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Performance and Emission Investigation of CI Engine using Waste Plastic Oil and Algae Oil

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ABSTRACT

This paper represents research to find alternative fuel that can be used as a instead of Diesel fuel. Various type of alternative fuels can be used for diesel engines. Plastic oil and algae oil is of these. Plastic oil and Algae oil is experimented by (Kirloskar, Model TV1) Diesel Engine and calculated the efficiency. The aim of this research to analyze Specific fuel Consumption, Mechanical Efficiency, Brake Thermal Efficiency, CO, HC, NOx by considering load, Compression Ratio, and %of Bio-Diesel. RSM method is used for this experiment with the help of Design Expert Software. Micro algae are the source of algal oil methyl ester. With the aid of the transesterification process, the oil was transformed into bio-diesel. This test revealed a considerable reduction in NOx of 24% under conditions of heavy load. By extending the injection timing under high load conditions, the exhaust gas temperature is also decreased by 7.8%.

KEYWORDS: Plastic Pyrolysis Oil, Algae Oil, RSM Method, Design Expert Software

1. INTRODUCTION

All industries, including the transportation and industrial services sectors, depend heavily on energy for growth. The demand for fuels made from petroleum really outpaces that for any other fuels or energy sources. From 85 million barrels per day in 2006 to 107 million barrels per day in 2030, liquid fuel demand will increase globally. Between kerosene and lubricating oils, diesel fuels are petroleum fractions. The crude source and the refinement process have an impact on the qualities of diesel fuel. Heavy fuel oils or diesel fuels are obtained after kerosene and petrol. As an alternate we can utilize bio-diesel in the CI engine for transport as well as other applications because bio- diesel is safe to handle, biodegradable, non-toxic, has good lubricity and runs in any conventional diesel engine. It has very similar combustion properties to petroleum diesel. Without engine modifications these oils can be used in any CI Engine. One such alternative fuel for CI engine application is Plastic pyrolysis oil and Algae oil. is a good lubricant about 66% better than Diesel, produce less smoke and particulates maters as it is free of Sulphur and aromatics, have higher cetane number having good anti knocking property.

2. METHODOLOGY

1. PRODUCTION OF BIODIESEL (PLASTIC PYROLYSIS OIL & ALGAE OIL)

1.1. Stages in Plastic Pyrolysis:

The simplest way to bring in the waste plastics into the reactor is without any preprocess. Large and uneven pieces would occupy a large volume of the reactor hence, soft plastics such as films and bags are often treated with a shredder and a hot melt extruder in order to reduce its size. The feed system consists of arrangement which segregate elements by their size as thin, thick and hard materials at a temperature of 275°C to 375°C. For monitoring the temperature during the process thermocouples are mounted on inside walls of vessel reactor. Vessel rotates at very low speed and heat is given to it by electric equipment to melt inner materials. Solid to liquid and liquid to vapor transformation carried out in a reactor. In this large chain hydrocarbons break into small chain hydrocarbons. This vapor is taken out from vessel by piping arrangement and then this vapor is passed through condenser which cools it and vapor transforms into liquid. This liquid also contains water so to achieve pure oily liquid water is separated by oil-water separator. After this process we get Plastic Pyrolysis Oil. This process has done with the below flowchart.

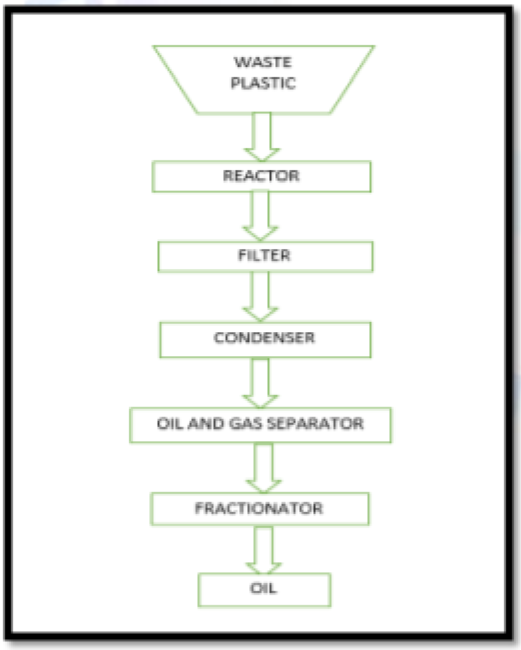


Fig: Stages in Plastic Pyrolysis Process

1.2. Stages in Algae Oil:

The most popular and effective approach for reducing the viscosity of algae oil is transesterification. In this procedure, a catalyst is used to help a triglyceride react with three alcohol molecules to produce a combination of fatty acids, alkyl esters, and glycerol. Esterification is the process of completely removing all of the glycerol and fatty acids from the algae oil while using a catalyst. Biodiesel is made from esterified algal oil.

