IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. VI (May- Jun. 2016), PP 94-99
www.iosrjournals.org

Comparative analysis on Performance and Emission characteristics of VCR diesel engine using Nitrogenated based Additives

Ravi Shankar Padwa[1], Vivek Singh[2], Gajendra Padwa[3], Neeraj Kumar[4]
[1, 2, 4]*(Mechanical Engineering Department, Jodhpur Institute of Engineering & Technology, India)*
[3]*(Mechanical Engineering Department, Vellore Institute of Technology, India)*

Abstract : *Demand of petroleum products are increasing every year due to urbanization, increase in vehicular density and power requirement is going up and to reduce emission produced by today's diesel engine, which in turns require a clean burning fuel that perform well under the variety of operating conditions. Smoke and NOx are main contents of emission from diesel engine and it is very difficult to control both of them simultaneously. In this investigation Ethanol and Nitromethane was used as an additive to improve the performance and emission characteristic of a compression ignition engine. The performance and emission characteristics of an engine run on diesel at compression ratio 17.5:1 were evaluated and compared with engine operating on* ***E-Diesel(90% diesel+10% ethanol)***, ***E-NM$_2$-Diesel(90% diesel+9.8% ethanol+ .2%nitromrthane)*** *blend at compression ratio of 17.5:1 and 16.5:1. The graph plotted for performance and emission characteristics.*
Keywords: *VCR diesel engine, Diesel, Ethanol, Nitromethane.*

I. Introduction

In the last six decades, India's energy consumption rate increases by 16 times and currently, India stands 6th in the world of oil consuming countries with an oil utilization of 2,438,000 barrels per day because of fast rate of population growth. At this rate, the fossil fuel will not be available for a long time as the gap between supply and demand increases large. The production of crude oil in India is estimated to have a decreasing trend after the year 2010. But there will be an increase in the vehicle population every year which will demand an increase in crude oil imports. With this scenario the need for an alternate fuel arises to maintain the economy of the country. As we know that, compression ignition (CI) engine plays a vital role in power generation, transportation and industrial activities. The main advantages of the diesel engine over the gasoline spark ignition engine include its durability, reduced fuel consumption and lower emission of carbon monoxide and unburned hydrocarbon. The search for alternative fuels for CI engines is very important.

1.1 Need of Alternative Fuels

The alternative fuels are required due to the following reasons:

- Scarcity of crude oil
- Environmental damage
- Global warming
- Oil spill
- Acid rain
- Air pollution

1.2 Health threat of fossil fuel use

Fossil fuel provides a reliable energy for consumer there is a major risk associated with it. Carbon dioxide, produced from combustion of fossil fuels, is not a poisonous gas, but it is dangerous to the earth's natural climate system. Particulate matter is comprised of tiny particles that remain in the emissions of fossil fuels. The smoke, also called "soot", contains fine particles that are resulted from the chemical components as a result of combustion of fossil fuels particularly in diesel engines. Particulate matter (PM) is essentially a mixture of solid particles and liquid droplets. They are dispersed through vehicle emissions and remain suspended at low levels, so that when we breathe, these particles enter our nose and mouth and become embedded in the deepest recesses of the lungs. Numerous scientific studies have proven that the particulate matter emitted from CI engine cause the following:

- Premature death
- Cancer
- Acute respiratory illnesses (asthma, chronic bronchitis, painful breathing)
- Shortness of breath

- Heart disease
- Lung damage

1.3 Emission from Diesel Engines

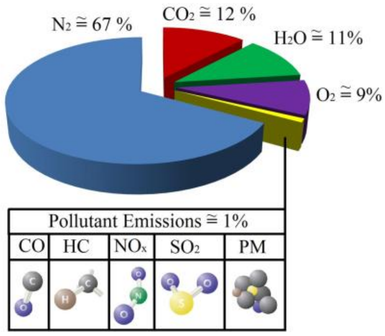

Fig. 1.1 shows the approximate composition of diesel exhaust gas

A number of harmful products are generated during combustion. The most significant harmful products are CO, HC, NOx, and PM. Pollutant emissions have a rate of less than 1 % in the diesel exhaust gas. NOx has the highest proportion of diesel pollutant emissions with a rate of more than 50 %. After NOx emissions, PM has the second highest proportion in pollutant emissions. Because diesel engines are lean combustion engines, and the concentration of CO and HC is minimal.

1.4 Solution to Reduce Emissions

One of the solution and to reduce the emissions is the use of alternative fuels. These alternative sources of fuel are currently being researched and developed.

1.4.1 Fuel Additives

Fuel additives are compounds formulated to enhance the quality and efficiency of the fuels used in motor vehicles; researchers have developed a range of additives which give these fuels an added property which serves a pressing need from consumers by improving the performance of engine. Its unique blend also utilizes a high detergent action which pushes the engines to work at maximum efficiency. Additives have been developed to increase combustion rates, as anti-oxidants, to effect burn rates, to enable fuels to work under extreme temperatures, reduce harmful emissions and more.

1.5 Properties of Diesel, Ethanol and Nitromethane:

There are some properties essential to check before using the additives in C.I. engines.

