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A REVIEW ON PERFORMANCE, EMISSION AND COMBUSTION ANALYSIS OF DIESEL ENGINE FUELED WITH BIODIESEL

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Abstract
The increasing concerns over environmental pollution and depleting fossil fuel reserves, alternative and renewable fuels have gained significant attention. various types of biodiesels derived from vegetable oils, animal fats, and waste cooking oils have been investigated, highlighting their influence on engine performance and combustion characteristics. The effects of biodiesel blends on engine power output, torque, and thermal efficiency are analyse, along with their impact on emission levels of nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and hydrocarbons (HC). The review also delves into the combustion behaviour of biodiesel-Fueled engines, including ignition delay, heat release rate, and combustion duration. the investigation addresses the challenges associated with the use of biodiesels, such as increased NO_x emissions at higher engine loads and the potential for engine deposits due to differences in fuel properties. Overall, the review provides valuable insights into the performance and environmental impact of using biodiesels in diesel engines**.**

Keywords: FFA, Biodiesel Neem oil, Transesterification, Combustion characteristics, Performance and emissions.

I. Introduction

The use of biodiesel as an alternative fuel for diesel engines has gained significant attention in recent years due to its potential to reduce greenhouse gas emissions and dependence on fossil fuels. Performance analysis shows that biodiesel, derived from renewable sources such as vegetable oils or animal fats, exhibits comparable engine efficiency to conventional diesel fuel. Biodiesel's higher cetane number often leads to improved engine combustion, resulting in better thermal efficiency and reduced fuel consumption.

Its lower energy content compared to diesel may slightly affect the engine's power output. Regarding emissions, biodiesel demonstrates promising results in reducing harmful pollutants, particularly carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM). The oxygen content in biodiesel facilitates more complete combustion, leading to lower CO and HC emissions. Additionally, the absence of sulphur in biodiesel helps mitigate sulphur dioxide (SO_2) emissions, reducing the formation of acid rain. However, biodiesel's combustion characteristics differ from conventional diesel, resulting in increased nitrogen oxides (NO_X) emissions. The higher oxygen content in biodiesel leads to elevated combustion temperatures, favoring NO_X formation. Researchers have explored various techniques, such as exhaust gas recirculation (EGR) and catalytic converters, to address this issue and improve NO_X reduction. The combustion analysis of biodiesel in diesel engines reveals altered ignition delays and combustion durations compared to diesel. The viscosity and chemical composition of biodiesel influence the fuel spray characteristics, affecting the air-fuel mixing and combustion processes. Engine modifications and tuning may be required to optimize the performance of the engine when using biodiesel.

II. Literature

There are different types of biodiesels We studied some of the journals papers and mentioned them below:

Qixin Ma et.al., [1] Biodiesel has great potential as an alternative fuel for diesel engines. Overall consideration, using diesel/biodiesel/alcohol ternary fuels may be a better choice for diesel engines. Therefore, alcohol comes into researchers' eyes as a promising additive for diesel–biodiesel (DB) blends. The declining rate with speed decreased for indicated thermal efficiency (ITE) when adding alcohol to diesel–biodiesel blends, especially n-pentanol. However, poor low-temperature flow property and high viscosity of biodiesel limit its use in engines. The results indicated that the maximum pressure rise rate (MPRR) maintained a consistent drop ratio as speed increased from 1500 rpm to 1800 rpm for the tested fuels. In this study, the effects of lower and higher alcohol contents with different speeds on combustion and emissions characteristics were investigated in a modified single cylinder diesel engine.

Saroj Ranir et.al., [2] Today world's energy demands are increasing day by day due to increase in population, standard of living, industrialization& urbanization and which are mostly fulfilled by fossil fuels. Biodiesel can be good alternative fuel because of its renewability and environmental benefits and apart from this it can be a strategic source of energy for the countries which doesn't have oilfields. Biodiesel can be produced from edible, non-edible, algae and waste cooking oils. There are four essential approaches to make biodiesel, direct use and mixing, miniaturized scale emulsions, warm breaking (pyrolysis) and Transesterification. The most regularly utilized technique is transesterification of vegetable oils and creature fats. This researches the transesterification response of refined vegetable oils by methods for ethanol, utilizing sodium methoxide and sodium hydroxide as impetuses. Especially, the goal of this work was to plan ethyl esters with the two distinctive homogeneous impetuses, while the response had been done in one stage.

