IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e- ISSN: 2278-1684, p-ISSN : 2320–334X
PP 08-17
www.iosrjournals.org

EXPERIMENTAL ANALYSIS OF DIRECT INJECTION DIESEL ENGINE USING PALMAROSA OIL

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ABSTRACT**:** *The depleting fossil fuel resources, increases the price of fuel continuously. At one point of time the whole resources may come to end. Keeping this in view many researchers identified various alternative fuels and tested successfully.*

In the present investigation the performance and emission characteristics of single cylinder four stroke direct injection diesel engine using palmarosa oil as an alternate fuel is evaluated. Here palmarosa oil is used in the form of blends at various proportions with diesel. High viscosity is one important difference between palmarosa oil and commercial diesel fuel. Bio-diesel is prepared from palmarosa oil using double Trans esterification process. A single cylinder, four stroke, constant speed, water cooled, direct injection diesel engine is used for the experiment.

The performance of the engine is measured using electrical dynamometer and the emissions such as $CO_{2,}$ CO; HC & No_x is measured using exhaust gas analyzer. The experimental data for various parameters such as thermal efficiency, brake specific fuel consumptions (BSFC) are analyzed. Acceptable thermal efficiencies of the engine were obtained with blends containing up to 75% of palmarosa oil biodiesel blend.

Key words: *Palmarosa oil, Bio diesel, Alternate fuel, CI Engine.*

1. INTRODUCTION

The palmarosa grass cultivation in India is abundantly done and the availability of palmarosa grass is also high. The oil obtained by crushing these grasses can be used as an alternate fuel and they are also non edible. Due to the high FFA content of the oil esterification is done before using it as alternate fuel. The emission characteristics and engine performance are acceptable .Also due to the high availability of palmarosa grass oil the impact of fossil fuel on Indian economy can be minimized. If mass production of oil is done, it will favor the agricultural sector of our country.

Alternate fuels should be easily available at low cost, be environment friendly and fulfill energy security needs without sacrificing engines operational performance. For the developing countries, fuels of bio-origin provide a feasible solution to the twin crises of fossil fuel depletion and environmental degradation. Now bio –fuels are getting a renewed attention because of global stress on reduction of greenhouse gases (GHGs) and clean development –mechanism (CDM).The fuels of bio-origin may be alcohol, vegetable oils, biomass, and bio gas. Some of the fuels can be used directly while others need to be formulated to bring the relevant properties close to the conventional fuels. For diesel engines, a significant research has been directed towards using vegetable oils and their derivatives as fuels.

Diesel engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long –term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. Unlike rest of the world, India’s demand for diesel fuel is roughly six times of gasoline hence seeking alternative to mineral diesel is a natural choice.Palmarosa oils have comparable energy density, cetane number, heat of vaporization, and stoichiometric air / fuel ratio with mineral diesel. In addition they are bio degradable, non-toxic, and have a potential to significantly reduce pollution. Palmarosa oil and its derivatives in diesel engines, lead to substantial reductions in emissions of sulfur dioxides, carbon monoxide (CO), poly aromatic hydrocarbon (PAH), smoke, particulate matter (PM) and noise. Furthermore, contribution of bio fuels to greenhouse effect is insignificant, since carbon dioxide (CO2) emitted during combustion is recycled in photosynthesis process in plant

2. CHARACTERIZATION

2.1 PROPERTIES OF PALMAROSA OIL:

In the present investigation palmarosa oil, a non-edible type of vegetable oil, has been considered as a potential alternative fuel for compression ignition (CI) engines. The palmarosa grass production potential in India is about 150 kg/ha per annum. The estimated availability of palmarosa grass is about 30,000 MT/year. palmarosa kernels (50–60% of grass) contain 40–50% of pale yellow oil. At present, palmarosa oil has not found any major application and hence the natural production of grass remains underutilized. The properties of palmarosa oil in comparison with diesel are given in Tables 1, 2, 3 respectively. The purpose of the present study is to analyze the suitability of palmarosa oil as fuel.

