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Investigation on Effect of Oxygenated Additive on Multicylinder Diesel Engine Performance and Emission

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ABSTRACT— This paper present the experimental investigation on effect of oxygenated additives on multi-cylinder Diesel engine performance and emission. The experimental trail was carried out at constant speed of 1500rpm with variable load conditions and 10% of oxygenated additive in diesel fuel. Six different additives were selected for investigation. After the experimentation, it's found that DIGILYME shows least brake specific fuel consumption of all other additives but around 10 -20% higher than that of diesel for the same load variation. All additive shows rise in EGT except DMC which is quite close to that of diesel. Brake thermal efficiency of DMC is high at idle to moderate load after that it drop than that of diesel due to low calorific value. It shows around15% rise in low load condition. DMC looks very promising in emission control. DMC shows around 15-30 drop in CO high load condition while 20 % drop in HC. Also It is good option in NOx control as it shows around 10% drop at low load and 15% drop at higher load condition. The only limitation is high smoke production by DMC where other additive like N Butyl Alcohol help in lowering smoke production that is its show around 30% drop at high load condition.

KEYWORDS: Oxygenated additive, performance, emission, HC, CO, NOx , .

I. INTRODUCTION

According to world trade, fuel market responsible for 25 % trade in merchandise and primary product, mostly due to diesel that is essential for transport and heavy duty engines. Due to low cost of Diesel fuel and more power, diesel engine is more common than gasoline engines. It contributes to prosperity of worldwide economy since it is widely used due to high combustion efficiency, reliability, adaptability and cost effectiveness. However, pollutant emissions are major drawback. Like inherent higher Particulate Matter(PM) and nitride oxide (NOx) emissions. Reduction of exhaust emissions is extremely important for diesel engine development in view of increasing concern regarding environmental protection and stringent exhaust gas regulations. The diesel fuel properties have become even more stringent controlling diesel exhaust emissions through fuel modification seems to be promising because it would affect both the new and old engines. Modification of diesel fuel to reduce exhaust emission can be performed by increasing the Cetane number, reducing fuel sulphur, reducing aromatic content, increasing fuel volatility and decreasing the fuel density to have the compromise between engine performance and engine out emissions, one such change has been the possibility of using diesel fuels with oxygenates. These blends usually enhance the combustion efficiency, burn rates, power output, and the ability to burn more fuel, but first of all, these blends offer the reduction of exhaust

The research on dimethyl ether (DME) as an alternative fuel produced great enlightenment. DME contains oxygen element and has no C–C bonds, which therefore helps to achieve smokeless combustion that is superior than

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with a diesel fuel even without high-pressure injection or turbocharger, however, the use of DME requires significant modifications on the fuel supply, delivery, and injection systems, which largely limits its application. The blending of oxygenates into a diesel fuel could effectively reduce the smoke emission from diesel engines, which has a strong synergy to the use of methanol, ethanol, or dimethyl carbonate (DMC). The studies are carried out on a set of paper on oxygenated fuels, which include DMC, diethylene glycol dimethyl ether (DGM), and diethyl succinate (DES). The results indicated that the smoke emission decreased linearly as the oxygen content increased and notably near zero smoke emission was attained when the oxygen content was higher than 30%. But all the available data were for different engine and hence comparison of all oxygenated additive on single platform is very necessary which is done in my present work.[2]

II. LITERATURE SURVEY

An In my previous review papers, I try to consolidate the data about effect of additive on single chart where we can make the conclusion about the effect of different additive on diesel engine. But this can be used as just reference for primary conclusion since experimental data were for different engine at different condition.[1]

Nubia M. Riberia, Angelo C Pinto has in detail discussed about the role of different additive, their types and their effect on performance and emission of C I Engine. [2]

T. Nibin, A. Sathiyagnanam and S. Shivprakasam, 2003 to improve the performance of a diesel engine by adding oxygenated fuel additive of known percentages as discussed in [3].

