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UTILISATION OF ALTERNATE FUELS IN DIESEL AND CRDI ENGINE FOR ELIMINATING VEHICULAR EMISSIONS

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RESEARCH ARTICLE

ABSTRACT: Nitrogen oxides and smoke are the substantial emissions for the diesel engines. The objective of this research is to assess the potential of bio-fuels by comparing it with diesel. Initially, the biofuel and diesel were taken in separate containers, then it was measured for the different proportions by volume basis and were mixed together. After 24 hours, it was used as a fuel. Experiments have been conducted with net biofuel (B100), diesel and (B80-D20 and B60-D40) type blends. Fuel undergoes good combustion and hence there is a significant improvement in performance and reduction in emissions. Similarly, I have conducted my own research work and found out results by using an CRDi engine with Jatropha oil-diesel blend. I could attain a decrease in emission levels of Smoke opacity by 20% for JD10 than diesel at IP of 400 bar. NOx emission for JD10 at 400bar has been found to be 20 ppm less than that of diesel. Better atomization of fuel is found at 600 bar IP. The usage of alternate fuels like Jatropha, Ethanol can help us move towards a greener society, help us to live emission free by inhaling pure oxygen content and can reduce the dependence on conventional fuels.

KEY WORDS: *Alternate fuel, Biofuel, CRDi engine, Diesel engine, Emission, Injection pressure*

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UPOTREBA ALTERNATIVNIH GORIVA U SAMNJENJU EMISIJE VOZILA KOD DIZEL I CRDI MOTORA ZA ELIMINISANJE EMISIJA VOZILA

Oksidi azota i dim su značajni zagađivači iz emisije dizel motora. Cilj ovog istraživanja je da se proceni potencijal bio-goriva u poređenju sa dizel gorivom. U početku su biogorivo i dizel su uzimani u odvojenim kontejnerima, zatim su izmerene različite zapreminske proporcije i pomešani zajedno. Posle 24 sata mešavina je korišćena kao gorivo. Eksperimenti su sprovedeni sa neto biogorivom (B100), dizelom i mešavinama tipa (B80-D20 i B60-D40). Gorivo je dobro sagorevalo i stoga dolazi do značajnog poboljšanja performansi i smanjenja emisija. Slično, su realizovana samostalna istraživanja i dobijena saznanja korišćenjem mešavine dizela i ulja barbadoskog oraha kod CRDi motora. Bilo je moguće smanjenjiti nivoa emisija neprozirnosti dima za 20% za JD10 u odnosu na dizel gorivo pri IP od 400 bara. Utvrđeno je da je emisija NOx za JD10 na 400 bara za 20 ppm manja nego kod dizela. Bolja atomizacija goriva je dobijena pri IP od 600 bara. Upotreba alternativnih goriva kao što su ulje barbadoskog oraha, ethanola može pomoći: da se krene ka zelenijem društvu, da živimo bez emisija zagađivača, da udišemo čist kiseonik i da se smanji zavisnost od konvencionalnih goriva.

KLJUČNE REČI: *Alternativno gorivo, Biogorivo, CRDi motor, Dizel motor, Emisija, Pritisak ubrizgavanja*

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INTRODUCTION

The demand for renewable energy sources can be satisfied by alternative fuels that have minimal negative environmental effects, including biodiesel and ethanol. Ethanol is being used as a full or partial gasoline substitute in several countries. The uses of ethanol as a fuel are discussed below.

The effects of the use of ethanol being added to diesel oil- soybean biodiesel blends on fuel consumption have been investigated. The authors discovered that adding more ethanol to the fuel blend resulted in a longer cold start time, while adding more biodiesel to the fuel blend or using 2% ethanol as an addition had no effect on the amount of a particular fuel that was consumed. However, the B20 blend's increased specific fuel consumption was caused by the usage of 5% ethanol content [13].

Another research focused on lowering the brake specific fuel consumption (BSFC) of diesel engines by incorporating ethanol or dimethyl ether (DME) into the air intake while also supplying the diesel engine with emulsified fuel [17]. With all the benefits of renewable ethanol in terms of the environment and energy security, higher fuel conversion efficiency had been noticed for a dual fuel ethanol-diesel than the diesel solely throughout the whole range of speeds and loads [3].

