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Combustion Characteristics of Rice Bran Oil Derived Biodiesel in a Single Cylinder Diesel Engine-A review

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ABSTRACT
Because of their low pollution levels and promise as a green alternative fuel for diesel engines, methyl esters of vegetable oils, often known as bio-diesel, are extremely popular. They don't necessitate any major changes to the present C.I. Engine. The transesterification process produces the methyl ester of rice brain oil. According to previous study, BSFC is lower in comparison to diesel. Co and Hc smoke emissions decreased, however NOx emissions increased. The combustion characteristics of a single cylinder C.I. engine using diesel and a 20% blend of rice bran methyl ester with diesel fuel were investigated in an experimental study.
Keywords: - Measurement of combustion pressure, rate of pressure rise, and other cylinder parameters such as instantaneous heat release rate and cumulative heat release rate.

I. INTRODUCTION

Depletion of petroleum reserves, rising vehicle populations, rising fuel prices, and concerns about petroleum accessibility, as well as strict emission standards and global warming due to carbon dioxide emissions, have compelled the development of alternative energy sources, which are becoming more important by the day. The hunt for an environmentally suitable alternative fuel has intensified. The energy density and cetane number of vegetable oils are equivalent to mineral diesel. Vegetable oils as a diesel engine fuel is not a novel concept. Although peanut oil and other vegetable oils were used for engine fuels when Rudolf Diesel originally built the diesel engine, they may become as vital as gasoline in the future.

Vegetable oils may be utilized in diesel engines either unaltered (called straight vegetable oil) or converted into biodiesel (called biodiesel). However, certain features of oils, such as high viscosity, high molecular weight, and low volatility, result in poor fuel atomization, resulting in difficulties such as severe engine deposits, injector coking, and piston ring sticking [2,3]. Biodiesel is made from trans esterified vegetable oil that has been chemically changed. Transesterification is a chemical process in which triglycerides in vegetable oils are transformed to mono alkyl esters of fatty acids (biodiesel) utilizing primary alcohols and a catalyst [4,5]. Figure 1 depicts the transesterification chemical scheme. The physical and chemical properties of crude vegetable oil can be determined.

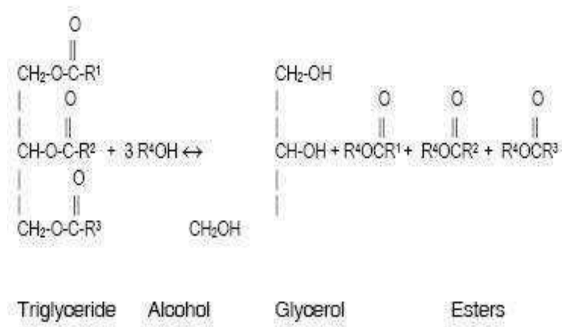

Fig.1: Transesterification Reaction.

Zhang et al [14] studied the combustion characteristics of a turbocharged direct injection diesel engine employing a blend of methyl, isopropyl, and winterized methyl ester of soybean oil as a fuel. Except for isopropyl ester, they discovered that all fuel mixtures exhibited comparable combustion behaviour. The ester/diesel blend has a shorter ignition delay than diesel as a fuel. Senator et al. [15] found that when using rapeseed oil as a fuel, methyl ester heat release occurs earlier than when using diesel, that injection begins earlier, and that the average cylinder gas temperature is higher when using biodiesel as a fuel. Mc Donald et al, [16], studied soy bean oil methyl ester as a fuel on a caterpillar in a direct injection diesel engine and discovered that overall combustion parameters were relatively similar to diesel fuel, with the exception of soy bean methyl ester having a shorter ignition delay. Kumar et al. [19] discovered that the ignition delay for Jatropha oil methyl ester was longer than the ignition delay for diesel as a fuel in a constant speed diesel engine. Selim et al [9] used a Ricardo compressions swirl diesel engine to test jojoba oil methyl ester (JME) as a fuel and discovered that the pressures and pressure rise rates for JME are very close to those for gas oil. JME, on the other hand, has a somewhat slower pressure rise rate than gas oil, and the combustion of jojoba oil methyl ester appears to be slightly delayed. Agarwal et al [7] discovered that a 20 percent linseed oil blend is the best blend for greatest thermal efficiency. In a previous investigation using rice bran oil on a single cylinder diesel engine, we observed similar results,[8].

