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THE IMPACT OF USING BIODIESEL PREPARED FROM WASTE SUNFLOWER OIL & IRAQI CONVENTIONAL DIESEL ON COMPRESSION IGNITION ENGINE PERFORMANCE AND EMISSIONS

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ABSTRACT

The biodiesel fuel is a future fuel due to has oxygen in its chemical composition enhances thereby the chemical reaction process during combustion. The waste sunflower oil is selected for biodiesel preparation because it is commonly used as cooking oil. Furthermore, due to the climate circumstances of the Middle-east, very suitable for production the sunflower oil in a huge amount. This paper concern on studying the impact of using biodiesel prepared from waste sunflower oil and Iraqi conventional diesel on compression ignition engine performance and emissions. The samples of fuel were examined in a single cylinder, air cooled, naturally aspirated and four-stroke compression ignition engine. The biofuel is prepared by mixing the waste sunflower oil into a volumetric percentage of (5%,10%,15%,20%). The engine speed at which the engine performance and emissions measured are (1000,1300,1600,1900,2200,2500) rpm with different engine load. The practical results reveal that the CO, HC emissions are reduced up to (24.375%,35.71%) respectively, but the NO_X and CO_2 emission are increased by (22.62%,36.90%) respectively. The engine brake specific fuel consumption is increased by (12.11%).

KEYWORDS

Waste Corn Oil, Compression Ignition, Alternative Fuels, Combustion.

1. INTRODUCTION

Energy The finding of biofuels has solved many of the problems caused by the lack of fuel and its high price in the world. Biofuel can be prepared in low-cost ways, including the mix of regular diesel fuel with vegetable oils, which are extensively available on the ground. The goal of using biofuels in combustion is not only to permit the price and availability in different areas but also to reduce the emission of pollutants from combustion within the engine cylinder. When mixing of vegetable oils with conventional diesel, the process of a chemical reaction between the substances with a catalyst factor where carbon, hydrogen, and oxygen atoms are combined with the diesel-containing hydrocarbon chain. The fuel contains a hydrogen atom and oxygen within the chemical structure. The presence of oxygen in the chemical structure of the biofuel atoms increases the opportunity for complete combustion. Researchers in the field of combustion and energy in recent years focused on their research on the effects of the use of biofuels, on the emission of combustion. The reason of the increasing number of environmental disasters in the world from spreading diseases, droughts and floods in some regions of the world as a result of the increased concentrations of combustion products in the upper atmosphere. The gases resulting from the combustion process affect negatively and harshly on the ozone layer.

Ziesjewski et al. in their research combined 25% sunflower SVO and 75% petrodiesel and used it in CI engine as fuel. They determined that dilution of SVOs with solvents lowers the viscosity. In this way, some engine performance problems such as injector coking and more carbon deposits could be addressed [1]. Bajpai et al. measured the engine emissions practically when fueled with Karanja SVO blended with petrodiesel. The engine which was used in experimental work is a single cylinder, constant speed 1500 rpm with a compression ratio of 17.5. The biodiesel was prepared from 10% Karanja oil and 90% conventional diesel. The experimental results show that the biodiesel as a fuel improved brake thermal efficiency and reduced brake specific fuel consumption. The NOx emissions are reduced up to 4% when used biodiesel. They also conducted fuel characterisation of preheated Karanja SVO. They reported that by preheating the viscosity of Karanja SVO at 900C was found to be very close to that of petrodiesel.

Finally, they concluded that the self-lubricity and oxygen content of Karanja SVO played a key role in engine performance [2]. Devan et al. examined biodiesel prepared from conventional diesel and poon oil in single cylinder air cooled four stroke compression ignition engines run at a speed of 1500 rpm. The experimental results revealed that the engine fuel consumption and engine output power remain the same when fuel the engine with biodiesel contained low percent of poon oil. The maximum reduction in CO, NO_X and HC emissions is (12%,32%,18%) respectively, which occur when fueled the engine with biodiesel contained 20% poon oil and 80% conventional diesel [3]. Aksoy has an experimental investigation of using vegetable oil as biodiesel. The type of engine which is used in the experimental work was a single cylinder, four strokes and air-cooled fueled with biodiesel which prepared from 50% opium poppy oil – 50 % diesel fuel mixture. The experimental work is accomplished at different engine speed in which the power, torque, and emissions are measured. The experimental results manifest the engine torque and power decrease at 4 % and 5.73 %, respectively.

