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Potentiality of Dibutyl Ether on Diesel Engine Performance and Emissions

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Abstract

The goals of reducing the pollutants and to improve the performance of diesel engines have intensified research in diesel engines. The goal of this study was to provide insight into the emission and performance of diesel engine with the use of oxygenated fuels (used as blending agents). Experimental investigations were carried out to assess the impact of using Dibutyl ether-diesel blends on diesel engine performance and emissions. The fuel injection timing was also varied to investigate the engine emission and performance.

Key words: Emission, Performance, Oxygenated fuels.

Abbreviations

BSFC : Brake specific fuel consumption

NOx : Oxides of Nitrogen

NO : Nitric Oxide

O_3 : Ozone gas

PM : Particulate matter

HC : Hydrocarbons

CO : Carbon Monoxide

DSL : Diesel

DBE : Dibutyl ether

CR : Compression ratio

INJ : Injection timing

STD : Standard engine

ppm : Parts per million

Introduction

Diesel engine is the well known efficient engine among the internal combustion engines. The better fuel economy, low green gas emission, much longer life span, less maintenance and reliability are the properties of a diesel engine results in their wide spread use in transportation, thermal power generation and many more industrial and agricultural applications.

Despite its many advantages, the diesel engine is inherently dirty and is the most significant contributor of NOx and particulate matter, both of which contribute to serious public health problems. Particulate matter (PM) emissions from diesel combustion contribute to urban and regional hazes. Nitrogen oxides (NOx) and hydrocarbons (HCs) are precursors for O_3 and PM. NOx emissions from diesel vehicles play a major role in ground-level ozone formation. Ozone is a lung and respiratory irritant causes a range of health problems related to breathing, including chest pain, coughing, and shortness of breath. Particulate matter has been linked to premature death, and increased respiratory symptoms and disease. In addition, ozone, NO, and particulate matter adversely affect the environment in various ways, including crop damage, acid rain, and visibility impairment.

In view of increased concerns regarding the effects of diesel engine particulate and NOx emissions on human health and the environment, reducing the NOx and particulate emission from diesel engines is one of the most significant challenges today due to continuing stringent emission requirement. A lot of research work has taken up in this direction to develop after treatment and in-cylinder control techniques to mitigate the tailpipe NOx emission and NOx formation in the cylinder respectively.

From the review of literature, significant interest is focused on the use of oxygenated fuels to reduce pollutants from diesel engine.

Oxygenated fuels are the attractive class of synthetic fuels in which oxygen atoms are chemically bound within the fuel structure. This oxygen bond in the oxygenated fuel is energetic and provides a chemical energy that result in no loss of efficiency during combustion. In addition, the benefit of low net carbon release could be achieved.

The objective of the work is to study the effect of using Dibutyl ether as an oxygenated agent on diesel engine performance and emissions. Dibutyl ether has high cetane number with oxygen content of 12.3 % by weight.10 and 20 ml of Dibutyl ether were added to 1000 ml diesel. Dibutyl ether was first blended with diesel and emulsion was formed as the properties of DBE are similar to that of diesel. The samples are prepared by using the 1000 ml measuring jar and a 10 ml graduated test tube. Tests were done at constant speed under variable load conditions with base diesel and DBE-Diesel blends. Performance and emission parameters were compared.

Experimental apparatus and Procedure

Schematic diagram of the engine test rig is shown in fig. 1. The engine test was conducted on four-stroke single cylinder direct injection water cooled compression ignition engine connected to eddy current dynamometer loading. The specification of the engine is given in Table 6.1. The engine was always operated at a rated speed of 1500 rev/min. The engine was having a conventional fuel injection system. The injection nozzle had three holes of 0.3 mm diameter with a spray angle of 120^{o}. A piezoelectric pressure transducer was mounted with cylinder head surface to measure the cylinder pressure. It is also provided with temperature sensors for the measurement of jacket water, calorimeter water, and calorimeter exhaust gas inlet and outlet temperatures. An encoder is fixed for crank angle record. The signals from these sensors are interfaced with a computer to an engine indicator to display P-Ө, P-V and fuel injection pressure versus crank angle plots. The provision is also made for the measurement of volumetric fuel flow. The built in program in the system calculates brake power, thermal efficiency and brake specific fuel consumption. The software package is fully configurable and averaged P-Ө diagram, P-V plot and liquid fuel injection pressure diagram can be obtained for various operating conditions.

