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Comparative Investigation of Performance Analysis & Carbon Emission of Biodiesel and Conventional Fuel

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Abstract: In recent years, the world's largest democracies have recognized the threat posed by vehicle pollutants to our ecosystem, particularly the emission of hazardous gases. As a result, they have taken steps to tighten emission standards for motor vehicles in order to reduce toxicity. Additionally, the rapid urbanization taking place worldwide has led to increased consumption of petroleum products, such as diesel and petrol, which are derived from crude oil. Unfortunately, the reserves of crude oil are limited, and the availability of natural gas stocks is also restricted. Therefore, it is crucial to explore alternative sources of energy. This study focuses on examining the effects of using biodiesel as an additive in diesel engines (D.E) to observe its impact on various performance parameters such as noise emissions, break thermal efficiency, fuel consumption, carbon monoxide, and carbon dioxide. By comparing the effects of biodiesel blended fuels with conventional diesel fuel, we can analyze the behavior of diesel engines. The result shows the study indicate that the use of biodiesel as an additive reduces noise emission levels compared to diesel fuel. Additionally, the analysis of carbon monoxide and carbon dioxide emissions shows that biodiesel blended fuel results in lower carbon emissions when compared to traditional diesel fuel. These findings highlight the potential of biodiesel as a more environmentally friendly alternative in the context of diesel engines.

Keywords: Compression Ignition Engine, Biodiesel, Diesel Fuel, Noise Emissions, Carbon Emissions

1. Introduction

Transportation systems of the world are mostly dependent on diesel engine machinery. It encompasses all kinds of vehicles and machinery such as heavy-duty transport vehicles, railway engines, agricultural-related machinery, construction machinery, power generation plants, etc. However, emissions of them consist of different types of air pollutants that cause environmental and health repercussions. It is observed in the last two decade the rise in pollution and depletion of fossil

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fuels becomes the major concern of the world to meet their energy demands [1] The Automobile exhaust and emissions of pollutant gasses from industries are the major drivers to pollute the environment. Sources for the most of these pollutants are diesel engines which are widely used in all such sectors either for generating electricity to meet your energy demands or by heavy vehicles for transportation of goods and supplies. Furthermore these diesel engines are also the source of noise pollution which produces higher noise level that directly impacts to the life of worker who is engaged in direct contact where such activities are being per formed by using diesel engine [2]. Such problems have accelerated the world to search for alternatives to meet the energy demands which should be more efficient and environment friendly. The bio-fuels have such potential to be used as alternative fuels which are less pollutant and more environmental friendly. These fuels can be produced by regionally available raw materials such as recycled waste cooking oil, fats of animals, or they can be also obtained by growing your seed such as soybeans, canolaand Jatrophato extract bio-fuels which are the environmental friendly products and can be used such as alternative fuels. Such bio-fuel scan be pre-eminent source of fuel to replace the conventional diesel due to its distinctive properties which may helps us to reduce in green house gas emission, reduction in toxicity level of particulates of matter pollutants such as sulfur emission by biodegradation [3].

2. Background and Literature Review

Environmental consequences due to these emissions are the greenhouse effect, depletion of the ozone layer, acid rain, climate variations [4]. Diesel fuel emissions are the biggest environmental pollutants that carry multiple hydrocarbons (HC), sulfur (S), and residues of crude oil [5]. Moreover, according to the reporting of the USA department of energy, the oil supply of the world will reach its highest production and will become at the point of depilation [6]. Concerning this, reserves of fossil fuels are depleting along with increasing prices of raw fuel which indicates an alarming threat to the global economy owing to negative loads on the global trade balances. Therefore, energy security is a fundamental factor concerning to stability of the economy, its rising demand, rising world population, enhancing living standards, and large industrialization have forced in utilizing limited sources with wisdom and alsodevelopingalternativenon-petroleumfuelsforastableeconomyandenvironment[7] . Initially, trans-esterified vegetable oil (biodiesel) was usedin diesel engine before world war-II in south Africa. After this, it is known as ‘biodiesel’[8], straight-chain vegetable oils, edible and non-edible, cooking oil, and animal fat [9]. Using vegetable oil is an old idea, Rudolf Diesel was the first person who used peanut oil for combustion in diesel engine during 1910[10].

In a short period, the use of biodiesel fuel in the engine was dropped due to the availability of petroleum oil in the world. The eye-catching charateristics of biodiesel consist of high cetane number, biodegradability, negligible sulfur, non-toxic-emissions, aromatic compounds, and excellent lubricity [11]. Many fuels have been tested in CI engines from time to time. All fuels were analyzed in terms of performance, exhaust emission and combustion owing to their physical and chemical properties.

These properties have solid relationships with their fatty acid composition [12-18]. Additionally, it was reported from different research studies that biodiesel or blends in CI engines have shown reduced trends in noise pollution and good noise quality [19-27]. Moreover, renewable fuels derived from vegetable oils have suitable engine performance, in other operations, some fuels can reduce performance, high carbon and lacquer deposition, and cause of engine damage [28-31]. Deposition around the injector tip is due to high temperatures owing to the advanced diesel injection system [31-34].

