

REVIEW ON PERFORMANCE AND EMISSION CHARACTERISTICS OF VARIOUS BIODIESEL BLENDS

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Abstract - As population and transportation are accelerating forward fossil fuel couldn't stay alive for a longtime with its warehouse resources. In this regard, renewable energy turns into a remedy to solve this issue. Researchers have done extensive work to use renewable energy as a source of fuel for transportation sector. Biodiesel, an alternative for diesel fuel obtained from various feed stocks that can directly use in engine or as a mixture with diesel fuel without any modification in the engine. This paper emphasis on overview of biodiesel and its production technique followed by its performance and emission characteristics on diesel engine. From this attempt the result states that based on performance vice using biodiesel tends to drop in efficiency meanwhile as of considering the environmental concern the biodiesel pushes itself forward with reduction harmful emissions like unburnt hydro carbon, particulate matter and Carbon monoxide.

Keywords: Mahua biodiesel, Pongamia biodiesel, Mango seed biodiesel, Zizipus jujube, CO emission, brake thermal efficiency

1. INTRODUCTION

Energy is one of the most important resources for mankind and its sustainable development. Today, the energy crisis becomes one of the global issues confronting us. Fuels are of great importance because they can be burned to produce significant amounts of energy. In the transportation sector, private vehicles, buses, trucks, and ships also consume significant amounts of diesel and gasoline. Main energy resources come from fossil fuels such as petrol oil, coal and natural gas. Fossil fuel contributes 80% of the world's energy needs. However, the energy demand due to the population growth is not covered by domestic crude oil production. Fossil oils are fuels which come from ancient animals and microorganisms. Fossil fuel formation requires

millions of years. Thus, fossil oils belong to non-renewable energy sources.

Bio fuels made from agricultural products reduce the countries dependence on oil imports, support local agricultural industries and enhance farming incomes, while offering benefits in terms of sustainability and reduced particulate matter emissions. Since the carbon in the biodiesel originated mostly from CO₂ in the air, the full cycle CO emissions for biodiesel contribute much less to global warming than fossil fuels. Among the bio fuels currently in use or under consideration, biodiesel (methyl or ethyl ester) is considered as a very promising fuel for the transportation sector since it possesses similar properties with diesel fuel, it is miscible with diesel practically at any proportion, and is compatible with the existing distribution infrastructure.

2. DIESEL ENGINE USING MAHUA BIODIESEL

In this paper, aluminium oxide nanoparticles (ANPs) were added to Mahua biodiesel blend (MME20) in different proportions to investigate the effects on a four stroke, single cylinder, common rail direct injection (CRDI) diesel engine. The ANPs were doped in different proportions with the Mahua biodiesel blend (MME20) using an ultrasonicator and a homogenizer with cetyl trimethyl ammonium bromide (CTAB) as the cationic surfactant. The experiments were conducted in a CRDI diesel engine at a constant speed of 1500 rpm using different ANP-blended biodiesel fuel (MME20 + ANP50 and MME20 + ANP100) and the results were compared with those of neat diesel and Mahua biodiesel blend (MME20). The experimental results exposed a substantial enhancement in the brake thermal efficiency and a marginal reduction in the harmful pollutants (such as CO, HC and smoke) for the nanoparticles blended biodiesel.

2.1. MAHUA METHYL ESTER-NANOFUID BLEND PREPARATION

The aluminium oxide nanofluid was added to the Mahua methyl ester blend (MME20) in two different proportions (50 and 100 ppm). After the addition of aluminium oxide nanofluid, it is shaken well. And then it is poured into signification apparatus where it is agitated for about 30–45 min in an ultrasonic shaker, making a uniform MME20-ANP blend. The properties of Mahua methyl ester (MME) and ANPs blended Mahua methyl ester blend are given in Table 1.

Properties	Diesel	MME	MME20	MME20 + ANP 50	MME 20 + ANP 50
viscosity @ 40 °c	3	4.9	3.4	3.37	3.33
Density @ 15 °c	815	869	826	827.5	829
Flash Point	56	136	76	71	65
Cetane number	47	56	49	49.5	51

Table 1 Fuel Properties

2.2 ENGINE PERFORMANCE

2.2.1 BRAKE THERMAL EFFICIENCY

The brake thermal efficiency (BTE) increases with the load for both Mahua biodiesel blend (MME20) and ANP-blended MME20. The BTE of the MME20 + ANP100 was better than that of other fuel blends and neat diesel. A gain of 1.58% and 7.34% in BTE was recorded when ANP was added with the MME20 in different concentrations of 50 ppm and 100 ppm. This could be attributed to the better combustion characteristics of ANP. The catalytic activity of ANP might have improved because of the existence of high active surfaces. In addition, for MME20 + ANP100 fuel, the catalytic activity may be improved due to the high dosage of ANP compared to that of MME20 + ANP50.

