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Exploration of diesel-oxygenated fuel blends: An experimental investigation and numerical simulation

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Abstract: These days, there is a dire need for petroleum products due to increased use, which is also leading to major environmental issues. The search for alternative fuels has become more popular as a result of the growing rate of urbanization, the air quality index, the economy, and the supply of fuel. Everyone is searching for a better fuel that can be used in compression ignition engines due to the rising emission regulations. A VCR CI engine is used to test the effects of the oxygenated additives NM and EEA. Different percentages of EEA are blended with NM-Diesel blends (5%, 10%, and 15% v/v), and the effects of each mixture on engine performance and combustion byproducts are assessed. Ternary mixes have a considerable impact on engine performance, according to experiments.

Keywords: Diesel engine, EEA, NM, HC, CO, NOx

1. Introduction

Due to the rising global population and corresponding rise in energy demand, environmental pollution may become a problem. On the contrary, it is obvious that fuels which are fossil-based as a source of enduring energy are limited. The urging for oil-based fuels (i.e., fossil fuels) has risen considerably as a result of globalization. Crude oil currently provides 12.2 x 109 tonnes of worldwide annual energy consumption. By 2035, this energy consumption will have increased to 1.75 x 109 tonnes of crude oil. [1] Due to depletion of fuel reserves, the globe will face a future fuel scarcity. [2] In order to meet energy demand, the transportation industry used half of all fossil fuels. [3] Transportation sector is the backbone of oil use and it will be responsible for 50% of greenhouse gas emissions by 2030. [4]

In addition to economic issues, the excessive use of fossil fuels has led to a persistent environmental problem like the climate catastrophe and global warming. The major source of energy in various forms is Combustion.

Reciprocating engines have higher stability and dependability. So it is often used in the agriculture and transportation field. Due to the accelerated rate of urbanization, large scale use of engines, poor air quality index, economy and scarcity of fossil fuels, it is necessary to protect the environment and look for alternative energy sources. Diesel engines have a better thermal efficiency than Spark Ignition engines. However, using a CI engine comes with two main risks. One is linked to concerns about the engine's exhaust emissions to the environment, while the other is linked to the viability of fossil fuels. CI engines produce a variety of toxic substances, including carbon monoxide (CO), unburned hydrocarbons (UHC), particulate matter (PM), nitrogen oxides (NOx), and others. High use of diesel fuel results in severe air pollution, which includes Nitrogen Oxides, Hydrocarbons, Carbon monoxide, Carbon dioxide, ozone depleting particulates, Sulphur dioxides, toxic organic micro pollutants, lead, benzene, and heavy metals, as well as a few particulate matters ejaculated from the engine's ignition chamber. [5]

Since the emission norms have been revised for CI engines, the introduction of cleaner fuel is being encouraged more and more by the government. Numerous fuels, including oxygenated fuels like alcohols, are used as fuel additives with a different emphasis from regular diesel fuel in order to reduce

engine exhaust emissions without altering engine parameters. A number of additives other than alcohol-oxygenated additives are available for blending with diesel (i.e. nitro paraffin, acetate, ether, etc.) and are capable of accelerating the combustion process or complete the combustion in engines by improving the cetane number, oxygen content, etc. and by reducing the delay period. As a result of the complete combustion of the fuel, the engine operates at high performance and low emissions. [6]

2. Methods and Materials

The engine used for this test is a single-cylinder, four-stroke, DI water-cooled, compression ignition engine. The engine may be manually or self-starting, and it is usually equipped with a centrifugal speed controller. Specifications for the engine are shown in reference table 3.

Table 3- Engine setup's specifications

Equipment	Specification
Engine	4-stroke, single cylinder, water cooled, steady 1500 RPM Diesel Engine, 3.75 kW, 660 CC
Load Capacity(Nm)	Load cell Transducer, Torque Reso. : 0.01 kg–m, Range: 0- 6.00 kgm , radius: 0.16 m
Dynamometer	RPM: 1500 rpm - 2200 rpm, 3.75 kW Rating of torque
Measurement of Temp (Five channel indicator)	RTD Sensor (Pt 100), Reso. : 0.1°C ,Range: 0–400°C
Exhaust Gas analyzer	AVL-DIGAS-444N, NOx gas-Electrochemical, Range 0-5000 PPM , Resolution 1PPM
Smoke Analyzer	AVL-437C, Range 0-99.99 m-1, Resolution 0.01
Fuel flow rate calculation	Range: 0–5 kg, Weighing Reso. :- 1g, fuel flow range: 0–10kg/h, Reso. :- 0.06 kg/h, Measuring the Fuel rate By weight loss
Control Panel Connectivity	Connected by Comm 1 port with computer, RS232-RS485 Transformer
Water Flow Measurement	Turbine flow transducer, Reso. :- 0.1 cc/s, Range: 0–99.9 cc/s

The whole study was performed at a steady speed of 1500 revolutions per minute of engine, with a load ranging from 0 to 4, 8, 12, and 16 kg using 100% diesel and D-EEA-NM Mixtures. Before taking the final readings, run each test for 30 minutes (to get better steady-state conditions). When the test with 1 fuel blends was completed, the leftover fuel mixture was removed from the intake line & fuel tank to avoid blending and adulteration to the true blend ratio. The experiments are carried out in various stages at CR 17, injection timing (IT) 23° CA before TDC and injection pressure (IP) 210 bar were used to test diesel and Diesel-Ethoxy Ethyl Acetate-Nitromethane mixes under standard engine test conditions. with Arabic numerals.

