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Performance of Computerised Single Cylinder Diesel Engine with Blends of Bio Diesel

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Abstract

A nation's economic progress is significantly influenced by the production of energy. Energy is the main source of electricity for the home, the commercial and manufacturing sectors, transportation, agriculture, and industry. The demand for diesel engines has shown two levels of uncertainty over the last 20 years. First, the cost of pure fossil fuels is out of control, and the wealth disparity between importing and exporting nations has grown. Compression ignition (CI) engines use biodiesel, gradually replacing non-renewable fossil fuels. In the presence of a catalyst, they interacted with alcohol. The main benefit of biodiesel is that it is based on renewable energy sources and causes less environmental harm. The results of various studies in the literature concluded that because biodiesel has a higher oxygen content, less aromatic compounds, and a lower compressibility than diesel, it performs better as an engine fuel than diesel in terms of unburned hydrocarbon, carbon monoxide, smoke, and NOx emissions. The primary goals of the research are to improve the overall performance of the single-cylinder, four-stroke compression ignition engine using biodiesel fueled by various blends of jatropha and palm oil in accordance with the trends and regulations currently in place in the internal combustion engine industries.

Keywords: *CI Engine, Fuel, Performance, Emissions*

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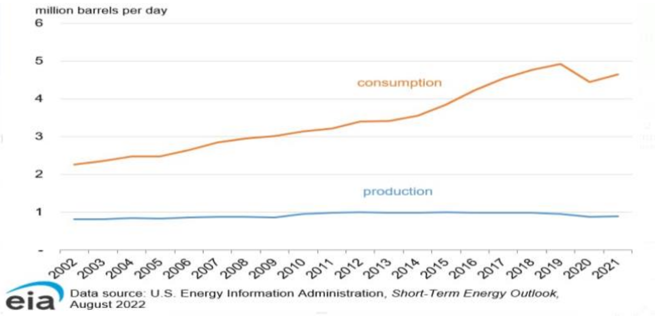
I. INTRODUCTION

1.1 Energy scenario

Energy generation has a significant role in a country's economic development. Agriculture, transportation, manufacturing, commercial, and home sectors rely on energy as a primary source of power. Since independence, a tremendous quantity of energy has been required to carry out India's economic development ambitions. As a result, energy demand is gradually increasing across the country. As there is increasing demand for oil and gas, there is the potential for an energy supply crisis resulting from sustained economic growth. Modernity and industrialization have led to significant increases in the demand for petroleum products around the world. Rapid economic growth in developing countries results in rising energy demand. The energy demand in India is growing at a rate of 6.5% per year over the next five years. Petroleum-based fuels are insufficient, and limited reserves are concentrated in a few areas of the world (Jain & Sharma, 2010). Energy consumption is expected to exceed population increase by a large margin. By 2030, 39 percent of global greenhouse gas emissions and 31 percent of world energy demand are predicted, therefore developing a clean alternative to fossil fuels that is locally available, ecologically acceptable, and technically feasible has become a global goal.

1.2 Indian energy scenario

India's energy demand for petroleum-based products has been rapidly increasing. In March 2023, India, the world's third-largest oil consumer, was forecast to use 194.6 million tonnes of refined goods (Source: Petroleum Planning & Analysis cell, India). Moreover, it has had the second-largest increase in transport fuel use in India in the recent decade. In addition, because of the economic reforms, the manufacturing of road cars is predicted to expand, increasing gasoline demand. As a result, research into the patterns of gasoline demand in India is required. In addition, the ever-increasing number of automobiles with internal combustion engines is driving up energy demand. When fossil fuel reserves run out, and demand for energy rises, and an energy crisis emerges. Oil and coal provide the majority of the energy used by industries and transportation. Petroleum is a non-renewable and rapidly decreasing source of energy. The oil crisis of 1973 brought this issue to the forefront. Petroleum prices are constantly fluctuating, and most countries' costs are increasing. Global energy consumption is predicted to be 147 trillion kWh, with this figure expected to climb in the future. Table 1.1 illustrates the production and consumption of India petroleum and other liquids from 200-2019. Crude oil imports have increased dramatically in recent decades.



Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, August 2022

Fig. 1.1 India's Petroleum Production and Consumption

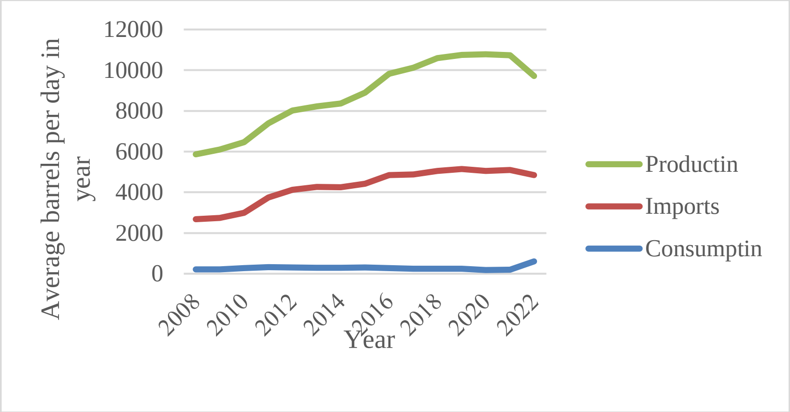


Fig. 1.2. India Petroleum Production, Consumption and Imports

1.3 Problems of diesel engines

For the past two decades, the demand for diesel engines has revealed two levels of uncertainty. First, straight fossil fuel prices are too high, and importing nations' wealth has become more distressing. Figure 1.3 shows changes in petrol and diesel price per liter for the last 20 years in India. Over the years, the difference in petrol and diesel prices per liter has fallen, and still, a good chance is that gasoline and diesel will be price-close.

