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The Effects of Dill Oil Biodiesel on CI Engine Emissions and Performance

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ABSTRACT

The primary cause of global warming and human respiratory problems is the impact of engine emissions from fuel combustion. The mitigation procedure for these pollutants involves altering the design of engine components or using alternative fuel sources. To effectively use biofuel, one must focus on minimizing engine emissions and addressing the issue of fuel shortages. This work specifically examined the impact of using novel forms of biodiesel derived from dill oil on the performance and emissions of CI engine. Blends of conventional Iraqi diesel fuel and dill oil biodiesel were created and mixed in volumetric proportions of 10%, 20%, 40%, 60%, 80%, and 100%. A compression ratio of 18 and a fuel injection timing of 23° bTDC were the settings used for the test engine. The testing findings reveal that this particular biodiesel enhances brake-specific fuel consumption (BSFC), themass of fuel burnt rate, and exhaust gas temperature (EGT), while decreasing engine thermal efficiency (BTHE), delay period time (DP), and cylinder pressure (ICP). Also, it decreased emissions of HC, soot, and CO, but increased emissions of CO_2 and NOx.

1. INTRODUCTION

The wide-ranging use of (CI) engines has led to the depletion of fossil fuels and environmental degradation. The CI engine operation increased demand for conventional fuels and reduced subterranean carbon reserves. The four primary pollutants diesel engines release are HC, CO, PM, and NOx [1, 2]. To address these environmental issues, countries are implementing tighter emission limits. Researchers are exploring renewable alternative fuels to balance energy conservation, sustainable growth, and environmental protection. This research aims to find new ways to produce and use CI engine alternative fuels [3-5].

Gopal et al. [6] examined the impacts of using BDF generated by trans-esterifying waste oil from stoves, BDF, and DF to fuel automobiles. Based on the data collected during the experiments, using BDF decreased the BTHE and the emissions of CO, UHC, and smoke. The utilization of BDF in CI engines also has the additional side effect of increasing the engine's overall specific energy consumption. Raman et al. [7] examined the influence of blending DF and cooking oil to create BDF for CI engines. The tests compare DF with waste-cooking BDF. They found no significant differences in their performance. The BDF decreases exhaust emissions and improves the BTHE. Kandasamy et al. [8] examined a CI engine running on vegetable oil and DF to determine its emissions and performance. The engine ran on vegetable oil and DF. Vegetable oil and DF mixture of 20%, 40%, 60%, and 80%. They were warming the mixture before feeding it to the diesel engine. Results demonstrate that preheating DF increases engine thermal efficiency and performance. Engine efficiency is optimal with 60% pun gam oil and 40% conventional DF or 40% rice bran oil and 60% conventional Radhi and Imran [9]. Experimented with BDF effect on engine emissions and performance. DF was mixed with olive oil and Castrol oil BDF at various percentages for CI engines. Separate amounts of vegetable oils make a "5% to 20%" BDF. Results show a lessening in CO and UHC emissions but a rise in CO_2 and NOx. The engine's BSFC rises somewhat with steady power. Logesh et al. [10] studied how coconut BDF affects CI engine exhaust pollution and fuel efficiency. They combined BDF with DF at 5% and 10% volumetric percentages. The investigations showed 1.7%, 1.9%, 2.1%, and 2.7% reductions in CO, HC, soot, and NO_X volumetric percentages. BSFC dropped to 1.3%, but engine thermal efficiency rose to 1.2%.

Imran and Kurji [11] tested the impact of waste corn oil BDF on CI engine performance and emissions. The researchers tested with engine speeds ranging from 1400 to 3000 rpm, adding waste cooking oil and conventional DF in various volume ratios. The findings showed that by combining used cooking oil with diesel, BSFC was enhanced by 11.4% while HC and CO exhaust gas emissions were reduced by 32.2% and 25.625%, respectively. Savariraj et al. [12] examined the impact of fish oil BDF mixed with DF on CI engines. They discovered that the B100 mix raised the amount of BSFC and BTHE than the DF blend. The study also found lower peak cylinder pressures and earlier combustion times for fish oil BDF than DF. However, B100 fuel emitted higher smoke, NOx, CO, and HC emissions than DF at higher loads.

Pandhare and Padalkar [13] evaluated CI engine performance with DF and Jatropha oil BDF combination. Experimental results reveal that B100 burns 15% more fuel than DF. BDF blends have slightly higher BTHE than DF. BDF rises engine EGT, NO_X, and CO_2 emissions but lowers CO emissions.

Agarwal and Dhar [14] found that Neem oil BDF mixtures had greater BSFC than DF but lower than BTHE. The engine emitted higher levels of NO but less CO and HC when using BDF as engine fuel. Combustion research indicated BDF fueled engines start sooner in all conditions, while 20% of blends begin later. Subhanandh et al. [15] assessed a CI engine's emission parameters and performance using blends of Calophyllum inophyllum BDF. During the testing phase, the CR of the engine exhibited values ranging from 15 to 18. Also investigated was the lessening of CO, NOx, and HC emissions and their exhaust gases in traditional diesel engines.

Prbakaran and Viswanathan [16] Analyzed the combustion, performance, and emissions characteristics of CI engine mixtures including anhydrous ethanol and non-edible methyl ester of cottonseed oil under several loads. The blends, ranging from 10% to 50%, had a BTHE equivalent to DF. Higher loads led to decreased NOx, smoke, CO, and HC emissions, while lower loads increased them. Greater loads increased the mixtures' maximum HRR and pressure.