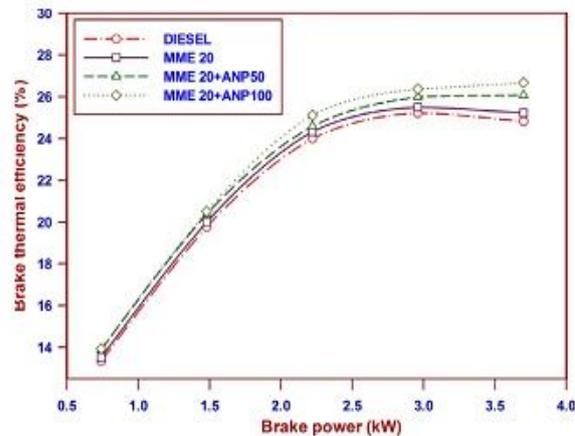


Figure 1: Brake thermal efficiency against brake power

2.2.2 CARBON MONOXIDE (CO) EMISSION

The effects of ANP with a biodiesel blend (MME20) on the carbon monoxide emission at various engine loads have been studied. ANPs have high surface contact areas which raise the chemical reactivity which consecutively shortened the ignition delay period. From Fig. 2, it is shown that the nanoparticles blended fuel has no major influence on the CO emission at minimum load condition, but for the full load, the CO emission increases considerably due to the use of ANP additives. These CO decrements are about 26% and 48% of the cases of MME20 + ANP50 and MME20 + ANP100 fuels, respectively, at the full load compared with neat diesel fuel.

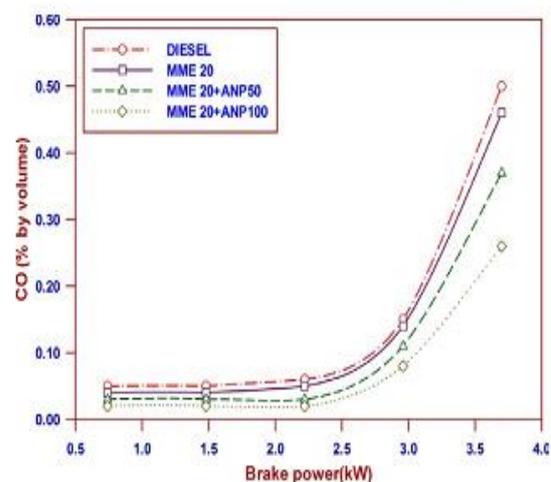


Figure 2 : CO against brake power

3. DIESEL ENGINE USING PONGAMIA BIODIESEL

Biodiesel produced from pongamia oil has been considered as promising option for diesel engines because of its environmental friendliness. In this work, bio-diesel from pongamia oil is prepared (PME 100), tested on a diesel engine for different blends such as PME 20, PME 40, PME 60 and PME 80. Comparison is made with diesel operation. Parameters such as brake thermal efficiency, brake specific fuel consumption, carbon monoxide, unburned hydrocarbons, smoke and NO x emissions are evaluated. Even though the performance reduces slightly when the engine is fueled with biodiesel, significant changes in the combustion parameters observed in case of biodiesel blends are significant to note. On the other hand, reduction in CO, HC and smoke is observed.

3.1. PONGAMIA BIODIESEL BLEND PREPARATION

The biodiesel fuel used in this study (methyl ester) is obtained from pongamia oil by transesterification process. It is the process by which fatty acid is converted into its corresponding ester. The mixture of pongamia oil, methanol (molar ratio of 6:1) and sodium hydroxide (NaOH) (1% w/w) as catalyst is taken in the reaction chamber fitted with condenser and thermometer. The entire mixture is heated at a temperature of 65°C for 2 h and then cooled down to room temperature. After cooling, two layers are observed with top layer identified as methyl ester and bottom layer as since it has more density. Then the top layer is washed with distilled water and drained out. Finally, pongamia oil methyl ester (PME) is obtained as product and is used in the present study. Numbers of tests are conducted in the laboratory to analyze PME20, PME40, PME60, PME80 and PME100 represent various volumetric biodiesel quantities in the test fuel (biodiesel–diesel blend). Properties of all the test fuels are presented Table 2.

