Optimizing the Fuel Concentration for a Diesel Engine Driven By Diesel – Ethanol Emulsion By Techno-Evaluation

Dr.S.Peniel Pauldoss
Professor, Mech.Dept, Kasireddy Narayan Reddy College Of Engineering And Research, Abdullapurmet, Hyderabad, Telengana, India

ABSTRACT

The focus of this study lies on evaluating the performance, emission and combustion characteristics of Di-Diesel Engine for various compositions of Diesel-ethanol emulsion stabilized by 2% Tetra Methyl Ammonium Bromide. A performance window encompassing the core data base is created. The fuel proportion is optimized with Historical Data in the design of experiments software using Annova.

Keywords: Performance, Techno-evaluation, Diesel-ethanol emulsion, Diesel engine

INTRODUCTION

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 tradeoff 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 (Heywood JB, 1988). When oxygen content in the fuel reaches approximately 30% by mass, smokeless combustion in diesel engines could be realized (Stone R, 1999). 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 (Kouremenos DA, 1986).

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 color change in the fuel. The above fuel solution was then tested in a CI engine to determine its performance and emission characteristics and the results were optimized

EXPERIMENTATION

Experimental Set Up: 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 experimental set up employed for this investigation is shown in figure 1.

The fuel components and their individual properties are presented in table1.

Evaluation and Testing: It is imperative to assess the system with respect to three prominent factors that significantly govern the overall behavior and performance viz., Performance, Emission and Combustion. The results are briefly presented in the following section:

Performance Assessment: Fig. 2 shows the 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 SFC at higher blends indicates that there are no cavitations due to ethanol additions. Fig 3 shows the optimization result for peak load using design of experiments software and reveals that 92.5% diesel along with 7.5% ethanol is the optimum ratio of the fuel mixture.

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 11, November 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

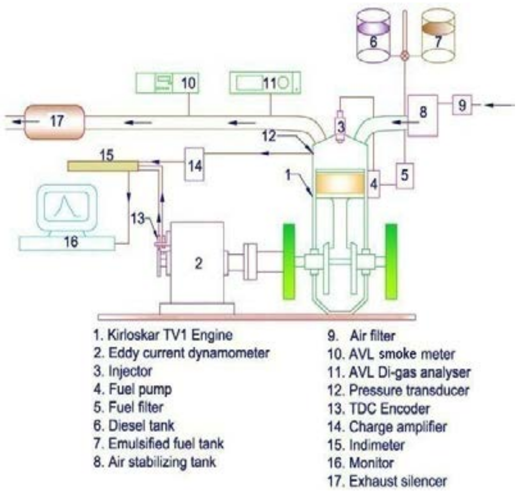


Figure.1.Experimental Set Up

Table 1. General fuel properties of diesel and ethanol

Chemical Property of Diesel and Ethanol	Molecular Formula	Molecular Weight	Density at 20°C (×103kg/ m2)	Boiling point (°C)	Flash point (°C)	Viscosity (mPa s)	Cetane Number	% of oxygen by weight
Diesel[a]	CxHy	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