Meisam Ahmadi Ghadikolaei et.al., [3] Among the three fueling modes, the blended mode gives the highest engine performance and lowest emissions, except for NO_X. In contrast, the fumigation mode gives the worst engine performance and emissions, except for NOX. In the blended mode, the fuel was composed of 80% diesel, 5% biodiesel and 15% ethanol (DBE), by volume. In addition, the F + B mode has the effects between those of the fumigation and blended modes. In addition, a combined fumigation and blended mode (F + B) of fueling was introduced to understand its behavior in comparison with the blended and fumigation modes. In the fumigation mode, a mixture of biodiesel and ethanol (BE) was injected into the intake manifold and diesel fuel was used as the main fuel.

K. Sivaramakrishnan et.al., [4] The overall optimum is found to be 25% biodiesel–diesel blended with a compression ratio of 18. The impact of compression ratio on fuel consumption, brake thermal efficiency and exhaust gas emissions has been investigated and presented. Experimental analysis on the performance of biodiesel over diesel was evaluated by response surface methodology to find out the optimized working condition. Experiment has been conducted at compression ratios of 15:1, 16:1, 17:1, and 18:1. The performance and emission of a single cylinder four stroke variable compression multi fuel engines when fueled with 20%, 25% and 30% of Karanja blended with diesel are investigated and compared with standard diesel.

Alex de Oliveira et.al., [5] Carbon monoxide (CO), total hydrocarbons (THC) and oxides of nitrogen (NO_x) emissions showed different behavior, depending on load and ethanol concentration. Increasing ethanol concentration caused increased ignition delay, decreased combustion duration and reduced exhaust gas temperature. The use of ethanol decreased carbon dioxide (CO_2) emissions, up to 8.6% lower than B7. The effects of fuel blends containing 5, 10 and 15 wt.% of anhydrous ethanol in diesel oil with 7% of biodiesel (B7) on performance, emissions and combustion characteristics of a diesel power generator are investigated. The engine was tested with its original configuration, with the fuel blends directly injected into the combustion chamber, and the applied load varied from 5 to 37.5 kW.

Kim-Bao Nguyen et.al., [6] Hydrogen peroxide in a solution of water at a concentration of 30% was used for making the emulsions with mixing mass ratios of 5%, 10%, and 15%. A single cylinder, four-stroke, high speed, direct injection diesel engine was used for the experiments. In the present research, experiments have been designed and performed to study the effects of Jatropha hydrogen peroxide emulsion on combustion, performance, and the emission characteristics of a diesel engine. Therefore, it is necessary to find some way to reduce the emissions of diesel engines. While running the engine on the Jatropha hydrogen peroxide emulsion fuel, improvements in performance and emissions were found and the optimum mixing ratio of the solution with hydrogen peroxide was 15%.

Gvidonas Labeckas et.al., [7] the same as a straight diesel running on slightly richer air–fuel mixture k = 1.5 at rated 2200 rpm speed. The test results were analysed and compared with a base diesel engine running at the same air–fuel ratios of k = 5.5, 3.0 and 1.5 corresponding to light, medium and high loads. An additional ethanol–diesel–biodiesel blend E15B was prepared by adding the 15 vol% of ethanol and 5 vol% of biodiesel (B) to diesel fuel (80 vol%). The same air–fuel ratios predict that the energy content delivered per each engine cycle will be almost the same for various ethanol–diesel–biodiesel blends that eliminate some side effects and improve analyses of the test results. Fueled with blend E15B the diesel engine develops the brake thermal efficiency of 0.362.

Gajendra Singh et.al., [8] For controlling HCCI combustion, different EGR conditions (0%, 15% and 30%) were also applied. In the present research, effect of biodiesel content on homogeneous charge compression ignition (HCCI) engine combustion, performance and emission characteristics has been investigated experimentally. A small increase in CO, HC and smoke emissions was observed with increasing biodiesel content due to slower evaporation rate of biodiesel. A reduction in power output and an increase in ISFC were observed upon increasing the biodiesel content in the test fuel. HCCI engine can be operated with a wide variety of fuels starting from mineral diesel to various blends of biodiesel (B20 and B40). Experiments were performed in a modified two cylinder engine, in which, one cylinder was operated in HCCI mode while other was operated in conventional CI mode.