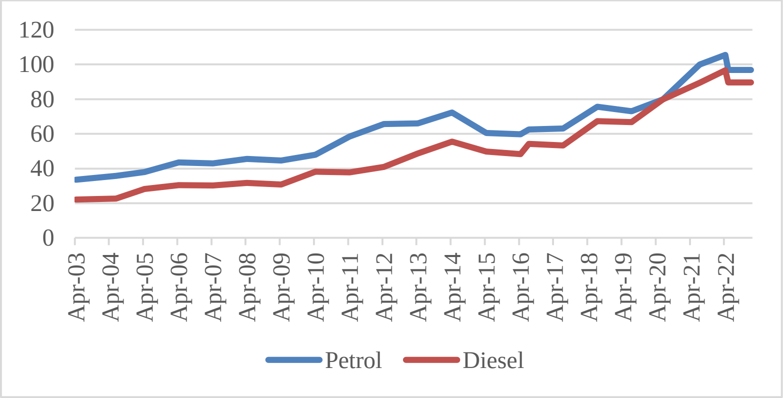


Fig. 1.3 Price of Petrol Diesel from Last 20 Years

Secondly, fossil-fuelled combustion is the main factor in increasing the global CO2 level, a global warming outcome. Table 1 shows the emissions standards in India. It indicates that strict emission standards are adopted. There are also concerns about the shortage and reduction in conventional resources, and research on alternative energy sources for internal combustion (IC) engines is encouraged in the world. It causes damage to health and the environment due to diesel engine emissions. Therefore, emission control regulations were imposed on all countries to reduce emissions from vehicles. The emissions of hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM), and nitrogen oxides (NOx) constitute a concern for the regulators. As is the case with BS

I to BS-VI, the limitations of these emissions are substantially strict. From BS IV to BS VI standards compared that large percentage of reduction in NOx emissions. Fuel additives of nano additives and antioxidants play a significant role in reducing NOx emissions of diesel engines.

1.4 Biodiesel demand and availability in India

The NBM set a target of devoting 11.2 to 13.4 ha of land to Jatropha cultivation by the end of its 11th Five-Year Plan to meet its 20 percent biodiesel target in high speed diesel (HSD) 2012. Farmers had tax incentives for Jatropha and other unedible olive seeds provided by central and several state governments. But due to the lack of enough Jatropha seeds to produce the specified amount of biodiesel, the Government's ambitious plan has not been implemented. The yield of feedstock per hectare was half of what was supposed to be at the laboratory stage, contrary to expectations. NBM was therefore requesting from the beginning a chronic lack of biodiesel feedstock. Moreover, the cost of biodiesel production was 20 to 50% higher than the minimum purchase price established for the production (MPP).

Consequently, no biodiesel sales occurred. Almost 20 Indian biodiesel plants produce between 140 and 300 million liters of biodiesel every year, primarily local irrigation, electricity, and so on, in the informal sector and automotive companies for experimental projects. So far, only Jatropha was planting 0,5 Mha land, and the GoI has not started the biodiesel purchase through designated purchase centers. However, in 2006, an announcement of an MPP amounting to 0,49 dollars per liter was made. In January 2015, the Union Cabinet amended the NPB to facilitate customers from private manufacturers, authorized dealers, and licensed OMC joint ventures purchasing biodiesel directly. Biodiesel prices are currently determined on the market. According to a study by Dhar & Shukla , under a BAU scenario, demand for diesel for transport is expected to grow from 46.9 billion liters in 2010 to 155.7 billion liters in 2030.

II. LITERATURE REVIEW

Previous studies conducted experimental and theoretical investigations in a diesel engine to study the alternate fuel for diesel.

Palvannan et al. [1] investigated the effect of cashew nut biodiesel on a diesel engine. The performance results showed that BTHE of B20 fuel was equal to diesel as fuel, but further increase blend percentage shows the low BTHE value correlated to conventional diesel. The smoke and HC emissions reduced, but it increases NO_x and carbon dioxide (CO_2) emissions because of the complete combustion of biodiesel and high exhaust gas temperature (EGT).

Renuraman et al. [2] examined Rice Bran Oil-Fueled IC Engine Performance and Emission Characteristics Improved by Nanoadditives. The BTHE value decreases with a higher percentage of blends because of the high viscosity of biodiesel. The BSFC, CO_2, and NO_x emissions increased by using biodiesel blend compared with conventional diesel because of the oxygen content of biodiesel, poor atomization of fuel, and higher combustion temperatures.

