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Performance characteristics of CI Engine fuelled Diethyl - Ether and its comparison with diesel fuelled CI engine

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Abstract

In the present world where every day new economics are arising, the need of fuel to fulfil the requirement of these growing industries is must. It cannot be denied that diesel fuels have played significant role in development of these industries. Diesel Engines have proved its utility in transportation, agriculture and power sector of India. These engines also help in developing decentralized system energy for rural electrification.

However, very little work has been reported on diethyl ether, being used as alternative fuel. In the present study, various engine trails have been conducted to analyse the influence of diesel fuel blends while comparing the performance and emission characteristics with diesel fuel. [1] The determination of performance and emission characteristics of the engine with various diesel blends was done and comparative assessment with baseline data of diesel fuel was also made.

Keywords: Diethyl ether, diesel engine, Alternative Fuel, Biodiesel ,Variable compression engine.

Introduction

The International Energy Agency (IEA) forecasts that world primary energy demand between now and 2030 will increase by 1.5% per year from just over 12,000 million tons of oil equivalent (Mtoe) to 16,800 Mtoe- an overall increase of 40%. Developing Asian countries are the main drivers of this growth, followed by Middle East. [2]

Figure 1: World Energy Demand

The world energy consumption shows a marked increase in the consumption of China from 2002. The energy consumption in the rest of the world is almost constant with an exception to India which shows a steady increase from 2006. This clearly shows that the developing countries of Asia are emerging as the major user of energy. This has also led to an increase in the energy growth per capita of these countries with respect to rest of the world.

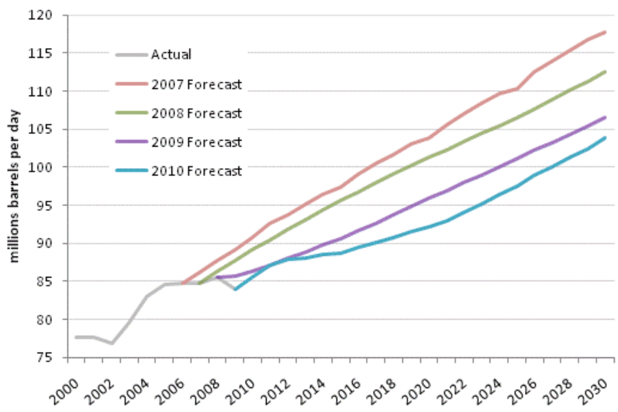

Figure 2: World Energy Consumption

Need of diethyl ether (DEE)

Diethyl ether (DEE),$CH_3CH_2OCH_2CH_3$, is a diesel blend and is liquid at ambient condition which makes it attractive for fuel handling and infrastructure requirement .DEE has several favoured properties including an outstanding cetane number and reasonable density of broad storage .DEE is expected to improve the low temperature flow and properties and reduce the engine exhaust emission .It has high oxygen content, so blend DEE are of cover because of a tendency to oxide ,forming peroxide in storage. It has broad flammability limit and miscibility and diesel fuel. [3]

It has slightly higher fuel consumption due to lower calorific value of biodiesel. It also has higher nitrous oxide (NO_x) emission than diesel fuel. It has higher freezing point than diesel fuel, so it is inconvenient in cold climate .It is less stable than diesel fuel therefore long term storage (more than six month) of biodiesel is not recommended. It dissolve the deposit of sediment and other contaminant from diesel fuel in storage tanks and fuel lines, which then are flushed away by bio fuel into the engine, where they can cause the problem in valve and injection system .In consequence , the cleaning of tanks prior to filling the biodiesel is recommended. It must be noted that these disadvantage are significantly reduced when biodiesel is used in blend with diesel fuel 1.6 Blend of DEE and diesel as a fuel Diethyl ether might be expected to improve low temperature flow properties.[4] Previous studies have suggested that the weight percent of oxygen content in the fuel is the most important factor for PM reduction and it is more important than other properties such as chemical structure or volatility.[5] Including diethyl ether and diesel blend can increase oxygen content which may increase further PM emission .It was studied an oxygenated additive diethyl ether was blended with biodiesel in the ratio of 5% and 10% and tested their performance.

