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CRDI EnginePerformance with Jatropha Curcas Biodiesel Blend and Exhaust Gas Recirculation (EGR)

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ABSTRACT: *Renewable fuels have taken center stage of discussion during present scenario due to their ability to reduce hazardous engine exhausts gas emissions from diesel engines. In the present experimental study jatropha curcas biodiesel blends which is produced by trans-esterification process is used in a Twin cylinder CRDI engine. The main objective is to investigate the combined effect of biodiesel blends and exhaust gas recirculation (EGR) on the performance, emission and combustion characteristics of a CRDI engine. Brake thermal efficiency (BTE), carbon monoxide (CO), unburned hydrocarbons (HC), oxides of nitrogen (nox) and smoke opacity were measured to estimate the performance and emissions from bio-fuelled engine. B10 blend with 10% 15% and 20% EGR ratio were used for the investigation. Though lower CO, HC and smoke opacity emissions were observed but nitrogen oxides increased marginally for biodiesel. The combination of biodiesel blend along with EGR leads to simultaneous reduction of nitrogen oxides and smoke opacity without affecting engine efficiency. The investigated results show that B10 blend at 15% EGR exhibit superior characteristics compared against neat diesel operation.*

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I. INTRODUCTION

Renewable biofuel usage in internal combustion has taken center stage mainly because of concern over global warming, depletion of fossil fuels and their higher prices [1-2, 8]. Source of environmental pollution and global warming is mainly from global industrialization and increase of worldwide fleet of vehicles. It well known fact that Diesel engines yield highest fuel economy, however emissions like particulate matter (PM) and oxides of nitrogen (NOx) are comparatively higher than those emitted from modern gasoline engines, reduction of these emissions by preserving the fuel economy is difficult [1-6].

One of the best methods of reducing these pollutants is reformulation of conventional diesel fuel which can be done by adding the synthetic or biologically renewable oxygenates which are made from renewable raw material. This type biodiesels have been used by many academic researchers in diesel engines and most results show very close engine performance characteristics to diesel fuel with reduction in emissions [7-12].

Therefore, in the present experimental study involves usage Jatropha curcas methyl ester and EGR on CRDI for performance and emission characteristics analysis.

II. MATERIAL AND METHODS

The experimental test setup shown in Figure 1 consists of two cylinder four stroke direct injection diesel engine connected to eddy current type dynamometer for loading. Instrumentation facility of engine provides online measurement of performance and combustion parameters like fuel flow, airflow, temperatures, load and speed along with pressure vs crank diagrams through computer interfaced signals and It is also provided with Labview based Engine Performance Analysis software package “Enginesoft” for online evaluation.

The emissions namely carbon monoxide (CO), carbon dioxide (CO2), nitric oxide (NOx) and unburnt Hydrocarbons (UBHC) were measured using an AVL DI Gas 444 five gas analyser and AVL 415SE smoke meter which estimate the soot concentration. The engine performance and emissions characteristics were recorded at full loads for variable speeds from 2000-3500 rpm in the step of 500rpm. Fuel properties are analysed as per ASTM standrds, Averages of three set of reading were taken for performance as well as for emission characteristics after achieving steady state, results were analysed and presented here.

Exhaust gas recirculation (EGR)

Exhaust gas recirculation (EGR) is an effective overall process to control engine emissions with no after treatment process [9]; this technique has been used by many researchers including A K Agrawal [10], Saleh [11], Maiboon [12], Ladommatos [13] and Abd-Alla [15]. The exhaust gases coming out from engine are cooled using water cooled heat exchanger fitted in the exhaust line of the engine, the cooled exhaust gases are fed back into engine manifold system where it mixes with fresh air and enters the combustion chamber replacing same volume of fresh air. The following equation is used to estimate the EGR ratio [6, 9]

$$\text{EGRRate}(\%) = \left\{ \frac{\text{massofairwithoutEGR} - \text{massofairwithEGR}}{\text{massofairwithoutEGR}} \text{x } 100 \right\}$$

III. RESULTS AND DISCUSSION

3.1 BRAKE THERMAL EFFICIENCY (BTE):

The gradual application of the load steadily decreased the heat loss and improved the thermal efficiency [1].The performance of the engine increases with the addition of biodiesel blend, the oxygen content of biodiesel helps in better combustion resulting into higher efficiency. Trend of Brake thermal efficiency is as shown in Figure 2.The maximum value 35.3% for B10 blend is observed at 2500 without EGR condition.

