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Experiment With a Diesel Engine Fuelled by Biodiesel Mixes with Balanites Aegyptiaca (L.)

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ABSTRACT
The purpose of this research was to look at the performance, combustion characteristics, and emissions of a single-cylinder variable compression ratio diesel engine running on Balanites aegyptiaca biodiesel mixes. The mixes' physical characteristics were computed and compared against ASTM standards. The experimental parameters were examined while running on biodiesel mixes of Balanites aegyptiaca and diesel fuel. The mix ratios of Balanites aegyptiaca biodiesel with diesel fuel were evaluated at 0%, 10%, and 20% on a volume basis. Under different measured load situations, the effect of these mixes on performance, combustion, and emission characteristics was studied. The findings show that mixes performed similarly to diesel fuel, with the exception of advance ignition behaviour. The use of biodiesel blends resulted in improved performance characteristics under greater load situations. The findings indicate that the cylinder peak pressure is mostly affected by engine load and blending ratio. Blends were found to reduce the ignition delay time, lowering cylinder pressure. In terms of emissions, blends significantly reduced CO, HC, and NOx rates under observed load levels. According to this research, Balanites aegyptiaca biodiesel mixed with diesel fuel may be utilised as a diesel engine substitute.

Introduction

The world is rapidly upgrading its communications for transportation facilities. Due to its efficiency and lack of maintenance, a mainly diesel engine in the automotive sector is a witness to tremendous growth globally, particularly in the transportation zone. On the other hand, due of the widespread use of diesel engines, emissions rates such as CO, HC, and NOx have a negative impact on the environment. These emissions primarily contribute to concerns about ozone layer depletion and the greenhouse effect, both of which endanger human existence in the environment. Because diesel fuel is the most often used fuel in the transportation sector, resource constraints have compelled the automotive industry to seek alternative diesel fuel alternatives in order to increase fuel economy and reduce emissions. Biodiesel, whether made from animal fats or plants, is environmentally beneficial and pollution-free. Although edible oils are the primary source for biodiesel production, non-edible oils are used in developing nations such as India owing to their availability. Many research have been conducted to investigate the use of edible oils as alternative fuels. [19] The combustion, performance, and exhaust characteristics of a diesel engine running on soybean biodiesel were investigated. [10] The researchers discovered a high basic fuel consumption rate as well as reduced CO emissions and smoke opacity rates. In a single-

cylinder four-stroke diesel engine, the performance of the engine was studied using sesame oil biodiesel and its mixes.
[11] Sesame biodiesel blends outperform pure diesel with no engine modifications in terms of performance and emissions. Biodiesel produced from warmed palm oildiesel mixes was tested for combustion and performance properties. [12] Engine performance in a variable compression ratio engine was tested at various blending ratios. Palm oildiesel mixes outperformed pure diesel in terms of performance and emissions.The combustion and emission characteristics of a multicylinder direct injection diesel engine using rapeseed biodiesel as an alternative fuel were investigated.[13] Rapeseed methyl esters were shown to decrease NOx and soot emissions at various injection pressures and timings. The current study investigates the experimental assessment of the performance, combustion, and emission characteristics of a single-cylinder variable compression ratio diesel engine using Balanites aegyptiaca (L.) Del oil as an alternative fuel. Balanites aegyptiaca is an evergreen xerophytic multifunctional tree species that is helpful to developing nations, such as India, where there is a large drought region that may be used to produce such xerophytes species as an alternative source of energy. [14]

Materials and procedures

Aedes aegyptiaca Balanites aegyptiaca Balanites aeg Aside from its distinctive character as xerophytes, Balanites aegyptiaca (L.) Del is an edible oil producing species discovered as an alternative. The oil derived from the kernel is processed, and the tree is highly adaptable.
Each and every component of the tree is important. The leaves and bark have therapeutic properties, while the edible fruit is high in oil content and utilised as a vegetable oil, with the pulp used as feed for animals in drought-stricken regions. [15] The fruits may be eaten, and oil can be extracted from the outer pulp, shell, and kernel. The kernel of the fruit produces up to 4451 percent, and its remarkable nature promotes development in the driest regions of the country, where it is dispersed in the most unfavourable dry desert settings.
Oil extraction from balanites
The fruit kernel is dried using a drier or in the sun before being crushed with a mechanical press. A solvent extraction method is used to extract the oil from the pulverised kernel. It is the process by which oil is extracted from feedstock using a liquid solvent. This technique is mostly dependent on the extraction mode, as well as particle size and temperature. This chemical extraction method is the best since it removes oil from each lipid, but it is the most time-consuming.

