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Investigation on the performance and emission characteristics of diesel engine with the blends of mustard oil, grape seed oil & sesame oil

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Abstract
This paper presents the experimental results on Performance and Emission Characteristics of Diesel Engine with different blends of Diesel Fuels on an Unmodified Diesel Engine. The tests were conducted with total of Six Blends. B15, B30, B45 are the three blends that have been tested. Load tests were conducted using Petroleum Diesel and Biodiesel Blends on Kirloskar Single Cylinder 4-Stroke Diesel Engine. During load tests, the engine performance and oil sample analysis are conducted. The experimental results indicate that the engine can be safely operated with Blends of Grape Seed Oil, Sesame Oil and Mustard Oil varies as 50-50-900 ml, 100-100-800 ml, without significant changes in the Engine Power, Fuel Economy and Lubricating Oil Properties. However due to lower calorific value of Bio Diesel, the Engines operated with Bio Diesel blend developed lower output. Therefore, it is necessary to use optimum blend of Biodiesel to minimize the reduction in power output. Earlier studies have been limited to power output an Emissions only. The effect of Bio Diesel blends on Engine Performance but also on the engine lubricant. This report presents the results of load tests conducted on Single Cylinder Diesel Engine using Petroleum Diesel and Bio Diesel blends with Grape Seed, Sesame, Mustard Oil varies as 50-50-900 ml and 100-100-800 ml with the same quantity of engine oil in the tests. The Performance of Kirloskar Single Cylinder Diesel Engine by varying the Mustard Oil, Grape Seed Oil and Sesame Oil as B10, B20, B10(2) and calculate the different characteristic parameters were estimated and concluded that the efficiency of the engine is increased for some blends. The brake power of the B10 (2) blends is higher in 15% of load condition. In 30 % load conditions blends show better output than diesel. The mechanical efficiency of the B 10 (2) blend is superior to all other blends and diesel. And even the emissions are also very good comparing to other blends and diesel. So, the diesel blend B 10 (2) can be used as fuel along with diesel. B 10(2) is a blend of sesame oil and mustard oil and along with this other blends are also be used for some extent. The CO emitted is very less in diesel than any other blends but oxygen content is high in blends so as blending increases the Nox emission reduced by considerable amount. The amount of HC released is negligible in all cases of blends and diesel.

Keywords: diesel engine, bio diesel blends, transesterification, grape seed, sesame, mustard oil, performance & emission

1. Introduction
There is ongoing research into finding more suitable crops and improving oil yield. Bio fuels defined by the ASTM international (formerly known as the American Society for Testing and Material), is a fuel blend stock comprised of long chain fatty acids derived from vegetable oil, recycled cooking grease or animal fats, and contain only one alcohol molecule on one ester linkage. The bio fuel mainly consist of blends derived from mustard oil, grape seed oil and mustard oil, sesame oil separately with diesel oil in the required proportions. The proportions are B10, B20 and B10 respectively for the above combinations with diesel. The B10 indicates 10% of blending oil with 90% of diesel and B20 indicates 20% of blending oil with 80% diesel. The majority of these oils is found in India. Modernization and increase in the number of automobiles worldwide, the consumption of diesel and gasoline has enormously increased. As petroleum is non- renewable source of energy and the petroleum reserves are scarce now days, there is a need to search for alternative fuels for automobiles. The intensive search for alternative fuels for compression ignition engines has been focused attention on fuels which can be derived from blending of diesel. Diesel Engines are the most efficient prime movers. From the point of view of protecting global environment and concerns for long-term energy security, it becomes necessary to develop alternative fuels with properties comparable to petroleum based fuels. A. Serdari K. Fragioudakis (2000) [1] *et al.* were experimented the substitution of' mineral diesel with biodiesels produced from sunflower oil. Corn oil, olive oil and used frying oils leads to a combination of positive and negative outcomes. The four types of biodiesel examined performed in a similar way; they clearly decreased particulate matter emissions, and resulted in a limited change of nitrogen oxide emissions and slightly increased the volumetric fuel consumption. e cases where the biodiesel blends had a negative or neutral effect on NOx emissions. D. Rachel Evangelene Tulip (2013) [2] *et al.* were investigated. Mustard oil was analyzed for physical and chemical properties. Composition of mustard oil was determined by the gas chromatography. Mustard biodiesel was produced by transesterification process and further, physical and chemical properties were analyzed. The present experimental results were obtained on the performance and the emissions of CO, HC, CO2, O2and NOX by an Internal Combustion Engine (ICE). Comparison of mustard biodiesel blends (B20, B40 and B60) with engine diesel was done. Smoke, temperature and pressure of the ICE was determined on using mustard biodiesel blends with the current load (A), given at 0A, 4A, 8A, 12A and 16A. CO emissions are slightly less, HC emissions were