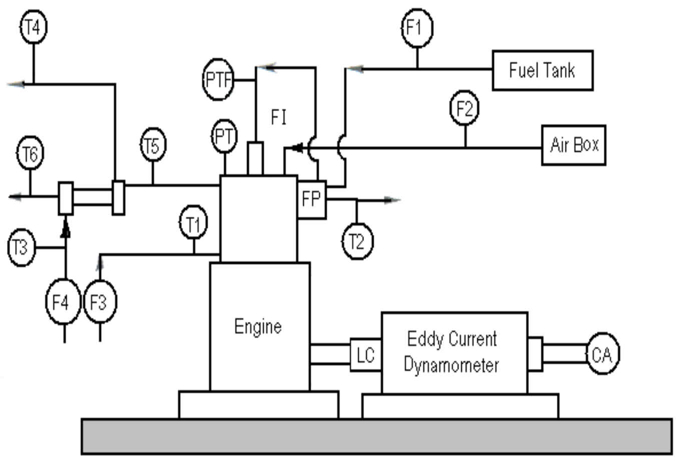

Figure 1. Schematic Diagram of the Experimental Set-up

PT Combustion Chamber Pressure Sensor
PTF Fuel Injection Pressure Sensor
FI Fuel Injector
FP Fuel Pump
T1 Jacket Water Inlet Temperature
T2 Jacket Water Outlet Temperature
T3 Calorimeter Water Outlet Temperature
T4 Calorimeter Water Outlet Temperature
T5 Exhaust Gas Temperature before Calorimeter
T6 Exhaust Gas Temperature after Calorimeter
F1 Liquid fuel flow rate
F2 Air Flow Rate
F3 Jacket water flow
F4 Calorimeter Water flow rate
LC Load Cell
CA Crank angle Encoder

EGC Exhaust Gas Calorimeter

Table 1. Engine Specifications

Sl. No.	Engine Parameters	Specification
01	Machine supplier	INLAB Equipments, Bangalore.
02	Engine type	TV1 (Kirloskar, Four Stroke)
03	Number of cylinders	Single
04	Number of strokes	Four
05	Rated power	5.2kW (7 HP) @ 1500 RPM
06	Bore	87.5 mm
07	Stroke	110 mm
08	Cubic Capacity	661 cc
09	Compression ratio	17.5 :1
10	Rated Speed	1500 RPM
11	Dynamometer	Eddy Current, make SAJ
12	Type of cooling	Water
13	Fuel injection Pressure	190 bar
14	Fuel	Diesel

Table 2. Properties of Dibutyl ether

Sl. No	Properties	Dibutyl ether
1	Molecular formula	$[CH_3(CH_2)_3]_2O$
2	Oxygen content (% by weight)	12.3
3	Density (kg/m^3)	771
4	Boiling point (^{o} C)	142
5	Cetane number	91
6	Calorific value (MJ/kg)	38.7