Properties	Diesel	PME 20	PME40	PME80	PME 100
viscosity @ 40 °c	2.30	2.85	3.22	8.25	10.39
Density @ 15 °c	824	844	852	889	912
Flash Point	53	56	56	80	175

Table 2 Fuel Properties

3.2 ENGINE PERFORMANCE

3.2.1 BRAKE THERMAL EFFICIENCY

Brake Thermal Efficiency (BTE), commonly known as fuel conversion efficiency that replicates the percentage of fuel energy converted into useful energy. If different fuels are to be compared for the same engine, brake thermal efficiency is the most suitable parameter instead of specific fuel consumption. Fig. 3 shows the BTE of all biodiesel blends and petroleum diesel under different loading conditions. The maximum brake thermal efficiencies at full load condition for diesel, PME 20, PME 40, PME 60, PME 80 and PME 100 are calculated as 30.03%, 29.1%, 27.74%, 27.78%, 26.34% and 25.37%. It can be observed that the brake thermal efficiency of pongamia biodiesel is 15.5% lower than that of petroleum diesel at rated load. The lower BTE of biodiesel is greatly influenced by its BSFC and heating value.

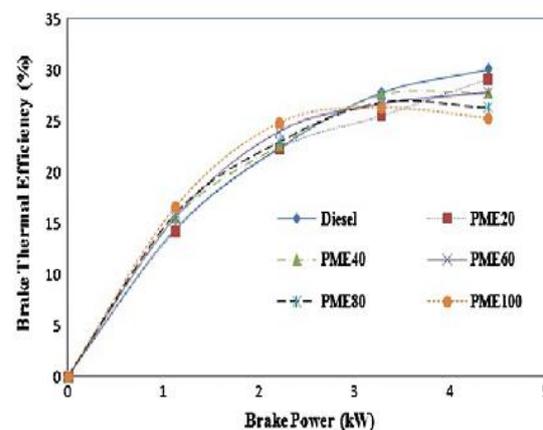


Figure 3 : Brake thermal efficiency against brake power

3.3.2 CARBON MONOXIDE (CO) EMISSION

Carbon monoxide (CO) is the most common type of fatal air poisoning in many countries. It is colorless, odorless and tasteless, but highly toxic gas. Fig. 4 shows the variation in carbon monoxide of all the tested fuels with respect to brake power. It is learned that the variation in CO emissions for all biodiesel blends and diesel is fairly small. It is also identified that CO concentration of PME 20 and PME 100 is 67% and 19% lower than conventional diesel at rated load. This may be due to the oxygen content and less C/H ratio of biodiesel that causes complete combustion. However, it is revealed that the decreasing trend of CO emission does not rely on biodiesel percentage in the blends

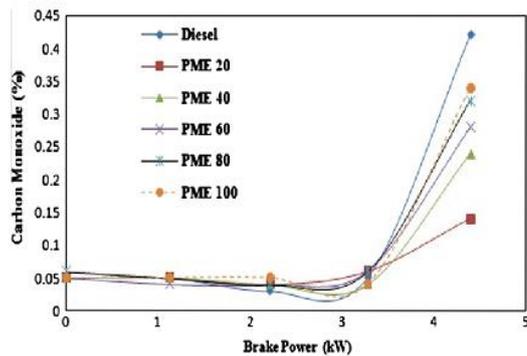


Figure 4 : CO against brake power

4. DIESEL ENGINE USING MANGO SEED BIODIESEL

In the present work, neat mango seed oil is converted into their respective methyl ester through transesterification process. Experiments are conducted using various blends of methyl ester of mango seed oil with diesel in a single cylinder, four stroke vertical and air cooled Kirloskar diesel engine. The experimental results of this study showed that the MEMSO biodiesel has similar characteristics to those of diesel. The brake thermal efficiency, unburned hydrocarbon and smoke density are observed to be lower in case of MEMSO biodiesel blends than diesel. The CO emission for B25, B50 and B75 is observed to be lower than diesel at full load, whereas for B100 it is higher at all loads. On the other hand, BSFC and NO_x of MEMSO biodiesel blends are found to be higher than diesel. From this study, it is concluded that optimized blend is B25 and could be used as a viable alternative fuel in a single cylinder direct injection diesel engine without any modifications.