significantly reduced than the diesel emission, CO2 emissions were slightly less when compared to diesel. However, NOx emissions of the blends were found to be increased significantly than diesel as blend ratio increased. Smoke emission was found to be reduced slightly when compared to diesel. P.K. Devan (2008) [3] *et al.* experimental tests have been carried out to evaluate the performance, emission and combustion characteristics of a diesel engine using Neat Poon oil and its blends of 20%, 40%, and 60%, and standard diesel fuel separately. The common problems posed when using vegetable oil in a compression ignition engine are poor atomization; carbon deposits, ring sticking, etc. This is because of the high viscosity and low volatility of vegetable oil. When blended with diesel, Poon oil presented lower viscosity, improved volatility, better combustion and less carbon deposit. It was found that there was a reduction in NOx emission for Neat Poon oil and its diesel blends along with a marginal increase in HC and CO emissions. Brake thermal efficiency was slightly lower for Neat poon oil and its diesel blends. From the combustion analysis, it was found that Poon oil–diesel blends performed better than Neat poon oil. Hanbey Hazar (2010) [4] *et al.* Many studies are still being carried out to find out surplus information about how vegetable based oils can efficiently be used in compression ignition engines. Raw rapeseed oil (RRO) was used as blended with diesel fuel (DF) by 50% oil–50% diesel fuel in volume (O50) also as blended with diesel fuel by 20% oil–80% diesel fuel in volume (O20). The test fuels were used in a single cylinder, four stroke, naturally aspirated, direct injection compression ignition engine. The effects of fuel preheating to 100-C on the engine performance and emission characteristics of a CI engine fuelled with rapeseed oil diesel blends were clarified. Results showed that preheating of RRO was lowered RRO’s viscosity and provided smooth fuel flow Heating is necessary for smooth flow and to avoid fuel filter clogging. It can be achieved by heating RRO to 100 -C. It can also be concluded that preheating of the fuel have some positive effects on engine performance and emissions when operating with vegetable oil. Murat Karabektas (2009) [5] *et al.* were investigated the suitability of isobutanol–diesel fuel blends as an alternative fuel for the diesel engine, and experimentally determine their effects on the engine performance and exhaust emissions, namely break power, break specific fuel consumption (BSFC), break thermal efficiency (BTE) and emissions of CO, HC and NOx. For this purpose, four different isobutanol–diesel fuel blends containing 5, 10, 15 and 20% isobutanol were prepared in volume basis and tested in a naturally aspirated four stroke direct injection diesel engine at full -load conditions at the speeds between 1200 and 2800 rpm with intervals of 200 rpm. The results obtained with the blends were compared to those with the diesel fuel as baseline. The test results indicate that the break power slightly decreases with the blends containing up to 10% isobutanol, whereas it significantly decreases with the blends containing 15 and 20% isobutanol. There is an increase in the BSFC in proportional to the isobutanol content in the blends. Although diesel fuel yields the highest BTE, the blend containing 10% isobutanol results in a slight improvement in BTE at high engine speeds. The results also reveal that, compared to diesel. Herchel T. C. Machacon (2001) [6] *et al.* were studied the ejects of pure coconut oil and coconut oil diesel fuel blends on the performance and emissions of a direct injection diesel engine. Operation of the test engine with pure coconut oil and coconut oil diesel fuel blends for a wide range of engine load conditions was shown to be successful even without engine modifications. It was also shown that increasing the amount of coconut oil in the coconut oil diesel fuel blend resulted in lower smoke and NOx emissions. However, this resulted in an increase in the BSFC. This was attributed to the lower heating value of neat coconut oil fuel compared to diesel fuel. T. Elango (2011) [7] *et al.* were investigated performance and emission characteristics of a diesel engine which is fuelled with different blends of jatropha oil and diesel (10-50%). A single cylinder four stroke diesel engine was used for the experiments at various loads and speed of 1500 rpm. An AVL 5 gas analyzer and a smoke meter were used for the measurements of exhaust gas emissions. Engine performance (specific fuel consumption SFC, brake thermal efficiency, and exhaust gas temperature) and emissions (HC, CO, CO2, NOx and Smoke Opacity) were measured to evaluate and compute the behaviour of the diesel engine running on biodiesel. The results showed that the brake thermal efficiency of diesel is higher at all loads. Among the blends maximum brake thermal efficiency and minimum specific fuel consumption were found for blends up to 20% Jatropha oil. The specific fuel consumption of the blend having 20% Jatropha oil and 80% diesel (B20) was found to be comparable with the conventional diesel. The optimum blend is found to be B20 as the CO2 emissions were lesser than diesel while decrease in brake thermal Efficiency is marginal. Aman Hira (2012) [8] *et al.* were experimentally investigated the performance and emissions of C.I engine. Due to exponential growth in industrialization the demand for conventional automotive fuels is also increased sharply which adversely affects not only the economy but also the environment. This makes the search for an alternative fuel more important today. In this research the blends of ethanol & biodiesel with diesel in varying proportions are used. The performance& emission levels has been investigated under the various parameters like Brake Thermal efficiency, BSFC, BSEC, Smoke density, HC, CO & exhaust temperature. The experimental results show that the BE20 fuel gives the best performance in comparison to conventional diesel fuel along with fairly reduced exhaust emission. Mohamed Shehatta (2011) [9] *et al.* Experimental study has been carried out to investigate performance parameters, emissions, cylinder pressure, exhaust gas temperature and engine wall temperatures for direct injection diesel engine. Tests were conducted for sunflower oil (S100) and 20% jojoba oil + 80% pure diesel fuel (B20) in comparison to pure diesel fuel with different engine speeds. S100 and B20 were selected for the study because of its being widely used in Egypt and in the world. Also, series of tests are conducted at same previous conditions with different percentage of exhaust gas recirculation (EGR) from 0% to 12% of inlet mass of air fresh charge. Results indicate that S100 or B20 gives lower brake thermal efficiency (gB), brake power (BP), brake mean effective pressure (BMEP), and higher brake specific fuel consumption (BSFC) due to lower heating value compared to pure diesel fuel. S100 or B20 gives lower NOX concentration due to lower gas temperature. Siddharth Jain (2009) [10] *et al.* were indicated that up to B20, there is no need of modification and little work is available related to suitability and sustainability of biodiesel production from