2.2Properties of fuels

Table- 1

SL.No	Fuel property	Diesel	Palmarosa Oil
1.	Density @15^{o} C in kg /m^{3}	850	928.2
2.	Flash point in	68^{o} C	228^{o}C
3.	Kinematic viscosity at 40^{o} C	2.51 cst.	33.89 cst
4.	Cetane index	47-53	40
5.	Calorific value	42927 kJ/kg	36672 kJ/kg
6.	Firepoint	210^{0} C	240^{0} C

.3 OTHER PROPERTIES OF PALMAROSA OIL

TESTS	RESULTS
Appearance	Dark brownish yellow oil.
Water content	0.12%
Ash	0 .005%
Conradson Carbon residue	1.86%
Acidity as mg of	54.9

KOH/gm.	
Iodine Value(Wij's)	104.1
Sediments(Insolublein Hexane)	0.07%
Sulphur content	0.09%

2.4 PROPERTIES OF BLENDS:

PROPERTY	DIESEL	25%R 75%D	50%R 50%D	75%R 25%D	100%R
DENSITY in Kg/m^3	820	849.1	876.9	888.3	922.6
CV in KJ/Kg	42960	39502	38154	36575	34662

3. ENGINE SPECIFICATION

Make	KirloskarAV1 model
Type of Engine	Vertical,4-Stroke cycle, single acting, High speed , DI, diesel engine.
Number of Cylinder	One
Speed	1500rpm
Maximum power output	5Hp(=3.7 kW)
Bore	80mm
Stroke	110mm

Cubic Capacity	0.553 litres
Normal compression ratio	16.5:1
Fuel timing by spill	23 Deg. BTDC
Lubrication	Forced Full Pressure lubrication
Type of cooling	Water cooled
BMEP at1500 rpm	5.42 bar

3.3 AIR FLOW MEASUREMENTS

An orifice meter attached with an anti-pulsating drums measures air consumption of an engine with the help of U tube manometer. The anti-pulsating fixed in the inlet side of an engine maintains a constant suction pressure, to facilitate constant air flow through the orifice meter.

3.4 EXHAUST EMISSION MEASUREMENTS

Five gas analyzer is used to measure the quantity of emission constituents such as CO, CO_2, O_2, UBHC, and NO_x present in the exhaust gas. HC and NO_x were measured in ppm and CO, O_2 and CO_2 measured in percentage (%) by volume.

The measurement of exhaust gases was carried out by placing the probe into the exhaust pipe. The probe can be pulled out after taking reading. Similarly measurements were made for all trials. The printout can be obtained from the analyzer for each trial.

3.5 FUEL FLOW MEASUREMENTS

This device consists of graduated burette, fuel tank and two-way cock. During measurement, the two-way cock is arranged in such a way that the fuel descends from burette alone. Then the time taken for specific quantity of fuel consumption was found out using the stopwatch and the fuel consumption rate was evaluated.

3.6 TEMPERATURE MEASUREMENTS

The inlet air temperature and exhaust gas temperature is measured using K- type thermocouples and digital temperature readout. This thermocouple was located at approximately 15 cm from exhaust and inlet pipe of the engine.

3.7 COMBUSTION PRESSURE MEASUREMENT

The measurement of cylinder pressure is made using a KISTLER quartz piezo - electric pressure transducer. An 8-bit DAS receives this signal and acquires it at an interval of 1^o crank angle to analyze the combustion behavior of fuel

