PERFORMANCE OF COMPRESSION IGNITION ENGINE BY USING BIODIESEL AND DIESEL

Abstract

Biodiesel is an alternate fuel for compression ignition diesel engines. Demand for petroleum products has sharply increased as a result of global increases in industrialization and motorization. Alternative fuels are derived from vegetable oils to lessen and replace the use of fossil fuels. In the present study, HCN biodiesel oil was used as an alternative fuel for diesel engine, and the outcomes were compared with those of diesel fuel. The tests are conducted on a single-cylinder, four-stroke, variable compression ratio diesel engine at a compression ratio of 17:5. Performance parameters like brake power, volumetric efficiency and carbon monoxide are measured.

Keywords: Biodiesel; performance; emission; combustion

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I. INTRODUCTION

Oil consumption is expected to rise as energy demand rises. India is projected to have the third-highest oil consumption by 2030. The majority of this oil demand is currently met by imports of oil from the Gulf of Mexico and other countries. Along with rising oil prices and a decline in the amount of oil reserves, diesel and petroleum products are becoming more expensive. It is predicted that the current oil reserve level will be adequate to meet demand through 2030. Another important issue with them is the fact that the consumption of these oil products is one of the main contributors to air pollution. India is now looking for alternative sources of oil and petroleum products, and diesel and petrol are crucial. Reduce emissions that contribute to air pollution, create a more domestically based, sustainable method of production, and lessen reliance on imported oil. Alternative energy sources like biofuels and biodiesel serve as a strategic and effective replacement for petrol and diesel fuel. Alternative fuels are made from non-petroleum sources. While some are derived from renewable sources, the majority are domestically produced and help us become less dependent on foreign oil. They typically emit fewer pollutants than diesel or petrol. They are made up of bio mass, alcohols, liquefied and compressed natural gas, as well as fats and oils from both plants and animals. The feedstocks for biofuels can be divided into four technological generations: the first generation (corn, vegetable oils, and animal fats), the second generation (methanol, ether, and butanol), the third generation (algae and hydrogen), and the fourth generation (algae and cyan bacteria). Due to its less harmful emissions, biodiesel is an environmentally friendly fuel. Alternative fuels need to be economically viable if they are to compete with the fossil fuels currently in use. Biodiesel is a type of fuel made up of monoalkyl esters of long-chain fatty acids derived from vegetable or animal fats. Transesterification is a step in the conventional production of biodiesel. Transesterification occurs when triglycerides from plant and animal feedstocks interact with alcohols in the presence of a catalyst. Due to its many advantageous qualities, such as a higher Cetane number, a higher oxygen content, better lubricity, virtually no sulphur, and environmental friendliness, biodiesel can be used in CI engines without requiring significant engine modifications. When using biodiesel directly in a CI engine, it is difficult due to the higher viscosity of the fuel, which can be produced through transesterification procedures and then blended with diesel fuel.

