Study of emissions from diesel engine by addition of additives

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ABSTRACT

An experimental investigation is conducted to evaluate the effects of using diethyl ether, n-butanol and 2-ethoxy ethanol as additives to diesel blends on the emissions characteristics of a single cylinder diesel engine. The test fuels are added in 3% additive and 97% diesel by volume, 6% additive and 94% diesel by volume and 9% additive and 97% diesel by volume respectively. The results indicates that, compared with diesel as a fuel, Nitrogen oxide (NOx) and carbon dioxide (CO_2) emissions are found higher for diesel blends. Hydrocarbon (HC) emissions are slightly higher for diesel blends in maximum loads, remains same in minimum loads, but carbon monoxide (CO) and smoke emissions are very lower in all loads. Result also indicates that when using additives there is no change in engine performance and combustion characteristics.

Key words: Fuel additives analyses, emission control by additives.

INTRODUCTION

Automotive engines emit several types of pollutants into the atmosphere which significantly contributes to air pollution. When petroleum-based fuels such as petrol or diesel burn in an engine the main toxic substances present in the exhaust gases are incomplete combustion oxides of hydrocarbon containing CO, NOx, HC, and particulates. The vehicle exhaust emissions are typically measured using a gas analyser and reported in parts per million (ppm) and volume percent (vol%). Air quality in developing countries like India has reached an alarmingly high level. Most cities have exceeded the National Ambient Air Quality (NAAQ) standards. Vehicular Emission is a major concern in Indian cities and 60 out of 62 metropolitan cities have exceeded World Health Organization (WHO) standards. Two-wheelers and cars subscribed 78 percent and 11 percent of pollution load respectively in cities. Emissions in internal combustion engines are of major concern because of their negative impact on air quality, human health, and global warming. Therefore, there is a concerted effort by most governments to control them. Undesirable emissions include unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM). “Emissions” is a collective term that is used to describe the undesirable gases and particles which are released into the air.

EXHAUST POLLUTANTS AND ITS HEALTH EFFECTS

Hydrocarbons (HC): Hydrocarbon emissions result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. A number of exhaust hydrocarbons are also toxic, with the potential to cause cancer.

Nitrogen Oxides (NOx): Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NOx. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain.

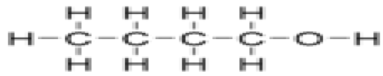
Carbon Monoxide (CO): Carbon monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO). Carbon monoxide reduces the flow of oxygen in the blood stream and is particularly dangerous to persons with heart disease

Carbon Dioxide (CO_2): Carbon Dioxide is a naturally occurring chemical compound composed of 2 oxygen atoms. It is a gas at standard temperature and pressure and exists in earth atmosphere in this state, as a trace gas a concentration of 0.04 per cent (004ppm) by volume

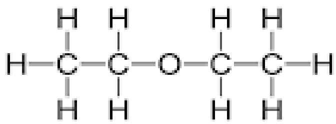
Particulate Matters (PM): The A particulate matter is an air pollution term for a mixture of solid particles and liquid droplets found in the air. The pollutant comes in a variety of sizes and can be composed of many types of materials and chemicals. Particles that are small enough to be inhaled have the potential to cause health effects. Particulate matters allow getting deep into the lungs and thus leading to breathing problems and reducing lung functions.

Fuel Additives Used For Blending

Di Ethyl Ether (DEE): Di Ethyl Ether ,also known as ethoxy ethane, ethyl ether, sulphuric ether or simple ether is an organic compound in the ether class with the formula $(C_2H_5)_2O$. It is colourless, highly volatile flammable liquid. It is commonly used as a general anaesthetic.



n-butanol (n-B): N-butanol or n-butyl alcohol or normal butanol is a primary alcohol with a 4-carbon structure and the chemical formula C_2H_9OH. N-Butanol has been proposed as a substitute for diesel fuel and gasoline.



