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Performance Analysis of Sesame Oil and Linseed Oil Biodiesel: A Relative Comparison

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ABSTRACT :

In the present research, the oils were trans-esterified using methanol and potassium hydroxide as catalysts resulting in methyl esters of sesame (Sesamum indicum) and linseed (Linum usitatissimum). Sesame and linseed oil blends, B20 and B20, respectively, have been investigated for performance via diesel fuel in a compression ignition diesel engine. Lower concentrations of the methyl ester blends B20 and B20 sesame oil and linseed oil optimize engine performance. Thus, linseed oil and sesame oil methyl ester are capable of being used as supplements in smaller doses.

Keywords - Linseed B20, Sesame B20, VCR, BMEP

Introduction:

The environment is significantly degrading day by
day and exhaustion of fossil fuels seems a near future. Aftereffects has led to increased interest in learning and exploring more sustainable, renewable energy.

Automobile sector is among the major contributor to climate change and significant reform is needed to change the current course. Creation of environmentally friendly blends is necessary to reduce emissions. Hence, reducing after-effects.

Sesame oil is produced from sesame seeds and is known for its super resistance to higher temperatures, minimal evaporation levels and antioxidant properties.

Similarly, Linseed oil, which is derived from flaxseed has exceptional combustion capabilities and low-emission parameters.

This experiment aimed at studying linseed & sesame methyl esters blends with diesel (B20) in CI engine. CRDI VCR engine was used in this experiment to test B20 blends of sesame and linseed methyl ester. Assessment of specific fuel consumption, braking thermal efficiency, volumetric efficiency, and mechanical efficiency were carried out.

The end point of this study was to analyse different performance aspects of sesame and linseed methyl ester with diesel (B20) blends in CI engine.

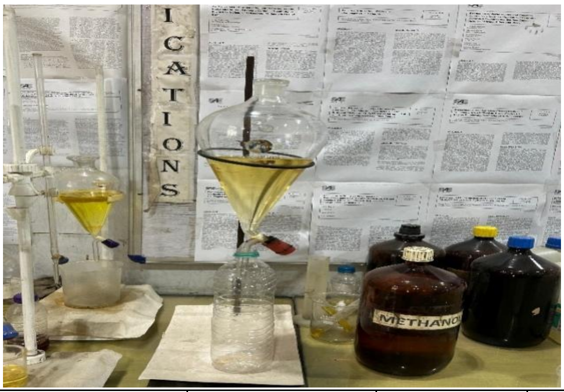
Sesame oil and linseed biodiesel have been blended with diesel fuel separately in order to develop B20 blends. subsequently, the blends were tested on a compression ignition (CI) engine, which was operated at a constant velocity while the load was systematically changed. The results of this test were analysed and results were made. Sesame oil and linseed oil both have properties that would make them perfect as fuel for vehicles. Triglycerides, which contribute to most of their composition, are precisely the same as in regular diesel fuel. Both linseed oil and sesame oil has proved to be capable in compression ignition (CI) engines without any modifications in the engine.

Experimental procedure:

To extract biodiesel, we originally collected linseed oil and sesame seed oil from the appropriate traders named Fragrance World, situated near Tilak Nagar, New Delhi and then we treated these oils for manufacturing biodiesel.

2.1 Manufacturing of Biodiesel

The supplier of the sesame and linseed oils was Fragrance World located near Tilak Nagar in New Delhi. Linseed and sesame oil were used to produce biodiesel via process known as transesterification. The transesterification process entailed separately combining linseed and Sesame raw oils with 20% (V/V) methanol and 0.5%(W/W) KOH. Subsequently, the mixture of oil and the catalysis (20% (V/V) methanol and 0.5% (W/W) KOH) was subjected to a temperature of 60°C for 4 to 5 hours at the same time stirred at a rate of 600 revolutions per minute on a Magnetic hot plate Stirrer. Once the reaction is finished, the resultant biodiesel was transported to the funnel to separate it from the glycerol. After 12 hours, the lower section of the funnel consists of glycerol and impurities, and the upper section consists of biodiesel. The glycerol-containing contaminants were eliminated. To create the fuel samples, a 20:80 combination of diesel and biodiesel was used. Four fuel samples were generated for this experiment: LND20, including 20% Linseed biodiesel and 80% Diesel, and SBD20, comprising 20% sesame biodiesel and 80% Diesel.