Jatropha as non-edible oil sources. In addition, the use of vegetable oil as fuel is less polluting than petroleum fuels. The basic problem with biodiesel is that it is more prone to oxidation resulting in the increase in viscosity of biodiesel with respect to time which in turn leads to piston sticking, gum formation and fuel atomization problems. The report is an attempt to present the prevailing fossil fuel scenario with respect to petroleum diesel, fuel properties of biodiesel resources for biodiesel production, processes for its production, purification, etc. Lastly, an introduction of stability of biodiesel will also be presented. Jalpit B. Prajapati (2014) [11] *et al.* exposed the environmental concern and availability of petroleum fuels have caused interest in the search for alternative fuels for internal combustion engine. Experiments will performed for fixed compression ratio i.e. 18 using biodiesel diesel blends i.e. B0, B10, B20, B30, with load variation from no load to full load and compared with base cases i.e. engine using diesel as a fuel. The parameters which will study in performance brake power, brake specific fuel consumption and brake thermal efficiency, In emission carbon monoxide, unburnt hydrocarbons, nitrogen oxide. As per the literature survey B20 (20%biodiesel and 80% diesel) is best in performance compare to other blends. But NOx formation is also little higher in B20. Herchel T.C. Machacon (2000) [12] *et al.* were revealed that the ejects of pure coconut oil and coconut oil diesel fuel blends on the performance and emissions of a direct injection diesel engine. Operation of the test engine with pure coconut oil and diesel fuel blends for a wide range of engine load conditions was shown to be successful even without engine medications. It was also shown that increasing the amount of coconut oil in the diesel fuel blend resulted in lower smoke and NOx emissions. However, this resulted in an increase in the BSFC. This was attributed to the lower heating value of neat coconut oil fuel compared to diesel fuel.

2. Manufacturing Process

A lot of research work has been carried out to use vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable. The high viscosity of vegetable oils and the low volatility affect the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking. The methods used to reduce the viscosity are 1) Blending with Diesel 2) Emulsification 3) Pyrolysis 4) Transesterification**.** Among these, the Transesterification is commonly used commercial process to produce clean and environmental friendly fuel. However, this adds extra cost of processing because of the transesterification reaction involving chemical and process heat inputs. Transesterification involves reaction of the triglycerides of Atrophy oil with methyl alcohol in the presence of a catalyst Sodium Hydroxide (NaOH) to produce glycerol and fatty acid ester.

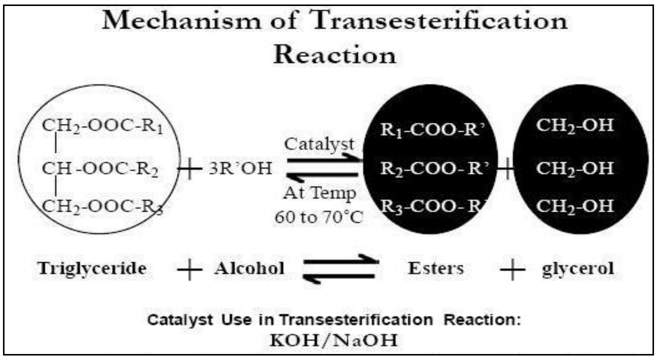

Fig 1

The production of biodiesel by transesterification of the oil generally occurs using the following steps:1. Mixing of Alcohol and Catalyst-For this process, a specified amount of alcohol (e.g. methanol) and Sodium Hydroxide (NaOH) is mixed in a round bottom flask.2. Reaction-The alcohol-catalyst mix is then charged into a closed reaction vessel and Jatropha oil is added. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters.3. Separation of Glycerin and Biodiesel-Once the reaction is complete, two major products exist: glycerin and biodiesel. The quantity of produced glycerin varies according to the oil used, the process used, the amount of excess alcohol used. Both the glycerin and biodiesel products have a substantial amount of the excess alcohol that was used in the reaction. The reacted mixture is sometimes neutralized at this step if needed.4. Alcohol Removal.5. Glycerin Neutralization-The glycerin by-product contains unused catalyst and soaps that are neutralized with an acid and sent to storage as crude glycerin. In some cases, the salt formed during this phase is recovered for use as fertilizer. In most cases the salt is left in the glycerin.6. Methyl Ester Wash-The most important aspects of biodiesel production to ensure trouble free operation in diesel engines are complete reaction, removal of glycerin, removal of catalyst, removal of alcohol and absence of free fatty acids.