Mahesh et al. [3] conducted the experiments using honge oil methyl ester (HOME) as fuel on a diesel engine. The performance results showed that BTHE and BSFC values increased because of the low calorific value correlated to diesel. The NO_x emissions and EGT value increased because of the complete combustion of biodiesel. Sahoo et al. [4] examined the influence of Karanja, polanga, and jatropha biodiesel as fuels on a tractor engine. The emission results showed reduced HC and PM emissions because of the complete combustion. Still, it increased BSFC, CO, NO_x emissions because of low calorific value (CV), biodiesel oxygen percentage, and high fuel viscosity. Abed et al. [5] investigated the effect of waste cooking-oil biodiesel on a diesel engine's performance and exhaust emissions. It reported low BTHE and higher BSFC and EGT obtained by biodiesel blends as correlated to convention diesel. The biodiesel blends produced less CO, HC, and other emissions except for NO_x and CO_2 emissions correlated to convention diesel.

Uyumaz [6] studied the effects of combustion, performance, and emission characteristics of a direct injection (DI) diesel engine fueled with mustard oil biodiesel blends at different engine loads. It reported low BTHE and higher BSFC obtained by mustard biodiesel blends as correlated to convention diesel. The biodiesel blends produced less CO and smoke emissions except for NO_x emissions as correlated to convention diesel.

Shrivastava et al. [7] investigated the effects of engine performance and emission characteristics of CI engines operated with roselle and Karanja biodiesel. The results revealed reduced NO_x and smoke emissions and increased BSFC and CO_2 emissions obtained by roselle biodiesel blends correlated to convention diesel. The results showed decreased BTHE, EGT, NOx, smoke emissions, and increased BSFC obtained by Karanja biodiesel blends correlated with convention diesel.

Anantha Raman et al. [8] investigated the performance, combustion, and emission analysis of a direct injection diesel engine fuelled with rapeseed oil biodiesel. It reported low BTHE, heat release rate (HRR), maximum cylinder pressure, and higher BSFC and EGT obtained by biodiesel blends correlated to convention diesel. The biodiesel blends produced less CO and HC emissions except for NO_x and smoke emissions correlated to convention diesel.

Simsek [9] studied canola, sefflower oils, and waste oils as biodiesels on engine performance and exhaust emissions. The results revealed that BSFC and BTHE increased as the ratio of BD75 and decreased by 1.95% of BD correlated to diesel. Biodiesel blends produced less CO, HC, and smoke and increased NO_x and CO_2 emissions than conventional diesel. The literature findings on the CI engine's performance, combustion, and emission analysis by adding biodiesel as a fuel summarizes in table 1. Previous studies reported that biodiesel's use in diesel engines increases BSFC and lowers brake power (BP). The emissions of HC, CO, PM reduced, and NO_x and CO_2 emissions raised by biodiesel as fuel in diesel engines. Nanoparticles and antioxidants additives added with biodiesel blends overcome the drawbacks of biodiesel blends used as fuels on a diesel engine.

2.1 Impact of different biodiesel on performance, combustion, and emissions

Raheman and Phadatare [10] 2004 Karanja biodiesel It reported low BTHE and higher BSFC obtained by biodiesel blends as correlated to convention diesel. In addition, the biodiesel blends produced less CO, NOx, and smoke emissions as correlated to convention diesel. Ramadhas et al. [11] 2005 Methyl esters of rubber seed oil It reported that higher BSFC and NOx emissions obtained by biodiesel blends as correlated to convention diesel. 14 S. Puhan et al. [12] 2005 Mahua oil methyl ester The results reported that biodiesel fuel has a low CV value, increasing the engine's BSFC value. Labeckas and Slavinskas [13] 2005 Rapeseed methyl ester and blends with diesel The NOx emissions because of the complete combustion of biodiesel. Yoshimoto [14] 2006 Rapeseed oil It reported that slight performance values enhanced but higher CO and NOx emissions because of the complete combustion of fuel. Pereira et al. [15] 2007 Soybean biodiesel The biodiesel blends produced less CO, HC, and sulfur dioxide (SOx) but higher NOx emissions correlated to convention diesel. Roskilly et al. [16] 2008 Biodiesel from recycled cooking oil It reported that higher BSFC and lower CO and NOx emissions obtained by biodiesel blends correlated to convention diesel. Altun et al. [17] 2008 Sesame oil blended with diesel The biodiesel blends produced less CO and NOx emissions as correlated to convention diesel. Correa and Arbilla [18] 2008 Commercial biodiesel It reported that low speeds produced higher total carbonyls as compare to higher speeds.

