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Potential of Diethyl Ether Blends with Biodiesel in DI Diesel Engine – An Experimental Investigation.

S.Sudhakar[1], Dr.S.Sivaprakasam[2]

[1] Assistant Professor, Department of Mechanical Engineering, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India

[2] Associate Professor, Department of Mechanical Engineering, Annamalai University, Annamalainagar – 608 002, Tamil Nadu, India

Abstract:

In this experimental investigation, the various percentage of diethyl ether were blended with biodiesel (B20) and the performance , emission and combustion characteristics of single cylinder DI diesel engine were compared to analyze the potential of diethyl ether. The optimal percentage of diethyl ether blend had derived to find out the maximum possibility of fossil fuel replacement. The best blend of Mahua oil with diesel (B20) was chosen with previous observations made, and then addition of diethyl ether in the percentages of 5, 10, 20 and 30 were done respectively and the observations are compared. The results indicated that brake thermal efficiency of DEE blends were improved than others. The smoke densities were slightly increased for all DEE blends. The NOx emissions were decreased at full load of test engine and the deviations were small in all other loads. The shortened ignition delay was noticed for all blends of DEE. The variations in cylinder pressures were nominal compare with sole diesel and B20.

Key words:

Performance, Emission, Combustion, Diethyl Ether (DEE), Mahua blends, Bio diesel.

Introduction:

The growing percentage of vehicle population makes us hardly to find alternative fuels. Harmful emissions like nitrogen oxide (NOx) and particulate matter from the diesel engines are detrimental to the environment as well as to the human being which adds to the problem. Alternative fuels like biodiesel, etc. are getting importance due to their performance and emission characteristics. Many researches on Diethyl ether have been investigated in literature [1–3]. However, only a few studies related to using Diethyl ether in diesel engines have been conducted.

In an experimental study, carried out by Agarwal et al and Jai-In Samai [4 -6] the effects of using Biodiesel on the performance, combustion and exhaust emission characteristics were investigated in a DI diesel engine. They found that NO, smoke and PM emissions were reduced. Pugazhvadivu et al and B. Bailey [8-10] experimentally evaluated and stated that 15% to 20% of Diethyl Ether addition was more beneficial in reducing NOx compared to 10% Diethyl ether by using the combination of Diesel, Pongamia biodiesel. From the literature review reveals that Diethyl ether having some potential viability to replace the fossil fuel.

India is an agricultural based country and having large potential for Ethanol production. Large quantity of diethyl ether can be produced from ethanol in India by the process of dehydration. From intensive literature survey it was clearly known that biodiesel are the best substitute for CI engine fuels.

Test fuels:

Table 1: Properties of Test Fuel.

Properties	Diesel	Mahua Oil	B20	DEE
Density- Kg/m^3	833	884	838	713.4
Specific gravity	0.831	0.889	0.84	0.712
Kinematic Viscosity cSt (mm^2/s) @40° C	3.0	6.04	3.5	0.23
Cetane number	49	52.4	50.6	127
Flash point °C	64	170	71	-40
Low calorific value(MJ/KG)	42.5	39.7	41.9	33.8

From the previous evaluation, optimal blend of mahua oil with diesel has been chosen by comparision the results. The emission and performance characteristics of 20% mahua oil with diesel (B20) were produced the evitable results. So various percentages of Diethyl ether like 5, 10, 20 and 30 with B20 were made and subjected to the stability test. More than 30% of Diethyl ether with B20 is not stable for longer days. According to the stability test results the limitations are made the blend of Diethyl ether up to 30 percentages with B20. Finally the study involves the comparison of emission and performance parameters of sole diesel, B20, B20+5%dee, B20+10%dee, B20+20%dee and B20+30%dee. The properties of test fuels were shown in table 1.

Experimental setup:

The experiment was conducted on Kirlosker TV-1 engine. The specifications of the engine were tabulated in table 2.The engine ran at constant speed at 1500 rpm for different load conditions. For applying loads the engine was coupled to an eddy current dynamo meter and the smoke density was measured using an AVL smoke meter. Nitrogen oxides emissions were measured using AVL Di-gas analyzer. The exhaust gas temperature was measured by the thermocouple connected with digital indicator. Combustion parameters like cylinder pressure, heat release rate and maximum pressure were measured by AVL combustion analyzer and specifications of all measuring instruments are given in table 3.

Table 2: Specifications of Test Engine.