3. Technical Specifications

- All engines are designed and manufactured for a fuel that has certain characteristics. In the US, the industry organization that defines the consensus on fuels is the American Society for Testing and Materials (ASTM). In the case of diesel fuel (and biodiesel), the responsibility for setting standards lies within ASTM Committee D02 on Petroleum Products and Lubricants.
- ASTM fuel standards are the minimum accepted values for properties of the fuel to provide adequate customer satisfaction and/or protection. For diesel fuel, the ASTM standard is ASTM D 975. All engine and fuel injection manufacturers design their engines around ASTM D 975.
- In December of 2001, ASTM approved the full standard for biodiesel, with the new designation of D-6751

(succeeds PS 121-99). This standard covers pure biodiesel (B100), for blending with petro-diesel in levels up to 20% by volume. Higher levels of biodiesel are allowed on a case-by-case basis after discussion with the individual engine company, since most of the experience in the US thus far has been with B20 blends.

- EN 14214 is a European Standard that describes the requirements and test methods for FAME - the most common type of biodiesel Blends are designated as "B" followed by a number indicating the Percentage Biodiesel. For example: B100 is Pure Biodiesel. B99 is 99% Biodiesel, 1% Petro-Diesel. B20 is 20% Biodiesel and 80% fossil diesel.

4. Use in Diesel Engines

Additives are abundantly manufactured and mixed with IC engine fuels to meet the proper performance of fuel in engine. Additives act like catalyst so that they aid combustion, control emission, control fuel quality during distribution and storage and reduce refiners operating cost.The performance of diesel engine using diesel additive and methyl-ester of Jatropha oil as the fuel was evaluated for its performance and exhaust emissions. The fuel properties of biodiesel such as kinematic viscosity, calorific value, flash point, carbon residue and specific gravity were found. Results indicated that B25 have closer performance to diesel and B100 had lower brake thermal efficiency mainly due to its high viscosity compared to diesel. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuels efficiencies. Its diesel blends showed reasonable efficiencies, lower smoke, CO2 and CO. Multi-DM-32 additives with methyl ester of Jatropha offer fuel conservation as well as reduce pollution.

Mustard Oil

This oil has a distinctive pungent taste, characteristic of all plants in the mustard (Brassicaceae)family(for example, cabbage, cauliflower,turnip, radish, horseradish or wasabi). It is often used for cooking in North India, Eastern India, Nepal, Bangladesh and Pakistan. In Bengal, Orissa, Assam and Nepal, it is the traditionally preferred oil for cooking. The oil makes up about 30% of the mustard seeds. It can be produced from black mustard (Brassica nigra), Brown Indian Mustard (B.Juncea), and White Mustard (B.Hirta).The characteristic pungent flavor of mustard oil is due to allyl Isothiocyanate. Mustard oil has about 60% monounsaturated fattyacids(42% erucicacid and 12% oleicacid); it has about 21% polyunsaturated fats (6% the omega-3 alpha-linolenic acid and 15% the omega-6linoleicacid), and it has about 12% saturated fats.

Sesame Oil

Sesame oil is an edible vegetable oil derived from sesame seeds. Besides being used as a cooking oil in South India, it is often used as a flavor enhance in Korean, Chinese, Japanese, Middle Eastern, and Southeast Asian cuisine. It has a distinctive nutty aroma and taste. The oil is popular in Asia and is also one of the earliest-known crop-based oils, but world-wide mass modern production continues to be limited even today due to the inefficient manual harvesting process required to extract the oil.Sesame oil is composed of the following fatty acids: Linoleic acid (41% of total), Oleic acid (39%), Palmitic acid (8%), Stearic acid (5%) and others in small amounts.

Grape Seed Oil

Grape Seed oil is pressed from the seeds of grapes, and is thus an abundant by-product of making. This oil has a moderately high smoke point of approximately 216 °C (421 °F). Due to its clean, light taste, and high polyunsaturated fat content, it may be used as an ingredient in salad dressings and mayonnaise and as a base for oil infusions of garlic, rosemary, or other herbs or spices. It is widely used in baked goods, pancakes, and waffles. It is sprayed on raisins to help them retain their flavor. The metabolic energy density of grape seed oil is typical of vegetable oils: approximately 3,700 kJ (880 kcal) per 100 g, or 500 kJ (120 kcal) per 15 ml tablespoon.