Logesh et al. [17] investigated the influence of using coconut BDF on the efficiency and emissions of engines. Combinations of BDF with DF at concentrations of 5% and 10% by volume. According to the results of the experiments, the emissions of CO, HC, soot, and NO_X all fell by 1.7%, 1.9%, 2.1%, and 2.7%, correspondingly. While the BSFC fell to 1.3%, the engine BTHE increased to 1.2%. De Almeida et al. [18] used palm oil as an additive in the preparation of BDF. Their findings revealed that as the quantity of palm oil increased, both the EGT and the (BSFC) exhibited an increase. As the loads increased, there was a corresponding rise in CO emissions. This refers to the absence of oxygen at higher equivalence ratios. Nevertheless, the emissions levels of NOx during the combustion of palm oil BDF were lower than the combustion of DF.

Gad and Mustafa [19] examined the impact on CI engine emissions and performance by fueling diesel engines with 10% and 20% volume mixes of DF and roselle BDF, respectively. Experiments were conducted with engine loads ranging from zero to full. Engine BTHE and NOx emissions were increased by the roselle BDF mix, whereas BSFC, CO and HC emissions were lowered. Saravanakumar et al. [20] used various ratios of lemongrass oil BDF and methanol combined with DF. The systematic analysis found that lemongrass 30%, methanol 20% and DF 50% blend had greater BTHE and BSFC than DF. Dual-BDF blends decrease CO, HC, and CO_2 better than Imtenan et al. [21] enhanced the Palm BDF (P20) with Diethyl ether (DEE), an oxygenated cold-starting fuel. The (P15) and (P10) were the enhanced fuels. Both emissions and combustion were areas where DEE blends excelled over P20. Above P20, the oxygenated DEE composition decreased CO emissions by 25% and smoke emissions by 35.5%. The NO emission decreased by 20% when comparing P10D10 to P20. Mixtures of DEE increased HC emission. The HRR and ICP profiles of the adjusted mixes vary from those of the P20 blend due to the chemical changes. Kassim et al. [22] researched in the influence of burning BDF prepared using palm oil on CI engine performance and level of emissions. The BDF was added to the DF in a volumetric ratio of 5%, 10%, 15%, and 100%. The practical results show that the BSFC and levels of emissions of CO_2 and NO_X increased. The BTHE and level of CO and HC emissions decreased.

The benefit from the previous literature review is learning how can be prepared BDF and mixed it with DF, as well as the effect of using BDF on CI engine levels of emissions and performance.

The gap between this research and other BDF research is particular; investigations have yet to be conducted on the combustion of a dill BDF blend in CI engines and its emissions properties. The most novel aspect of this study is the analysis of how the dill BDF mixture affects the efficiency and emissions of a four-stroke diesel engine with a single cylinder. Thus, it is vital to discover how dill BDF mixtures are prepared to operate the diesel engine and how much emissions they emit. Experiments were conducted utilizing a diesel engine and several dill BDF mixtures.

Figure 1. Preparation steps of dill oil biodiesel

2. BIODIESEL FUEL PREPARATION METHOD

The preparation process of dill biodiesel is accomplished by a trans-esterification reaction in many steps, as shown in Figure 1. Step one in making biodiesel is making the methoxide, which is done by combining one gram of KOH with 0.2 litres of pure methanol for every litter of dill oil. The mixture is then mixed using a hot plate magnetic stirrer mixer dual control type (SH-2) at a speed of 500 rpm. The dill oil is extracted through steam distillation from the dried seeds and whole dill plant and heated at a later to 60°C using a hot plate stirrer. Before placing the mixture on the hot plate stirrer, the methoxide was mixed with the heated dill oil. While the dill oil and methoxide were being mixed at 900 rpm for 120 minutes at 60°C, a chemical reaction took place. Using the dedicated funnel with a capacity of one liter, the glycerin was extracted from the liquid after mixing. After rinsing the BDF with deionized water, it was heated to 110°C to eliminate any remaining moisture. The final preparation step includes a BDF filtering process to remove the impurities. The dill BDF blended with the conventional Iraqi DF into volumetric percentages of 10%, 20%, 40%, 60%, 80% and 100%. The preparation process is according to the information references [23-25].

3. BIODIESEL FUEL BLENDS PHYSICAL AND CHEMICAL PROPERTIES

At Kerbela University's Petroleum Engineering Department, the Ministry of Petroleum's Centre of Research and Development, and the Ministry of Manufacturing and Materials' Centre of Research and Development, the chemical and physical properties of the BDF blends were studied. Table 1 lists the test fuel's final results. On average, 96.5% of biodiesel yield is through the trans-esterification of dill biodiesel. Table 2 displays the results of the gas chromatography-mass spectrometry (GC-MS) analyses of the (FAME) found in the BDF that was obtained. Figure 2 shows the chromatogram of the dill BDF obtained. The biodiesel contains esters, which lead to the presence of fifteen peaks on the chromatogram.