It is reported from different studies that few properties of bio-diesel which are: high viscosity, small volatility, and the reactivity of unsaturated hydrocarbon chains, can cause injector coking and trumpet creation on the injector, high carbon deposition occurs when the engine is run for alongtime [35].foundthattheuseofbiodieselresultedinlowercarbonemissionscompared to diesel fuel. The study reported a reduction of up to 24% in CO2 emissions when using biodiesel. Similarly, a study [36-38]

reported a reduction of up to 20% inCO_2 emissions when using biodiesel compared to conventional diesel fuel[39]. investigated the effect of biodiesel on the performance of a diesel engine. The study found that the use of biodiesel had a negligible effect on engine performance in terms of power and torque output. However, the study reported that the use of biodiesel resulted in lower engine efficiency and increased fuel consumption compared to conventional diesel fuel. [40].
Compared the engine performance of biodiesel and diesel fuel.
The study found that biodiesel had similar engine performance to diesel fuel, with a slight decrease in power output. The study also reported that the use of biodiesel resulted in higher brake-specific fuel consumption compared to diesel fuel [20]. Investigated the engine performance of a diesel engine using biodiesel and diesel fuel blends. The study found that the use of biodiesel had a negligible effect on engine performance in terms of power and torque output. However, the study reported that the use of biodiesel resulted in higher brake-specific fuel consumption compared to diesel fuel. [40]. investigated the engine performance and emissions of a diesel engine using biodiesel and diesel fuel blends. The study found that the use of biodiesel resulted in lower NOx emissions but higher particulate matter emissions compared to diesel fuel. The study also reported a slight decrease in power out put and engine efficiency when using biodiesel [40]
The studies also highlighted the potential of using biodiesel produced from different blends of oils and nano-metal additives to reduce greenhouse gas emissions and mitigate environmental impacts. Additionally, bibliometric analyses showed that research on biodiesel production from waste cooking oil provides opportunities for sustainable environmental development but also highlights limitations in the area of research.

2.1 Problem statement

The literature review reflects that significant studies have been carried out to investigate the performance and emissions of compression ignition engines using different fuels; however, very limited studies have been reported in the literature to investigate compression ignition parameters using waste cooking oil biodiesel oxide. Moreover, it was also not reported regarding the carbon monoxide, carbon dioxide, therefore, an investigation of compression ignition engine carbon monoxide, carbon dioxide, and particulate matter emissions is very much needed to better explore the performance and engine life.

3. Research Methodology

In this study involved testing two oil samples in a diesel engine, while investigating here critical factors: diesel engine performance analysis, engine noise emission levels, and carbon emission levels as in Figure 1. To ensure accuracy, fuel properties were determined based on ASTM standards. Additionally, the elemental analysis was evaluated under constant load and speed conditions, while engine performance and sound pressure level tests were carried out under different loads and constant speed. A detailed flow diagram of the research methodology can be found in Figure 1.
To achieve the objectives of the research has been given. Two oil samples were tested in the diesel engine. In this research, three different factors like, the performance analysis of the engine, noise emission level and carbon emission level have been investigated. Fuel properties were determined based on ASTM (American Society of Testing Materials) standards. Moreover, In this work, performance, and sound pressure level tests were determined on different loads and constant speed. All such work to evaluate the study results of research objectives was performed at thermodynamics laboratory in the department of Mechanical Engineering at Quaid-e-Awam University of Engineering, Science, and Technology Nawabshah which was chosen for conducting all the tests. A single-cylinder horizontal type water-cooled 4-stroke diesel engine was used to evaluate the engine's performance on using biodiesel blend fuel (B25). The specifications of the engine used in the research study are presented in Table3.1.

