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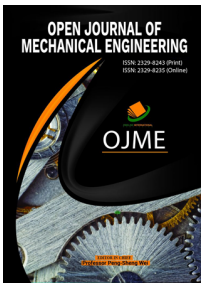


# PERFORMANCE AND EMISSION CHARACTERISTICS OF DIESEL ENGINE WITH EGR FOR VARIOUS BIODIESEL BLENDS: A REVIEW

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**ABSTRACT**

Nowadays, Internal Combustion engines are the essential parts of transportation and mechanized agricultural system. So the consumption of diesel and petroleum has been upsurged. As petroleum is a nonrenewable source and recent surge in petroleum prices have regenerated interest in bio-fuels. In this present work, study has been carried out to find effect of biodiesel blends on Engine performance with Exhaust Gas Recirculation (EGR). Most of the researchers have reported that biodiesel-fueled engines produce less CO, unburned HC and smoke emissions compared to diesel fuel, but higher NOx emissions. The literature shows that, Exhaust Gas Recirculation (EGR) is an efficient technique to reduce NOx emission as it lowers the flame temperature in the combustion chamber with higher fuel consumption

**KEYWORDS**

Exhaust Gas Recirculation (EGR), biodiesel blends, engine emissions, NOx

## 1. INTRODUCTION

Today most of the problems arise due to environmental pollution. The major gas that affects the human and the atmosphere is Nitrogen Oxides. It causes the breathing illness, smog, ozone layer depletion along with that it may cause acid rain also. Basically NOx is formed at higher temperature in the presence of air and nitrogen. Compression ignition engine are preferred prime movers due to excellent drivability and higher thermal efficiency. In order to meet the emission norms and also the fast depletion of petroleum oil reserves lead to the research for alternative fuels for diesel engines. Biodiesel from vegetable oils are alternative to diesel fuel for diesel engines. The use of biodiesel in diesel engines does not require any engine modification. Biodiesel gives considerably lower emissions of particulate matter (PM), Carbon Monoxide (CO) and Hydrocarbon (HC) without any fuel consumption or engine performance penalties. Many researchers have found that with biodiesel fueled engine produces higher NOx emissions compared to diesel. EGR is an effective technique of reducing NOx emissions from the diesel engine exhaust. Controlling the NOx emissions primarily requires reduction of in-cylinder temperatures.

Exhaust Gas Recirculation (EGR) is used for controlling the NOx emissions. 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.

## 2. LITERATURE REVIEW

The topic of experimental analysis of different Biodiesel blends in diesel engine with EGR attracted the attention of many researchers across the globe and several studies are available in the literature.

A group of researchers carried out experimental investigation on a single cylinder four stroke, water cooled diesel engine operated on diesel fuel and Pongamia pinata methyl ester (PPME) and soybean oil methyl ester (SOME) with exhaust gas recirculation [1,2]. They demonstrate the influence of using Exhaust Gas Recirculation (EGR) of different rates on the engine performance parameters such as specific fuel consumption, brake thermal efficiency and emission characteristics such as hydrocarbon emission, smoke density and NOx emission. The NOx emissions were decreased with increase in EGR flow rate for both net diesel fuel with PPME and SOME.

A scholar taken effort to study performance and emission characteristics of a diesel engine fueled with biodiesel and diesel fuel using EGR [3]. The engine performance and brake thermal efficiency obtained in biodiesel case were less, which could be attributed to lower calorific value of biodiesel. CO and UHC emissions for biodiesel were lower than that of diesel fuel. However, it was observed that NOx emissions for biodiesel were higher than that of diesel fuel. EGR is a very effective technique to reduce NOx emissions from diesel engine. In this study the venturi type EGR system was used. When similar percentages (% by volume) of EGR were used in the cases of diesel and canola oil ethyl ester, NOx emissions were considerably reduced to lower values.

