J Ther Eng, Vol. 10, No. 2, pp. 396−403, March, 2024

Journal of Thermal Engineering
Web page info: https://jten.yildiz.edu.tr
DOI: 10.18186/thermal.1448677

Research Article

Study on exhaust gas recirculation diesel engine using karanja oil methyl ester with low heat rejection in direct injection

Ravisankar RAJENDRAN[1], V.S.K. VENKATACHALAPATHY[1], K. VELMURUGAN[1], M. ELANGOVAN[1], P. BALU[2]

[1]*Department of Mechanical Engineering, Sri Manakula Vinayagar Engineering College, Puducherry, 605107, India*
[2]*Department of Automobile Engineering, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, 600073, India*

ARTICLE INFO

Article history
Received: 03 March 2023
Revised: 10 May 2023
Accepted: 13 May 2023

Keywords:
Combustion; Emission; Exhaust Gas Recirculation; Karanja Oil Methyl Ester; Low Heat Rejection; Performance

ABSTRACT

Energy is a fundamental necessity for man›s life in the digital world today. The rapid depletion of fossil fuel resources forces rigorous alternative fuel analysis. Petroleum diesel can better replace vegetable oils, edible or motored today. The rapid depletion of fossil fuel resources forces rigorous alternative fuel analysis. Petroleum diesel can better replace vegetable oils, edible or not. Karanja may be a possible supplier of diesel fuel for non-edible oil substitution. Current combustion surfaces for pistons, valves, and cylinders have been filled with ceramic materials, which make the engine totally adiabatic (LHR). The performance of a biodiesel-powered compressing ignition (CI) engine may be further boosted by utilising the engine›s heat effectively and increasing thermal efficiency. Exhaust Gas Recirculation (EGR) is actually one of the most important methods of limiting NOx emissions in internal combustion engines. Explore the output with and without exhaust gas recirculation on a retarded timing engine with diesel and karanja oil methyl ester (KOME). The LHR with a retarded timing engine yielded improved thermal brake efficiency (TBE), decreased HC, smoke, and CO emissions, while increasing KOME›s NOx in comparison with an uncoated engine. As the EGR rate grew, NOx and BTE were reduced marginally with increased HC, CO, and smoke. 24.1 g/kw-hour CO, 10.1 g/kw-hour NOx, and 0.55 g/kW-hour HC were registered at 20 percent of EGR.

Cite this article as: Rajendran R, Venkatachalapathy VSK,Velmurugan K, Elangovan M, Balu P. Study on exhaust gas recirculation diesel engine using karanja oil methyl ester with low heat rejection in direct injection. J Ther Eng 2024;10(2):396−403.

INTRODUCTION

The rapidly rising Indian economy is heavily dependent on oil. Current requirements are approximately 146 million tonnes (MMT), compared to 34MMT for domestic production [1]. Biodiesel, the monoalkyl ester of food-generate/ non-edible oils or animal fats, is an alternative to fossil fuels. The challenges in raw vegan oil as fuels are low atomization as a result of their high viscosity, extreme deposits, coking of injectors and sticking the piston ring, and incomplete burning, resulting in increased smoke density [2]. A

***Corresponding author.**
*E-mail address: ravihari2000@gmail.com

This paper was recommended for publication in revised form by Editor-in-Chief Ahmet Selim Dalkılıç

Published by Yıldız Technical University Press, İstanbul, Turkey
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nation is highly worried about the import of such a large gap in supply. It is by replacing these fossil fuels with the use of renewable alternatives that we can achieve this growing requirement. Alternative fuels must meet the strict emission standards at the same time.

The Low Heat Rejection (LHR) engines are called compressor ignition (CI), combustion chamber engines (CC) which are covered with ceramic material. An LHR engine can increase fuel saving by using a portion of the heat that is typically left unused for useful mechanical work. For selected biodiesel combinations, many researchers used LHR engines [3].

Exhaust gas recirculation (EGR), which maintains the combustion temperature within an admissible level, is an efficient method for minimizing NOx emissions into the exhaust system. The use of EGR has a negative effect on the consistency and longevity of the lubricant oil. Many researchers have indicated that wear on piston rings and cylinder liner does not extend to heavy-duty diesel engines. The explanation is that the concentration of sulphur oxide in oil is closely linked to the rates of EGR. The use of partial EGR is one way to reduce the emissions of NOx by a diesel engine. This function reduces NOx, but raises emissions of PM at a higher load [4].

