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# Operating Experience and Analysis of Engine Operated on Ethanol - Diesel Emulsion

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*Keywords :* *Oxygenated fuel, additive, alternate fuels, performance and emission.*

OPERATING EXPERIENCE AND ANALYSIS OF ENGINE OPERATED ON ETHANOL - DIESEL EMULSION

*Strictly as per the compliance and regulations of:*

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## I. Introduction

Reducing the emissions and fuel consumption are no longer future goals instead they are the demands of the day. Indiscriminate extraction and increased consumption of fossil fuels have led to the reduction in carbon based resources. Alternative fuels promise to harmonize sustainable development, energy conservation, efficiency management and environmental preservation. Diesel engines have the advantages of high thermal efficiency lower emission of CO and HC. However, they have the disadvantage of producing smoke, particulate matter & oxides of nitrogen and it is difficult to reduce both NOx, and smoke density simultaneously in diesel engine due to trade off between NOx and smoke. It follows therefore, that substantial amount of effort has been directed at providing solutions to these problems. Among various developments to reduce emissions, the application of oxygenated fuels to diesel engines is an effective way to reduce smoke emissions. The potentiality of oxygenated fuels to suppress soot precursor formation is dominated by molecular structure as well as fuel oxygen contents [1]. When oxygen content in the fuel reaches approximately 30% by mass, smokeless combustion in diesel engines could be realized [2]. Since ethanol is a widely available oxygenate with a long history of use in gasoline blends it has also been considered as a potential oxygenate for diesel fuel blending. Researchers have investigated the use of ethanol in diesel engines over the past several decades. The limited miscibility at lower temperature, less heating value, poor lubricating properties and the required minor variations in fuel delivery systems restrict the use of ethanol in diesel fuel [3]. Also the addition of ethanol to diesel fuel decreases the blend's viscosity and causes cetane number of the blends linear reduction at ambient temperature [4]. Usually, when ethanol content in the blends reaches 20–40%, high concentration of additives are needed to ensure the mixture homogeneity in the presence of high water contents, and to attain the required cetane number for suitable ignition [5],[6]. Literary survey revealed that several oxygenated organic compounds (ether, amino alcohols, surfactants etc….) may be used as additives and when the ethanol concentration increases beyond 20%, high concentrations of additives needed to stabilize the mixture. Choosing unsuitable organic additive meets with several difficulties viz; immiscible fuel-alcohol blends, difficulty to handle, high cost etc., [7] [8] [9].

C. Sundar Raj et al investigated the effect of 1, 4 dioxane on ethanol diesel blends and reported even though 10% dioxane is capable to stabilize 30% ethanol with 60% diesel with significant reductions in emissions, 70% diesel- 20% ethanol with 10% dioxane is the optimum mixture [10].

Diesel-ethanol emulsion stabilized by 2% Tetra Methyl Ammonium Bromide is investigated in this study. Each of the different ethanol proportions were mixed with diesel in different percentages by volume (20%, 25%, 30% & 35%). The mixture was then kept for 5 days during which constant stirring were carried out. This was done so as to allow maximum amount of the oil to become dissolved. After this the mixture was thoroughly filtered to remove any undissolved particles. It was absorbed that there is a colour change in the fuel. The above fuel solution was then tested in a CI engine to determine its performance an emission characteristics.

## II. Fuel Properties of Diesel, Ethanol

General fuel properties of diesel and ethanol are presented in Table 1.

