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Investigation on a Twin Cylinder Diesel Engine using Jojoba oil methyl ester with Di-Methyl Carbonate

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Abstract: -- **Due to modernization, increase the number of industries and automobiles sector the consumption of petroleum products has increased which leads to fuel crises. It was estimated consumption of diesel fuels in India was 28.30 million tones, which is 43.2% of the consumption of petroleum products. This requirement was met by importing crude petroleum as well as petroleum products, with the expected growth rate of diesel consumption of more than 14% per annum, for this shrinking crude oil reserves and limited refining capacity, as per the research survey petroleum products may available another 30 to 50 years, it has made us think and focus on search alternate fuels for diesel fuel. Our main objective for this work is to use and run diesel engine by 100% vegetable fuels and decreases the dependency on fossil fuels. The main objective of this work investigates the performance and emission characteristics of a twin cylinder diesel engine is fuelled with non-edible vegetable oil such as jatropha jojoba biodiesel with Di-methyl carbonate as an additive and compared with diesel fuel. The experimental setup consists of a double cylinder, oil cooled, and four strokes constant speed diesel engine. The experimental engine started with diesel fuel and its performance and emission readings are taken and observed at various load condition, later the admission of jojoba oil make the engine run using dimethyl carbonate and conducting the same trail from zero loads to full load condition. Based on the performance and emission characteristics of jojoba biodiesel with additive it is concluded that it is a good alternative fuel with closer performance and good emission characteristic to that of diesel. From the results, it is concluded that Jojoba biodiesel shows better performance hence the Jojoba oil is best suitable alternatives for diesel.**

Index Terms - Diesel; Jojoba oil; Di-methyl Carbonate; Twin cylinder engine; Performance; Exhaust emissions

1. INTRODUCTION:

Due to widespread utilization of petroleum-based fuels in industry and automobile applications at the present time, issues like worldwide vitality emergency, natural contamination and worldwide warming. In this way, worldwide awareness has taken up to develop to keep the fuel emergency by delivering option fuel hotspots for motor application. Numerous exploration projects are committed to supplanting diesel fuel with a more attractive option like biodiesel. Non-consumable sources of oil like mahua, karanja, Jojoba, jatropha, and Simarouba are currently being examined for biodiesel generation. Unsaturated fats like stars, palmitic, oleic, linoleic and linolenic corrosive are regularly situated up in non-palatable oils [1]. Vegetable oils mixed with diesel in different proportions have been demonstrated by a number of analysts in different states. In developing nations like India, it is effectively conceivable to get these non-eatable vegetable oils, yet not monetarily feasible to persuade them to methyl esters experiencing diverse sorts of concoction methodology [2]. In this way, preheated oils mixed with diesel are utilized and used as another fuel option in motor vehicles. This study reports the results of tests performed on a diesel motor examining its operation and parameters relating to Jojoba biodiesel and an additive (dimethyl carbonate). The utilization of an additive as a part of a combination with biodiesel is aimed at improving ignition and reducing emissions.

1.1 Transesterification reaction

Transesterification is a reversible response in the middle of triglyceride and liquor in the heading of an impetus to create glycerol and monoalkyl ester, known as biodiesel [3]. The weight of monoalkyl ester is one third that of regular oil and hence has a thinner consistency. Antacid (NaOH, KOH), corrosive (H_2SO_4, HCL) or catalysts (lipase) catalyzed response. Corrosive catalyzed transesterification is a process generally utilized because it is reversible. In the transesterification process, methanol and ethanol are more regular. Methyl liquor is utilized most widely because of its ease of use and favorable physiochemical characteristics, with triglycerides and antacids broken down in it [4]. Studies have been done on various oils such as soybean, sunflower, jathropa, and Jojoba. Basically biodiesel is delivered by a base catalyzed transes terification procedure in vegetable oils and it is cheaper.

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2. MATERIALS

2.1 Jojoba seed as a source of biodiesel

Jojoba, native to India, is a member of the simmondsiaceae family. It is an evergreen plant with a lifespan of more than 200 years. It grows in both semiarid and sub humid areas. Jojoba is also found in tropical and subtropical conditions with a yearly mean temperature of 21–32°C[5]. The Jojoba plant can produce hundreds of large blooms. In one growing season, a mature plant can yield a huge number of seeds which yield 40–60% oil. Considering the base level of seed oil as 30%, annual Jojoba oil production could reach 30,000 tons. For most extreme oil generation, the dampness of the seeds is kept at a low sum. To guarantee nonstop seed availability, the capacity of the seeds is imperative since their accessibility is occasional[6]. The free fatty acid composition of Jojoba seed oil is shown in Table 1.