Has been studied in a 5.9 kW Kirloskar DAF 8 diesel engine with methyl and ethyl esters from karanja oil blends with fossil diesel. BSFC›s CO emissions for KOME (B20) were lower and higher than all other biofuels for KOEE (B20) emissions. The emission of KOME (B100) was lowest. For all biodiesel mixtures 10-25 percent higher NOx emissions were observed. The efficiency and the emission characteristics of the entire methyl ester are higher than those of ethyl esters [5].

The NOx reduction process was investigated using hot EGR in a Kirloskar 3,7 kW AV1 diesel motor, which was used to power JOME. When worked under hot EGR levels of 5-25%, NO emissions were decreased. In particular, the lowest emissions of CO, HC and NO, along with the rational ones, were given by 15% of hot EGR. The negative problem with EGR technology was however a higher level of smoke [6].

The CI engine combustion surfaces were coated with PSZ (0.5mm) in the present experimental work to run in a retarded engine mode in LHR. The study also explored the use of EGR in order to deal with less NOx in these increasing EGR-rate LHR engines powered by Karanja oil methyl ester (KOME).

METHODS AND MATERIALS

Figure 1 (a). The study was designed to improve engine performance and increase the wear resistance of engine components. To this end, a plasma spray coating system adds thermal barrier coverings to the cylinder head, the piston and the valves. Ceramic coating will also absorb these parts› negative wear, friction, heating, corrosion and oxidation. Due to a greater temperature in the combustion chamber than in uncoated engines for the ceramic coated engine, poor-quality fuel might be used.

EGR System

By constructing an external EGR pipeline, the exhausts from the engine cylinder have partially been recirculated to the feed system. Adequate distance was given in order to thoroughly mix fresh air with exhaust gases. Before entering the cylinders, the gasses were passed through a particulate filter containing steels and the particles entering the combustion chamber were reduced [7]. The EGR percentage is computed on the basis of the following equation:

EGR rate (%) =100 x Qwithout EGR - Qwith EGR /; Qwithout EGR

The airflow rate before EGR and QEGR is the airflow rate with EGR where Qwithout EGR is. In stages of 10% and 20%, EGR percentages were changed.

Experimental Setup

Figure 1 displays a schematic of the test set-up with an EGR arrangement (b). At a constant 1500 rpm speed, the experiments were carried out on a CI engine. By constructing an external EGR pipeline, the engine cylinder›s exhaust gases were partially recirculated into the intake manifold. Water was used in an EGR cooler to lower the exhaust gas temperature, and a valve was installed in the EGR channel to regulate flow. The pulsing character of the exhaust gases was taken into account by installing an air dampening box along this path. The test bench includes instruments for measuring different parameters, such as engine load, anemometer airflow, and K-type thermocouple gas temperatures. The consumption of fuel was determined by the electronic weighting of the fuel. Smoke opacity was measured with the Hartridge smoke metre. The exhaust gas analyzer has measured the emissions of hydrocarbons (HC), CO, and NOx. CO and HC are calculated by electrochemical sensors using the concept of non-dispersive infrared (NDIR) and NOx. The in-cylinder combustion pressure is recorded with C7112. The data acquisition system was used to acquire pressure signals. For the estimation of the combustion pressure parameters, the average pressure data from 20 consecutive cycles was used. The acquired data measured the net HRR and accumulated heat release (CHR).