J. Wang, F. Wu, J. Xiao has discussed that fuelling oxygenated blends, the direct soot constituent in PM emissions decreases significantly as the fuel oxygen content increases. However, when the oxygen content reaches 15% or higher, reduction rate becomes slow This experiment was carried out by H. Hess, A. Boehman and J. Perez on six cylinder diesel engine by using a diesel fuel reformulating agent, CETANER, has been examined in a popular light-medium duty turbo diesel engine over a range of blending ratios as discussed in paper [4]

K.I. Burshaid A, M.A. Hamdan in their paper [5] found that methanol has significant effect on the reduction of soot formation and acetone has least effect on the same.

Bhavin H. Mehta, Hiren V Mandalia in paper [6] discussed about properties of synthetic oxygenates and ther effect on emission from engine and found that oxygenates play good role in reducing PM, CO, and HC without increase in NOx emission. way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it. [6]

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Additive	Smoke Density	CO	HC	CO_2	NO_x	EGT	SFC
DPE 15		🟢	🟢			🟢	
DIGLYME		🟢	🟢		🔴	🟢	
MTBE	🟢	🟢	🟢		🔴		
ETBE WITH EGR	🟢				🟢		
Ethanol Fung.	🟢	🔴	🔴				
DMC	🟢	🟢	🟢				
EGM			🟢		🔴		🟢
7.5% EGM + 7.5% DCM	🟢		🟢				
2-MEA	🟢		🟢	🟢	🔴		
OCTYLATED BUTYLATED DIPHENLAMINE ANTIOXIDANT		🟢	🟢		🟢		
15 DME+ 10 BIPHENYL ETHER		🟢	🟢				
HYDROGEN		🔴			🔴	🔴	
METALLIC ADDITIVE		🟢		🔴	🟢	🟢	

Table 2.1 Comparative Table of effect of additive on diesel fuel.[01-14]

III. PRESENT WORK

Present work has been concentrated on investigating the effect of different oxygenated additive on CI engine performance and emission. Six Oxygenated additives as mentioned below were selected and added in proportion of 10% by volume to diesel. Then these fuel samples were tested on multi cylinder C I Engine at constant speed of 1500rpm and variable load condition. The experimental results of performance like brake specific fuel consumption , brake thermal efficiency and smoke parameter like HC,CO,NO, smoke opacity, BP, were analyzed at various loads points of idle, 20%, 40%, 60%, 80% and 100%.

Oxygenated Additives:
1. Dimethyl Carbonate (DMC), 2. Di Methyl Methane (DMM), 3. Diethyl Glycol Di Methyl Ether (DIGLYME), 4. ISO Propyl Alcohol (IPA), 5. Di phenyl Ether(DPE), 6. N-butyl Alcohol.

IV. EXPERIMENTION

A typical Multi-cylinder 4-stroke water-cooled diesel engine at 1500 rpm was used for the investigation purpose The schematic diagram of the experimental set up is shown in Figure 4.1 An Hydraulic dynamometer was used for load control on the engine.. Various thermocouple temperature sensors were installed at appropriate locations to measure water inlet and outlet, manifold air temperature, exhaust outlet, and heat exchanger outlet temperatures. A temperature thermocouple was installed on the surface of high pressure fuel pipe. A precision crank angle encoder was coupled with the main shaft of the engine. Two openings were made in exhaust gas pipeline for sampling purposes.. The mass flow rate of intake air was measured with an orifice meter connected to a manometer. A surge tank was used to damp out the pulsations produced by the engine, for ensuring a steady flow of air through the intake manifold. An AVL 444 Di gas analyzer was used for measuring the CO, HC, and NOx emissions and the smoke density was measured using AVL 437 smoke meter.