II. LITERATURE SURVEY

A concise report on the history of biodiesel, its price and production, engine performance and emissions and their effects on the environment and human health was provided by [1]. The advantages and disadvantages of biodiesel are non-toxicity, quick decomposition, improved engine performance, low emissions, ease of handling and transportation, and the potential use of the transesterification byproduct glycerol in the chemical and pharmaceutical industries. It is also a renewable energy source with a safe and healthy environment. Biodiesel has drawbacks including higher viscosity and copper strip corrosion, the ability to clog filters at low temperatures, being more dense than diesel, and being more expensive due to lower vegetable oil production [2]. By using heat, pyrolysis reduces a biomass's volatile components to substances with lower molecular weights. Hibiscus rosa sinensis and Nerium oleander leaves and stems under pyrolytic conditions. Using a thermogravimetric balance, which combines differential thermal analysis of the heat flux type with thermogravimetric analysis at various heating rates under a nitrogen atmosphere, pyrolysis experiments were conducted. As a result of their higher percentage of volatile matter, low sulphur content, lower ash content, and higher calorific value, Nerium oleander leaves were found to be more suitable for producing fuel through pyrolysis [3]. Seeds of Hibiscussabdariffa L were purchased from a nearby market. The seeds had any foreign objects or dirt removed, and they had been dried by air. The cold maceration solvent extraction method was used to extract the oil. Since particle size affects oil yield, 1000 g of Hibiscus sabdariffa L. was weighed and blended using an electric blender to a coarse particle size in order to increase its surface area. Hexane and ether solutions each containing 1 litre were used to soak the blended Hibiscus sabdariffa L. After the mixture had settled for 24 hours, the oil solvent mixture was decanted. In order to release n-Hexane, the decanted mixture was concentrated at 65^0C in a rotary evaporator [4]. The primary fatty acids in coconut oil are lauric acid (C12:0), which has the highest fatty acid content, followed by caproic acid (C6:0), caprylic acid (C8:0), and capric acid (C10:0). Lauric acid, myristic acid, palmitic acid, and oleic acid were all present in significant amounts in the waste coconut oil used to make coconut milk, totaling 40.55%, 17.43%, 15.14%, and 11.73%, respectively. When compared to the American Society for Testing and Materials standard, the coconut oil biodiesel has a low viscosity and acid value, preventing corrosion and operational problems. The ASTM-compliant cloud point, pour point, and high flash point of coconut oil biodiesel further demonstrate that it is suitable for use in both hot and cold climates [5]. To make biodiesel for use in single-cylinder, four-stroke, water-cooled compression ignition engines connected to diesel engines with eddy current dynamometers, two hibiscus species—Hibiscus cannabinus and Hibiscus sabdariffa—are used as feedstocks. At varying loads and constant speed, the efficiency and combustion characteristics of blends were evaluated, and the results were then compared to diesel. Hibiscus cannabinus and Hibiscus sabdariffa, members of the Malvaceae family of plants, are referred to by a number of common names, including hemp, ambadi, roselle, Jamaica sorrel, and pundi in Indian Kannada. Hibiscus is found in more than 300 different species. The majority of species produced vibrant flowers, and many people use the plants in landscaping as small trees or shrubs. The seeds of two distinct hibiscus species were gathered [6]. Exergy analysis on a diesel engine running on blends of palm, jatropha, and cottonseed oils was performed. At various loads with 10%, 20%, and 30% of biodiesel, the first law, second law efficiency, fuel exergy destruction, and total exergy destruction were calculated. In biodiesel blends (J30), the first law's effectiveness was greater. The efficiency of the second law increases when using diesel. All biodiesel blends display the same exergy destruction range of 63 to 65% at 20 N-m loads. The total amount of energy destroyed was not significantly impacted by the amount of biodiesel in the blend [7]. Waste tyres were used to make the pyrolysis oil, and glycine max is used to make biodiesel. Different mixtures of used tyre oil, glycine max biodiesel, and diesel were used: 10% tyre oil + 90% diesel (10T), 20% tyre oil + 80% diesel (20T), 30% tyre oil + 70% diesel (30T), 10% tyre oil + 10% biodiesel + 80% diesel (10TB), 10% biodiesel + 90% diesel (10B), and 30% tyre oil + 10% biodiesel + 60% diesel (30T10B60D). These fuels are used to boost performance in DI diesel engines. Poor solubility, poor engine performance, and high emissions are present in more than 30% of waste tyre pyrolysis oil. All performance indicators are measured between 1500 and 3300 rpm at various engine speeds, then compared to simulation results [8]. The response surface method was used to model the performance and exhaust emissions of a homogeneous charge compression ignition (HCCI) engine powered by petrol. High desirability of 77% was achieved at an engine speed of 935 rpm, a compression ratio of 12, an intake air temperature of 333 K, a lambda value of 1.8, and a compression ratio of 12. Indicated mean effective pressure was 5.08 at this point, thermal efficiency was 35%, specific fuel consumption was 243.28 g/kWh, and maximum pressure rise rate was 4.43 bar/CA. It was discovered that the best engine emissions occurred at 355.586 ppm for unburned hydrocarbons, 3% for carbon monoxide, and 0 ppm for nitrogen oxide [9]. Using diesel-acetylene and biodiesel-acetylene, optimised the design of the toroidal piston bowl geometry to improve dual fuel performance, emission, and combustion characteristics. the piston bowl geometry's impact on the turbulence in the combustion chamber. The Ansys fluent CFD code is used to simulate the modified piston bowl geometries. The simulation results demonstrate that a piston bowl with five 1-mm-diameter holes in a diesel-acetylene dual fuel engine induces more turbulence than other piston bowl geometries. The biodiesel-acetylene-fueled dual fuel engine piston bowl with five 2-mm-diameter holes