After esterification of the Algae oil its density, viscosity, cetane number, calorific value, and atomization and vaporization rate, molecular weight, and fuel spray penetration distance are improved more The properties of the algae oil are improved further after esterification, including density, viscosity, cetane number, calorific value, atomization and vaporization rate, molecular weight, and fuel spray penetration distance. Thus, the CI engine performs well due to these increased features.

a. Catalyzed by acid Processes Catalyzed by Acids in Transesterification Sulfonic and sulfuric acids are preferred as the Bronsted acids that catalyze the transesterification process. These catalysts provide extremely high yields of alkyl esters, although the reactions are sluggish and often take longer than three hours to complete. In order to prevent the competitive synthesis of carboxylic acids that would lower the yields of alkyl esters, an acid-catalyzed transesterification should be carried out without the presence of water.

b. Transesterification Catalyzed by the Base Algae oil transesterification that is base-catalyzed advances more quickly than an acid-catalyzed reaction. Industrial operations typically favor base catalysts such alkaline metal alkoxides and hydroxides as well as sodium or potassium carbonate because of this and the fact that alkaline catalysts are less corrosive than acidic substances.

1.3 Transesterification setup:

A 2-liter, three-necked, flat-bottomed glass flask was used for the transesterification reaction. For the purpose of condensing methanol vapors during the reaction, a double coiled reflux condenser was attached to the glass flask's neck. Water was pumped through the condenser's coils. The flask's contents were heated uniformly using a plate heater and magnetic stirrer. The third neck of the flask was used to transfer algae oil, methanol, and NaOH. Triglycerides from algae oil combine with methyl alcohol in the transesterification process in the presence of a catalyst (NaOH), creating fatty acid ester and glycerol. In this procedure, a round-bottomed flask was filled with 1000 g of rice bran oil, 200 g of methanol, and 8 g of sodium hydroxide. The mixture was poured into a separating funnel and left to settle overnight under the influence of gravity. The ester forms in the upper layer of the separating funnel, and the glycerol in the bottom layer is eliminated from the mixture. After mixing the separated ester with 250 gramme of hot water, it was let to settle naturally for 24 hours. The catalyst and fatty acids that were dissolved in the lower layer are removed by water washing. Using a separating funnel, fatty acids and dissolved catalyst were eliminated.

Chemical Reaction of Transesterification Process:

The methanol is used in the process of transesterification, and hence this process is called as metanalysis. In the transesterification process, one molecule of triglyceride reacts with three molecules of methanol to produce three molecules of methyl ester, while one molecule of glycerin separates out. General equation for metanalysis of triglycerides is shown below. CH2OOC – R1 CH3OOC – R1CH2OH CHOOC – R2 + 3 CH 3OH CH3OOC – R2 + C H2 O H CH2OOC – R3 CH3OOC – R3CH2OH 1 Triglyceride + 3Methanol 3Methyl Ester + Glycerol.

3. MODELING AND ANALYSIS

Figure-1: Experiment setup for engine

The emissions such HC, CO, CO2, NOx, are measured using five gas analyzer and smoke density was measured by using smoke mete an eddy current dynamometer that allowed for either full or partial engine motoring was directly attached to the engine. A control panel was interfaced to the engine and dynamometer. The engine's speed was determined using a photo sensor and a digital rpm indicator. The digital rpm meter receives voltage pulses from the sensor, converts them into pulses, and displays the engine speed with a precision of 1 rev/min.

