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# Experimental Analysis of Performance and Pollutants of CI Engine using Jatropha Biodiesel with Exhaust Gas Recirculation

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**ABSTRACT:**

*Gradual depletion of the petroleum reserve and growing danger to the atmosphere from exhaust emission has created international attention in emerging substitute of non-gasoline fuels. Bio fuel is the better solution for CI engines to reduce fossil fuel consumption and to reduce the emission from exhaust gas. Biodiesel with exhaust gas recirculation has been chosen for this study. The outcome shows that the $NO_X$ emission is reduced as compared to the diesel fuel apart from the HC and CO emissions.*

**KEYWORDS:**

*CI Engine; Biodiesel; Exhaust gas recirculation; Pollution; Performance*

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## 1. Introduction

Most of the energy desires are delivered by the petrochemical resources, coal and natural gases and at these existing usage rates it will be exhausted soon. Diesel fuels have a crucial purpose in the industries for an emerging state and utilized for transporting manufacturing and farming goods, operation of tractor and pump in farming sector. Unlike rest of world, India's claim for diesel is approximately '6' times larger than gasoline henceforth searching for substitute to diesel is an expected choice. Esters from vegetable oils are the best substitutes for diesel because they do not claim any alteration in the engine. The increasing fuel demand and pollution caused by automobile and industrial emission have made biodiesel to be considered as a major substitute for petro-diesel. Since petroleum fuel sources are finite, the quest for substitute fuel is currently going on the entire world. The mounting cost of gasoline fuels, exhaustion of assets and strict world protocols on exhaust emissions have also demanded the need for replacement of petroleum fuels with lesser contamination, readily available and renewable non-edible sources of fuels for automobile and industrial engines [1-2].

The high efficiency and cost effectiveness of diesel engines have made them to be widely used in most internal combustion engines. Their efficiency is due to high compression ratio that creates heat and cause spontaneous ignition of fuel [3]. The incessant recognition of diminishing petroleum fuel reserves and possibility of using readily available low cost non-edible plant and waste-oils as sources of environment-friendly renewable substitutes have created a lot of interest in biodiesel research [4]. Biodiesel consists of alkyl esters of fatty acids and can be easily prepared from animal fats, plant or vegetable seed and restaurant waste oils [5-6]. Base catalysed trans-esterification reactions employing sodium hydroxide (NaOH) or potassium hydroxide (KOH) which are extensively used in commercial production of biodiesel are pretty fast but are sensitive to presence of water and free fatty acids [7]. The most commonly employed biodiesel, fatty acid methyl esters are usually produced by trans-esterification of oils/fats with methanol in the existence of an alkaline substance [8-10].

As diesel engine fuel is a great subject for research and development, many researchers have been working on many vegetable oils to produce diesel like engine fuel. This is also becoming important due to depleting oil reserves and environmental consciousness. Many studies have been done on the environmental friendly and wide availability of alternative fuel. Their straight use in CI engines was limited owing to higher viscosity which ensued in reduced atomization, imperfect burning and carbon deposition on the injector/valve seats triggering severe engine fouling.

## 2. Jatropha biodiesel

The calculated density of the jatropha biofuel is 860-900 $kg/m^3$ and the diesel density varies from 836-850 $kg/m^3$. It shows that it approximately reaches the specified limit of ASTM standard. The calculated viscosity of the jatropha biofuel is 4.2 cst at 30°C and it is also in the specified range of the ASTM. Also its viscosity is very similar to diesel which varies from 2.2 cst. Flash point of the jatropha biofuel is 168°C and this obeys the ASTM standard of minimum of 93°C and for diesel it is about 80°C. The increase in flash point of the fuel causes start ignition delay of engine which tends to increase $NO_x$ emission. The tested calorific value of the jatropha biofuel is found to be 39,000kJ/kg, which is very much similar to that of diesel which is 42,000kJ/kg. This little decrease in the calorific value of the biofuel tends to increase the specific fuel consumption by a tiny margin. The cetane number of the biofuel is found to be 49 meeting the ASTM standards and also very close to the value of diesel which varies from 51 to 60.

## 3. Exhaust gas recirculation

Exhaust gas recirculation (EGR) is used extensively to lessen and govern the oxides of nitrogen ($NO_x$) emission from CI engines. EGR governs the ($NO_x$) since it drops $O_2$ concentration and flame temperature in the burning chamber. The trials were conceded out to experimentally assess the emissions for dissimilar EGR rates of the engines. Emissions of hydrocarbons (HC), $NO_x$ carbon monoxide (CO), exhaust temperature, and smoke opaqueness of the exhaust, etc. were gauged. Performance factors such as Brake Thermal Efficiency (BTE) and Brake Specific Fuel Consumption (BSFC) were calculated. Decreases in $NO_x$ and exhaust temperature were detected but emissions of PM, CO and HC were increased with practice of EGR. The engine was worked for usual running settings with EGR and the performance/emissions were witnessed. CI engines are presumed as a good substitute to gasoline engines since they produce lesser quantity of emissions but high emissions of $NO_x$ and PM have been observed as major difficulties. Even though, major components of diesel exhausts include $CO_2$, water vapour, nitrogen and oxygen, CO, HC, $NO_x$ are existent in lesser but ecologically substantial quantities. So, we have to reduce these emissions by using EGR in diesel engines.