2.2 Effects of engine performance and emissions with different antioxidant

A few research work did by blending antioxidant additives with diesel-biodiesel blends. Therefore, exploring the fullest potential is a new concept for researchers. Diesel fuel consists of unstable species, and it produced free radicals which combine with O_2 to create further free radicals in a chain reaction and react with olefinic compounds to form gums. These can also polymerise to form nitrogen, sulfur compounds, and organic acids to form sediments. Antioxidants inhibit chain branching reactions free radicals to form stable hindered radicals, which do not propagate further. It leads to fuel darkening and the production of gums and sediments, consequently reducing the fuel instability of biodiesel through the application of antioxidants. Many research studies argue that biodiesel used in diesel engines resulted in increased NO_x emissions because of the oxygen content in biodiesel. Therefore, the vital feature of antioxidants is reduced NO_x emission by absorbing excess oxygen while using biodiesel in fuel blends (Varatharajan et al., 16; Palash et al., 18). In this work, the literature studies the impacts on engine performance and emissions of various antioxidant additives with diesel-biodiesel blends. Ileri et al. [19] studied the effects of a turbocharged direct injection (TDI) diesel engine using biodiesel with antioxidants. The results reported that low BSFC obtained using Tert-butyl hydroquinone (TBHQ) antioxidant with biodiesel, among other fuel blends. The lower NO_x emissions obtained by using 2-Ethylhexyl nitrate (EHN) antioxidants with biodiesel among all different fuel blends, but CO emissions were increases with all fuel blends. Varatharajan et al. [20] examined the use of various antioxidant additives blended with jatropha biodiesel as fuel on a CI engine. The results reported that low BSFC obtained using ethylenediamine and p-phenylenediamine but slightly increases with L-ascorbic acid, BHT and a-tocopherol as correlated to conventional biodiesel. The lower NO_x emissions obtained by using all antioxidant additives, but p-phenylenediamine gave optimum reduction related to other fuel blends. The emission of CO and HC emissions increased with all antioxidant fuel blends. Palash et al. [22] conducted experiments on CI engine with the influence of performance and emission parameters by adding N, N'-diphenyl- 1,4-phenylenediamine (DPPD) antioxidant in jatropha biodiesel. The obtained results showed that this additive gave the same power and BSFC with and without adding the additive. The obtained results revealed that the reduction of NO_x emissions increases with increased blends of biodiesel. However, it slightly increases the emissions of HC and CO. Still. It should be low compared to conventional diesel. Rashed et al. [23] investigated the effects on a diesel engine using Calophyllum biodiesel with antioxidants additives NPPD, EHN, and DPPD. The results showed high BSFC and low brake power (BP) and BTHE obtained using biodiesel without additives. The BP and BTHE of biodiesel with antioxidants were increased and reduced BSFC as compared to conventional biodiesel. These all antioxidants reduced NO_x emissions but increased CO and HC emissions as compared to traditional biodiesel.

Karthikeyan et al. [24] investigated the effects of performance and emission characteristics on a diesel engine by using Pistacia khinjuk methyl ester (PB) with Geraniol (GE) and Pyrogallol (PY) antioxidants. The results reported that PB20 + PY blend noticed better performance characteristics than PB20 + GE. In addition, the lower CO, HC, and smoke opacity and NO_x emissions of PB20 + PY blend compared to PB20 + GE blend.

Katam et al. [25] studied the effects of the CI engine's performance and emissions using algal biomass as an antioxidant additive in coconut and karanja methyl esters. The results revealed that biodiesel blend with antioxidant showed high BTHE and low NO_x emissions than biodiesel blends.

Cristina Dueso et al. [26] investigated the effects of a diesel engine's performance and emissions using sunflower biodiesel with a renewable antioxidant additive from bio-oil. The results reported that a slight difference in performance parameters found with and without antioxidants of biodiesel. The antioxidant additive combined with the sunflower biodiesel reduced NO_x emissions and smoke opacity and increased CO and HC emissions of the diesel engine compared to diesel.

2.3 Aim and objectives of the Report

The main objectives of the research are to reduce exhaust emissions and increase the overall performance of the single-cylinder four-stroke variable compression ratio (VCR) compression ignition engine biodiesel fuelled with different additives by the current trends and legislation in internal combustion engine industries.

- The effects of performance on diesel engine by using biodiesel blends added with multiple additives at a constant speed, and variable load need to be studied further.
- The effects of emissions on diesel engine by using biodiesel blends added with multiple additives at a constant speed and variable load needed to be studied further.

