

Combustion and Emission Characteristics of Jatropha Blend as a Biodiesel for Compression Ignition Engine with Variation of Compression Ratio

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Abstract

In this research study, an experimental investigation was conducted to appraise and evaluate the performance, combustion and exhaust emission levels of different blends of diesel with Jatropha oil and diethyl ether in a fully instrumented single cylinder direct injection diesel engine. The parameters were measured for two different compression ratios. The compression ratio was reduced from 17.5 to 16.8:1 by increasing the bowl size of the piston. The aim of the reduced compression ratio is to reduce the in-cylinder temperatures. The different blends such as J20, J17+DEE3%, J16+DEE4%, J15+DEE 5% were used for experimentation on the engine. The experimental results indicates that BTE of the blend increases with increase in applied load and maximum BTE at full load is 30.31% for J17+DEE 3% which is 7.3% higher than that of diesel. The NO_x emission decreases when the compression ratio decreases but using of biodiesel increased NO_x upto 10% because of higher cetane number. So reducing the compression ratio and using biodiesel gives almost same value of NO_x as that of diesel by controlling that 10% increase in NO_x but it produces less smoke.

Keywords: Jatropha oil, Diethyl ether, performance, emission, compression ratio.

1. Introduction

Internal combustion engines are most commonly used for mobile propulsion in vehicles and portable machinery. In mobile equipment, internal combustion is advantageous since it can provide high power-to-weight ratios together with excellent fuel energy density. Generally using fossil fuel, these engines have appeared in transport in almost all vehicles. Due to the fast depletion of fossil fuels and the increasingly strict emission laws, there is an urgent need to find alternatives to fossil fuels. Biodiesel has attractive properties and research carried out by NATIONAL RENEWABLE ENERGY LABORATORY for US department of Energy and Agriculture has confirmed that lifecycle environmental cost of biodiesel is far better than that of petroleum-based diesel.

Jatropha is a kind of biodiesel used for an alternate fuel in place of diesel in compression ignition engines. Normally it is manufactured from the vegetable oils. It reduces carbon emission as well as fuel consumption. M.Varman, M.Hazrat investigated the engine performance and emissions of diesel fuel and blends of Jatropha oil in different proportions and compared with diesel fuel. According to their study, engine torque and brake power for blend fuels are lower than diesel fuel whereas their BSFC values are higher than diesel fuel[1].

Diethyl ether is also a renewable fuel as it is produced from ethanol by dehydration process. It has several favorable properties such as higher cetane number, high oxygen content, low auto-ignition temperature and high volatility. Therefore it can assist in improving engine performance and reducing the cold starting problem and emission when used as a pure or additive in diesel fuel. S.Jindal, V.Vashistha conducted test with 5%, 10% and 15% diethyl ether and 6%, 10% ethanol to bio diesel blend. According to their study BSFCs and HC emissions reduced with addition of diethyl ether in the fuel mixture. The higher cetane number of DEE is an advantageous for obtaining lower smoke opacity and also lower NO_x emission[2].

B.P Nandwana ,N.S Rathore conducted the test on direct injection diesel engine running on jatropha methyl ester to evaluate the effects of compression ratio and injection pressure. According to their study , increase in compression ratio leads to increase in emission of HC and exhaust temperature whereas Smoke and CO emissions reduces [3].

Table 1: Properties of fuel.

Property	Diesel	Jatropha	Di ethyl Ether
Sp. Gravity	0.841	0.8175	0.714
Viscosity	4cst	5.65cst	6.83cst
Calorific Value (KJ/kg)	44000	38450	33892
Cetane number	40 to 65	50 to 53	85 to 89
Flash point (°F)	165	163 to 170	-45
Density (kg/m	840	880	713.4

2. Experimental Setup

In this experimental study, single cylinder direct injection AVL TAF1 Kirloskar engine was used to analyze the combustion and emission characteristics of engine with blended fuels. The diesel engine (Kirloskar made) was directly attached with dynamometer and load cells to test engine with different loads and crank angle encoder for detecting the angle at which the crankshaft rotates. The different measurement device was attached in the test engine such as U tube manometer for measuring air consumption, AVL415 smoke meter for measuring smoke opacity and exhaust temperature, AVL DIGAS 444 which has 4 gas analyser were connected with engine to measure the reading of emissions such as NO_x, CO, HC.

Table 2: Engine Specifications.

Model	TAFI
TYPE	Vertical Four-stroke cycle, compression ignition diesel engine
No of cylinder	1
Cooling type	Air-cooled engine
Cubic capacity(litre)	0.662
Rated speed	1500 rpm
Governing	Class "B1"
Connecting rod length	234 mm
Stroke length	110 mm
Cylinder bore	87.5 mm
Engine power	4.4 KW

3. Test Procedure

The engine is completely dismantled to remove the conventional piston. Then the modified piston is fitted properly. The timing belt and all other required parts are tuned and the engine is again assembled completely and the engine is now ready to use. For this piston fitted engine the readings are taken using the conventional diesel and blended fuel mixture with Jatropha 20% and 80% conventional diesel, and a completely Jatropha only as fuel. These fuels are used and tested in engine for various load conditions.