Engine type	Single cylinder,4stroke,DI
Bore	87.5 mm
Stroke	110 mm
Comp. ratio	17.5 : 1
Rated power	5.2 KW
Rated speed	1500 rpm
Fuel type	Diesel
Cooling System	Water
Injection pressure	220 kgf/cm^2
Ignition Timing	23° Before TDC (rated)

The experimental setup are shown in figure 1.The experiment was conducted on sole diesel, B20(Diesel+ 20% mahua oil), B20+5%dee, B20+10%dee, B20+20%dee and B20+30%dee to find out the optimum blend of Diethyl ether. The engine was allowed to run with sole diesel fuel at a constant speed for nearly 30 minutes to attain the steady state condition at the lowest possible load. The following observations were made two times and the average was recorded.

Table3: Measuring Instruments Specifications

TYPE	Measuring Range
AVL- Smoke meter	0 – 99.99 opacity in %
AVL-DIGAS Analyzer	HC / ppm 0 - 20000 CO / % 0 – 10, NOx / ppm 0 – 4000, CO2 / % 0 – 20.
AVL-Combustion Analyzer	Upto 250 bar

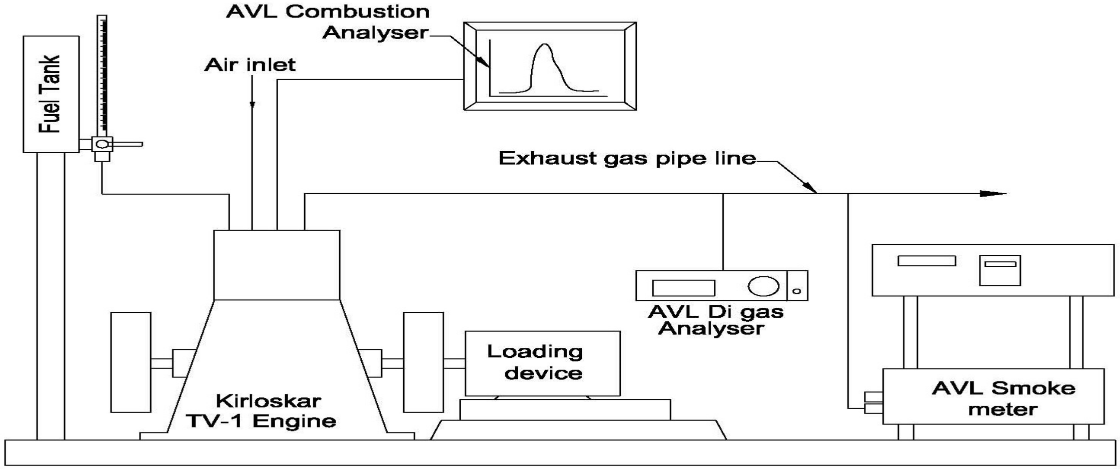

Figure 1 – Experimental Setup

Result and Discussion:

Performance Characteristics:

The specific fuel consumption variations with brake power of the tested fuels were shown in figure 2. It was obvious that the SFC for all DEE blends decreases but B20 shows the similar with sole diesel. When the percentage of Diethyl ether increases, the specific fuel consumption was reduced significantly. This was due to lower heating value of biodiesel and combination of biodiesel and diethyl ether. The calorific value of diethyl ether is much lower than diesel fuel. Therefore, more fuel was required to obtain the same.

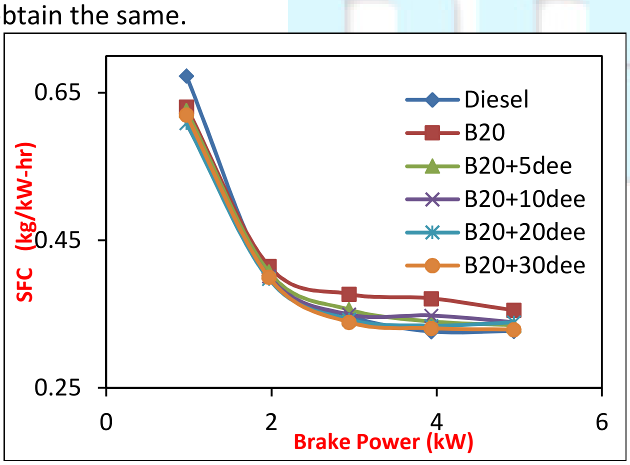

Figure 2: Specific Fuel Consumption variations.