Table 1.1 Comparison of Physical and Combustion Properties of diesel, ethanol and nitromethane

Properties	Diesel	Ethanol	Nitromethane
Molecular formula	$C_{10}H_{20}C_{15}H_{28}$	C_2H_6O	CH_3NO_2
Molecular weight	170	46.07	61.04
Density (kg/m3)(°C)	837	789	1138
Boiling point (°C)	180 - 360	78.5	100 - 103
Flash point (°C)	60 - 80	9 - 11	35
Auto-ignition temperature (°C)	315	365	418
Specific gravity	0.837	.79	1.138
Lower heating value (MJ/kg)	43	26.952	11.3
Latent heat of vaporization (kJ/kg)	250	846	561
Cetane number	50	5	NA
Viscosity (40°C) cSt	4.8	1.5	4.8
Oxygen content (wt%)	0	34.7	52.4
Carbon content (wt%)	85 - 88	52.1	19.6
Hydrogen content (wt%)	12 - 15	13.2	4.9

II. Related Work

AlirezaValipour et al. (2014) studied a review on performance, combustion and exhaust emission characteristics of diesel and biodiesel blend with additives. According to the results of the review, additives were an effective method for obtaining the reduction in the PM, CO, CO2 and UHC emissions but minimum increase in the NOx emission. C.-Y. Lin et al. (2003) conducted experiment on marine diesel engines to evaluate the performance and emission characteristics using oxygenated diesel fuel. In this work, oxygenated diesel fuel was prepared by the mixing of ethylene glycol monoacetate with diesel fuel in various proportions. M. Nurun Nabi et al. (2009) reviewed the effects of oxygenated fuel on diesel combustion and exhaust emissions. In review, it was reported that the oxygenated fuels reduced the exhaust emissions which included total unburnt hydrocarbon (THC), particulate matter (PM), carbon monoxide (CO), smoke and engine noise. It also reported that NOx emissions were reduced, and increased in some cases, basically depending on the engine operating conditions. K.Manikanta et al. (2010) conducted experiment to investigate the influence of CR on variable compression ratio engine using diesel oil. In this experiment the performance characteristics were investigated at different compression ratios and loads. R. Senthil et al. (2011) conducted test on a single cylinder, four stroke Diesel engine to investigate the performance and exhaust emission characteristics using Diesel-2 Ethoxy Ethyl Acetate (EEA) Blends. Studies were conducted using fuel blends of 5%, 10% and 15% of EEA with standard diesel. Chockalingam et al. experimentally investigated the effects of Diesel-hexanol blends, blended in different percentage ranging from 10%-50% by volume on a single cylinder, water-cooled, direct injection diesel engine. The engine developed a power output of 5.2 kW at 1500 rev/min. the results showed that the performance was improved with blends and compared to neat diesel fuel with considerable reductions in smoke and increase of NOx emissions.

III. Experimental Setup

Fig. 3 shows a single cylinder, direct injection, four-stroke, vertical, water-cooled, naturally aspirated variable compression ratio multi-fuel engine, with a bore of 80 mm and a stroke of 110 mm was selected for the research study. This test engine, which is a compact engine; having rated power output of 3 to 5 HP, manufactured by Technical Teaching Equipment, Bangalore (India). The engine has a provision of loading by eddy current dynamometer. The engine can be started by hand cranking/self start and it is provided with a centrifugal speed governor.

Fig. 3.1 shows the Experimental Set up

IV. Indentations and Equations

Brake Thermal Efficiency:

$$\eta = \frac{B.P.}{m_f \times C.V.}$$

Brake Power:

$$B.P = \frac{2\Pi NT}{60}$$

Calorific Value = Vol. of Diesel in % (V/V) × C.V. + Vol. of Ethanol in % (V/V) × C.V. + Vol. of Nitromethane in % (V/V) × C.V.

V. Experimental Results

1.4 Brake Thermal Efficiency:

Fig. 5.1 shows the variation of the BTE with brake power at CR 17.5 and 16.5. When brake power increases, brake thermal efficiency of E-NM2-diesel blend at compression ratio 17.5 increases as compared to other blends on both C.R.