G. Kasiraman et.al., [9] These blends were tested in a single cylinder 1500 rpm, 5.2 kW, direct injection diesel engine fitted with eddy current dynamometer. The smoke emissions are 4.22, 3.91, and 3.64 Bosch Smoke Unit for CSNO, CMPRO 30 and diesel, respectively. The brake thermal efficiency of CMPRO 30 is 29.1% compared to base diesel engine brake thermal efficiency of 30.14%. The neat CSNO emits 983 ppm of NO. The CMPRO 30 emits 1040 ppm of NO, while diesel emits 1068 ppm. The usage of neat cashew nut shell oil (CSNO) as a fuel in direct injection diesel engine suffers from the problems of incomplete combustion and low brake thermal efficiency due to high viscosity.

Aman Hiraa et.al., [10] This paper is based on experimental investigation of performance and emissions of CI engine. Due to exponential growth in industrialization the demand for conventional automotive fuels is also increased sharply which adversely affects not only the economy but also the environment. This makes the search for an alternative fuel more important today. In this research the blends of ethanol & biodiesel with diesel in varying proportions are used. The performance& emission levels has been investigated under the various parameters like Brake Thermal efficiency, BSFC, BSEC, Smoke density, HC, CO & exhaust temperature. The experimental results show that the BE20 fuel gives the best performance in comparison to conventional diesel fuel along with fairly reduced exhaust emission.

D.N.Mallikappa et.al., [11] This This work composed with performance and emission studies of three stationary diesel engines operated with 20% cardanol biofuel volumetric blends. The carbon monoxide emissions increased with higher blends and decreased slightly at higher loads. A single cylinder diesel engine and VCR engines were used to evaluate the performance and emission characteristics of cardanol biofuel. The cardanol biofuel volumetric blends between 0-25% and base fuel (Petro diesel) were tested at various loads between 0-full load. An extended experimental study was conducted on a double cylinder CI engine, to evaluate the performance and emission characteristics. From this investigation, it is observed that up to 20% blends of cardanol biofuels may be used in CI engines without any modifications. The NOx emissions (ppm) increased with increased proportion of blends.

Atul Dhar et.al., [12] Rate of heat release for all biodiesel blends were almost identical to mineral diesel. Combustion duration for biodiesel blends was found to be shorter than mineral diesel. Brake specific CO and HC emissions for biodiesel fueled engine were lower than mineral diesel but NO emissions were higher for biodiesel blends. Detailed combustion characterization revealed that combustion starts earlier for higher biodiesel blends however start of combustion was slightly delayed for lower blends of biodiesel in comparison with mineral diesel. Performance, emission and combustion characteristics of this biodiesel and its various blends with mineral diesel were compared with baseline data in a direct injection (DI) diesel engine.

Dattatray Bapu Hulwan et.al., [13] Experiments are conducted on a multi cylinder, DI diesel engine, whose original injection timing was 13CA BTDC. However advancing injection timing almost doubled the NO emissions and increased peak firing pressure. The blends tested are D70/E20/B10 (blend A), D50/E30/ B20 (blend B) D50/E40/B10 (blend C), and Diesel (D100).Feasibility of using high percentage of ethanol in diesel–ethanol blends, with biodiesel as a co-solvent and properties enhancer has been investigated. The comparison of blend results with baseline diesel showed that brake specific fuel consumption increased considerably, thermal efficiency improved slightly, smoke opacity reduced remarkably at high loads. The P–h and net heat release diagrams shows that the combustion process of these blends delayed at low loads but approaches to the diesel fuel at high loads.

T. Ganapathy et.al., [14] For this purpose, the experiments were conducted using full factorial design consisting of (33) with 27 runs for each fuel, diesel and Jatropha biodiesel. Nevertheless, minimum NO emission yielded an optimum injection timing of 350 CAD. However, retarded injection timing caused effects in the other way. Similarly the percentage increase in BTE, Pmax, HRRmax and NO emission at this injection timing, load and speed were 5.3%, 1.8%, 26% and 20% respectively. The study of effect of injection timing along with engine operating parameters in Jatropha biodiesel engine is important as they significantly affect its performance and emissions. The present paper focuses on the experimental investigation of the influence of injection timing, load torque and engine speed on the performance, combustion and emission characteristics of Jatropha biodiesel engine.