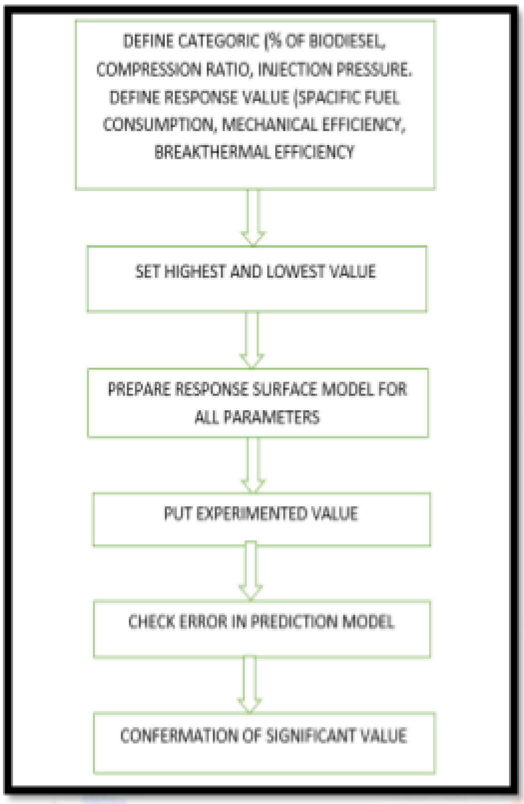
Engine Specification

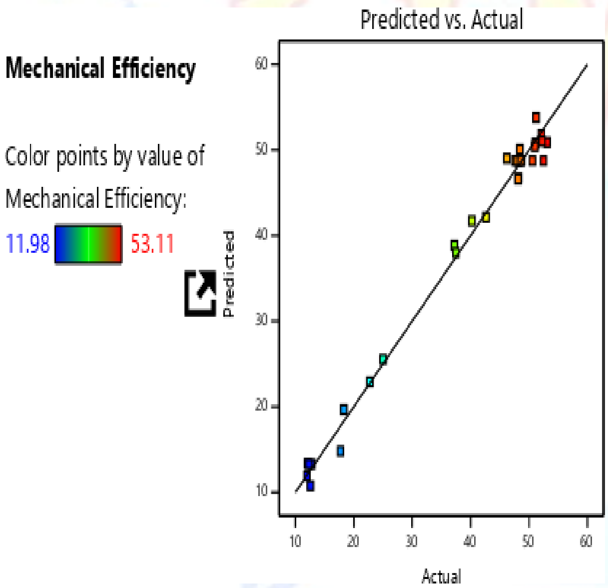
Table-1: Engine Specification

Make and Model	Kirloskar Model AV 1
Number of cylinders	4-stroke Single Cylinder C.I Engine
Swept Volume	552.64 cc
Bore	80 mm
Stroke	110 mm
Power	3.7 kw
Speed	1500 rpm
Compression ratio range	12 to 18
Loading	Eddy current dynamometer, water cooling

DESIGN-EXPERT 13 SOFTWARE

Minitab provides analytical and graphical tools to help understand the results after the following steps to create, analyze, and graph of experimental design. This method will help to predict, which parameters are more affected to response parameters. Also, Optimization of output parameters will be done with the help of this flowchart.





4. RESULT AND DISCUSSION

The findings of an examination done on a single-cylinder; normally aspirated diesel engine is presented in this section. The engine was kept running at a steady 1500 rpm. The injection timing was kept constant at 27°BTDC, injection pressure of 230 bar and compression ratio of 17.5

From the diagram it is found that, Specific fuel consumption of Bio diesel is highest at bland ratio B10, compression ratio-14 and load-7 N. Specific fuel consumption is lowest at B10, compression ratio 17 and load 3N.