RESULTS AND DISCUSSION

Brake Thermal Efficiency

The BTE fluctuation is seen in the Figure 2. The figure demonstrates that BTE was 1.86% and 5.73% greater than the identical engine for ceramically-coated, retarded injected gas recirculation motors with a maximum load of 10 percent or 20 percent. The findings have shown that EGR has degraded the thermal efficiency of every fuel. The admission of diluents, resulting in a decreased BTE

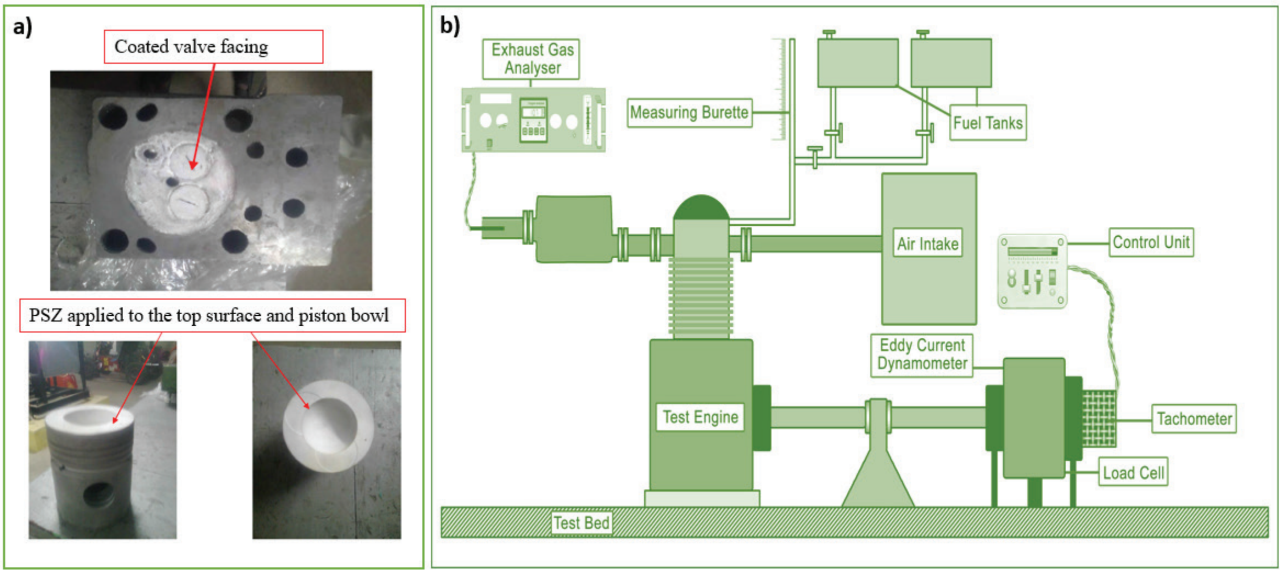

Figure 1. a). Cylinder head and piston bowl; **b).** Experimental setup with exhaust gas recirculation.

Table 1. Fuel properties

Properties	Karanja Oil	Diesel	ASTM test no.
Calorific value (kJ/kg)	7 735	43,000	-
Cetane number	50	45–55	-
Carbon residue (%)	-	0.1	-
Flashpoint (C)	220	75	D93
Viscosity (cSt) Centi Stokes	38.86	2–5	D445
Density (kg/m^3)	904	840	D4052