Balanites aegyptiaca (L.) Del seed oil esterification

The transesterification method is used to create esters from balanites oil and improve engine performance.At optimum circumstances, a single stage base-catalyzed esterification process with 1.26 wt. percent KOH catalyst loadings, molar ratio of 8:1, reaction duration of 2.5 h, and temperature of 658C yields a maximum ester yield of 89 percent. The engine's performance, combustion, and exhaust properties are investigated utilising balanites oil methyl esters and diesel as fuel. [5] Balanites aegyptiaca biodiesel characteristics Balanites aegyptiaca (L.) Del is an edible oil producing species with a low oil concentration.

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Table 1. Comparison of physical properties with ASTM standards.

Property	Unit	ASTM	BAME	B10	B20	D100
Density	kg/m^3	–	874.8	845.2	848.5	842
Viscosity	Cst	D445	4.46	2.80	2.98	2.60
Calorific value	MJ/kg	–	42.50	42.3	42.2	42.5
Acid value	Mg KOH/gm	D664	1.26	0.126	0.253	–
Flash point	^0C	D93	>160	64.4	76.8	52
Pour point	^0C	D2500	0	−15.3	−13.6	−17
Water content	%	D2709	214	21.4	42.8	–
Ash content	%	D874	0.001	0.009	0.008	0.01
Sulphur content	–	D5453	0.03	0.048	0.046	0.05
Carbon residue	%	D4530	0.19	0.154	0.158	0.15
Specific gravity	Kg/m^3	D854	903.5	855.3	860.7	850
CFPP	^0C	–	0	−22.5	−20	−25
Cetane no.	–	D613	42	48.3	47.3	52

Cst = Centistrokes. CFPP = Cold filter plugging point.

Balanites aegyptiaca biodiesel in a fuel combination including Balanites aegyptiaca biodieseldiesel. D100 (100 percent diesel fuel), B10 (10 percent Balanites aegyptiaca biodiesel C 90 percent diesel fuel), and B20 (20 percent Balanites aegyptiaca biodiesel C 80 percent diesel fuel) are the terms used to describe them.

The chemical and physical features of Balanites aegyptiaca methyl ester (BAME), D100, and biodiesel blends B10 and B20 were investigated since they have a significant impact on performance, combustion, and emission characteristics. Table 1 compares the exact characteristics of D100, BAME, and blend ratios B10 and B20 to the ASTM standard.

Methodology and experimental design

Experiments were carried out in order to investigate biodiesel derived from Balanites aegyptiaca as an alternative.

The performance, combustion, and emission properties of the source fuel were tested on a variable compression ratio engine. The test rig is made up of a single-cylinder, auxiliary water-cooled, variable compression ratio diesel engine that is computer-based. The test rig uses compression ignition with an 87.5 mm bore and 110 mm stroke length. The cylinder pressure, diesel pressure, and crank angle were all measured and recorded on a computer. It is made comprised of an auxiliary water-cooled head that is connected to an eddy current dynamometer. A silicon braided rope lowers heat, which aids in precisely calculating heat loss. Load is applied and changed using an eddy current dynamometer connected to the engine. To detect the flow rate of water, two turbine type water flow sensors are connected.

Table 2 contains the technical parameters for the test setup.

The performance, combustion, and emission characteristics of a diesel engine operating on pure diesel are compared. A main test using diesel fuel is performed to evaluate experimental evaluation of performance, combustion, and emission characteristics.

The load recorder automatically recorded 0.6 Nm increments from 0 to 10.2 Nm at an increasing rate of load. By keeping the compression ratio at 17.5:1,

Table 2. Specifications of test engine.

Make	KIRLOSKAR
BHP	3 kW
Rpm	1580–1500
Cooling	water cooled (for auxiliary head)
Bore	70 mm
Stroke length	110 mm
Starting	self starter / cranking
Method of ignition	compression ign
Compression ratio	17.5:1
Load	eddy current dynamometer
Capacity	3.7 KW

Throughout this experiment, the engine's speed is permitted to settle around the 15801500 rpm range.

The same testing method was performed for each mix while keeping the speed and compression ratio unchanged. The experimental data from the testing includes braking power, thermal efficiency, brake specific fuel consumption, combustion parameters, cylinder pressure, diesel pressure, and emission rates.

The emissions from the engine's exhaust pipe were measured using a 5-Exhaust Gas Analyzer. CO, hydrocarbons, and NOx are the most important emission characteristics from engine exhaust. The effect of various biodiesel blending percentages on the above-mentioned emissions from diesel engines has been studied and explored further.