2-Ethoxy ethanol(2-EE): 2-Ethoxy ethanol is a clear, colorless and odorless liquid. Molecular formula is $C_4H_{10}O_2$.2-Ethoxyethanol can be manufactured by the reaction of ethylene oxide with ethanol. It is used in products, such as varnish removers and degreasing solutions

Table.1.Fuel Properties

Properties	Diesel	N-Butanol	2-Ethoxy Ethanol	Diethyl Ether
Formula	$C_{10}H_{22}$	C_2H_9OH	$C_4H_{10}O_2$	$(C_2H_5)_2O$
Cetane number -	45 - 55	12	58	62
Lower calorific value (MJ/kg)	42	33.1	22	33.8
Stiotometric air-fuel ratio	15.01	11.20	8.5	5.22
O_2 content by weight	0	21.62	35.51	30.51
Flammability limits(%of volume of air)	1 - 5	1.4 - 11	1.6 - 12	1.7 - 48
Density (kg/m³)	833 - 881	810	930	710
Melting point (°C)	<-7	-90	-70	-116
Boiling point (°C)	163 - 399	117.4	135	35
Flash point (°C)	52 - 96	35	54	40
Auto ignition temperature (°C)	257	346	235	160 - 180

EQUIPMENT USED FOR THIS STUDY

ENGINE

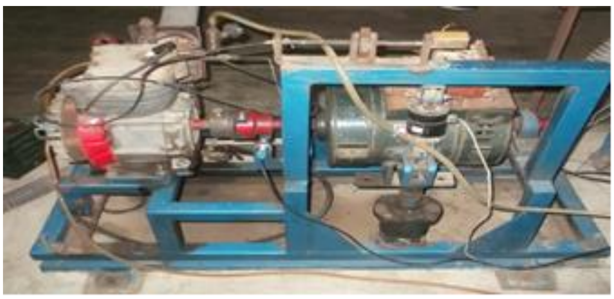


Fig.1.Engine

Fig.2.Crypton gas analyser

Single cylinder direct injection diesel engine used for this experimental study

Engine Specification:

Engine	-	single cylinder engine
Bore and stroke	-	102 × 118(mm)
Capacity	-	948cc
Maximum power	-	10 BHP
Compression ratio	-	17.5: 1
Speed	-	1500 rpm
Injection pressure	-	200bar
Injection timing	-	26 btdc

Crypton 5gas Analyzer: The Crypton 5gas Analyser is a fully microprocessor controlled device and this analyser is capable of measuring gas like hydrocarbon (HC), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Carbon Dioxide (CO_2) and Particulate Matters (PM). Use of an exhaust gas analyser will allow narrowing down the potential cause of driveability and emission concern. Crypton 5gas analyser also helps to measure the effectiveness of repair by comparing before and after exhaust reading. These analysers are capable of measuring exhaust emissions from petrol engine, diesel engine and LPG engine.

Technical specifications of Crypton 5gas analyzer:

Ranges

CO - 0 to 10 %
CO_2 - 0 to 20 %
HC - 0 to 10 %
O_2 - 0 to 25 %

Accuracy / Performance

HC ± 10 ppm
HC absolute
CO ± 300 ppm
CO_2 ± 5000 ppm
O_2 ± 1000 ppm

Resolution

HC - 1 ppm vol.
CO - 0.01 % vol.
CO_2 - 0 1 % vol.
O_2 - 0.01 % vol.
RPM -0 - 10,000 rpm

Temperature

Oil Temperature = 0 – 120 °C
Operating Temperature = +5 to +40 °C
Storage Temperature = -20 to +55 °C