Diesel- - diethyl ether blends (DDEB) show better stability and can be used in diesel engine without any modification .The BSFC of DDEB is slightly low. DDEB having higher oxygen content show excellent ability to eliminate smoke emission especially at high engine load .Diethyl ether has higher volatility than ethanol, so DDEB exhibit more reduction of smoke. [6]

Properties	
Chemical formula	$C_4H_{10}O$
Molar mass	74.12 g·mol^{-1}
Appearance	Colourless liquid
Odour	Dry, sweetish odour
Density	0.7134 g/cm^3, liquid
Melting point	−116.3 °C (−177.3 °F; 156.8 K)
Boiling point	34.6 °C (94.3 °F; 307.8 K)
Solubility in water	6.05 g/100 Ml
Vapour Pressure	440 mmHg (20°C)
Main hazards	Extremely Flammable, harmful to skin, decomposes to explosive peroxides in air an light
Flash point	−45^{0}C(−49 °F; 228 K)
Auto ignition Temperature	160 °C (320 °F; 433 K)

Method

Diethyl ether, or simply ether, is an organic compound in the ether class with the formula (C2H5)2O. It is a colourless, highly volatile flammable liquid. It is commonly used as a solvent in laboratories and as a starting fluid for some engines. It was formerly used as a general anaesthetic, until non-flammable drugs were developed, such as halothane. It has been used as a recreational drug to cause intoxication. [7]

Diethyl ether has a high cetane number of 85-96 and is used as a starting fluid, in combination with petroleum distillates for gasoline and Diesel engines because of its high volatility and low flash point. Ether starting fluid is sold and used in countries with cold climates, as it can help with cold starting an engine at sub-zero temperatures. For the same reason it is also used as a component of the fuel mixture for carbureted compression ignition model engines. In this way diethyl ether is very similar to one of its precursors, ethanol.

Preparation of Diesel Blend

Diesel Blend is prepared from Diethyl ether & Diesel.

Sample 1: 5% DDE & rest Diesel by Volume are mixed & stirred till they are completely mixed.

Sample 2: 10% DDE& rest Diesel by Volume are mixed & stirred till completely mixed.

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has standalone panel box consisting of air box, two fuel tanks for duel fuel test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement.

The setup enables study of VCR engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Lab view based Engine Performance Analysis software package "*EnginesoftLV*" is provided for on line performance evaluation. [8]

Formulae used in calculations

Indicated Power It is the power developed in the cylinder and thus, forms the basis of evaluation of combustion efficiency or the heat released in the cylinder.

I.P=Pm*L*A*n*K/60
Where, Pm= Mean effective pressure, m2
L= Length of the stroke, m
A= Area of the piston, m2
N= Rotational speed of the engine, rpm
K= Number of cylinders

Brake Power*:* It is used to specify that the power is measured at the output of shaft, and is the usable power delivered by the engine to the load.

B.P=2Πnt/60*1000 KW
N= Speed, rpm

Specific Fuel Consumption*:* It measures how efficiently an engine is using the fuel to do useful work.
Sfc = Fuel consumption per unit time/power

Brake Specific Fuel Consumption: It the ratio between mass flow rates of the fuel to the brake power generated in the engine.
BSfc = mf/B.P Kg/KW.hr

Indicated Specific Fuel consumption*:* It is the ratio between mass flow rates of the fuel to the indicated power generated in the engine.
Isfc=mf/I.P Kg/KW.hr

Mechanical Efficiency: The difference between the I.P and B.P is the indication of the power lost in the mechanical components of the engine and forms the basis of mechanical efficiency, which is defined as follow
Mechanical Efficiency= B.P/I.P

Brake Thermal Efficiency*:* The ratio of work produced to the amount of heat energy that can be released in the combustion process is called brake thermal efficiency
Brake Thermal Efficiency= Heat in B.P*100/Heat supplied by fuel %. [9]

Air Fuel Ratio: It is defined as the ratio between mass of the air to the mass of the fuel consumed
A/F Ratio= ma/F.C [10]

Results
Sample 1: Pure diesel
Sample 2: 5% DEE, 95% Diesel by vol.
Sample 3: 10% DEE, 90% Diesel by vol.

Compression ratio 18

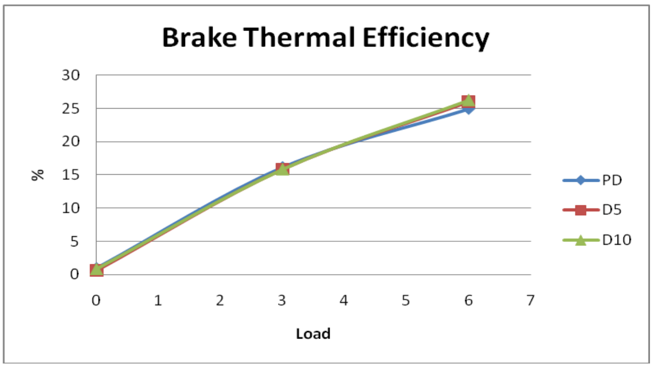

Figure3: Brake thermal efficiency for Compression ratio 18
The above graph shows that at CR 18 BTE improves little bit or nearly constant with increase load.