4. EXPERIMENTAL ANALYSIS

A series of tests were carried out on a constant speed four stroke direct injection water cooled single cylinder compression ignition engine at the rated speed of 1500 rpm. The detailed specifications of the engine are given in Table 4. Bio Diesel from Palmarosa oil–diesel blends was tested successfully in the unmodified diesel engine. Tests were carried out separately on Palmarosa bio diesel and diesel for comparative assessments. All the blends were tested under varying load conditions (no load to full load) at rated speed. Emissions were measured using Exhaust gas Analyser.The experimental data generated are presented in Fig 1-7. The optimum blend was found out on the basis of maximum thermal efficiency and lower smoke emission considerations .The comparison of the specific consumption for various blends of palmarosa oil and diesel is presented in Fig 2. It was observed that specific fuel consumption of the all fuels tend to decrease with increasing load. The blends containing 75% of palmarosa oil yielded an engine performance closely matching that of diesel oil. Though the blends as well as biodiesel of Palmarosa oil maintained a similar trend to that of diesel, the value of the specific fuel consumption for palmarosa oil was higher compared to that of diesel in the entire load range of the engine. This is due to the combined effect of viscosity and calorific value of the blend. From Fig 1 it is revealed that, with increasing brake power, the brake thermal efficiency of the blends was increased. There was considerably increased efficiency with blends compared to the use of palmarosa oil alone. In the case of 75:25 (palmarosa oil: diesel) blend, the highest thermal efficiency was observed. Brake thermal efficiency of 50:50 blend closely matches that of diesel oil. An increase in exhaust gas temperature with increase in brake power irrespective of the blend ratio occurred is observed from Fig3 Blends in the range of 25%R of palmarosa oil resulted in similar exhaust gas temperature values to that of the diesel. The results shown in Fig 4-7 indicate that, as expected, smoke increases with increasing load in all cases. The highest value of smoke observed was 25R%, is found to closely match that of diesel.

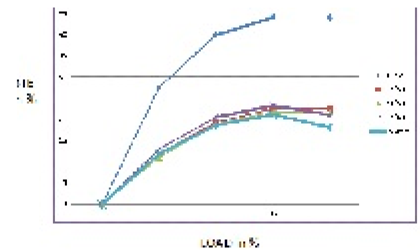

Fig-1.BTE vs. Load

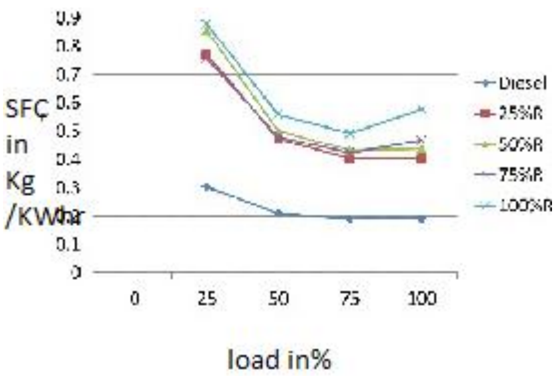

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Fig- 2.SFC vs. Load

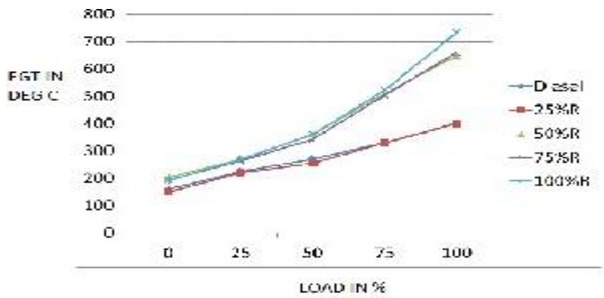

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Fig -3.EGT vs. Load

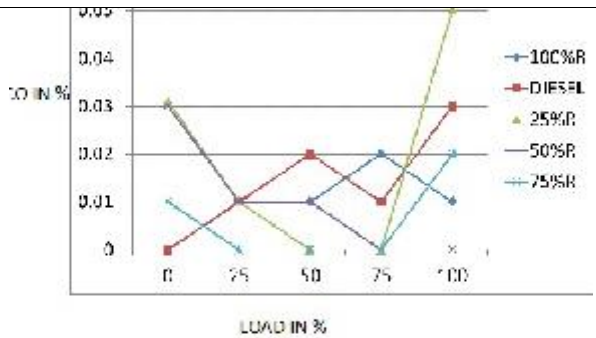

Fig-4.co vs. Load.

