Experimental Investigation of the Performance of VCR Diesel Engine Fuelled by NM-Diesel blend

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Abstract - Increasing the consumption of fuel in power and automobile sector, increase the pollution of the environment. Smoke and NOx are main pollutants of emission from diesel engine and it is very difficult to control them simultaneously. A preliminary literature review suggests that smoke and NOx can be reduced by adding additives in diesel. But some additives are very costly and not viable because they reduce smoke and NOx while decreasing the performance of combustion.

In the present study Nitromethane (NM) (2%) was used as an additive with diesel, and investigate the performance characteristic of it on compression ignition engine (A single cylinder, direct ignition, four stroke, vertical, water cooled, naturally aspirated, variable compression ratio diesel engine). The performance and emission characteristics of the engine run on diesel at compression ratio 17.5:1 were evaluated and compared with engine operating on NM-Diesel blend at compression ratio 17.5:1 and 16.5:1. The performance has been studied and compare for diesel and NM- Diesel blend for two compression ratios.

Keywords- NM-Diesel, VCR diesel engine, acetone.

I. INTRODUCTION

The objective of this dissertation is to investigate the performance and emission characteristic of a VCR diesel engine fuelled by NM-Diesel blend. Worldwide increase of demand for diesel fuel and environmental emission control has led to considerable research for better fuel formulations and thus reduction in smoke and particle levels. Overtime advances in engine design reduced the emission levels considerably. However, it is difficult to achieve the required emission standards with engine improvements alone. Blending the diesel with different additives has proven to be an alternative method to achieve the low emission and better performance diesel combustion. This has been the focal point of most researches in this field within last two decades.

India’s environment is constantly under the increasing pressure imposed by the rapid urbanization coupled with the rapid growth in the population. Increasing population, leading to an increase in number of vehicles and growth in the industrial and power sectors are exerting tremendous pressure on the atmosphere.

Major polluting industries and automobiles emit tonnes of pollutants every day, thereby leading to the deterioration in air quality and exposing citizens to greater health risks.

1.1 Health Effects of Diesel Engine Emission

Diesel emission has the potential to cause adverse health effects. These effects include cancer and other pulmonary and cardiovascular diseases. Diesel exhaust, in addition to generating other pollutants, is a major contributor to particulate matter pollution in most places in the world. More recently the possible effects of fine particles below 10 µm on respiratory morbidity and mortality, especially in subjects with established chest disease, have been broached. It is apparent that exposure to diesel fumes in sufficient concentrations may lead to eye and nasal irritation but there is no evidence of any permanent effect. There is also some evidence that the chronic inhalation of diesel fumes leads to the development of cough and sputum. Higher exposures may lead to acute symptoms, primarily affecting the conjunctivae and upper respiratory tract that is nearly always reversible within a few days. The human health effects of poor air quality are far reaching, but principally affect the body’s respiratory system and the cardiovascular system.

1.2 Additives

So many additives are readily available to prepare blends with diesel and used in CI Engines. Among the various additives, oxygenated compounds are the most widely used. This is due to the participation of their oxygen in reactions and leading to a better combustion thus lowering the emissions. The molecular structure and oxygen content of the additives have a direct influence on soot reduction. This also depends on the oxygen concentration in the fuel plume. The results revealed that in order to reduce soot formation, 10–20% volume of oxygenate chemicals should be blended with diesel fuel. The presence of additives in such a high quantity will alter the physical and chemical properties such as: viscosity, density, volatility, and the cetane index, significantly.

Nitroparaffin compounds have high oxygen content in their molecular structure. Therefore, they are considered as oxygenated additives.
These additives improve the performance via the increase of thermal energy output and combustion products alteration, which is related to chemical structure of the nitroparaffins.

1.3 Merits Of Additives

a. Engine Performance:- It is reported in literature that some of additives improves thermal efficiency upto 18% without affecting the torque.

b. Emissions Reduction:- Diesel fuel additives can reduce pollutants and greenhouse gas emissions upto 50% or more.

1.4 Demerits Of Additives

a. Fuel Cost:- The diesel fuel additives blends cost increases due to high cost of additives.

b. Preparation of blend:- Prepatation of diesel fuel additives blends are difficult in many cases.

1.5 Nitromethane

Nitromethane is an organic compound with the chemical formula CH₃NO₂. It is the simplest organic nitro compound. It is a slightly viscous, highly polar liquid commonly used as a solvent in a variety of industrial applications such as in extractions, as a reaction medium, and as a cleaning solvent. As an intermediate in organic synthesis, it is used widely in the manufacture of pharmaceuticals, pesticides, explosives, fibers, and coatings. It is also used as a racing fuel in top fuel drag racing, and as an important component in the fuel for miniature internal combustion engines that are used in radio-controlled models.