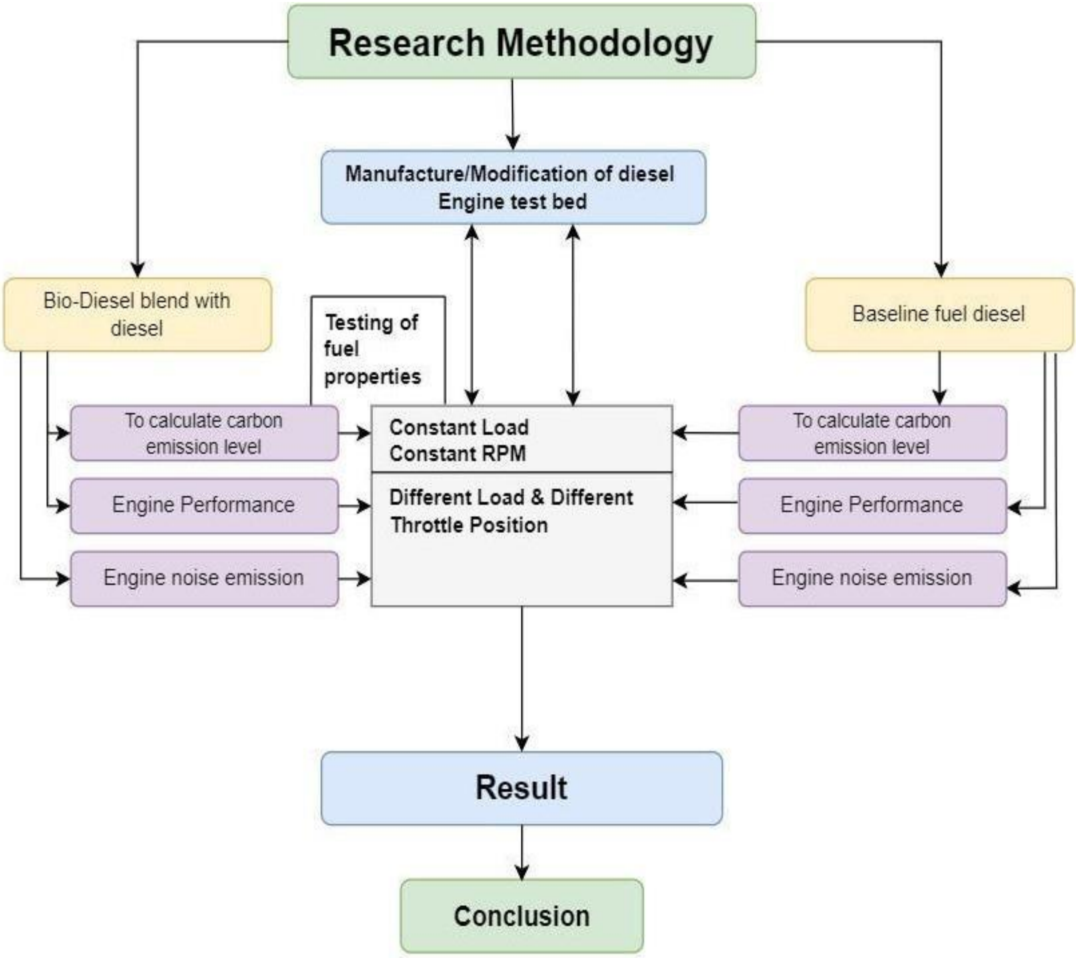

Fig. 1 - Flow diagram of research methodology

Table 1 - Diesel Engine Test Bed Specifications

Cooling system	Water-cooled
Type	Horizontal
Number of cylinders	1
Bore(Piston size)	80mm
Stroke(Piston Displacement)	95mm(477cc)
Compression Ratio	23:1
Starting Method	Manual
Output/rotational speed	8.5PS/2200rpm(max)

The engine test bed was connected with two fuel tanks, one for D100 and another forB25. A single and the same pipeline for fuel supply were connected to both fuel tanks; however, the flow of fuel supply was regulated by two different valves visible in Figure 2. and the final data was collected after the engine had stabilized for approximately 10 minutes. Additionally, we evaluated the performance of two fuel samples on D100 and B25, which is detailed in results & discussion.

3.1 Noiseemission Level

As part of our objective, we have calculated the sound pressure level of the CI engine. To do so, we tested two different fuels under various loading conditions and at a constant speed. The sound pressure level was measured from three different directions - front, back, and left - as illustrated in Figure 2. To capture accurate data, we installed three microphones at distances of 1 meter from the test bed and positioned them in the locations specified in the previous paragraph. All measurements were obtained using a sound pressure level dB meter, as depicted in Figure 2. Specific details regarding the equipment used are provided in Figure 2.

Fig. 2 - Sound emissions measuring device

3.2 Carbonemission Level

In the experimental work of internal combustion engine the flue gas analyzer was used. It is portable and possesses wide applications in industrial emission analysis. This equipment is flexible, and easy to transport. This equipment is controlled to the control unit fitted in flue gas analyzer test to 350-XL. It can be used by great distance between the gas sampling site and the burner, provision is made through data bus cable by which the control unit can be connected for sampling to the flue gas analyzers owning Figure 4. Furthermore the print facility is provided with built-in printer in the control unit. This unit can be used as a separate hand-held measuring appliance for different parameters such as temperature and pressure, humidity, velocity etc., using the additional probeinput. The control unit tests 350-XLas shown in Figure 3

Fig. 3 - Gas analyzer control unit

The flue gas analyzer is the "heart" of the measuring system and is available in two different versions. The test to 350-XL is equipped with measurement modules for CO and CO2 as standard. In addition to this, measurement modules for CxHy, SO , H2Sby infrared module are optionally available. Parallel to the features of the S-version, the flue gas analyzer test to 350-XL has a Peltier gas preparation with a peristaltic chose pump for controlled removal of condensate as well as a fresh air valve for long-term measurements over several hours.

4. Results and Discussion

In this section the result obtained from the experimental work have been discussed in this regard. In this regard, the results for elemental analysis of lubricating oil, engine performance and engine noise emission have been presented. Moreover, three lubricating oil samples were taken by using D100 and B25 fuel at intervals of 10 mints respectively. Moreover, the elemental analysis was carried out at constant load and constant speed while engine performance and noise emission were calculated at variable load and constant speed at the above-mentioned intervals. Furthermore, we have calculated Carbon emission level of Diesel engines (D.E) by using bio-dieselas an additive to ASTM standards.

4.1 Engine Performance Analysis

The brake thermal efficiency (BTE) is the ratio of the thermal power available in the fuel to the power that the engine delivers to the crank shaft. The brake thermal efficiency was observed at B30 proportion of the biodiesel blend at variable loads which are given in Figure 4. The Brake thermal efficiency (BTE) of D100 has a lower thermal efficiency of B25. In Figure 4 at 1.8 kW, the maximum value of thermal efficiency was observed at 46.68% on B25 and while on D10036.4% was observed. The increase deficiency of Diesel Fuel is 22% in comparison to biodiesel fuel. The increased efficiency on B25 is 17.9% in comparison toD100.The difference in efficiency between the above is 4.1%.

