Performance Analysis of Diesel Engine Fuelled With Blend of Waste Cooking Oil Biodiesel and Diethyl Ether

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Abstract- Bio-diesel production technology and its use as fuel for diesel engine is an area for researchers due to the depletion, increase in the price and the environmental issues using petroleum diesel. Transesterification is the most common method used for preparation of monoalkyl esters of vegetable oils and fats now called bio-diesel. Physical and chemical properties of biodiesel are comparable with that of diesel therefore bio-diesel can be an alternative to petroleum-based fuels. To improve the quality of the bio diesel based fuel additives can be added which also helps in reducing the exhaust emissions from engine. In the present work, bio diesel is prepared from waste cooking oil (WCO) collected from various sources like restaurants, mess, catering services etc and Diethyl ether is added to it (5%.10%, 15% w/w) as an additive. Experiments are conducted with these fuels for operating single cylinder diesel engine. Results indicate engine performance with bio diesel and 15% diethyl ether is comparable with diesel.

Indexed Terms- Biodiesel, Transesterification, Diethyl ether, NO_x.

I. INTRODUCTION

Physical and chemical properties of biodiesel are comparable with that of diesel like energy density, heat of vaporization, and stoichiometric air/fuel ratio [1]. However bio diesel has higher viscosity, cold starting problems, lower power output and higher nitrogen oxides (NOx) emission compared with diesel oil. In order to increase the engine power output and reduce emissions especially NOx, addition of Diethyl Ether (DEE) as an oxygenated additive to the biodiesel appears to be a promising approach. The advantages of using this alternative fuel are its renewability, better quality of exhaust gas emissions, and its biodegradability [7]. Investigations made on the addition of diethyl ether (DEE) to biodiesel revealed that these additives are very promising in reducing the emissions and the smoke because of the oxygen content present in it [2].

II. EXPERIMENTAL WORK

In this present work, biodiesel from waste cooking oil (WCO) was prepared using esterification process. The Diethyl Ether is used as an additive to WCO biodiesel. DEE is clear colorless liquid at room temperature and was found to be miscible with WCO biodiesel. Fuel samples were prepared by adding DEE 5% to 15% with an increment of 5% to WCO biodiesel. The engine performance tests were conducted on a computerized 3.5 KW VCR single cylinder four-stroke, direct injection and water-cooled diesel engine test rig. It is directly coupled to an eddy current dynamometer. The engine and the dynamometer are interfaced to a control panel, which is connected to a computer. Test rig is provided with necessary equipment and instruments for the measurements of cylinder pressure and crank angle with accuracy.

These signals are interfaced to computer through an analog and digital converter (ADC) card PCI-1050 which is mounted on the motherboard of the computer. The computer software Engine Soft Version 2.4 supplied by the test rig supplier "Apex Innovations Pvt. Ltd" was used for recording the various test parameters.

The experiments are conducted at standard injection timing, injection pressure, compression ratio, constant speed of 1500 rpm, at no-load, 25%, 50%, 75% and 100% full load conditions with diesel, WCO and WCO with DEE (5%, 10% and 15% w/w). The required data recorded online using software and stored in the computer hard disk and used for further calculations.

2.1 PROPERTIES OF DIETHYL ETHER

The fuel additive, Diethyl ether is a clear colourless liquid at room temperature. It is also known as ether and ethoxyethane, is a highly flammable liquid with a low boiling point and a characteristic smell. It has a high volatility and low auto ignition temperature. Molecular formula of diethyl ether is C2H5OC2H5. Table 1 gives some of the physical and chemical properties of Diethyl ether.

Properties	Diesel	Diethyl
Formula	C_8 to C_{20} and	$C_2H_5OC_2H_5$
Density(kg/m^3)	833	713
Viscosity at 20°C	2.6	0.23
Boiling point °C	163	34.4
Auto-ignition	257	160
Calorific value	42500	33900

Table 1.Physical and chemical properties of diesel and DEE

2.2 EXPERIMENTAL SETUP

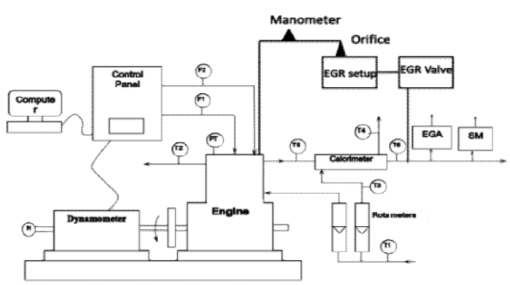

Figure.1. Engine Test-rig block diagram

Where,
T1, T3: Inlet Water Temperature
T2:Outlet Engine Jacket Water Temperature
T4:Outlet Calorimeter Water Temperature
T5:Exhaust Gas Temperature before Calorimeter
T6:Exhaust Gas Temperature after Calorimeter
F1:Fuel Flow DP (Differential Pressure) unit
F2: Air Intake DP unit
PT:Pressure Transducer
N: RPM Decoder
EGA: Exhaust Gas Analyser (5 gas)
SM: Smoke meter

