International Journal of
I.C. Engines and Gas Turbines
Vol. 5: Issue 1
www.journalspub.com

The Influence of Hexanol and Methyl Acetate as Oxygenated Additives with Diesel Fuel in a Diesel Engine Generator

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ABSTRACT

Diesel engines play a vital role in all the major sectors (such as transportation and industrial) due to their high efficiency, durability, reliability and low operating cost. At the same time, they are considered as one of the biggest contributors of environmental pollution by releasing enormous amount of toxic gases to atmosphere (such as NO_x, HC, CO_2 and PM). Emissions from transport, especially motor vehicles, increase the level of gases in the atmosphere. Due to these problems, many researchers have put their efforts and carried out several experiments to curtail harmful emissions from diesel engines. In present work, oxy additive chemicals (such as Hexanol and Methyl Acetate) are blended with pure diesel in specific proportions to run in a diesel engine generator. The whole experimentation was conducted in six stages. In the first stage, critical information collection of oxy-additive chemicals was carried out. In second stage, blending of selected oxy-additive chemicals with pure diesel was carried out in different proportions (like 95D5H, 90D10H, 85D15H, 80D20H, 95D2.5H2.5MA, 90D5H5MA, 85D7.5H7.5MA, 80D10H10MA). In the third stage, the prepared blended fuels were subjected for stability investigations. In the fourth stage, the prepared stable fuels were subjected for testing the fuel properties (such as flash point, fire point, density, kinematics viscosity). In the fifth stage, performance and emissions attributes of diesel engine was studied using pure diesel (for reference). Finally, in the sixth stage, the performance and emissions attributes of diesel engine was investigated using the above prepared stable fuels by varying the engine load (from 1000W to 4000W). The experiment results revealed a sharp reduction in the harmful gases for the prepared fuels compared to that of neat diesel. Also, the hexanol and methyl acetate blended fuels revealed a better performance characteristic than that of neat diesel.

Keywords: *Blending, diesel engine, emissions, oxy-additives, performance*

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INTRODUCTION

In the current energy scenario, exhaustive researches have been tried out to replace the fossil fuels on using some alternative fuels in diesel engines to adhere with the latest strict emission regulations [1]. In this perspective, oxy additives (rich in oxygen content) produced from the oxygenate chemicals has provided a viable alternative fuel to accustom in compression ignition or diesel engines [2, 3]. Pure diesel fuel does not possess oxygen content in its molecular structure and in turn has led to the formation of NO_x (Nitrogen Oxides) and unburnt hydrocarbons emissions under high temperature burning environment during the combustion process in the diesel engine cylinder and amenable for the global degradation. Further, to ameliorate the fuel properties, reformulation technique has been adopted by many researchers [4–21] on adding some chemicals to any base fuels (such as diesel, petrol, biodiesel, etc.) to achieve some specific fuel properties so as to; (i) reduce the deleterious pollutants [3–20] (ii) modify the degree of ignition [3–20]. Recently, many researchers, scientists and engineers have incorporated many additives such as nanoparticles, ethanol, di-ethyl ether, oxygenated chemicals with diesel fuels in specific proportions to investigate the working characteristics (performance and emission) of the diesel engine. In the present investigation, hexanol and methyl acetate are chosen as oxygenated additives with the diesel fuel owing to their appreciable better-quality attributes. The whole investigation was carried out in six phases, in the first phase; critical collection of oxy-additives chemicals was carried out. In the second phase, selection of oxy-additives (based on oxygen percentage and fuel property) and later mixed with diesel fuel in specific proportions. In the third phase, stability investigation of oxy-additive blended diesel fuels was carried out. In the fourth phase, fuel properties were investigated. In the fifth phase, experimentation of neat diesel as a fuel was carried out in a compression ignition engine generator. In the sixth phase, experimentation of prepared stable additive fuels was carried out in a compression ignition engine generator.