also produces more turbulence than the other piston bowl geometries [10]. In a CRDI diesel engine, waste frying oil methyl ester is used in place of regular diesel fuel with titanium oxide nanoparticles added. Blends (0–20%), injection pressure (400–600 bar), compression ratio (16–20), and nano concentration (60–220 ppm) are the input parameters. Investigations were conducted into the ignition delay, maximum cylinder pressure, combustion duration, and heat release rate. The ideal set of output parameters was predicted by the central composite design and RSM. The ideal combination of input parameters was 27.7% biodiesel and 201 ppm TiO2 NPs at 454 bar IP and 19.4 CR with diesel. The desired output also had Pmax 67.1 bar, HRR 72.95 J/deg CA, CD 42.54 deg CA, and ID 8.12 deg CA at the aforementioned optimum combinations [11]. The effects of nanoemulsions like zinc and titanium on a four-stroke D.I.VCR engine. To make biodiesel, used cooking oil was used. The samples are prepared as follows: S1 is chemically synthesised ZnO, S2 is chemically synthesised TiO2, S3 is biologically synthesised TiO2, and S4 is biologically synthesised ZnO. S1 has the highest concentration of CO emissions, whereas pure diesel has the lowest. Similar trends in less oxygen emissions were shown by PD and S2. The samples of nanoparticles demonstrated an impressive reduction in NOx emissions compared to pure diesel, with S4 sample touching the lowest value. At maximum load, every sample except S2 and PD showed a reduction in HC emission [12]. Using a transesterification process with a KOH catalyst at a temperature of 60°C and a methanol to oil molar ratio of 1:2, biodiesel is produced from used cooking oil residue. With the aid of two different solvents (de-ionized water and methanol) in 15% water and WCO biodiesel emulsion, test samples are made by adding 100 ppm of microwave-produced hydroxyapatite nano-rods using Hibiscus Rosa Sinensis additives. For uniform additive dispersion in fuel samples, an ultrasonicator is used. Fuel was tested in the diesel engine of the Kirloskar TV 1. When compared to B100, the test fuel (B20HW100) emits 30% less NO_2, 60% less CO_2, 44% fewer hydrocarbons, and 38% fewer smoke particles [13]. Due to their improved fuel conversion efficiency, diesel engines are typically used in the transportation, industry, and agricultural sectors [14]. Diesel consumption is high in the transportation industry. Crude oil reserves are dwindling and may soon run out as a result of rising crude oil consumption [15]. Air pollution has been made worse by diesel engines. During the burning of fuel, nitrogen oxides, particulate matter, and smoke are produced. The health of people is harmed by air pollution. Research is being done on alternative fuels to lessen the impact. The need for energy is also growing globally. The depletion of fossil diesel fuel can be slowed down with the help of biodiesel, a sustainable energy source [16]. Biodiesel can be produced using a variety of ingredients, including waste vegetable oil, animal fat, and other oils. The four generations of biodiesel are waste oil, solar biodiesel, and biodiesel [17]. The first generation of biofuels were created using agricultural products like sugar cane, maize, and vegetable oils. Second-generation fuels include butanol, diethyl ether, and methanol. Third generation biofuels are typically produced using photosynthetic microorganisms like bacteria and microalgae. Third-generation biofuels include methane, bioethanol, biobutanol, biodiesel, and biohydrogen, among others [18]. A renewable fuel with a higher viscosity, more oxygen, less volatility, and a higher cetane number is biodiesel. Additionally, it is non-toxic and degradable [19]. Engine emissions are decreased when biodiesel is used. However, compared to diesel fuel, NOx emissions are higher [20]. Vegetable oils and animal fats are used in the transesterification process to create biodiesel. About 11% of the weight of biodiesel is oxygen. Biodiesel is safer to transport and has the same heating value as diesel. These features make it more dependable than diesel fuel [21]. In a four-cylinder, turbocharged, CRDI engine operating at 2000 rpm, argemone biodiesel is used under moderate, partial, and peak load conditions. B20 increased its BSFC and brake thermal efficiency by 5.58 percent and 7.8 percent, respectively, at high load. A blend of argemone biodiesel reduced NOx emissions by 30% at all loads. For all blends, CO and HC emissions rise. The igniting delay was longer for the 30% and 50% blends compared to the other blends. In all experiments, barring low load, the blend B20 had the highest heat release rates and in-cylinder pressure [22]. Biodiesel is created through the pyrolysis process using used cooking oil. NaOH and KOH catalysts are used in pyrolysis at various concentrations. A biodiesel yield of over 70% was attained with 1% NaOH. Various ratios of the biodiesel to diesel fuel were used. With higher blend ratios, NOx and CO emissions at higher loads were reduced [23]. Diethyl ether is used to convert used cooking oil into biodiesel, which has the effect of CR on diesel engines. When compared to diesel fuel at a CR 15, 0.8% DEE with 19.2% biodiesel fuel results in efficiency gains of 16.06%, BSFC reductions of 4.12%, and emissions reductions [24]. At 1800 rpm and maximum load, the combustion and emission phenomena of a diesel engine are investigated. Different carbon nanotube blends of 10%, 20%, 30%, and 40% were used in experiments. Comparing sample B10 with 50 ppm of carbon nanotubes to diesel fuel, the cylinder pressure rose by 4.64%. The highest cylinder temperatures were noted in all samples at a 150 degree crank angle. For 50 ppm of nanotubes, the B20 blend generates more CO_2. The NOx content of B20 and B40 blends has decreased [25]. Croton macrostachyus kernel oil is used to make biodiesel. By adjusting the molar ratio, reaction time, and catalyst loading, the response surface method was used to optimise the synthesis process. To determine the performance and emissions of a diesel engine, biodiesel was blended with diesel at 5%, 10%, 15%, and 20%. Compared to diesel, BTE is lower, the BSFC is bigger, and the temperature of the exhaust gases is also higher. Emissions are reduced in a similar way by using manufactured biodiesel blends [26].