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| TABLE 1 CHEMICAL PROPERTY OF DIESEL, AND ETHANOL | Molecular Formula | Molecular weight | Density at 20 °C (×10³kg/m³) | Boiling point (°C) | Flash point (°C) | Viscosity (mPa s) | Cetane Number | % of oxygen by weight |
|---|---|---|---|---|---|---|---|---|
| Diesel[a] | $C_xH_y$ | 190–220 | 0.829 | 180–360 | 65–88 | 3.35 | 45–50 | 0 |
| Ethanol[b] | $C_2H_6O$ | 46.07 | 0.789 | 78.4 | 13 | 1.20 | 8 | 35 |

*a. Table on Gasoline and Gasohol from Alcohols and Ethers, API Publication 4261, Second Edition (July 1988)*
*b. http://en.wikipedia.org/wiki/Ethanol*

## III. PARAMETER TESTED AND EXPERIMENTAL PROCEDURE

Experiments were conducted on Kirloskar TV1, Four stroke, single cylinder, and air cooled diesel engine. The rated power of the engine was 5.2kw at 1500 rpm. The engine was operated at a constant speed of 1500 rpm and standard injection pressure of 200 bars. The fuel flow rate was measured on volume basis using a burette and a stop watch. K-type thermocouple and a digital display were employed to note the exhaust gas temperature. AVL smoke meter was used for measurement of smoke density. NOx emission was measured by AVL digas analyzer. In cylinder pressure was measured with help of AVL combustion analyzer. The schematic experimental setup is shown in Fig. 1.

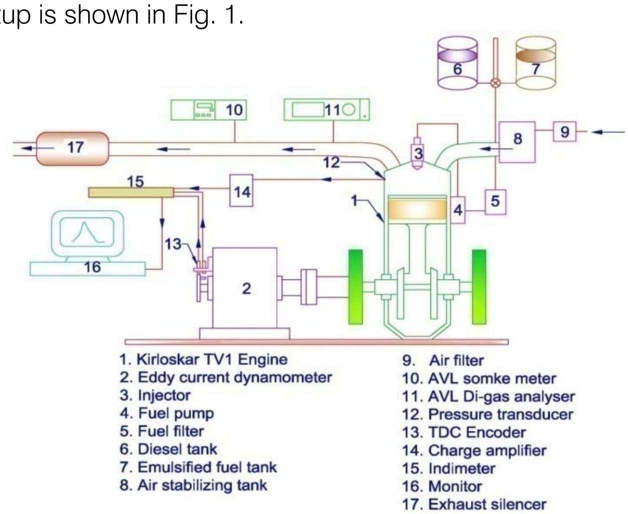


*Fig. 1 : Experimental set up*

## IV. RESULTS AND DISCUSSIONS

### *a) Performance Parameters*

The lower heat value of the ethanol makes heat value of the mixture to decrease and hence the BSFC to increase for higher blends. Fig. 2 shows the brake specific fuel consumption for different ethanol additions at peak load. Among the blends 10% ethanol shows minimum brake specific fuel consumption to other blends. Increase in BSFC at higher blends indicates that there is no cavitation due to ethanol additions.