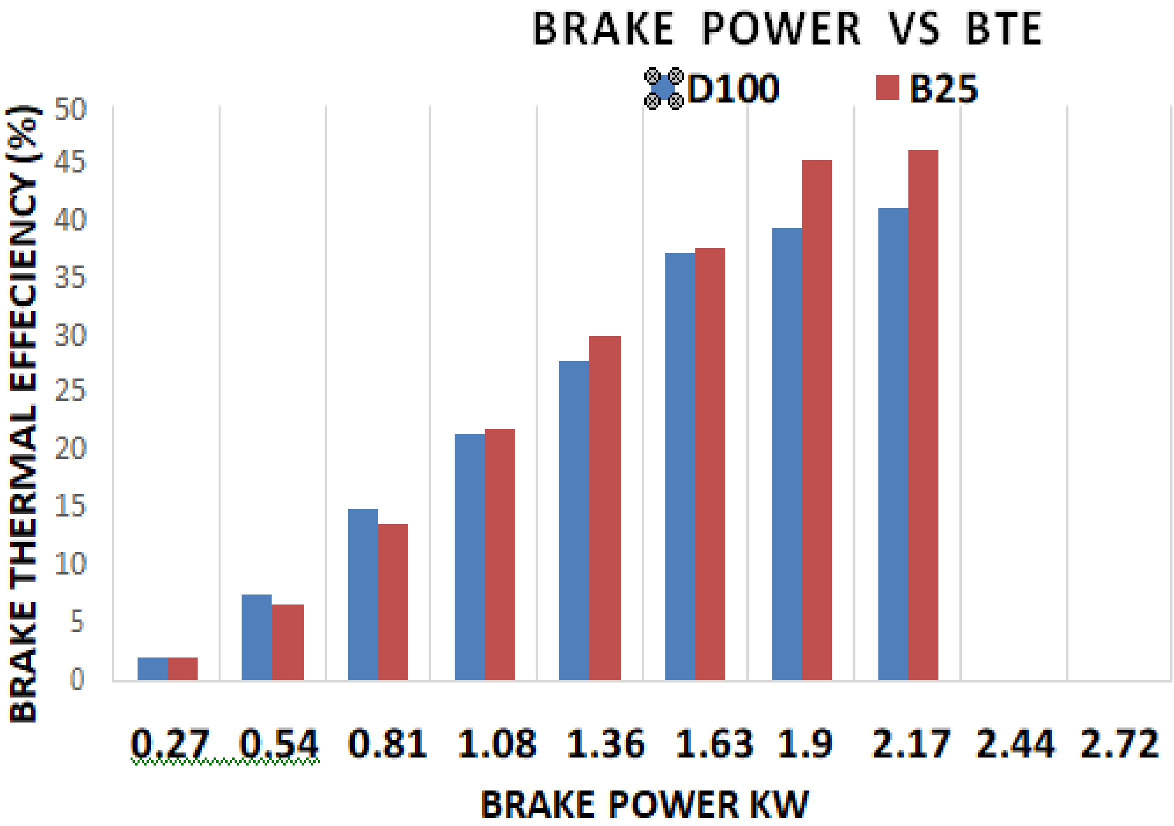

Fig. 4 - Brake specific fuel consumption (BSFC) vs Brake power(BP)