III. RESULTS AND DISCUSSIONS

3.1 Brake Thermal Efficiency (BTE)

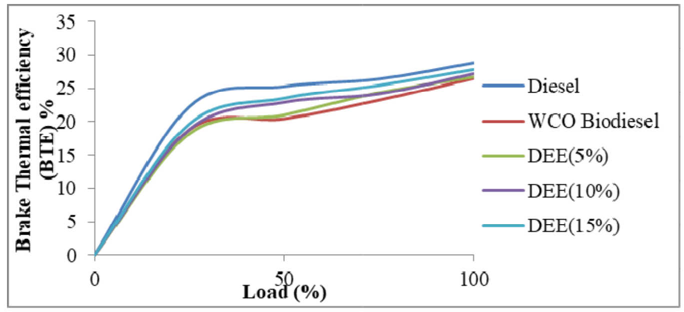

Figure2.The variation of BTE for various fuel samples

3.2. Brake Specific Energy Consumption (BSEC)

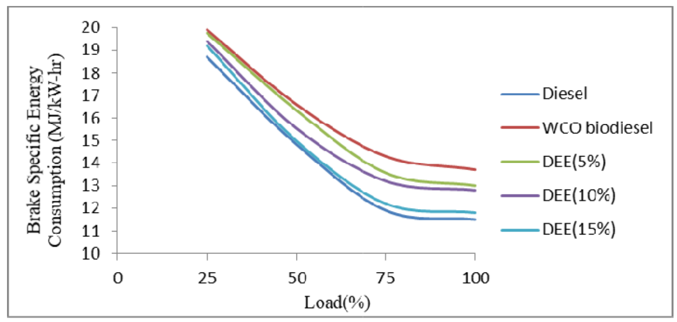

Figure.3. the variation of BSEC for various fuel samples

3.3. Brake Specific Energy Consumption (BSEC)

Figure 3 shows the variation of brake specific energy consumption for various fuels. It is observed that as the load increases decrease in BSEC is observed for all the sample fuels. However, lower energy consumption is observed for diesel fuel. As the percentage of DEE in WCO biodiesel is increased reduction in brake specific energy consumption is observed at all loads. Brake specific energy consumption with DEE (15%) in WCO biodiesel at full load is 11.8 MJ/kW-hr is observed whereas that of for diesel is 11.5 MJ/kW-hr, which is comparable to that of diesel.

3.4. Nitrogen Oxides (NOx) Emissions

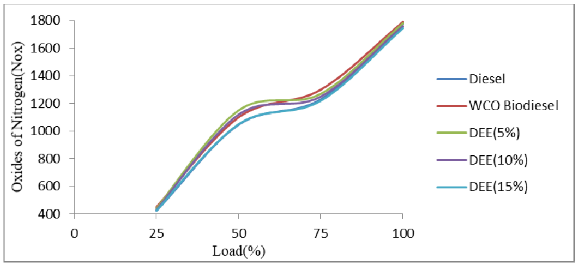

Figure.4. the variation of oxides of nitrogen for various fuel samples

Figure 4 shows the variation of oxides of nitrogen for various fuels. It is observed that as the load increases emission of oxides of nitrogen increases for all fuels due to increase in in- cylinder combustion temperature with increase load, as more fuel is burnt in combustion chamber for developing higher power. Higher emission of oxides of nitrogen is observed for WCO biodiesel compared to all the sample fuels. The reason may be due to higher combustion temperature as compared to diesel. The impact of adding DEE to WCO biodiesel fuel on NOx emission is observed. With addition of diethyl ether to WCO biodiesel decrease in NOx emission is observed. This result is may be due to addition of DEE improves cetane number of fuel, which decreases NOx emission fuel accumulated during delay period and higher latent heat of evaporation of DEE. Lowest NOx emission is observed with DEE (15%)

IV. CONCLUSION

Salient features of the conclusions that were drawn based on this experimental analysis using various DEE blends with WCO biodiesel are as follows:

- Use of DEE addition to WCO biodiesel increased BTE in general due to its oxygen content and its effect on lowering the viscosity of the blend.
- A reduction in brake specific energy consumption with addition of DEE in WCO biodiesel at all loads is observed.
- Addition of 15 percent of DEE to WCO biodiesel results in lower level of oxides of nitrogen emission to that of diesel at all load conditions.

From the various sample fuels DEE (15%) was found to be the optimum blend on the basis of emission and performance characteristics.

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