III. MATERIALS AND METHODS

Any material that contains free molecules of fatty acids, whether they are saturated or unsaturated, can be converted into biodiesel. As a result, mixtures of vegetable oils and fats, animal fats, leftover greases, used cooking oil, and non-edible oil can be used as the feedstock for making biodiesel. Biodiesel is made in India using a variety of edible and non-edible oils, including rice bran oil, coconut oil, palm oil, pongamia oil, jatropha oil, and rubber seed oil in Asia [27]. Hibiscus rosa sinesis and coconut oil are the two components used to make the oil. Flowering plants belonging to the genus Hibiscus can be found in the Malvaceae family of mallows. There are more than a thousand species in the genus Hibiscus, including Hibiscus Rosa Sinensis. It is a global facility. Rosa sinensis is the name of the hibiscus plant native to China. Coconuts have a lot of oil and can withstand cold temperatures. Due to its inherent qualities, it is regarded as one of the best feedstocks for the production of biodiesel. It is well-soluble, has a high specific energy, and has a high cetane number. As part of the HCN oil preparation procedure, melt the coconut oil in a large pan. Incorporate the Hibiscus flowers. Hibiscus leaves should be cooked over medium heat until crisp and browned. After the heat is turned off, take the pan out and let it cool for about 24 hours. Put the oil in a jar or bottle after it has been removed from the filter. Through the transesterification process, triglycerides are converted into biodiesel in the presence of alcohol and a catalyst. Because they are both affordable and widely available, KOH and NaOH are the two types of catalysts most frequently used in the production of biodiesel.

IV. EXPERIMENTAL SETUP

A single-cylinder, four-stroke compression ignition engine is used in the setup (fig 1), and it is connected to a loading dynamometer of the eddy current variety. The air temperature, coolant temperature, and throttle position are all connected to the electronic control unit, which controls the ignition coil, fuel injector, fuel pump, and idle air. The setup offers the tools required to measure combustion pressure, diesel line pressure, and crank angle. These signals are connected to computers, which produce pressure crank-angle diagrams. Instruments are interfaced for the measurement of airflow, fuel flow, temperatures, and load. Computers are interfaced with these signals to create pressure crank-angle diagrams. A stand-alone panel box with an air box, two fuel tanks for a dual fuel test, a manometer, a fuel measuring unit, transmitters for measuring the flow of air and fuel, a process indicator, and hardware interface is a part of the setup. There are two Rotameter that can be used to measure the flow of cooling and calorimeter water. A battery, starter, and battery charger are offered to aid in the electric starting of the engine. Table 1 shows the specifications of the experimental setup.