EXPERIMENTAL METHODOLOGY

Numerous oxygenated additives were studied (with regard to the oxygen content and appreciable fuel properties). Based on the safety aspects, feasibility and potentiality characteristics of various oxygenated fuels, hexanol and methyl acetate chemical were chosen to blend with the diesel fuel in specific proportions. The calculation of the oxygen percentage in a chemical compound is found by:

$$\text{Oxygen \%} = \frac{\text{Molecular Weight of an Element}}{\text{Total Molecular Weight of the Compound}} \times 100$$

Totally, eight fuels of oxygenated blended diesel fuels were prepared in specific proportions. The fuel codes and description of the blended fuels are tabulated in Table 1.

Table 1. *Fuels codes and description.*

Codes	Description
D	Diesel fuel
95D5H	95% of diesel fuel + 5% of Hexanol
90D10H	90% of diesel fuel + 10% of Hexanol
85D15H	85% of diesel fuel + 15% of Hexanol
80D20H	80% of diesel fuel + 20% of Hexanol
95D2.5H2.5MA	95% of diesel fuel + 2.5% of Hexanol + 2.5% of Methyl Acetate
90D5H5MA	90% of diesel fuel + 5% of Hexanol + 5% of Methyl Acetate
85D7.5H7.5MA	85% of diesel fuel + 7.5% of Hexanol + 7.5% of Methyl Acetate
80D10H10MA	80% of diesel fuel + 10% of Hexanol + 10% of Methyl Acetate

Hexanol and methyl acetate were mixed with the diesel fuel in a reactor vessel in the following proportions (95% of Diesel + 5% of Hexanol, 90% of Diesel + 10% of Hexanol, 85% of Diesel + 15% of Hexanol, 80% of Diesel + 20% of Hexanol, 95% of Diesel + 2.5% of Hexanol + 2.5% of Methyl Acetate, 90% of Diesel + 5% of Hexanol + 5% of Methyl Acetate, 85% of Diesel + 7.5% of Hexanol + 7.5% of Methyl Acetate, 80%

of Diesel + 10% of Hexanol + 10% of Methyl Acetate). After mixing hexanol and methyl acetate with diesel fuels (Figure 1), stability investigations were carried out to check the miscibility and stability attributes (Refer Figure 2). It was found that hexanol and methyl acetate blended diesel fuels were stable for more than 30 days. Subsequently, the prepared hexanol and methyl acetate blended diesel fuels were subjected for testing (Refer Tables 2 and 3) fuel properties (such as density, flash point, fire point, kinematic viscosity). Hexanol and methyl acetate blended diesel fuels were tested in a diesel engine generator (Table 4 and Figure 3). Diesel fuel was first tested in the diesel engine generator in order to obtain the baseline readings (Figure 4) to compare with the other prepared tested fuels. Subsequently, hexanol and methyl acetate blended diesel fuels were tested in a diesel engine generator. Electrical loading was applied to the diesel engine generator with the aid of an electrical loading (1000W in each load). The full load of electrical loading to the diesel engine generator is 5000W. The performance of the tested fuels was studied in terms of volume basis and emissions of the tested fuels were tested using a QRAE emission analyzer.

Table 2. *Properties of hexanol and methyl acetate.*

Chemical Name	Hexanol	Methyl Acetate
Chemical Formula	$C_6H_{14}O$	$C_3H_6O_2$
Molecular Weight	102	74
Density (at 20°C)	0.82 g cm^{-3}	0.932 g cm^{-3}
Melting Point	-45°C	−98°C
Boiling Point	157°C	56.9°C
Flash Point	59°C	−10°C

Table 3. *Properties of additive blended diesel fuels.*

Fuel	Density kg/m^3	Flash Point °C	Fire Point °C	Kinematic Viscosity(cSt)
95D5H	1.88	26	89	4.843
90D10H	1.86	40	79	4.595
85D15H	1.84	56	72	4.441
80D20H	1.84	62	82	4.138
95D2.5H2.5MA	1.86	64	87	4.222
90D5H5MA	1.88	65	85	4.255
85D7.5H7.5MA	1.89	62	81	4.259
80D10H10MA	1.90	63	82	4.345