Table 1. Physical and chemical characteristics of the biofuel blend

Property	Unit	Method	DF	BD10	BD20	BD40	BD60	BD80	BD100
Density @ 15°C	Kg/m^3	ASTMD-4052	831	833.5	837	844	851	858	866
Kinematic viscosity @ 38.8°C	mm^2/s	ASTMD-445	2.51	2.62	2.84	3.21	3.5	3.9	4.2
Flash point temperature	°C	ASTMD-93	62	69	78	87	101	119	131
Fire point temperature	°C	ASTMD-93	73	88	99	112	125	139	156
Calorific value	MJ/kg	ASTMD-224	46.5	46.1	45.73	45.13	44.53	43.82	43.41
Cetane number	-	ASTMD-2699	46.3	48.8	51.42	54.9	56.74	59.3	61.55

Table 2. FAME content of dill biodiesel

Compounds Detected	Molecular Formula	Composition (%)	#Peaks
Cyclohexanol, 1-methyl-4-(1-methyl phenyl)-	$C_{10}H_{18}O$	6.20	1
Dodecanese	$C_{12}H_{26}$	0.55	2
Cyclohexanone,	$C_{10}H_{16}O$	8.68	3
Cyclohexanone2-methyl-5-(1-methyl phenyl)-, trans-	$C_{10}H_{16}O$	2.18	4
D-Carvone	$C_{10}H_{14}O$	8.22	5
Apiol	$C_{12}H_{14}O_4$	3.13	6
Cyclotetradecane, 1,7,11-trimethyl	$C_{20}H_{40}$	0.84	7
Hexadecenoic acid, methyl ester	$C_{17}H_{34}O_2$	18.34	8
9,12-Octadecadienoic acid (Z,Z)-,	$C_{18}H_{32}O_2$	33.18	9
11-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	9.08	10
16-Methylheptadecanoic acid	$C_{18}H_{36}O_2$	6.38	11
11,14-Eicosadienoic acid, methyl ester	$C_{21}H_{38}O_2$	1.11	12
2-(7-Heptadecynyloxy) tetrahydro-2H-pyran	$C_{22}H_{40}O_2$	0.74	13
17-Pentatriacontene	$C_{35}H_{70}$	0.60	14
Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	0.77	15

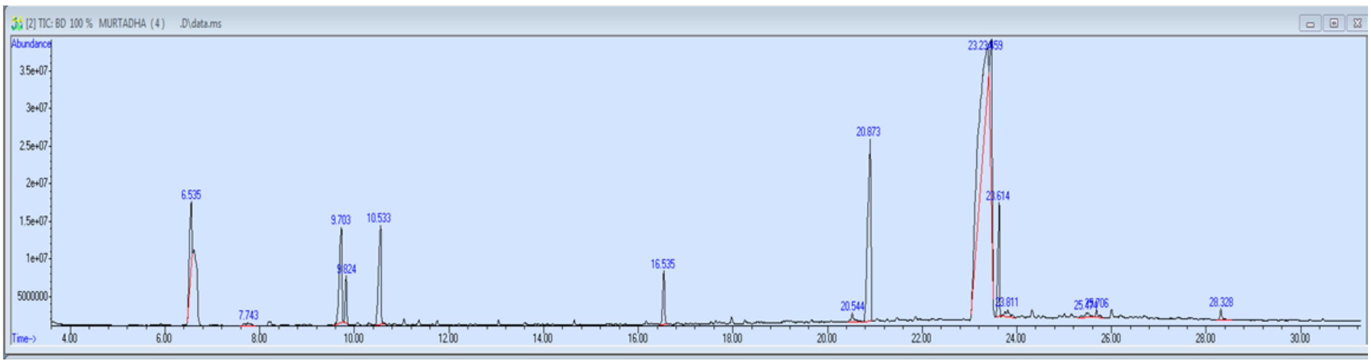
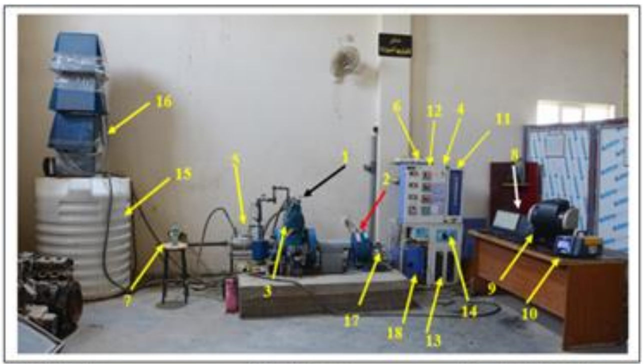


Figure 2. (GC–MS) chromatogram of BDF

4. EXPERIMENTAL SETUP

The engine exhaust pollution and performance were tested on VCR research engines running by DF and dill biodiesel blends (BD10 to BD100) at the University of Babylon's College of Musayyib Engineering labs, as illustrated in Figure 3. The VCR engine characteristics are recorded in Table 3. The starter motor started the engine. The test was run on a 1500-rpm VCR.