Specific fuel consumption increases by 12%when compare the results of pure diesel and biodiesel prepared from 50% opium poppy oil – 50 % diesel fuel mixture. The engine emissions of carbon monoxide and nitrogen oxides decrease to 15.5 % and 5.9 %, respectively [4]. Koli and Bansal did experimental research to study the impact of biodiesel on a single cylinder, direct injection four-stroke compression ignition engine performance. The type of biodiesel which is examined in the engine is a combination of Diesel 80% by volume, Mustard oil 10% by volume and Palm oil 10% by volume. Another blend was used, it was a combination of Diesel 90% by volume, Mustard oil 5% by volume and Palm oil 5% by volume. The experimental work results proved that the first blend has a higher value of thermal efficiency, brake specific fuel consumption and lower fuel consumption than the other biodiesel [5].

Degife1 et al. studied the effect of using biodiesel prepared from sunflower oil and conventional diesel on compression ignition engine performance. The test engine was four strokes, single cylinder, water cooled, and naturally aspirated Kirloskar computerised diesel engine test rig. The engine loaded by using eddy current dynamometer. The practical results show the biodiesel reduced the brake power by 6.2% and increase specific fuel consumption by percent of 9.3% [6]. Reddy et al. tested the Jatropha SVO oil on single cylinder constant speed and direct injection diesel engine. The injection time is retarding throughout of engine operation. The experimental results showed that the HC emissions produced from jatropha oil combustions are 532 ppm, but for conventional diesel, combustion is 798 ppm.

The NOx emissions are 1163 ppm when using jatropha oil as fuel, but for diesel, the NOx emissions are 1760 ppm. The smoke emissions are reduced by 0.7 but when fueled the engine with jatropha oil [7]. Radhi and Imran tested the biofuel prepared from olive oil and Castrol oil and conventional diesel. The fuel is combusted in the single cylinder four stroke air cooled and naturally aspirated. The recorded practical data show that the fuel consumption and specific fuel consumption is increased. The engine emissions of NO_X and CO_2 increased, but the emissions of UHC and CO_2 is decreased [8]. Miqdam Tariq Chaichan studied the impact of using biofuel prepared from corn oil and Iraqi conventional diesel which mixed into three different of volumetric percentage on engine performance.

The type of fuel which are used in the practical work is B20, B50, and B100. The engine specification which was used in experimental work was four-cylinder, four strokes and water cooled. The experimental results reveal a better reduction in particulate matter concentration the maximum decreasing in particulate matter emissions was 343.96%. The reduction in smoke emissions in idle mode with reductions of 8.6%, 18%, and 39.75% for B20, B50, and B100 respectively compared to diesel [9]. GITAY1 and SELOKAR studied the impact of using bio diesel with the composition of jaropha oil,mathel ester and conventional diesel in different volumetric percentage which are D80B15E5, D70B20E10 and D70B25E5. The test rig provided with the single cylinder 4-stroke water-cooled compression ignition coupled with the dynamometer to change the load from (0% to 100%) in step of 20% which causes a reduction in engine speed from 1560 rpm to 1500 rpm.

The experimental results show the brake specific fuel consumption, and fuel consumption was decreased by increasing the percentage of vegetable oil volumetric percentage in fuel. CO emission for D70B20E10 fuel blend is observed lower than the other fuel blends. HC emission for D70B20E10 fuel blend is observed lower than the all fuel/fuel blends & higher in case of the D80B15E5 fuel blend [10]. Imran and Kurji studied the effect of using biodiesel on compression ignition engine performance. The biodiesel is prepared from waste corn oil and conventional Iraqi diesel fuel with waste corn oil concentration of (5%,10%,15%,20%) is burned in single cylinder air cooled four strokes and naturally as parted. The practical collected data reveals the fuel consumption and specific fuel consumption is increased. The emissions of CO_2 and NO_X increased but the emissions of CO, UHC is decreased [11].

This work is concerned with the effect of using biodiesel prepared from conventional Iraqi diesel fuel and waste sunflower oil. In this study, the engine speed was varied from 1000 to 2500 into 300rpm increments. The emissions were measured by using the gas analyser. There are two benefits from this experimental study by using this blend, firstly is a reduction in engine emissions. Secondly is used waste cooking oil as fuel to reduce the fuel cost and to lower the concentration level of waste cooking oil in wastewater which causes a mechanical problem in water treatment plant facilities so that the wastewater purified process cost will rise.