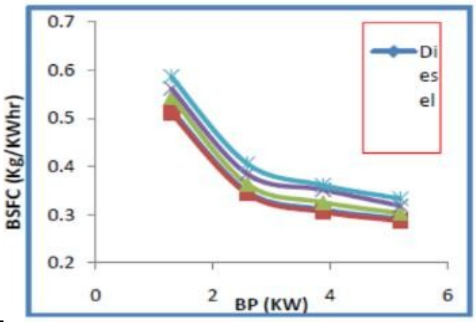


Figure.3. Specific Fuel Consumption for various ethanol concentrations

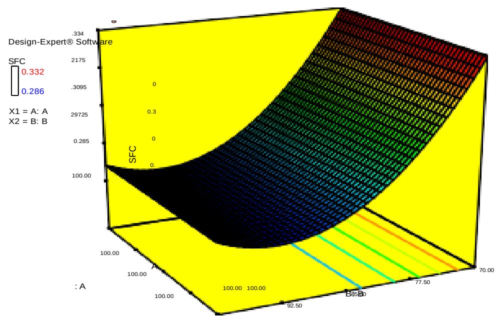


Figure.4.Optimized value of fuel ratio with respect to SFC at peak load

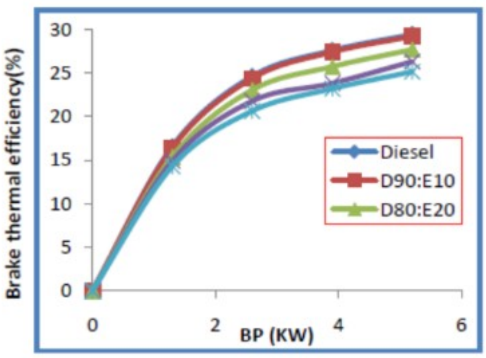


Figure.5.Brake Thermal Efficiency for Different Ethanol Consumption

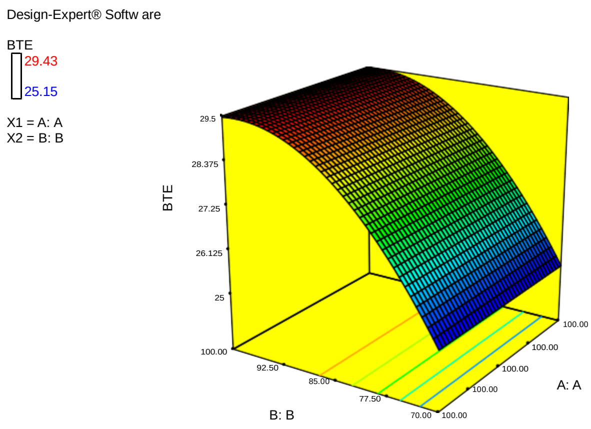
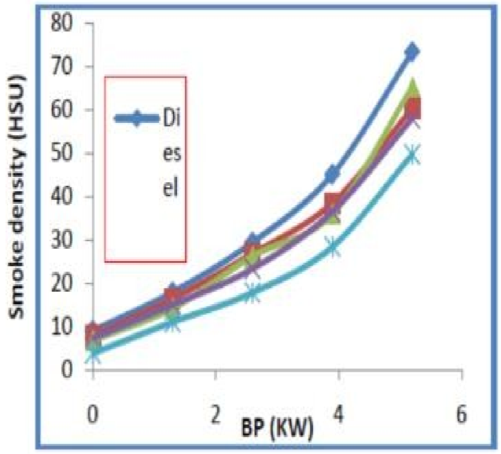


Figure.6.Optimized value of fuel ratio with respect to BTE at peak load



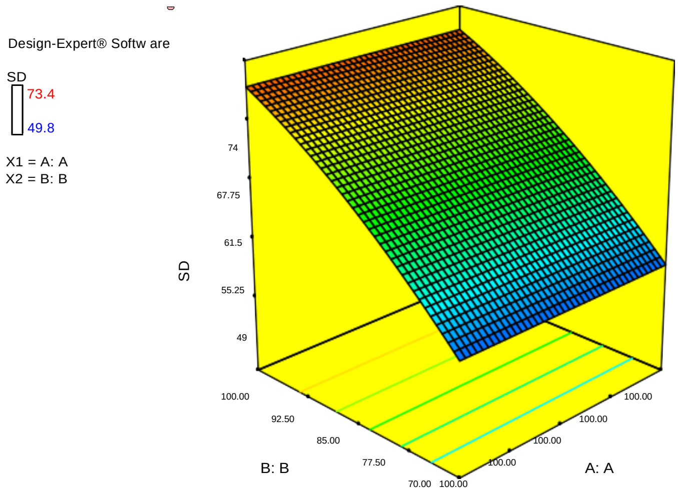
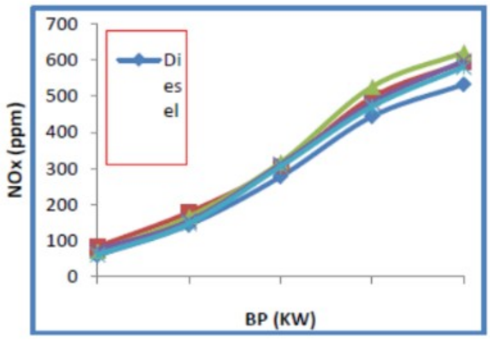


Figure.7.Variation of smoke density for different ethanol concentration

Figure.8.Optimized value of fuel ratio with respect to smoke density at peak load



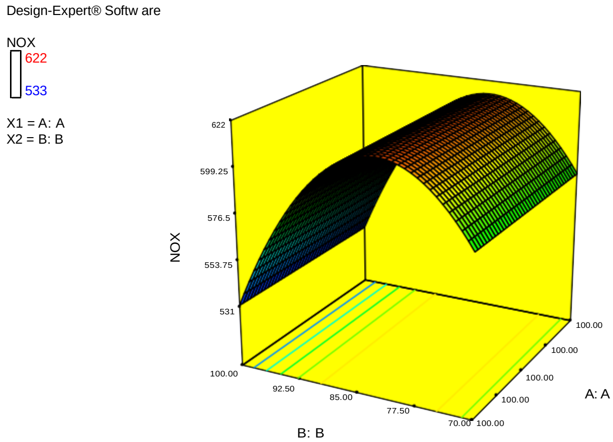


Figure.9.Variation of NOx emissions for different ethanol concentration

Figure.10.Optimized value of fuel ratio with respect to NOx at peak load

Emission Behavior: The variation of smoke density with respective of engine brake power is shown in Fig.7. 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. The optimization chart on peak load is shown in Fig. 8

The presence of oxygen increases the heat release rate for the oxygenated fuel and hence the NOx emission will be high. 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. The optimization process is shown in Fig. 10

Combustion Factor Analysis: Oxygen molecules presented in ethanol increase the spray optimization and evaporation and hence the combustion process of the engine. Fig. 11 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. Optimization process using study of experiments software is presented in Fig. 12