1	VCR engine	7	Noise meter	13	water flow meter
2	Eddy current dynamometer	8	Laptops	14	Load control
3	VCR mechanism	9	Smoke meter	15	Water tank
4	Power supply	10	Gas analyzer	16	Cooling tower
5	Calorimeter	11	Fuel tube	17	encoder
6	Control panel	12	Temperature recorder	18	Air box

Figure 3. ICE test rig

Table 3. Engine specification

Property	Unit
Make and model	Kirloskar, TV1
General details	Four-stroke, CI, DI
Number of cylinders	One
Cooling type	Water cooling
Bore	87.5 mm
Stroke	110 mm
Compression ratio	18:1
Swept volume	661.1 CC
Rated output	3.5 kW at 1500 rpm
Fuel injection at	23° bTDC
Inlet valve opens at	4.5° bTDC
Inlet valve closes at	35.5° aBDC
Exhaust valve opens at	35.5° bBDC
Exhaust valve closes at	4.5° aTDC

The engine CR is 18 and an IT of 23° bTDC. A separate panel box contains a speed manometer, digital indication, fuel tank, air box, digital temperature indicator, and fuel metering unit. The test rig provided with the strain gauge-type load sensor measures 0-12 kg to measure the load, a pressure transducer to measure the ICP, a speed sensor to measure the engine speed, an encoder to measure the crank angle, a pressure differential system to measure the fuel flow rate, hot wire sensor to measure the speed of the inlet air, thermocouples of the exhaust system to measure the EGT and calorimeter thermocouples to measure the HRR. The mentioned sensors and devices are connected to the computer by an interface card, and the incoming order from the sensors is operated by VCR engine software, which stores all measured data during operation in an Excel sheet. The engine cooling water flows into a range of 40-400 LPH, and the calorimeter is 25-250 LPH. Water circulation in the engine and calorimeter utilizing a self-priming pump. A portable gas analyzer analyzed tailpipe emissions. The gas analyzer measures exhaust emissions of CO_2, CO, O_2, NO_X, and HC. The test unit was prepared with a smoke meter to measure the smoke emissions.

5. MEASUREMENT OF UNCERTAINTY AND ACCURACY ANALYSIS

One approach to verify the accuracy of the experimental results is to examine the measurement uncertainty and system precision. Increased uncertainty may result from several sources, including but not limited to defective or inaccurately calibrated equipment; the characteristics of the testing environment; the characteristics of the test strategy and plan; and the process of interpreting or viewing the results. You may think of the overall uncertainty as the sum of all the uncertainties for the study's parameters. We might get the total percentage of uncertainty using the following formula [26, 27].

$$\text{the experiment Total uncertainty} = \text{square root uncertainty of } ([\text{pressure transducer}]^2 + [\text{Smoke opacity}]^2 + [\text{angle encoder}]^2 + [HC]^2 + [CO_2]^2 + [CO]^2 + [O_2]^2 + [NOx]^2 + (\text{thermocouple})^2 = \text{square root of } ([0.11]^2 + [0.21]^2 + [0.2]^2 + [0.22]^2 + [0.21]^2 + [0.25]^2 + [0.22]^2 + [0.7]^2 + [0.23]^2) = \text{square root of } (0.84) = \pm 0.961\%$$

6. RESULTS AND DISCUSSION

An investigation was carried out to demonstrate how the emissions level and performance of CI engines are affected by biofuel that is derived from dill oil. During the experimental work, the primary operational variables that were investigated regarding the percentage of dill BDF in the BDF blend were BSFC, BP, ICP, EGT, delay period time, HR, the mass of fuel burned rate, and engine emissions. The operating conditions included a constant CR of 18 and an IT of 23° bTDC, a variable dynamometer load, and a constant speed of 1500 revolutions per minute. Given the circumstances, the subsequent are succinct summaries of the findings deemed most noteworthy:

The findings of the experiments that were conducted to determine the effect that utilizing dill BDF would have on the engine parameter will be detailed in the points listed below.

6.1 Influence of BDF on engine BTHE

The BTHE measures the engine's BP in relation to the energy released when fuel is burned in the engine cylinder. Because various kinds of fuel provide more power when burned, the BTHE typically increases as engine load increases. Figure 4 shows that as the ratio of BDF in the fuel blend rises, the BTHE of the engine is reduced. At maximum engine load, the BTHE was reduced by 0.58%, 1.04%, 1.52%, 1.87%, 2.27%, and 2.66% while utilizing fuel mixes of BD10, BD20, BD40, BD60, BD80, and BD100, respectively. The reduced HV of the BD blend, in comparison to regular DF, is responsible for the BTHE decrease. The engine's BTHE will diminish as a result of the low ICP and temperature generated during combustion, which was carried out with a low HV of fuel [28, 29].

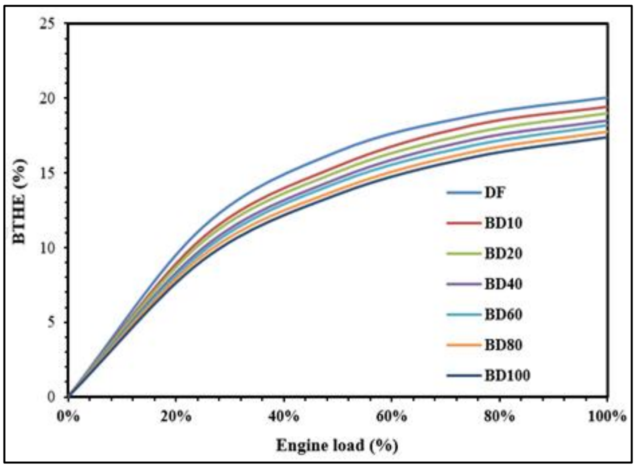


Figure 4. The relationship between BTHE and a load of the engine for various fuel mixes

6.2 Impact of BDF on engine BSFC

Raising the BD volumetric ratio in Iraqi DF increased BSFC. Figure 5 shows that under full engine load, the BSFC rose by 1.50%, 3.85%, 6.24%, 8.06%, 10.06%, and 12.01% when BD10, BD20, BD40, BD60, BD80, and BD100 were used, respectively. The blending process lowers the fuel HV because of the oxygen in the chemical composition, which is responsible for the rise in fuel consumption. More energy must be used due to the fuel reduction HV to achieve precise power needs or keep the operating parameters constant therefore Fuel BSFC will rise as a consequence [30, 31].

