Exhaust emission analysis of a diesel engine fueled with emulsified biofuel blends

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Abstract

Many countries including India whose economy is very expeditiously incrementing have very high consumption of mineral diesel in wide variety of applications. With the fervently growing economy, demand is withal going up sharply which is resulting in incremented level of vehicular traffic and is the main reason for environmental pollution compared to other sectors. To cope up with the supply and authoritatively mandate, to keep pace with the time and minimize pollution levels we have to ascertain certain alternative resources in lieu of diesel. Alcohols (especially ethanol) are a felicitous renewable fuel because it can be facilely derived from different vegetative crops. The present experimental work is carried out on a Kirloskar make 3.5 KW constant speed (2000 rpm) diesel engine. All the tests were conducted on prepared fuel blends and exhaust emissions mainly carbon mono-oxide (CO), carbon dioxide (CO_2), unburnt hydrocarbons (UHC), NOx and O_2 emissions were analyzed and recorded at different loads.

The study demonstrates that emulsified fuel blend E10S5D85 and E15S10D75 of 195 proof ethanol may be utilized for this engine in lieu of diesel which may result in 12 to 20% supersession of diesel emanated pollution levels these days caused by conveyances. The emulsified fuel blend E15S10D75 has shown lowest emission of CO at all applied load conditions as compared to diesel as well as other emulsions. The fuel blend E10S5D85 shows minimum emission of unburned hydrocarbons and insinuate better than diesel from UHC emission perspective at proximately all the loads. The emission of NOx from the exhaust of engine was found lower on all the emulsified fuel blends then diesel. It is pellucid that NOx emissions were on lower side for emulsified fuel than diesel.

Key words: Emissions, ethanol, carbon mono-oxides, engine, gas analyzer.

1. Introduction

Today's Economics is much more propitious in the engenderment of ethanol and is able to consummate fairly well with standard diesel. Hence, there has been renewed interest in the ethanol diesel blends with particular accentuation on emission reductions. When considering an alternative fuel for use in diesel engines, emission parameters are consequential. The purport of this study is to analyze and understand the effect of those parameters which has practical application and environment perspective.

Ethanol has the property of absorbing moisture from the atmosphere until it has the composition of 95% alcohol and 5% dihydrogen mono-oxide [1]. The commonly available ethanol grade contains 10 to 20% dihydrogen mono-oxides and ergo they are aqueous ethanol. Ethanol is much more frugal than petrol and anhydrous ethanol has the potential for lower emissions and higher engine efficiency. Study shows that NOx emission reductions of up to 40% can be obtained by utilizing aqueous bio origin fuels. When dihydrogen mono-oxides is present in the cylinder, its mass absorbs energy and the result is lower peak temperatures as well as abbreviated CO due to dihydrogen mono-oxides gas shift reaction. Emission truncation is not the only benefit to be gained from utilizing aqueous ethanol.

Hasen et al. [2], conducted experimental work on oxygenated biofuels such as biodiesel and ethanol coalesced with diesel fuel to analyze the

performance and NOx emissions of biofuel blends in a turbocharged and intercooled diesel engine, found that the ethanol-diesel fuel blend NOx emissions by 2.7% and was highly sensitive to load, with incremented temperature and NOx emissions at light load. Additament of only 5% ethanol to biodiesel suppressed NOx emissions, with only a 2.6% increase occurring. It was concluded that ethanol could act as an efficacious NOx emissions truncating additive. Similarly, Sathiyagnanam et al. [3] utilized Hexanol in ethanol – diesel fuel to obviate dissension of ethanol from diesel. They have found that diesel 37% ethanol 73% (D35E) concentration shows better smoke minimization than the other blends and diesel. The smoke density is minimized by 45.3 HSU than the diesel at maximum brake potency. All the coalescences marginally increase the NOx emission beyond 75% load than that of diesel. The cylinder pressure is higher for all the coalescences. Barsic et al. [4], evaluated crude soybean oil, a 50:50 coalescence of crude Soyabean and diesel, and degummed soybean oil can a direct injection engine. In the Pennsylvania University State University [5], Braun conducted short-term test on the coalescences of degummed soybean oil, ethanol and diesel in the respective ratios of 40: 20: 40 and 40:30:30. The engine was run for 25 hours on each blend. They have reported no operational quandary. Jori and Hanzely [6], examine the diesel engine with rapeseed oil. The utilization of renewable and nonrenewable liquid and gaseous fuel in compression ignition engines has been analyzed with the accentuation on engine performance, technical feasibility and economical viability. Ethanol is one of the several alternative conveyance fuels considered for supersession of conventional gasoline and diesel fuel [7].