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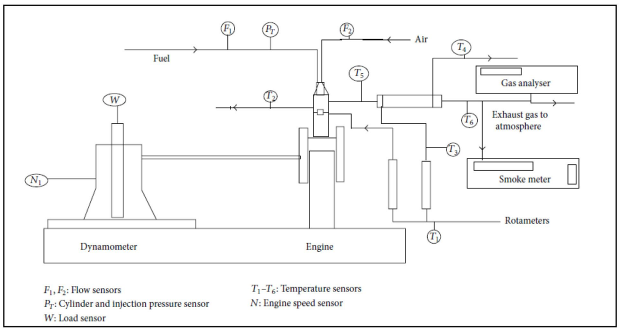

Fig 4.1 Engine Test Setup [15]

Table 4.1 Technical Specification of Engine

Parameter	**Specification**
Engine Type	Multi Cylinder DI, Water cooled
No of cylinder	03
Rated Power	27.9kW,1500rpm
Displacement	3300cc
Bore * Stroke Length	110mm x 116mm
Compression Ratio	18:1
Orifice Diameter	50mm
Orifice Coefficient of Discharge	.60
No of Nozzel Holes	5
Dynamometer Arm Length (mm) , Hydraulic	350.09mm

During the tests with Fuel sample, first, the engine was started with diesel until it was warmed up and then fuel was switched to various diesel-additive blends. After finishing the tests with diesel-additive blends, the Engine was always switched back to diesel fuel and the engine was run until the additives had been purged from the fuel line, injection pump, and injector. This was done to prevent starting difficulties at the later time. Initially the test engine was operated with base fuel diesel for about 10 minutes to attain the normal working temperature conditions. After that the baseline data was generated and the corresponding results were obtained. The engine was then operated with blends of additives mentioned above for different load condition. At every operation the engine speed was checked and maintained constant. The different performance and emission parameters analyzed in the present investigation were brake thermal efficiency (BTE), brake specific fuel consumption (SFC), exhaust gas temperature (EGT), carbon monoxide (CO), unburned hydrocarbons (UHC), nitrogen oxides (NOx), and smoke opacity

V. RESULT AND DISCUSSION

5.1 Engine Performance: The engine performance indicators considered were brake specific fuel consumption (BSFC), brake thermal efficiency (Bth) and exhaust gas temperature

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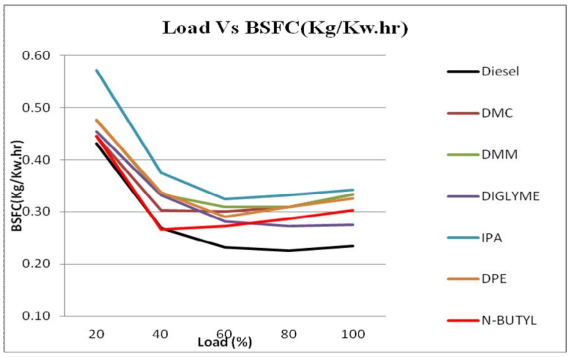

Fig.5.1.1 Load Vs BSFC

Fig.5.1.1 shows BSFC variation of different additives at different load conditions. Diesel shows lowest BSFC value throughout the test. Also It has been observed that BSFC has been increased for all oxygenated additives from 5% rise at low load condition till 20% rise at full load condition. Rise in BSFC for additives is due lowering of calorific value of fuel sample since calorific value of oxygenated additive is much lower than that of diesel. It is observed that N butyl alcohol is having lowest BSFC behaviour while Iso propyl Alcohol shows highest BSFC.