Figure 1: Experimental Setup

Table 1: Experimental Setup Specifications

Parameter	Specifications
Make	Kirloskar
Rated Power, kW	3.5
Speed, rpm	1500
Number of cylinders	Single
Number of strokes	Four

V. RESULTS AND DISCUSSIONS

1. Brake Power (BP):

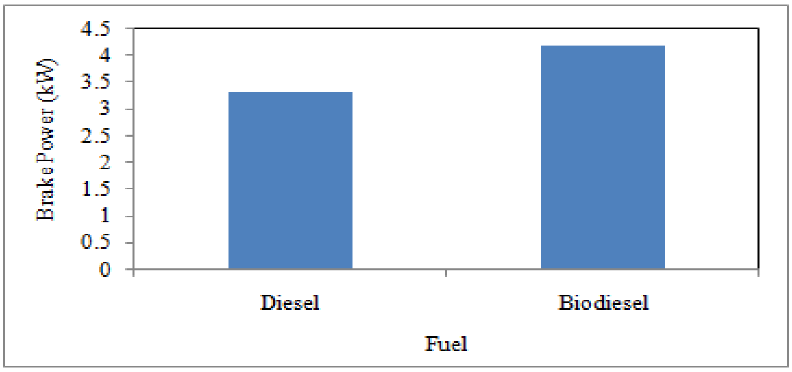

Figure 2: Effect Biodiesel on Brake Power at Full Load

The amount of power available at the crankshaft, as measured by B.P., is referred to as brake power. The measurement of torque and engine output shaft speed makes it the most crucial of all I.C. engine measurements.

$$\text{Brake power (kW)} = \frac{2\pi NT}{60,000} \qquad (1)$$

Figure 2 shows the brake power developed by the engine by using diesel and biodiesel when engine is running at full load and 1500 rpm. Brake power developed by the engine by using biodiesel is higher than diesel due to complete combustion of biodiesel.

2. **Volumetric Efficiency (VE):** The efficiency with which an internal combustion engine can move the charge of fuel and air into and out of the cylinders is known as volumetric efficiency. It also indicates the proportion of the cylinder's swept volume to the volume of air drawn into the cylinder. Figure 3 shows the volumetric efficiency developed by the engine by using diesel and biodiesel when engine is running at full load and 1500 rpm. Volumetric efficiency developed by the engine by using biodiesel is higher than diesel.

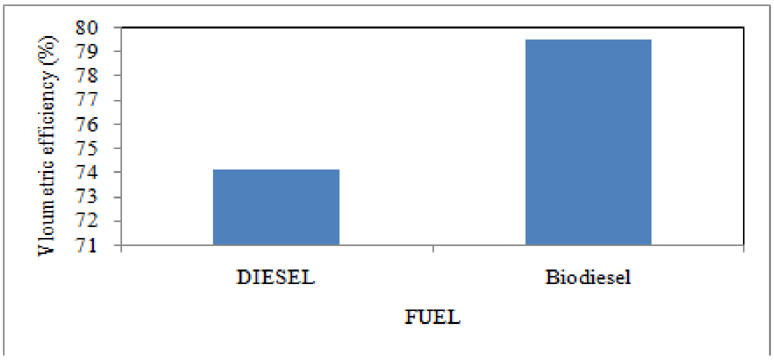

Figure 3: Effect Biodiesel on Volumetric Efficiency at Full Load

3. **Carbon Dioxide (CO_2):** Chemically, carbon dioxide is a compound with the formula CO_2. It is composed of molecules, each of which has a covalent double bond between two oxygen atoms and one carbon atom.

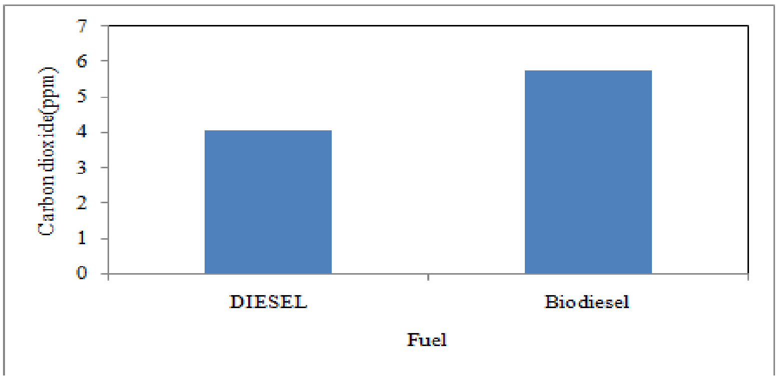

Figure 4: Effect Biodiesel on Carbon Dioxide Emission at Full Load

Figure 4 shows the carbon dioxide emission developed by the engine by using diesel and biodiesel when engine is running at full load and 1500 rpm. Carbon dioxide emission developed by the engine by using biodiesel is higher than diesel due to density of fuel.

VI. CONCLUSSIONS

The following conclusions are made;

- Brake power is increased by 28.44% than diesel
- Volumetric efficiency is increased by 7.24 than diesel.
- Carbon monoxide emission increased by 38.09 % than diesel

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