Composition

Table 1

Acid	Type	Percentage
Linoleic acid	ω−6 unsaturated	69.6%
Oleic acid	ω−9 unsaturated	15.8%
Palmitic acid (Hexadecanoic acid)	Saturated	7%
Stearic acid (Octadecanoic acid)	Saturated	4%
Alpha-Linolenic acid	ω−3 unsaturated	0.1%
Palmitoleic acid (9-Hexadecenoic acid)	ω−7 unsaturated	less than 1%

5. Properties of bio oils

Bio-fuel is non-volatile fatty oil taken from seeds of various plants and from animal fats. It ranges in color from colorless to greenish. Castor oil, mustard oil, sesame oil, grape seed oil etc are the various types of bio-fuels. Table 5.1 shows the comparison of properties of mustard oil, sesame oil, grape seed oil with diesel. Effect of dilution on viscosity of blends with B10, B20, B10 (2) licensed on volume basis and the mixture is stirred well to get homogeneous stable mixture. Here B10, B20 indicates blend of grape seed oil and mustard oils whereas B10(2) indicates blend of mustard oil and sesame oil.The properties of Bio Diesel used in this experimentation has calculated by using different apparatus like pensky martins apparatus for flash point, clevland’s operator for fire point, Redwood viscometer for kinematic viscosity, Bomb calorimeter for calorific value are shown in the table.

Table 5.1: Comparison of Properties of Individual oils with Diesel at Room Temperature

Property	Custard Oil	Grape Seed Oil	Sesame Oil	Diesel
Flash Point (°C)	147.7	128.3	135	60
Fire Point (°C)	236.6	205.1	221.1	62
Density (gm/cc)	0.888	0.884	0.884	0.830
Kinematic Viscosity (Centi Stokes)	38.15	36.35	40.63	3.15
Calorific Value (J/kg)	39764	39413	43540	45219

6. Experimental Setup (Engine Details)

The Engine used in the present study is “kirloskar Single Cylinder Four Strokes Diesel Engine. This is connected to electric type dynamometer for loading provision is also made for interacting air flow, fuel flow, temperatures and the load measurement. The load as the break drum can be varied from 0 kg to 10 kg. The setup has stand-alone panel box one fuel tank for fuel test, manometer, and fuel measuring unit, transmitter for air and fuel flow measurements. The Kirloskar Engine is one of the widely used engines in agriculture tractors, pump sets machinery, transport vehicles and small and medium scale commercial purposes. The engine can withstand the peak pressure encountered because of its high compression ratio.

Fig 2: Kirloskar Single Cylinder Diesel Engine

Fig 3: Exhaust Gas Analyzer

Table 6.1: Specifications of Engine Part & List of Engine Details

Part No	Part Name	Quantity	Type	Kirloskar
1.	Engine	1	No. of cylinders	1
2.	Flywheel	1	No of strokes	4
3.	Electrical Dynamometer	1	Bore	87.5 mm
4.	Crank	1	Stroke length	110 mm
5.	Air Box	1	Rated power	3 H.P
6.	Manometer	1	Speed	1500 rpm
7.	Temperature Indicator	1	Cooling system	Water cooled
8.	Fuel Measurement Burette	1	-	-
9.	Fuel Tank	2	-	-
10.	Cooling Water Inlet	2	-	-
11.	Cooling Water Outlet	2	-	-
12.	Exhaust Pipe	1	-	-

The above apparatus is coupled with engine to obtain Emission Characteristics.

Table 6.2: Comparison of Properties of Blending Oils with Diesel at Room Temperature

Property	B10	B20	B10(2)	Diesel
Flash point (°C)	51	50	52	60
Fire point (°C)	55	54	55	62
Density (gm/cc)	0.8356	0.8412	0.8579	0.830
Kinematic Viscosity (Centi Stokes)	3.653	3.459	3.261	3.15
Calorific value (J/Kg)	44655	44092	44862	45219

7. Preparation of Bio-Diesel Mixture

Blends of Mustard, Grape Seed Oil varies as 50-100 ml and Diesel oil varies as 800-900 ml, initially 50m1 of mustard oil and 50 ml grape seed oil is mixed with 900 ml of diesel and load test is conducted after the experiment is over the residual diesel is measured which contains 10% of Bio-fuel (5% mustard and 5% grape seed oil) and required excess bio-fuel is mixed to make it to blend (50 50 900). Similarly the other two blends are prepared.

8. Experimental Procedure

This investigation is carried on a Single Cylinder 4-Stroke, Water Cooled, and Stationary Diesel Engine with the rated power 4HP operating at a Speed 1500rpm. The specification of test rig are given Table 4.1, the engine is directly coupled to an Electrical Dynamometer. The Engine and Dynamometer were interfaced to a control panel. The test rig is used for recording the test parameters such as fuel flow rate, temperature, air now rate, energy meter readings etc. and for calculating the engine performance characteristics such as brake thermal efficiency, brake specific fuel consumption, volumetric efficiency, mechanical efficiency etc. The different observations were made during the running of engine and they are tabulated as below.

Table 8.1: Table of Observations

Load	Brake Power (KW)	Speed (RPM)	Time for 10 Revolutions of Energy Meters(Sec)	Time for 10 ml of Fuel Consumption (Sec)

The exhaust gas analyzer which is coupled to the muffler also gives the information regarding the exhaust gases and they are also tabulated as below

Table 8.2: Table of Observations

Blend	Load	CO (%)	CO2 (%)	HC (ppm)	O2 (%)	NOx (ppm)

9. Sample calculations

A. Brake Power (B.P.): The power available at crank shaft is called brake power.

$$B.P = \frac{10\times3600\times100}{t1\times EMC\times75} \text{ KW}$$

Where
EMC = energy meter constant= 1800 rev/kw.hr
t_1 =time for 10 revolutions
Generator efficiency= 75%

B. Fuel Consumption (F.C): It is defined as the rate of discharge of liquid through which an orifice depends on the static head causing flow.
Fuel Consumed in t s =20ml
Fuel Consumed in 1 s=20 / t ml/s

$$F.C = \frac{20 \text{ x } \rho d}{tx1000} \text{kg/s}$$

'ρd' indicates the Density of the Diesel. The density of diesel is taken as 0.825 gm/ml.'t' is the time taken for 10 ml of fuel consumption.