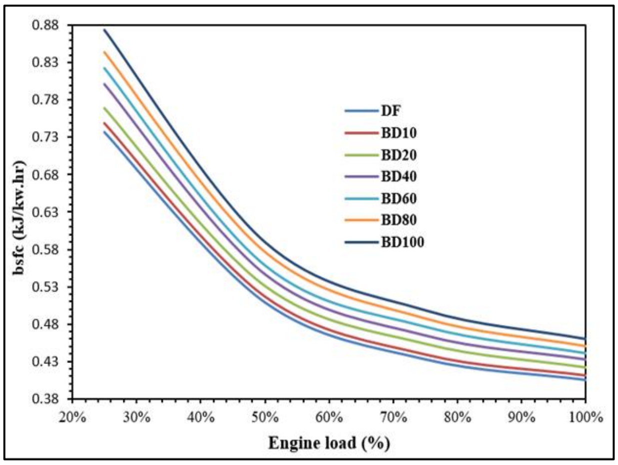


Figure 5. The relationship between BSFC and the load of the engine for various fuel mixes

6.3 Effect of biodiesel on engine ICP

As the engine load raised, the fuel injection rate also rise, leading to an increase in the ignition temperature and pressure, which in turn increased the (ICP). Blends with a higher volumetric proportion of dill oil BDF had lower (ICP). As indicated in the Figure 6, the maximum pressure for BD10, BD20, BD40, BD60, BD80, and BD100 was 82.15, 81.33, 80.27, 79.07, 78.12, 76.87, and 75.71 bar, consecutively. There is a direct correlation between combustion temperature and pressure, and the low HV and high viscosity, surface tension, and latent heat of evaporation properties of the biodiesel and its blend are the main causes of this pressure drop [32, 33].

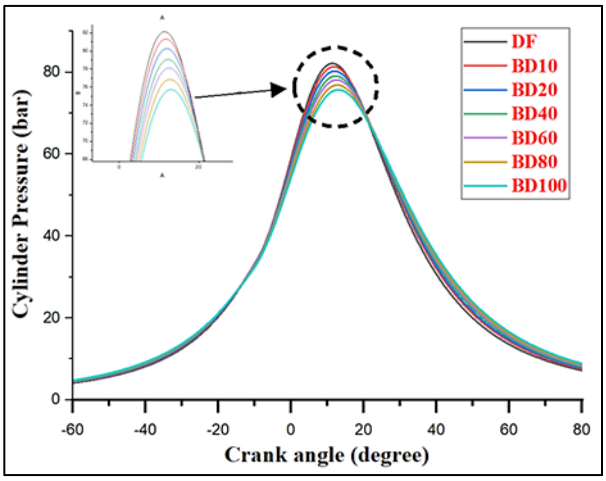


Figure 6. Cylinder pressure fluctuation with CA for various fuel mixes

6.4 Effect of biodiesel on heat release

A determination of the necessary combustion heat for the engine cylinders was made by analyzing the HR. The relationship between HRR and CA at maximum load for DF and BDF is seen in Figure 7. It was observed that there was a negative heat discharge when combustion began because the fuel that had collected throughout the ID took longer to vaporize. This turned into a good when the eruption began. The graph shows that when the volumetric percentage of BDF in the fuel mix was raised, the peak HRR for BDF blends was decreased. The highest amount of heat that could be released was measured at 28.45, 27.88, 27.33, 26.78, 26.24, 25.72, and 25.20 J/°CA for BD10, BD20, BD40, BD60, BD80, and BD100, respectively. The HRR was lower for BDF than DF because of its low HV. Additionally, compared to BDF blends, DF had a higher HRR during premixed combustion due to its higher volatility and better air-blending capabilities [34, 35].

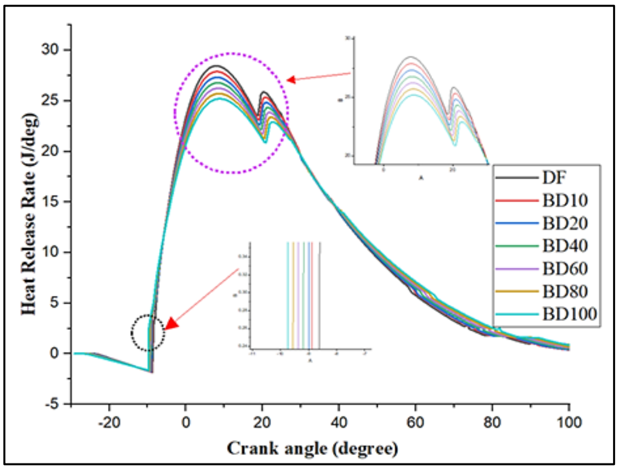


Figure 7. HR rate vs. CA for varied fuel blends

6.5 Effect of biodiesel on delay period time

There are several features, mostly physical and chemical ones, that influence the length of the ID time. The physical delay is caused by the atomization of small droplets, the mixing of fuel droplets, and the evaporation of fuel [36]. On the other hand, the chemical delay is a result of the interactions that occur between the fuel and air combination before combustion. The behavior we are seeing may be caused by the gas within the cylinder being hotter, which shortens the physical ID. Figure 8 shows how the ID and BP variations for all fuel blends relate to one another. The BD has a lower ID and mixes than DF because of its greater CN [37, 38].