4.1. MANGO SEED BIODIESEL BLEND PREPARATION

The production of biodiesel from mango seed oil is done by transesterification process. It is the process of reacting the mango seed oil with methanol in the presence of catalyst (KOH). During the process, the molecule of mango seed oil is chemically broken to form methyl ester of mango seed oil (biodiesel). The biodiesel is filtered to separate from glycerol. A maximum of 850 ml methyl ester of mango seed oil production is observed for 1 l of raw mango seed oil, 250 ml of methanol and 12 gm of potassium hydroxide at 60 °C. A series of tests are conducted to characterize the properties and fatty acid composition of the produced biodiesel. The properties and compositions of biodiesel and its blends with diesel fuel are shown in Table 3

Properties	Diesel	B25	B100
viscosity @ 40 °c	2.57	3.33	5.6
Density @ 15 °c	828	845	894
Flash Point	53	82	168
Cetane number	51	51.3	52

Table 3 Fuel Properties

4.2 ENGINE PERFORMANCE

4.2.1 BRAKE THERMAL EFFICIENCY

Brake thermal efficiency (BTE) is the ratio between the power output and the energy introduced through fuel injection, the latter being the product of the injected fuel mass flow rate and the lower heating value. The brake thermal efficiency plots in Fig. 5 show an increase in brake thermal efficiency with an increase in the engine load as the amount of diesel in the blend increases. Even a small quantity of diesel in the blend improves the performance of the engine. The brake thermal efficiency of the B25 blend is better than other blends, which is very closer to diesel. This is due to reduction in viscosity which leads to improved atomization, vaporization and combustion. Due to a faster burning of biodiesel in the blend (B25), the thermal efficiency improved. The value is 28.13% as against 28.56% for diesel at 100% load. The highest BTE's are 28.56%, 28.13%, 27.6%, 27.44% and 26.82% for B0, B25, B50, B75 and B100 respectively.

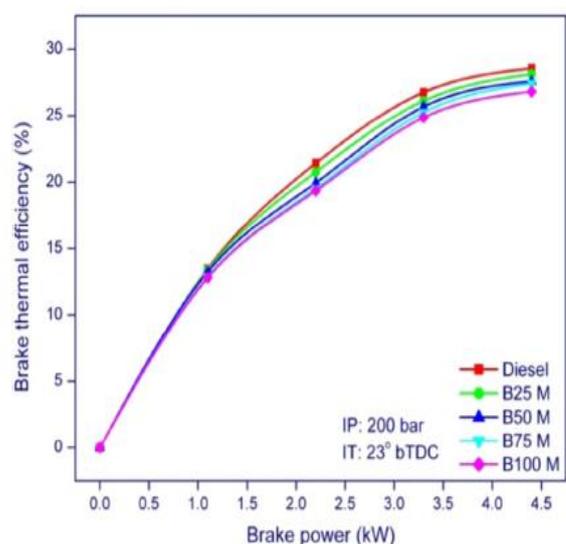


Figure 5 : Brake thermal efficiency against brake power

4.2.2 CARBON MONOXIDE (CO) EMISSION

The air–fuel mixing process is affected by the difficulty in atomization of biodiesel due to its higher viscosity. Fig. 6 shows the variations of CO emission with respect to brake power of the engine. Also, the resulting locally rich mixtures of biodiesel cause more CO to be produced during combustion. However, biodiesel that contains more number of oxygen atoms leads to more complete combustion. At low and middle engine loads, the percentage of CO emissions of biodiesel and its blends is higher compared to diesel. This may be due to relatively poor atomization and lower volatility of biodiesel. As a result, some of the fuel droplets may not get burned. When these unburned droplets mix with the hot combustion gases, oxidation reactions occur, but do not have enough time to undergo complete combustion. At full load, the percentage of CO emission of diesel is 0.1 but the percentage of CO emission of B25, B50, B75 and B100 is 0.07, 0.08, 0.09 and 0.12 respectively. It vividly indicates that the combustion efficiency improves with the blend of MEMSO with diesel and reduction in CO emission when compared to neat diesel except B100. It may be due to incomplete and smaller premixed combustion for B100 compared to other blends.