Results and Discussion

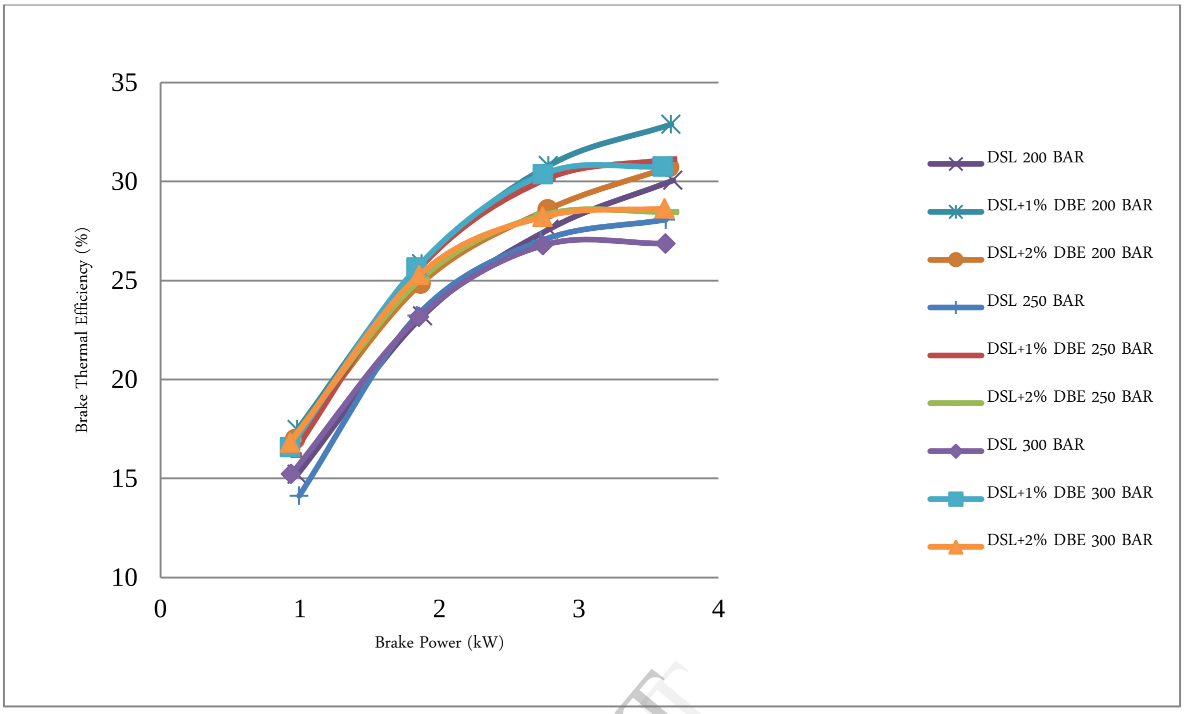

Figure 2. Brake Thermal Efficiency vs. Brake Power, CR=17.5, Standard Injection Timing

Fig 2 shows that brake thermal efficiency with diesel with 1% Dibutyl ether at 200 bar is better than the base diesel operation at part load and full load conditions. This is due to rapid increase in the premixed heat release rate and complete combustion due to the presence of Dibutyl ether.

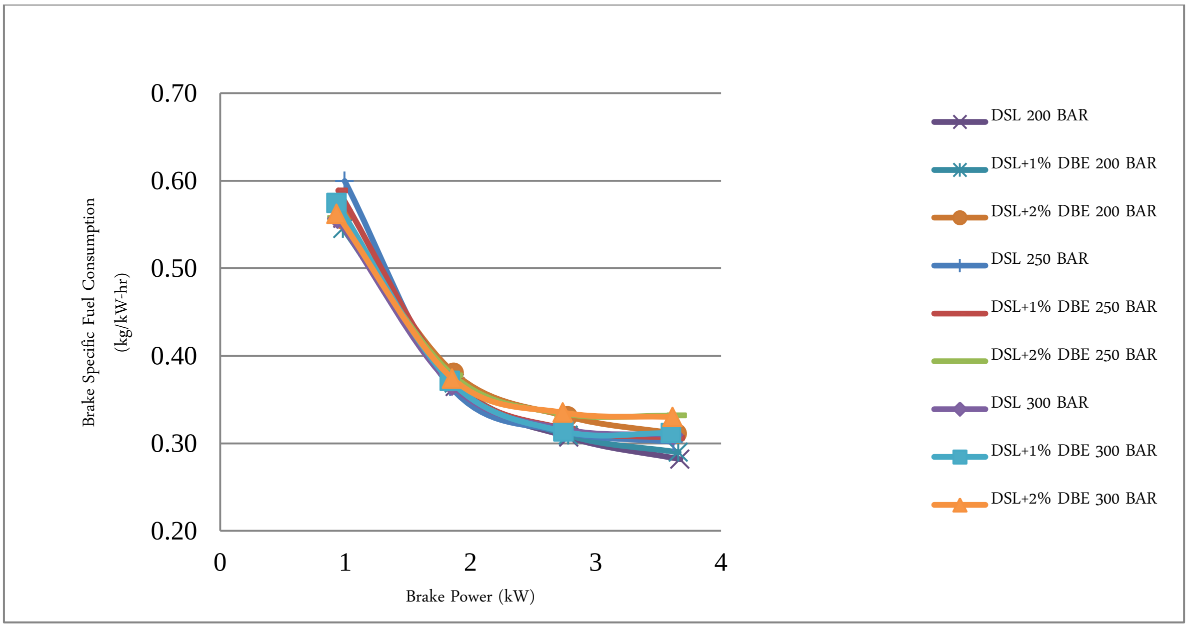

Figure 3. Brake Specific Fuel Consumption vs. Brake Power, CR=17.5, Standard Injection Timing

Fig 3 shows that the brake specific fuel consumption diesel with 1% Dibutyl ether at 200 bar is comparable to base diesel operation. Use of Dibutyl ether increases the combustion efficiency of the engine.