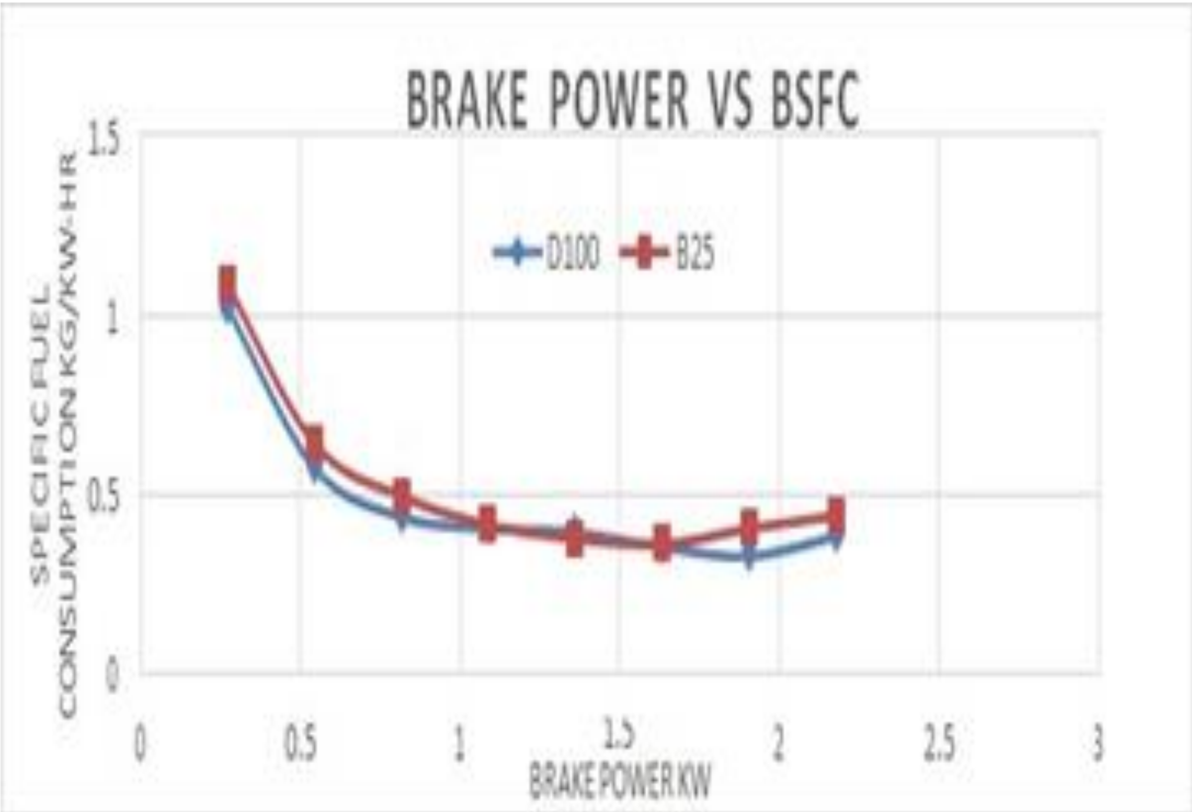

Fig. 5 – Specific fuel consumptions vs brake power

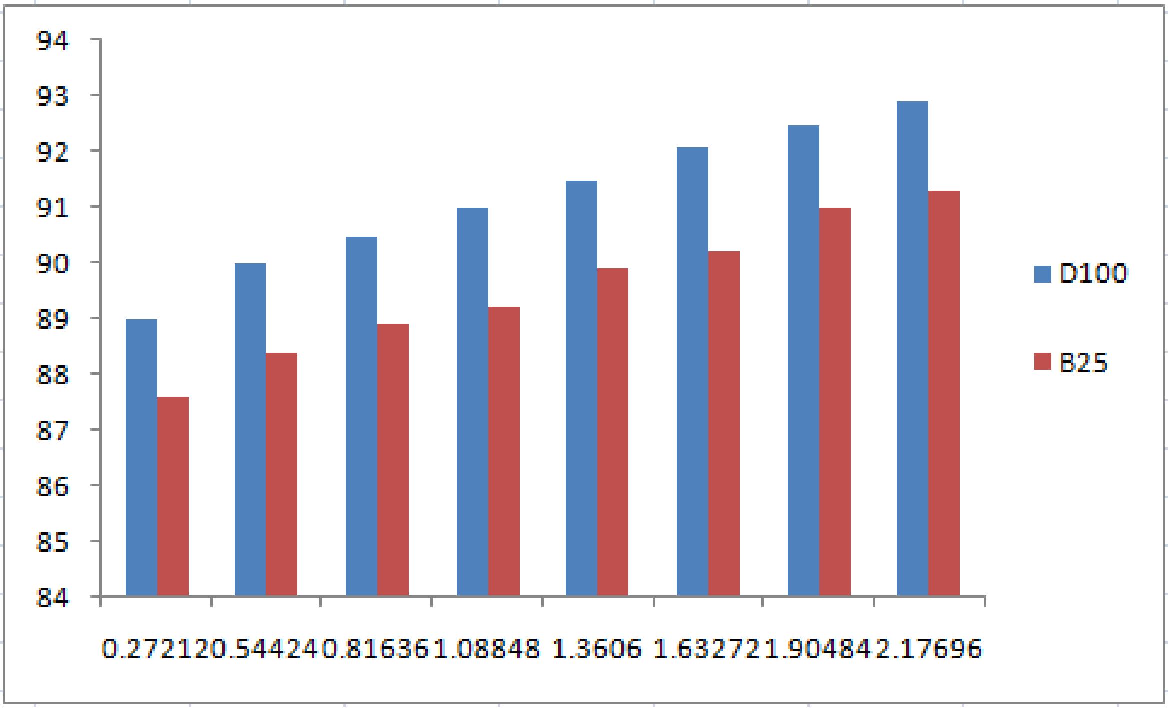

Fig. 6 – Sound pressure levels Brake power (back position)