Depending upon the need of research work in the area of Automobile technology to combat exhaust emission pollutants from diesel engine the present study is carries out on emulsified fuel blends with different ethanol proofs and diesel using sodium dodecyl sulphate (SDS). This study aims to provide partial substitution to mineral diesel also with reduced tail pipe emissions.

1. Materials and methods

The experiments were conducted on preparation of emulsified fuel blends with different ethanol proofs and diesel utilizing sodium dodecyl sulphate (SDS) as emulsifier. An emulsion is a coalescence of two or more immiscible liquids, being present in the other in the form of droplets. In this present study sodium dodecyl sulphate (SDS) was utilized as surfactant. Ethanol and oxygenated organic carbon compound additionally kenned as ethyl alcohol. 195, 190 and 185 ethanol proofs were utilized for experimental work. Table 1 depicts the prepared and emulsified fuel blends with their constituents.

Table: 1 Selection of various emulsified fuel blends used for experimentation

S. No	Emulsified blend		Composition in (ml)		
	Proof	Blend Designation	Ethanol	SDS	Mineral diesel
1	195	E10S5D85	100	50	850
2	195	E15S10D75	150	100	750
3	190	E10S10D80	100	100	800
4	190	E15S15D70	150	150	700
5	185	E10S15D75	100	150	750
6	185	E15S20D65	150	200	650
7	---------	Mineral diesel	-----	-----	1000

A Kirloskar make single cylinder 5.0 BHP, 3.5 kW, 2000 rpm, 4 stroke, vertical air cooled, and manual hand start type compression ignition engine was culled for the exhaust emission testing work. The engine is commonly utilized for different field operations as well as prime movers in electric engenderer. The engine is coupled to a dynamometer with the following details rating 50 Hz, torque 4.5 kg m, speed 120-2000 rpm, weight 279 kg.

2. Experimental procedure

The emission quantification test of the engine was conducted in the following manner. Initially the engine was commenced on diesel and then run for a few minutes. The engine operation was then switched onto the fuels culled for this study at no load condition. The engine on culled fuel was for the run for a minute under no load condition for warming up and for stable operation. After warm up the engine was gradually loaded up to 100% load to stabilize its operation. Once the engine operation was

stabilized, it was brought to full (100%) load condition and overload conditions were withal gradually applied. The full load on the engine corresponds to the state of the engine when it is developing the perpetual rated brake power at the rated speed of 2000 rpm: zero load implicatively insinuates no load condition while the engine is running. The experiment with each fuel type was done two times and the average value of different parameters quantified was taken for analysis. The parameters quantified were tabulated and plotted. Experiment was conducted at the ambient room temperature of 15- 45 ^{0}C. The emission of exhaust gases emanating from burning of different fuel types at different load conditions were recorded and analyzed utilizing exhaust gas analyzer. Following emissions were recorded:

- CO emission, ppm
- CO_2 emission, ppm
- UHC emission, ppm
- NOx emission, ppm
- O_2 emission, ppm

The load applied was directly read from the digital load designated in kg and was converted into torque by quantifying the arm length (16.5 cm arm length). Torque (T) was calculated in N-m by multiplying load in kg with an arm length in meter and multiplying it by 9.81 m/s^2. The maximum load that the engine can bear to be around 17.5 kg (full load), however in terms of torque it emerges to be to be 28.025 N-m with the present engine test facility which was considered in this study.

3. Results and discussion

The engine was run utilizing different emulsified fuel blends i.e. diesel and of emulsions which were utilizing anhydrous ethanol (195, 190 and 185 proof) and SDS as surfactant.

The potency minimization in light load region occurs due to abbreviate heat content of micro emulsions and increment in ignition delay with alcohol when light loads are encountered. Meiring et al. [8] verbalized that the combustion efficiency of these emulsions amends and ignition delay is abbreviated at higher load conditions.

3.1 Exhaust emission measurement

The Carbon mono-oxides (CO), Carbon dioxide (CO_2), unburnt hydrocarbons (UHC), Oxides of nitrogen (NOx) and Oxygen emissions (O_2) from the engine at different applied loads on diesel and six culled micro emulsions were quantified during the test.

3.2 Carbon mono-oxide emissions

The emission of CO from the exhaust gases of the test engine at full load was found to be around 0.008% for the diesel fuel and for emulsified fuel blend E15S10D75 also.

At 75% load it was found lower in all the emulsions as compared to diesel, except in the fuel blend E15S20D65. It was found that at 75% load condition the CO the emission was 0.007% for the fuel blends E10S10D80 and E15S10D75. Emulsified fuel blend E15S10D75 has shown highest caliber of emission about 25% load condition compared to other culled fuels and diesel.