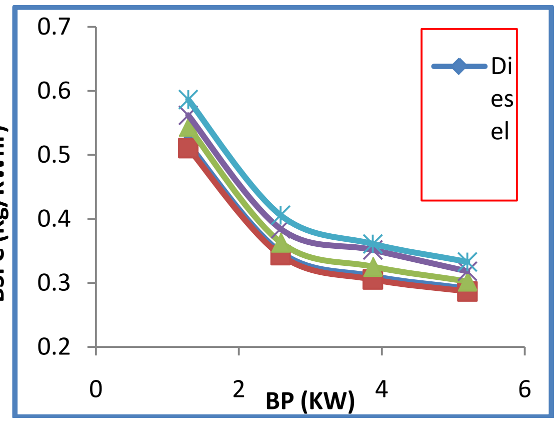


*Fig. 2 :* Breake specific fuel consumption for different ethanol concentration

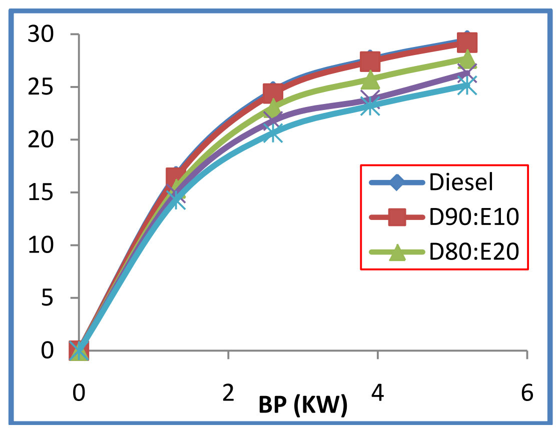


*Fig. 3 :* Breake thermal efficiency for different ethanol Concentration

Fig. 3 shows the brake thermal efficiency for different ethanol additions. From the figure it is observed that the brake thermal efficiency of 10% ethanol blends recorded a maximum of 30.5% efficiency. Improvement in combustion, especially diffusion combustion due to the increase in oxygen concentration from ethanol in the fuel is the reason for this increase in brake thermal efficiency. However, decrease in heat value of the blend makes the efficiency to decrease for higher blends.

### *b) Emission Parameters*

The variation of smoke density with respective engine brake power is shown in Fig. 4. The addition of ethanol, decrease the smoke density especially between part loads to peak load. Addition of ethanol reduces smoke density uniformly at peak load because of the decreased quenching distance and the increased lean flammability limit due to the high combustion temperature. The presence of oxygen in the fuel assists in permitting the oxidation reactions to proceed close to completion. The results reveal that the tendency to generate soot from the fuel-rich regions inside diesel diffusion flame is decreased by ethanol in the blends. 16% reduction of smoke was observed for 90D: 10E blend ratio compared with the neat fuel.

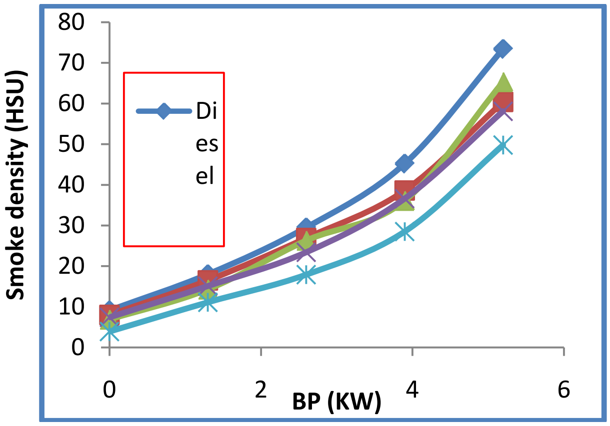


*Fig. 4 :* Veriation of smoke density for different ethanol concentration

The presence of oxygen increases the heat release rate for the oxygenated fuel and hence the NOx emission will be high. The anticipated increase in NOx emissions as a function of increasing ethanol concentration is apparent in Fig. 5. Nitrogen oxides emissions are predominately temperature phenomena. It can be seen that NOx emissions of all blends increase more rapidly than those of neat fuel as ethanol proportion and load increase at medium and high loads. The maximum increase in NOx emissions occur at 80~100% full load conditions because of long ignition delay and rich oxygen circumstance from ethanol in the mixture.