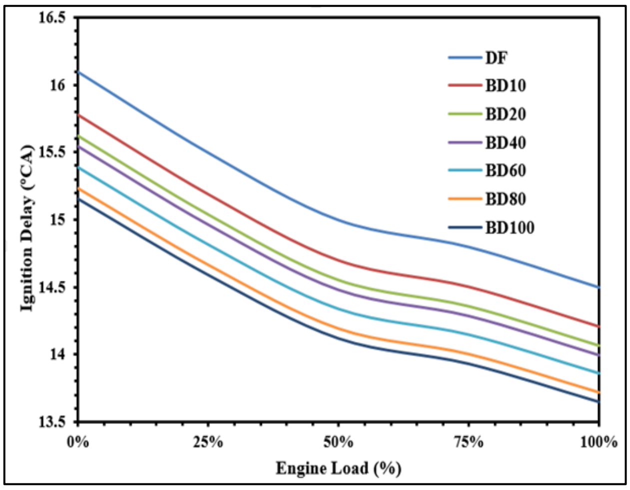


Figure 8. ID and engine load correlation for a variety of fuel mixtures

6.6 Impact of biodiesel on fuel mass fraction burned rate

The mass proportion of fuel burnt rate was directly related to the fuel's auto-ignition ability, which was assessed by the fuel CN. As seen in Figure 9, the rate of mass fuel combustion raised with engine load and the volumetric ratio of dill oil BDF in the fuel blends. Due to its high concentration of CN and oxygen, BDF burns more quickly than conventional DF [39].

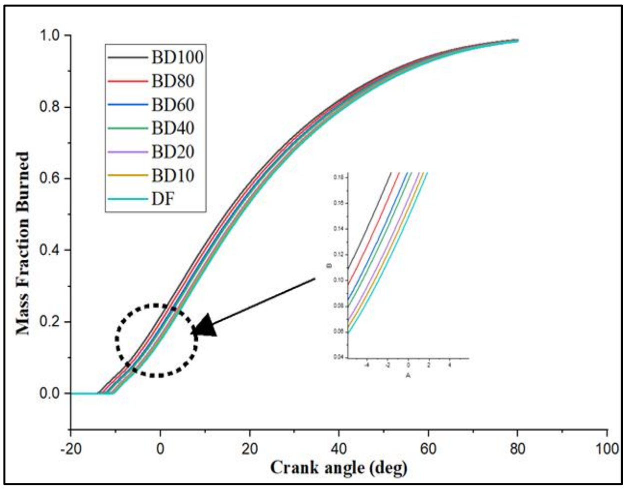


Figure 9. The correlation between the mass percentages of fuel used and the combustion angle (CA) for different fuel blends

6.7 Effect of biodiesel on (EGT)

The change of EGT with respect to engine load is shown in Figure 10. As the load on the engine heightens, the EGT rises. The EGT is greater than the DF for different engine loads due to the increased amount of BDF in fuel mixes. The greater EGT is a direct outcome of BDF's improved combustion process, which is in turn caused by its high CN content, which shortens the time needed for premixing and boosts combustion efficiency [40]. In the case of DF, BD10, BD20, BD40, BD60, BD80, and BD100, the EGT at full engine load was 389.33℃, 410.70℃, 416.01℃, 438.35℃, 445.20℃, 467.13℃, and 475.94℃, respectively.

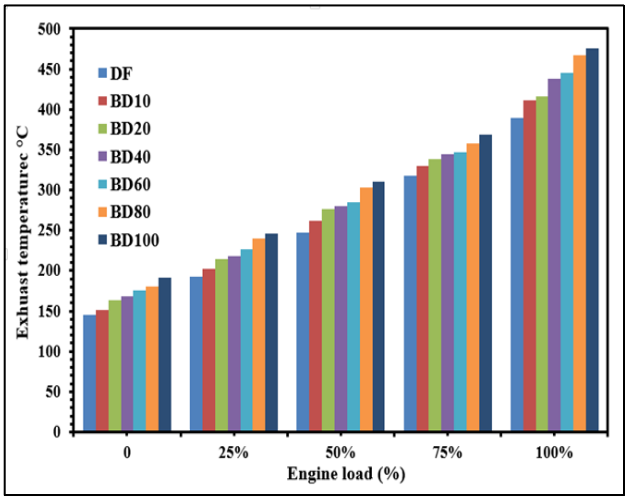


Figure 10. The relationship between (EGT) and engine load for various fuel mixtures

6.8 Influence of biodiesel on HC emissions

A decrease in oxygen concentration inside the engine cylinder or improper mixing of air and vapour before to combustion caused the HC to be released into the exhaust system. Figure 11 demonstrates that the increase in the engine BP causes a rise in the fuel-to-air ratio, which in turn causes the HC emissions to increase. However, the HC emissions drop when there is an increase in the amount of dill BDF that is present in the fuel blends. At maximum engine load, the combustion of BD10, BD20, BD40, BD60, BD80, and BD100 biodiesel fuels results in 6.20%, 16.71%, 25.58%, 34.61%, 46.18%, and 59.84% reductions in HC emissions, respectively. The high oxygen content in BDF causes more oxidizers in the combustion chamber (CC) to create more CO_2, which is the primary cause of the decrease in HC emissions that is seen as the BDF volumetric percentage increases. Second, the fuel evaporation rate will increase due to early burning caused by reduced delay time caused by high CN dill BDF [41-43].