Properties	Diesel 100%	LBD 20%	SBD 20%
Density @20^0C [g/l]	830	848	852
Kinematic Viscosity @40^0C [mm^2/SEC]	3.24	3.67	3.48
Flash Point [^{0}C]	51	78	70
Calorific Value [KJ/Kg]	44,500	41,500	41,940
Cetane Number	49	52.5	49.5

Fig. Biodiesel Separation Setup

The ASTM Methods were used to determine the attributes of test fuel samples including Density, kinematic viscosity, flash point, calorific value and cetane number. The characteristics of the fuel samples are displayed in Table 1.

TABLE1. Properties of Fuel blends

2.2 Experimental equipment for engine performance

A comparative research study was done to assess the efficiency of B20 biodiesel blends of linseed and sesame oil. This was done to evaluate the effectiveness of that blend. For this experiment, a compression ignition (CI) engine with a single cylinder having four strokes with direct injection and air cooling was deployed.

The engine was subjected to a variety of loads by the utilization of a dynamometer. The compression ignition (CI) engine was ignited by using clean diesel fuel, and before it was started, it was given enough time to achieve its maximum operating temperature. This was done before the engine was started. Next, several parameters, such as speed, efficiency in fuel consumption, and the capacity to transport loads, were measured and characterized numerically. These parameters included the capacity to transport loads. The average value was determined by conducting five separate replicates for each reading to get an accurate result.

The aim of the research was to evaluate the engine's efficacy while maintaining a constant engine speed across various engine loads. This was accomplished by keeping the engine speed at 1500 revolutions per minute during the entire investigation. The goal of determining the velocity at which the greatest torque was achieved was successfully accomplished.

Engine Specification	**CRDI VCR**
No. of Cylinders	1
No. of Strokes	4
Diameter of cylinder	87.55mm
Length Stroke	110mm
Length of Connecting Rod	234mm
Diameter of Orifice	20mm
Arm Length of Dynamometer	185mm
Fuel	**Diesel**
Power produced	3.5kW
Speed of engine	1500RPM
Compression ratio	12:1 to 18:1

TABLE2. Main Characteristics of the Test Engine

2.3 CRDI VCR Engine Setup

Test setup includes a VCR Diesel engine (single cylinder, Four stroke) coupled to an eddy current dynamo-meter for loading. Tilting the cylinder blocks changes the compression ratio without stopping the engine or changing the geometry of the combustion chamber.

The test used constant fuel injection timing at 23 degrees BTDC. It is provided with measurement equipment for both the crank angle and the combustion pressure. Engine indicators are used to establish connections between signals and computers to create Pθ-PV diagrams. Measurement interfaces of air-fuel flow, temperatures and load are all included in this package. Components of Panel box includes fuel tank, manometer, air box, fuel measuring device, process indicator and an engine indicator and Rotameters feed water to cool the engine, whilst calorimeters measure the flow. The system enables analysis of CRDI VCR engine performance in several aspects such as Mechanical efficiency Volumetric efficiency, brake thermal efficiency, Indicated thermal efficiency, Air fuel ratio, specific fuel consumption (SFC), IMEP (indicated mean effective pressure), BMEP (brake mean effective pressure). Based on Labview Engine Performance Analysis software "ICEnginesoft_9.0" evaluates online performance. Computerized Diesel injection pressure can be measured. Table 2 displays engine specs and Fig. 1 illustrates the test setup. This experiment used a setup consisting of four-stroke with water-cooled and naturally aspirated engine. Commercial engine with dynamo-meter. AG series eddy current dynamo-meter tested engines up to 3.5 kW. Bidirectional dynamo-meter. Shaft-mounted finger rotors run in dry gaps. Closed-circuit cooling allows a sump. A 360 PPR rotary encoder was installed on a shaft to monitor speed, while a strain gauge load cell was installed to measure the dynamo-meter stress.

To test engine performance at a 17.50 compression ratio, the load was changed. Diesel engine fuel was tested first, then Linseed and Sesame biodiesels. Every time the fuel tank and line were entirely drained, the engine was run for 5–10 minutes to get additional fuel. For steady-state readings, oil temperature must stay consistent for at least five minutes.