Previous research study has examined the emission characteristics of a four-stroke motorbike engine using a fuel mix that contained 10% ethanol and 90% gasoline (E10) [8]. They discovered that using E10 fuel reduces the amount of CO and HC emissions in the exhaust compared to using unleaded petrol. According to He et al research, blending ethanol with diesel fuel can lower particulate matter (PM) emissions while also improving the flexibility of NOx emissions management under a range of engine operating situations. This research also denotes that the increased fuel consumption and poor ignition quality are the main barriers to ethanol use in diesel engines [7].

In a two-stroke diesel engine with exhaust gas recirculation, ethanol fuel benefits from a low cetane number. This study also demonstrated that ethanol increases thermal efficiency by 2% to 3% while also produces less soot and NOx [9].

The performance and emissions of a four-cylinder turbocharged indirect injection diesel engine running at various fuel injection pressures (150, 200, and 250 bar) at full load were examined in the presence of 10% and 15% by volume of ethanol. The addition of ethanol reduces CO, soot, and SO2 emissions but increases NOx emissions and causes power reductions of between 12.5 and 20 % [4].

The usage of biofuels as a diesel engine fuel replacement has increased recently [2]. Biofuels are manufactured from biomass and come from either biological waste or agricultural practises (such as producing maize for ethanol) (i.e waste products from animals). Any diesel engine may consume biofuels, typically without any modifications. In comparison to diesel fuel, it promises a decrease in hazardous emissions (excluding NOx emissions) [6].

Large volumes of garbage are generated by the industries as a result of both industrialisation and a rise in world population. These trash streams and piles are currently disposed as landfill or left to fester. During the decomposition process, CO2 contained in trash is released into the atmosphere [5]. The solution to these issues is to turn these wastes into energy. The term "Waste to Energy" (WTE) refers to a broad range of technologies, and the best way to handle wastes is using a heat-based process like direct combustion (incineration), pyrolysis, or gas cleaning [10].

Pramanik used diesel and Jatropha oil blends to investigate the performance of a single-cylinder Compression Ignition (CI) engine. Compared to utilising only vegetable oil, engine performance was markedly enhanced. The reduced viscosity of the vegetable oil led to a drop in the amount of fuel used and the temperature of the exhaust gases. It was possible to get a satisfactory level of thermal efficiency for the engine with blends including up to 50% volume of jatropha oil. Based on the characteristics and the outcomes of engine tests, it has been found that 40 to 50 % of diesel can be replaced with Jatropha oil without altering the engine [12].

Forson used a single-cylinder direct-injection engine to research various diesel and Jatropha oil mixtures. 97.4%/2.6%, 80 %/20%, and 50 %/50 % by volume were the mixes' tested concentrations. They found that although all fuels had equivalent carbon dioxide emissions, the 97.4% diesel/2.60% Jatropha fuel blend had the lowest net contribution to the atmospheric level. The 97.4% diesel/2.6% Jatropha fuel blend produced the highest values of brake power and brake thermal efficiency as well as the lowest values of specific fuel consumption, which is the study's most significant discovery. The test results for Jatropha oil and its blends with diesel generally demonstrated improvements in brake thermal efficiency, brake power, and reduced specific fuel consumption. Jatropha oil was also recommended as a diesel fuel additive for use as an ignition-accelerator [1].

1. JATROPHA OIL

For Compression Ignition (CI) engines, vegetable oils are produced as fuels. Due to their higher cetane number, vegetable oils can be used in diesel engines. When compared to traditional fuels like diesel and gasoline, vegetable oils including Jatropha oil are viscous. To fix this, the injection system's injection pressures can be raised, which will atomize the fuel mixture. The thermal efficiency of this Jatropha oil is inversely correlated with the length of its fatty acids. Due to its increased density, Jatropha oil has a similar heat content to diesel oil [11]. With a rise in saturation, the heating value decreases. The location of the double bonds on this particular glycerol backbone determines how the heat content and cetane number differ. Vegetable oil including Jatropha oil is environmentally user friendly. The engine is preheated before using any vegetable or green oil due to its higher viscosity.