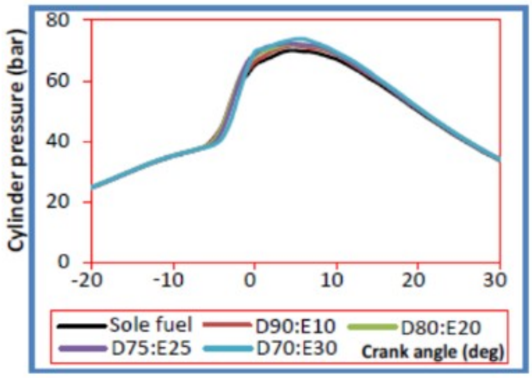


Figure.11.Cylinder pressure for different crank angle

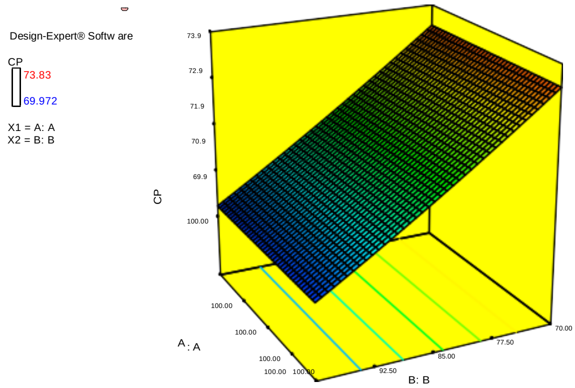


Figure.12.Optimized value of fuel ratio with respect to cylinder pressure at peak load

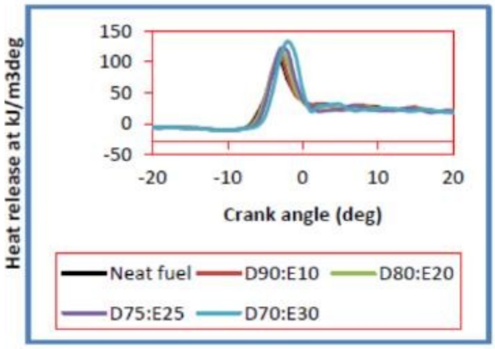


Figure.13.Heat release rate for different crank angle

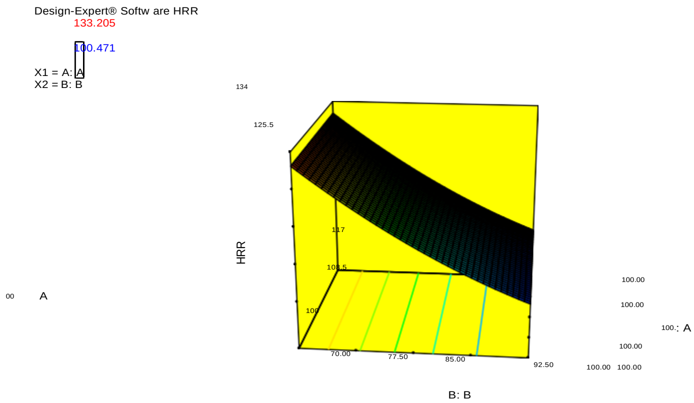


Figure.14.Optimized value of fuel ratio with respect to Maximum Heat Release Rate at peak load

Fig.13 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. The optimization process for the peak load is shown in the Fig. 14

CONCLUSIONS

Conclusions are summarized in this section: The specific fuel consumption increases with increase in ethanol blend in diesel fuel but less than sole fuel. 90D: 10E shows lower specific fuel consumption. The brake thermal efficiency for 90D: 10E blend is almost same when compared to sole fuel. Smoke reduction is 8 HSU for 80D: 20E at peak load for the normal engine. All blends shows increase in NOx emission when compared to sole fuel at all engine conditions. Cylinder pressure is higher for 90D: 10E blends than other blends. The peak pressure and heat release rate for blends are higher than sole fuel. On the whole it is concluded that 90D:10E with 2% TMAB as surfactant can be used as fuel in a compression ignition engine with improved performance and significant reduction in exhaust emissions except NOx as compared to neat diesel and that can be controlled by other techniques like turbo charging, exhaust gas recirculation, etc. The study of experiments software is used for optimizing the results with initial design using Historical Data at peak load by considering SFC, BTE, SD, NOx, HRR, CP as variables and found that 92.5D:7.5E is the optimum fuel ratio.

REFERENCES

C. Sundar Raj and C. G Saravanan, Influence of Hexanol – Diesel Blends on a single cylinder Diesel Engine, Thermal Sciences, 15(4), 2011, 1215-1222

C. Sundar Raj and C. G Saravanan, Performance and Emission Analysis of a Single Cylinder Constant Speed Diesel Engine Fuelled with Diesel-Methanol-Isopropyl Alcohol Blends, SAE index 2012-01-1683

C. Sundar Raj, S. Arul, S. Sendilvelan, C.G. Saravanan, Comparative Assessment on Performance and emissions characteristics of Diesel Engine Fumigating with Methanol, Methyl Ethyl Ketone and LPG, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 32(17),2010, 1603-1613.