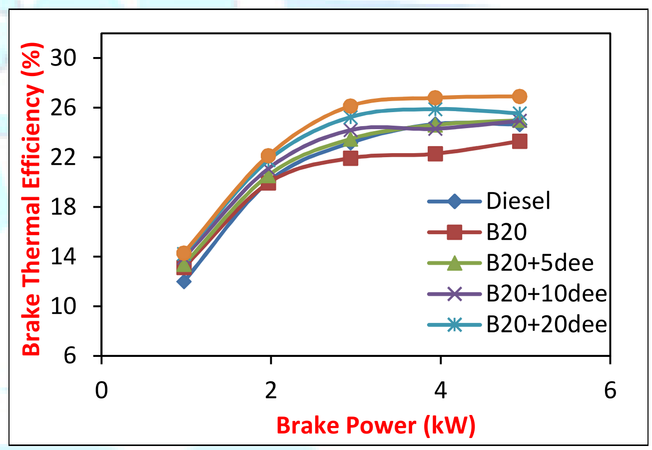

Figure 3: Brake Thermal Efficiency Variations.

Engine BTE was improved by means of adding oxygenated fuel to diesel. The variations in BTE were shown in figure 3. From the comparison, it clearly shows that all blends of diethyl ether particularly B20+30%dee proven higher brake thermal efficiency for the following reasons: the quality of the spray with blend fuels was improved since the viscosity of Diethyl ether is lesser than that of diesel; the combustion is more complete in the fuel-rich zone due to the oxygenate of ether, so that the combustion efficiency is enhanced.

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Emission Characteristics:

The variations of the exhaust gas temperature were shown in figure 4. The enhanced combustion leads the temperature of the engine slightly high at initial stages of diethyl ether blends than biodiesel, but in higher level loads it shows identical. The variations of smoke density were shown in figure 5. From the results, the smoke density remains same at low loads of test engine for diethyl ether blends than biodiesel (B20), due to high viscosity of mahua oil that affects the ionization of test fuel in combustion chamber, when engine tested with only B20.At higher level loads the smoke density increases for diethyl ether blends than sole diesel, biodiesel B20.

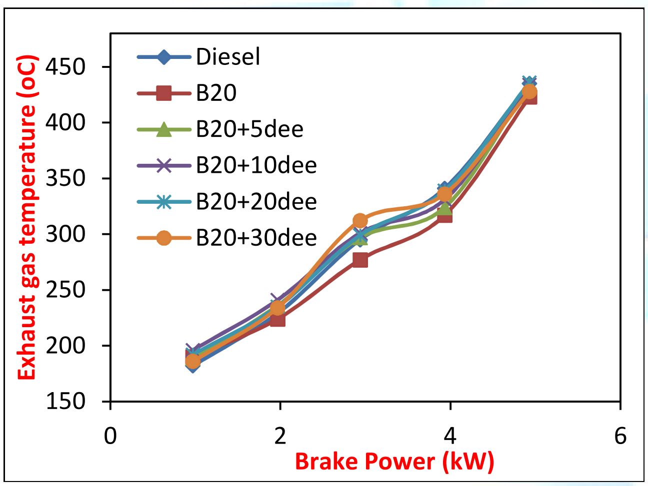

Figure 4: Exhaust Gas temperature Variations.

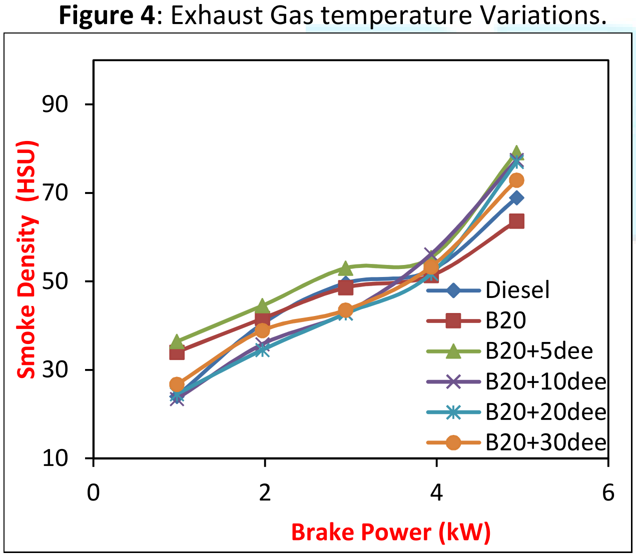

Figure 5: Smoke Density Variations.

