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Performance test of dual fuel engine using octagonal with algae biodiesel

S Karthikeyan*[,1] & Ekrem Yanmaz[2]

[1]Deparment of Mechanical Engineering, Syed Ammal Engineering College, Ramanathapuram 623 502, Tamil Nadu, India

[2]Department of Electrical and Electronics Engineering, Engineering and Architecture Faculty, Nisantasi University, Istanbul/Turkey

E-mail: karthikeyan@syedengg.ac.in

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In comparison to internal combustion engines, diesel engines are high thermal-efficient. However, the application of diesel engines is still dependent on fossil fuels. This fuel has limited availability and the effects are also very dangerous, especially its emission. Octagonal has been used as an alternative fuel to replace fossil-based diesel fuel. The purpose of this work is to explore the performance of the dual fuel engine-octagonal diesel. The performance test has been carried out by running the indirect injection engine that is modified to direct injection at 1500 rpm using four types of like diesel fuel, and diesel mixed with octagonal 2.5, 5 and 10%. The results show that there was an increasing effect of engine-indicated mean effective pressure (IMEP) value and brake-specific fuel consumption (BSFC) reduction when the engine is operated using octagonal diesel fuel blends. The emission of hydrocarbon (HC) tended to increase, while the emission of smoke and carbon monoxide (CO) decreased when the engine is operated using dual fuel-octagonal diesel.

Keywords: Diesel engine, Dual fuel, Emission, Octagonal, Performance test

Diesel engines are the most efficient of all types of internal combustion engines and can produce a large torque. It is utilised for a wide range of purposes, for example in buses, trucks, heavy equipment, and generator sets. Currently, emission control has become a major issue in the development of diesel engines. The simultaneous use of fossil fuels to support every line of human life, besides causing climate change that can lead to environmental damage, the availability of fossil fuels is increasingly limited. Climate change can occur due to the greenhouse effect caused by diesel engine emissions that use fossil fuels. Some emissions will be reduced if fossil fuels are replaced with vegetable oil-based fuels. Climate change and global environmental issues due to the development and use of fossil-based energy are considerations in the selection of alternative energy in diesel engines. Octagonal has a number of advantages over conventional fuels in that it can be directly mixed in a fuel tank, injected into the combustion chamber, and burned with the aim of reducing exhaust emissions[1]. It is derived from an unlimited renewable resource, which is plants that can grow well or biomass that contains sugar, starch or cellulose. In addition, octagonal can be blended with premium or diesel oil to help extend the life of petroleum supplies, ensure greater fuel security, and avoid dependence on oil-producing countries. In addition to the many advantages of octagonal as a replacement or blending fuel for diesel fuel, octagonal diesel blends also have disadvantages compared to diesel fuel. The disadvantages of octagonal diesel blends are: (a) additives are required to ensure a homogeneous blend of the two fuels, and (b) the blend has low lubricity. Several studies have reported on improving the performance of dual-fuel engines. octagonal diesel is suspected of its shortcomings[2]. The effects of 10% and 15% octagonal addition on the performance and emissions of turbocharger-equipped indirect injection diesel engines with different injection pressures have been studied. The results show that with octagonal addition, engine power is reduced and there is a decrease in CO, soot, and SO emissions but NOx emissions tend to increase. It tested a conventional six-cylinder direct injection diesel engine equipped with a turbocharger and aftercooler using diesel fuel mixed with 5% and 10% octagonal volume at 1200 and 1500 rpm.The results obtained showed a decrease in smoke, NOx, and CO emissions but an increase in HC. While fuel consumption increased slightly with the addition of octagonal and in terms of engine performance, the increase in brake thermal efficiency was very small[3]. Although there has been a lot of literature and research on the utilisation of octagonal blended with diesel fuel in dual-fuel engines, the completeness of information about the blending and variation of the percentage encourages further research. This paper aims to present the results of engine performance testing with octagonal diesel dual fuel mode at a mixture of 2.5, 5 and 10%. The engine used is a two-cylinder indirect injection diesel engine modified to direct injection. In addition to performance, the effect of emissions generated from dual-fuel engines will also be discussed for completeness of information for researchers and academics who are interested in exploring dual-fuel diesel octagonal engine research.