Characteristics	Rice bran oil	Diesel	Rice bran oil Methyl ester	20% bio diesel blend (B20)
Specific gravity at 30^{o}C	0.928	0.839	0.877	0.847
Viscosity (cSt) at 40^{o}C	42	3.18	5.3	3.48
Flashpoint (^{o}C)	316	68	183	--
Fire point (^{o}C)	337	103	194	--
C:H:O(%)	74:11:12	82:13:1	73:13:11.6	--

Table1: Properties of the Fuels.

II. FUEL PREPARATION AND CHARACTERIZATION

Rice bran oil was trans esterified in the presence of a NaOH catalyst using methanol. Temperature, catalyst amount, molar ratio of alcohol to oil, and reaction temperature were all optimized, and it was discovered that a 9:1 molar ratio of alcohol to oil, 55 C temperature, 0.75 percent (w/w) catalyst, and a one-hour reaction time were the best for transesterification of rice bran oil [8]. Rice bran oil was heated in a round bottom flask for transesterification in the lab. In a separate vessel, NaOH was dissolved in methanol and poured into a round bottom flask while continually swirling the liquid. The mixture was swirled for about an hour while it was kept at 55 degrees Celsius. For around 24 hours, the reaction products were stored in a separating funnel. Rice bran oil methyl ester and glycerol were produced during transesterification. The glycerol that makes up the bottom layer was separated. The ester was rinsed with 10% v/v warm water (70 C) and maintained for about 24 hours to allow the catalyst dissolved water to settle out. The ester is then blended with mineral diesel at a rate of 20% by volume. Rice bran oil, rice bran oil methyl ester, and diesel were all characterized in the lab according to ASTM standards. Table 1 lists some of the features of several fuels.

III. EXPERIMENTAL SETUP

For engine testing, a single cylinder DI diesel engine (MDI 3000, Mahindra & Mahindra Ltd, India) was employed. The engine's parameters are listed in Table2.1.

Type of Engine	Four stroke, Naturally Aspirated, Water-Cooled Engine.
Number of Cylinders	Single Cylinder
Bore/Stroke(mm)	89.9/ 102.6
Displacement Vol. (cc)	2320
Compression Ratio	16 :1
Rated Power	42.4kWat 4000rpm
Max. Torque	155N-m at1550rpm

Table2: Specifications of the Engine.

Eddy current dynamometer was connected to the engine (Schenck Avery, India, model ASE 70). The dynamometer controller was used to control engine speed and load by adjusting excitation current to the eddy current dynamometer. Figure 2 depicts the experimental setup.

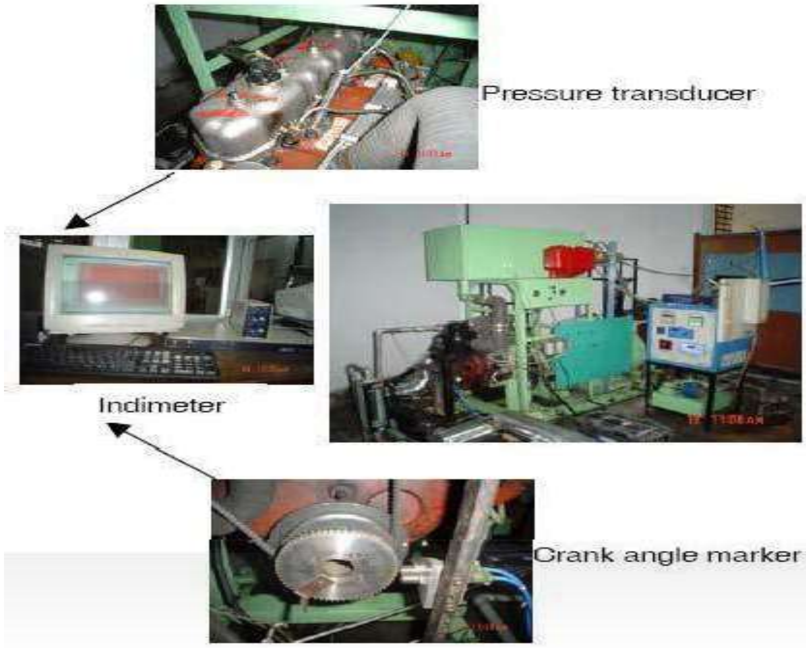

Fig.2: Experimental Setup.