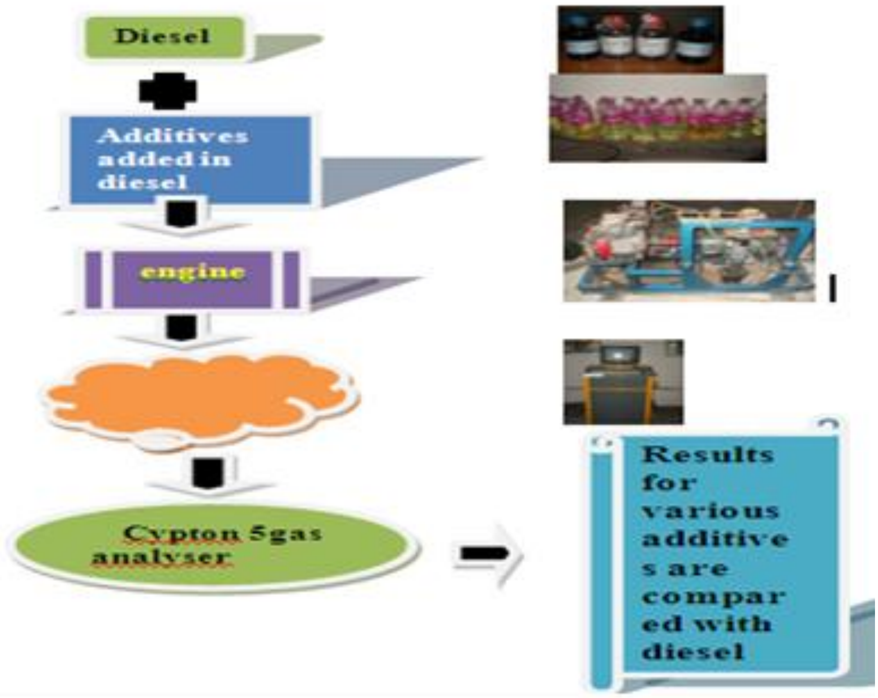
Other Technical Specifications

Warm-up Time - 60 Seconds
Response Time - 11 seconds
Flow Rate - 8 litres /min
Operating Pressure -750 - 1100 mbar
Power Requirements - 100 - 250 volts AC, 50 - 60 Hz
Power Consumption- 60 watts maximum - 343mm x 220mm x 170mm
Weight - 5.2kg

Blending proportions

DEE 3% + 97% diesel
DEE 6% + 94% diesel
DEE 9% + 91% diesel
n-B 3% + 97% diesel
n-B 6% + 94% diesel
n-B 9% + 91% diesel
2-EE 3% + 97% diesel
2-EE 6% + 94% diesel
2-EE 9% + 91% diesel

Methodology followed in this study:



RESULT S

Following results are option from Crypton 5gas analyzer when engine runs in maximum load condition

Blending ratio	NO_X (ppm)	HC (ppm)	CO (%by vol)	CO_2 (%by vol)	SMOKE m^{-1}
100% diesel	359	45	0.17	5.9	5.54
n-B3%+97% diesel	510	45	0.25	9.0	3.13
n-B6%+94% diesel	520	42	0.2	9.1	2.40
n-B9%+91% diesel	560	33	0.21	9.2	1.95
2-EE3%+97% diesel	347	43	0.11	7.8	3.04
2-EE6%+94% diesel	368	36	0.10	8.9	2.36
2-EE9%+91% diesel	400	35	0.10	9.3	1.87
DEE3%+97% diesel	440	44	0.16	8.1	3.59
DEE6%+94% diesel	460	56	0.12	8.0	2.80
DEE9%+91% diesel	548	51	0.09	8.6	2.30

CONCLUSION

When compared to diesel as a fuel following conclusions are made

BLENDING RATIO	NO_X (PPM)	HC (PPM)	CO (%BY VOL)	CO_2 (%BY VOL)	SMOKEM^{-1}
N-B3%+97% DIESEL	42% ↑	=	47% ↑	45% ↑	48% ↓
N-B6%+94% DIESEL	44% ↑	7% ↓	17% ↑	48% ↑	63% ↓
N-B9%+91% DIESEL	55% ↑	27% ↓	23% ↑	50% ↑	65% ↓
2-EE3%+97% DIESEL	4% ↓	=	35% ↓	32% ↑	46% ↓
2-EE6%+94% DIESEL	2% ↑	20% ↓	42% ↓	45% ↑	58% ↓
2-EE9%+91% DIESEL	11% ↑	23% ↓	42% ↓	50% ↑	66% ↓
DEE3%+97% DIESEL	22% ↑	=	6% ↓	37% ↑	35% ↓
DEE6%+94% DIESEL	28% ↑	24% ↑	30% ↓	35% ↑	50% ↓
DEE9%+91% DIESEL	48% ↑	13% ↑	48% ↓	45% ↑	58% ↓

Increasing in emission denoted as ↑
Decreasing in emission denoted as ↓
No change in emission denoted as =

The following conclusions are arrived from the experimental studies carried out in single cylinder diesel engine by using additives. All the three diesel blends are found to be effective in reducing smokes intensity by (40% - 60%) and In Carbon monoxide (CO) reduction diethyl ether and 2-ethoxy ethanol being more effective than. n-butanol. Oxygen content alone is not factor that influences smoke reduction properties of blended fuel like solubility, stability, biodegradability also takes major role in smoke reduction.

All the three diesel blends are found to have less effect (10% - 25%) in reducing Hydrocarbon (HC) emission. But in any load (min & max) conditions Carbon Dioxide (CO_2) and Nitrogen oxide (NOx) increase 20%-50% by volume. This experimental study also indicates that these additives (Di Ethyl Ether, n-butanol, 2-ethoxy ethanol) can be use in single cylinder diesel engine without any modifications in the engine.

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