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Effect of Exhaust Gas Recirculation (EGR) on Diesel Engine Using Simarouba Glauca Biodiesel Blends

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ABSTRACT

This study investigates the impact of Exhaust Gas Recirculation (EGR) on the performance, combustion, and emission characteristics of a diesel engine using Simarouba glauca biodiesel blends. The objective is to evaluate the feasibility of using Simarouba glauca biodiesel as an alternative fuel while employing EGR to reduce NOx emissions. The experiment was conducted on a single-cylinder diesel engine, running on B10, B20, and B30 blends with varying EGR rates (0%, 10%, and 20%). The results indicate a significant reduction in NOx emissions with EGR implementation, though at the cost of increased particulate matter and carbon monoxide emissions.

Keywords : Exhaust Gas Recirculation (EGR), Simarouba Glauca Biodiesel, Diesel Engine Performance, Nox Emissions Reduction, Combustion Characteristics

1. Introduction

With growing environmental concerns and depleting fossil fuel resources, biodiesel has emerged as a viable alternative fuel. Simarouba glauca biodiesel, derived from the seeds of the Simarouba tree, exhibits properties suitable for compression ignition engines. However, biodiesel combustion results in higher NOx emissions compared to conventional diesel.

Exhaust Gas Recirculation (EGR), a technique used to mitigate NOx emissions, recirculates a portion of exhaust gases into the intake air to lower combustion temperatures. This study examines the combined effect of EGR and Simarouba glauca biodiesel blends on diesel engine performance.

2. Experimental Setup

(a)

A single-cylinder, four-stroke, water-cooled diesel engine was used for the experiments. The engine was operated at a constant speed of 1500 rpm with three fuel blends:

- B10: 10% Simarouba glauca biodiesel + 90% diesel
- B20: 20% Simarouba glauca biodiesel + 80% diesel
- B30: 30% Simarouba glauca biodiesel + 70% diesel

EGR rates of 0%, 10%, and 20% were applied to study their effects on engine performance and emissions.

2.1 Exhaust Gas Recirculation (EGR) System

EGR is a well-known technique used to control NOx emissions in diesel engines by rerouting a portion of exhaust gases back into the intake manifold. This reduces the oxygen concentration and lowers peak combustion temperatures, which are responsible for NOx formation. In this study, a cooled EGR system was used to ensure better mixing with intake air, preventing excessive power loss and reducing combustion instability. The system was equipped with:

- **EGR Valve**: To control the percentage of exhaust gases recirculated.
- **Cooling Unit**: To reduce the temperature of the recirculated gases before mixing with intake air.
- **Flow Measurement Sensors**: To monitor and adjust the amount of recirculated gases.
- **Piping and Ducting**: To ensure a steady flow of exhaust gases into the intake manifold.
- **Control System**: To regulate and optimize the flow rate based on engine load conditions.

2.2 Advantages and Challenges of EGR

Advantages:

- Significant reduction in NOx emissions due to lower combustion temperature.
- Improved fuel economy at part-load conditions.
- Reduction in combustion noise due to controlled flame propagation.

Challenges:

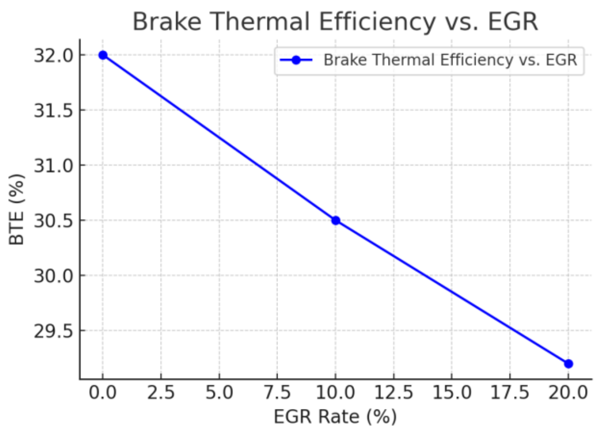
- Increased carbon deposits in intake manifold and valves.
- Potential increase in particulate matter and hydrocarbon emissions.
- Higher soot formation leading to frequent maintenance of the system.
- Reduction in oxygen availability, leading to incomplete combustion.

3. Results and Discussion

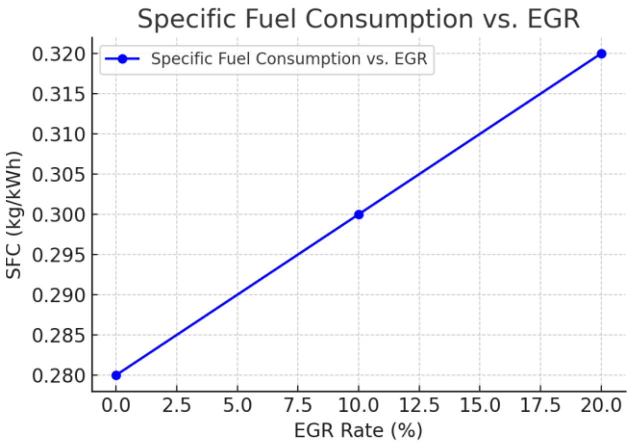
3.1 Performance Analysis

The brake thermal efficiency (BTE) of the engine showed a slight reduction with increasing EGR rates due to lower oxygen availability. The specific fuel consumption (SFC) increased marginally, indicating a minor efficiency loss.