2. ENGINE PERFORMANCE MATHEMATICAL MODEL

Based on general heat engine thermodynamics, the engine performance can be simulated according to the following simple model [11]:

1-Fuel mass flow rate.

$$\dot{m}_f = \frac{V_F}{\text{time}} \times \rho_F \quad {}^{\text{kg}}/_{\text{sec}} \tag{1}$$

2- brake power

$$bp = \frac{2\pi * N * T_b}{60 * 1000} \quad kW \tag{2}$$

3- Brake specific fuel consumption

$$\text{bsfc} = \frac{\dot{m}_f}{\text{bp}} \times 3600 \quad \frac{\text{kg}}{\text{kW.hr}} \tag{3}$$

4-Air consumption (C.I. engine)

$$\dot{m}_{\text{a,act.}} = 2.056 \times 10^{-4} \times \sqrt{\nabla P} \quad \frac{\text{kg}}{\text{sec}} \tag{4}$$

5- brake thermal efficiency

$$\eta_{bth.} = \frac{bp}{\dot{m}_f * \text{L.C.V}} \tag{5}$$

Where;

V_F: the volume of fuel consumption.

ρ_F : the density of fuel kg/m^3.

N: rotational speed rpm.

Tb: The torque of engine N.m.

∇P: pressure differences by the manometer.

LCV: low heating value J /kg

3. EXPERIMENTAL WORK

The experimental work of this research was achieved in internal combustion engines laboratory in Kerbala university. The test rig in which the experimental work is accomplished is designed and manufactured in arm filed company, the test rig provided with good instrumentation tools in which can be measured the important engines parameters during the calibration process of the engine under the effect of different factors.

3.1 Experimental setup

The test rig includes four strokes; single cylinder diesel engine has a capacity of, 175 cm^3, cooled by air, coupled with swing dynamometer via a belt to measure the brake torque and power as shown in figure 1. On the other hand technical specification is shown in table 1. The dynamometer worked as a starter at first of engine operation and loaded the engine throughout of the engine operation. The dynamometer speed is regulated by using modern control system. The engine parameter that can be calculated in this test rig is brake torque (N.M), exhaust temperature, engine speed (r.p.m), engine emissions, air and fuel consumption. The torque sensor was employed to measure the brake torque which is installed alongside the dynamometer. The torque sensor that is shown in figure 2 is loaded because of the great change in speed between the dynamometer and engine to permit the dynamometer swing and exerted a load on torque sensor which generates the electric signal as a result of this load. The speed sensor is used to measure the engine speed which is installed at the end of the dynamometer shaft.

The fuel consumption is calculated by using a stopwatch and a scalar cylinder. The air consumption can be measured by using air box which is connected to the engine intake manifold by using rubber pipe. A thermocouple is used to measure the exhaust temperature which is installed before the exhaust muffler. Mod 488 – Italy exhaust gas analyser was used to measure emissions from the engine. The analyser calculates the percentage of the carbon monoxide, carbon dioxide, unburned hydrocarbon, and nitrogen oxide in the exhaust gases.

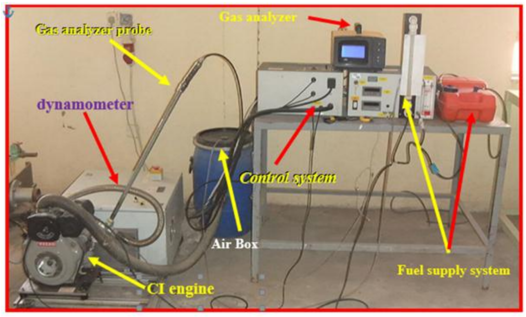


Figure 1: Combustion system test rig.

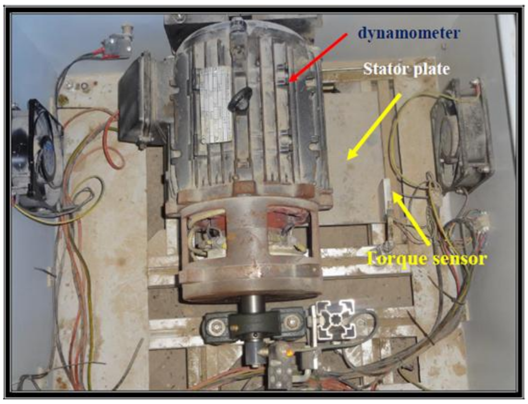


Figure 2: Torque measuring system.

Table 1: Main technical specifications of compression ignition engine.