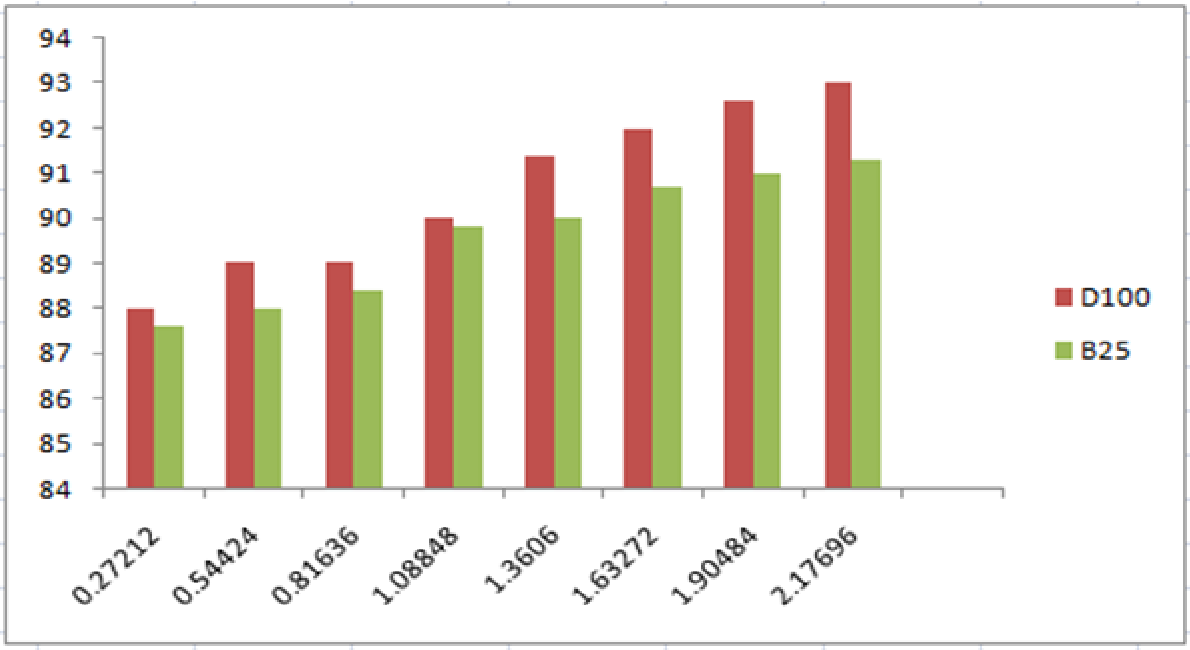

Fig. 7 - Sound pressure levels Brake power (left position)

The brake specific fuel consumption (BSFC) is an indicator of fuel consumption in an IC engine. It depends on the speed of the engine; load and biodiesel blend ratio, and additives. The diesel and biodiesel fuels are mentioned in Table 3.2. From the results, it is clear that BSFCofB25 is higher than D100 at unloading conditions as shown in the following Figure 5-10 2BSFC shows the performance of the engine and shows its unit is kg/kW-hr. The BSF Cof biodiesel fuel is higher due to the maximum contents of oxygen, which results in declined heating value. The lower densities and lower heating values of the fuels require higher mass fuel is required for the same energy output from the engine. It has been reported that density and calorific value are impacted on the degree of un saturation, and it has been noted that unsaturated esters lower heating value have lower mass-energy content (MJ/kg), compared to saturated esters.

4.2 Noise Emission Level

The results of the study indicate that the sound pressure level (SPL) of the CI engine was measured under different load conditions using two different fuels: diesel fuelD100 and biodiesel blend B25. Three specific positions were selected to record noise levels: the front, back, and left sides, all situated at a distance of 1m from the piston head. The comparative analysis clearly demonstrates that the engine operating on diesel fuel D100 exhibited higher noise emissions compared to biodiesel blend B25. It is worth noting that lower sound levels were observed during initial loads, while slightdifferencesinfrictionwereobservedwhenusingbiodieselfuelundermediumloads.