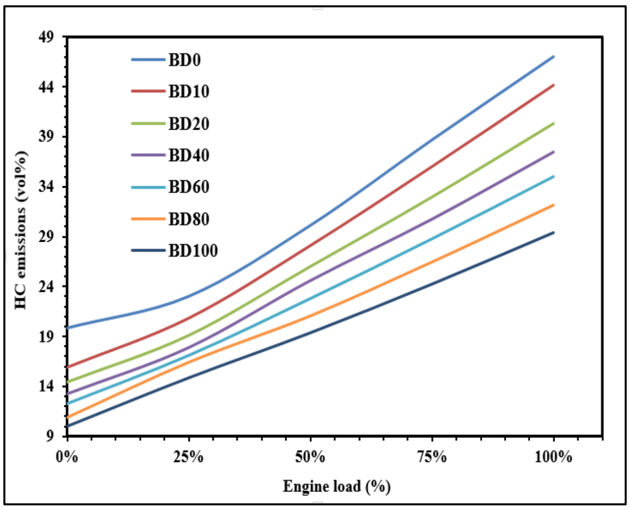


Figure 11. The relationship between emissions of HC and engine load for various fuel mixtures

6.9 Effect of biodiesel on CO emissions

The increased CO emissions out of the exhaust system are a result of imperfect combustion caused by the oxygen shortage inside the (CC) during combustion. As the engine runs at a higher load, the fuel-to-air ratio increases, leading to higher CO emissions. Rising the volumetric ratio of BDF in the fuel mix reduced CO emissions; the greatest drop at full load for BD10, BD20, BD40, BD60, BD80, and BD100 was 8.50, 14.91%, 20.86%, 26.40%, 31.55%, and 36.69%, respectively as shown in (Figure 12). The oxygen in biodiesel fuel oxides CO, which in turn changes it to CO_2 and generates more heat in the oxidation process, which is related to the decreased CO emissions [44].

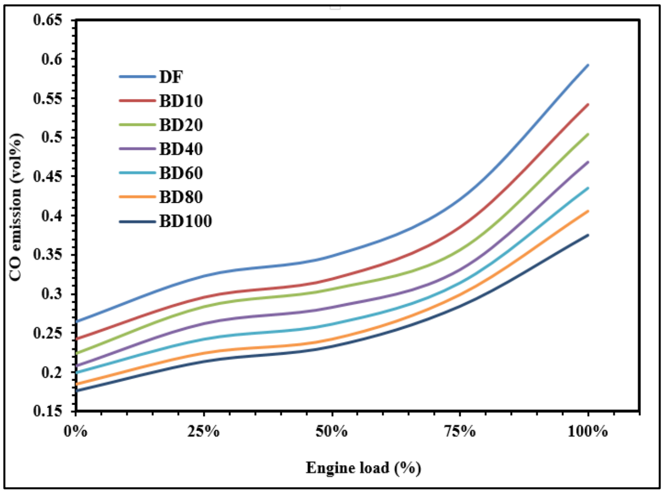


Figure 12. The relationship between CO emission and engine load for various fuel mixes

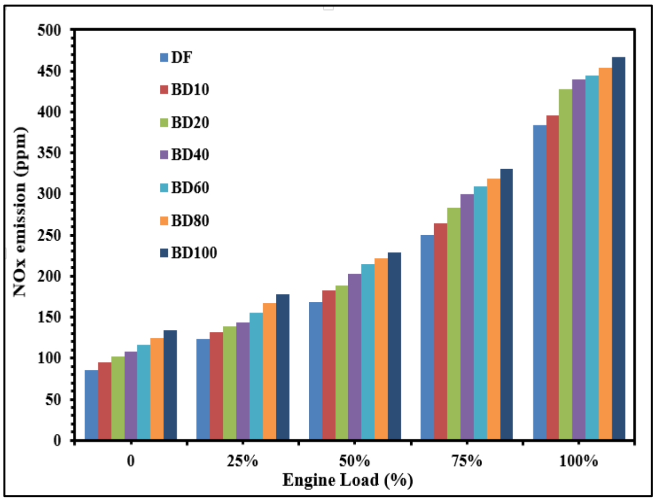


Figure 13. the relationship between emissions of NO_X and load of the engine for various fuel mixes

6.10 Effect of biodiesel on NO_X emissions

Exhaust gases include (NOx), which are made up of (NO) and (NO_2). The amount of (O_2) in the fuel, the temperature within the (CC), and the length of time that chemical reactions take all play significant roles in the formation of nitrogen oxide (NOx). Adding more BDF to the fuel mix increases the NOx emissions. Figure 13 shows that at full engine load, the proportion of rising NOx emissions for BD10, BD20, BD40, BD60, BD80, and BD100 combinations was 11.24%, 14.58%, 15.72%, 18.04%, and 21.58%, respectively. As engine load increases, so do NO_X emissions; this is due to the (O_2) concentration in the BDF and the corresponding increase in EGT with the volume ratio of BDF [45].