The combustion pressure was measured using a piezoelectric pressure transducer (AVL, GU21C) mounted in the engine cylinder head. The pressure transducer's signals were routed into the charge amplifier. TDC and crank angle signals were provided via a high-precision magnetic shaft encoder. As illustrated in Fig.2, the signals from the charge amplifier and shaft encoder were sent into a high-speed data acquisition system (AVL, Indi meter-619).

Both B20 and mineral diesel were put through their paces at a constant speed of 700 rpm under five different engine load conditions: no load, 25%, 50%, 75%, and 100%. For the purpose of decreasing the effect of cyclic variation, cylinder pressure data was recorded for fifty consecutive cycles and then an average was taken. All of the tests were conducted with the engine running at a constant speed. The acquired data was compared to baseline data using diesel as a fuel.

IV. COMBUSTION PARAMETERS

During the premixed burning phase, i.e., the initial stage of combustion, cylinder pressure in a compression ignition engine is determined by the burned fuel fraction. The ability of a fuel to mix well with air and burn is measured by cylinder pressure. A significant volume of fuel consumed in the premixed combustion stage corresponds to a high peak pressure and maximum rate of pressure rise. For diesel and B20 fuel, the cylinder pressure crank angle history is obtained at various loads. These tests yield peak pressure and maximum rate of pressure rise under various loads.

Figures 3-5 depict the pressure-crank angle diagram for both fuels under various loads. These results show that peak pressure rises as the load rises, and that fuel combustion for B20 begins earlier than for mineral diesel.

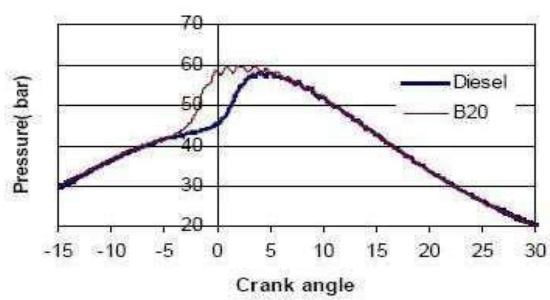

Fig.3: Pressure-Crank Angle Diagram at No load,600rpm.

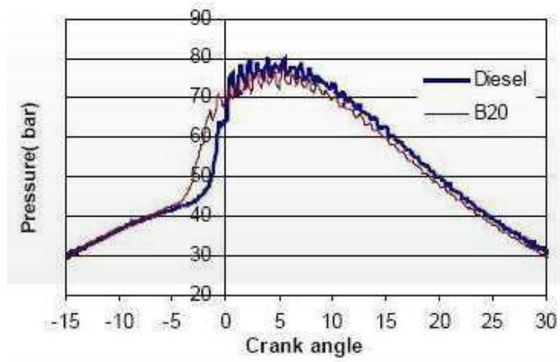

Fig.4: Pressure Crank Angle Diagram at 50% load,600rpm.

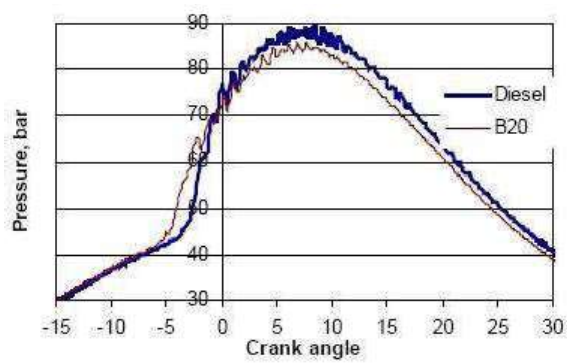

Fig.5: Pressure-Crank Angle Diagram at 100% Load,600rpm.

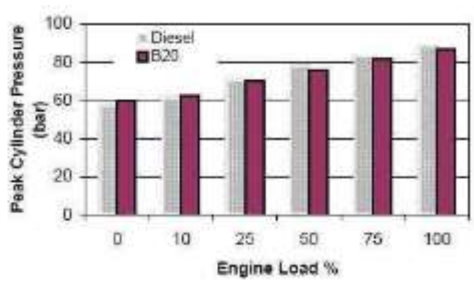

Fig.6: Variation of Peak Cylinder Pressure with Engine Load(at600rpm).