A group of researchers investigated the performance and emissions of a direct injection (DI) diesel engine fueled by neat diesel and 20%- 80% blend of Soy biodiesel and diesel (B20) under various load conditions and engine speeds without and with low percentage (10 %) of (EGR) conditions [4]. With 10% EGR condition, B20 always produced lower NOx than that of diesel at all engine speed and load conditions. Some scholars, present research work is to use B10, B20, B30, blend of Jatropha Methyl Ester and cooled EGR in order to reduce pollutant from single cylinder diesel engine [5]. Result indicates the reduction of NOx and brake thermal efficiency decreased with the application of EGR.

A researcher investigates the usage of biodiesel and EGR simultaneously in order to reduce the emissions of all regulated pollutants from diesel

engine [6-8]. From the experiment, it can be suggested that EGR is optimum technique for NOx reduction without significant penalty on brake thermal efficiency, HC and smoke opacity. The same result was also shown when diesel engine fueled with Madhua oil and Karanja Oil [9,10]. Karanja have better performance and emission characteristics than Mahua, Sesame and Kusum Biodiesels said by a group of scholars [11].

A scholar has investigated the usage of biodiesel from Jatropha Seed Oil and simultaneously implementation EGR in order to reduce the emissions of all regulated pollutants from diesel engine [12-16]. Also it has been noticed that by the use of three combined system such as EGR, air dilution system and three-way catalytic converter results in NOx reductions without compromising engine performance and emissions [17,18].

A scholar reported that exhaust from biodiesel fuel has higher NOx emission than operated with diesel fuel [19-21]. They investigate how to reduce NOx emission by using an effective after gas treatment technique like cooled EGR as it enables lower flame temperature and oxygen concentration in combustion chamber. Diesel, biodiesel like Cotton Seed Oil Methyl Ester (CSOME), Sunflower Methyl Ester (SFME) and their blends were used as fuel for conducting experiments and recommended to use these biodiesel as substitute fuel with various EGR rate for optimum performance-emission characteristics.

According to a research, they performed experiment of addition of esters to ethanol-diesel blends can cause an improvement in stability of the fuel blend [22]. Exhaust gas recirculation was adopted to control NOx emissions. Considerable reductions in emissions also been observed with the addition of ester, and using the EGR option reduction of NOx emissions was observed.

Study showed reports on the preparation of methyl ester from selected vegetable oil and predicted its combustion, performance and emission characteristics and describes the reduction of NOx techniques when used in diesel engine like [23]:

i. Effect of injection timing retardation on the performance and emissions.
ii. Effect of EGR on performance and emissions.
iii.Effect of adding Diethyl ether as an additive in small percentages.

The recirculation of the exhaust gas into the engine dilutes the gases in the combustion chamber. Hence the temperature inside the combustion chamber reduces, correspondingly NOx emission also reduces. Introduction of EGR in the biodiesel engine reduces the exhaust gas temperature remarkably. To improve the performance and emission characteristics of biodiesel fueled engine diethyl ether is chosen as fuel additive.

A researcher carried out study the on the combined effect of Exhaust Gas Recirculation and Cetane Improver on Biodiesel-fueled (fish oil B30) Diesel Engine, as Diesel-biodiesel blends increase Nitrogen Oxides (NOx) emission of engine exhaust [24]. Exhaust Gas Recirculation (EGR) is an effective way of reducing the NOx emissions. Cetane improvers Di Tertiary Butyl Peroxide (DTBP), on the other hand reduce the ignition delay, which in turn reduces the combustion temperatures as a result of which NOx emissions decrease.

A group of researchers used four stroke compression ignition engines fuelled with diesel/methanol blend of 10:90, 20:80 and 30:70 of methanol to diesel respectively to evaluate the performance and emission of engine [25]. They conclude that by adding methanol HC, CO emission will decrease while the NOx emission will increase, on other side by application of EGR the NOX emission will be drastically decrease and HC, CO and PPM will increase.

Based on a study, experimental investigation on diesel engine using diesel-biodiesel (Palm Stearin Oil) blends with cetane improver Ethyl Hexyl Nitrate as an additive under different Exhaust Gas Recirculation conditions [26]. The combined effect of EGR and Ethyl Hexyl Nitrate found the reduction of NOX emissions. They found that with increase in EGR percentage CO2, CO emissions increases while HC, NOX emissions decreases [27].