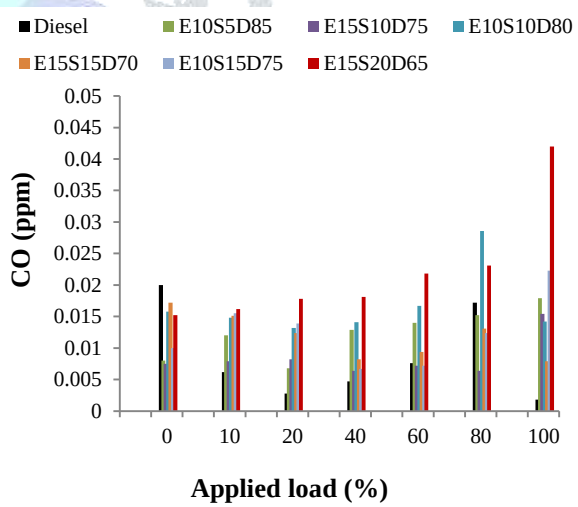

Figure 1: Carbon mono-oxides emission v/s applied load (%) of the engine on diesel and selected fuel blends.

The CO the emission is less in alcohol coalesced fuel due to the presence of oxygen molecules and alcohol which oxidizes CO_2 carbon dioxide. [9, 10]. Figure 1, shows that at no load condition the Co emission of six culled emulsified fuel blends was lower compared to diesel. The emulsified fuel blend E15S10D75 has shown lowest emission of CO from no load to full load conditions or rather at all loads it was lowest as compared to diesel or any other culled

emulsified fuel blend. So looking to CO emissions in the exhaust gases the culled fuel E15S10D75 of 195 proof seems to be a promising example of alternative fuel for compression ignition engines.

3.3 Carbon dioxide emissions

The plotted results depicted in figure. 2, represents the downward trend of CO_2 emissions for all fuel mixes and diesel with respect to the different loading conditions.

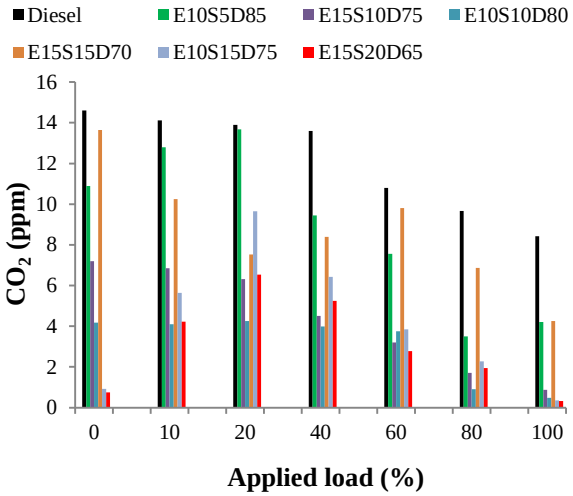

Figure 2: Carbon dioxides emission v/s applied load (%) of the engine on diesel and selected fuel blends.

Though the experimental results indicates highest CO_2 emissions at higher load (100%) for diesel, further for various fuel mixes E10S5D85, E15S10D75, E10S10D80, E15S15D70, E10S15D75 and E15S20D65 is 7.2, 3.4, 0.28, 0.62, 3.8 and 0.72 ppm for diesel respectively.

The emission of CO_2 is affected by the carbon content in fuel and the fuel consumption, by this experimental study CO_2 emission was observed with the emulsified fuel blends about 0.28 ppm and 0.72 ppm which is lower in comparison to diesel.

At a load of 60% emulsion fuel mixture shows highest CO_2 emissions i.e. 14.52 ppm due to fuel blending with higher carbon content for higher fuel consumption similar to diesel. In a similar way CO_2 emission is the product of complete combustion due to proper amount of air fuel mixture.

3.4 Unburnt hydrocarbon emissions

The UHC emission in the exhaust gases of the engine on diesel was in the range of 1-7 ppm, for emulsified fuel blends E10S5D85, E15S10D75, E10S10D80, E15S15D70, E10S15D75 and E15S20D65 it was in the range of1-4, 3-8, 5-7, 5-7, 4-6 and7-15 ppm respectively as shown in figure 2.

At full load condition it was 2 PPM for diesel and emulsified fuel blend E10S5D85. It was highest for the fuel blend E15S20D65 at all load conditions. So with the incrementing percentage of ethanol in the fuel the UHC emission was found to be incrementing.