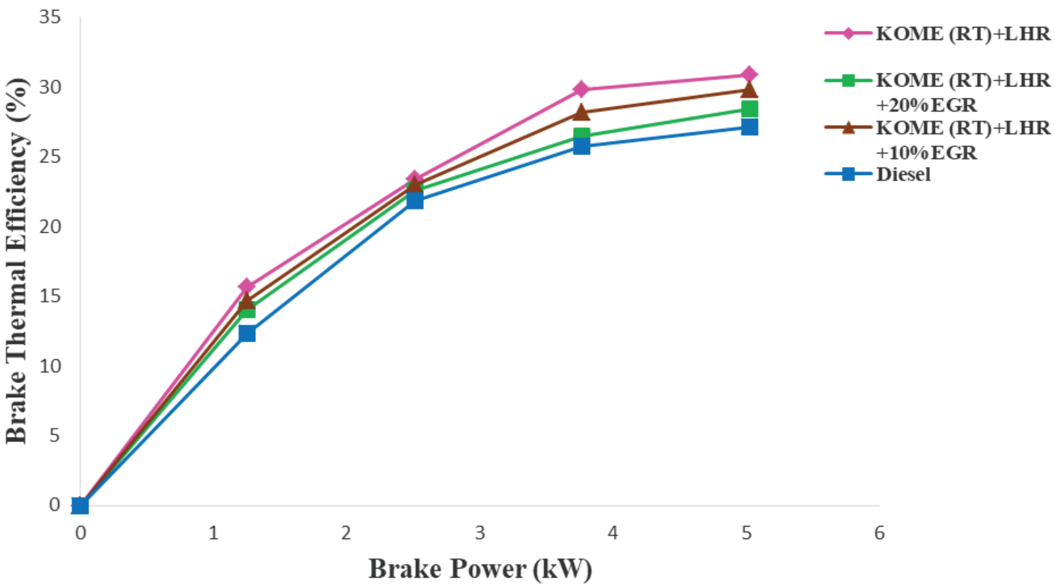

Figure 2. Brake Thermal Efficiency vs BP.

[8], may result in a drop in the flamme temperature. The outcome shown that the EGR has a tendency to lower the thermal efficiency of all fuels. The possibility is that the introduction of diluents caused the flame temperature to drop, lowering BTE in the process.

Brake Specific Fuel Consumption

Figure 3 shows the BSEC load variance. The maximum load for the BSEC of the Karanja Oil Methyl Ester ceramic-coated, delayed injection timing engine was 13.07 MJ/kW-hr. Similarly, 10%, 20%, EGR and 12.09 MJ/KW hour and 12.55 MJ/KW hour for ceramic-capped motors (LHR) were delayed by the BSEC motor. The drop with EGR in BSEC is due to an increase in feed temperature which increases the fuel burn rate and hence leads to a fall of BSFC [9].

Exhaust Gas Temperature

Figure 4. The temperature variation of exhaust gas with load for different EGR flow rates is seen. The exhaust gas temperature decreases slightly at all loads as the volume of EGR increases. Figure 438°C and 403°C For Karanje oil methyl ester exhaust gas temperature at full load for ceramic lacquer delayed injection molding engines, they were greater than the same engin with 10% and 20% exhaust gas recycling accordingly. As the EGR quantity inside the engine cylinders has risen, the maximum combustion temperature has been lowered and the exhaust gas temperature has therefore been decreased [10].

Oxides of Nitrogen Emission

Figure 5 The variance of the nitrogen oxides at load for different EGR percentages is presented. It can be found from figure 13.5 g/kW-hr for ceramic layered retarded injection timing engine NOx emission of Karanja oil methyl ester at full load. Also, with 10 and 20 percent and with 9.2 g/kW-h and with 7.1 g/kW-h, NOx emissions for the ceramic coated (LHR) motor have retarded. The decrease in NO emissions and the rise of EGR in the percentage of inert gas (CO2and H2O) can be attributed to EGR. These gases consume combustion-free energy, reducing the overall combustion

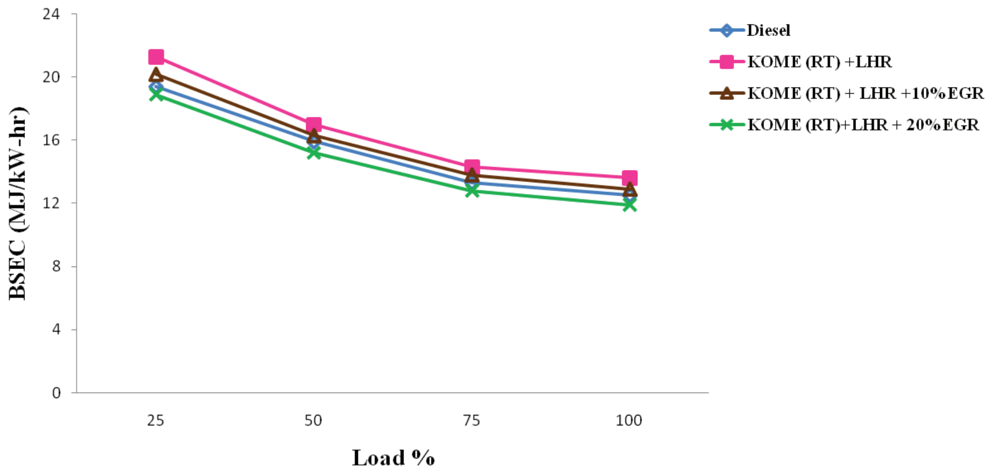

Figure 3. Brake specific energy consumption (BSEC) vs Load.