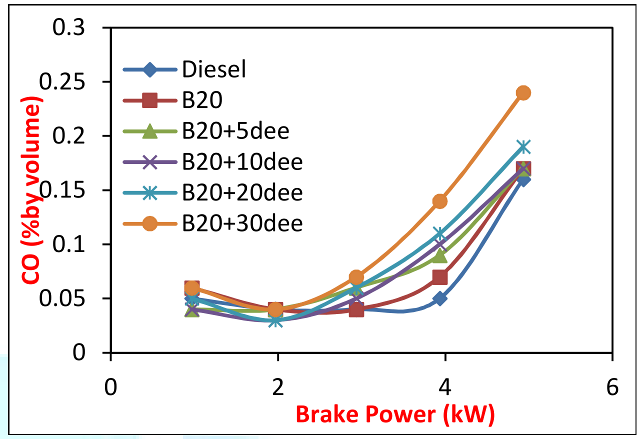

Figure 6: CO Emission Variations.

The CO emission variations for different percentage of diethyl ether were shown in figure 6. At lower level loads (20%, 40% and 60%loads) CO emissions were similar but in high level loads the CO emissions were observed high. While increasing percentages of diethyl ether at high loads leads a significant increase in CO emission due to lower combustion temperature affects the oxidation of CO. Emissions of CO from a DI diesel engine mainly depends upon the physical and chemical properties of the fuel. However biodiesel shows the reduced smoke emission than diesel.

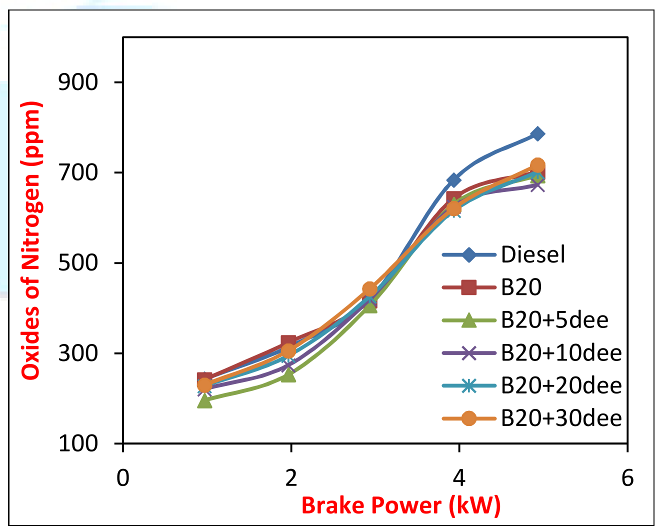

Figure 7: Oxides of Nitrogen Emission Variations.

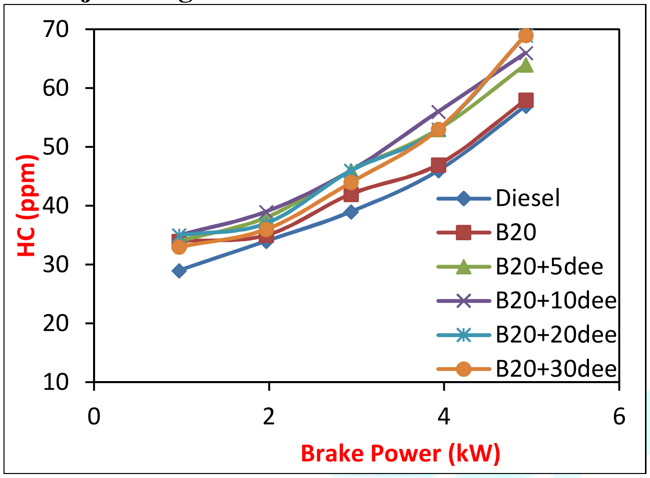

Figure 8: HC Emission Variations.

The oxides of nitrogen emissions were shown in figure 7. The 10, 20 percent diethyl ether addition produced decreased NOx emission than other test fuels. Combustion was more complete in the fuel-rich zone due to oxygenate of ether leads poor diffusion phase combustion. This may cause for decreased NOx emission. The variations of HC emission were shown in figure 8. The hydrocarbon emissions of diethyl ether blends are increased significantly compare with sole diesel, biodiesel (B20). The formation of unburned HC originates from various sources in the engine cylinder. It can be observed that HC emissions are slightly higher than that of B20.