Table 4: *Specifications of diesel engine generator.*

Particulars of the engine	Values
Max AC output (W)	5350
Rated output (W), Speed	5000, 3000 RPM
Type	Single Cylinder, Forced Air cooled, 4 Stroke
Displacement (cc)	418
Fuel	DIESEL
Fuel Tank Capacity (L)	12.5
Noise Level (@7M dB)	78
Net Weight (kg)	120
Voltage, Current, Phase, Frequency	230 V, 25 A, Single, 50 Hz

Fig. 1. *Photographs of (a)hexanol, (b) methyl acetate and (c) hexanol + methyl acetate blended diesel fuels.*

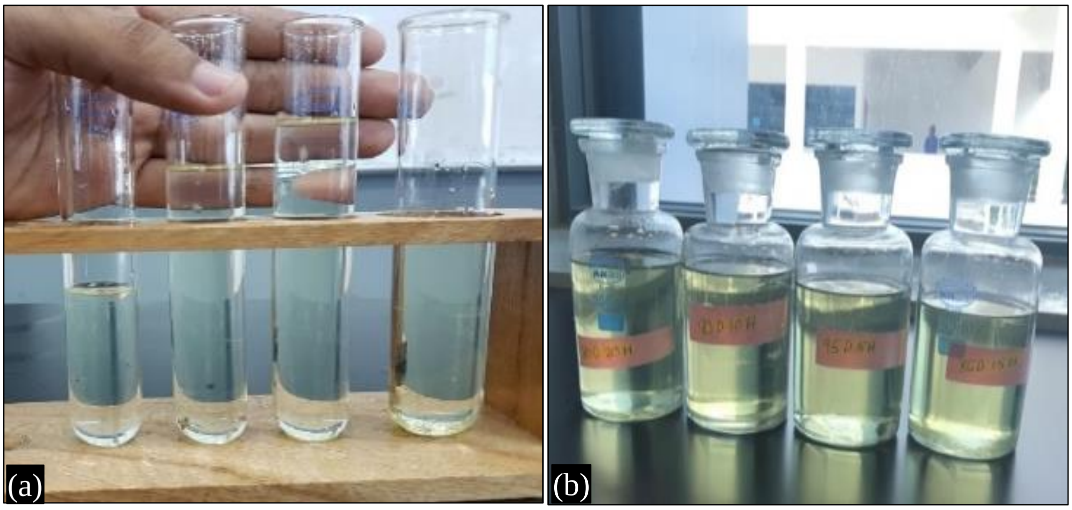

Fig. 2. *Stability investigation of additive blended diesel fuels.*

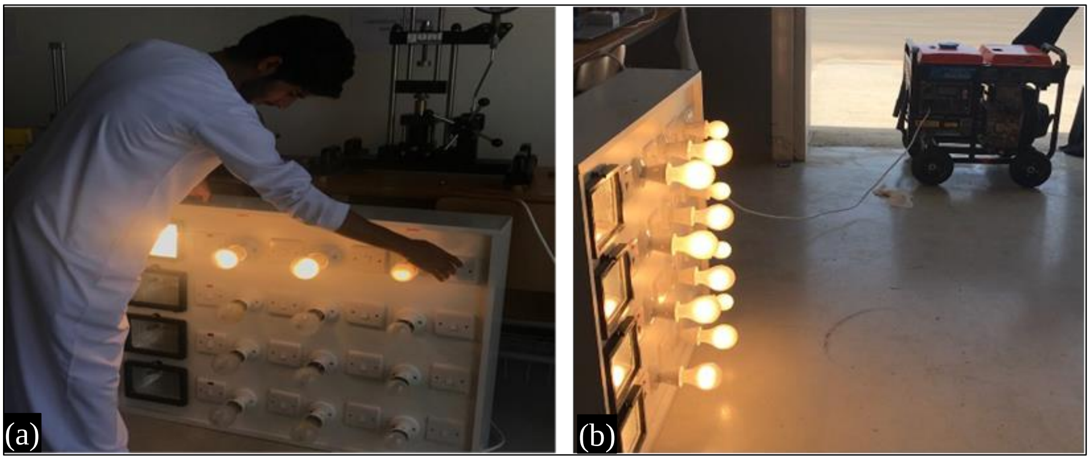

Fig. 3. *Electrical loading to diesel engine generator.*

RESULTS AND DISCUSSIONS

The subsequent section deals about the experimental results carried out in the present analysis with regards to performance and emission attributes of a diesel engine generator utilizing neat diesel, hexanol blended diesel fuels and hexanol + methyl acetate blended diesel fuels.