6.11 Effect of biodiesel on CO_2 emissions

Fuel-burning inside the (CC) was more complete when the air-to-fuel ratio approached the stoichiometric value, leading to greater CO_2 output. Figure 14 shows that when the volumetric ratio of dill oil BDF in the mix rose the fuel burning rate within the CC also raised, leading to an increase in CO_2 emissions with engine load. The BDF blends of BD10, BD20, BD40, BD60, BD80, and D100 resulted in 9.09%, 14.34%, 20.79%, 27.19%, 33.28%, and 42.98% increases at maximum engine load, respectively. The actual cause of this increase is the (O_2) concentration of the BDF mix, which is essential for the oxidation of fuel vapour or CO, which ultimately results in the conversion to CO_2 [46, 47].

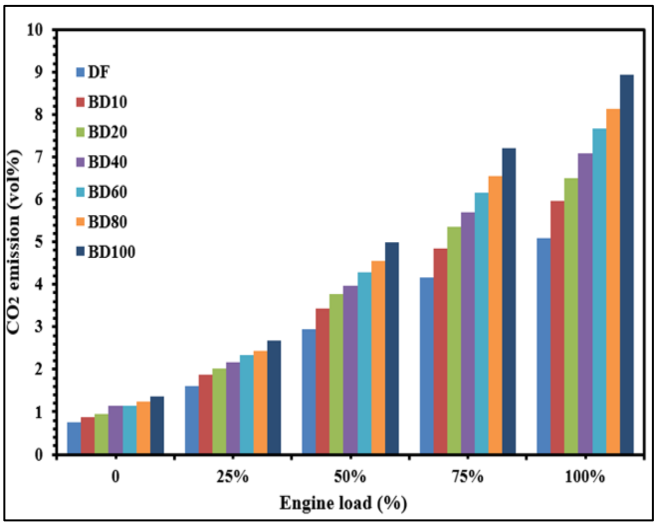


Figure 14. The relationship between emissions of CO_2 and load of the engine for various fuel blends

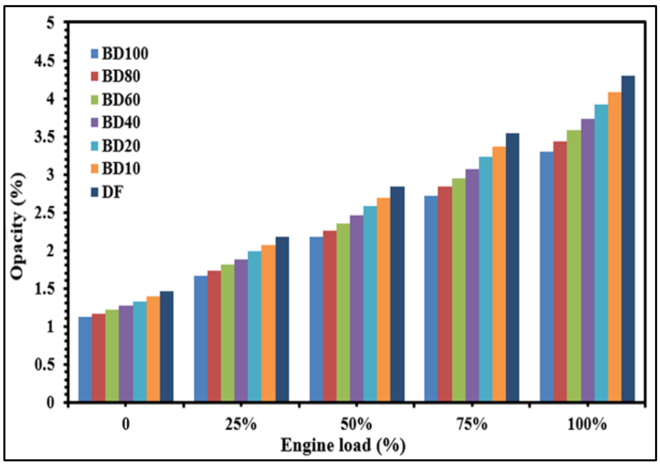


Figure 15. The relationship between emission of soot and load of the engine for various fuel blends.

6.12 Effect of biodiesel on soot emissions

Figure 15 shows that the soot emissions rose as engine BP increased because of the fuel-to-air ratio, but fell as the volumetric percentage of BDF in the fuel mix rose. At maximum engine load, the percentage of soot emissions decrease for the fuel blends BD10, BD20, BD40, BD60, BD80, and BD100 was 5.0%, 8.8%, 13.4%, 16.8%, 20.2%, and 23.3%, respectively. Because BDF contains (O_2) in its chemical structure, increasing the proportion of BDF in a fuel mix reduces soot [48, 49].

7. CONCLUSION

This study examined DF and dill oil BDF blends from several angles, such as BDF production, properties, combustion parameters, engine emissions, and performance. The results of the experiment may be used to draw the following conclusions:

1-The BDF and its mixtures engine had a lower BTHE than the DF engine.

2-The BTHE of the BD20 blend was somewhat lower than that of other blends, but it was still within the acceptable range when compared with DF.

3-Use of plain BDF or mixes thereof causes an increase in the engine's BSFC and EGT.

4-When compared to DF, the maximal ICP and HRR of BDF mixed fuels are more modest.

5-When compared with DF-powered engines, BDF and BDF blends produced lower levels of CO, soot, and HC emissions.

6-Emissions of nitrogen oxides and carbon dioxide were on the increase due to the use of BDF and fuel mixes.

7-Fuels made using BDF mixes have a higher oxygen content, which gives them better combustion and makes them more sustainable. There is hope that renewable energy sources could one day partly replace fuels made from petroleum.

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NOMENCLATURE

CO	Carbon Monoxide, vol%
NO_X	Nitrogen Oxides, ppm
HC	Hydrocarbon, ppm
CO_2	Carbon Dioxide, vol%
O_2	Oxygen
BSFC	Brake-Specific Fuel Consumption, $KJ.kg^{-1}.hr$
BTHE	Brake Thermal Efficiency
bTDC	Before The Top-Dead-Centre
CN	Cetane Number
CI	Compression-Ignition
CC	Combustion Chamber
ICP	In-Cylinder Pressure, bar
ID	Ignition Delay, degree
IT	Ignition Time, degree
EGT	Exhaust Gas Temperature, ℃
BD	Dill Biodiesel Blend
DF	Diesel Fuel
HRR	Heat Release, J.
LHV	Low heating value, $KJ.kg^{-1}$
CR	Compression Ratio
CA	Crank Angle, degree
ICE	Internal Combustion Engine
BP	Brake power, KW
BDF	Biodiesel fuel
FAME	Fatty Acid Methyl Esters