III. MATERIALS AND METHODS

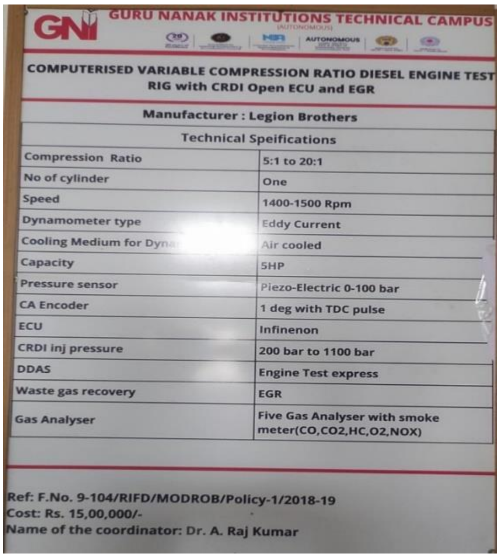
3.1 Selection of Fuels

The feedstock, processing, transportation, crude oil price, and other factors all affect the economic feasibility of traditional biodiesel. Vegetable oils are a renewable, alternative source of energy with a similar energy content to diesel fuel. The cost of raw materials accounts for 60–75% of the total cost of biodiesel fuel, also explained a 40% increase in the price of biodiesel as a result of an increase in feedstock costs. Several studies [28] reported that feedstock is the high cost of biodiesel, accounting for approximately 75% of total biodiesel production costs. Chemicals and catalysts also have an impact on the cost of producing biodiesel. Biodiesel is still gaining popularity, despite recent increases in petroleum prices and the uncertainty of petroleum availability owing to depletion. As a result, it is critical to seek alternate feedstocks and develop cost-effective manufacturing processes. Biodiesel feedstock might differ from one country to the next, depending on agricultural techniques and geographical regions. Therefore, the best feedstock must be selected to keep biodiesel production costs low. Non-edible oils such as neem, pongamia, jatropha, karanja, animal fats, and waste cooking oil used converted into biodiesel [27]. However, the high concentration of free fatty acids (FFA) found in these low-cost oils is frequently an issue. Therefore, before proceeding to transesterification, pretreatment is required to eliminate these free fatty acids. The transesterification process and glycerol recovery are two factors that influence production costs. The cost of producing biodiesel can be reduced by using a continuous and unwavering transesterification process with a short reaction time and a large production capacity. Furthermore, if a biodiesel manufacturing industry has its glycerol recovery facilities, the cost of producing biodiesel can be lowered. However, many challenges and constraints must be solved for biodiesel to become established on the market. The main issues are the use of low-cost feedstock such as non-edible vegetable oils or waste cooking oils, improving the efficiency of the production process through optimum process variables and conditions, and lowering the cost of the catalysts used through catalyst regeneration [28]. Furthermore, to remain acceptable to the public, the emission characteristics of biodiesel can be improved through a blending process. Therefore, further development of using products like glycerol will improve the overall economic viability of the biodiesel production process. 23 Furthermore, the biodiesel industry's success will be determined in part by strong government support and regulatory enforcement. The biodiesel business is currently lagging behind the conventional oil and gas industry regarding financial profitability and infrastructure support. As a result, enacting a carbon tax that rewards the use of renewable fuels, such as biodiesel and its blends, over fossil diesel could boost the biodiesel industry. In addition, renewable energies will be promoted even more by mechanisms that encourage a greater engagement of the global community in reducing greenhouse gas (GHG) emissions [28]. represents the price comparison of biodiesel from the different feedstock. Jatropha biodiesel showed less cost compare to other biodiesels. The figure showed the oil production of different edible and non-edible oils in gallons per acre. Palm oil production rate more compare to other biodiesels. Coconut and jatropha oils produce a high production rate compared to other oils except for palm oil. Palm and jatropha oils are alternative fuels to diesel because of oils' price and oil production rate.

3.5 Experimental details

Experimental study on a Computerized Single Cylinder Diesel Engine, fuelled with diesel and different percentages of nonedible oil blended with diesel were investigated with respect to the performance and emission characteristics. The setup consists of computerized 4-stroke diesel engine with the facility of single cylinder and water cooling direct ignition. The crankshaft is coupled to an eddy current dynamometer with the help of flexible coupling firmly set on a concrete base. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand-alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for BP, IP, FP, BMEP, IMEP, BTE, ITE, Mechanical Efficiency, Volumetric Efficiency, SFC, AFR and heat balance. Labview based Engine Performance Analysis software package “EnginesoftLV” is provided for on line performance evaluation. Initially the engine was run with pure diesel and after blends of Jatropha oil Biodiesel and Palm Oil Biodiesel of 20% with Diesel at different loads varying with help of loading unit. Various engine performance parameters and exhaust emission were measured with the help of digital lab view software.

Fig. 3.1 Schematic Diagram of Experimental Setup



GURU NANAK INSTITUTIONS TECHNICAL CAMPUS
(AUTONOMOUS)

COMPUTERISED VARIABLE COMPRESSION RATIO DIESEL ENGINE TEST RIG with CRDI Open ECU and EGR

Manufacturer : Legion Brothers	
Technical Speifications	
Compression Ratio	5:1 to 20:1
No of cylinder	One
Speed	1400-1500 Rpm
Dynamometer type	Eddy Current
Cooling Medium for Dyn	Air cooled
Capacity	5HP
Pressure sensor	Piezo-Electric 0-100 bar
CA Encoder	1 deg with TDC pulse
ECU	Infinenon
CRDI inj pressure	200 bar to 1100 bar
DDAS	Engine Test express
Waste gas recovery	EGR
Gas Analyser	Five Gas Analyser with smoke meter(CO,CO2,HC,O2,NOX)

Ref: F.No. 9-104/RIFD/MODROB/Policy-1/2018-19
Cost: Rs. 15,00,000/-
Name of the coordinator: Dr. A. Raj Kumar

Fig. 3.2engine specification

IV. RESULT AND DISCUSSION

4.1 Introduction

This project investigated the effects of performance and emission parameters of CI engine by using nanoparticles blended with biodiesel and diesel fuels. Experiments were carried out in a computerized single cylinder variable compression ratio (VCR) CI engine equipped with a hydraulic dynamometer. The experimental investigations conducted in different fuel blends, as listed below, are discussed in this section.