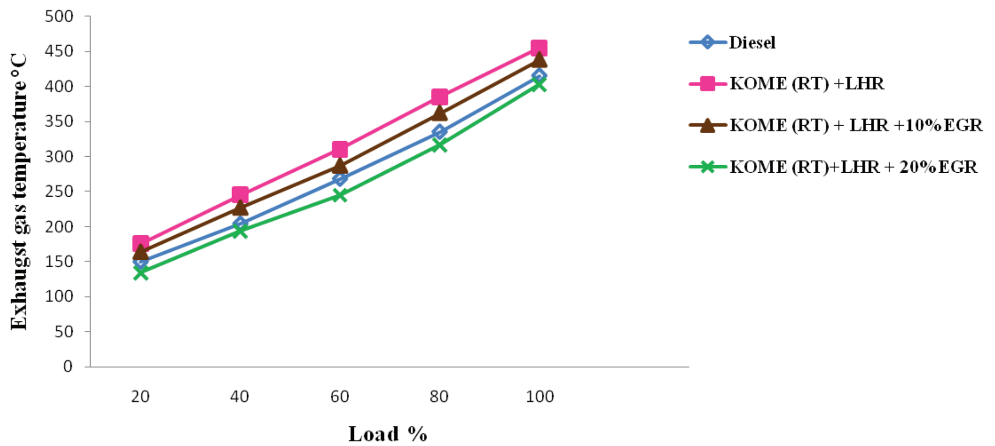

Figure 4. EGT vs Load.

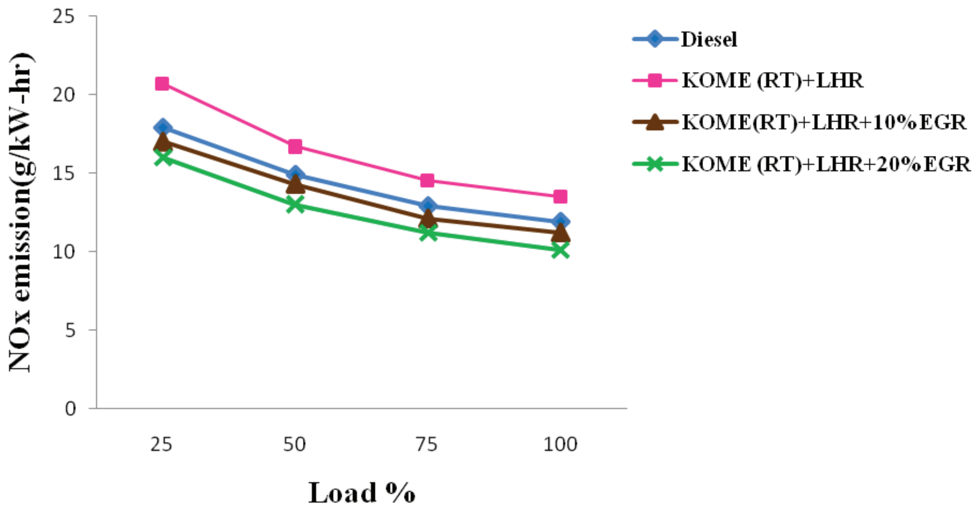

Figure 5. NOx vs Load.

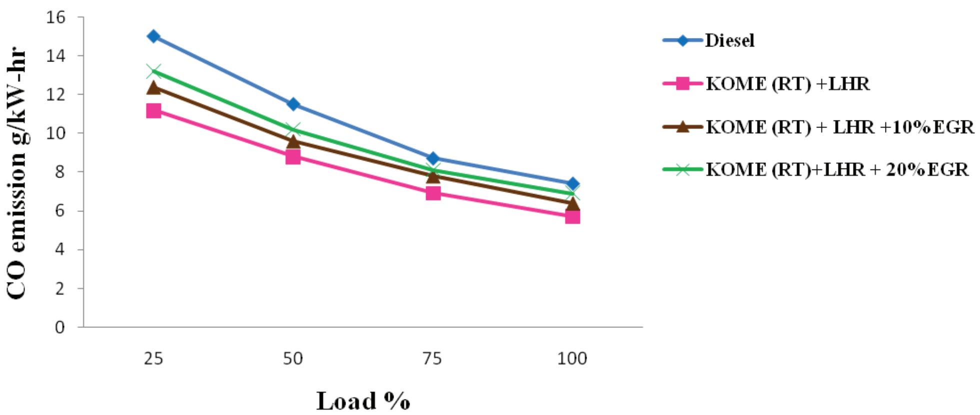

Figure 6. CO vs Load.

temperature in the combustion chamber and replacing the oxygen in the combustion chamber. The temperature and oxygen reduction decreased the amount of NOx [11].