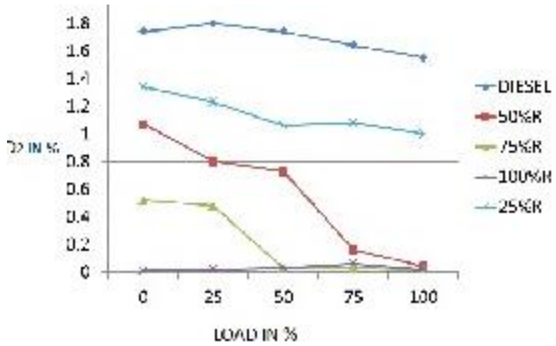

Fig -5.CO2 vs Load

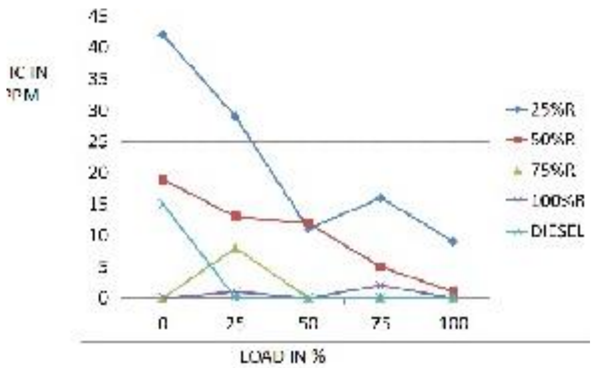

Fig-6.HC vs. Load

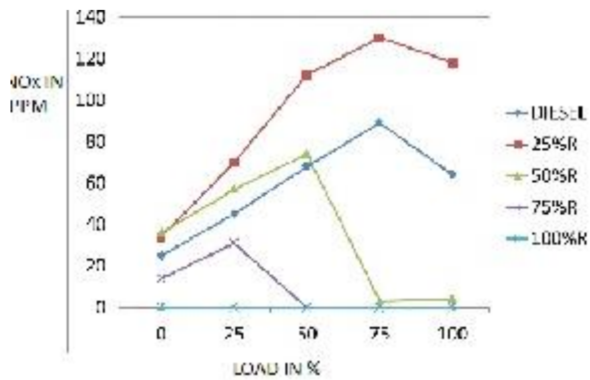

Fig-7.Nox vs. Load

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e- ISSN: 2278-1684, p-ISSN : 2320–334X
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5. COMBUSTION ANALYSIS