Results analysis

The experimental analysis of Balanites aegyptiaca biodiesel on a single-cylinder variable compression ratio diesel engine determined several parameters such as brake power, basic fuel consumption, brake thermal efficiency, cylinder pressure, diesel pressure, exhaust gas temperature, CO, HC, and NOx emissions. Figures 19 and 20 illustrate the findings.

Figure 1 depicts the change of braking power with increasing motor torque. As can be observed, D100 produces the highest values for braking power at various torques. However, the B20 Balanites aegyptiaca fuel mix provides braking power levels that are comparable to the D100. As a result, B20 mixed with diesel fuel increases engine efficiency, and Balanites aegyptiaca oil may be utilised as a fuel enhancement additive for diesel oil.

The impact of mixes and torque on specific fuel consumption is shown in Figure 2. Blends have higher specific fuel consumption than D100 gasoline at measured torque, and this rises as the blending ratio increases. Blends have lower values than diesel fuel due to lower heating value, poor atomization, greater density, and viscosity. In comparison to diesel fuel, blends B10 and B20 use more fuel.

Figure 3 demonstrates that, up to a particular measured torque, the thermal efficiency of blends B10 and B20 is greater than that of diesel fuel. As demonstrated in Figure 3, increasing the blending ratio of Balanites aegyptiaca biodiesel blends yields a high thermal efficiency for a given outcome. This is due to the increased oxygen concentration in biodiesel blends, which improves combustion quality and has a beneficial impact on brake thermal efficiency by efficiently regulating cylinder pressure and temperature.

Figure 4 depicts the impact of cylinder pressure on crank angle for biodiesel blends and diesel. As the blending ratio of the fuel mix is raised, the pressure data is moved to a lower value.

The similar high viscosity impairs the atomization process and lengthens the ignition delay time as the blending ratio rises.

Figure 5 depicts the impacts of diesel pressure increase with crank angle for blends and diesel at measured crank angle graphs. Because of the presence of oxygen in the fuel, the diesel pressure increase for biodiesel blends is greater than for diesel.

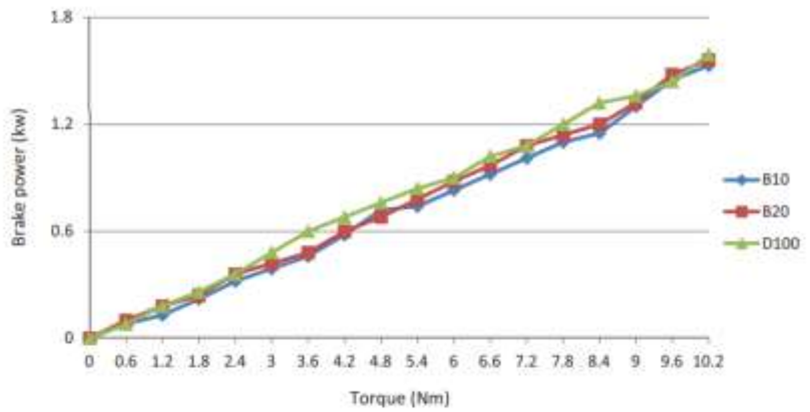

Figure 1. Variation of brake power vs. torque for fuels.

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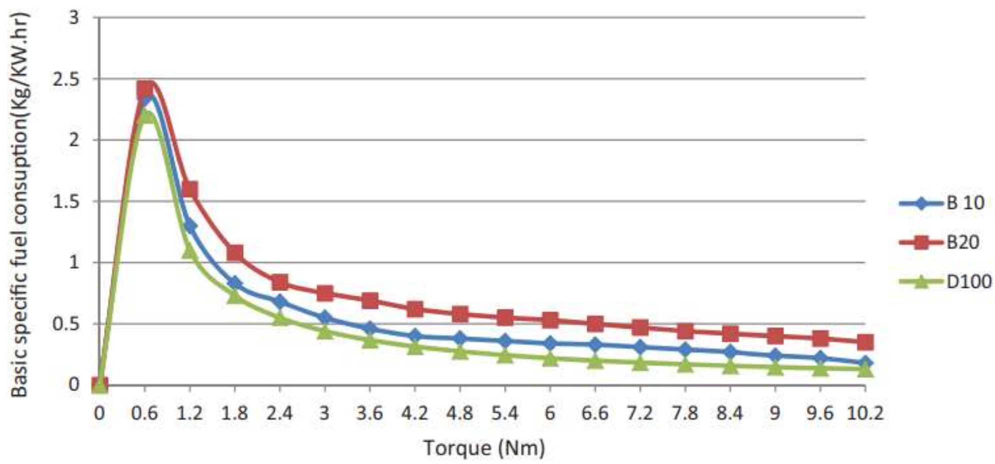
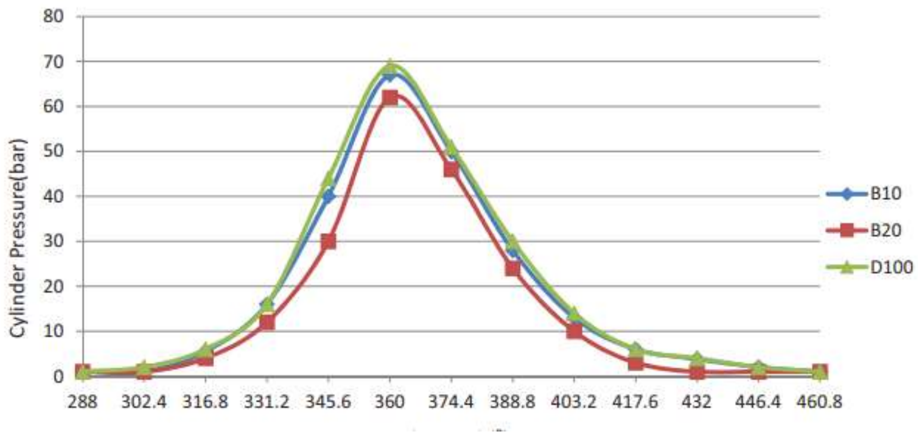