M.Mathiyazhagan et.al., [15] Since most of the biodiesels were derived from edible oils like soy bean, sunflower, rapeseed, palm etc. Biodiesel is a more attractive alternative fuel to diesel engines. On the other hand, diversion of edible oils as feed stocks for biodiesel production leads to food crisis. However the non-edible oils having high FFA content which is not suitable for normal transesterification process. For this study biodiesel yield from various nonedible oils and its cost optimization were discussed. Normally alkali catalyzed method was followed for biodiesel production process. Therefore this research mainly concentrates the non-edible oils as feed stocks for biodiesel production to reduce the cost of biodiesel. For this study the following non-edible oil samples such as Jatropha, Pongamia, Madhuca and Azhadirachta were used to extract the biodiesel.

Lei Zhu et.al., [16] In comparison with Euro V diesel fuel, the biodiesel and BE blends have higher brake thermal efficiency. On the whole, compared with Euro V diesel fuel, the BE blends could lead to reduction of both NO_x and particulate emissions of the diesel engine. The results indicate that when compared with biodiesel, the combustion characteristics of ethanol–biodiesel blends changed; the engine performance has improved slightly with 5% ethanol in biodiesel (BE5). With high percentage of ethanol in the BE blends, the HC, CO emissions could increase. But the use of BE5 could reduce the HC and CO emissions as well. The effectiveness of NO_x and particulate reductions increases with increasing ethanol in the blends.

Bhupendra Singh Chauhan et.al., [17] Diesel engines have proved its utility in transport, agriculture and power sector. Thus, by using heat exchanger preheated Jatropha oil can be a good substitute fuel for diesel engine in the near future. CO (carbon monoxide), HC (hydrocarbon), CO_2 (carbon dioxide) emissions from Jatropha oil were found higher than diesel fuel. Optimal fuel inlet temperature was found to be 80 C considering the BTE, BSEC and gaseous emissions. Oil derived from Jatropha oil plant has been considered as a sustainable substitute to diesel fuel. Emissions of NO_X from Jatropha oil during the experimental range were lower than diesel fuel and it increases with increase in FIT. Increase in fuel inlet temperature resulted in increase of BTE and reduction in BSEC.

Huseyin Aydin et.al., [18] The use of biodiesel as an alternative diesel engine fuel is increasing rapidly. Besides, the exhaust emissions for BE20 were fairly reduced. Therefore, in this study, we used ethanol as an additive to research the possible use of higher percentages of biodiesel in an unmodified diesel engine. However, due to technical deficiencies, they are rarely used purely or with high percentages in unmodified diesel engines. The experimental results showed that the performance of CI engine was improved with the use of the BE20 especially in comparison to B20. The effect of test fuels on engine torque, power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature, and CO, CO_2, NO_X and SO_2 emissions was investigated.

M. Gumus et.al., [19] In this study, apricot (Prunus armeniaca) seed kernel oil was transesterified with methanol using potassium hydroxide as catalyst to obtain apricot seed kernel oil methyl ester. Neat apricot seed kernel oil methyl ester and its blends with diesel fuel were tested in a compression ignition diesel engine to evaluate performance and emissions. Apricot seed kernel oil methyl ester and its blends can be successfully used in diesel engines without any modification. Lower concentration of apricot seed kernel oil methyl ester in blends gives a better improvement in the engine performance and exhaust emissions. Therefore lower percent of apricot seed kernel oil methyl ester can be used as additive.

S. Saravanan et.al., [20] It was observed that the delay period and the maximum rate of pressure rise for CRBME blend were lower than those of diesel. When operating with CRBME blend the cylinder pressure was comparable to that of diesel. The occurrence of maximum heat release rate advanced for CRBME blend with lesser magnitude when compared to diesel. CRBME blend requires more crank angle duration to release 50% & 90% of heat when compared with diesel. CRBME blend has lower smoke intensity and higher NO_x emission than those of diesel. Since the measured parameters for CRBME blend differs only by a smaller magnitude, when compared with diesel, this investigation ensures the suitability of CRBME blend as fuel for CI engines with higher fuel cost.

M. Mani et.al., [21] As an alternative, non-biodegradable, and renewable fuel, waste plastic oil is receiving increasing attention. The waste plastic oil was compared with the petroleum products and found that it can also be used as fuel in compression ignition engines. Waste plastics are indispensable materials in the modern world and application in the industrial field is continually increasing. In the present work, the influence of injection timing on the performance, emission and combustion characteristics of a single cylinder, four stroke, direct injection diesel engine has been experimentally investigated using waste plastic oil as a fuel. In this context, waste plastics are currently receiving renewed interest.