Brake Thermal Efficiency



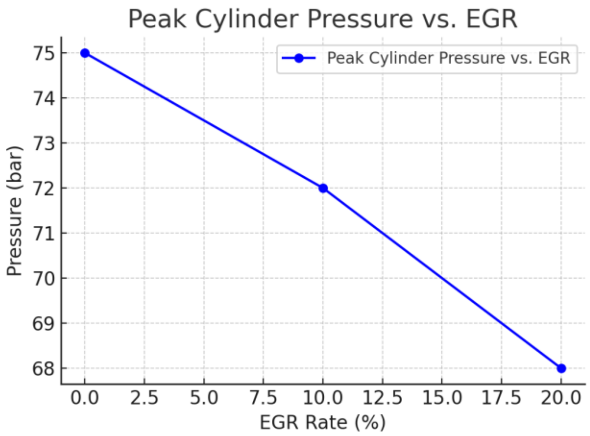
Specific Fuel Consumption



3.2 Combustion Characteristics

The peak pressure decreased with higher EGR rates, confirming a drop in combustion temperature. Ignition delay slightly increased, affecting combustion efficiency.

Peak Cylinder Pressure



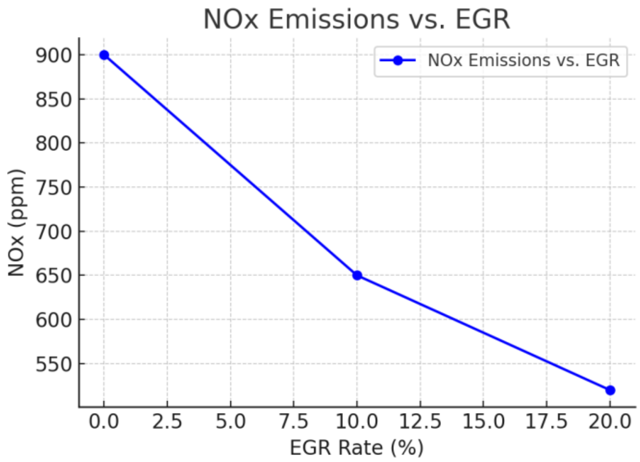
1) 3.3 Emission Analysis

• NOx Emissions: A significant reduction was observed with increasing EGR, with a maximum NOx reduction of 42% at 20% EGR for B30.

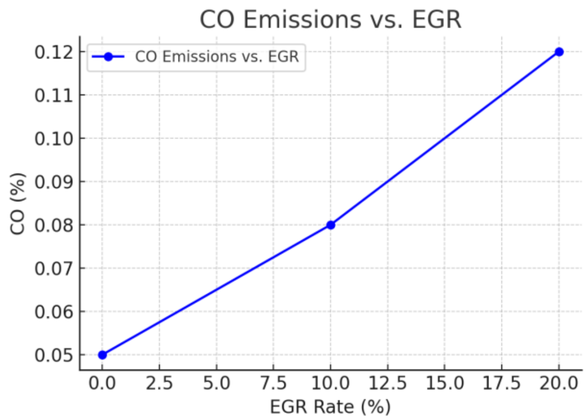
• CO and HC Emissions: Both carbon monoxide (CO) and hydrocarbon (HC) emissions increased with EGR due to incomplete combustion.

• Particulate Matter (PM): A rise in PM emissions was noted due to reduced oxidation rates.

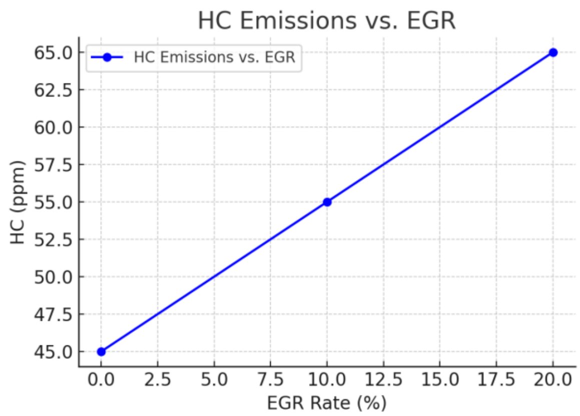
NOx Emissions



CO Emissions



HC Emissions



4. Conclusion

The use of Simarouba glauca biodiesel with EGR effectively reduces NOx emissions, making it a viable strategy for sustainable diesel engine operation. However, increased CO, HC, and PM emissions require further optimization, such as employing after-treatment technologies.

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