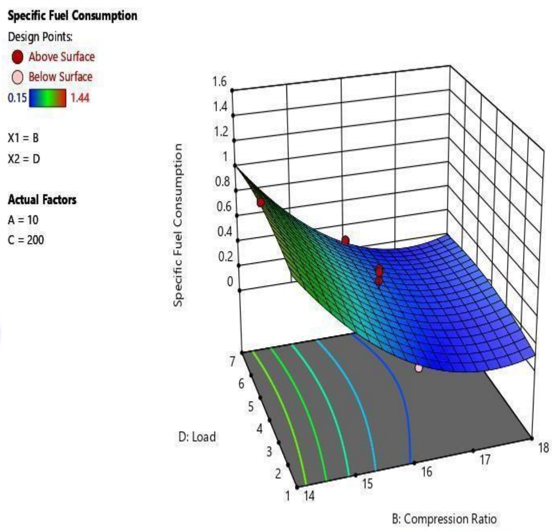
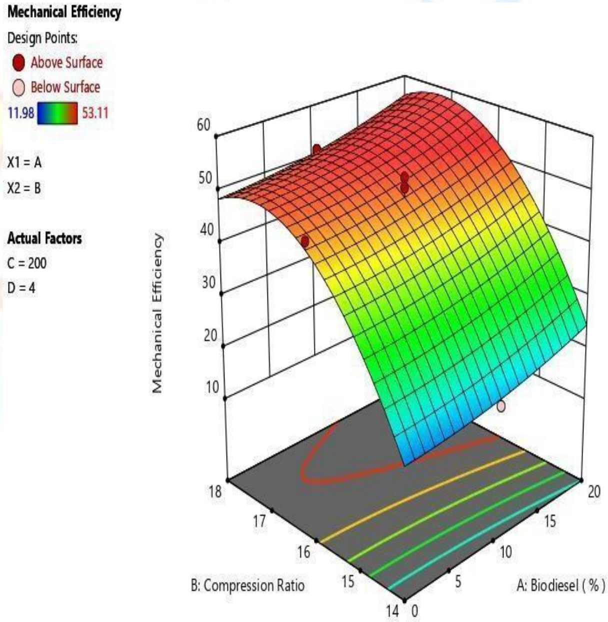


Diagram-1: specific Fuel Consumption 3D diagram with depending variable Compression Ratio & Load.



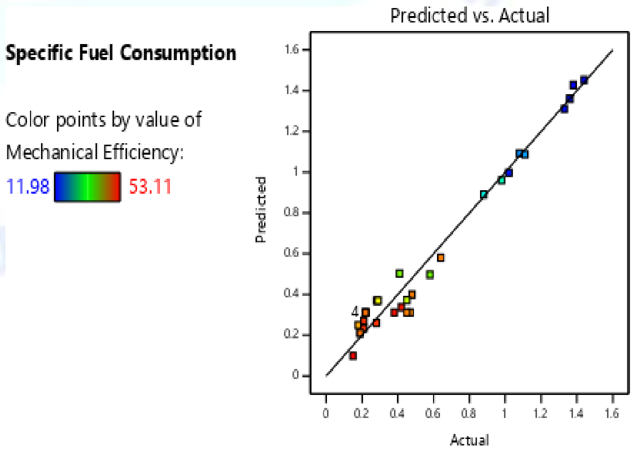
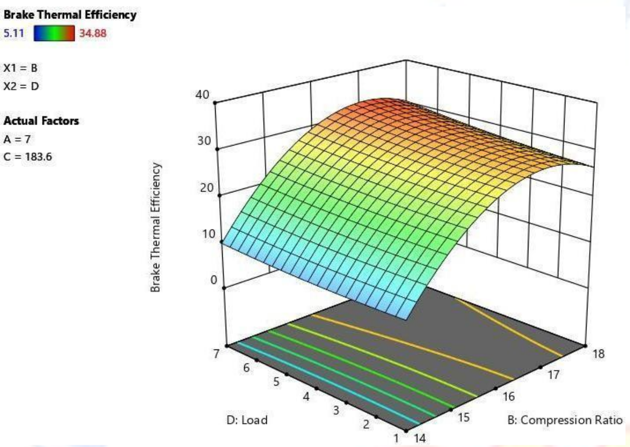


Diagram-2: Mechanical Efficiency 3D diagram with depending variable Compression Ratio & % of Bio-Diesel.

For Mechanical efficiency, it is found that it is highest at B15, compression ratio 17, load 4N. Mechanical efficiency is lowest at B10, compression ratio 16 and load 6N. For Brake thermal efficiency, it is found that it is highest at B10, compression ratio 17, load 6N. Mechanical efficiency is lowest at B20, compression ratio 17 and load 4N.