Compression ignition engine	
Engine type	Single cylinder, four stroke
Engine model	95310
Ignition timing	25^0 BTDC
Displacement	$118cm^3$
Valve per cylinder	two
Bore	60 mm
Stroke	42 mm
Compression ratio	17
Engine cooling type	forced air cooled
Lubrication	Forced lubrication
Engine oil capacity	1.5 L
engine rotation direction	counterclockwise (view from output shaft)

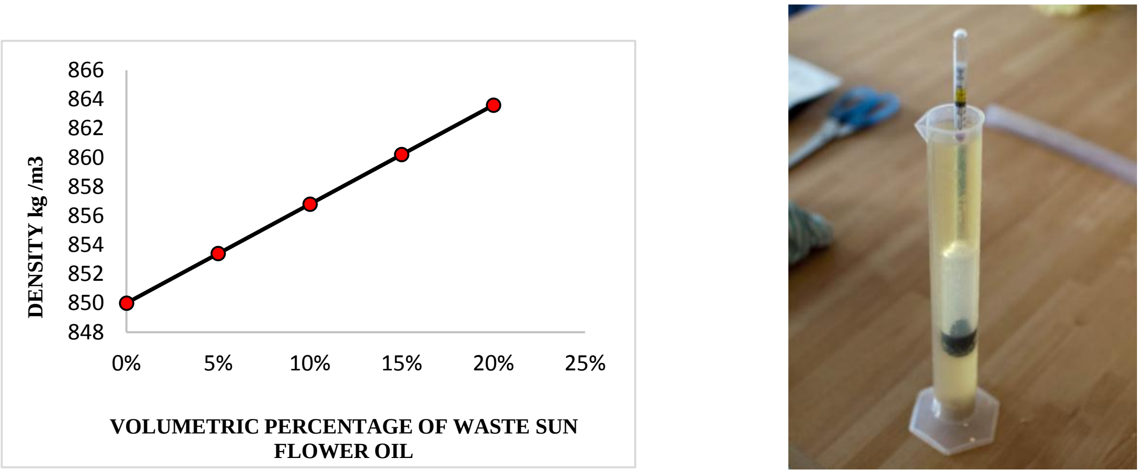
3.2 Preparation of fuel samples

The biofuel was used in experimental work is prepared by mixing the waste sunflower oil which are results from food cooking process as a waste oil in a home with conventional Iraqi diesel fuel into a volumetric percentage of (5%,10%,15%,20%) of waste cooking oil. The waste sunflower oil filters from impurities by using a special filter before mixing process, the temperature of the mixture (diesel and waste sunflower oil) is 60^0C during preparation when adding KOH or NaOH as a catalytic to segregate the gumming material from the biofuel mixture. The material gum effects may damage the engine causing, for example, fuel pipelines clogging and compression ring sticking. So, it should be removed from the blend of diesel and waste cooking oil. The samples of biodiesel are shown in figure 3.

Figure 3: Fuel samples.

3.3 Biofuel Density Measurements

During biofuel preparation the waste sunflower oil of (5%,10%,15%,20%) are to be added into (95%,90%,85%,80%) conventional Iraqi diesel fuel by volume respectively. As a result, the density of the waste oil and fuel mixture will change. The density of fuel was measured by using a hydrometer device shown in figure 4.



A

B

Figure 4: A-The relation between density and waste sunflower oil concentration in the blend, B-Hydrometer.

The variation of density for biodiesel according to the waste sunflower oil volumetric percentage of fuel was shown in figure 4. The density is an important factor that should be considered, because of the high-density effects on fuel droplets size during the combustion process. The increase in fuel droplets size reduced the outer surface area of fuel vapor which will be exposed to the heat and oxidizer at a later stage within the combustion chamber in this situation the fuel droplets will burn in a rich pocket. The burning process in a rich composition of the reactant leads to reduce engine output power and increase in fuel consumption and emissions.

3.4 Biofuel heating value Measurements

The process of adding the waste sunflower oil in diesel during biofuel preparation effects directly on heating value. The heating value was measured by a Bomb Calorimeter device which is shown in figure 5. The experimental results from heating value measuring device explain the variation of heating value in a different type of biodiesel mixture are shown in figure 5. The experimental results show the increase in the volumetric percentage of waste sunflower oil reduced fuel heating value this behavior attributed to that the oxygen molecules concentration is increased with waste sunflower volumetric percentage in biofuel. The high oxygen concentration in fuel and air mixture lead to produced excess air in products of combustion which reduced the temperature during combustion process because of the excess air molecules will not participate in combustion process but absorbed the heat from the flame during the combustion process to reach thermodynamic equilibrium. The excess air effected directly on the second stage of combustion in diesel engines.