Table 1. Free fatty acid composition of Jojoba oil

Fatty Acid	Structure	Amount (%	Chemical Structure	Systematic name
Palmitic	16:0	14.8	CH3(CH2)14COOH	Hexadecanoic
Palmitoleic	16:1	0.10	C16H30O2	9-cis-Hexadecanoi
Stearic	18:0	20.6	CH3(CH2)16COOH	Octadecanoic
Oleic	18:1	43.8	CH3(CH2)7CH=CH(CH	Cis-9-Octadecanoi

2.2 Dimethyl carbonate

Dimethyl carbonate is a colorless, transparent liquid under normal temperatures. Its key properties are given in Table 2.

Table 2. Characteristic properties of Dimethyl carbonate.

Quantity	**Value**
Molar gas constant	8.314 KgJ/mol K
Molar mass	90.07 g.mol
Critical temperature	557 K
Critical pressure	4908.8 kPa
Critical density	4.0 dm^{-3}
Triple point temperature	277.06 K
Triple point pressure	2.2 kPa

2.3 Physicochemical properties of Jojoba biodiesel

Various biodiesel properties were investigated including kinematic viscosity, density, flashpoint, fire point, acid content, cold flow properties, and so on (see Table 3).

2.3.1 Kinematic viscosity

Kinematic viscosity is a measurement of fluid density over time. For biodiesel, viscosity is an important factor in regard to the fuel performance of the engine. ASTM D 445 is the preferred method of measuring viscosity [7]. The acceptable viscosity range of biodiesel, according to ASTM D 6751 is between 1.9 and 6.0 mm2.

2.3.2 Flashpoint

In terms of shipping and safety regulations, the flashpoint is generally used to define the flammable or combustible properties of biodiesel. It varies with fuel volatility. Biodiesel is classified as non-flammable if the flashpoint is above 130°C as specified in ASTM D 6751 indicating ASTM method D 93.

2.3.3 Pour point and cloud point

The pour point is the lowest temperature at which the fuel becomes semi-solid and loses its flow characteristics. It is always below the cloud point. Cloud point is the temperature at which crystallization of small, solid crystals starts when the fuel cools. ASTM D2500 and D 97 are utilized for measurement of pour point and cloud point.

2.3.4. Calorific value

Calorific value is an important property which represents the amount of heat transferred to the chamber during combustion and indicates the available energy in a fluid. The test method used for calorific value detection in biodiesel is ASTM D 240, using a bob calorimeter.

Table 3. Properties of Diesel, Jojoba oil & Jojoba oil methyl ester (JOME).

Properties	**Diesel**	**Jojoba oil oil**	**JOME**
Density (kg/m^3)	846.3	913.2	874
Kinematic Viscosity at 40 ^{0}C	3.64	37.3	4.11
Acid Value (mg KOH/ gm)	0.35	9	0.34
FFA (mg of KOH/ gm)	0.175	5.4	0.502
Pour point ^{0}C	-15	28.6	4
Flash point ^{0}C	55	261	173
Fire point ^{0}C	74	283	191
Calorific value (MJ/Kg)	42.72	37.54	38.86

2.4 Preparation of test fuel blends

Various test fuel blends were produced by blending Jojoba biodiesel with additives in various proportions by volume. In the present work B05, B10, B15, B100, and diesel fuel were used as the test fuels where B05 represents 95% biodiesel and 5% additive[8]. Similarly B10 and B15 represent 90% biodiesel with 10% additive and 85% biodiesel with 15% additive, respectively.

2.5 Engine testing

Testing was carried out on a single-cylinder, four-stroke, vertical water-cooled diesel engine equipped with an eddy current dynamometer, consisting of a U-tube manometer, graduate burette, and measuring jar, utilizing diesel and various blends like B05, B10, and B15 in single mode for different loads, i.e. 0, 2, 4, 6, 8, 10 KW. Detailed

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specifications of both engine and gasifier are tabulated in Table 4.