Compression ratio 16

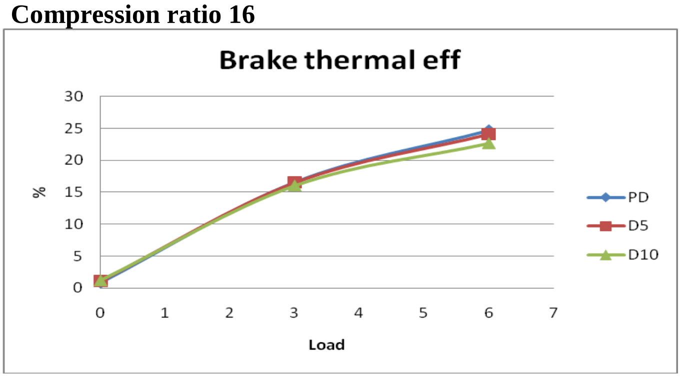

Figure 4: Brake thermal efficiency for Compression ratio 16
The above graph suggests that BTE at CR 16 decrease with increase load with increasing diethyl ether content.

Compression ratio 14

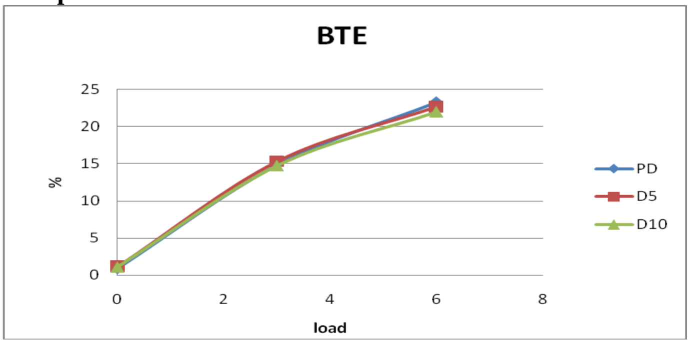

Figure5: Brake thermal Efficiency for Compression ratio 14

The above graph shows that BTE decrease with increase load at CR 14 with increase DEE content.

Brake Specific Fuel consumption (bsfc vs. load)

Compression Ratio 18

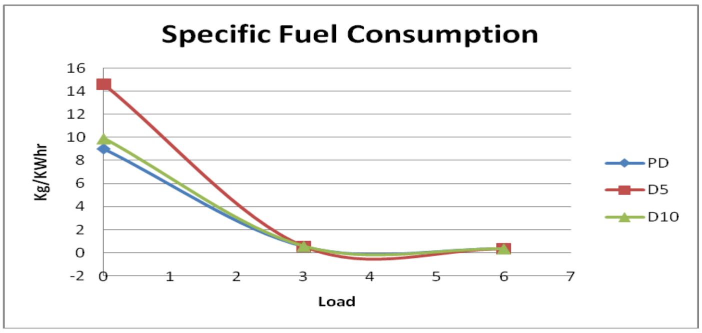

Figure6: BSFC for Compression ratio 18

This graph suggest that at starting fuel consumption is low for sample 2 and 3 as compared to sample 1 but with increasing load condition fuel consumption are nearly same.

Compression Ratio 16
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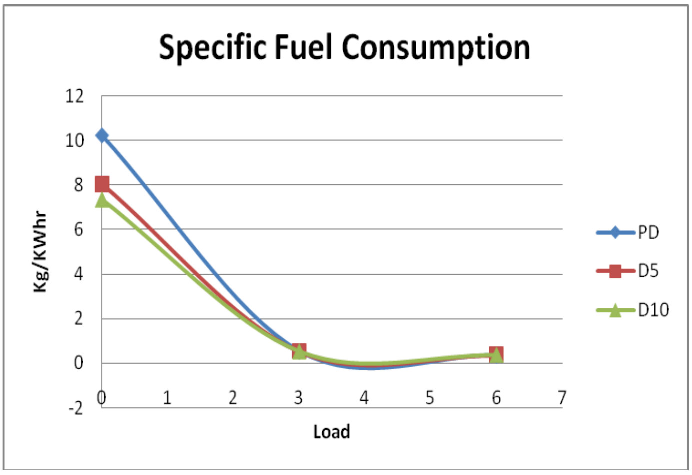

Figure 7: BSFC for Compression ratio 16

This graph suggest that at starting fuel consumption is low for sample 2 and 3 as compared to sample 1 but with increasing load condition fuel consumption are nearly same.