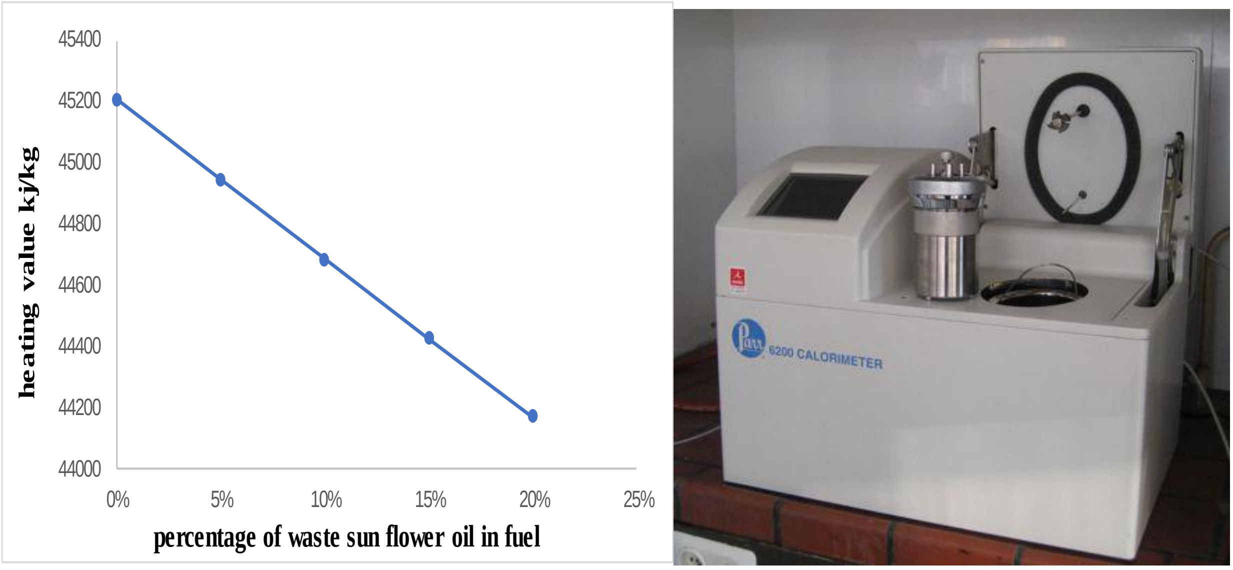


Figure 5: A- the relation between fuel heating value and percentage of waste sunflower oil in biofuel, B- Bomb Calorimeter

3.5 Experimental procedure

The experimental work is accomplished in the following procedure.

I. The involvements tools are calibrated to ensure its measure the engine parameter in accurate values. The biofuel was prepared earlier before starting the test.

II. Determining engine speed, brake torque, the pressure differential between the atmosphere and pressure inside the air box, engine emissions (CO, HC, NO, CO_2) and fuel consumption timing of for the volume of (100) ml with and without using the three types of biofuel.

4. RESULTS AND DISCUSSION

The results of engine calibration which are collected from practical work when fueled the engine with the diverse types of bio fuel prepared from waste sun flower oil and conventional Iraqi diesel fuel include measuring of brake power, fuel consumption, brake specific fuel consumption and engine emissions.

The results of the practical work are abstracted and discussed as a below:

1– The fuel consumption is increasing with increasing the volumetric percentage of waste sun flower oil in a convectional diesel.

The maximum increase of fuel consumption in waste sun flower oil and diesel blend is (11.4%) at 20% volumetric percentage of waste sun flower oil and 80% of diesel as shown in figure 6. The reason of increasing fuel consumption with increasing the percentage of waste sunflower oil in biofuel attributed to that the heating value of the fuel is decreased with increasing the volumetric percentage of waste oil in biodiesel due to oxygen presence in biofuel atoms. The experimental results of heating value test reveal that the heating value is decreased by increasing the volumetric percentage of waste oil in biofuel.