Combustion Characteristics:

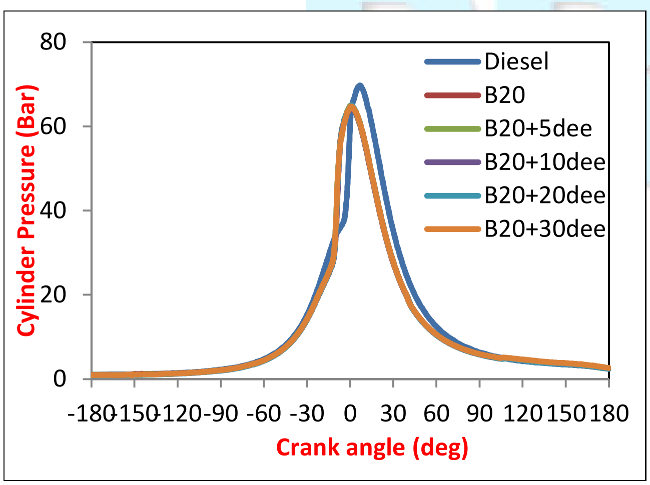

Figure 9: Cylinder Pressure Curves for Full Load of Test Rig.

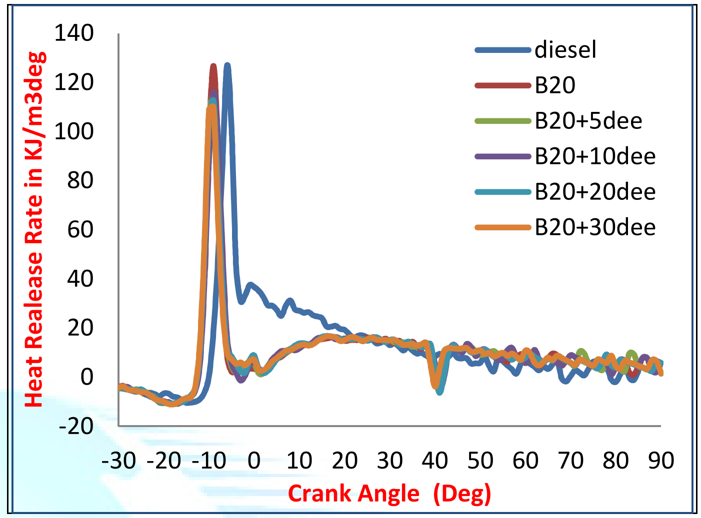

Figure 10: Heat Release Rate Curves for Full Load of Test Rig.

The heat release rate and cylinder pressure for full load of test rig with crank angle were shown in the figures 9 and 10 respectively. The vaporization of the fuel accumulated during ignition delay period leads to negative heat release rate at the beginning of combustion were observed for all type test fuels. The B20 and diethyl ether blends were produced improved pre combustion than diesel fuel. After combustion was initiated, the heat release rate becomes positive, which leads to combustion starts earlier for B20. The peak heat release rate of B20 slightly higher than diethyl ether blends, and B20+30%dee is the lowest. The crank angle of peak heat release rate of B20 and diethyl ether blends were earlier than sole diesel. The reason may be similar to that latent heat value of diethyl ether is lower than that of biodiesel and sole diesel. In addition, the cetane number of biodiesel and diethyl ether were very high, which can further explain the shortened ignition delay.

Conclusion:

From this experimental study, it was concluded that blending of diethyl ether with biodiesel upto 20 percent shows better stability than others and it can be used in DI diesel engines without any modifications. Addition of DEE with biodiesel decreased the viscosity and thereby increased the atomization of air fuel mixture. This was the cause for the enhancement in Brake thermal efficiency.

Biodiesel, Diethyl ether having higher oxygen content than diesel, shows excellent ability to eliminate smoke emissions at lower level engine loads. NOx emissions were decreased when diethyl ether percentage increases due to low ignition temperature of DEE leads to good combustion. The CO and HC emissions of bio diesel and diethyl ether blends were slightly higher at full load of test rig. The combustion characteristics for B20 and diethyl ether with B20 were almost identical. The 10% to 20% addition of higher oxygen content and high volatility fuels, such as diethyl ether, can be a promising alternate with biodiesel/diesel blend without any modifications of engine.

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