Experimental Section

Testing machine

The test was conducted by placing a diesel engine on an eddy current engine test bed type dynamometer, installing a fuel balance, emission meter, and smoke meter, and installing several pressure sensors and temperature sensors on the intake and exhaust manifolds (Fig. 1). The diesel engine tested was connected to the eddy current dynamometer for setting the rotation and load, fuel balance was used to measure food consumption Combustion, and intake air consumption is measured with a hot wire anemometer[4]. A pressure sensor and a crank angle sensor were used to measure the IMEP pressure. The diesel engine tested is a two-cylinder indirect injection diesel engine modified to direct injection with specifications as shown in Table 1.

Fuel preparation

The fuels tested were 100% diesel (diesel), and diesel with octagonal blends of 2.5% (Oct 2.5%), 5% (Oct5%), and 10% (Oct10%). Diesel fuel was obtained from Hindustan petroleum under the brand name biodiesel, which is a mixture of 95-97.5% diesel and 2.5-5% biodiesel. Octagonal with a purity of 99.6% and surfactant in the form of microalgae methyl ester brand were obtained from a general chemical supplier, in Chennai, India. A comparison of the properties between 100% diesel fuel and 99.6% octagonal is shown in Table 2. Diesel octagonal blended fuel was prepared by stirring according to the desired dose in a stirring machine at 250 rpm for 15 min. This is intended to obtain a homogeneous mixture. To maintain the stability of the mixture, an additional surfactant of 1% of the total volume of the mixture was used[5].

Implementation of testing

The engine was run at 1,500 rpm using the following materials fuel test with 10, 20, 30 loading

Table 1 — Engine specifications

Type	4-Stroke Diesel
Number of valves	4
Cooling system	Natural
Number of cylinders	2
Volume (cc)	1630 cc
Cylinder specification	95 x 115 mm
Compression ratio	19 : 1
Maximum torque	96.9 Nm
Maximum power	13.5 kW
Fuel system	Indirect injection modified to Direct Injection