## 4. Experimental setup

A single cylinder, 4 stroke, water cooled Kirloskar TV1 diesel engine, coupled with electrical dynamometer is used for this project. The specification of the engine is given in Table 1. The suction of the engine is attached with anti-pulsating drum to evaluate intake capacity. The tank is connected with a 20 mm orifice over which air is passed into the engine. The pressure variance owing to air flow over orifice is evaluated by inlet air thermocouple. The exhaust of the engine comprises of succession of device such as gas analyser, smoke meter and exhaust gas thermocouple and quartz piezoelectric pressure transducer with 8-bit data acquisition system. The combustion analyser is attached through the trial rig to study the burning behaviour of the engine. Figs. 1 and 2 show the photographs of the experimental setup.

**Table 1: Specifications of engine**

| Description | Specification |
|---|---|
| Rated power | 5.20 kW |
| Rated speed | 1500 rpm |
| Bore diameter | 87.5 mm |
| Stroke length | 110 mm |
| Compression ratio | 17.5:1 |
| Orifice diameter (d) | 20.00 mm |
| Co-efficient of discharge (Cd) | 0.60 |

**Fig. 1: CI diesel engine setup**

**Fig. 2: Exhaust gas recirculation**

## 5. Results and discussion

### 5.1. Performance characteristics

The specific fuel consumption (SFC) is defined as the consumption of fuel to produce unit power. It should be always low to have better engine efficiency. The SFC for diesel and biodiesel is shown in Fig. 3. The diesel & biodiesel (B25) have the same SFC whereas B25 consumes more fuel than diesel. The SFC is decreased as the load is increased gradually. Fig. 4 clearly shows that the diesel and B25 have a slight dissimilarity in the BTE as the conventional diesel till 50% of load is applied. But, further increase in load shows slight increase in diesel efficiency than the blend efficiency. The biodiesel has almost same BTE compared to conventional diesel.

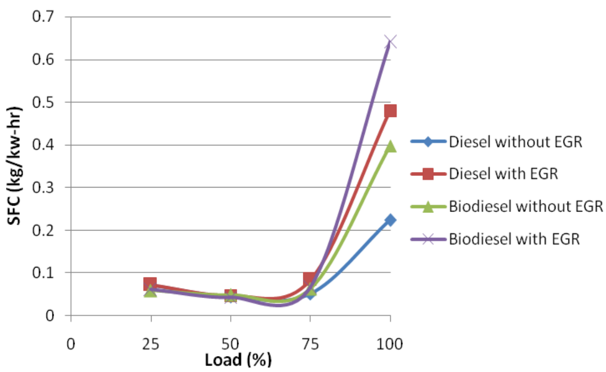


**Fig. 3: Load (%) vs. SFC for diesel and biodiesel**

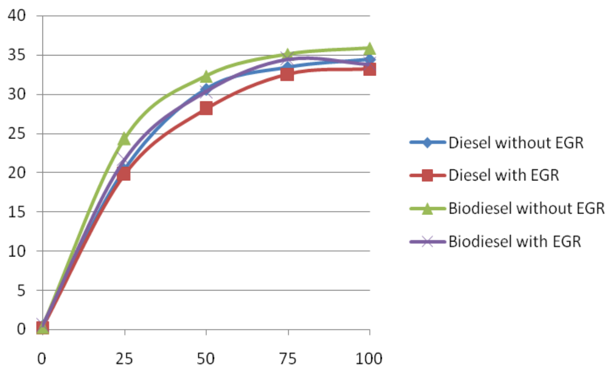


**Fig. 4: Load (%) vs. BTE for diesel and biodiesel**

### *5.2. Emission Characteristics*

Carbon monoxide is emitted with the exhaust gas due to incomplete combustion of carbon. Fig. 5 shows that the incomplete combustion occurs due to dissociation process. The measured concentration of CO is greater than the equilibrium concentrations. CO does not drop to zero when the mixture is chemically correct or leaner. B25 has a lower CO emission % (at least 0.02%) than the conventional diesel as the load is increased gradually. The reason for low CO emission from the biofuel is that they contain high oxygen content. Hydrocarbons (HC) are the consequence of incomplete combustion of hydro carbon fuel. The fuels with high volatility tend to undergo incomplete combustion. As shown in Fig. 6, B25 have a lower HC emission in PPM than the conventional diesel.