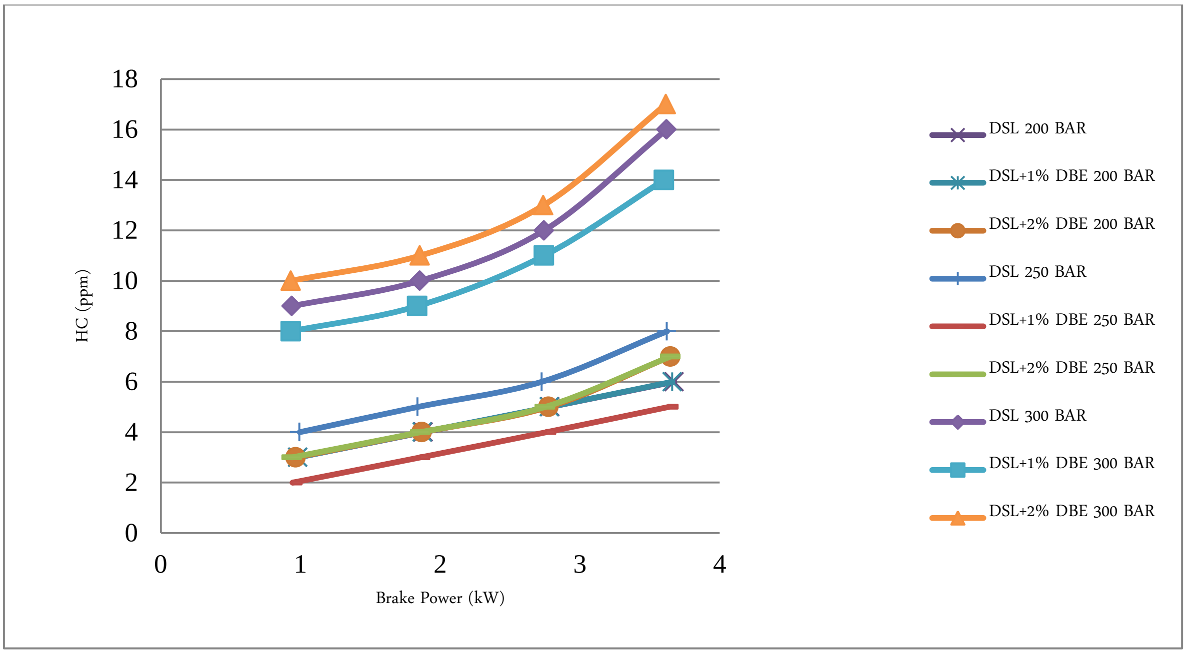

Figure 4. HC Emission vs. Brake Power, CR=17.5, Standard Injection Timing

Fig 4 shows that HC emissions with diesel with 1% Dibutyl ether at 250 bar is lower than the base diesel operation at part load and full load conditions. It may be due to fact that Dibutyl ether contains 12.3 % oxygen by weight which leads to more complete combustion.

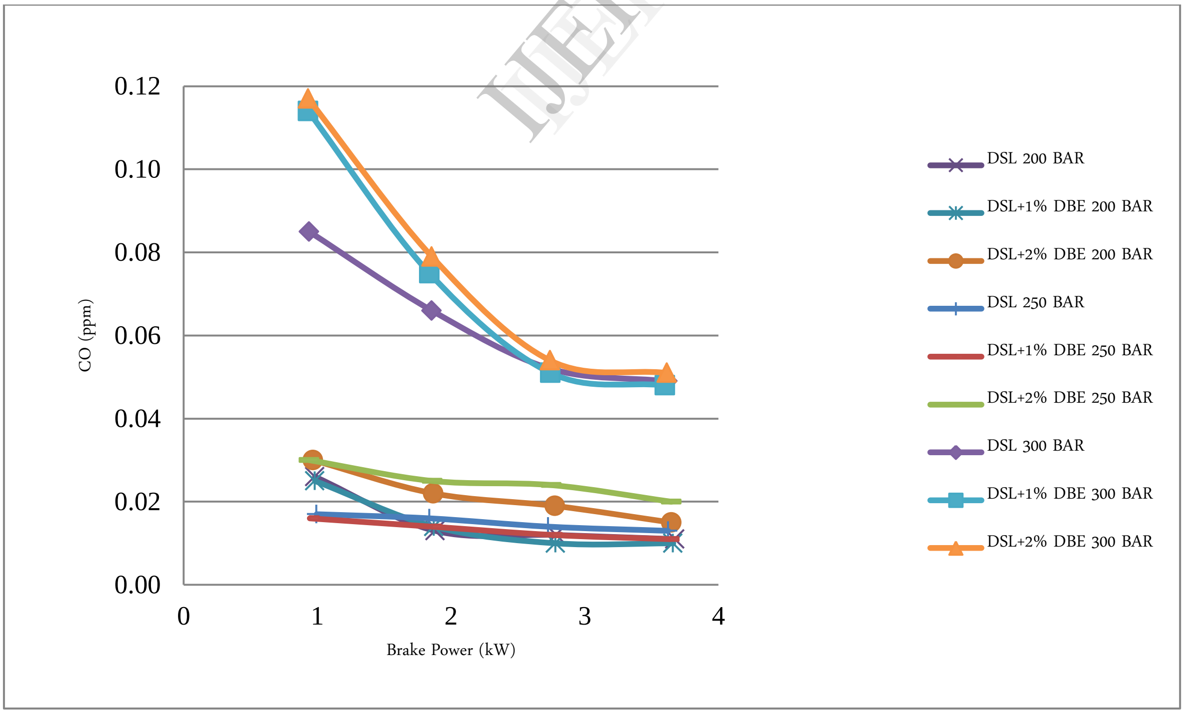

Figure 5. CO Emission vs. Brake Power, CR=17.5, Standard Injection Timing

Fig 5 shows that CO emissions with diesel with 1% Dibutyl ether at 200 bar and 250 bar is lower than the base diesel operation at part load and full load conditions. It may be due to the fact that Dibutyl ether contains 12.3 % oxygen by weight which leads to more complete combustion.