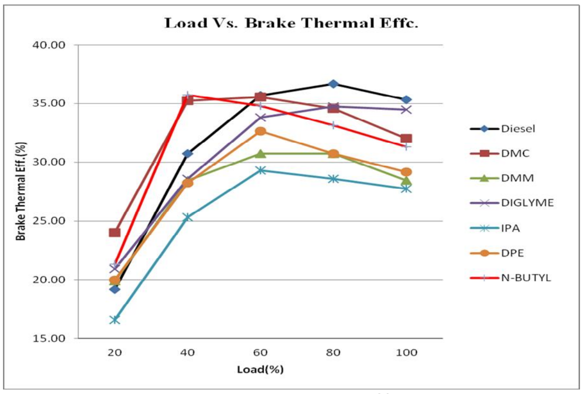

Fig. 5.1.2 Brake Thermal Efficiency Vs. Load

Fig. 5.1.2 shows Brake thermal Efficiency variation of fuel sample at various load condition. It is seen that brake thermal efficiency increases with load but again drop down at high load condition due to bad combustion which is due to very low time available for combustion process. It is seen that DMC and N butyl shows around 15 % rise in efficiency till 60% then there is sudden drop in it. The reason for this due to low heating value, they may not able to produce power as required by load hence consumed more fuel to compensate it.[15]

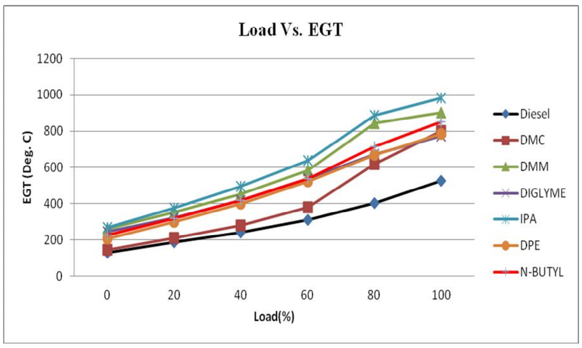

Fig. 5.1.3 Load Vs Exhaust Gas Temperature

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Fig. 5.1.3 shows Exhaust Gas temperature behavior of different additives at different load condition. It is observed that except DMC all other fuel sample show very high temperature rise particularly at high load conditions. This may be due to abnormal combustion happening in exhaust port due to very high temp of exhaust pipe. Due to low time available for combustion , some fuel sample may escape into port and come into contact with very hot surface resulting into self ignition hence sudden rise in EGT.

5.2 Emission Characteristics:

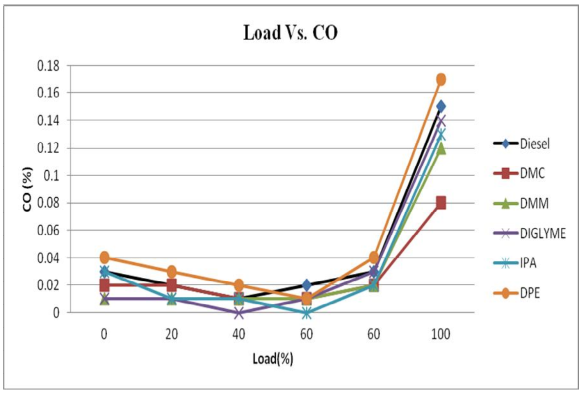

Fig. 5.2.1 Load Vs CO Emission

Fig 5.2.1 shows variation of CO emission with respect load her it si observed that DMC shows maximum drop which is around 30% in HC formation at all load condition while DPE is showing increase in CO emission..

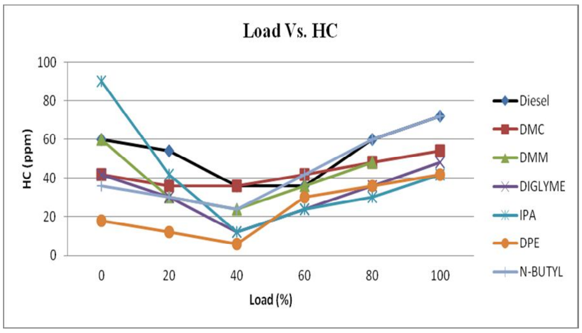

Fig 5.2.2 Load vs. HC Emission

Fig. 5.2.2 shows that HC emission has been dropped by use of oxygenated additive particularly DMC and DPE show considerable drop at all load conditions. The reason is that these additive increases the oxygen percentage in diesel hence reduces the local richness of air fuel mixture of diesel at the time of combustion which is the one reason for CO emission. All other additive also show drop in HC formation due to their increased oxygen content.