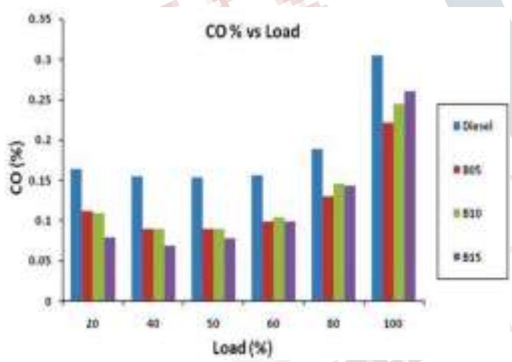
Table 4. Specification of Test engine

Make	Four stroke vertical water cooled DI diesel e
Rated horse power (HP)	14
No. of cylinders	2
No. of strokes	4
Rotation per minute (rpm)	1500
Compression ratio	16:1

3. RESULTS AND DISCUSSION

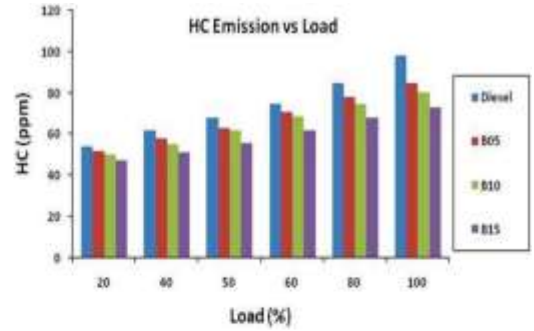
3.1 CO emission

CO emission depends solely upon the strength of the mixture, availability of oxygen, and viscosity of the fuel. From Figure 1 it is noted that CO emission initially decreased at lower loads then sharply increased after 80% loading for all tests. This is due to incomplete combustion under very high loads which results in higher CO emission[9]. CO emission was found to be highest for diesel and lowest for pure biodiesel in all tests. It was also determined that CO emission decreased with increase in the percentage of additives in the blends. B100 recorded the lowest carbon monoxide emission compared to all other test fuels up to 80% loading, and then increased due to incomplete burning[10].



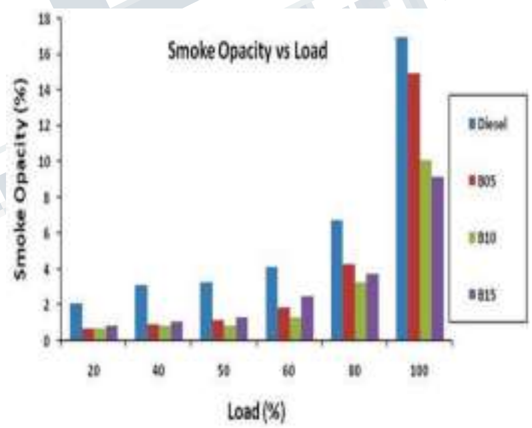
3.2 Hydrocarbon emission

Hydrocarbon emission solely depends upon the strength of the mixture, availability of oxygen, and viscosity of the fuel. Figure 2 shows that hydrocarbon emission increased with load for all test fuels. Increase in hydrocarbon emission was steep under 80% loading. This is again due to incomplete combustion at very high loads, which causes higher hydrocarbon emission [11]. It is also considered that hydrocarbon emission decreased with an increase in the additive percentage in biodiesel. B85 shows the lowest hydrocarbon emission under 80% loading, and then increased due to incomplete burning.



3.3 Smoke opacity

From Figure 3 it is observed that the smoke opacity for all test fuels almost linearly increased up to 80% loading and then increased very sharply, which is due to incomplete combustion and lack of oxygen under very high loading [9]. Peak smoke emission was observed for pure biodiesel and lowest for diesel, which is a result of the lower heating value and higher viscosity of biodiesel [12]. It was also determined that smoke emission decreased with increase in additive percentage in the biodiesel. B85 showed low smoke emission compared to the other test fuels up to 80% loading and then increased due to incomplete combustion and oxygen deficiency at higher loading[13].



4. CONCLUSIONS

From the present experimental investigation the following conclusions were drawn. CO and hydrocarbon emissions were found highest for diesel, but were reduced with an increase in the additive percentage in biodiesel. Smoke opacity was found highest for pure biodiesel but decreased with an increase in the additive percentage in biodiesel. Hence, it can be finally concluded that Jojoba biodiesel can successfully be utilized as an alternative fuel for present agricultural engines with minimal modifications.

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