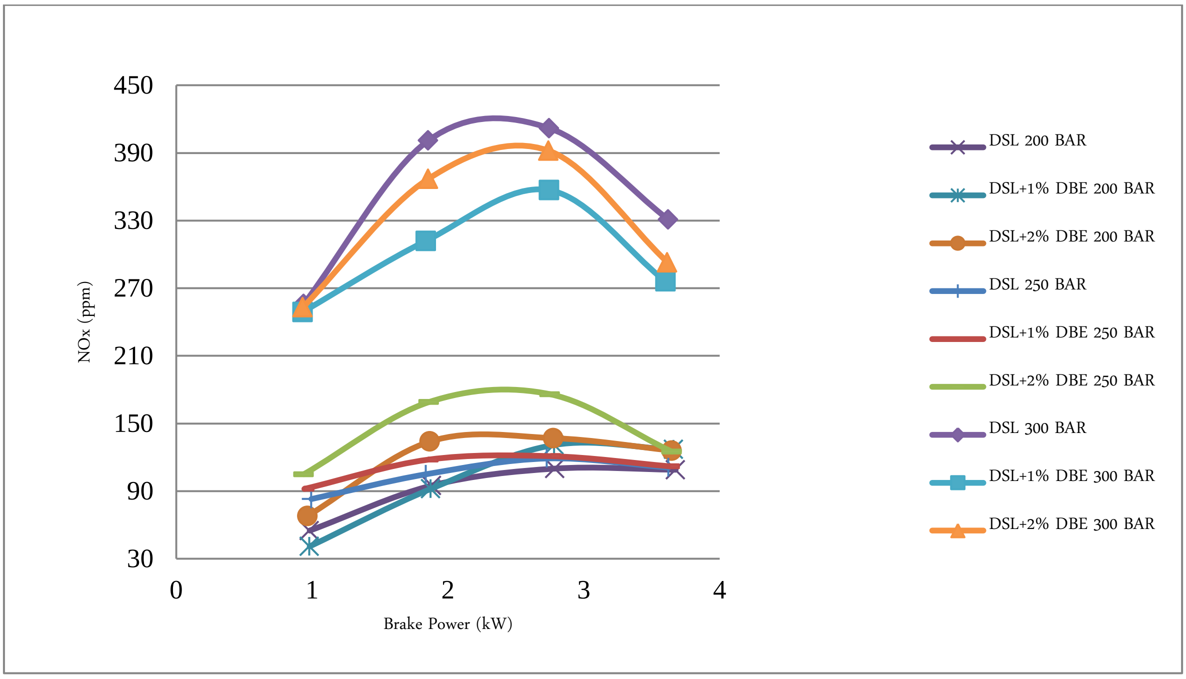

Figure 6. NO_x Emission vs. Brake Power, CR=17.5, Standard Injection Timing

Fig 6 shows that NOx emissions for higher injection pressure is more than at lower injection pressure, as at higher injection pressure give rise to more rapid combustion leading to higher combustion temperature. With blending of DBE a nominal decrease in NOx is observed.