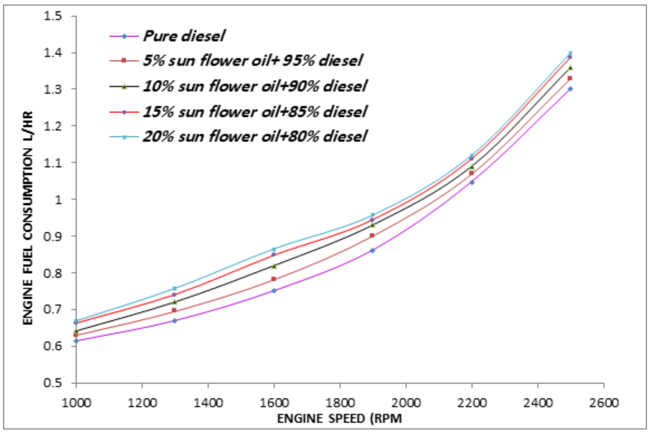


Figure 6: Displays the relation between engine speed and fuel consumption (L/h) engine in C.I. engine with and without using biofuel.

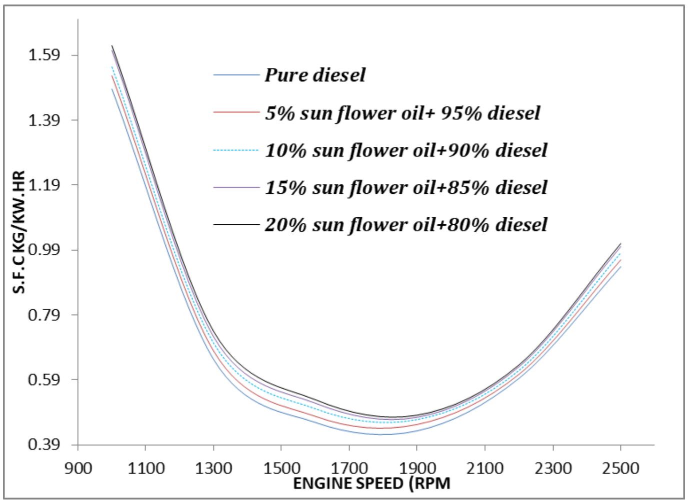


Figure 7: Displays the relation between engine speed and b.s.f.c. in C.I. engine with and without using biofuel.

2 –The brake specific fuel consumption is increased by increasing the volumetric percentage of waste sunflower oil in biofuel during the preparation process. The maximum increase in brake specific fuel consumption is (11.4%) at 20% volumetric percentage of waste sunflower oil and 80% of diesel, as shown in figure 7. The increasing in brake specific fuel consumption with a concentration of waste oil in biodiesel attributed to that the heating value of biofuel is reduced with increase the waste oil volumetric percentage. The reason for that oxygen presence which reduced the mean effective pressure during combustion process so that the output power will decrease due to reduce the value of force effected on the crank shaft off sett.

3-The emission of carbon monoxide is decreased by increasing the volumetric percentage of waste sunflower oil in biofuel as shown in figure 8. The maximum reduction in CO emission is (25.625%) when fueled the engine with biofuel contain 20% of waste sunflower oil. The reason of this decreasing is more oxygen presence within combustion chamber lead to the carbon monoxide atoms will meet the oxygen atoms to form carbon dioxide easily, or the presence of more oxygen prevent the rich pocket combustion process so that the level of carbon monoxide will reduce.

4-The increasing in volumetric percentage of waste sunflower oil with the conventional diesel causes decreasing in unburned hydrocarbon (UHC) emission as shown in figure 9. The maximum decreasing in unburned hydrocarbon emissions is (40.47%) which resulted in fuel the compression ignition engine with biodiesel include 20% as a volumetric percentage of waste sunflower oil. The main reason of this slight decreasing is that the existence of oxygen molecules within in fuel atoms causes increasing in quantity of oxygen within the combustion chamber in this situation the fourth stages of combustion process for diesel fuel will accelerate rapidly due to more oxidiser presence.

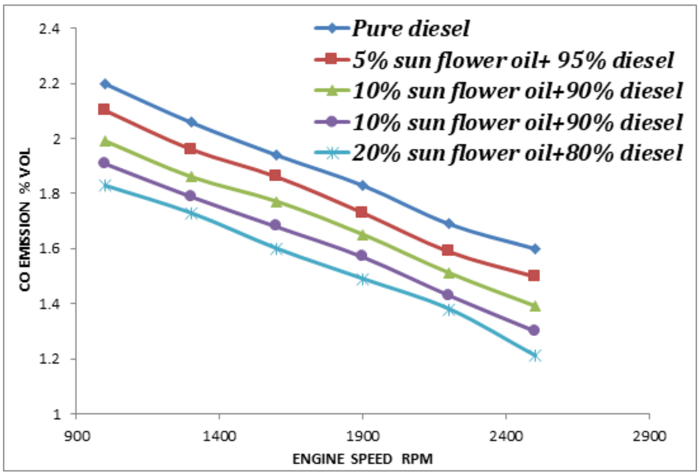


Figure 8: Shows the relation between engine speed and (CO) emission in compression ignition engine with and without using biofuel.