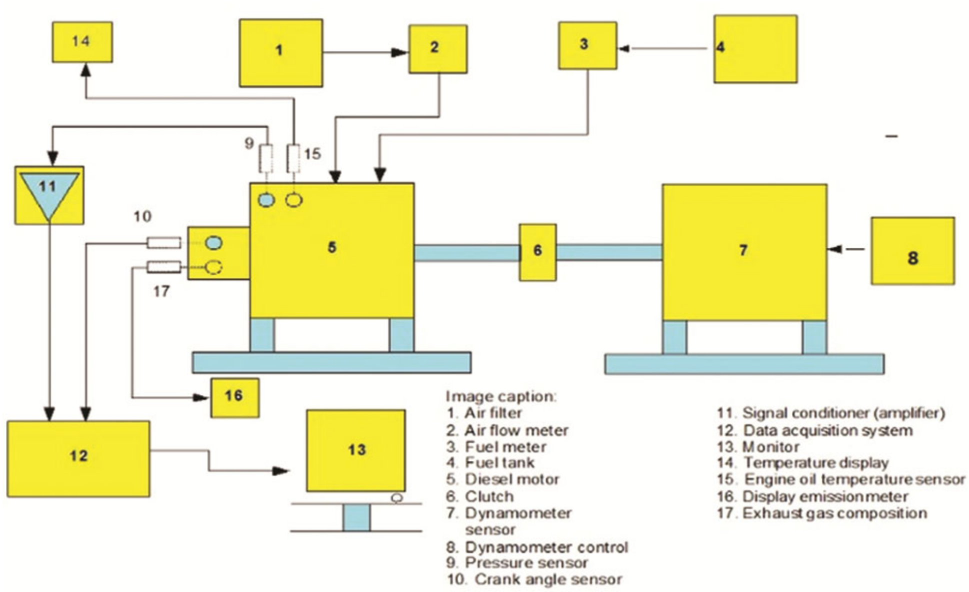

Fig. 1 — Schematic diagram of engine

Table 2 — Properties of fuel

Fuel properties	Diesel fuel	Octagonal
Density at 20° C, kg/m^3	837	788
Cetane number	50	5-8
Kinematic viscosity at 40° C, mm^2 /s	2.6	1.2
Surface tension at 20° C, N/m	0.023	0.015
Lower heating value, MJ/kg	43	26.8
Specific heat capacity, J/kg° C	1850	2100
Boiling point	180-360	78
Oxygen, % by weight	0	34.8
Latent heat of vapourisation, kJ/kg	250	840
Bulk modulus of elasticity, bar	16000	13200
Stoichiometric air-fuel ratio	15.0	9.0
Molecular weight	170	46

Table 3 — Uncertainty of measurements

Measurement	Accuracy
Soot density	+1 g/m^3
CO	+5 %
HC	+20 ppm
Round	+5 rpm
Torque	+0.2 Nm
Calculation result	Uncertainty (%)
Fuel volume rate	+2
Power	+1
Specific fuel consumption	+1.5
Efficiency	+1.5

variations, 40, 50, and 60 Nm. Then the parameters measured at each engine conditioning during operation include IMEP pressure, fuel consumption, air consumption, oil temperature, intake and exhaust air temperature, cooling water temperature both in and out of the radiator, CO, HC, and smoke emissions. Data were collected twice in one test for fuel consumption and IMEP values. Each measuring instrument and sensor has been well calibrated and each has measurement accuracy and uncertainty in accordance with its specifications. The accuracy and uncertainty of measurements or calculations in this study are shown in Table 3.

Results and Discussion

Effect of diesel octagonal blend on IMEP value

Figure 2 shows the effect of octagonal blends on IMEP values plotted in the IMEP to load the graph. In Fig. 2, the graph shows the same trend, namely as the load increases, the IMEP value also increases. The highest IMEP value is obtained in the fuel mixture E5% followed by E10% while the lowest value was obtained from the engine using E2.5% fuel. In this case, the addition of octagonal blends results in an increase in the IMEP pressure value because the lower cetane value of octagonal causes the initial combustion process to take place more slowly so that there is more fuel in the initial mixing phase, which will result in a higher maximum combustion chamber pressure[6].

Effect of octagonal diesel blends on specific fuel consumption (BSFC)

BSFC can be calculated by the power formula (Equation 1) and BSFC formula (Equation 2).7 The effect of testing dual fuel engines fuelled by pure diesel, octagonal blends of E2.5%, E5%, and E10% on BSFC is shown in Fig. 3. As the load increases, the amount of fuel required decreases. From the graph, it can be seen that the highest BSFC is obtained from a pure diesel engine and the lowest BSFC is obtained from a dual-fuel engine fuelled with E10%. It can be said that the addition of an octagonal mixture can reduce the amount of fuel consumption or a more efficient engine. This is very different from the results of previous research which is with the increase in the octagonal ratio should show an increase in BSFC value. The increase in BSFC value in dual fuel engines with octagonal diesel blends can occur because the lower heating value (LHV) per unit mass of octagonal fuel is lower than diesel fuel. The amount of fuel fed into the combustion chamber for