Performance Characteristics

Figure 4 reveals about the fuel consumption (ml) or performance characteristics of the diesel engine generator for all the tested fuels. It is observed from the figure that hexanol + methyl acetate blended diesel fuels reflected lesser fuel consumption compared to that of neat diesel. It is due to the enhanced fuel properties and additional oxygen content present in the oxy-additive blended fuel than that of neat diesel [2, 17]. Pure diesel reflected more fuel consumption than the other tested fuels due to the inferior combustion in the engine cylinder. The fuel 85D7.5H7.5MA reflected overall better or reduced fuel consumption among all the tested fuels. This could be due to the complete combustion in the engine cylinder associated with the enhanced fuel properties and oxygen content. The fuel consumption for the neat diesel was 2000 ml; whereas for the additive blended diesel, fuel consumption was 1850 ml, 1825 ml, 1900 ml, 1925 ml, 1950 ml, 1920 ml, 1800 ml, 1920 ml for 95D5H, 90D10H, 85D15H, 80D20H, 95D2.5H2.5MA, 90D5H5MA, 85D7.5H7.5MA and 80D10H10MA, respectively.

EMISSION CHARACTERISTICS OF DIESEL ENGINE GENERATOR

This following section focuses the level of emissions perceived during the investigation using the QRAE gas analyzer.

It is observed from Figures 5 and 6 that the hexanol and methyl acetate blended diesel fuels produced lesser NO_x emissions compared to that of neat diesel at all the loads (i.e., 0–4 kW). Similar effect was also reflected in case of exhaust gas temperature (Figure 6). Many researchers [2–19] have reported the direct proportionality between the exhaust gas temperature and NO_x emissions. Further, the additive blended fuels have influenced better combustion in the engine cylinder which in turn produced lesser NO_x emission compared to that of neat diesel. This could be due to the improved fuel properties of hexanol and methyl acetate blended diesel fuels. With regard to 85D7.5H7.55MA fuel, the magnitude of nitrogen oxides decreased overwhelmingly compared to that of neat diesel. This could be due to the better quality attributes of the fuel (such as shortened ignition delay and better combustion in the combustion chamber) during combustion in the engine cylinder [22].

Variation of CO and HC Emissions

In Figures 7 and 8, the harmful pollutants (unburnt hydrocarbons and monoxides of carbon) from the diesel engine generator are reduced for the additive blended diesel fuels compared to that of neat diesel fuel. Improved quality of additive blended diesel fuels (in terms of better flash and fire point temperature, kinematic viscosity) has led to better combustion attributes. Owing to these effects, the unburnt hydrocarbons and monoxides of carbon are appreciable reduced for the additive blended diesel fuels while comparing to those of neat diesel. Among the tested fuels, the HC emission for 85D7.5H7.55MA observed was 25 ppm, whereas it was 35 ppm for the neat diesel at the full load. This is due to possibly because of better atomization effects in the combustion chamber, which leads to uniform dispersion [6–17] of hexanol and methyl acetate molecules in the fuel mixture assuring improved combustion. The level of monoxides of carbon was 0.36% (by vol.) for 85D7.5H7.55MA and 0.41% (by vol.) for the neat diesel.