5- The nitrogen oxide (NO_X) emission is increasing with increasing volumetric percentage of waste sunflower oil in a traditional diesel. The NOx emissions increased up to (29. 92%). The biofuel which investigated maximum increasing in NOx emissions includes 20% of waste sunflower oil as shown in figure 10. This behavior of increasing in (NO_X) emissions attributed to that presence of oxygen in biofuel increase. The greater temperature reaction produced by the additional oxygen and enhanced combustion in the saturated biodiesel could likewise lead to higher Zeldovich emissions (thermal NOx) [12].

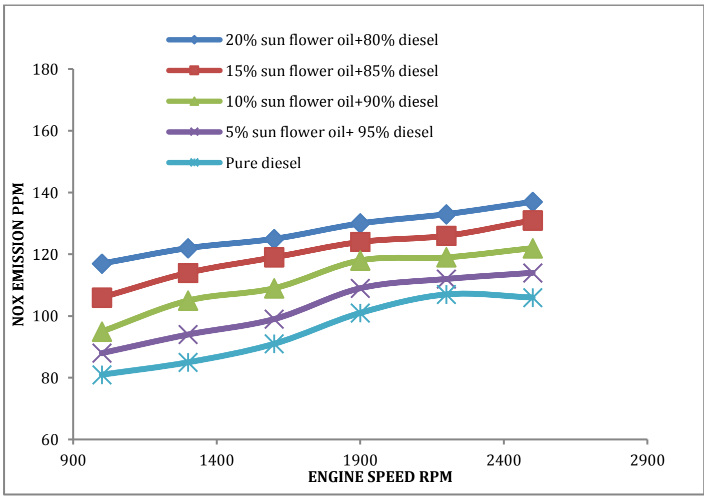


Figure 10: Shows the relation between engine speed and NO_X emission in compression ignition engine with and without using biofuel.

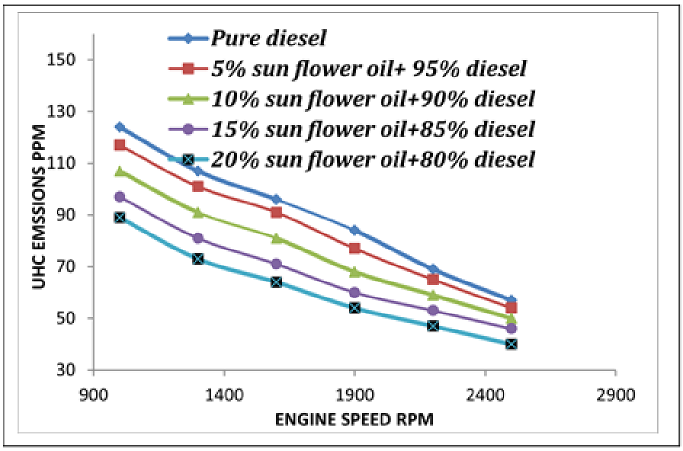


Figure 9: Shows the relation between engine speed and (UHC) emission in compression ignition engine with and without using biofuel.

6– The carbon dioxide (CO_2) emission increased with increasing volumetric percentage of waste corn oil in biodiesel. The maximum increasing in (CO_2) emission when using diesel and corn oil blend is (41.20%). This maximum increases in emissions occur when using a blend containing 20% of corn oil and 80% conventional diesel. Figure 11 demonstrates the increase in (CO_2) emission by increasing the volumetric percentage of waste vegetable oil in a conventional diesel. This behavior of growing in (CO_2) emissions attributed to that the oxygen present in biofuel cause whole combustion and produce more carbon dioxide. Moreover, the high carbon dioxide emissions for the mixtures was attributed to the presence of carbon monoxide in the fuels, with part of the CO produced was converted into CO_2 [13].