4. Results and Discussions

4.1 Emission characteristics

It is observed from the graph that for zero load condition, conventional piston produces a maximum smoke emission with J20 fuel and a minimum smoke emission is produced with J15+5DEE fuel. For same conditions the modified piston produces a maximum smoke emission with J16+4DEE fuel and a minimum smoke emission with diesel fuel. The same trend is followed for other load conditions with minor variations.

As per data collection we understand that J15+5DEE fuel for conventional piston and J16+4DEE for modified piston produces minimum smoke emission compared to others.

SMOKE VS LOAD

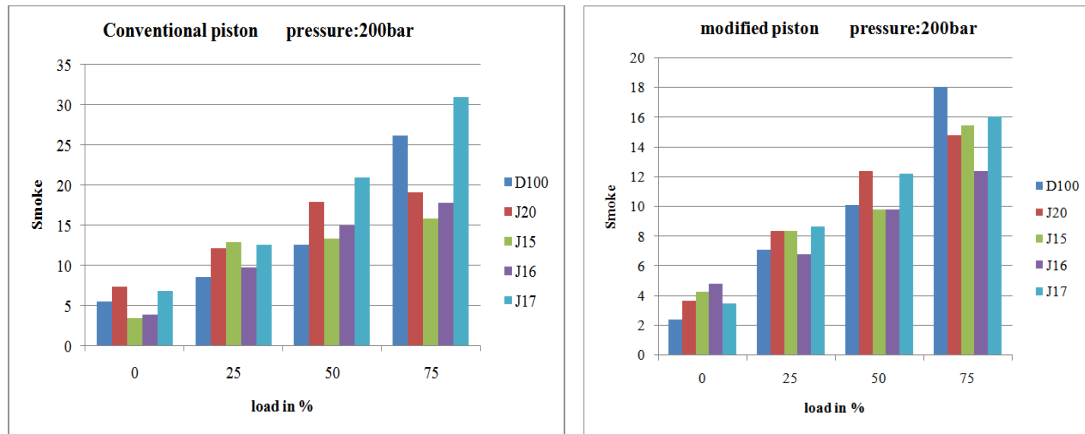


Fig. 1: Shows the Smoke level for different biodiesel blends at different load values.

NO_x EMISSIONS VS LOAD

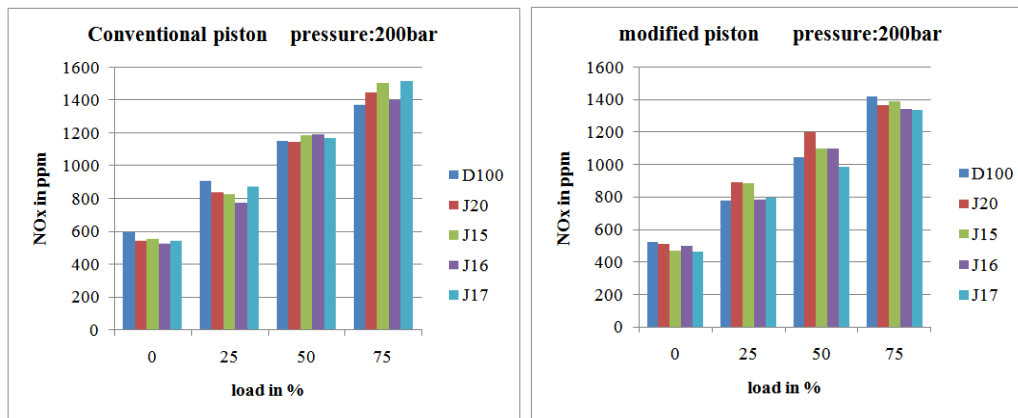


Fig. 2: NO_x vs load.

Fig. 2 shows the emission level of NO_x for different blends for conventional piston (CP) and Modified Piston (MP) at different load conditions. At zero load conditions, conventional piston produces a maximum NO_x emission with diesel fuel and a minimum NO_x emission is produced with J16+4DEE. For same conditions the modified piston produces a maximum NO_x emission with diesel fuel and a minimum NO_x emission with J17+3DEE fuel. As per data collection we understand that J16+4DEE fuel for both conventional and modified piston produces minimum NO_x emissions compared to other blends. By comparing conventional piston with the

modified piston, the NO_x values are lesser for modified piston. Because the peak value is decreased and oxygen availability in diesel is less.