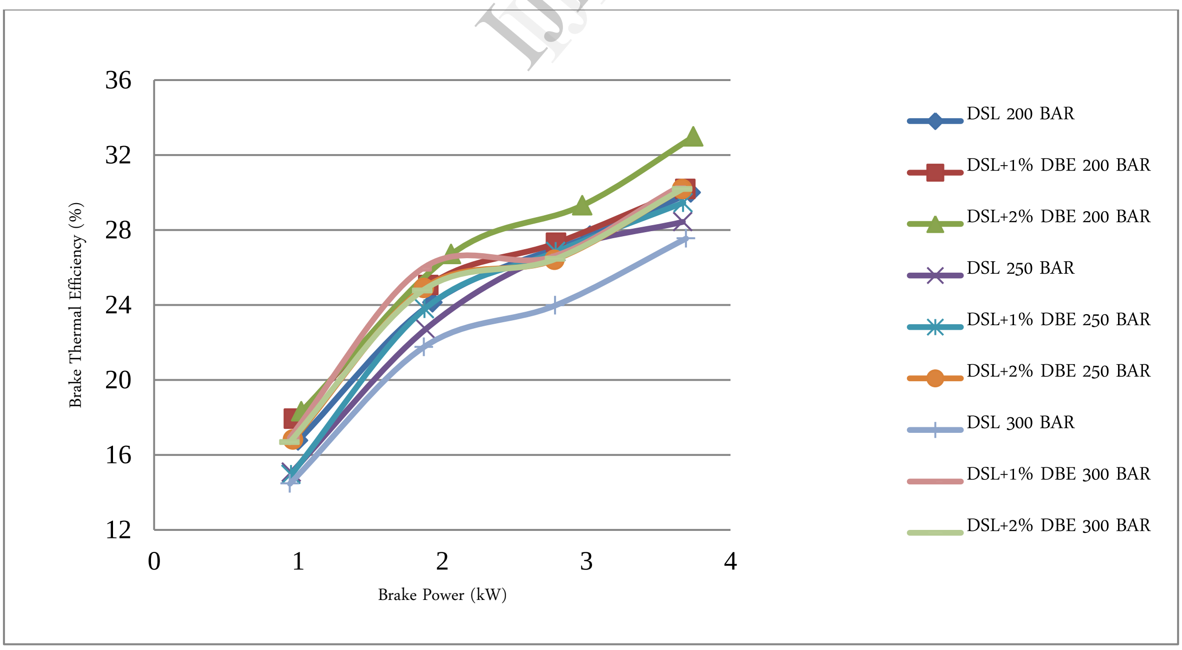

Figure 7. Brake Thermal Efficiency vs. Brake Power, CR=20, Standard Injection Timing

Fig 7 shows that brake thermal efficiency with diesel with 2% Dibutyl ether at 200 bar is higher than that of base diesel operation at part load and full load conditions as the compression ratio was increased to 20. This is due to complete combustion due to the presence of more Dibutyl ether (2% compared to 1% for compression ratio of 17.5).

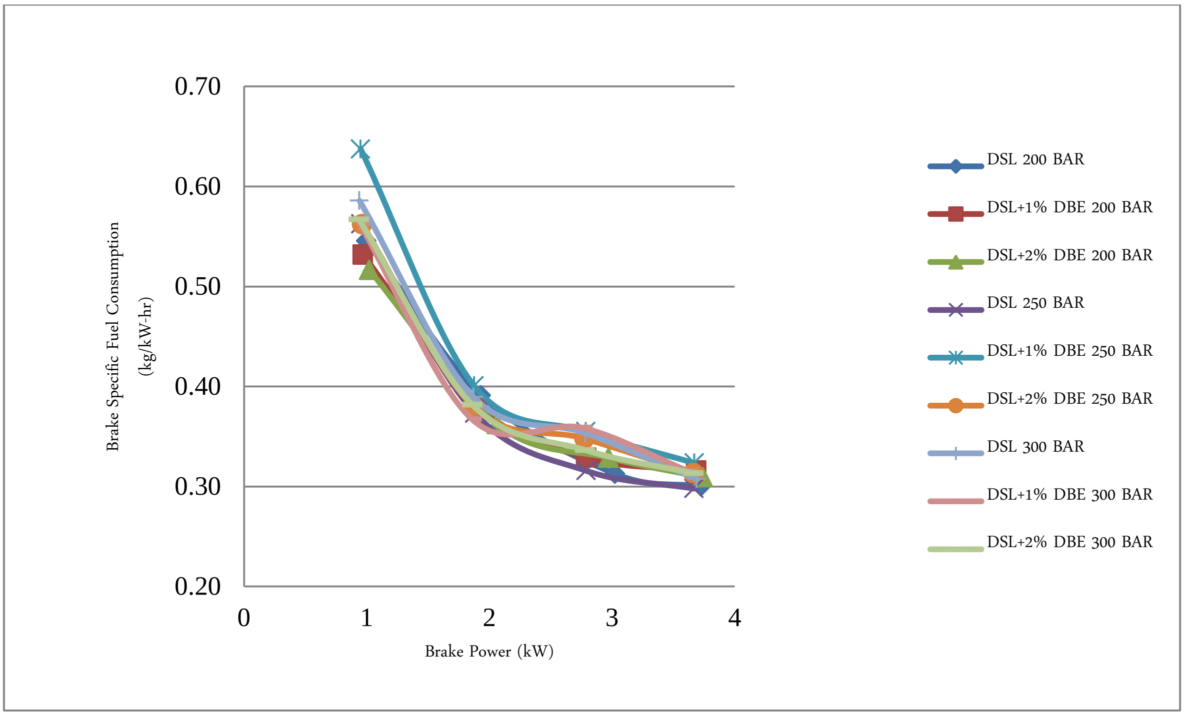

Figure 8. Brake Specific Fuel Consumption vs. Brake Power, CR=20, Standard Injection Timing

Fig 8 shows that the brake specific fuel consumption of diesel with 2% Dibutyl ether at 200 bar is less than that of base diesel operation with load. Use of Dibutyl ether increases the combustion efficiency of the engine.