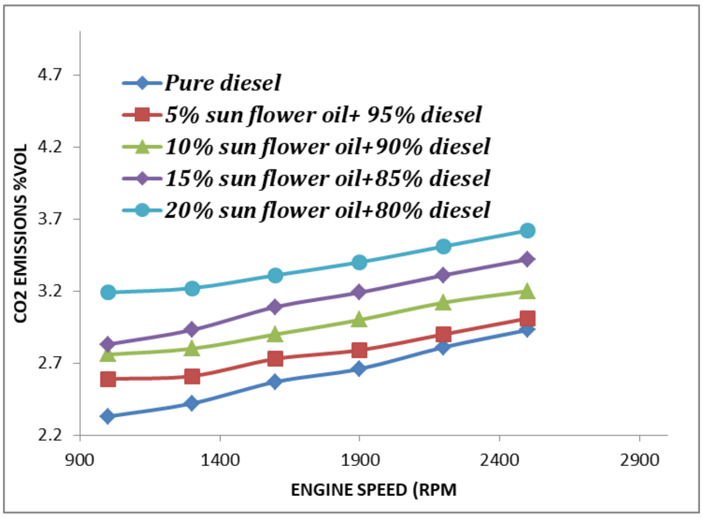


Figure 11: Shows the relation between engine speed and (CO_2) emissions in C.I. engine with and without using biofuel.

5. CONCLUSIONS

The effects of using biodiesel created from waste cooking oil on compression ignition engine performance, for a series of engine speed and load can be concluded as below:

1. Using biodiesel leads to reduce CO and HC emissions. This behavior of reduction in these pollutants attributed to that the biodiesel has oxygen atoms in its chemical structure enhance the combustion process and give complete combustion.

2. Using biodiesel increased CO2 and NOX emissions due to increasing the combustion efficiency.

3. Using biodiesel increase fuel consumption and specific fuel consumption because of the biodiesel has low heating value due to oxygen presence.

4. The burning process in a rich composition of the reactant leads to reduce engine output power and increase in fuel consumption and emissions.

REFERENCES

[1] Ziejewski, M., Goettler, H., Pratt, G.L. 1986. Paper No. 860301, in International congress and exposition, Detroit, MI, pp. 24–28.

[2] Bajpai, S., Sahoo, P.K., Das, L.M. 2009. Feasibility of blending karanja vegetable oil in petro-diesel and utilization in a direct injection diesel engine. Fuel, 88,4, 705–711.

[3] Devan, P.K., Mahalakshmi, N.V. 2009. Performance, emission and combustion characteristics of poon oil and its diesel blends in a DI diesel engine. Fuel, 88 (5), 861–867.

[4] Aksoy, F. 2011. The effect of opium poppy oil diesel fuel mixture on engine performance and emissions. International Journal of Environmental Science and Technology, 8 (1), 57–62.

[5] Koli, C.S., Bansal, R. 2014. Experimental Investigation of Performance of Single Cylinder 4s Diesel Engine Using Dual Vegetable Oil Blended. International Journal of Engineering Science, 4 (3), 78–85.

[6] Degife, W., Ashenafi, M., Thiyagarajan, R., Sahu, O. 2015. Extracted Biodiesel as Feed for Internal Combustion Engine, 3 (1), 1–7.

[7] Reddy, J.N., Ramesh, A. 2006. Parametric studies for improving the performance of a Jatropha oil-fuelled compression ignition engine. Renew Energy, 31 (12), 1994–2016.

[8] Radhi, R.M., Imran, M.S. 2016. Effect of Using Dual Fuel on Compression ignition engine performance, 12 (4), 37–47.

[9] Chaichan, M.T. 2016. Evaluation of emitted particulate matters emissions in multi-cylinder diesel engine fuelled with biodiesel. American Journal of Mechanical Engineering, 4 (1), 1–6.

[10] Gitay, J.S., Selokar, G.R. 2017. Critical Analysis & Performance Evaluation Of Ci Diesel Engine Using Bio Diesel.

[11] Imran, M.S., Kurji, H.J. 2018. The Effect of Using Waste Corn Oil on Compression Ignition Engine Performance, 13 (6), 3966–3974.

[12] Lee, M.C., Bin Seo, S., Yoon, J., Kim, M., Yoon, Y. 2012. Experimental study on the effect of N2, CO2, and steam dilution on the combustion performance of H2 and CO synthetic gas in an industrial gas turbine. Fuel, 102, 431–438.

[13] Shih, H., Hsu, J. 2012. A Computational Study of Flammability Limits of Opposed-Jet Syngas Diffusion Flames. International Journal of Hydrogen Energy, 36 (11), 15868–15879.