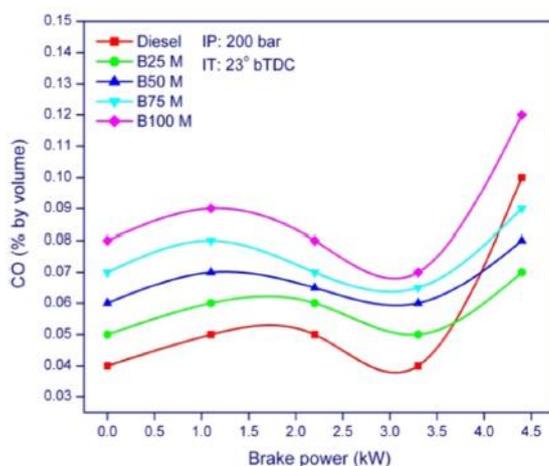


Figure 6 : CO against brake power

5. DIESEL ENGINE USING ZIZIPUS JUJUBE BIODIESEL

Experiments were conducted to determine engine performance, exhaust emissions and combustion characteristics of a single cylinder, common rail direct injection (CRDI) system assisted diesel engine using diesel with 25 percentage of zizipus jujube methyl ester blended fuel (ZJME25). Along with this ZJME25 aluminium oxide nanoparticles were added as additive in mass fractions of 25 ppm (AONP 25) and 50 ppm (AONP 50) with the help of a mechanical Homogenizer and an ultrasonicator. It was

observed that aluminium oxide nanoparticles blended fuel exhibits a significant reduction in specific fuel consumption and exhaust emissions at all operating loads. At the full load, the magnitude of HC and smoke emission for the ZJME25 before the addition of aluminium oxide nanoparticles was 13.459 g/kW h and 79 HSU, whereas it was 8.599 g/kW h and 49 HSU for the AONP 50 blended ZJME25 fuel respectively. The results also showed a considerable enhancement in brake thermal efficiency and heat release rate due to the influence of aluminium oxide

5.1. ZIZIPUS JUJUBE BIODIESEL BLEND PREPARATION

Nanoparticles addition in biodiesel–diesel blend. A potential diesel oil substitute is biodiesel, consisting of methyl esters of fatty acids produced by the transesterification reaction of triglycerides of vegetable oils with methanol with the help of a catalyst. One of the most common methods used to reduce oil viscosity in the biodiesel industry is called transesterification which takes place between a vegetable oil and an alcohol in the presence of a catalyst. Transesterification is basically a chronological reaction. Triglycerides are first reduced to di glycerides. The di glycerides are subsequently reduced to mono glycerides. The mono glycerides are finally reduced to fatty acid esters. Equipments used for transesterification reaction are magnetic stirrer, thermometer, and beaker. Raw materials are zizipus jujube seed oil, methanol, and potassium hydroxide. Zizipus jujube oil was measured to a capacity of 1000 ml and filled into the first beaker. Then, it was stirred at 1000 rpm and the oil was warmed up to 60°C. In addition, 5 g of potassium hydroxide was dissolved in 250 ml of methanol followed by forceful stirring. This catalyst/alcohol mixture was added to the zizipus jujube oil and stirred vigorously at 1000 rpm for 1 h at 60°C. Crude glycerine, the heavier liquid, was separated at the bottom and methyl ester on the top. After completion, water at 80°C was added to double volume of methyl ester, and then stirred for 15 min. The glycerine was allowed to settle again.

For the blending of aluminium oxide nanoparticles in biodiesel, taken a sample of ZJME25 biodiesel say 1 l and then 0.025 g of aluminium oxide in the nanoparticles form is added to make the dosing level of 25 ppm. Consequently, to increase the dosing level of 50 ppm, we have to increase to 0.05 g/l, respectively. After the addition of aluminium oxide nanoparticles, it is shaken well. And then it is poured into mechanical Homogenizer apparatus where it is agitated for about 30 min in an ultrasonic shaker making uniform suspension. It should be shaken well before use, as excess of nanoparticles settle down on solution. The physical and chemical properties of biodiesel were determined by standard methods and shown in Table 4.