Fig. CRDI VCR Engine Setup

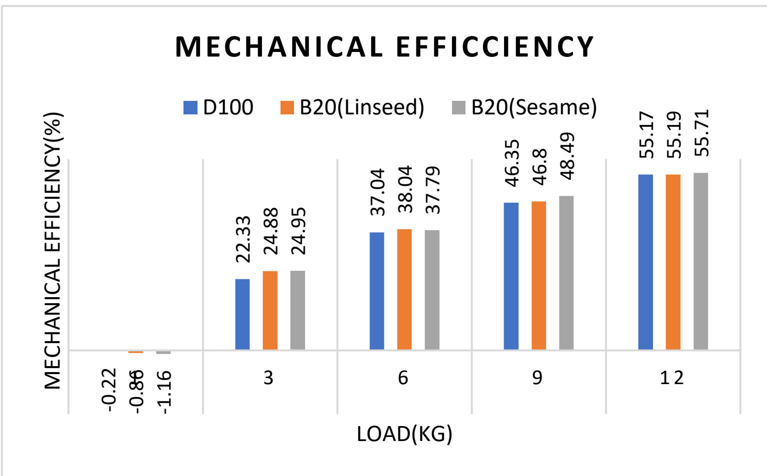
Results and Discussions

3.1 The potential of Linseed B20 and Sesame B20

The properties of Diesel fuel, Linseed oil methyl ester, and Sesame oil methyl ester are in acceptable ranges as given in Table 1.

3.2 Engine Performances

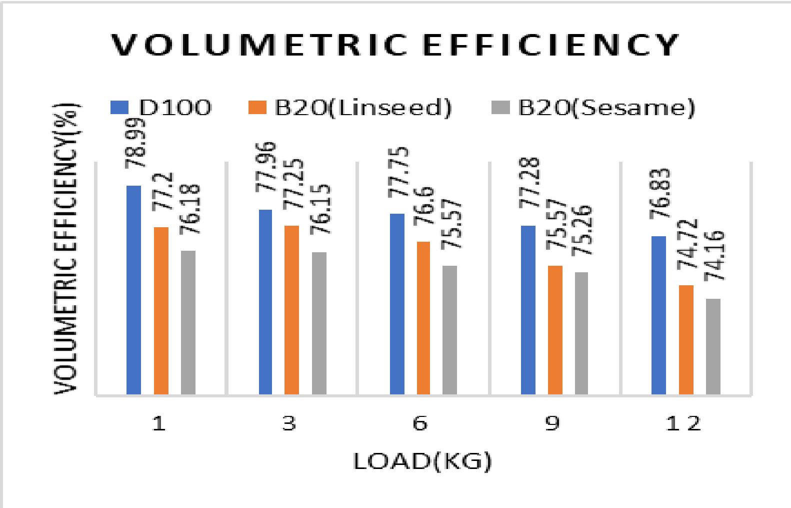
3.2.1 Mechanical Efficiency



Variation of Mechanical Efficiency to Load

Mechanical efficiency is the ratio of braking power delivered to the crankshaft to indicated power in an engine's combustion chamber.
It is always less than one. The graph shows that if we increase the load at constant speed the mechanical efficiency also get increases. With the increase in biodiesel concentration relative to diesel concentration the mechanical efficiency was found to increase. This is because that B20 (sesame oil) has higher mechanical efficiency due to the enhanced lubricity properties of biodiesel against diesel.