C. Brake Thermal Efficiency (ηbth): Ratio of energy in brake power to the energy in fuel.

$$\eta_{bth} = \frac{B.P}{F.C \text{ x } C.V}\times100 = \%$$

D. Specific Fuel Consumption (S.F.C): Mass of fuel consumed per one kilowatt Developed per hour.

$$S.F.C = \frac{F.Cx3600}{B.P} = \text{kg/kWh}$$

E. Indicated Power (I.P.): From graph F.C vs B.P (Willan'Sline),–Veintercepton B.P axis will give loss of Power to overcome friction.

I.P.=B.P.+F.L. = KW,

Where F.L.=Frictional Loss, kW from graph

F. Indicated Thermal Efficiency (ηith)

$$\eta_{it} = \frac{I.P}{F.C \text{ X } C.V} \text{ x } 100 = \% \text{ [Heat input = F.C ×C.V]}$$

G. Mechanical Efficiency (ηmech): The ratio of brake power to indicated power

$$\eta_{mech} = (B.P./ I.P) \text{ x}100$$

Table 9.1: Table of Calculation

S. No.	Load(kg f)	B.P. (kW)	F.C. (kg/s)	S.F.C. (kg/kWh)	I.P. (kW)	B Brake Thermal Efficiency ηbth(%)	Indicated Thermal Efficiency ηith(%)	Mech. Efficiency ηmech(%)

Model Calculations

Table 9.2: Model Tabular Form Record of Observations for Diesel

Load	Speed (Rpm)	Time for 10 revolutions of Energy Meter (Sec)	Time for 10 ml of Fuel Consumption (Sec)
15	1500	41.29	56.60
30	1500	20.22	48.44

10. Performance Evaluation

This chapter is meant for assuring the different Performance & Emission Parameters of the Diesel Engine under various conditions using the data extracted in the last chapter. The values thus obtained are used for analyzing the performance of the engine with Bio Diesel and Pure Diesel. A model calculation along with the different performance parameters is presented. The model calculations done below are mainly in order to find the performance parameters. Different parameters include brake power, fuel consumption, brake thermal efficiency, specific fuel consumption, indicator power, indicator thermal efficiency, thermal efficiency etc.
From above formulae 1.B.P=0.6458, 2. Fuel consumption = 1.46 x 10^-4 kg/s, 3. Brake Thermal Efficiency = 9.7%, 4. Specific Fuel Consumption value is 0.8148 kg/kwh
5. Indicated Power, I.P =2.4458 KW, 6. Indicator Thermal Efficiency = 37.04%,7. Mechanical Efficiency(η_{mech}) = 26.4%

Table 10.1: Simple calculation table

S. No.	Load(%)	B.P. (KW)	F.C. (Kg/s)	S.F.C. (Kg/Kwh)	I.P. (kW)	Brake thermal Efficiency η_{bth}(%)	Indicated Thermal Efficiency η_{ith}(%)	Mech. Efficiency η_{mech}(%)
1	15	0.645	1.46x10^-4	0.814	2.4458	9.7	37.04	26.40
2	30	1.318	1.70x10^-4	0.462	3.1186	17.03	40.56	42.28

Results and Discussions

11. Observation Table

As it is a Diesel Engine Air Flow Rate to Engine is constant and as a result manometer always shows constant water level difference 3.1 cms of water and the Speed of the Engine always maintained constant at 1500 rpm.

Table 11:.Readings for Variable Blends at all loads

Sl.No	Blended Oils	Load	B.P(K.W)	Time for 10 Revolutions of Energy Meter(sec)	Time for 10 ml of Fuel Consumption (sec)
1	B10	15	0.636	41.88	55.31
2	B10	30	1.3696	19.47	43.88
3	B20	15	0.648	41.12	54.44
4	B20	30	1.328	20.06	45.34
5	B10(2)	15	0.663	40.02	54.43
6	B10(2)	30	1.3654	19.53	44.13
7	Diesel	15	0.6458	41.29	56.60
8	Diesel	30	1.3186	20.22	48.94

12. Emissions at different load conditions

Various effluents like Co2, Co, Nox, etc. which pollutes the environment are estimated using Exhaust Gas Analyzer and at different loading conditions, different blending conditions. The analyzer which is coupled to the exhaust pipe gives the required characteristics.