**Combustion Characteristics :
Pressure Vs Crank Angle**

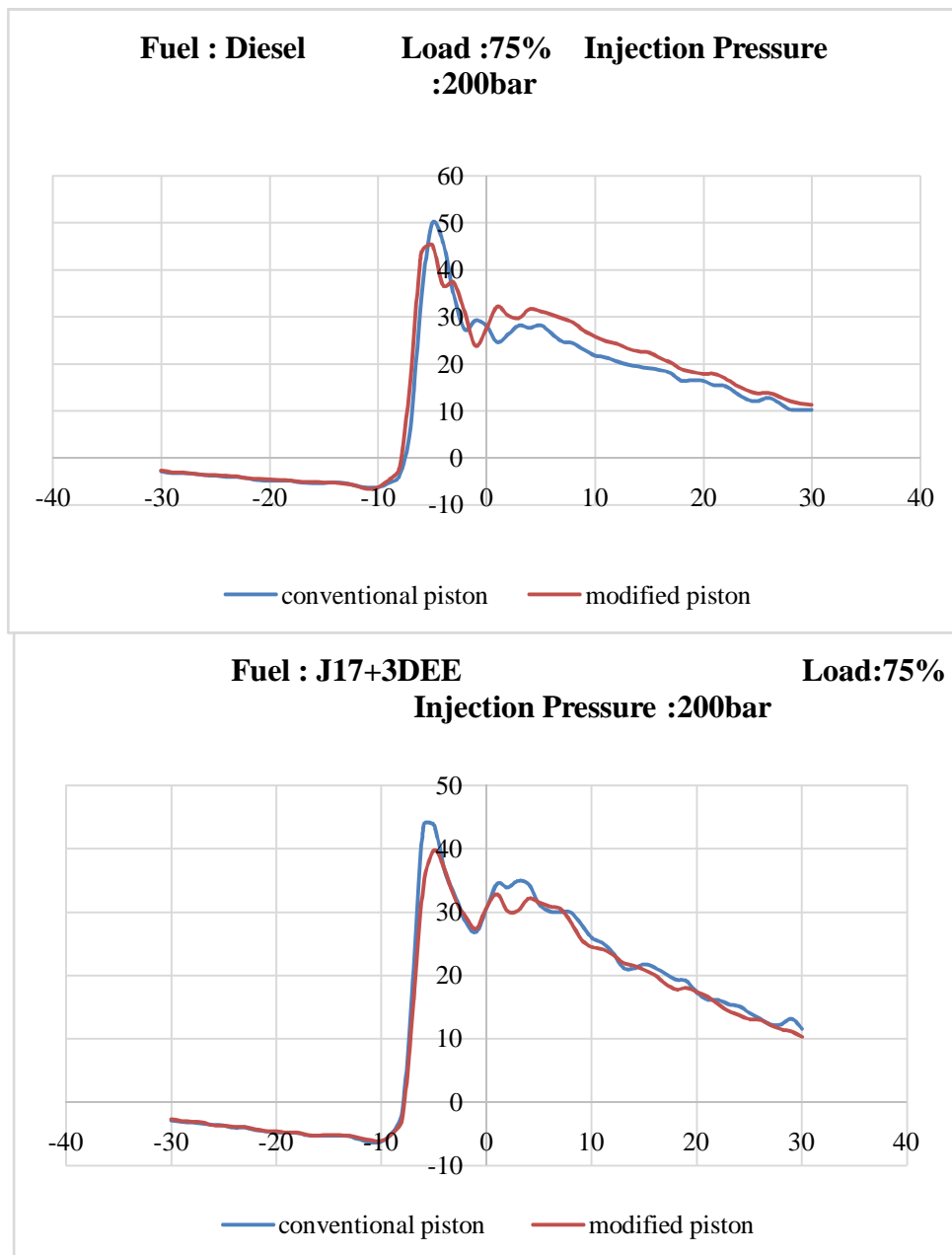


Fig. 3: Crank Angle Vs Pressure graphs.

Fig. 3 shows the variation of cylinder pressure according to the crank angle for diesel fuel and J17+3DEE blend. It is understood from the experimental values from that J17+3DEE shows combustion characteristics almost similar to diesel fuel when compared with other blends. It is observed from the graph that peak pressure is maximum for diesel fuel compared to biodiesel blends. The sudden pressure rise is observed between the crank angle of -5 to -3.5deg for all the blends and maximum pressure is attained between the crank angle of 5 to 8deg.