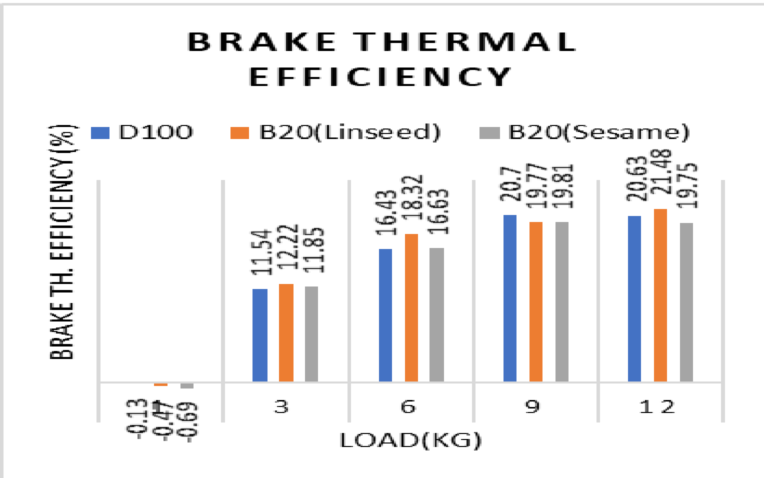
3.2.2 Volumetric efficiency



Variation of Volumetric Efficiency to Load

Volumetric efficiency refers to the proportion of air sucked into the cylinder compared to the total volume of the cylinder filled in each cycle.
By increasing the air intake, a higher quantity of fuel may be combusted, leading to a more substantial conversion of energy into power output. The optimal mass of air consumed during each cycle of an engine is determined by multiplying the swept volume of the cylinder to the density of atmospheric air. Volumetric efficiency is a parameter used to evaluate how well an engine's intake system works. The calculation involves dividing the volume flow rate of air which enters the engine intake system by the rate at which the piston displaces volume (Heywood 2012). The results demonstrated the volumetric efficiency of Diesel greater then the biodiesel blends. The graph shows that as increase in load causes the volumetric efficiency to decreased due to the change in air-to-fuel ratio.

3.2.3 Break Thermal Efficiency



Variation of Brake Thermal Efficiency to Load

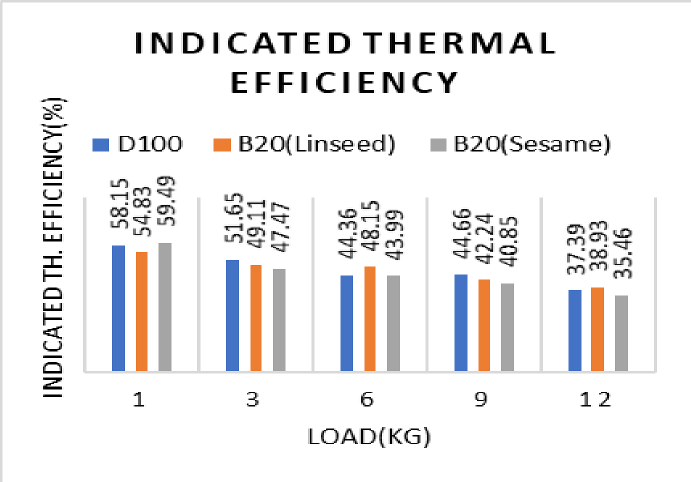
The braking thermal efficiency measures the percentage of total power produced by fuel combustion that is efficiently utilized by the engine crankshafts. Heat is a measurement used to quantify the fuel efficiency of internal combustion engines and brake thermal efficiency is similarly associated to the production of heat. with increase in brake thermal efficiency, fuel consumption is decreased dramatically.

The Brake Thermal Efficiency (BTE) of diesel and biodiesel blends was assessed at different engine loads while engine speed maintained at 1500 rpm.

The BTE's (brake thermal efficiency) performance fluctuates on the engine's individual design and the fuel types utilized. Biodiesel has higher oxygen concentration in comparison to diesel. Higher oxygen concentrations help fuel burn completely in the combustion chamber. Complete combustion leads to greater liberation of thermal energy. Linseed and sesame seed biodiesel have a lower calorific value compared to diesel. According to the study it was found that regardless of injection pressure, the engine demonstrated higher brake thermal efficiency when fueled with different B20 biodiesel blends than that of using diesel fuel.

Notably, the B20 blend of Linseed demonstrated the most promising results among all the blends. The graph shows that the Brake Thermal Efficiency gets increased by increasing the load. Specifically, the B20 Linseed has the greatest BTE, followed by diesel, and then B20 sesame seed.