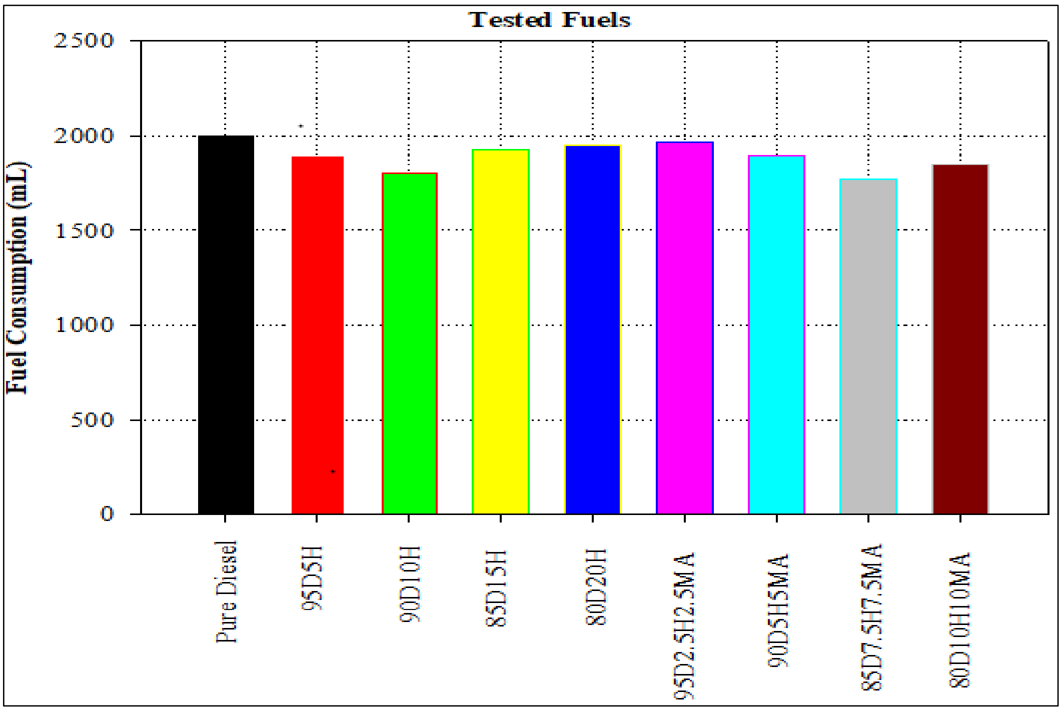

Fig. 4. *Performance characteristics variation of fuels.*

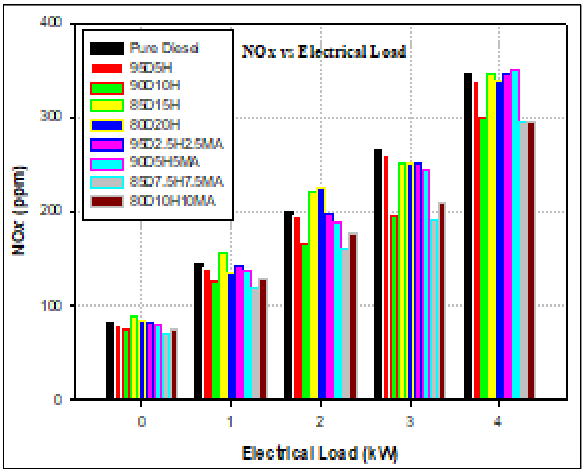

Fig. 5. *NO_x variations of fuels.*

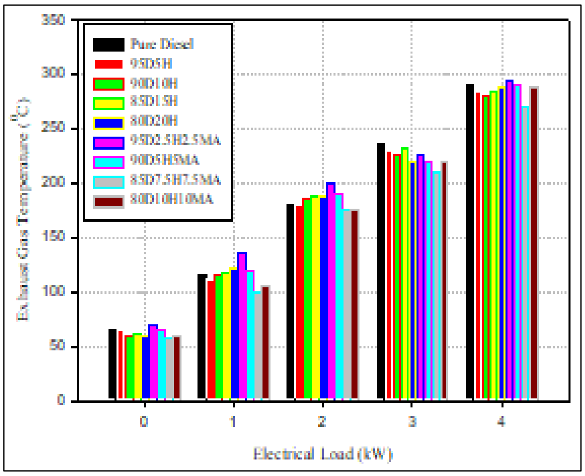

Fig. 6. *Exhaust gas temperature variations of fuels.*

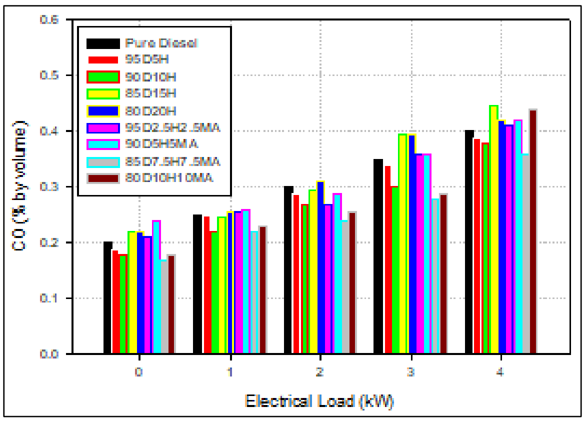

Fig. 7. *CO emission level of fuels.*

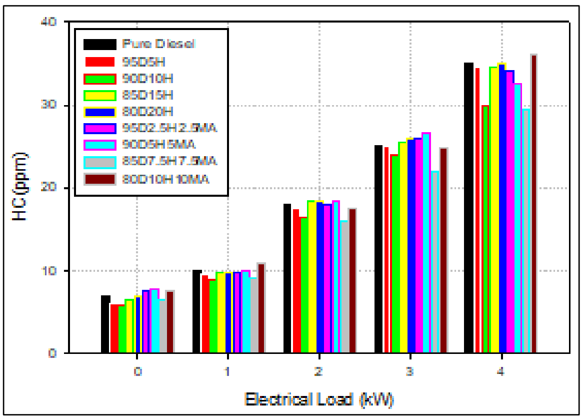

Fig. 8. *HC emission level of fuels.*

CONCLUSION

With an effort to enhance the performance attribute and reduce emissions from a compression ignition (CI) or diesel engine generator, the current analysis was carried out on blending oxy-additives with diesel fuel. The following conclusions were drawn:

- The stability of the hexanol and methyl acetate blended diesel fuels (such as 95D5H, 90D10H, 85D15H, 80D20H, 95D2.5H2.5MA, 90D5H5MA, 85D7.5H7.5MA and 80D10H10MA) was more than a month under static conditions.
- There was no compliance of any abnormal noise or starting difficulty during the entire experimentation using the hexanol and methyl acetate blended diesel fuels.
- Hexanol and Methyl acetate mixed diesel fuels have significantly improved the working aspects of the diesel engine generator.