Carbon Monoxide Emission

Figure 6 shows differences in emissions of carbon monoxide at different EGR percentages with activity of Karanja methyl ester oil. The figure shows that the Karanja oil methyl ester CO emissions were 5.07 g/kW-hr for ceramic-coated retarded injection timer engines at the full load. The CO emissions for ceramic coated engines (LHR) also retarded the engine, respectively at a 10% and 20% EGR rate and 6.44 g / kW hr and 6.90 g / kW hr. With rising EGR concentrations, carbon monoxide emissions increase. This may be because of the recirculated exhaust gas that induces incomplete combustion in some of the oxygen in the inlet charges. Similar carbon monoxide emission output was noted by [12] From their studies

Unburned Hydrocarbon Emission

In Figure the difference in unburned emissions of hydrocarbon with load is shown. 7 at various EGR amounts with optimized injection timing. The UBHC emissions of Karanja oil methyl ester for ceramic coat delayed injection timing engine equal to 0.492 g/kW hr. Figure 7 displays Figure 7. In addition, the UBHC ceramic covered emissions (LHR) delayed engines of 0.553 gram/kilowatt hours at 10 and 20 percent EGR and 0.527 gram/kilowatt hours. The rise in unburnt hydrocarbon with an increased rate of EGR is due to the EGR lowering of the oxygen load to the cylinder [13].

Smoke Emission

The smoke load variance for various EGR percentages is shown in Figre 8. The figure shows the smoking emission for ceramic coated delayed injection timing engines of Karanja oil methyl ester at full load to be 3.19 BSU. Also, the 10% and 20% EGR emission of smoke for the

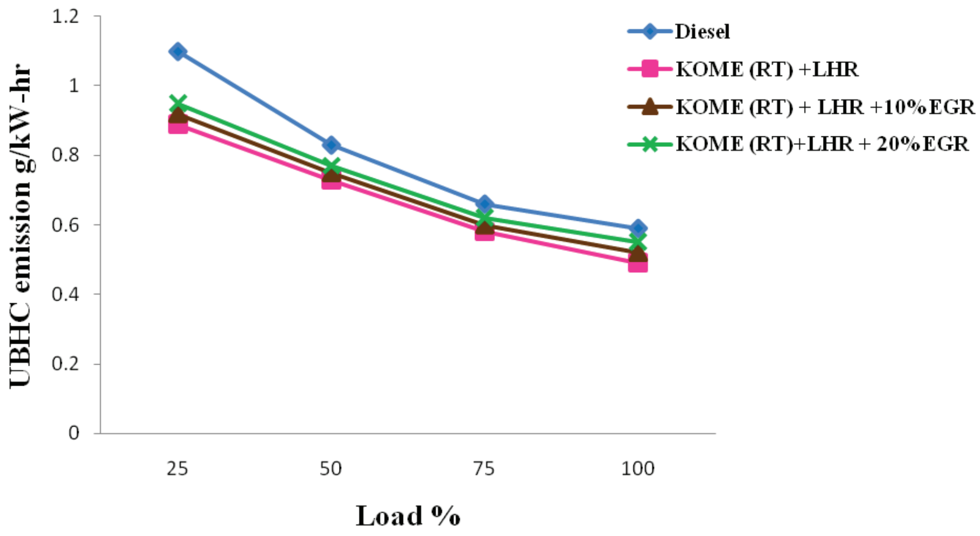

Figure 7. HC vs Load.