Properties	Diesel	ZJME25	ZJME25+ ANP 25	ZJME25+ ANP 50
viscosity @ 40 °c	2.54	3.56	3.39	3.17
Density @ 15 °c	833	846	849	853
Flash Point	50	56	57	58
Cetane number	52	55	57	58

Table 4 Fuel Properties

5.2 ENGINE PERFORMANCE

5.2.1 BRAKE THERMAL EFFICIENCY

Fig. 7 shows the variation of the brake thermal efficiency with the brake power. The results show that the brake thermal efficiency of the CRDI diesel engine is improved by the addition of AONP in the fuel. The metal oxide nanoparticles present in the biodiesel blend encourage complete combustion, when compared to the sole biodiesel blend. Aluminium oxide nanoparticles act as an oxygen buffer and thus improve the brake thermal efficiency. It has also been observed that the enhancement in the thermal efficiency increases with the dosing level of nanoparticles. A maximum increase of 2.5% in the brake thermal efficiency was obtained when the dosing level of nanoparticles is 50 ppm.

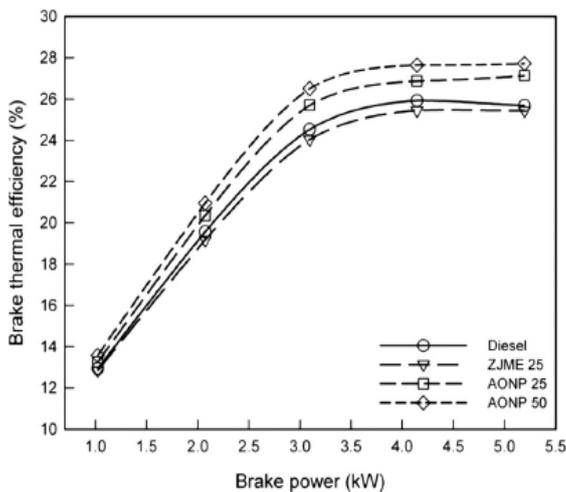


Figure 7 : Brake thermal efficiency against brake power

5.2.2 CARBON MONOXIDE (CO) EMISSION

Fig. 8 shows the influence of the aluminium oxide nanoparticles addition to biodiesel on carbon monoxide emissions. Nano metal oxide particles as an oxidation catalyst lead to higher carbon combustion activation and hence promote complete combustion. The nanoparticle blended fuels showed accelerated combustion due to the shortened ignition delay. Due to shortened of ignition delay, the degree of fuel-air mixing and uniform burning could have enhanced. Hence, there was an appreciable reduction in carbon monoxide emissions for aluminium oxide blended biodiesel. At the full load, the CO emissions for ZJME25, AONP25 and AONP50 were 8.079 g/kW h, 3.951 g/kW h and 6.284 g/kW h respectively. Up to 75% load, marginal reduction in CO emission beyond that slightly increases, which is lower than that of the diesel fuel.

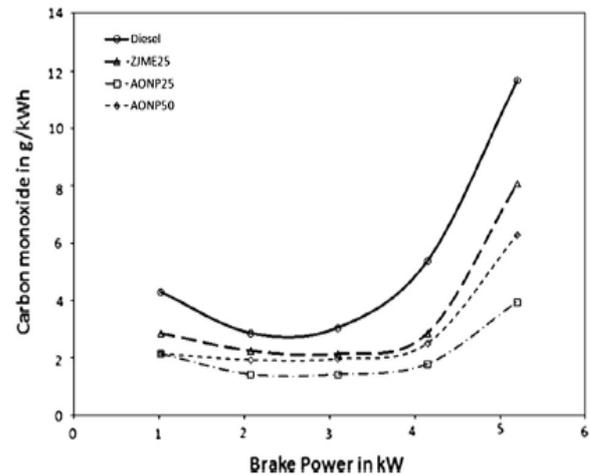


Figure 8 : CO against brake power

6. CONCLUSION

6.1 DIESEL ENGINE USING MAHUA BIODIESEL

- Brake thermal efficiency is higher
- Reduces co emission
- Reduces HC emission

6.2 DIESEL ENGINE USING PONGAMIA BIODIESEL

- Brake thermal efficiency is higher
- Reduces co emission
- Reduces NOx emission

6.3 DIESEL ENGINE USING MANGO SEED BIODIESEL

- Brake thermal efficiency is higher
- Specific fuel consumption is less
- Reduces co emission

6.4 DIESEL ENGINE USING ZIZIPUS JUJUBE BIODIESEL

- Brake thermal efficiency is higher
- Reduces co emission
- NOx emission is high

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