3.2.4 Indicated Thermal Efficiency

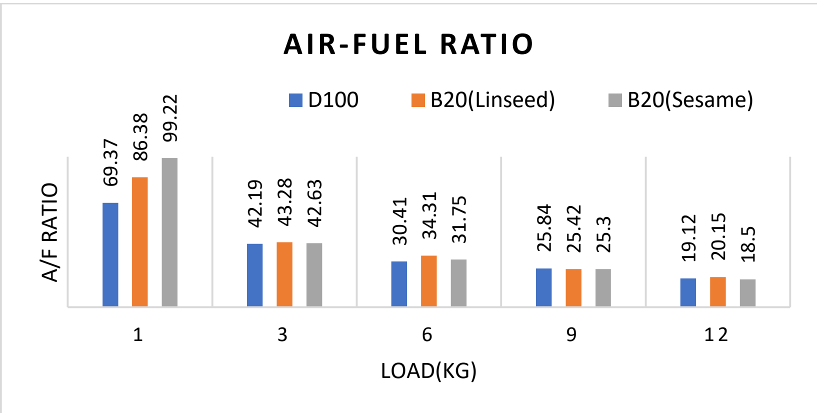


Variation of Indicated Thermal Efficiency to Load

Variation of indicated thermal efficiency to load

It is denoted as Fuel conversion efficiency is another name for thermal efficiency. This is defined as the ratio of the amount of work done per cycle to the amount of fuel energy available per cycle for burning. Thermal efficiency is sometimes referred to as fuel conversion efficiency. The graph displays the values of the stated thermal efficiency across the various loads that are being applied. A maximum suggested thermal efficiency of up to 1 kg is provided by B20 sesame seed oil, while the lowest indicated thermal efficiency is provided by B20 sesame seed oil, which does not exceed 12 kg.

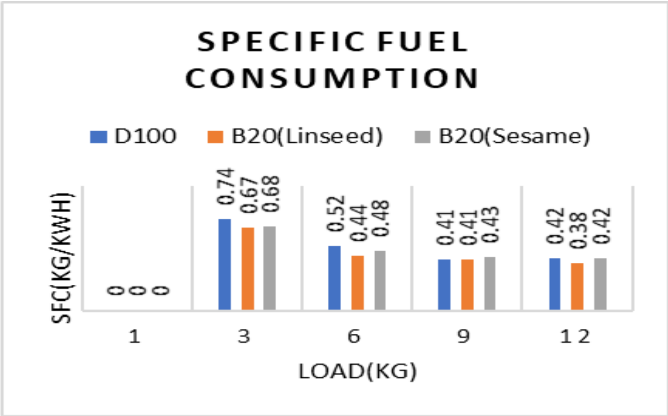
3.2.5 Air-Fuel Ratio



Variation of Air-Fuel Ratio to Load

According to Heywood (2012), the phrase "air-fuel ratio" refers to the ratio that exists between the mass flow rate of air to that of mass flow rate of fuel in the combustion chamber. A drop in the air-to-fuel ratio occurs when the load is increased because a greater quantity of fuel is required. When we compare the air-fuel ratio of the diesel with bio-diesel blends, we found that biodiesel higher air-to-fuel ratio than diesel does. The air-to-fuel ratio of Linseed B20 is the greatest among all of the other fuels that were tested and put through their paces. One possible explanation for this is that biodiesel has a higher volumetric efficiency than diesel.

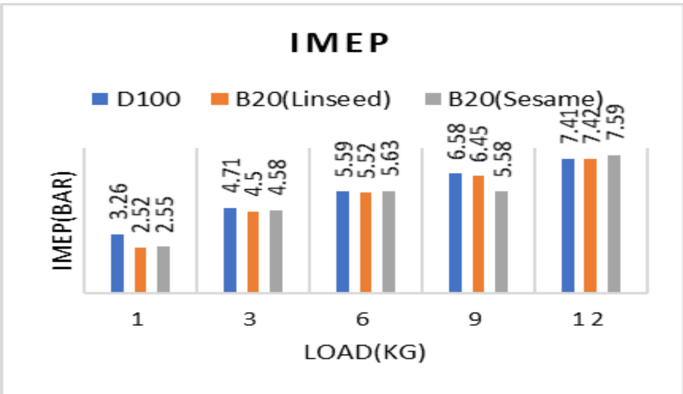
3.2.6 Specific Fuel Consumption



Variation of Specific Fuel Consumption to Load

Several fuel blends are examined to establish the correlation between specific fuel consumption and load. The data indicate that the specific fuel consumption (SFC) reached its maximum value at a power level of 0.74 kW, and then reduced as the load increased. Linseed B20, on the other hand, has a lower Specific Fuel Consumption (SFC) when compared to Sesame B20 and Diesel. When operating at its maximum capacity, the D100 displayed outstanding performance in terms of the particular fuel consumption it consumed.