5. Performance Characteristics :

5.1 Brake Thermal Efficiency(BTE) Vs Brake Power (BP)

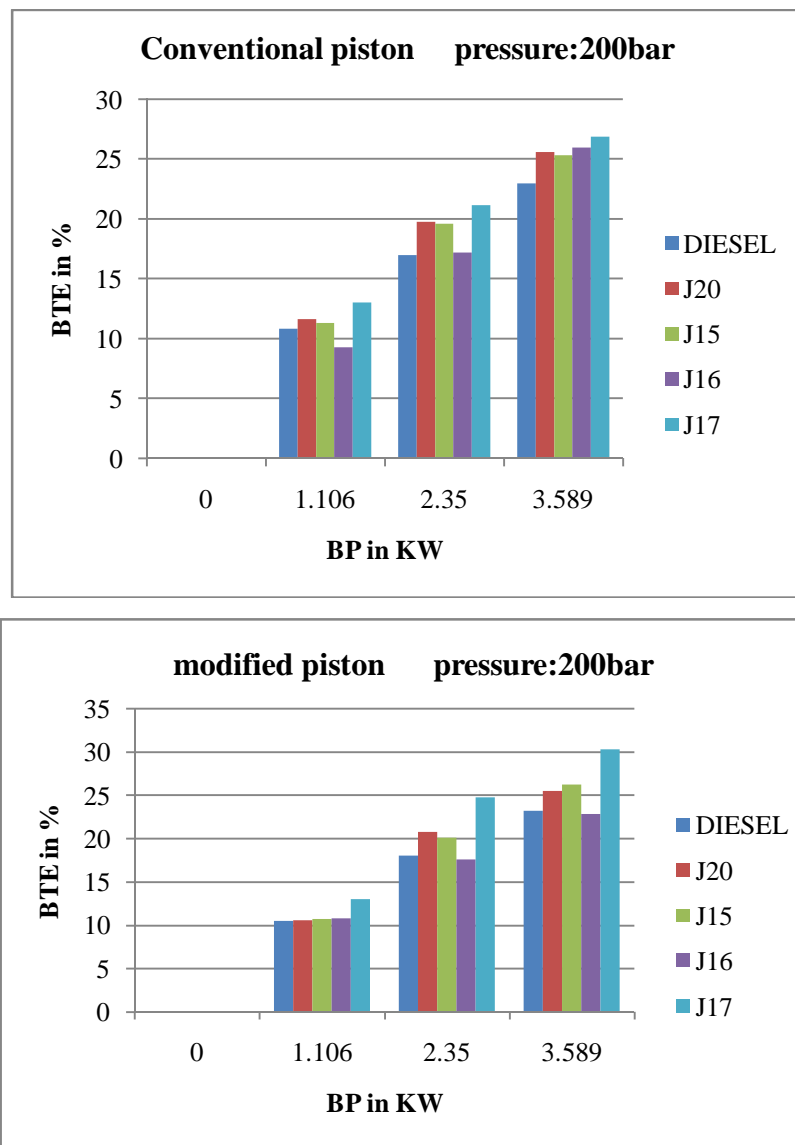


Fig. 4: BTE vs BP.

Fig. 4 shows the variation of Brake thermal efficiency for different brake power at constant pressure of 200bar. When brake power is 3.589, the conventional piston produces maximum brake thermal efficiency with J17+3DEE fuel and it produces minimum brake thermal efficiency with J16+4DEE fuel. For the same BMEP value, modified piston produces maximum BTE with J17+3DEE fuel and it produces minimum BTE with diesel fuel. It is observed that the brake thermal efficiency of blends is increasing with increase in applied load. As per data collection we understood that J17+3DEE with conventional piston and modified piston produces maximum efficiency compared to other fuel blends.

Conclusions

An experimental investigation was conducted in single cylinder direct injection diesel engine using biodiesel blends of various proportions such as J20 , J17+3DEE, J16+4DEE, J15+5DEE with diesel fuel and compared with pure diesel. The following conclusions were made from our experimental study.

From the analysis of performance characteristics, it is found that Brake thermal efficiency of the blend increases with increase in applied load. The maximum brake thermal efficiency at full load for J17+3%DEE in modified piston is 30.31% which is 7.3% higher than that of diesel.

From the analysis of exhaust emission levels of the blends, it is found that smoke emission of various blends are lower compared to diesel. This is because when blend fuel having more cetane number are used, combustion occurs faster compared to diesel fuel. As biodiesel blends used for test have more cetane number than diesel, it will result in increase in NO_x emission and decrease in smoke. It further produces lesser smoke in modified piston when compared with conventional piston. The NO_x emission for biodiesel blends is higher than that of standard diesel fuel except for J17+3%DEE which has NO_x emission almost similar to that of diesel fuel at lower load.

Considering all the performance, emission and combustion characteristics of different blends , it is found that performance of J17+3%DEE blend is superior when compared with the conventional standard diesel fuel. Even though small increase in NO_x emission is noted, it is still comparable with the diesel fuel and is also in the suitable range. The experimental result also proves that biodiesel blends are potentially good alternative fuels for diesel engine.

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