N.L. Panwar et.al., [22] In In this investigation, castor methyl ester (CME) was prepared by transesterification using potassium hydroxide (KOH) as catalyst and was used in four stroke, single cylinder variable compression ratio type diesel engine. The process of transesterification is found to be an effective method of reducing vegetable oil viscosity and eliminating operational and durability problems. The important properties of methyl ester of castor seed oil are compared with diesel fuel. It was concluded that the lower blends of biodiesel increased the break thermal efficiency and reduced the fuel consumption. The engine performance was analysed with different blends of biodiesel and was compared with mineral diesel. The results proved that the use of biodiesel (produced from castor seed oil) in compression ignition engine is a viable alternative to diesel.

P.K. Sahoo et.al., [23] Ten fuel blends (Diesel, B20, B50 and B100) were tested for their use as substitute fuel for a water-cooled three cylinder tractor engine. Change in exhaust emissions (Smoke, CO, HC, NO_x, and PM) were also analyzed for determining the optimum test fuel at various operating conditions. The maximum increase in power is observed for 50% jatropha biodiesel and diesel blend at rated speed. Brake specific fuel consumptions for all the biodiesel blends with diesel increases with blends and decreases with speed. Non-edible jatropha (Jatropha curcas), karanja (Pongamia pinnata) and polanga (Calophyllum inophyllum) oil based methyl esters were produced and blended with conventional diesel having sulphur content less than 10 mg/kg. There is a reduction in smoke for all the biodiesel and their blends when compared with diesel.

Mustafa Canakci et.al., [24] The complexity of the burning process and the measurement errors in the experimental study can cause higher mean errors. Higher mean errors are obtained for the emissions such as CO, NO_x and UHC. According to the results, the fifth network is sufficient for all the outputs. The fifth network has produced R2 values of 0.99, and the mean % errors are smaller than five except for some emissions. Using the artificial neural network (ANN) model, the performance and exhaust emissions of a diesel engine have been predicted for biodiesel blends. Biodiesel is receiving increasing attention each passing day because of its fuel properties and compatibility with the petroleum-based diesel fuel (PBDF). For all the networks, the learning algorithm called back-propagation was applied for a single hidden layer.

P.K. Devan et.al., [25] In the present investigation a methyl ester derived from paradise oil is considered as an ignition improver. The combustion characteristics of Me50–Eu50 blend are comparable with those of diesel. There was a 2.4% increase in brake thermal efficiency for the Me50–Eu50 blend at full load. For this purpose; bio-fuels, namely, methyl ester of paradise oil and eucalyptus oil were chosen and used as fuel in the form of blends. The significance of this study is the complete replacement of diesel fuel with bio-fuels. The results show a 49% reduction in smoke, 34.5% reduction in HC emissions and a 37% reduction in CO emissions for the Me50–Eu50 blend with a 2.7% increase in NOx emission at full load.

B. Ghobadian et.al., [26] The properties of biodiesel produced from waste vegetable oil was measured based on ASTM standards. Using some of the experimental data for training, an ANN model was developed based on standard Back Propagation algorithm for the engine. The experimental results revealed that blends of waste vegetable oil methyl ester with diesel fuel provide better engine performance and improved emission characteristics. The prediction MSE (Mean Square Error) error was between the desired outputs as measured values and the simulated values were obtained as 0.0004 by the model. Different activation functions and several rules were used to assess the percentage error between the desired and the predicted values.

Avinash Kumar Agarwal et.al., [27] The effect of temperature on the viscosity of Karanja oil has also been investigated. The gaseous emission of oxide of nitrogen from all blends with and with out preheating are lower than mineral diesel at all engine loads. Fuel preheating in the experiments – for reducing viscosity of Karanja oil and blends has been done by a specially designed heat exchanger, which utilizes waste heat from exhaust gases. These parameters were evaluated in a single cylinder compression ignition engine typically used in agriculture sector of developing countries. Significant improvements have been observed in the performance parameters of the engine as well as exhaust emissions, when lower blends of Karanja oil were used with preheating and also without preheating.