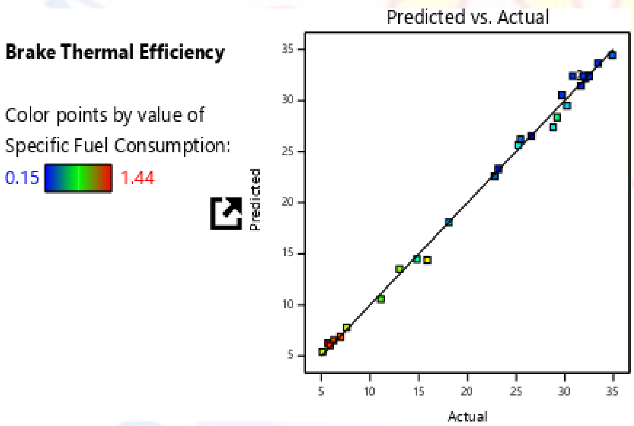
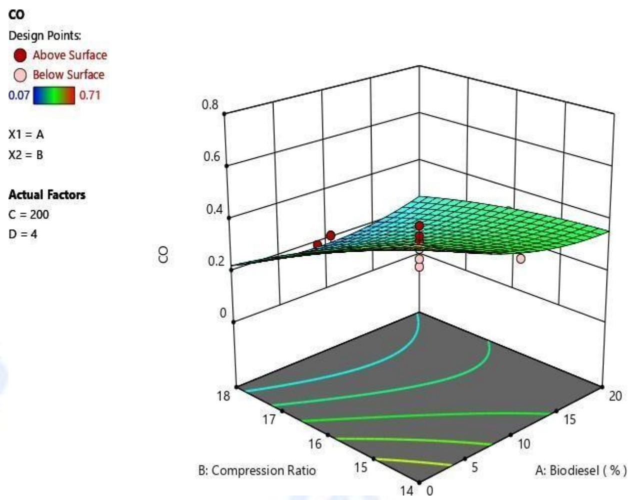


Diagram-3: Break Thermal Efficiency 3D diagram with depending variable Compression Ratio & Load

CO emissions increases as brake power increases. Biodiesel blended fuel emits less CO, especially on average, B05 emitting 4 percent less CO than pure diesel. Fuel containing 10% plastic pyrolysis oil, on the other hand, produce more CO at higher load and speed. It was 4% more expensive than pure diesel fuel.



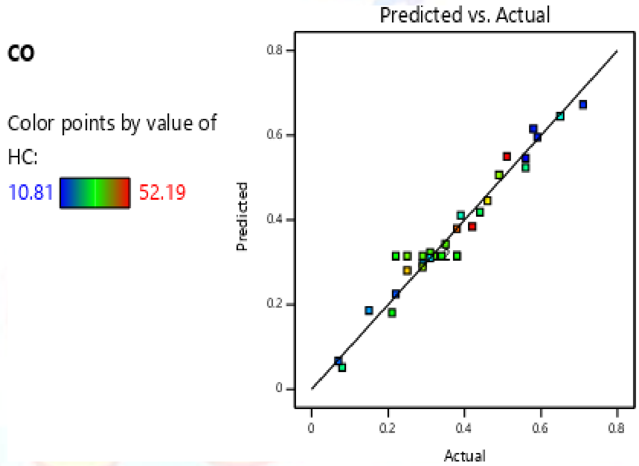
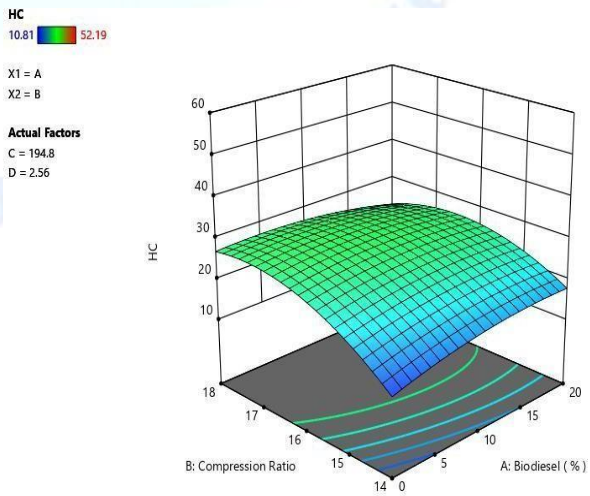


Diagram-4: CO2 emission 3D diagram with depending variable Compression Ratio & % of Bio-Diesel.

NOx emissions are higher than biodiesel blends. HC emission is highest at B10, compression ratio is 17 and lowest at compression ratio 16, B05 and load is 3N. NOx emission is highest at load 7N, B05, compression ratio 16. And lowest at B20, load 4N and compression ratio 15.