According to a study, the applications of both cooled and hot EGR to reduce NOx emission but incur loss of efficiency and increase HC, CO2 and smoke [28]. Also they found that Ethanol fumigation along with EGR is thought to compensate for the loss in efficiency and reduce other diesel emission constituents like HC and smoke, as ethanol has the benefits such as higher efficiency and specific power and lower emissions.

A scholar reviewed number of literature and suggests biodiesel as a good alternate to diesel but suffering with a drawback of an increase in nitrous oxide NOx, to reduce this NOx they coupled EGR with diesel engine [29-31]. Biodiesel used for experimentation was Palm methyl ester and Palm Stearin Methyl Ester and Palm Oil respectively. An eco-friendly alternate is required to fulfill the growing demand. Bio fuels have proved to be the best alternative. A group of scholars carried out overall performance and emission tests on Jatropha oil, have given good results except for the NOx component of the emission [32,33]. This experimental work focuses on the reduction of this component to a great extent with the implementation of techniques called Exhaust Gas Recirculation and Magnetic Fuel Treatment system.

A biodiesel–diesel blend level estimation method with explicit consideration of the EGR effect is presented by a group of researchers [34]. Since EGR is now widely used in modern diesel engines to mitigate NOx emissions, or to assist in multimode combustion, it is necessary to bring EGR into consideration and to investigate the validation of the estimation system in the presence of EGR. From both theoretical model and the experimental data presented in this work strongly indicate that EGR does not affect oxygen consumption factor of a fuel. The objective is to review the potential of EGR to reduce the exhaust emissions, particularly NOx emissions, and to delimit the application range of this technique with different Isobutonal blends with diesel [35]. They suggest that, using EGR technique in engines, the emissions are very much controlled and also this method is very reliable in terms of fuel consumption.

Study showed the properties if safflower oil and carry out experimentation on a diesel engine with different blends [36,37]. They concluded that Safflower oil and its blends can be used as an alternative fuel in the future. Also the engine was run without any problem and requires no modification in engine hardware. So Safflower is best substitution because it gives better performance and less smoke as compared to that of diesel fuel. Similar attempt has been made by a researcher by mixing Safflower Oil -Milk Scum Oil meeting with methyl ester as a new fuel in their work [38]. Also transesterification process is used by a researcher to produce biodiesel from safflower plant and Produced biodiesel was within recommended standards of biodiesel fuel [39]. An investigation has been carried out to study the emission and combustion characteristics of Safflower Methyl Ester (SME) as a fuel to diesel engine [40].

Today as the consumption of Diesel becomes more especially in transportation and industries so for controlling of diesel emission by using Ethanol as additives and EGR process together, to control the emissions. A researcher observed from the different ratio of ethanol and EGR, 10% Ethanol and 10% EGR is very effective from the others because it's increase thermal efficiency, decrease tremendous amount of NOx, decrease fuel consumption, decrease HC at lower load, decrease O2intake in combustion chamber [41]. Only the disadvantage of ethanol is increase water content in combustion chamber and also increases little amount of CO and CO2.

Most of the researchers have reported higher level of NOX emission using biodiesel compared with diesel. A group of researchers disuse various technique to reduce NOx emission like using Alcohols especially Ethanol in fumigation mode, Water emulsification technique, Among the various techniques discussed they found hot EGR technique is most effective technique without much adverse effect to reduce NOX level, and also reduces the Smoke and PM emission [42-46].

## 3. CONCLUSION

A lot of research has been carried out on internal combustion engines using biodiesel fuel and it shows that the engines produce less carbon monoxide, smoke emissions and unburned hydrocarbon compared to diesel fuel but higher NOx emission. Diesel engine combustion yields large amounts of NOx because of high flame temperatures in presence of ample oxygen and nitrogen in the combustion chamber. Upsurged environmental concerns and tougher emission norms have led to the development of advanced engine technologies to reduce NOx. This paper concluded that, engine gives remarkable performance with biodiesel blend fuel with EGR resulting reduction in NOx.

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