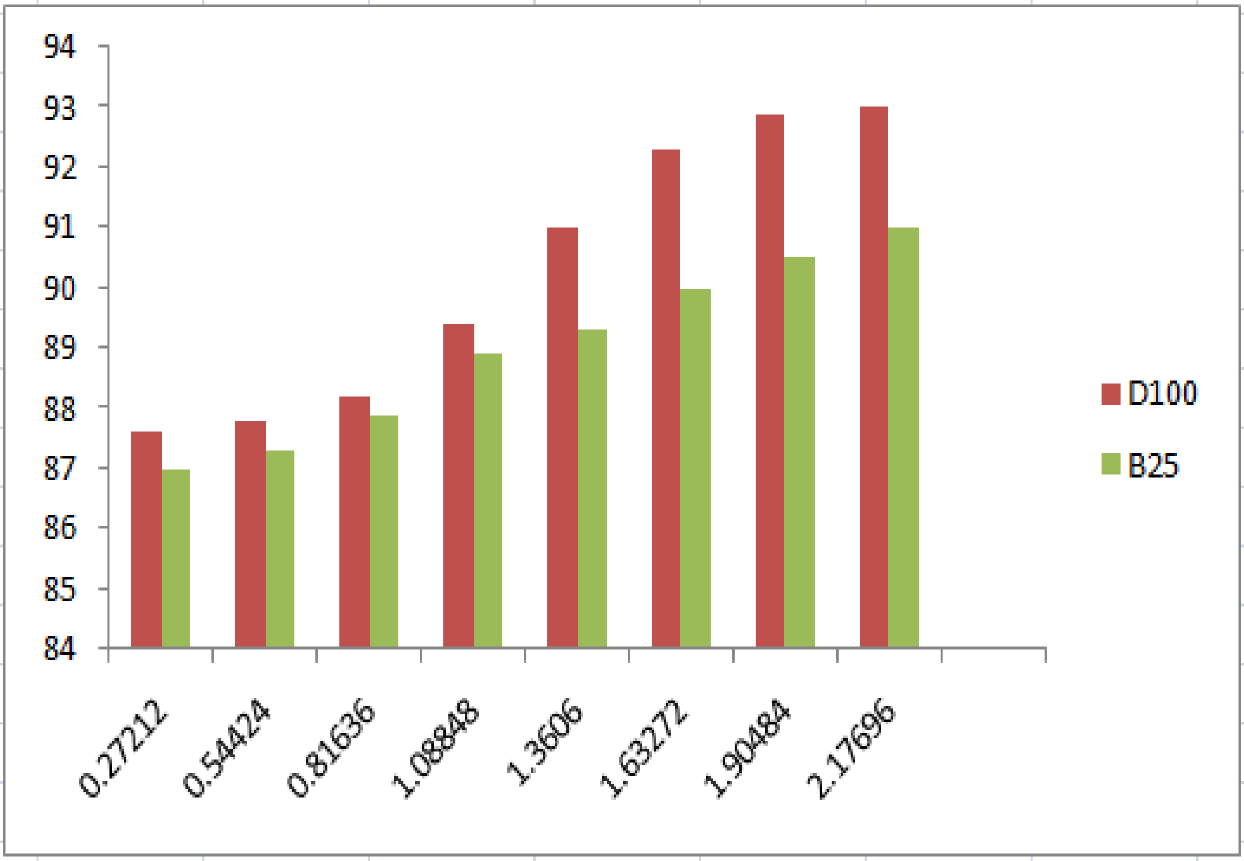

Fig. 8 – Sound pressure level vs brake power at front position

These findings suggest that biodiesel blend B25,which contains higher oxygen content than diesel fuel D100, contributes to a reduction in noise emissions. All sound pressure level measurements were conducted under variable brake loads while maintaining a constant engine speed of 1300 rpm.

4.3 Carbon Emission Level

Results of emission of CO characteristics of engine were determined by using B25 blended waste cooking oil such as biodiesel with pure diesel D100. To obtain he results of B25 with pure diesel of 75%, we use the gas flue analyser 350XL, tetso-meter was used to analysis the various emission parameters such as CO & co2 of flue gases emitted from slow speed diesel engine model no: DWE-6/10-JS-DV.From the out of engine silence. In the results it was found that the carbon monoxide emission has higher carbon content of carbon particles when pure diesel D100 was used comparative to B25. Further analysis of carbon dioxide using B25 & D100 have produced the results which found that B25 have lower content production of CO2 comparing to D100.As the results of are shown in fig:4.6&4.

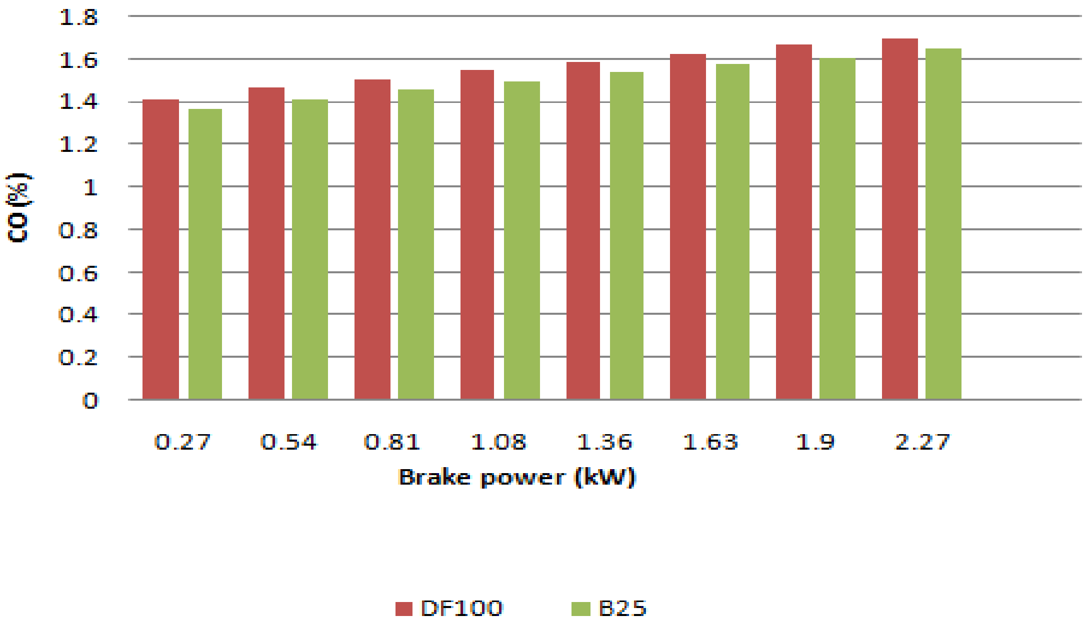

Fig. 9 – Carbon Monoxide emission vs Brake power(kw)