With application of EGR rate 10%, and 15%, a slight increase in efficiency (36.15%) is noticed, the increase in thermal efficiency with application of EGR may be due to the re-burning of unburnt hydrocarbons which mix with fresh air and entrain into the combustion chamber through the inlet manifold. At 20% EGR, the reduction in performance is due to reduced oxygen concentration as well decreased volumetric efficiency or breathing capacity of the engine, thus the net effect of EGR under Jatropha curcas operation results in marginal increase of performance.

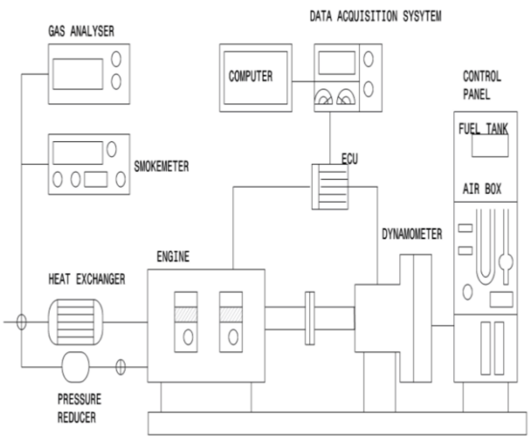

Figure 1. Schematic layout of an experimental setup

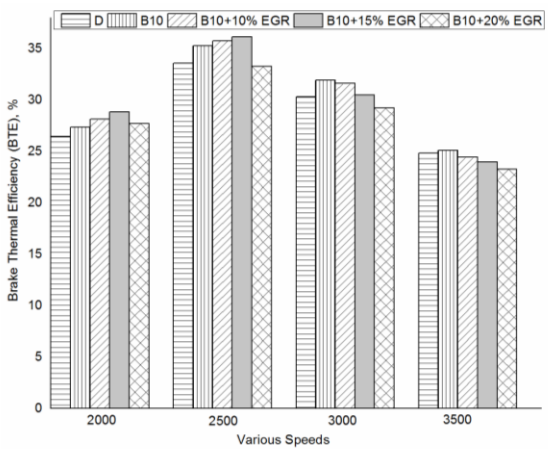

Figure 2. BTE vs Speeds

3.2 NITROGEN OXIDES (NO_X) EMISSIONS

Higher nitrogen oxides in engine exhausts are due to higher oxygen and elevated combustion temperatures mainly in the combustion chamber. It is observed that NOx formation decreases moderately with the application of EGR rate. This is owing to the fact that EGR dilutes oxygen concentration inside the cylinder, thereby limiting the flame temperature which reduces the NOx evolution as shown in Figures 3. Oxides of nitrogen for normal diesel is 1146 ppm and is increased to 1203 with B10 blend (3500 rpm), then with the application of 20% EGR rate NOx level decreased to 810 ppm and the reduction rate is proportional to EGR rate.