![Fig. 1.1 Structure of Nitromethane](image)

1.6 Properties Of Diesel And Additives

There are some properties essential to check before using the additives in internal combustion engines. Table 1.1 gives the comparison of physical and combustion properties of diesel and nitromethane.

<table>
<thead>
<tr>
<th></th>
<th>Diesel</th>
<th>Nitromethane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular Formula</td>
<td>C₁₀H₂₀.</td>
<td>CH₃NO₂</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>170</td>
<td>61.04</td>
</tr>
<tr>
<td>Density(Kg/m³)</td>
<td>837</td>
<td>1138</td>
</tr>
<tr>
<td>Boiling Point (°C)</td>
<td>180-360</td>
<td>100-103</td>
</tr>
<tr>
<td>Flash Point (°C)</td>
<td>60-80</td>
<td>35</td>
</tr>
<tr>
<td>Auto-ignition</td>
<td>315</td>
<td>418</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>.837</td>
<td>1.138</td>
</tr>
<tr>
<td>Lower heating value</td>
<td>43</td>
<td>11.3</td>
</tr>
<tr>
<td>Latent heat of vaporization (KJ/Kg)</td>
<td>250</td>
<td>561</td>
</tr>
<tr>
<td>Cetane Number</td>
<td>50</td>
<td>NA</td>
</tr>
<tr>
<td>Viscosity (40°C)cSt</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Oxygen Content (wt%)</td>
<td>0</td>
<td>52.4</td>
</tr>
<tr>
<td>Carbon Content (wt%)</td>
<td>85-88</td>
<td>19.6</td>
</tr>
<tr>
<td>Hydrogen Content (wt%)</td>
<td>12-15</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Nitromethane is having high auto ignition temperature, high oxygen content and very little carbon content, hydrogen content. Nitromethane increased combustion efficiency and improve cetane number. Therefore Nitromethane can be used as an additive with diesel for CI engine.

II. TEST ENGINE SELECTION AND DEVELOPMENT OF EXPERIMENTAL SETUP

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.2: Experimental Set up

III. FORMULAE USED AND SAMPLE CALCULATIONS

Following formulas are used during calculations.

Brake Thermal Efficiency: \( \eta = \frac{B.P.}{m_f \times C.V.} \)

Mechanical Efficiency: \( \eta = \frac{B.P.}{I.P.} \)

Volumetric Efficiency:
\( \eta = \frac{\text{Actual Vol of air fuel mixture inhaled at S.T.P.}}{\text{Swept Vol.}} \)

Brake Specific Fuel Consumption:
\( \eta = \frac{m_f}{B.P.} \)

Where:
- B.P. = Brake power in kW
- I.P. = Indicated power in kW
- \( m_f \) = mass of fuel(kg/sec)
- C.V. = calorific value(kJ/kg)

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

\[ = 0.98 \times 44800 + 0.02 \times 11300 \]
\[ = 44130 \text{ kJ/kg} \]

IV. PERFORMANCE PARAMETERS

4.1 Brake Thermal Efficiency

The graph shown in fig 4.1 is drawn between brake power (kW) and brake thermal efficiency (%). When brake power is increases, the brake thermal efficiency of the nitromethane-diesel blend at compression ratio 17.5 is decreases as compare to diesel at compression ratio 17.5 and compression ratio 16.5. Brake thermal efficiency of diesel at compression ratio 17.5 is decreases at higher load.

4.2 Mechanical Efficiency

The graph shown in fig 4.2 is drawn between brake power (kW) and mechanical efficiency(%). When brake power is increases, the mechanical efficiency of the nitromethane-diesel blend decreases as compare to diesel at compression ratio 17.5 and at compression ratio 16.5.
V. CONCLUSIONS

We have discussed the results of the experiments to be done for optimization of performance of Diesel-Nitromethane blends at compression ratio 17.5. We had also optimized of emission of compression ratios 17.5 for Diesel-Nitromethane blends. From this research work we conclude the followings:

- Brake thermal efficiency is increasing at compression ratio 17.5 for Diesel-Nitromethane blends as compare to Diesel at compression ratio 17.5 and Diesel-Nitromethane blends at compression ratio 16.5. The maximum Brake thermal efficiency at full load is 25.15%.
- Mechanical efficiency is decreasing at compression ratio 17.5 for Diesel-Nitromethane blends as compare to Diesel at compression ratio 17.5 and Diesel-Nitromethane blends at compression ratio 16.5.

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

REFERENCES