H. Raheman et.al., [28The differences of BTEs between HSD and B100 were also not statistically significant at engine settings of ‘CR20IT40’ and ‘CR20IT45’. However, a reverse trend for these parameters was observed with increase in the CR and advancement of IT. The BSFC of B100 and its blends with high speed diesel reduced, whereas BTE and EGT increased with the increase in L for the range of CR and IT tested. The performance of Ricardo E6 engine using biodiesel obtained from mahua oil (B100) and its blend with high speed diesel (HSD) at varying compression ratio (CR), injection timing (IT) and engine loading (L) has been presented in this paper.

Yi Ren, Zuohua Huang et.al., [29] Combustion Combustion and emissions of a DI diesel engine fueled with diesel-oxygenate blends were investigated. CO and HC concentrations decrease with the increase of oxygen mass fraction in the blends. The reduction of smoke is strongly related to the oxygen-content of blends. The smoke concentration decreases regardless of the types of oxygenate additives, and the smoke decreases with the increase of the oxygen mass fraction in the blends without increasing the NO_x and engine thermal efficiency. The results show that there exist the different behaviors in the combustion between the diesel-diglyme blends and the other five diesel-oxygenate blends as the diglyme has the higher cetane number than that of diesel fuel while the other five oxygenates have the lower cetane number than that of diesel fuel.

N.R. Banapurmatha et. al., [30] The high viscosity of vegetable oils leads to problem in pumping and spray characteristics. The inefficient mixing of vegetable oils with air contributes to incomplete combustion. The best way to use vegetable oils as fuel in compression ignition (CI) engines is to convert it into biodiesel. Biodiesel is a methyl or ethyl ester of fatty acids made from vegetable oils (both edible and non-edible) and animal fat. The main resources for biodiesel production can be non-edible oils obtained from plant species such as Pongamia pinnata (Honge oil), Jatropha curcas (Ratanjyot), Hevea brasiliensis (Rubber) and Calophyllum inophyllum (Nagchampa). This paper presents the results of investigations carried out on a single-cylinder, four stroke, direct-injection, CI engine operated with methyl esters of Honge oil, Jatropha oil and sesame oil.

P.K. Srivastava et.al., [31] Methyl ester of karanja oil from Jharkhand region has been prepared by transesterification method. Physical and chemical properties of the karanja oil and that of the methyl ester have been determined. Maximum thermal efficiency of methyl ester has been determined and found to be slightly less than that of the diesel. The brake specific fuel consumption of biodiesel of karanja oil is slightly higher as compared to diesel. Carbon monoxide, hydrocarbon and NO emission of methyl ester and blends have been determined and compared to that of the diesel. It appears that methyl ester of karanja oil is a suitable substitute of petroleum diesel fuel.

Deepak Agarwal et. Al., [32] A single cylinder, four stroke, constant speed, water cooled, direct injection diesel engine typically used in agricultural sector was used for the experiments. While operating the engine on Jatropha oil (preheated and blends), performance and emission parameters were found to be very close to mineral diesel for lower blend concentrations. However, several operational and durability problems of using straight vegetable oils in diesel engines reported in the literature, which are because of their higher viscosity and low volatility compared to mineral diesel fuel. Experiments were also conducted using various blends of Jatropha oil with mineral diesel to study the effect of reduced blend viscosity on emissions and performance of diesel engine. The scarce and rapidly depleting conventional petroleum resources have promoted research for alternative fuels for internal combustion engines.

O.D. Hebbal et. al., [33] In In this present investigation deccan hemp oil, a non-edible vegetable oil is selected for the test on a diesel engine and its suitability as an alternate fuel is examined. At rated load, smoke, carbon monoxide (CO), and unburnt hydrocarbon (HC) emissions of 50% blend are higher compared with diesel by 51.74%, 71.42% and 33.3%, respectively. The viscosity of deccan hemp oil is reduced first by blending with diesel in 25/75%, 50/50%, 75/25%, 100/ 0% on volume basis, then analyzed and compared with diesel. The thermal efficiency, brake specific fuel consumption (BSFC), and brake specific energy consumption (BSEC) are well comparable with diesel, and emissions are a little higher for 25% and 50% blends.

R. Karthikeyana et.al., [34] The approximately 75% diesel replacement with turpentine is possible by DF mode with little engine modification. The result showed that except volumetric efficiency, all other performance and emission parameters are better than those of diesel fuel with in 75% load. The toxic gases like CO, UBHC are slightly higher than that of the diesel baseline (DBL). The emission and performance characteristics of a D.I. Turpentine was inducted as a primary fuel through induction manifold and diesel was admitted into the engine through conventional fueling device as an igniter. The pollutant No_x is found to be equal to that of DBL except at full load.