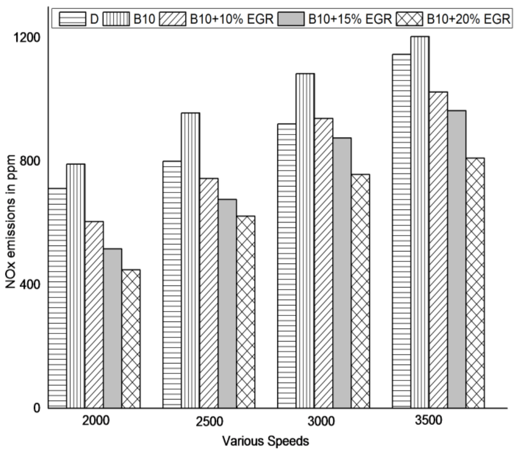

Figure 3 NOx vs Various Speeds

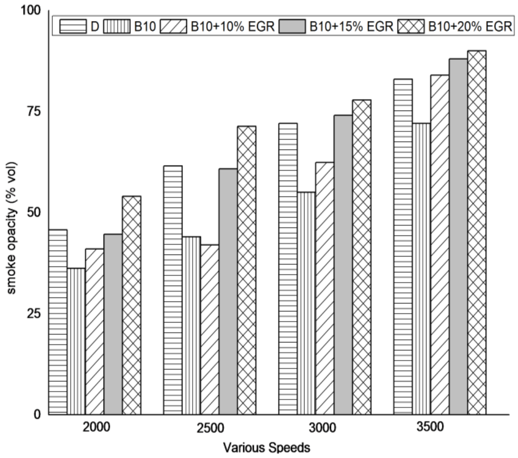

Figure 4 smoke vs Various Speeds

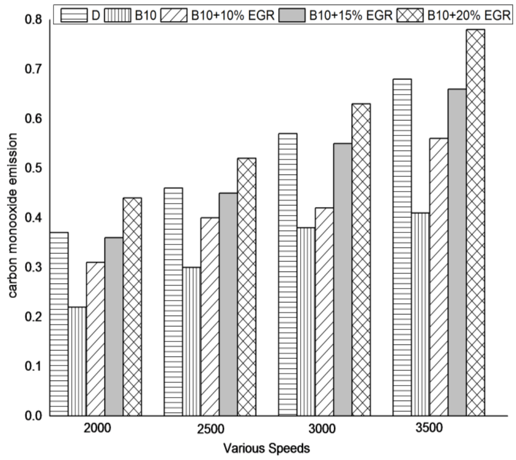

Figure 5 CO vs Various Speeds

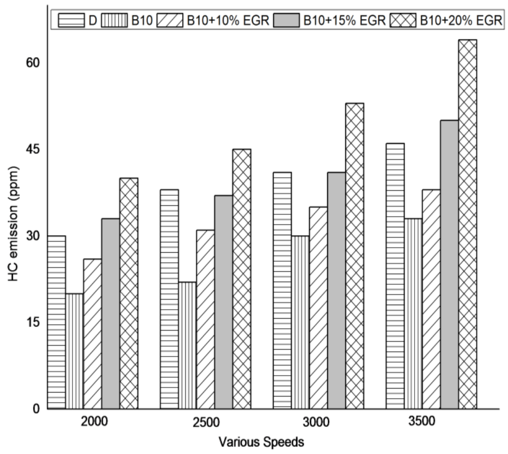

Figure 6 HC vs Various Speeds

3.3 SMOKE OPACITY

From the experimental study it is observed with the usage of biodiesel blend in diesel engine, the smoke opacity emission trend is lower than that of diesel. The smoke opacity reduced from 61.5% to 44% with B10 blend at 2500rpm. This is due to more oxygen concentration with lower carbon to hydrogen ratio in biodiesel and also an absence of aromatics in biofuel is also an added advantage for lower smoke.

With the application of EGR rates 10%, 15% though higher smoke opacity in the exhaust is noticed when compared with the biodiesel blend, but still it is lower than the diesel operating condition. At 20% EGR, the opacity value is observed to be higher than diesel. This is due to the fact that exhaust gas recirculated reduces the oxygen required for proper combustion of fuel inside the combustion chamber leading higher origination of smoke as shown in fig 4.

3.4 HYDROCARBON (HC) AND CARBON MONOXIDE (CO)

Blending diesel with biodiesel decreases the HC and CO emissions compared to baseline diesel value. Hydrocarbon and Carbon monoxide emissions level is reduced due to addition of blended fuel and this is the implication of adding oxygenate fuels which can decrease HC from the locally over rich mixture. Moreover oxygen enrichment is also favourable to the oxidation process of HC and CO during expansion and exhaust processes (Figure 5 & 6).

The minimum value for CO and HC is to be 0.22 (%vol) and 20 ppm for 2000 rpm at B10 blend. The maximum values are at 0.78 (%vol) and 64 ppm for 3500rpm with 20% EGR rate.

IV. CONCLUSIONS

Jatropha curcas biodiesel blends for various EGR rates for CRDI engine were tested for performance and emission charaecterstics for comparisons with fossil diesel fuel and following conclusions are obtained for this experimental study.

- Jatropha curcas biodiesel blend B10 can be used as an alternative fuel for diesel engine without any major modifications.

- Improvement in brake thermal efficiency for B10 blend concentration is obtained compared to neat diesel operation.
- With the application of EGR, BTE improves for 10% and 15% EGR rate and starts declining with the application of 20% EGR rate.
- CO, HC and opacity emissions decrease with the use of biodiesel blend but NOx emissions increase.
- At EGR rate 20% there is substantial increase in HC, CO and opacity but NOx values are lesser than the diesel operation.
- It is optimized that 15% EGR rate and B10 biodiesel blend gives better performance and lower emissions than neat diesel fuel operation.

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