Table 12.1: Showing the Different Emission Properties at all Blends

Blend	Load(%)	CO (%)	CO2 (%)	HC (ppm)	O2 (%)	NOx (ppm)
B10	15	0.071	3.35	0	16.01	15
B10	30	0.043	3.92	0	15.23	72
B20	15	0.083	3.57	0	15.81	23
B20	30	0.048	3.77	0	15.48	83
B10(2)	15	0.094	3.56	0	15.65	30
B10(2)	30	0.047	3.98	0	15.04	78
Diesel	15	0.0695	3.83	0	16.07	21
Diesel	30	0.05823	3.3025	0	15.57	52

Table 12.1: Calculated Data at Different Loads for all Blends

Blend	Load	B.P (kw)	F.C (x10^-4) (kg/s)	S.F.C (kg/ kwh)	Hbth (%)	I.P (kw)	Hith (%)	Hmech (%)
B10	15	0.636	1.506	0.855	9.44	2.436	36.15	26.1
B10	30	1.3696	1.89	0.5	16.27	3.1696	37.49	43.21
B20	15	0.648	1.54	0.852	9.44	2.448	36.002	26.4
B20	30	1.328	1.848	0.496	16.20	3.128	38.32	42.45
B10(2)	15	0.663	1.52	0.825	9.7	2.463	36.03	26.91
B10(2)	30	1.3654	1.88	0.4956	16.16	3.1654	37.46	43.13
Diesel	15	0.6458	1.46	0.814	9.7	2.4458	37.04	26.4
Diesel	30	1.3186	1.7	0.462	17.03	3.1186	40.56	42.28

13. Graphs: Emission Characteristics

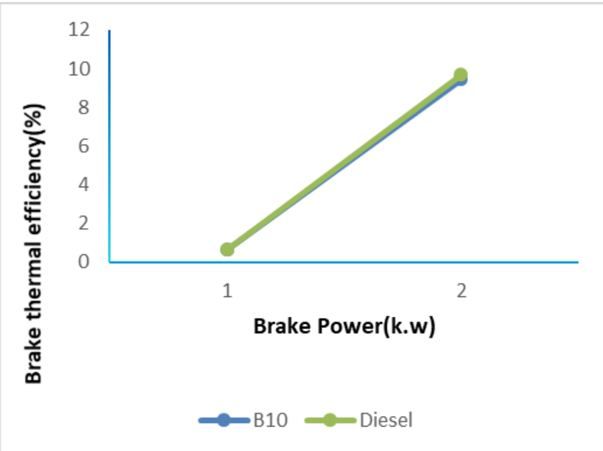

Fig 4

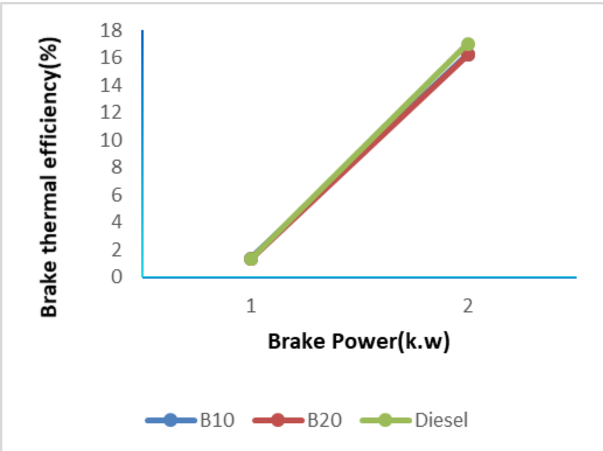

Fig 5

Brake Thermal Efficiency Vs Brake Power for Different Blends (15% load & 30% load)

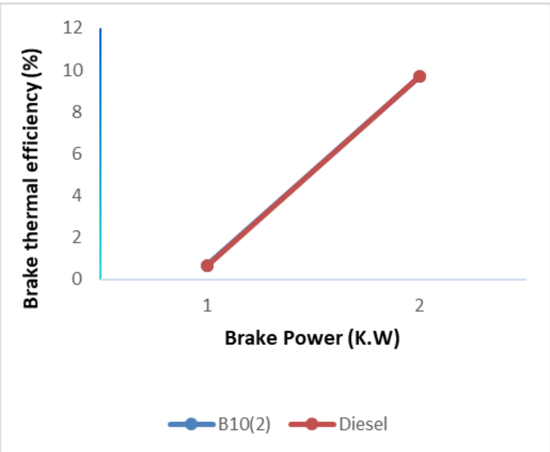

Fig 6

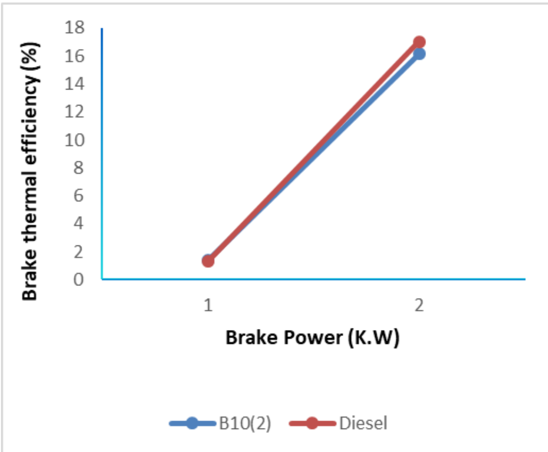

Fig 7

Fuel Consumption vs Brake Power for Different Blends (15% load & 30% load)