The emulsified fuel blend E10S5D85 shows minimum emission of unburnt hydrocarbons and looks to be e better than diesel from hydrocarbon emission perspective at virtually all the load conditions.

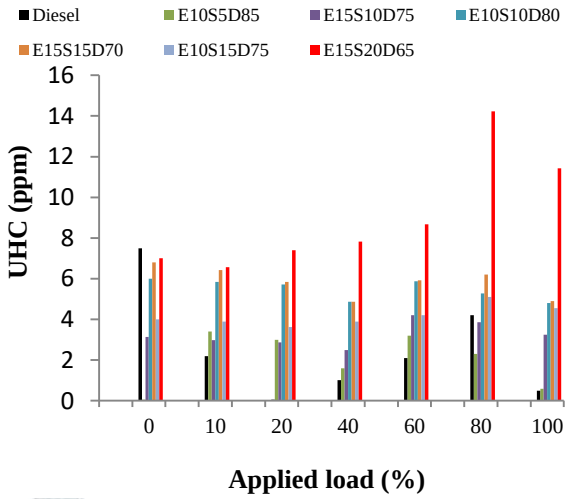

Figure 3: UHC emission v/s applied load (%) of the engine on diesel and selected fuel blends.

All other emulsifier caused more emission of UHC as compared to diesel and the fuel brand E10S5D85 as conspicuous from the study as depicted in figure 3.

4.4 Oxides of Nitrogen emission

Figure 4, designates that emission of NOx in the exhaust of the engine operating on diesel and culled coalesced fuels and variation of oxides of nitrogen apathetical emulsified fuels are withal shown. For Diesel it buried in the range of 121-421ppm between no load to full load/ overload

conditions. The caliber of NOx emission from the engine running on emulsified fuel blends E10S5D85, E15S10D75, E10S10D80, E15S15D70, E10S15D75 and E15S20D65 was in the range of 23-334, 43-411, 23-380, 25-486, 35-419 and 70-495 ppm respectively between no load to 100% brake load conditions.

The emission of NOx from the exhaust of the engine was found lower on all the emulsified fuel blends then diesel. The emission of NOx from the engine running was lowest for the fuel E10S15D75 which was on 180 proof ethanol. It was maximum at full load condition what the fuel E15S20D65 at 495 ppm amongst the prepared fuel samples.

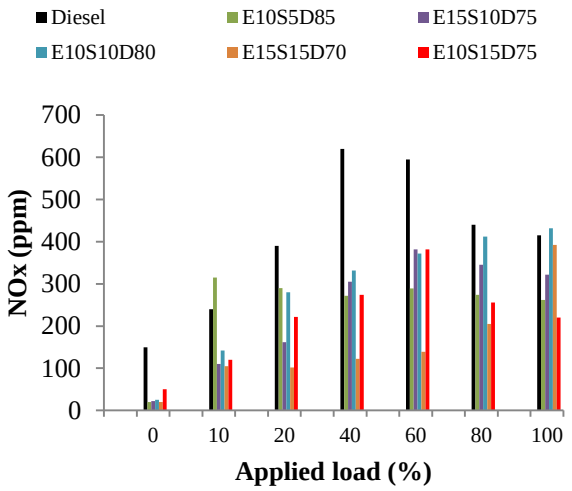

Figure 4: NOx emission v/s applied load (%) of the engine on diesel and selected fuel blends.

It is pellucid that NOx emission was on lower side when prepared emulsified fuel blends were utilized as compared to diesel.

4.4 Oxygen emissions

The ratio of oxygen emission value with load for diesel and emulsified fuel blends is illustrated in figure. If any type of conveyance emits more oxygen is a good sign for our environment and living beings additionally.

Utilizing theses emulsified fuel blends it was visually examined that oxygen content relinquished to the environment in every load and thus every fuel blend emits more oxygen content compared to diesel. According to the figure.5, at higher load higher ethanol blends emits more oxygen further it was visually examined that at higher loads emulsified plans emits more oxygen then at lower loads.

Ethanol contains more oxygen than diesel which avails to ameliorate the combustion so that at higher loads for diesel emulsified fuel blends E10S5D85, E15S10D75, E10S10D80, E15S15D70, E10S15D75 and E15S20D65 obtained as 10.25, 15.8, 16.52, 16.4, 13.58 and 17.25 ppm respectively.