Fig 1 - Jatropha Seed and Oil

2. METHODOLOGY

DIESEL ENGINE

For this experiment, a single cylinder, four-stroke, air cooled, DI, constant speed diesel engine producing 4.5 kW of power was used. Table 1 lists the specifications for test engines. An eddy current dynamometer, which transfers the mechanical energy produced by the engine power directly to the network, was attached to the engine and mounted on a permanent table. To handle the control and acquisition of measured signals, two systems were deployed. The first system manages the engine dynamometer as well as the collection of low-frequency measurements (torque, engine speed, pressure and temperature in the collectors). The second system measures high-frequency signals that mostly relate to the cylinder pressure, fuel injection pressure, as well as the crankshaft's angular position [14].

The intake air flow was measured using an LPX 5481 type differential pressure transducer. The test engine was equipped with a number of thermocouples of type K to measure temperature. The ambient temperature was determined using an active transmitter of type HD 2012 TC/150 for sensing temperature and humidity. The fuel flow was gauged by a Coriolis mass flow meter. A chemiluminescence nitrogen oxide analyzer, model number TOPAZE 32 M, was used to quantify emissions of nitric oxide (NO) and nitrogen oxide (NOx). Using a heated hydrocarbon analyzer, FID flame ionisation was used to detect hydrocarbon emissions (HC) (model GRAPHITE 52 M). The emissions of carbon monoxide (CO), carbon dioxide (CO_2), and oxygen (O_2) were measured using a 2 M MIR analyzer.

Table 1 - Specifications of test engine (diesel)

Parameters	**Specifications**
Cylinder Number	One
Type of cooling	Air cooled
Bore * stroke	95.5 * 88.94 mm
Length of Connecting rod	165.3 mm
Displacement	630 cm^3
Injection timing of fuel	20˚bTDC
Injection pressure of fuel	250 bar
Compression ratio	18:1
Rated power	4.5 kW @ 1500 rpm

CRDi ENGINE

Similarly, I have conducted a comparative study in a CRDi (Common Rail Direct Injection) engine by using alternate fuel blend of Jatropha oil and diesel blends. Various specifications of the CRDi engine are given in Table 2. This was carried out using a Kirloskar 5.2 kW power, 1500 rpm, single-cylinder, water-cooled diesel engine that is coupled to an eddy current dynamometer. We investigated the effect of FIP and SOI time on the motor copying characteristics using the uni-chamber model of the CRDi Engine. The exploratory investigation was expressed using four various FIPs (300, 500, 750, and 1000), four distinct SOI timings, and 4 distinct fuel intake measures at a constant motor speed of 1500 rpm.

Tests of the motor's consumption characteristics were conducted using information from the in-chamber pressure level. The roundabout infusion CI DICI motor, fuel vaporisation, and heat energy movement are combined by the timing of the FIP and SOI [15]. The injection boundary unit plays a key role in controlling the heat discharge rate (HRR) and charge per unit of weight rise (ROPR), which also has an impact on the motor's output power. Limiting the fuel inflow parametric quantity is essential for creating a CI diesel motor that burns efficiently and without pollution.

CRDi ENGINE SPECIFICATIONS

This study used a single-cylinder, water-cooled Kirloskar diesel engine with 5.2 kW of power that runs at 1500 rpm and is coupled to an eddy current dynamometer. To measure the quantity of exhaust gases and smoke, the AVL gas and smoke analysers were placed in the exhaust tail pipe. This kind of smoke metre can be used to determine the amount of smoke at 1% opacity. The engine's altered fuel ignition and timing are 200 bar and 20 deg, respectively, and this instrument's uncertainty percentage is 1.4. The production of power and efficiency were assessed by varying the load to 0%, 25%, 50%, 75%, and 100%. Prior to the load being applied for each test fuel, the engine is permitted to run for 10 minutes after starting with each test gasoline. Using the manual valve the engine produces, the EGR valve opens [16].

We have used a fuel blend with diesel (90%) and Jatropha oil (10%). The reason for choosing this blend is because Jatropha has a higher flash point and fire point. Jatropha also has a higher kinematic viscosity. It results in consumption of lower oil. Diesel on the other hand has lower viscosity than Jatropha oil. JD10 blend gives better fire and flash point while optimizing the kinematic viscosity of Jatropha oil along with diesel.