- Performance and emissions analysis of diesel engine with different biodiesels
- Performance and emissions analysis of diesel engine by using different biodiesels blended with nanoparticles

4.2 Performance and emissions analysis of diesel engine with different biodiesels

This section describes the effects of the diesel engine using palm oil methyl ester (POME) and jatropha oil methyl ester (JOME) biodiesel blends and comparisons with conventional diesel fuel. Experiments were carried out in a computerized single cylinder variable compression ratio (VCR) CI engine equipped with a hydraulic dynamometer. The brake specific fuel consumption (BSFC), brake thermal efficiency (BTHE), carbon monoxide (CO), unburned hydrocarbons (HC), and nitrogen oxides (NOx) measured at no load, 25%, 50%, 75%, and 100% of the diesel engine's rated load.

4.3 Performance and Emission Analysis On Diesel Engines With Palm and Jatropha Biodiesels

The following performance and emission characteristics discussed.
(i) Brake specific fuel consumption (BSFC)
(ii) Brake thermal efficiency (BTHE)
(iii) Carbon monoxide (CO)
(iv) Unburned hydrocarbons (UBHC)
(v) Nitrogen oxides (NOx)

(i) Brake specific fuel consumption (BSFC)

The term BSFC refers to the fuel efficiency of any engine that burns fuel and produces a required amount of power. It is entirely dependent on the properties of the test fuel blend, and the calorific value of the fuel has a significant impact on the BSFC of the CI engine. As shown in Figure 4.1, the BSFC of tested blends varies with load. In all cases, the BSFC of fuel decreases with increasing load on a diesel engine. The BSFC of biodiesel fuels raised because pure biodiesel produces 5-10% lower CV than diesel fuel. While the B20 fuel mixture contains 20% biodiesel and 80% diesel, it generates a 2% low CV compared with diesel. Therefore, the lower BSFC value obtains with the B20 blend than pure biodiesel and the higher BSFC value than diesel. For all tested fuel blends, the minimum BSFC observed at full load. Figure 4.1 shows that the BSFC of PB, JB, PB20, and JB20 blends increased 22.32 %, 16.90 %, 18.45 %, and 14.56 % compared to pure diesel. JB20 blend gave a low BSFC value compared to other biodiesel blends because of the CV of JOME higher than POME.

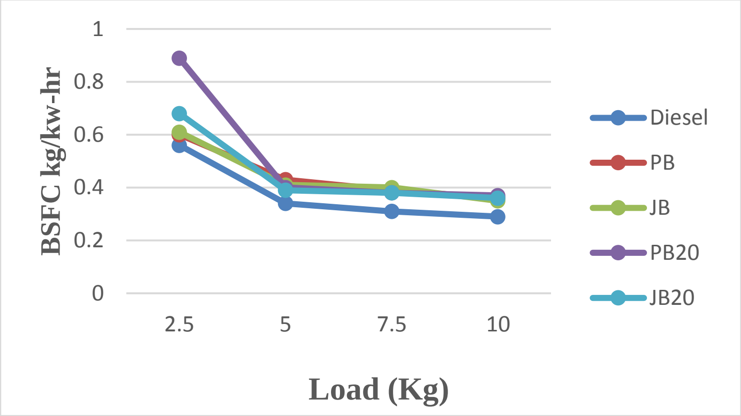


Fig. 4.1 BSFC vs Load

(ii) Brake thermal efficiency

BTHE represents the efficiency in which fuel energy transformed into mechanical work. BTHE is a BSFC function, showing the inversely trended BSFC trends. As shown in Figure 4.2, BTHE of biodiesel fuel showed less than diesel fuel. According to Figure 4.2, the biodiesel fuel produces a lower BTHE value when compared to other blends, and the B20 blends have a higher BTHE than the biodiesel fuel. For all blends, BTE increases with the increasing load but decreases with increasing blend proportion. When PB, JB, PB20, and JB20 blends compared to pure diesel, BTHE reduced 8.74 %, 6.58 %, 6.08 %, and 4.58 %, respectively. JB20 blend gave a high BTHE value compared to other biodiesel blends of lower calorific value and higher viscosity of biodiesel fuel.

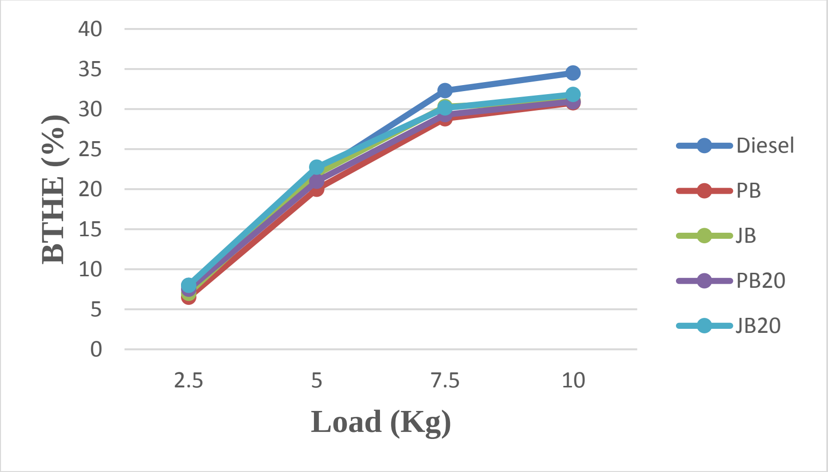


Fig. 4.2 BTHE vs Load

(iii) Carbon monoxide (CO)

The causes of CO emissions from a diesel engine were low flame temperature, lower injection pressure, and a too rich fuel-air ratio. A diesel engine's power losses can increase if CO emissions are higher. Too high (or) too low an equivalence ratio, as well as inadequate residence time, are all factors that lead to CO emissions.