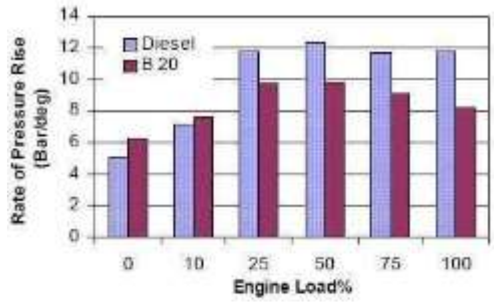

Fig.7: Variation of rate of pressure rise with Engine load(at600rpm).

Figures 6 and 7 indicate that peak pressure and rate of pressure rise for B20 gasoline are higher at low engine loads (up to 10% load), but decrease as the engine load increases. The difference in pressure, however, is not considerable.

The crank angle where the peak pressure occurs is shown in Fig. 8.

It indicates that at all loads, maximum pressure occurs between 2 and 7 crank angle degrees after top dead center for both fuels. At greater loads, pressure reaches its maximum a little later for B20, confirming that the rate of pressure rise is slower for B20.

Figure 9 depicts the crank angle at which 10% of the fuel mass is burnt. The biodiesel blend burns 10% of the fuel earlier, as shown in this graph. Figure 10 depicts the crank angle at which 90% of the fuel mass is burnt. This graph indicates that in the case of diesel, 90% of the fuel is consumed earlier, indicating a higher burn rate for mineral diesel. This observation backs with the findings in Fig.7. The delayed burning of the injected fuel causes an increase in combustion time. Due to an increase in the amount of fuel injected, the combustion duration for both fuels increase as the load increases.

The heat release rate diagrams for both fuels at half and full engine loads are shown in Figures 11 and 12. As is typical of naturally aspirated engines, both fuels experience quick premixed combustion followed by diffusion combustion. Following the ignition delay phase, the premixed fuel-air mixture burns quickly, releasing heat at a high rate, followed by diffusion combustion, with the burning rate controlled by the availability of combustible fuel-air mixture. By examining these pictures, it is clear that when an engine is fueled with B20, combustion begins sooner under all operating conditions, and B20 has a shorter ignition delay than mineral; diesel. Diesel has a larger premixed combustion heat release, which results in higher peak pressure and higher rates of pressure rise.

The cumulative heat release for both fuels at varied engine loads is shown in Figures 13-15. These diagrams confirm the biodiesel blend's early commencement of heat release. The cumulative heat release for biodiesel mix is likewise lower than for mineral diesel, probably due to the reduced calorific content of biodiesel blend.

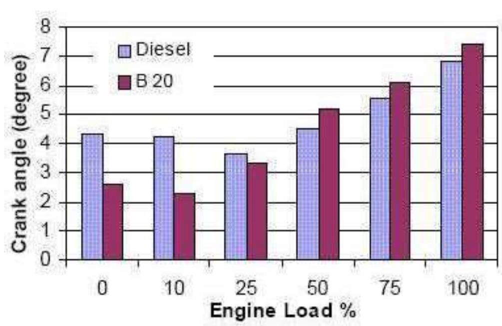

Fig.8: Crank Angle for Peak Cylinder Pressure.

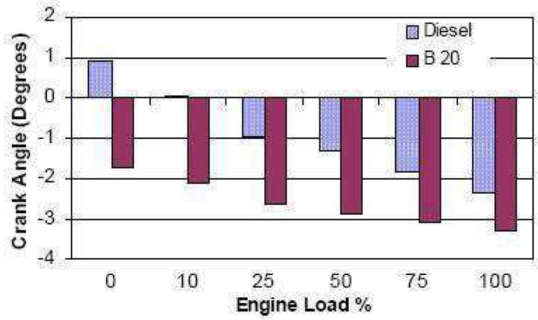

Fig.9: Crank Angle for 10% Mass Burn.

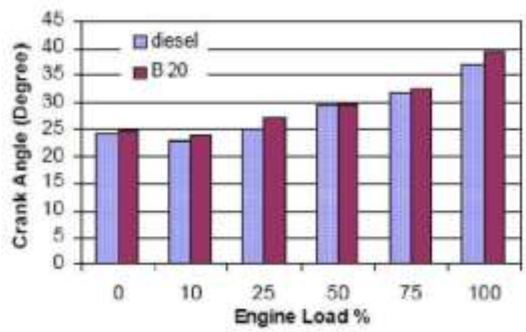

Fig.10: Crank Angle for 90% Mass Burn.