Table 2 - Specifications of CRDi engine

Specifications	**Parameters**
Make	Kirloskar TV1
Cylinder number	1
Stroke number	4
Fuel	Diesel
Rated power (kw)	3.5 kW@1500rpm
Type of dynamometer	Eddy current dynamometer
Bore of cylinder (mm)	87.5
Length of stroke (mm)	110
Swept volume(cc)	661.45
Compression ratio	18

Diameter of Orifice (mm)	20
Length of Connecting rod (mm)	234
Injection point variation of fuel	0 to 25˚ bTDC

Table 3 and 4 depicts the various fuel properties for Jatropha, biofuel and diesel oil.

Table 3 – Fuel Properties of Jatropha & diesel

S.NO	Characteristics	Diesel	Jatropha	JD(10) blend
1.	Kinematic viscosity @ 40°C in CST	2.3	37	5.14
2.	Flash point (°C)	45	75	48
3.	Fire point (°C)	53	83	56
4.	Gross calorific Value (kJ/kg)	42497.21	37555.5	41753
5.	Density in kg/m^3	830	918	846

Table 4 – Fuel Properties of biofuel and diesel

Properties	Unit	Biofuel	Diesel fuel
Flash point	˚C	57	56
Dynamic viscosity at 20˚C	Ns/m^2	2.32	2.52
Density at 20˚C	kg/m^3	825	830
Kinematic viscosity at 20˚C	mm^2/s	1.7	2
Auto ignition temperature	˚C	230	220
Cetane number	---	57	52

AVL GAS ANALYZER

An AVL DiGas 444 gas analyzer was used to examine the exhaust gases. It calculates NO, HC, CO, and CO_2. The Model 114 smoke metre, which operates in accordance with British Standard Institution testing standards BS AU 141:1967, was utilised to measure the smoke intensity. Its piston displacement for the suction pump is 330 cc. It has a 5 m long plunger hose. The plunger travels its distance in 30 seconds. The ammeter range of the evaluating unit is 0 to 10.

Fig 2 – AVL Gas Analyzer

SMOKEMETER

Prior to and after the start of serial production, emission monitoring and combustion optimization on prototype engines are the main applications for smoke metres. Additionally, the instrument can measure the bulk content of soot or black carbon in raw exhaust gas in compliance with ISO 8178-3 criteria (for example, upstream of a DPF). The AVL Smoke Meter's easy integration into an automation system and potential for remote maintenance save operational costs, service times, and training needs.

Fig 3 – Smoke meter

3. RESULTS AND DISCUSSION

The advantage of using biofuel in current diesel engines without modification is that it may be freely combined with diesel. The biofuel and diesel were first measured for the various ratios on a volume basis while still in separate containers. The prescribed quantity of biofuel and diesel were blended in a container. Each fuel is blended separately for 15 minutes, which causes the fuel (blend) to be stirred. The mixture was used as a diesel engine fuel while it was being monitored 24 hours for phase separation. In the studies, several blends of biofuel and diesel as well as pure biofuel (B100) were employed (B80D20 and B60D40).

Similarly, I have done a research work by using Diesel-Jatropha oil blend in the ratio (90:10) in a CRDi engine. In order to attain the best efficiency of engine and for minimising the various emissions emitted from a vehicle, fuel injection pressure was varied in the pressure range of 400, 500, 600 bar. The various results obtained in terms of performance and emission characteristics are given below.

4. PERFORMANCE CHARACTERISTICS

EFFECT OF BRAKE THERMAL EFFICIENCY BY USING BIOFUEL

For biofuel, diesel, and diesel addition with biofuel, the variation of brake thermal efficiency with braking power is analysed. The greatest brake thermal efficiency for neat biofuel (B100) is 32.4%, whereas the maximum brake thermal efficiency for neat diesel is 29.98% at 80% load. Due to the biofuel's high cetane number and high oxygen concentration, it has the highest possible brake thermal efficiency. At full load, the thermal efficiency of the brakes is slightly reduced for all fuels. Although the ignition delay is less than the quantity of gasoline injected at maximum load, the fuel amount prepared during the delay period is much less than the total amount of fuel supplied. Therefore, more gasoline is burnt following premixed combustion, reducing the thermal efficiency of the brakes at full load. Premixed combustion often directly reflects the thermal efficiency of the brakes in CI engines.