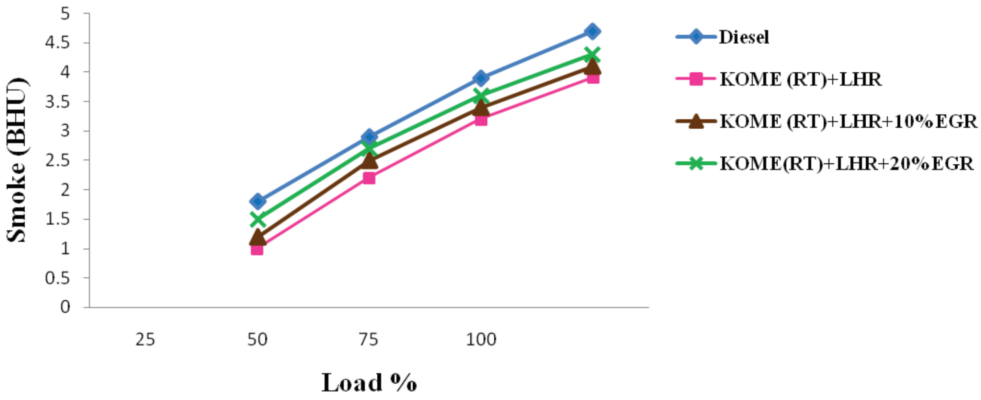

Figure 8. Smoke vs Load.

ceramic coated (LHR) engine is 4.63 BSU and 4.37 BSU. The increase in smoke is due to a partial exhaust gas substitution of the air, which contributes to combustion volatility. In the case of EGR, this contributes to increased smoke levels [14].

Ignition Delay

Figure 9 shows the variation in Ignition Delay with an optimal EGR (20 percent) of Karsa Oil Methyl Ester Oil and Diesel. In the case of a ceramic coated retart injection timer, Figures 3.54% and 7.33% were greater than the same engine with an exhaust gas recirculation of 10% and 20%, respectively. Increasing evaporation of gasoline through higher indoor temperatures lowered the chemical delay and reduced delay with increased braking power [15].

Cylinder Pressure Crank Angle Diagram

Figure 10 shows pressure differences in Karanja methyl ester and diesel, with an optimized EGR of about 20 percent at full load. The results demonstrate that the ethanol fuelled LHR motor has a maximum pressurized 70,2 bar at 12 °CA with a timed delay that is 4.37% and 8.12% more than the maximum regulated motor pressure at 10% and 20% of the EGR. This is because the recycling exhaust gases are used as a heat absorber, which decreases the loading cylinder in the burning chamber during the burning phase [16].

Heat Release Rate

Results show that the LHR fuel-driven LHR engine Karanja oil ester has a maximum heat release rate of 94 J/°CA, 6.63% and 11.27% above the peak pressures controlled by the same engines of 10% and 20% of EGRs. The peak heat release rate with EGR shows this clearly. The delay of ignition decreases significantly by increasing CO2 concentration by using EGR.

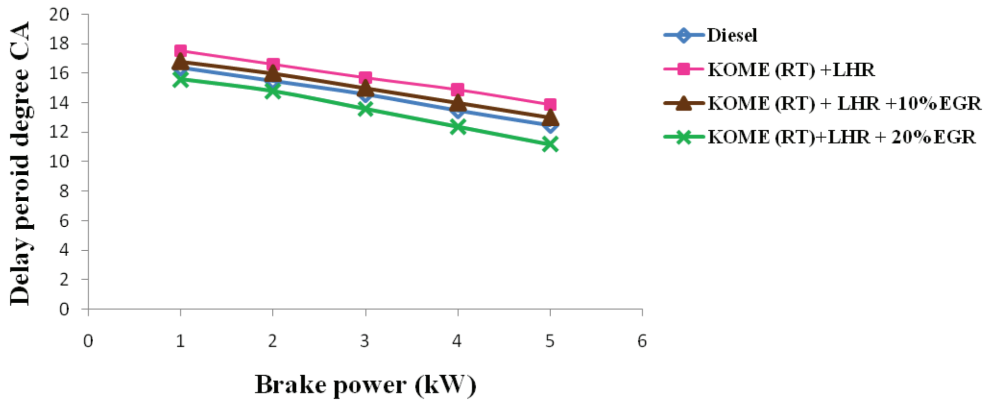

Figure 9. Delay period vs BP.