Increase the fuel oxygen concentration, residence time, and combustion temperature of biodiesel fuel to reduce CO emissions from diesel engines. As illustrated in Figure 4.3, the CO emissions of tested blends vary with load. Diesel engines emit lower levels of CO emissions, which further reduced when biodiesel used as fuel. Biodiesel contains oxygen molecules in its chemical composition, promoting complete combustion, leading to lower CO emissions. The high CN and oxygen (O_2) molecules in biodiesel, which allow for complete combustion of the fuel, were another factor in reducing CO emissions. When PB, JB, PB20, and JB20 blends compared to pure diesel, CO reduced by 23.28 %, 24.53 %, 13.9 %, and 12.33%. JB20 blend gave less CO emissions than other biodiesel blends because of the complete combustion of oxygenated biodiesel blends.

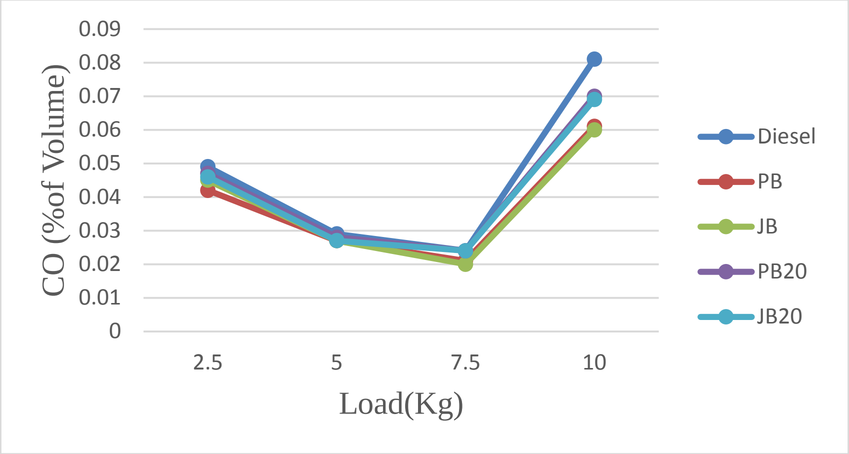


Fig. 4.3 CO vs Load

(iv) Unburned hydrocarbons (UBHC)

Incomplete flame propagation, the composition of the too lean or rich mixture, low injection pressure and lower charge temperature are the major factors in generating HC emissions. Diesel engines emit 1/5th fewer HC emissions than petrol engines because of the lean equivalence ratio. As illustrated in Figure 4.4, the HC emissions from tested fuel blends vary in load. In all cases, the increase in HC emissions by increasing the load of CI engines. Biodiesel fuel reduces HC emissions because it contains oxygen molecules and high CN, which ensures complete combustion. Figure 4.4 shows a decrease in HC in PB, JB, PB20 and JB20 of about 20.94%, 28.28%, 38.35% and 44.07% compared to pure diesel. JB20 blend gave fewer HC emissions than other biodiesel blends because of the better combustion of the biodiesel blends in the combustion chamber with excess oxygen content.

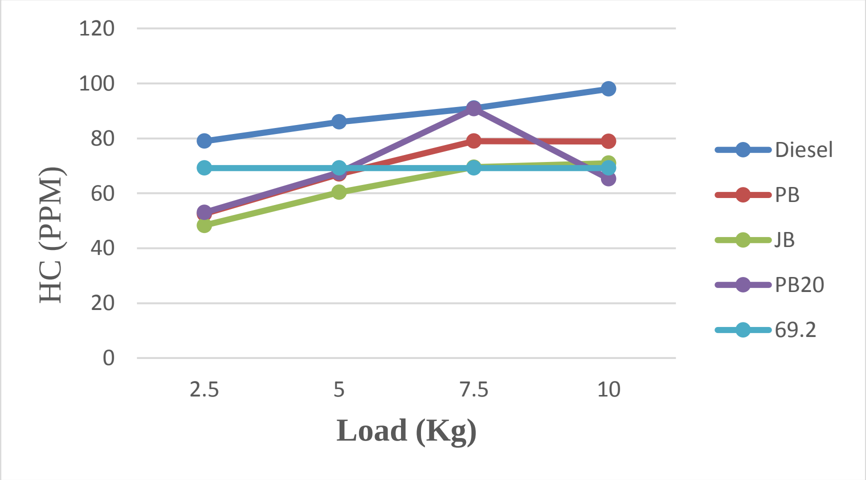


Fig. 4.4 HC vs Load

(v) Nitrogen oxides (NO)

The production of NOx emissions is dependent on volumetric efficiency, combustion duration, and high combustion temperature for the high energy activation required for the reactions involved. Biodiesel combustion emits more NOx than diesel because of its high oxygen content, which causes the fuel-rich areas to respond to oxidation at high combustion temperatures, resulting in NOx emissions. When contrasted with diesel fuel, the

B20 fuel blend showed high NOx emissions. Biodiesel molecular structure and the formation of CH radicals are the primary reason for increasing NOx emissions. Various theories of increasing NO_X emissions in a diesel engine using biodiesel fuel are the advancement in injecting fuel, the higher adiabatic flame temperature of biodiesel, more stoichiometric burning, larger spray droplet size, reduced soot particle radiation and fuel bound oxygen.