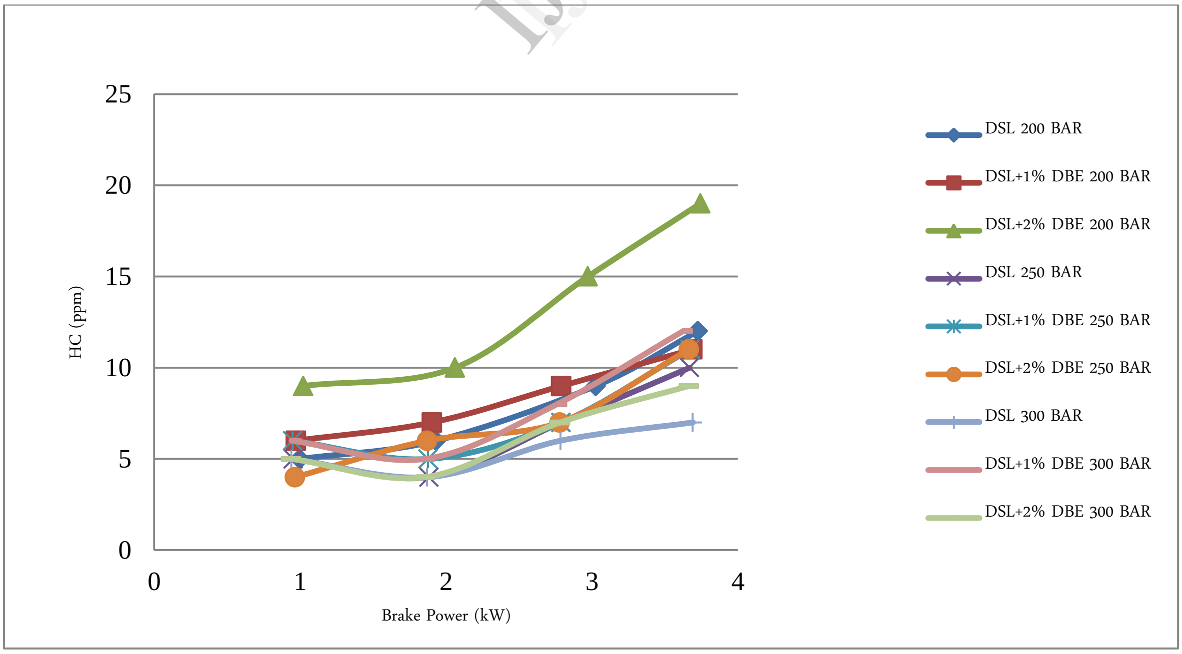

Figure 9. HC Emission vs. Brake Power, CR=20, Standard Injection Timing

Fig 9 shows that HC emissions with diesel blended with 2% DBE at 200 bar is higher and decreased with increased injection pressure indicating better penetration at part load and full load conditions.