Gvidonas Labeckas et.al. [35] It is difficult to determine the RME concentration in Diesel fuel that could be recognised as equally good for all loads and speeds. The maximum brake thermal efficiency varies from 0.356 to 0.398 for RME and from 0.373 to 0.383 for Diesel fuel. The carbon dioxide, CO_2, emissions along with the fuel consumption and gas temperature, are slightly higher for the B20 and B35 blends and neat RME. The highest fuel energy content based economy (9.36– 9.61 MJ/kW h) is achieved during operation on blend B10, whereas the lowest ones belong to B35 and neat RME.

A.S. Ramadhas et.al., [36] The lower blends of biodiesel increase the brake thermal efficiency and reduce the fuel consumption. The important properties of methyl esters of rubber seed oil are compared with other esters and diesel. This process is not suitable for production of biodiesel from many unrefined non-edible vegetable oils because of their high acid value. Hence, a two-step esterification method is developed to produce biodiesel from high FFA vegetable oils. The experimental results proved that the use of biodiesel (produced from unrefined rubber seed oil) in compression ignition engines is a viable alternative to diesel. At present, biodiesel is commercially produced from the refined edible vegetable oils such as sunflower oil, palm oil and soybean oil, etc.

M.P. Dorado et.al., [37] The end user is able to take advantage of time-of-use rates to store less expensive energy and avoid higher peak demand rates. The various loads for which solar energy is used have also changed. The charging time for Battery is 4.4 hours. To efficiently charge electric vehicles, end users need flexibility in generation and storage, utilising time-of use pricing, and reducing peak demand rates. This also benefits utilities by distributing loads throughout the day, reducing demand. A master controller is needed to link end-user demand to the utility power supply for an efficient system.

S. Bari et.al., [38] At this temperature, there is a concern that the close-fitting parts of the injection system might be affected. Over the entire load range, CPO combustion produced average CO and NO emissions that were 9.2 and 29.3% higher, respectively, compared with those from diesel combustion. However, at room temperature (30–32°C) CPO has a viscosity about 10 times higher than that of diesel. Both can be achieved by heating CPO to 60 °C. To lower CPO’s viscosity to the level of diesel’s viscosity, a heating temperature of at least 92 °C is needed. Crude palm oil (CPO) is one of the vegetable oils that have potential for use as fuels for diesel engines.

Herchel T.C. Machacon et. al., [39] This was attributed to the lower heating value of neat coconut oil fuel compared to diesel fuel. It was also shown that increasing the amount of coconut oil in the coconut oil–diesel fuel blend resulted in lower smoke and NO_x emissions. The objective of the present study is to reveal the pure coconut oil and coconut oil–diesel fuel blends on the performance and emissions of a direct injection diesel engine. Operation of the test engine with pure coconut oil and coconut oil–diesel fuel blends for a wide range of engine load conditions was shown to be successful even without engine modifications. However, this resulted in an increase in the BSFC.

D. Laforgia et.al., [40] The use of fuel with a low amount of sulphur cannot be delayed in the major European cities and the use of purposely transesterified and refined seed oils -- named biodiesel -- appears to be the most convenient solution. This investigation presents the results of a wide experimental campaign carried out on an IDI engine and aimed at evaluating the overall performance, the emissions and the combustion trends observed with the new fuel. Pure biodiesel and blends of biodiesel combined with 10% methanol have been evaluated in detail. A remarkable reduction of smoke emerged from both solutions. When the injection timing was advanced, better results were obtained, thus confirming the advantage of these fuels.

III. Conclusion

The use of biodiesels in diesel engines offers a promising avenue to mitigate harmful emissions and reduce dependence on fossil fuels. Biodiesels demonstrate potential for lowering CO and PM emissions, contributing to improved air quality and human health. However, challenges remain in managing NO_x emissions and fine-tuning engine performance for optimal efficiency when using biodiesels. Future research should focus on developing advanced combustion strategies and emissions control technologies to fully realize the environmental and economic benefits of biodiesel usage in diesel engines. Additionally, a comprehensive life cycle assessment should be considered to evaluate the overall environmental impact of biodiesel production, distribution, and use. By addressing these biodiesels can play a significant role in promoting a sustainable and greener transportation sector.

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