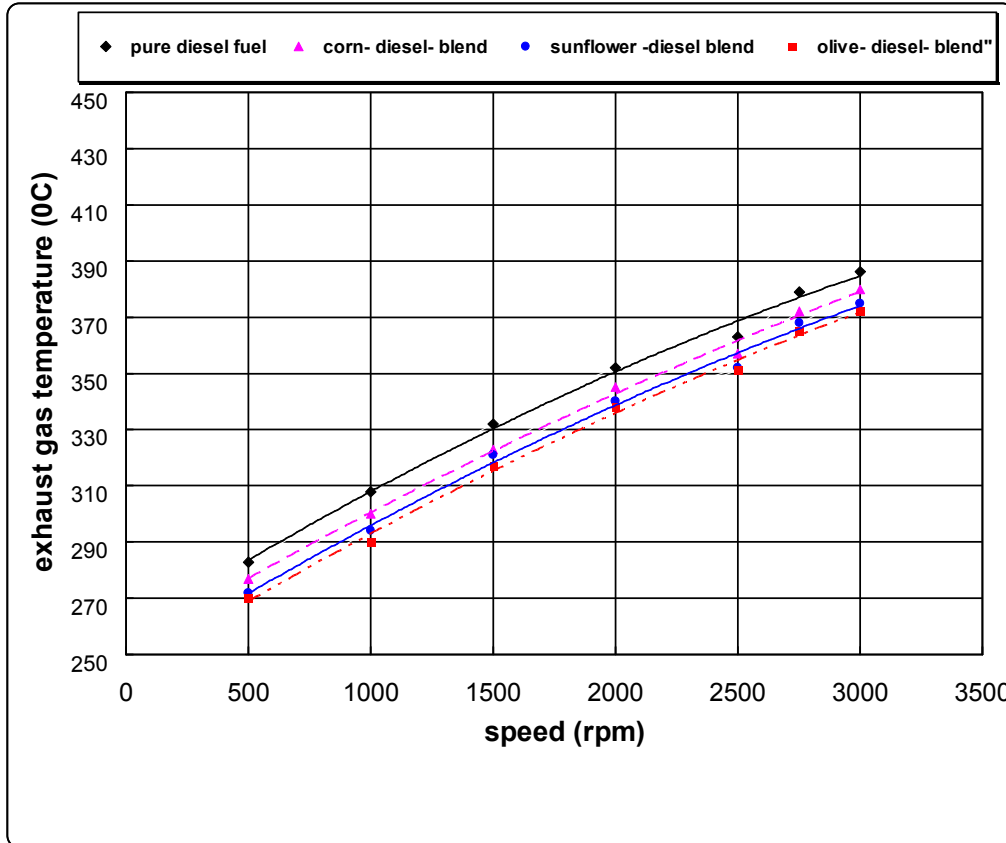


Figure (5): effect of fuel blends types on the exhaust temperature at difference speeds .

## دراسة عملية لخليط الزيوت النباتية- وقود الديزل على أداء محرك إشعال انضغاطي

إبراهيم ثامر نزال

مدرس مساعد

قسم الهندسة الميكانيكية

كلية الهندسة/ جامعة تكريت

### الخلاصة.

أن الهدف من البحث هو دراسة تأثير خليط الدهون النباتية - ديزل على أداء محرك إشعال انضغاطي أحادي الاسطوانة . تم في هذا البحث استخدام ثلاثة أنواع من الخلائط وهي (خليط 10% زيت الزيتون - ديزل) ، (خليط 10% زيت عباد الشمس - ديزل) و (خليط 10% زيت الذرة - ديزل) ومقارنتها مع وقود الديزل النقي . وتم دراسة تأثيرها هذه الخلائط للوقود على الأداء ومقارنتها مع وقود الديزل النقي . أجريت الاختبارات باستخدام محرك ثنائي الأشواط نوع (TD111) أحادي الاسطوانة ذو نسبة انضغاط ( 21:1) ولوحة قياس نوع (TD114).

أظهرت النتائج أن هناك تناقص في معاملات الأداء حيث تقل القدرة المكبحية مع استخدام الخلائط الثلاثة (خليط 10% زيت الزيتون - 90% ديزل) ، (خليط 10% زيت عباد الشمس - 90% ديزل) و (خليط 10% زيت الذرة - 90% ديزل) بالنسب (7.4%)، (5.2%)، و(1.3%) على التوالي بالمقارنة مع وقود الديزل النقي عند السرعة الدورانية (2000) دورة في الدقيقة . في حين عند نفس السرعة الدورانية تزداد الكفاءة الحرارية المكبحية مع استخدام (خليط 10% زيت الزيتون - 90% ديزل) ، (خليط 10% زيت عباد الشمس - 90% ديزل) و (خليط 10% زيت الذرة - 90% ديزل) بالنسب (10.9%) ، (5.7%) و(5.8%) على التوالي بالمقارنة مع وقود الديزل . وفي نفس الوقت نجد ان الاستهلاك النوعي المكبحي يزداد مع استخدام (خليط 10% زيت الزيتون - 90% ديزل) ، (خليط 10% زيت عباد الشمس - 90% ديزل) و (خليط 10% زيت الذرة - 90% ديزل) بالنسب (7.9%) ، (5.7%) و(2.4%) على التوالي بالمقارنة مع وقود الديزل النقي عند السرعة الدورانية نفسها . درجة حرارة العادم تقل بـ (7) ، (5) و(3) درجة مئوية مع استخدام (خليط 10% زيت الزيتون - 90% ديزل) ، (خليط 10% زيت عباد الشمس - 90% ديزل) و (خليط 10% زيت الذرة - 90% ديزل) على التوالي بالمقارنة مع وقود الديزل النقي عند السرعة الدورانية نفسها.

كلمات رئيسية : الأداء ، الخلائط ، الدهون النباتية ، بدائل الوقود، محركات الإشعال الانضغاطي .