3. Results and Discussion

This discussion will delve into the details of diesel engine functioning parameters and exhaust attributes when fueled with EEA-NM-Diesel blends. The objective of the study was to comprehensively examine the performance and emission parameters of diesel engines with various EEA-NM-Diesel blends, without any modifications or failures in the engine's operation.

BTE Analysis: Brake thermal efficiency (%) and brake power (kW) are correlated. Brake power and brake thermal efficiency are directly proportional to each other. It was observed that at standard engine parameters the blend EEA5NM2D93 gives the highest thermal efficiency (36.479%) as compared to other blends. Since EEA has a high oxygen content, it facilitates complete fuel consumption and increases ignition efficiency.

BSFC Analysis: The relationship between Brake specific fuel consumption and brake power (kW) for various blends. As brake power rises, BSFC drops, as shown in the graph. The heat content of the EEA-NM-diesel blend decreased as a result of the addition of EEA, resulting in the blend consuming more fuel than pure diesel to provide the same engine output torque, although the blend EEA5NM2D93 at standard engine parameters has the best BSFC of all the blends. Though the BSFC does not improve much throughout the course of the experiment, it is nearly as good as diesel.

UHC Analysis: The graph plotted between hydrocarbons (ppm) and brake power for different blends at normal CR for all load conditions. Hydrocarbon reduces when there is an increment in EEA. The Hydrocarbon % for blend EEA10NM2D88 is minimum. If % of EEA increases beyond 10%, HC emission increases.

CO Analysis: With the increase of EEA percentage content in the EEA-NM-diesel blend, the oxygen content in the EEA-NM-diesel mixture increases. Due to the high oxygen content in their molecular structure, the complete combustion of fuels occurs. Thus reducing CO emissions. Blend EEA10NM2D88 gives minimum CO emission values as compared to other blends.

NOx Analysis: At all engine loads, EEA-NM-diesel blends have higher oxides of nitrogen than pure diesel, because complete combustion is responsible for higher combustion temperatures. EEA has a stronger effect on NOx at higher loads.

Smoke Analysis: For all load conditions, the blends emit less smoke than pure diesel. This could possibly be due to the availability of higher oxygen content and better combustion properties of the fuel blends. The Blend EEA15NM2D83 produces the lowest level of smoke under full load conditions.

4. Conclusion and Future Directions

In this work, when we compares all Functioning parameters of engine and exhaust metrics for several blends at CR17 for various load condition. The results shows, ternary blends had a minor impact on Functioning of engine, but that emissions from ternary blends (EEA-NM-Diesel) were lower than pure Diesel. We found that the Blend EEA5NM2D93 demonstrates the highest Break Thermal Efficiency and the lowest specific fuel usage for CR17.

The increment in load conditions shows improvement in the performance of the engine with various blends for CR 17.

•BTE improves with increment in engines Compression Ratio as well as with the load. Mixture EEA5NM2D93 at CR17 gives the most extreme BTE of 36.79% at full load conditions.

•Minimum BSFC achieved is 0.214 kg/kW- hr at the compression ratio 17 and full load conditions with conventional IP for a DI Engine for Blend EEA5NM2D93

For all loading conditions, HC and CO decreased with increasing the EEA% and are minimum at EEA of 10% and CR of 17:1 Least Smoke % achieved for EEA15NM2D93 at medium load conditions. The best combination of performance and emission is observed at a CR of 17 for EEA10NM2D93. Beyond the 10% concentration % of EEA engine's performance start deteriorating. Less BSFC and High BTE achieved for EEA 5% and better emission characteristics observed for EEA 10%

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The 4th International Conference on "New and Renewable Energy Resources for Sustainable Future" (ICONRER-2023) organized by Department of Mechanical Engineering of Swami Keshvanand Institute of Technology, Management & Gramothan (SKIT), Jaipur (India) in collaboration with Department of Mechanical Engineering, Assiut University, Egypt and Institution of Engineers (India) during Nov 02-04, 2023. This scientific dialogue aims to provide a platform where scientists, researchers, academicians, industry experts, new aspirants, as well as students of science and technology can come together and engage in fruitful exchange of views and ideas to pave way for "New and Renewable Energy Resources".

The scope of this conference encompasses latest research outcomes pertaining to the "Energy" domain in the form of theoretical models, environmental impact, security and defense technology, innovative designs, enhancements and improvements in existing frameworks, sustainable technological advancement, societal welfare etc. Thus the conference intends to bring together the best minds from around the world to cover literally all aspects of energy technology from a multi-disciplinary perspective.

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