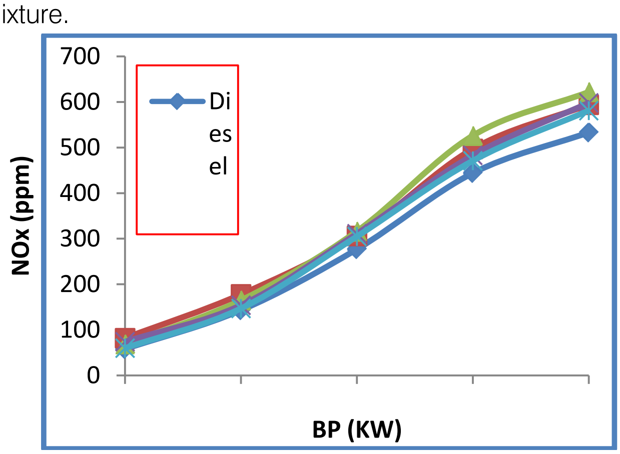


*Fig. 5 :* Veriation of NOx emmissions for different ethanol concentration

*b) Combustion Parameters*

Oxygen molecules presented in ethanol increase the spray optimization and evaporation and hence the combustion process of the engine. Fig. 6 illustrates cylinder pressure traces for different ethanol blended diesel fuels for various conditions of the engine. A peak pressure of 74 bars for 10% ethanol blend was recorded while it was 68 bars for neat fuel. The oxygenated fuel engine has longer delay period compared to neat fuel.

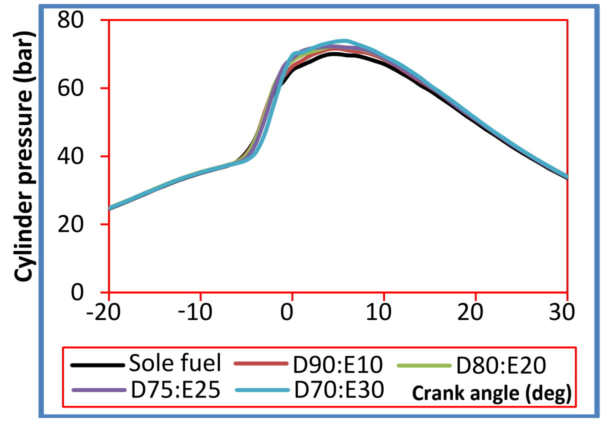


*Fig. 6 :* Cylinder pressure for different crank angle.

Fig. 7 illustrates heat release rate of the oxygenated fuel blends and neat fuel at different crank angle. The heat release rate is high for oxygenated fuels due to the longer duration of the combustion. It can be seen that heat release rate curves of the oxygenated fuel blends and neat fuel show similar pattern. The reason is the rate of diffusion combustion of the oxygenated fuel increases the heat release rate and consequently oxygenated fuel has controlled rate of pre-mixed combustion.

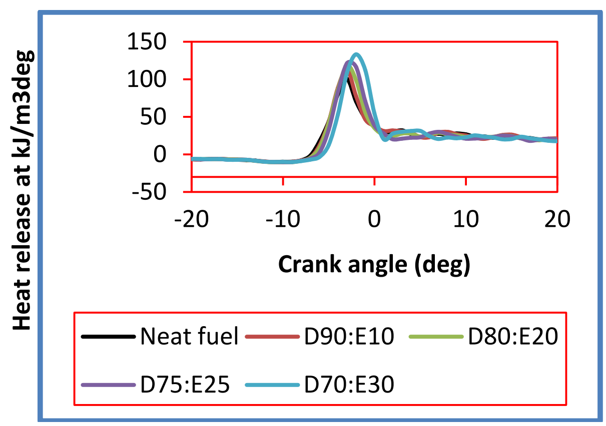


*Fig. 7 :* Heat release rate for different crank angle.

## V. Conclussions

The results of the present study may be summarized as follows,

- Addition of 2% Tetra Methyl Ammonium Bromide as surfactant can stabilize up to 30% ethanol with diesel.
- The specific fuel consumption decreases with increase in ethanol blend in diesel fuel but 90D: 10E shows lower specific fuel consumption.
- Brake thermal efficiency decreases with increase in ethanol ratio. However, 90D: 10E shows equal performance compared with neat fuel.
- Considerable amount of smoke reduction with a

little penalty in NOx was resulted

- Maximum cylinder pressure and heat release rate for blends were found to be increased.

On the whole it is concluded that 2% addition of Tetra Methyl Ammonium Bromide by virtue of its properties is capable to stabilize 30% ethanol with 70% diesel by volume, and 10% ethanol diesel emulsion can be used in a compression ignition engine with significant reduction in exhaust emissions as compared to neat diesel without any engine modifications.

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