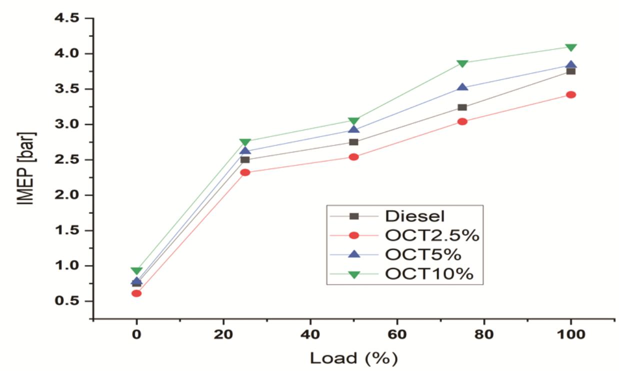

Fig. 2 — Effect of diesel ethanol blend on IMEP

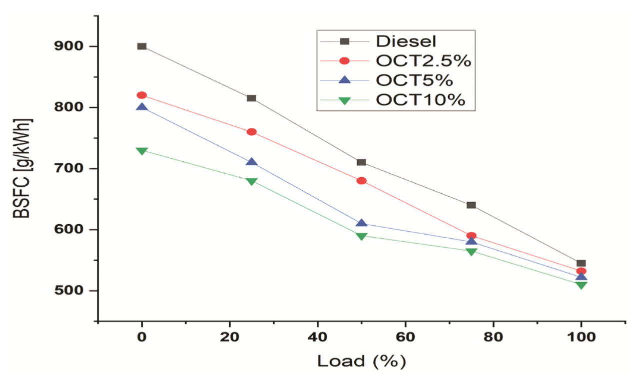

Fig. 3 — Effect of diesel ethanol blend on BSFC

the desired energy input should be greater when using octagonal fuel blends. In this research, different results were obtained, which may be due to the use of diesel fuel that is not 100% pure. Although the LHV value of biodiesel is still low at around 37.5 MJ/kg when compared to the LHV of pure diesel at around 43 MJ/kg, this may affect the amount of specific fuel consumption when the three fuels diesel, biodiesel, and octagonal are blended together. The decrease in BSFC can be explained by the fact that as the load increases, the increase in braking power is greater than the need for the increase in fuel consumption to reach combustion temperature (indicated by cylinder pressure). The conversion from heat energy to mechanical work with the increase in combustion temperature drives the decrease in BSFC against load. Another possibility indicated to affect the BSFC value is the modification of the engine from indirect injection to direct injection[7].

Effect of octagonal diesel blends on smoke, HC, and CO emissions

A comparison of smoke emissions between diesel engines fuelled by pure diesel, octagonal blends of E2.5%, E5%, and E10% is shown in Fig. 4. All graphs show the same type of trend, namely that with the increase in the load given to the engine, the percentage of smoke emissions produced increases. The highest smoke percentage value is produced by pure diesel fuelled engines and the lowest smoke percentage is obtained from engines with E10% fuel. Then, octagonal can reduce the formation of soot seeds due to the production of OH from octagonal. Thus, the reaction affects the conversion of hydro-atom reaction genes into hydrogen molecules that inhibit soot formation. Thus if referring to this, even though the engine used here is a stationary engine not for vehicles, it can be concluded that with 10% octagonal addition, loading at a maximum of 40 Nm still qualifies for emissions below the established threshold standards[8].

Meanwhile, a comparison of the amount of HC due to diesel engines fuelled by pure diesel, octagonal blends of E2.5%, E5%, and E10% is shown in Fig. 5. The type of graph shows the same trend, namely the value of HC emission content increases with the increase in the load given to the engine. The lowest HC values at each loading were obtained for the engine with E2.5% fuel. Meanwhile, the engine with E10% fuel tends to show the amount of HC that is always higher than the engine with pure diesel fuel. The emission tests conducted on engines with octagonal diesel blended fuels will produce an unclear effect on total hydrocarbons (HC). While according to engines operating at 1500 rpm with octagonal blended fuel will produce higher HC values compared to pure diesel fuel[9].

Figure 6 shows the comparison graph of CO against load due to the effect of pure diesel fuel,