EFFECT OF BRAKE THERMAL EFFICIENCY BY USING JATROPHA

Similarly, the performance stats for Jatropha-diesel blend are given below.

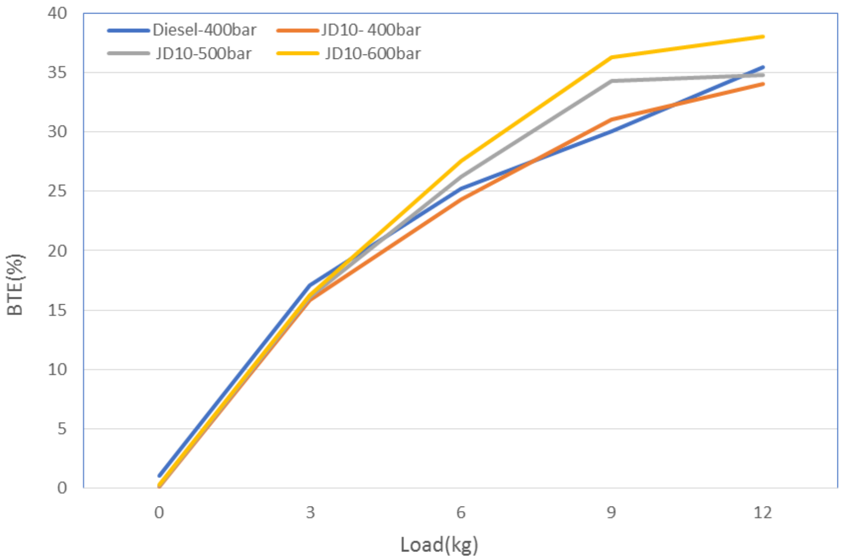

Fig 4 - Variation of BTE (%)

This graph displays the BTE for a Jatropha mix that was obtained at a constant speed of 1500 rpm. Due to an increase in power and a decrease in heat loss, BTE for JD10 mix is shown to rise for higher loads. Similar to stated thermal efficiency, brake thermal efficiency grows with increasing compression ratio at full load, but at a decreasing rate. The maximum BTE, which is 5.26% higher than that of diesel at 400 bar, was found at 600 bar injection pressure when employing a 9:1 fuel mix of Jatropha oil blend and diesel under full load conditions.

EMISSION CHARACTERESTICS

CO EMISSION USING BIOFUEL

Analysis has been done on the variance in CO emission with brake power for various test fuels. Comparing the neat biofuel to diesel and other blends, it emits a little less CO. This could be as a result of increased oxygen concentration and combustion temperatures, which promote the transition of CO to CO_2. Comparing blended biofuel to neat biofuel, CO emission rises. It is well known that biofuels with high oxygen content contribute to combustion much better than other fuels. At full load, the CO emission rates for neat biofuel, neat diesel, B80D20, and B60D40 are, respectively, 0.39%, 0.59%, 0.42%, and 0.45%.

CO EMISSION USING JATROPHA

When comparing the fuels at an IP of 400 bar, gasoline has a CO emission value of 0.38, whereas diesel has a value of about 0.23. Nearly similar to diesel value at 400 bar is JD10 mix at IP 600 bar. This might be because diesel and JD10 blend have different Cetane numbers. This might possibly be brought on by JD10's improved brake thermal efficiency at 600 bar.