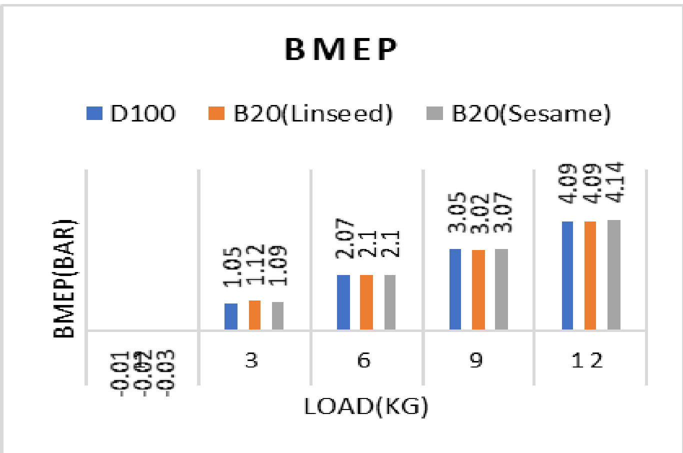
3.2.7 Indicated Mean Effective Pressure



Variation of IMEP to Load

The average pressure produced in the combustion chamber during the working cycle is known as the indicated mean effective pressure (IMEP). The IMEP equals the sum of the two variables obtained by adding the friction-effective pressure and the break-mean effective pressure. A graph is used to plot the fluctuations of IMEP to load for various blends of biodiesel under a variety of loading. Linseed B20 has the lowest indicated mean effective pressure, and it appears to be the best blend with the lowest frictional power. On the other hand, B20 which consists of diesel and sesame seed oil has the highest indicated mean effective pressure.

3.2.8 Brake Mean Effective Pressure



Variation of BMEP to Load

The Brake Mean Effective Pressure are also known as BMEP and It is defined as the average uniform pressure exerted to the piston from top to bottom dead center.

As engine load increases, BMEP also increases due to the efficiency of the fuel conversion process.

The reason for this is that the BMEP rises as the load for the fuels that were tested is increased. It was discovered that the BMEP was lower in the diesel than it was in linseed oil, sesame seed oil and diesel.

Conclusion

The performance of an engine relies heavily on three factors; brake efficiency and mechanical efficiency. With increase in the percentage of the biodiesel in the fuel mixture, it enhances the mechanical efficiency because it possess higher oxygen concentration. The blended biodiesel fuels burn cleaner and generate higher thermal energy compared to diesel. The brake mechanical efficiency of all B20 Linseed Biodiesel Blend is the best among them. While the sesame seed oil blend has the higher thermal efficiency and diesel has the lowest among them.

Furthermore, the performance of biodiesel blends is influenced by the air-fuel ratio, which is the ratio of air to fuel flow in an engine. The higher air-to-fuel ratio of Linseed B20 at higher loads was a result of the biodiesel's energy efficiency.

Among all the biodiesel blends and diesel fuels, Linseed B20 has the lowest specific fuel consumption (SFC), consuming approximately 0.74 kW. Regardless, Linseed B20 has a lower IMEP than Sesame B20 and Diesel.

Linseed biodiesel blend showed slightly lower brake mean effective pressure (BMEP) as compared to diesel and sesame biodiesel blends. This investigation clearly showed the significance of determining the difference in parameters of the performance of biodiesel blends. The compressed ignition engines can efficiently utilize a blend of diesel with linseed oil methyl ester or sesame oil methyl ester that is containing twenty percent linseed or sesame seed methyl ester and eighty percent diesel, without making any modifications to the compressed ignition engine. Apart from all this, there are certain possible environmental advantages. Adding the methyl ester of sesame and linseed oils to diesel fuel as additives can also boost the agricultural sector's profitability and reduce fuel dependence on the foreign countries.

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