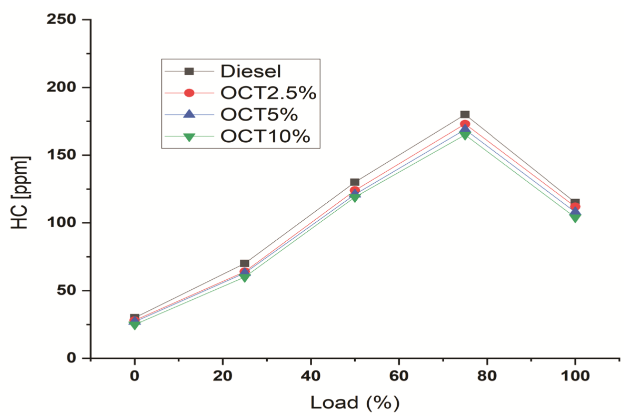

Fig. 5 — Effect of ethanol blend on HC emission content

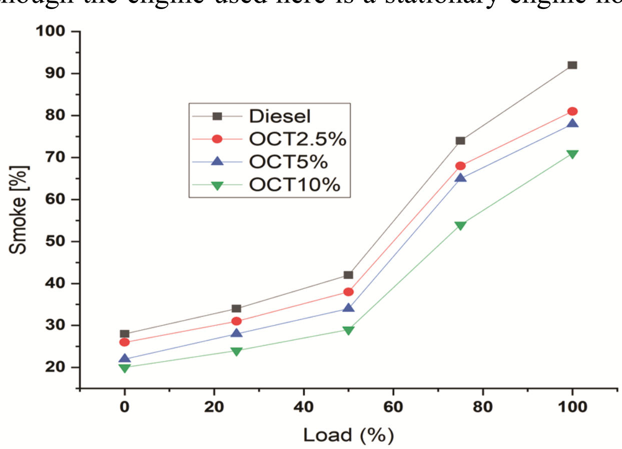

Fig. 4 — Effect of ethanol blend addition on smoke emission content

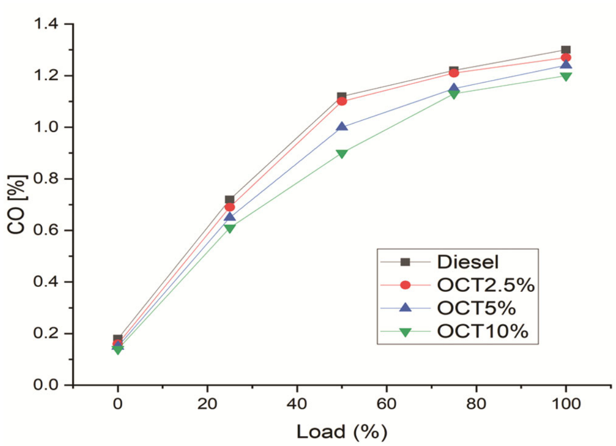

Fig. 6 — Effect of ethanol blend on CO emissions

octagonal blends of E2.5%, E5%, and E10%. The trend of the graphs is the same among all graphs, namely the increase in the percentage value of CO along with the increase in the load given to the engine.[10]However, there is a phenomenon that at E2.5% the CO percentage drops dramatically at50 Nm loading. The unknown cause of this could be due to the uncertainty of the measuring instrument or it could be because when the engine is operating at 1500 rpm with a load of more than half of its full load (50 Nm), the temperature inside the cylinder will be high, which will cause the CO percentage to drop makes the chemical reaction of the fuel with oxygen easier and combustion will be more complete. Although at higher loads (i.e. 60 Nm), the CO emission content increased dramatically again. This may also be the case, given the various possibilities in an operating diesel engine, including changes in temperature in the cylinder that change even if unnaturally. However, any reduction in CO emissions can occur with complete combustion. From all graphs, it can be seen that the lowest CO value at each loading change is obtained in the E10% fuelled engine. This is possible because the addition of more octagonal will cause a high oxygen content in the fuel, which is the main factor to reduce CO emission[11].

Conclusion

Tests have been conducted on an indirect injection engine modified to direct injection with a rotation of 1,500 rpm with fuel variations in the form of diesel oil, diesel octagonal 2.5%, 5%, and 10%. The results show that there is an effect of increasing the IMEP value and decreasing the BSFC value of the engine operated with the use of a mixture of octagonal and diesel oil. octagonal diesel. With the operation of a dual-fuel diesel engine model fuelled by diesel octagonal, the emissions produced in the form of smoke, and CO are reduced, while HC tends to increase.

Data availability statement

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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