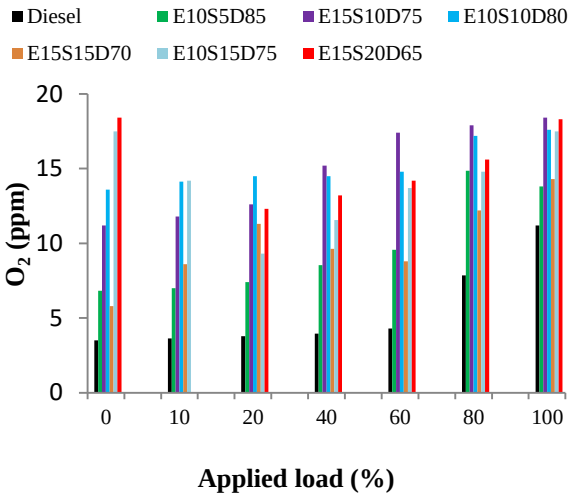

Figure 5: NOx emission v/s applied load (%) of the engine on diesel and sele cted fuel blends.

The result shows that when increase in the ethanol coalescing ratio in emulsified fuel more oxygen is emitted.

5. Conclusions

1. At no load condition the CO emission for all six prepared emulsified fuel blends was lower compared to diesel. The emulsified fuel blend E15S10D75 has shown lowest emission of CO from no load to full load conditions or rather at all loads it was lowest as compared to diesel or any other culled emulsified fuel blend. So from CO perspective, the culled fuel E15S10D75 of 195 proof ethanol is preponderant.

2. The emission of CO_2 is affected by the carbon content in fuel and the fuel consumption, by this experimental study CO_2 emission was observed with the emulsified fuel blends about 0.28 ppm and 0.72 ppm which is lower in comparison to diesel.

3. The emulsified fuel blends E10S5D85, shows minimum emission of unburnt hydrocarbons and is better than diesel from UHC perspective at virtually all the load conditions. All other emulsified fuel blends caused more emission of UHC as compared to diesel and the culled emulsified fuel blend E10S5D85.

4. The emission of NOx from the exhaust gases of the engine was the lowest for the fuel E10S15D75 which was on 180 proof ethanol. It was maximum at full load condition for the fuel blend E15S20D65 at 495ppm amongst the prepared fuel samples. The culled fuel E10S5D85 withal shows lower values of NOx emission as compared to diesel.

5. Ethanol contains more oxygen than diesel which avails to ameliorate the combustion so that at higher loads for emulsified fuel blends performed better then diesel. Further, it was visually examined that at higher loads emulsified fuel emits more oxygen then at lower loads.

The performance emission testing of 3.5 kW C.I engine shows that looking to sundry parameters, some of the culled emulsified fuel blends performed virtually kindred or even better than diesel. On the substratum of this experimental study performed on different emulsified fuel blends and diesel predicated on different parameters, it may be suggested that emulsion of 195, E10S5D85 and 195, E15S10D75 may be utilized in CI engines in lieu of pristine diesel to decrement pollution level in the diesel engine exhaust gases.

References

1. Ajav, E.A. and Akingbehin, O. A. A study of some fuel properties of local ethanol blended with diesel fuel. The CIGR Journal of scientific research and development, EE01003, Vol. IV, march 2002.
2. Hansen, A. C; Gratton, M. R; Yuan, W. Diesel engine performance and NOx emissions from oxygenated biofuels and blends with diesel fuel. American Society of Agricultural and Biological Engineers, St. Joseph, Michigan, Transactions of the ASABE. Vol. 49(3): 589-595. 2006
3. Sathiyagnanam, A. P; Saravanan, C.G; Gopalakrishnan, M. Hexanol-ethanol diesel blends on di-diesel engine to study the combustion and emission. Proceedings of the World Congress on Engineering, Vol II, WCE 2010, June 30 - July 2, 2010, London, U.K.
4. Alternative fuel data center, Government of India. www.adfc.doc.gov
5. Boruff, P. A; Schwab, A. W; Goering, C. E. and Pryde, E. H. Evaluation of diesel fuel ethanol micro emulsions. ASME Transactions, 25(1), 47-53, 1982.
6. Eucklund, E. Alchols in diesel engine. A review SAE paper no.840119, Society of Automotive engineers, 28(1), 70-74, 1984.
7. Ganeshan. V, Internal combustion engines TMH publishers, 2008.
8. Gupta, V. K. Studies on alcohol emulsification and performance evaluation of CI engine on emulsified fuels. 2005.
9. Methods of tests for internal combustion engines, Performance tests. IS;10000. 1980.
10. Meiring, P; Allan, R. S; Hansen, A. C and Iyne, P.W.L. Tractor performance and durability with ethanol- diesel fuels. ASME Transactions, 26(1), 59-62.