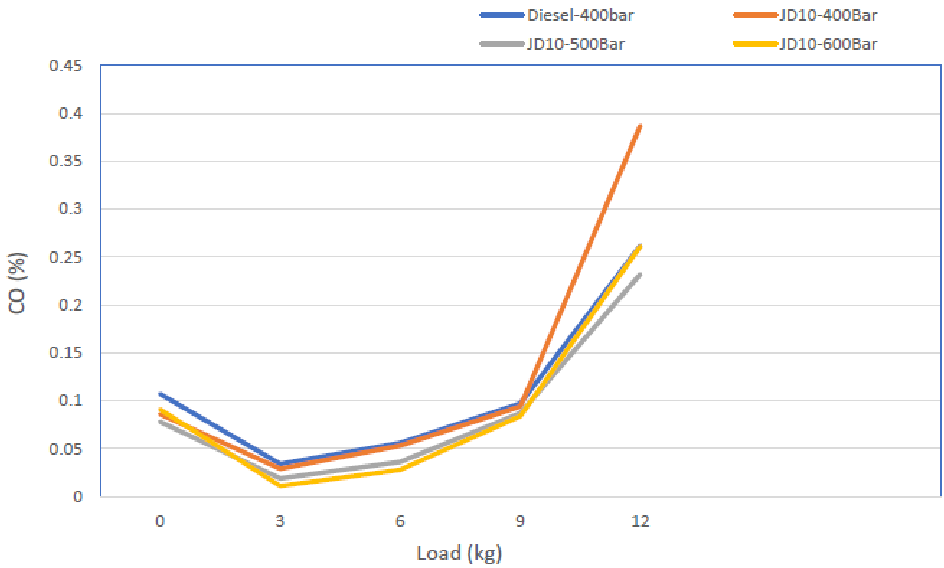

Fig 5 - Variation of CO emission

HC EMISSION USING JATROPHA

At 600 bar, we find that JD10 blend has a 20% lower HC emission than diesel. This is mostly because diesel has a higher viscosity and a larger atomization of the Jatropha blend at 600 bar compared to 400 bar. By raising the fuel injection pressure, HC were enhanced.

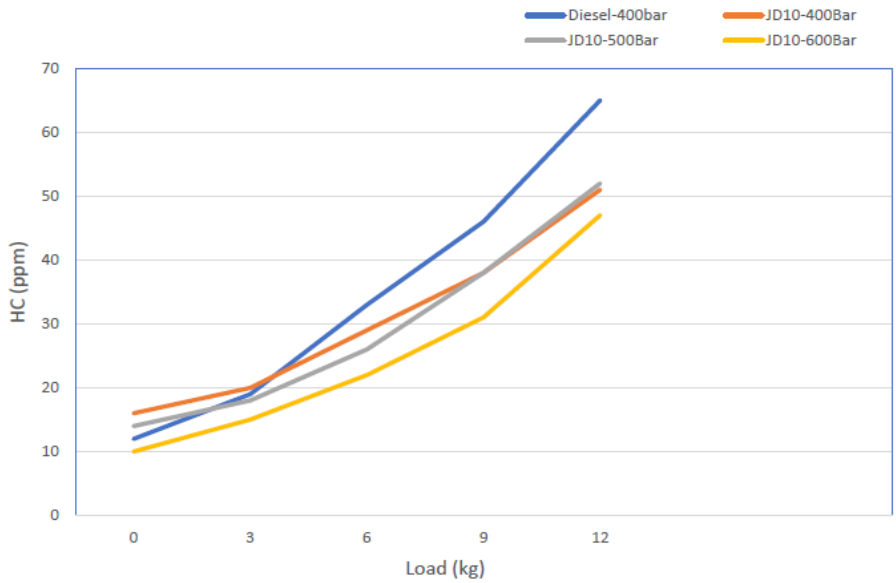

Fig 6 - Variation of HC emission

NO_x EMISSION USING BIOFUEL

From 20% load to 80% load, NO_x emissions rise, and at full load for all fuels, they fall. In comparison to other test fuels, NO_x emissions for the neat biofuel operation are maximal at 857 ppm at full load. Premixed combustion increased intensity, which occurs with neat biofuel operation, is what causes the increase in NO_x. The higher cetane number of the biofuel, which starts the combustion early, is what causes the higher premixed combustion. The gasoline burns quickly thanks to its higher oxygen content as well. As the percentage of diesel in the blend increases, NOx emissions fall down. At full load, B80D20 blend NOx emissions are 841 ppm and B60D40 blend NOx emissions are 826 ppm. The reduction in NOx is the result of inadequate fuel and air mixing, which also causes a reduction in premixed combustion.

NO_x EMISSION USING JATROPHA

The graph shows that NOx emissions rise with increasing load, which is caused by higher combustion temperatures. When operating at maximum load, NOx emissions at injection pressure of 600 bar are observed to be 4.6% higher than those at 400 bar (JD10 BLEND). When compared to regular diesel, JD10 at 600 bar varies by 6.7%.