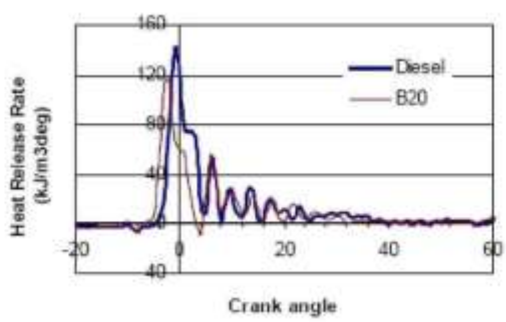

Fig.11: Heat Release Rate for 50% Engine Load, 600rpm.

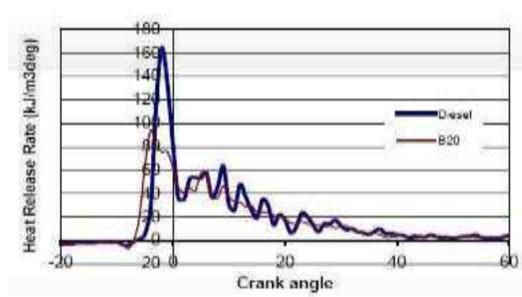

Fig.12: Heat Release Ratefor100%EngineLoad.

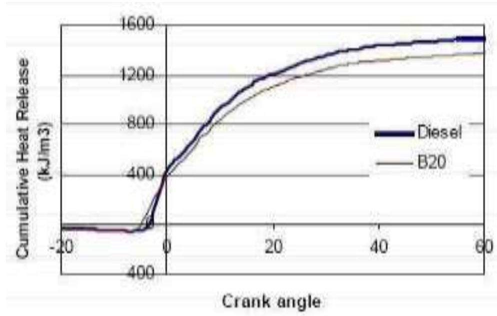

Fig.13: Cumulative Heat Release at 100% Engine Load.

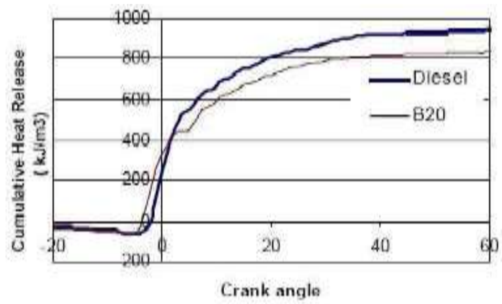

Fig.14: Cumulative Heat Release at 50% Engine Load.

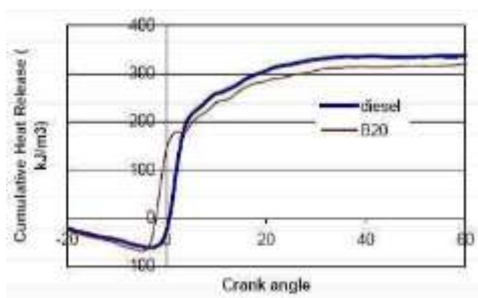

Fig.15: Cumulative Heat Release at 0% Engine Load.

V. CONCLUSIONS

Rigorous experimental research was carried out to determine the combustion properties of biodiesel mix (B20) against mineral diesel. Various combustion parameters were evaluated for different engine loads at a constant engine speed of 600 rpm in a single cylinder diesel engine, including pressure-crank angle diagram, peak pressures, crank angle for peak pressure, crank angle for 10% mass burn, crank angle for 90% mass burn, instantaneous heat release rate, cumulative heat release, and so on.

The overall combustion properties of biodiesel mix (B20) and mineral diesel were found to be very similar in the experiments. In the case of B20, however, combustion begins earlier. When compared to mineral diesel, B20 has a shorter ignition delay and a somewhat longer combustion duration. During the premixed combustion phase, B20 had a lower heat release rate than diesel.

In comparison to mineral diesel, the total heat released by B20 is smaller. There were no problems with fuel or combustion when a 20% blend of rice bran oil methyl ester was used. This extensive test indicates that biodiesel may replace mineral diesel in engines without requiring any engine modifications.

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