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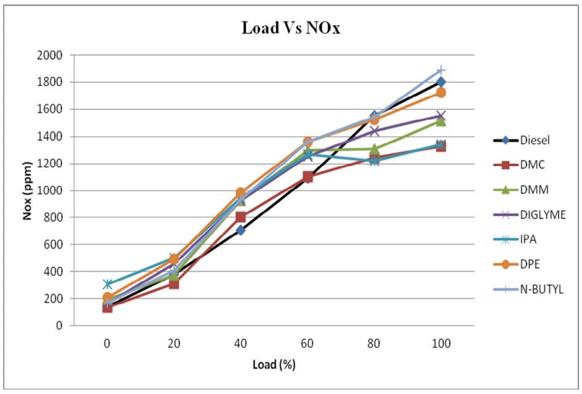

Fig. 5.2.3 Load Vs NOx Emission

From Fig 5.2.3, it is observed that, DMC shows highest drop in NOx emission. It observed that DMC shows around 10 % at low load condition while around 20 % drop at high load condition. Presence of Oxygen in these additive make combustion process more uniform reducing the sudden pressure rise with load hence giving more time for cooling through heat transfer and dilution and leading to localized gas temperatures. By reducing aromatics the flame temperature will drop, leading to a lower NO production rate. As a result the aromatics have high carbon-hydrogen ratios and thus fuels with lower aromatics will lead to a smaller amount of CO2 and larger amount of H2O being formed compared to high aromatic fuels. For other additive NOX drop is observed only at high load condition while there is increases in NOx emission at low load condition.

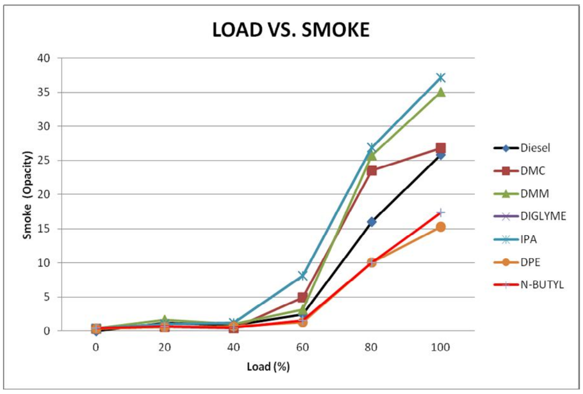

Fig 5.2.4 Load Vs Smoke Emission

Fig. 5.2.4 shows effect of oxygenated additive on Smoke formation at variable load condition and it is observed the except DPE and N Butyl alcohol which shows 30% drop at all load condition except at idle condition. All other additives shows considerable rise in smoke formation. This is due to higher density of these additives resulting in low flowbility hence some get deposited on combustion chamber outlet. When temperature is very high, these gets incompletely burned and carried away with exhaust resulting in soots particles. One more reason is presence of sulphur in the diesel which reacts with these forming sulphate and increasing the smoke formation.

VI. CONCLUSION

Primary investigations that N butyl alcohol shows lesser brake specific fuel consumption than other additive but around 10 - 20% higher than diesel for variable load. All additive shows considerable rise in EGT except DMC which is quite close to that of diesel. Brake thermal efficiency of DMC is high at idle to moderate load after that it drops by 5% than that of diesel due to low calorific value. It shows around15% rise in low load condition. DMC looks very promising in emission control. DMC shows around 15-30% drop in CO at almost all load conditions while 20 % drop in HC formation. Also it is good option in NOx control as it shows around 10% drop at low load and 20 % drop at higher load condition. The only limitation is high smoke production by DMC where other additive like N Butyl Alcohol help in lowering smoke production that is around 30% drop at high load condition. So from above DMC is helping improving almost all performance parameter along with reducing most of emissions. DMC is good option to use as oxygenated additive.

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