5.1 Cylinder pressure:

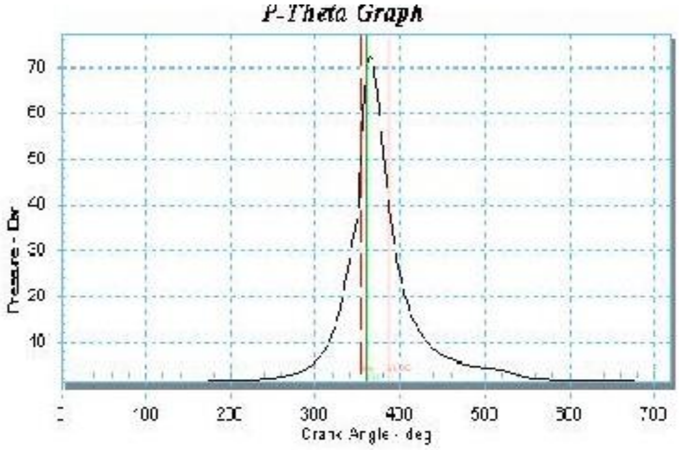

Fig 8 for Diesel

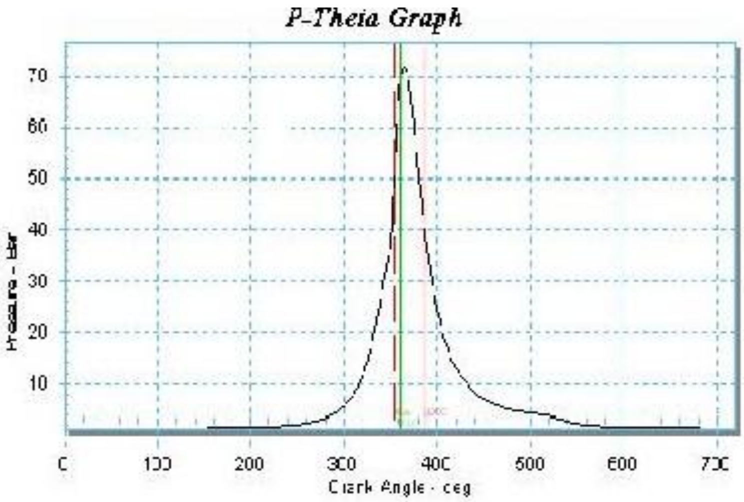

Fig-9 for 25%R

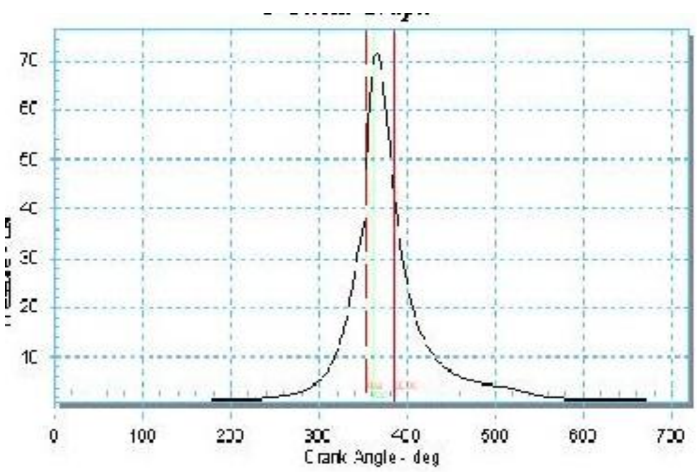

Fig- 10 for 50%R:

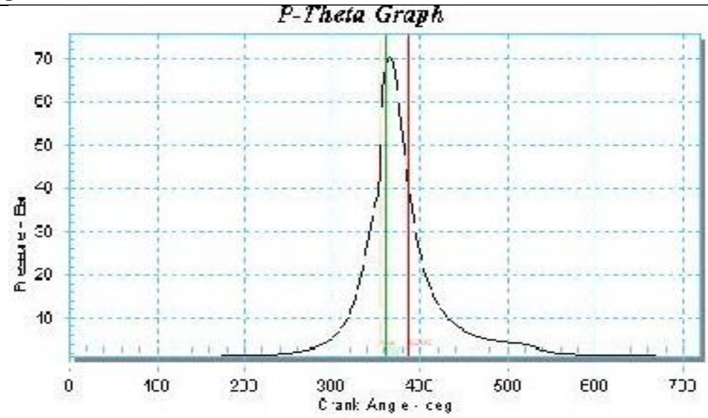

Fig- 11 for 75%R:

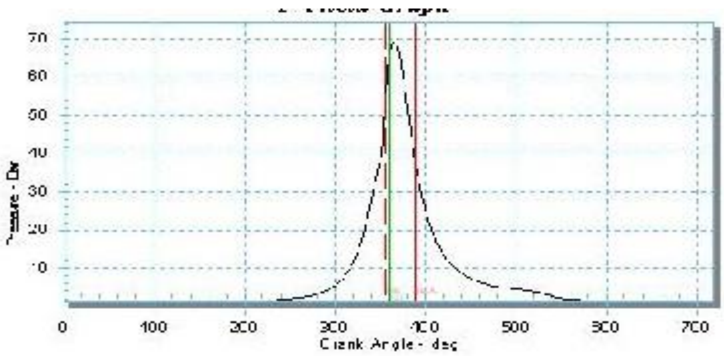

Fig-12 for 100%R:

5.2 Comparison of P-THETA diagram of various blends and Diesel operation at full loads.

Figure 8-12 shows the comparative P-Theta diagram of 25%R, 50%R, 75%R, 100%R and Diesel operation. As the 100%R oil possesses high viscosity, the P-theta diagram of 100%R is not similar to other blends and of Diesel. More specifically, it offers shorter ignition delay, low peak pressure, long burn duration and early occurrence of peak pressure. Hence the performance of 100%R is inferior in all load conditions compared to other fuels.

However, the P-theta diagram of 25%R is almost similar to that of Diesel with marginal difference in cylinder pressure. Both are offering same ignition delay, peak pressure .This may be due to increased volatility, increased latent heat of vaporization and reduced viscosity of this fuel. Hence it does not require any engine modification and performs similar to standard diesel fuel. The peak pressure values of 25%,50%,75% are 73,73,72 bars respectively. The highest peak pressure is obtained with 25%, 50% blend compared to other fuels. This is the main reason for better thermal efficiency of this fuel.