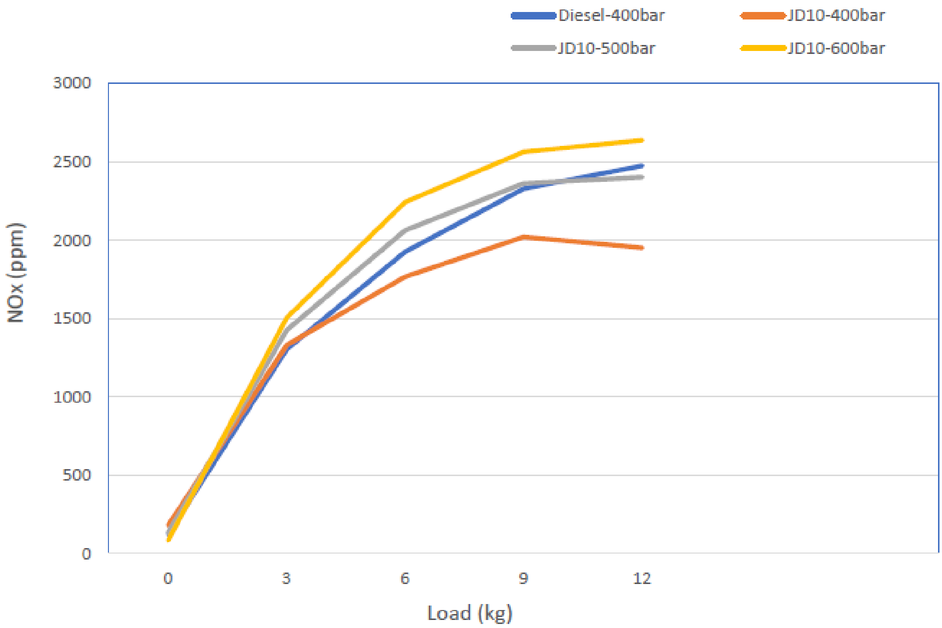

Fig 7 - Variation of NO_x emission

CO_2 EMISSION USING BIOFUEL

The primary cause of ozone layer loss and global warming is CO_2 gas. It is an understanding that biofuels with a high oxygen content aid burning significantly more effectively than other fuels. When using neat biofuel, the CO_2 emission is 9.74% at full load, which is extremely high when compared to other fuels. This is because the biofuel's oxygen-bound oxygen helps to greater fuel oxidation, which results in more CO being transformed to CO_2. With the addition of biofuel-based diesel, the CO_2 is decreased. Diesel has a 9.5% value, B80D20 a 9.42% value and B60D40 a 9.15% value.

CO_2 EMISSION USING JATROPHA

The CO_2 emission values for diesel and JD10 mixes are not significantly different. When using both fuels at increasing loads, the emission value falls between 7.7 and 7.7%. For both fuels, the fuel inside the piston gradually degrades. By raising the fuel injection pressure, CO_2 emissions increased. This is due to the fact that the fuel is more effectively atomized and the fuel drops get smaller as the injection pressure increases.