Compression Ratio 14

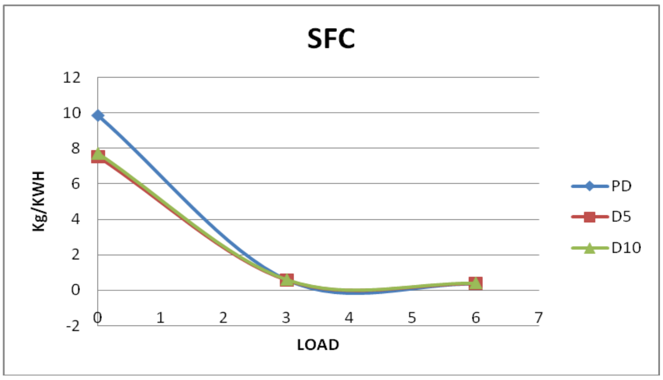

Figure 8: BSFC for Compression ratio 14

Brake Mean Effective Pressure

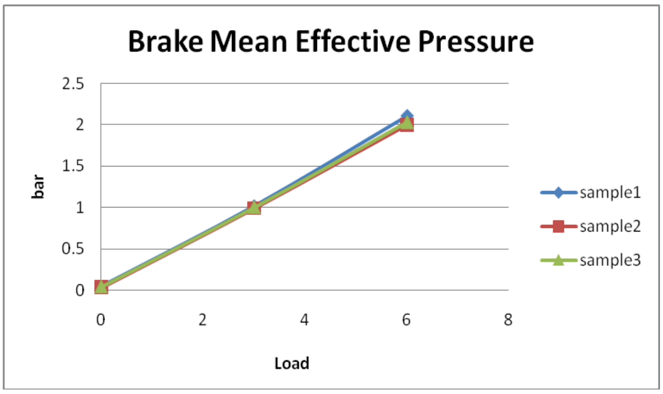

Figure 9: BMEP For Compression ratio 18

This graph shows that there is at most same BMEP but with increasing load there is slightly increase in BMEP at CR 18 with increasing diethyl ether content.

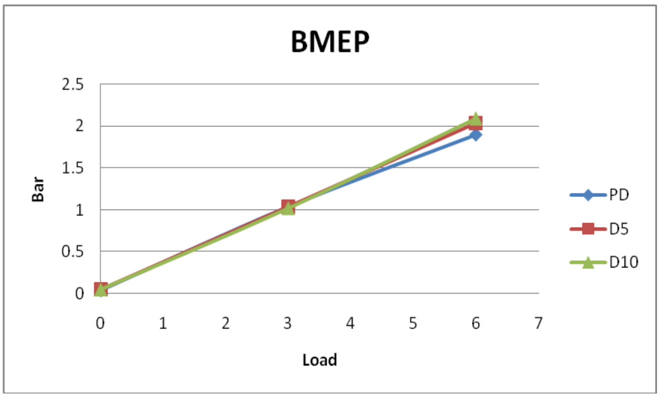

Figure 10: BMEP For Compression ratio 16

This graph shows that there is increase in BMEP with increasing load at CR 16 with increasing diethyl ether content.

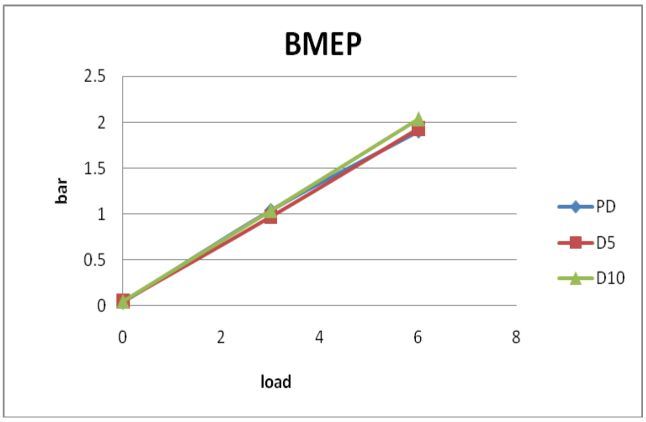

Figure 11: BMEP For Compression ratio 14

This graph shows that there is increase in BMEP with increasing load at CR 16 with increasing diethyl ether content.

Conclusion

Mechanical efficiency at CR 14 and CR 16 increase terrifically with increasing load for sample 2and sample 3. It is also noticed that mechanical efficiency more increase for sample 3 that is 10% of diethyl ether content ay CR 14 and CR 16 but for CR 18 mechanical efficiency decrease with increasing DEE.

BTE remains almost constant or little bit decrease with increase load for sample 2 and sample 3 as compared to sample 1.

Initially fuel consumption is low for sample 2 and sample 3 as compared to sample 1 but after increasing load specific fuel consumption remains same for all sample. Overall we can say that less fuel consumption for sample 2 and sample 3 by diesel engine as compared to sample 1 that is pure diesel.

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