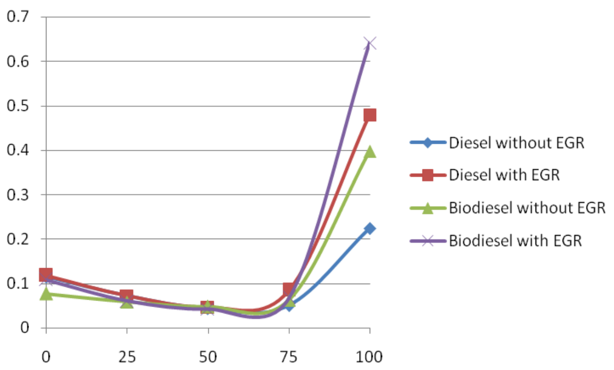


**Fig. 5: Load (%) vs. CO emission (%) for diesel and biodiesel**

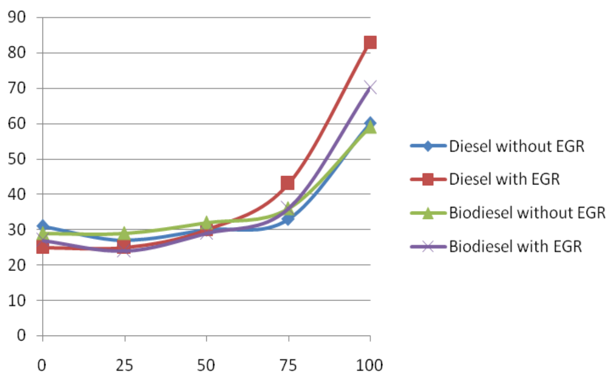


**Fig. 6: Load (%) vs. HC emission (ppm) for diesel and biodiesel**

As shown in Fig. 7, B25 has a slightly higher negligible $CO_2$ emission than the conventional diesel as the load is increased gradually. Fig. 8 clearly shows that the B25 have a slightly higher negligible $NO_x$ emission than the conventional diesel as the load is increased gradually.

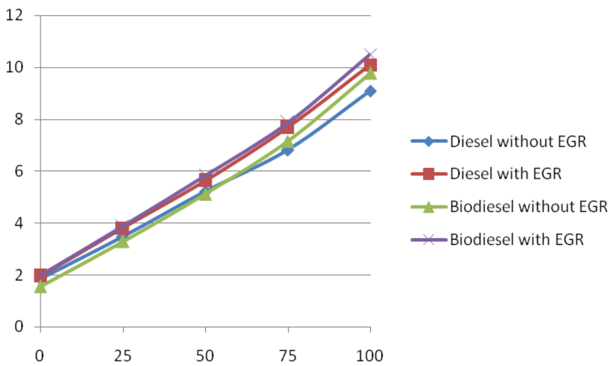


**Fig. 7: Load (%) vs. $CO_2$ emission (%) for diesel and biodiesel**

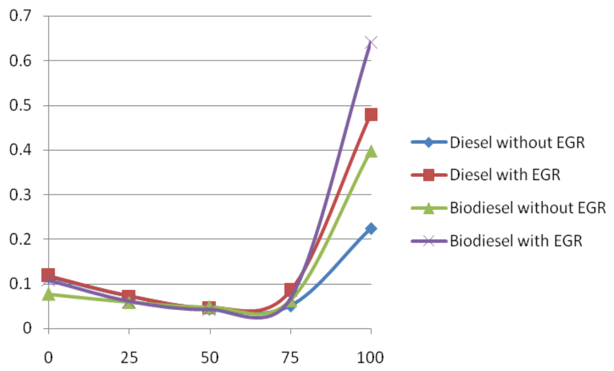


**Fig. 8: Load (%) vs. $NO_X$ emission (%) for diesel and biodiesel**

## 6. Conclusion

The jatropha oil used here as a biofuel as a fuel in CI engine and the trans-esterified oil was compared with diesel. The trans-esterified jatropha oil is blended with diesel by proportion of B25. The performance and emission of jatropha oil was carried in Kirloskar TV1 engine. The results were compared with that of diesel on the same engine. From the results, it is concluded that B25 blend shows almost same fuel consumption, higher mechanical efficiency, higher indicated thermal efficiency and higher brake thermal efficiency by load variations than that of conventional diesel. The emission test was carried out on 437C smoke meter & AVL DIGAS 444N and the results have been recorded. It is clearly seen that biodiesel blend has very low CO and $CO_2$ emission percentage than diesel. HC emission of B25 is also found to be less in biodiesel than diesel. $NO_X$ and $O_2$ content present in exhaust emission is also less than the conventional diesel.

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