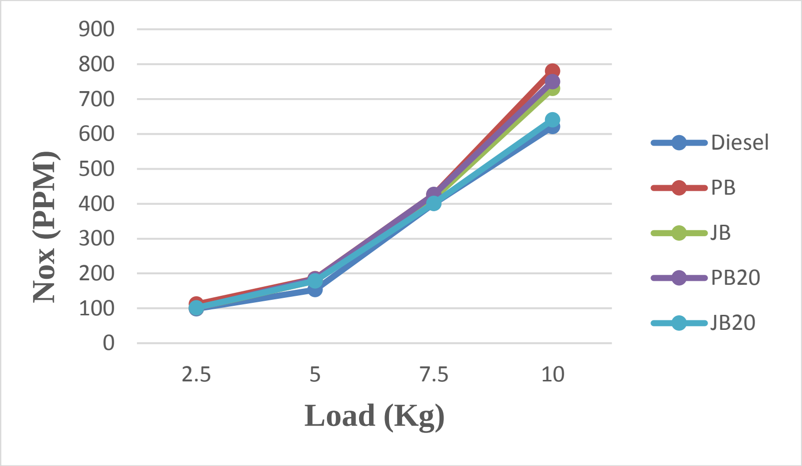


Fig. 4.5 NOx vs Load

For all blends, NOx levels rise with increasing load and blend proportion. When comparing pure diesel to PB, JB, PB20, and JB20 blends, NOx increased by about 10.11 %, 5.98 %, 8.24 %, and 4.17 %, respectively, as shown in Figure 4.5. JB20 blend gave fewer NOx emissions than other biodiesel blends but higher than diesel fuel. NOx emissions of biodiesel blends were increased due to oxygen in biodiesel blends, leading to higher combustion temperature. In the case of biodiesel blends, the adiabatic flame temperature within the cylinder rises as a result.

V. CONCLUSION

5.1 Conclusions

The performance and emission characteristics of a single cylinder, four stroke, water-cooled, direct injection VCR diesel engine with a power output of 3.5 kW at a constant speed of 1500 rpm, fueled with palm and jatropha biodiesel and its blends with and without nanoparticles and antioxidant additives, were analyzed and compared to diesel operation of the same engine using different loads. The following conclusions were drawn of each technique.

5.1.1 Performance and emission characteristics of a CI engine with biodiesel blends

- JB20 blend gave a low BSFC value compared to other biodiesel blends but higher than diesel fuel because of the CV of JOME higher than POME.
- JB20 blend gave a high BTHE value compared to other biodiesel blends but lower than diesel fuel because of lower calorific value and higher viscosity of biodiesel fuel.
- JB20 blend gave less CO emissions than other blends because of the complete combustion of oxygenated biodiesel blends.
- JB20 blend gave fewer HC emissions than other blends because of the better combustion of the biodiesel blends in the combustion chamber with excess oxygen content.
- JB20 blend gave fewer NOx emissions than other biodiesel blends but higher than diesel fuel. NOx emissions of biodiesel blends were increased due to oxygen in biodiesel blends, leading to higher combustion temperature. In the case of biodiesel blends, the adiabatic flame temperature within the cylinder rises as a result.

5.2 Scope for future work

The following are suggested as future work for the investigations on the use of fueled with palm and jatropha biodiesel and its blends with and without nanoparticles and antioxidant additives.

- Further investigations are needed to study the effects of performance and emissions by using biodiesel and its blends with additives at different compression ratios.
- Further investigations are needed to study the effects of performance and emissions by using biodiesel and its blends with additives at different injection pressures.

- Further investigations are needed to study the effects of performance and emissions by using biodiesel and its blends with additives at different speeds.
- Further investigations are needed to study the effects of nanoparticles traces in exhaust gas that should be investigated critically to avoid environmental damage.
- To study the various types of nano and antioxidant additives used in different biodiesel in different ratio of blends and the engine characteristics.
- The present research work can be extended for studying combustion characteristics on a diesel engine by using different biodiesel with nano and antioxidant additives.
- The emissions like carbon dioxide, Sulphur dioxide, particulate matter, volatile organic compounds, etc. also be studied further.
- Further studies are required to investigate and confirm that the use of antioxidants will ensure the long-term storage stability of biodiesel fuel.
- Various nanoparticle concentrations don't show any effect on performance beyond a particular concentration of nanoparticles. So, it is essential to find out the optimum blending ratio of nanoparticles.

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