- At all the loads, the monoxides of carbon and oxides of nitrogen of the hexanol and methyl acetate blended diesel fuels were convincingly reduced. The hydrocarbons undergone slight reductions for the hexanol and methyl acetate blended diesel fuels.

Henceforth, it is established that 7.5% of blending proportion of both hexanol and methyl acetate with diesel fuel has the potentiality to ameliorate the working attributes of diesel engine generator.

ACKNOWLEDGEMENT

The authors are highly indebted to Honourable Dean Dr. Hilal Al Hadhrami and the Management of International Maritime College Oman (IMCO) for providing us the basic facilities to carryout the above research work in a shorter period of time.

NOMENCLATURE

CI	-	Compression Ignition
CO_2		Carbon Dioxides
CO	-	Carbon Monoxides
H	-	Hexanol
HC	-	Hydrocarbons
MA		Methyl Acetates
NO_x		Nitrogen Oxides
PM	-	Particulate Matter

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Cite this Article: J. Sadhik Basha, Montaha Ali Said Al-Balushi, Khadija Mohammed Mubarak Al-Shibli, Manal Yousuf Mohammed Al-Fazari, Sulaiman Ali Sulaiman Al-Rumhi, Shahad Mohammed Khalfan Al-Mansouri, Rashid Nasser Said Al Balushi**.** The Influence of Hexanol and Methyl Acetate as Oxygenated Additives with Diesel Fuel in a Diesel Engine Generator. *International Journal of*. I.C. Engines and Gas Turbines 2019; 5 (1): 1–9p.

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