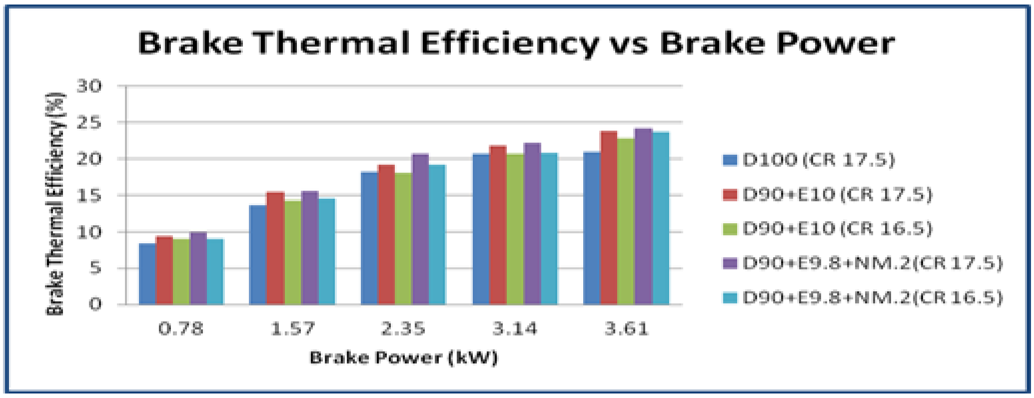

Fig. 5.1 shows the variations of BTE with B.P

5.2 Oxide of Nitrogen (NOx)

The reduction in the NOx emission is the prime objective of the engine researcher. Fig 5.2 shows the variation of nitrogen oxide emission with brake power at CR 17.5 and 16.5. The NOx emission of E-NM2-diesel blend at compression ratio 17.5 is lower as compared to other diesel blends on both C.R.

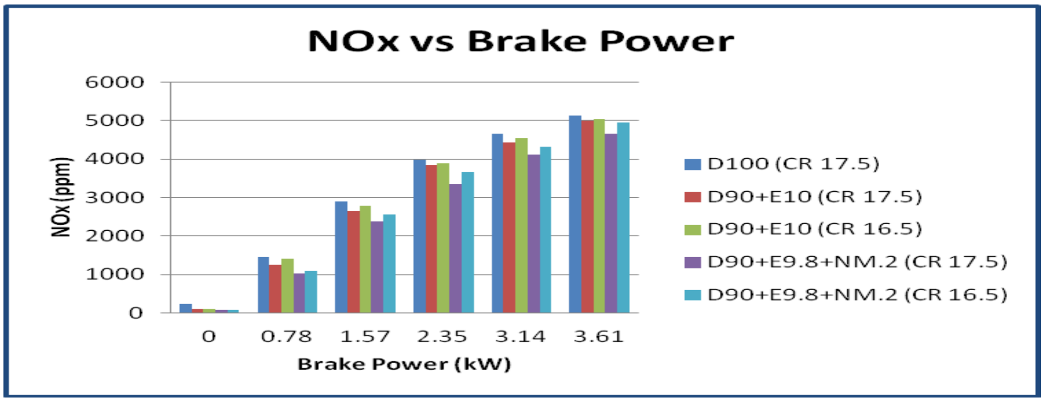

Fig. 5.2 shows the variations of NO_x with B.P

5.3 Opacity

Fig 5.3 shows the variation of opacity with brake power. The opacity emission of E-NM_2-diesel blend at compression ratio 17.5 is slightly less as compared to other blends on both C.R.

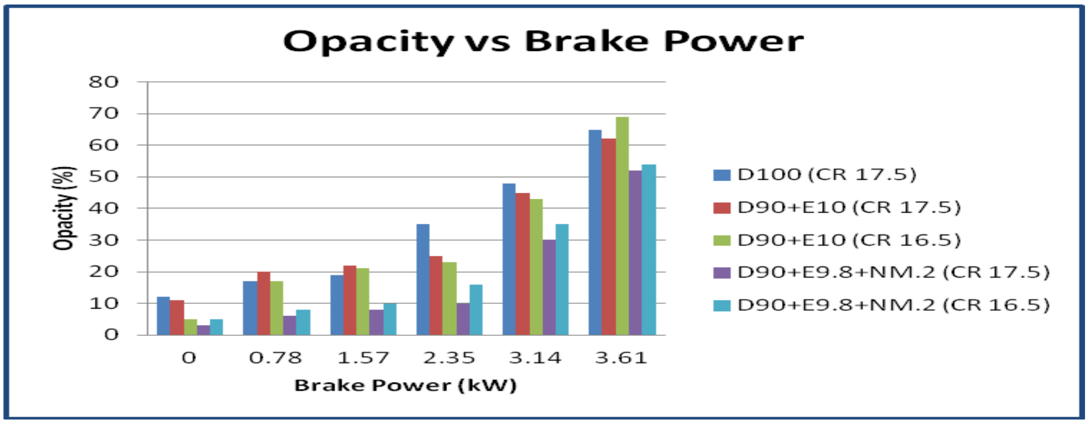

Fig. 5.3 shows the variations of Opacity with B.P

VI. Conclusion

We have discussed the results of the experiment to be done to analysis the performance and emission characteristics of VCR diesel engine using different nitrogenated based additives at compression ratio 17.5 and 16.5. From this research work we conclude the followings:

- Brake thermal efficiency is increasing at compression ratio 17.5 for E-NM_2-Diesel blends as compare to other blends at compression ratio 17.5 and 16.5. The maximum Brake thermal efficiency at full load is 24.16%.

- NOx emission of E-NM2-Diesel blend at compression ratio 17.5 is lower as compared to other diesel blends at compression ratio 17.5 & 16.5.
- The smoke of E-NM_2-Diesel blend at compression ratio 17.5 is less as compared to other diesel blends at both compression ratios.

From Performance parameters, E-NM_2-Diesel blend at compression ratio 17.5 is taken as optimum for the test engine.

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