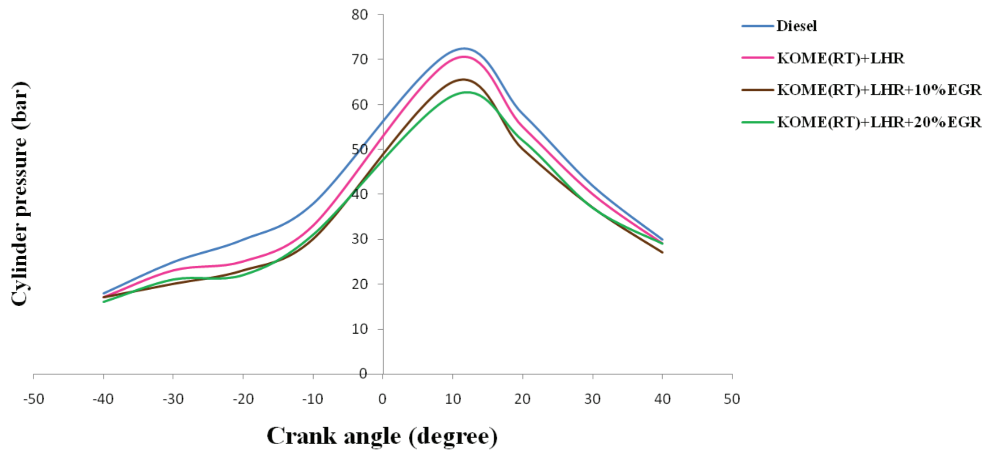

Figure 10. Cylinder Pressure vs Crank angle.

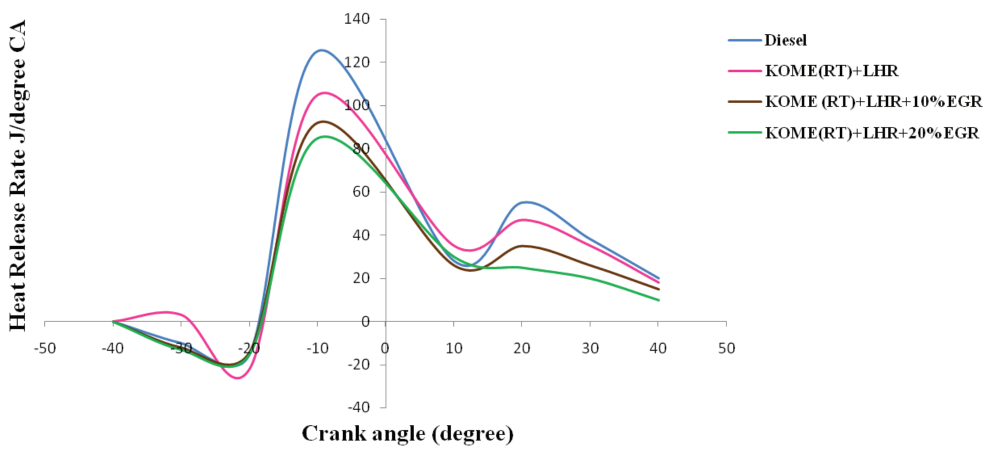

Figure 11. HRR vs Crank angle**.**

CONCLUSION

The key results of the experimental work with diesel and Karanja oil (LHR) with and without EGR are as follows:

- A delayed timing brake's thermal efficiency in a Karanja oil ester LHR engine ranges from 13 to 29% without EGR, compared to 14 to 26% with 20% EGR. At full load, heat efficiency decreases due to higher EGR percentages, which lead to larger air replacements with increased EGR flow rates.

- The Karanja oil methyl ester NOx emissions of retarded-timed LHR engines range from 14.63 g/kWh without EGR to 8.56 g/kWh, compared to 10.97–8.2 g/kWh of the 20% EGR. With the presence of increased hot gas capacity, which lowers the high temperature of peak combustion, NOx emissions reduce with the increase in the EGR percentage.
- The maximum heat release has been observed for Karanja oil ester powered by the retarded time engine LHR, which exceeds the peak pressures of 10% and 20% EGR of 7.63% and 14.27%, respectively. The addition of exhausted gas typically reduces any fuel's heat release behaviour because burned gases are present, which also limited heat output in our scenario.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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