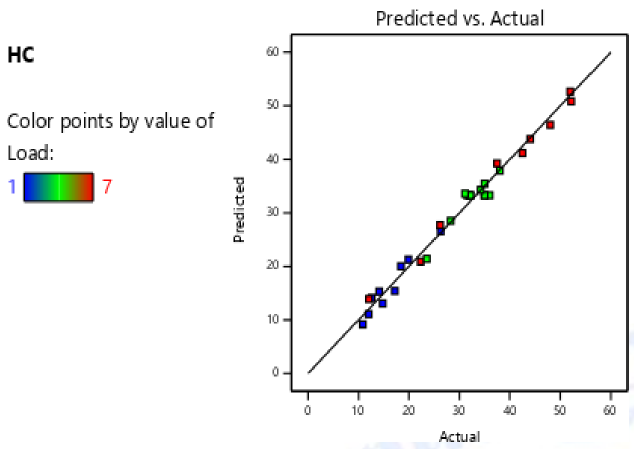


Diagram-5: HC emission 3D diagram with depending variable Compression Ratio & % of Bio-Diesel

According to the graph, it is evident that for medium as well as high load, diesel blend with 10% Bio-Diesel has higher NOx emissions than any other fuel. At high load diesel fuel has NOx emission of 591 ppm.

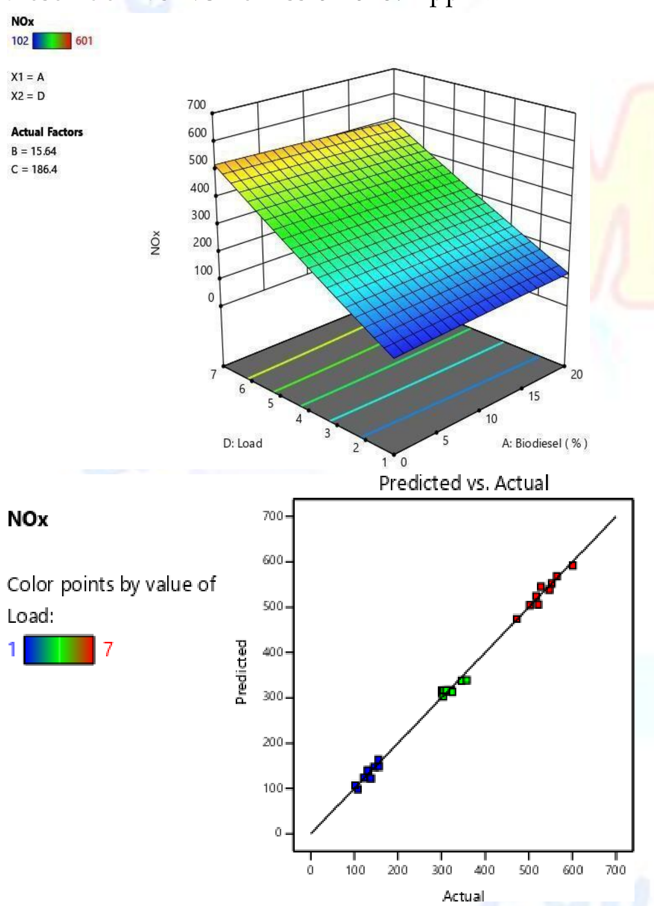


Diagram-6: NOx emission 3D diagram with depending variable Compression Ratio & % of Bio-Diesel

5. CONCLUSION

- Most of the chemical and physical properties of plastic pyrolysis oil and algae oil are comparable to those of diesel. As a result, they develop into strong fuel that may someday take the place of diesel.
- The acid number for diesel is much lower than that for plastic pyrolysis oil. As a result, it frequently causes the gasoline tank and other engine parts to rust. Additionally, the fuel's Sulphur content is higher. This stops it from blending with diesel more.
- Despite having a calorific value that is extremely close to that of diesel, biodiesel struggles to match diesel in terms of brake thermal efficiency. B20, on the other hand, performs better than any other blends.
- While B10 has increased CO2 and NOx emissions, higher blends of fuel have emission characteristics similar to diesel.
- When exhaust gas was recirculated, NOx emissions significantly decreased while CO2 emissions rose.
- In future more blends of these fuels can be tested for performance and emissions.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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