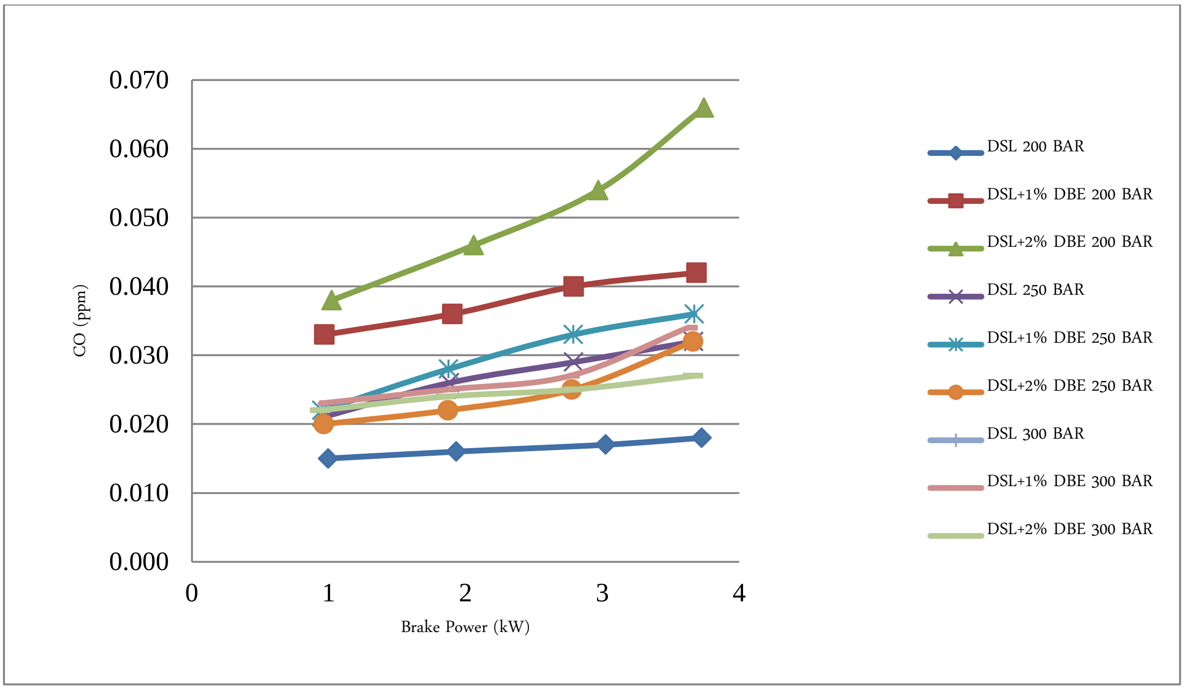

Figure 10. CO Emission vs. Brake Power, CR=20, Standard Injection Timing

Fig 10 shows that CO emissions with diesel at 200 bar is lower at part load and full load conditions also with DBE blends in case of increased compression ratio and injection pressure.

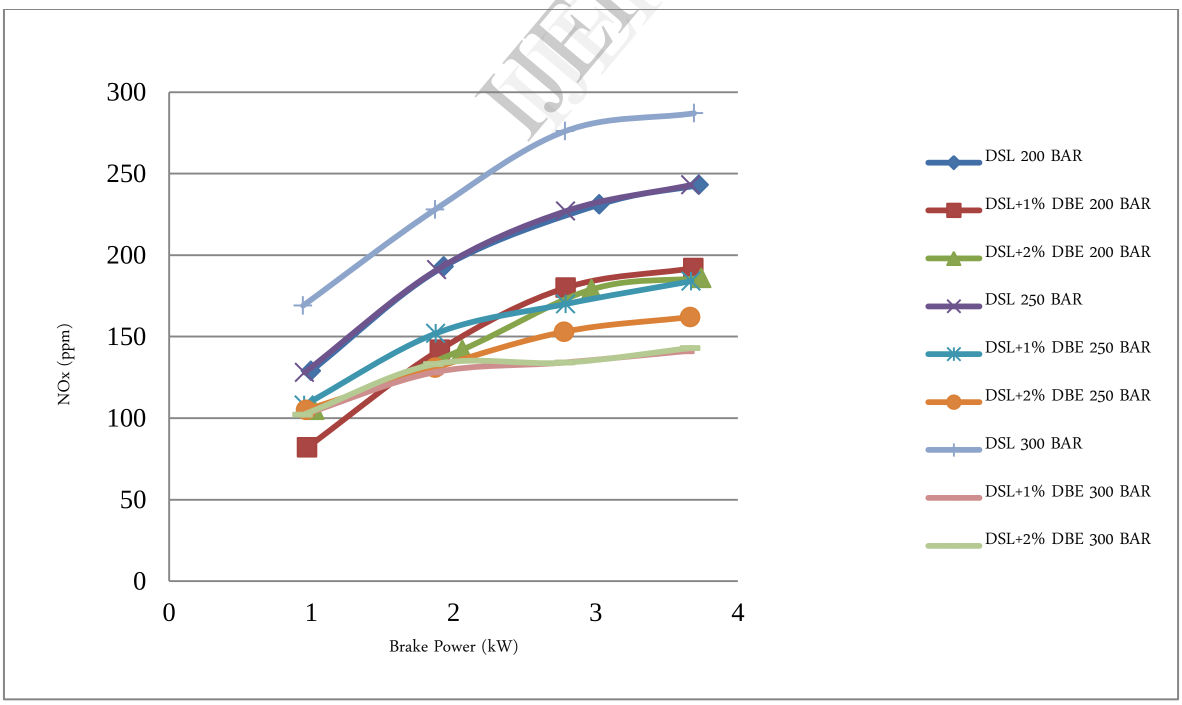

Figure 11. NOx Emission vs. Brake Power, CR=20, Standard Injection Timing

Fig 11 shows that NOx emissions with diesel with 2% Dibutyl ether at 300 bar is lesser compared to base diesel operation at part load and full load operation. This may be due to the enhancement in the availability of oxygen with diesel and Dibutyl ether blend which reduce the peak temperature.

Summary

Break Thermal efficiency is higher and BSFC is lower for 1%DBE with an injection pressure of 200 bar than other cases by marginal amount. The CO and HC emissions also are observed to be lower with addition of DBE but with increased injection pressure of higher than 200 bar. The NO_X emissions with 2% DBE at 300 bar is lower compared to base diesel operation at part load and full load operation.

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