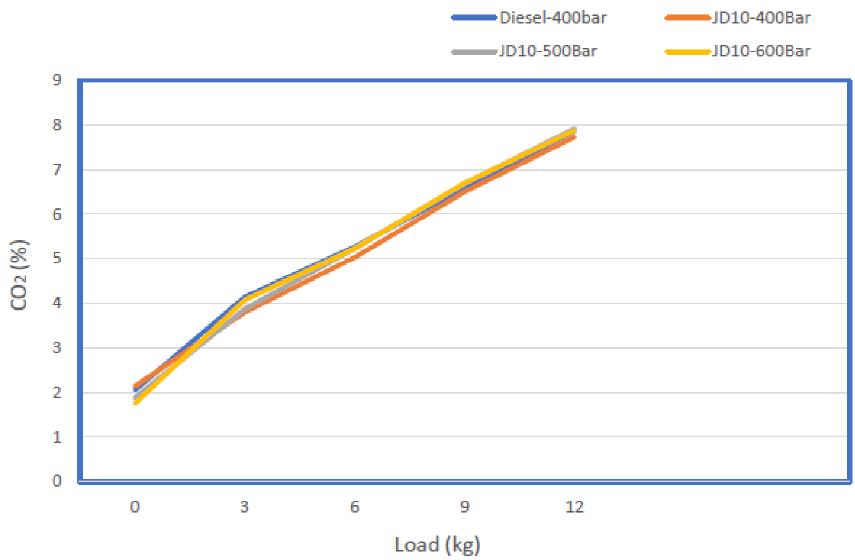

Fig 8 - Variation of CO_2 emission

OPACITY USING JATROPHA

We have lower values of opacity at higher FIP because JD10 blend has higher air fuel mix optimization. In contrast, diesel has a higher opacity because of the increased density of the smoke particles, which is brought on by light scattering. Diesel has very high opacity ratings because of its poor atomization, whereas blends have correct atomization and produce less smoke. Diesel produces a lot of smoke, which is bad for the environment. When compared to diesel, the smoke for JD10 at 600 bar is 37% more clear. This suggests that better atomization results in less smoke.

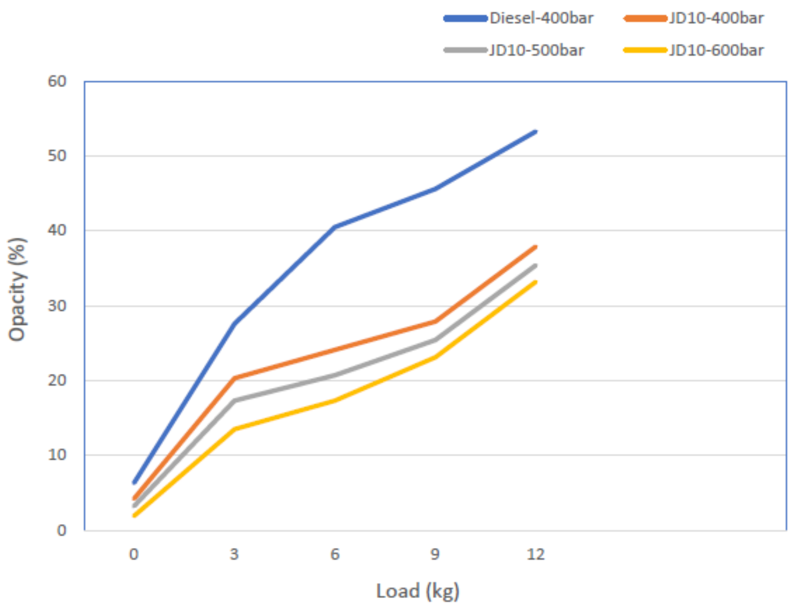

Fig 9 - Variation of Opacity

5. CONCLUSION

In the case of neat biofuel and its blend with diesel, the following are the main observations.

- The brake thermal efficiency is high with pure biofuel and it slightly reduces upon the addition of diesel. With the ideal B80D20 mix at 80% load, it falls from 32.4% to 31.8%.
- Due to early burning, clean biofuel has lower exhaust gas temperatures than diesel with an increase in the amount of diesel in the biofuel-diesel blend, the exhaust temperature rises.
- Because of the increased premixed combustion of neat biofuel compared to diesel, NOx emissions are particularly significant. When diesel and biofuel mixes, NOx emissions are only slightly reduced.
- Pure biofuel has been discovered to have very low UHC and CO emissions. Mixing of diesel and biofuel lead to a rise in UHC and CO emissions.

Jatropha oil can be directly utilised in a CRDi engine without making any changes to engine. It is very much better than conventional diesel fuel. The major points that are obtained by using this kind of alternate fuel blend are:

- By varying the injection pressures we could observe increase in the volumetric efficiency with better fuel consumption.
- There is a 33% decrease in frictional loss for JD10 blend at 600 bar when compared to diesel.
- BTE increases for JD10 blend at 600bar compared to other fuels at their respective injection pressures. BTE is increasing by a range of 3% for diesel (400bar) and 5% for JD10 (400bar).
- Opacity value for JD10 blend at 600 bar is 20% less than for diesel at 400 bar.
- Better atomization is found at 600 bar throughout the experiment.

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