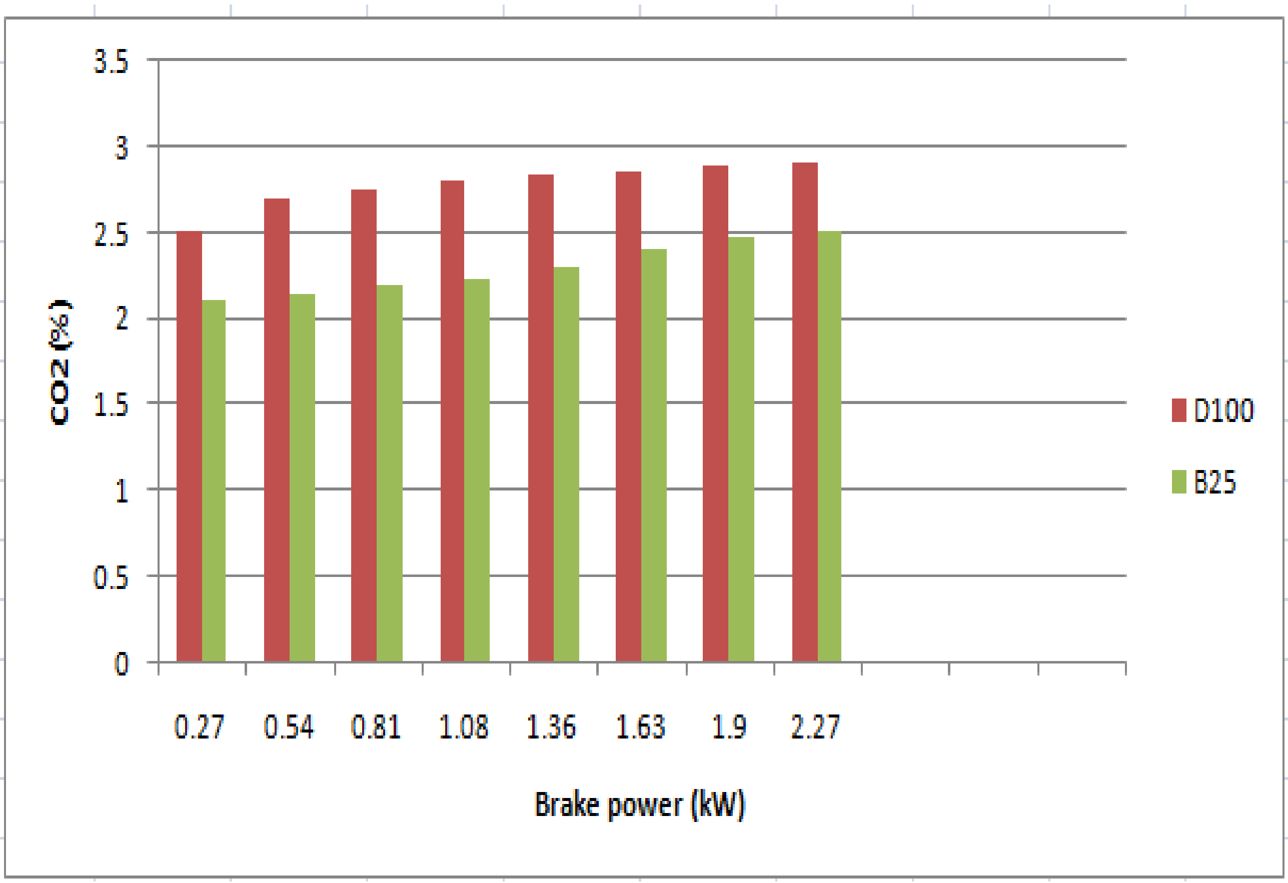

Fig. 10 – Carbon Dioxide emission vs Brake power(kw)

5. Conclusion

Performance Analysis: The research aimed to evaluate the performance of the diesel engine by measuring its brake thermal efficiency. It was found that the engine torque, brake power, and brake thermal efficiency were lower when using bio-fuel blends compared to pure diesel (D100). The higher density and lower heating value of the bio-diesel blends contributed to these results. Additionally, the brake specific fuel consumption (bsfc) was higher for theB25 blend compared to D100. Engine Noise Emission Analysis: The study also conducted an analysis of engine noise emission levels. The results indicated that the noise emissions from the engine were lower when using the B25 blend compared to D100. This reduction in noise emissions could be attributed to the physical properties and the increased oxygen content present in the biodiesel fuel". Carbon Emission Analysis: The research aimed to calculate the carbon emission levels of the diesel engine when using bio-diesel as an additive. The emission characteristics of carbon monoxide (CO) were measured by using B25 blended waste cooking oil (biodiesel) in comparison to pure diesel (D100). The researchers used a gas flue analyzer (model:350XL)and a tetso-meter to analyze the various emission parameters such as CO and CO2 of the flue gases emitted from the slow-speed diesel engine(modelno:DWE-6/10-JS-DV)at the engine outlet.

6. Future work

Further investigations can be conducted to optimize the performance of the diesel engine using bio-diesel blends. This can involve exploring different ratios and types of bio-diesel additives to achieve higher brake power, torque, and brake thermal efficiency while reducing fuel consumption. Future research can focus on developing and implementing emission reduction techniques for diesel engines using bio-diesel blends. This can involve studying the impact of different combustion strategies, after-treatment systems, and engine modifications to minimize carbon emissions, including CO and CO2. Conduct a more comprehensive analysis of engine emissions by measuring other pollutants such as nitrogen oxides (NOx), particulate matter (PM), and unburned hydrocarbons (HC). This will provide a more complete understanding of the environmental impact of using bio-diesel as an additive in diesel engine.

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