Performance Analysis of C. I. Engine Fuelled With Blend of Biodiesel and Diethyl Ether with Egr Technique

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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 and also NOx emission can be effectively controlled by employing exhaust gas recirculation (EGR). 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 15% w/w) as an additive. Experiments are conducted with diesel, WCO and blend of WCO and! %%DEE, these fuels for operating single cylinder diesel engine. Results indicate engine performance with bio diesel and 15% diethyl ether with 10% EGR is comparable with diesel.

Indexed Terms- Biodiesel, Transesterification, Diethyl ether, NOx, EGR

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. This higher NOx emission can be effectively controlled by employing EGR [1].The advantages of using this alternative fuel are its renewability, better quality of exhaust gas emissions, its biodegradability [2]. 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 [7]. Exhaust gas recirculation technique can be used for reducing the emission of oxides of nitrogen. Introduction of exhaust gases reduces the combustion temperature due to less air fuel mixture available and poor combustion results in lower oxides of nitrogen emission.

II. EXPERIMENTAL WORK

In this present work, biodiesel from waste cooking oil (WCO) was prepared using Transe-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 sample was prepared by adding DEE 15% to WCO biodiesel. The 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 were 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 15% w/w with 5%, 10% and 15% EGR. 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 colorless 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 $C_2H_5OC_2H_5$. 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

2.2 EGR calculations

EGR is an effective technique of reducing NOx emissions from the diesel engine exhaust. EGR involves replacement of oxygen and nitrogen of fresh air entering in the combustion chamber with the carbon dioxide and water vapor from the engine exhaust. The recirculation of part of exhaust gases into the engine intake air increases the specific heat capacity of the mixture and reduces the oxygen concentration of the intake mixture. These two factors combined lead to significant reduction in NOx emissions [1]. EGR (%) is defined as the mass percentage of the re-circulated exhaust (mEGR) in total intake mixture (mi).

$$\% EGR = \left(\frac{m_{EGR}}{m_i}\right) \times 100 \qquad (1)$$

Where $m_i = (m_a + m_f + m_{EGR})$

m_a = Mass flow rate of air into the engine

m_f = Mass flow rate of fuel into the engine

m_{EGR} = Mass flow rate of recycled exhaust gases

2.3 EXPERIMENTAL SETUP

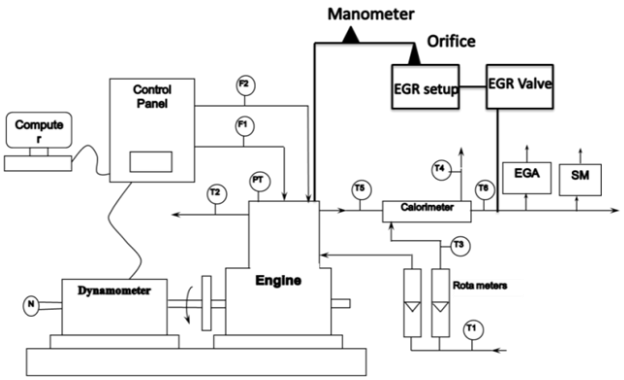

Figure 1. Engine Test-rig block diagram

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 Analyzer (5 gas)
SM: Smoke meter

III. RESULTS AND DISCUSSIONS

3.1 BRAKE THERMAL EFFICIENCY (BTE)

Figure 2 shows the variation of BTE for different fuels with and without EGR. It is observed that increase in percentage of EGR results in decrease in BTE for all fuels. This may be due to the facts that increase in percentage of EGR increases the dilution of charge available for combustion, reduction in flame speed leading to poor combustion and reduction in brake thermal efficiency. With 15% DEE and WCO biodiesel blend BTE is decreased to 27.4%, 27%, and 26.8% with 5, 7 and 10% EGR respectively compared to the 27.83% without EGR. Hence 15% DEE in WCO blend gives better thermal efficiency compare to diesel.

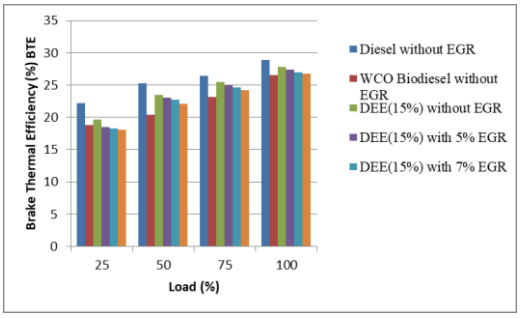

Figure 2: The variation of BTE for various fuel samples with EGR

3.2 BRAKE SPECIFIC ENERGY CONSUMPTION (BSEC)

Figure 3 shows the variation of BSEC for various fuel samples with and without EGR. It is observed that increase in percentage of EGR results in increase in the BSEC. Brake specific energy consumption with DEE (15%) in WCO biodiesel without EGR at full load is 11.8 MJ/kW-hr is observed. Whereas with 15% DEE and WCO biodiesel blend BSEC is increased to 12 MJ/kW-hr, 12.6 MJ/kW-hr and 12.8 MJ/kW-hr with 5, 7 and 10% EGR respectively. The 15% DEE in WCO biodiesel blend gives the better results with and without EGR at full load condition.

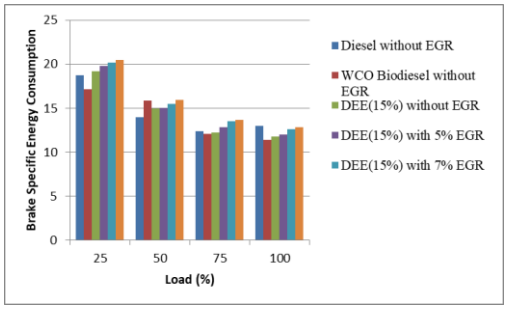

Figure 3: The variation of BSEC for various fuels with EGR

3.3 NITROGEN OXIDES (NO_X) EMISSIONS

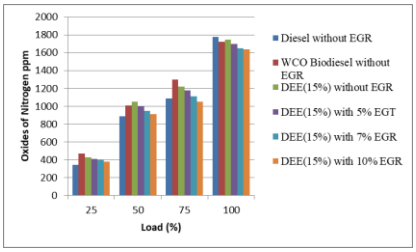

Figure 2: The variation of NO_x for various fuels with EGR

Figure 4 shows variation of NOx emissions with load for all test fuels. Increase in percentage of EGR resulted in reduction in oxides of Nitrogen emissions because of reduction in combustion temperature due to dilution of charge available for combustion. With 15% DEE and WCO biodiesel blend NOx is decreased marginally to 1700 ppm, 1650 ppm and 1640 ppm with 5, 7and 10% EGR compared to the without EGR. Hence 15% DEE and WCO biodiesel blend gives lower Nox emissions compared to diesel.

CONCLUSION

From above experimental investigations following conclusions are drawn

- Increase in percentage of EGR results in reduction in brake thermal efficiency.
- Reduction in oxides of nitrogen emissions are observed with increase in percentage of EGR.

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