5.3 HEAT RELEASE RATE:

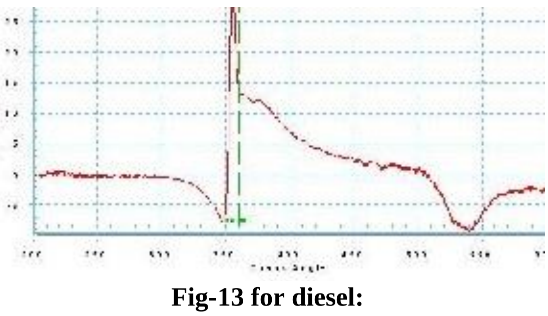

Fig-13 for diesel:

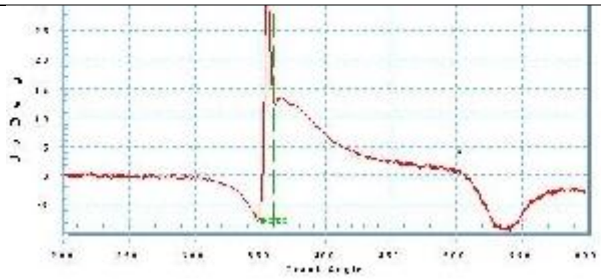

Fig-14 for 25%R:

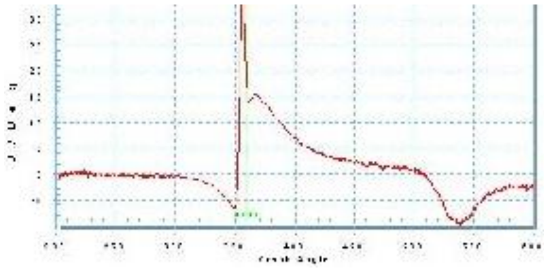

Fig 15 for 50%:

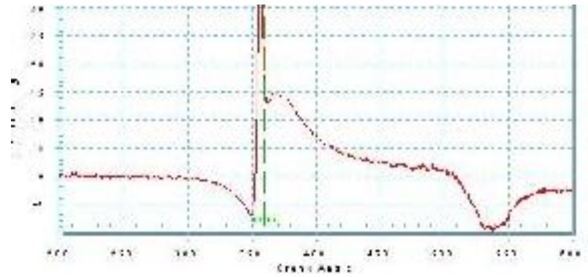

Fig-16 for75%:

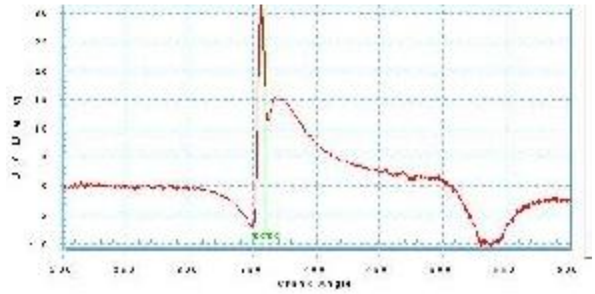

Fig-17 for 100%:

5.4 Comparison of HRR of blends of Palmarosa oil with Diesel operation at full loads:

Figure 13-17 indicates the comparative net heat release rate of 25%R,50%R,75%,100%R,diesel operation with respect to crank angle position. From the figure it is seen that all the net heat release rate of almost all the blends are similar to diesel operation with marginal difference in heat release rate. This is due to improved volatility, reduced viscosity .That is the two phase of combustion generally occurring in diesel fuel combustion is also occurring in blends of Palmarosa oil and diesel.

6. CONCLUSION

The main aim of the present investigation was to reduce the viscosity of Palmarosa close to that of conventional fuel to make it suitable for use in single cylinder, water cooled, vertical and direct injection diesel engine and to evaluate the performance of the engine with modified Palmarosa oil. Significant reduction in viscosity was achieved through double trans esterification and double filtration. The biodiesel from Palmarosa is blended with diesel at varying proportions. It is observed that maximum brake thermal efficiency of 75%R was 23.46% and it is similar to that of diesel operation and also increases SFC and EGT. Emissions from the blends were also acceptable. Brake thermal efficiency, Heat release rate of 50%R&75%R are similar to that of diesel. Hence they can be used as alternate fuel without any modification, operational difficulties in existing diesel engine.

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