Figure 2. Variation of basic specific fuel consumption vs. torque for fuels.

Figure 3. Variation of brake thermal efficiency vs. torque for fuels.



Conclusions

Based on the experimental findings, the experimental assessment of a single-cylinder, auxiliary water cooled, computer-based variable compression ratio diesel engine fuelled by diesel-biodiesel blends was explored.

(1) The fuel characteristics of biodiesel blends vary from those of diesel to some degree. The viscosity of blends B10 and B20 is 7.1 and 12.7 percent greater, respectively, than that of D100. Blends have calorific levels that are 0.47 percent and 0.7 percent lower than diesel.

The specific gravity and flash point are both greater than in pure diesel fuel.

(2) Because of the differences in physical properties between blends and diesel, these fuels show distinct performance characteristics when measured torque varies. As subjected to heavy loads, blends B10 and B20 show about 3.78 percent and 1.8 percent, respectively, of braking power fluctuation when compared to D100.

(3) Under low load circumstances, the basic fuel consumption rate rises as the blending % rises. It is possible to see that the fuel rate for 0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0 0.6 1.2 1.8 2.4 3 3.6 4.2 4.8 5.4 6 6.6 7.2 7.8 8.4 9 9.6 10.2

B10, B20, and D100 HC Emissions (g/kWh)

tensile strength (Nm)

Figure 8 shows the variation of HC emissions vs. torque for various fuels.

0 \s100 \s200 \s300 \s400 \s500 \s600 \s700 \s800

0 0.6 1.2 1.8 2.4 3 3.6 4.2 4.8 5.4 6 6.6 7.2 7.8 8.4 9 9.6 10.2

tensile strength (Nm)

nitrous oxide (NOx) (ppm)

Figure 9 shows the variation of NOx emissions versus torque for various fuels.

Blends B10 and B20 are raised by 5.9 percent and 9.09 percent, respectively, according to data downloaded by [McMaster University] at 15:39 on 18 May 2016.

(4) For blends B10 and B20, the brake thermal efficiency falls as the amount of biodiesel increases. Brake thermal efficiency of blends B10 and B20 at peak load is 3.02 percent and 5.7 percent, respectively.

(5) Combustion characteristics of blends against diesel at various crank angles. The lower crank angles at which blends show lower values are owing to the high viscosity of blends, which impedes combustion and results in a longer ignition delay.

(6) For blends B10 and B20, the temperature of the exhaust gas obviously rises with load. As subjected to heavy loads, B10 and B20 exhibited a rise in exhaust gas temperature of 7.6 percent and 11.12 percent, respectively, when compared to diesel.

(7) As the load increased, the CO emission rate of the blends dropped. When compared to D100, emission rates of blends B10 and B20 are lowered by 7.69% and 15.33%, respectively, at high load circumstances.

(8) As measured torque increased, the rate of HC emission dropped. Blends B10 and B20 decreased emissions by 10.52 percent and 15.7 percent, respectively, under high load.

(9) At high load, as the blending % rose, so did the NOx rate for both B10 and B20. The decrease in NOx emission rate at high load is 5.5 percent and 11.2 percent, respectively, when compared to D100.

This research indicates that biodiesel derived from Balanites aegyptiaca oil may be utilised as an alternative source in a diesel engine up to a blending ratio of B20 with diesel.

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