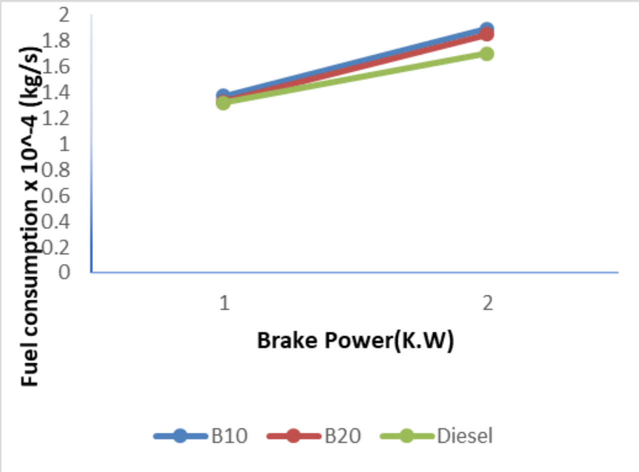

Fig 8

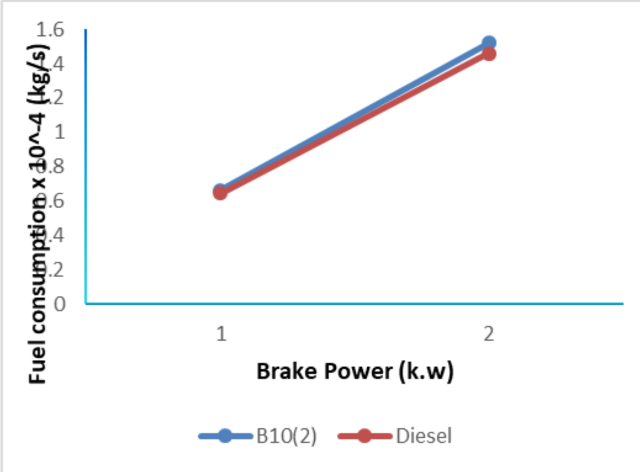

Fig 9

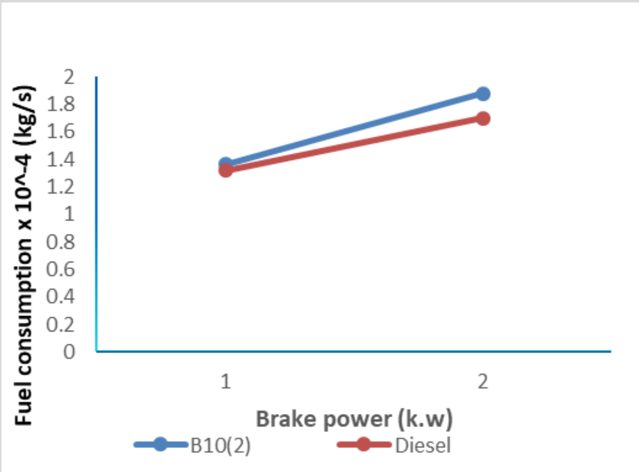

Fig 10

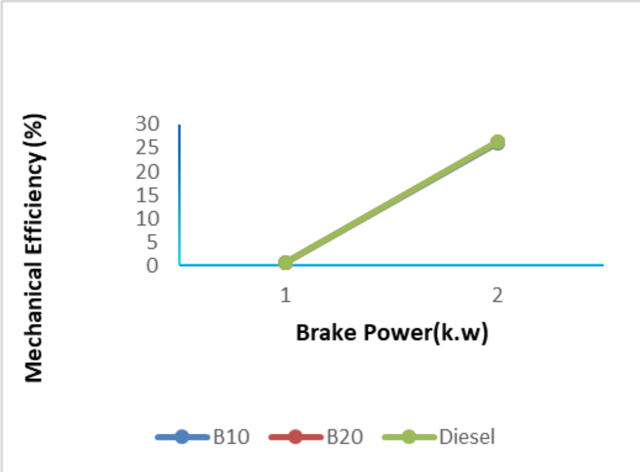

Fig 11

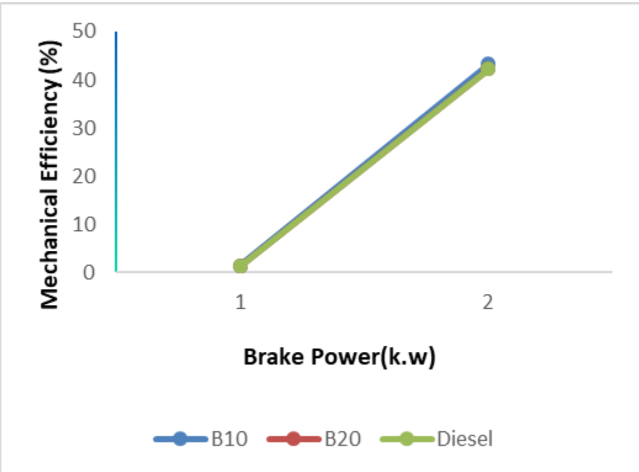

Fig 12

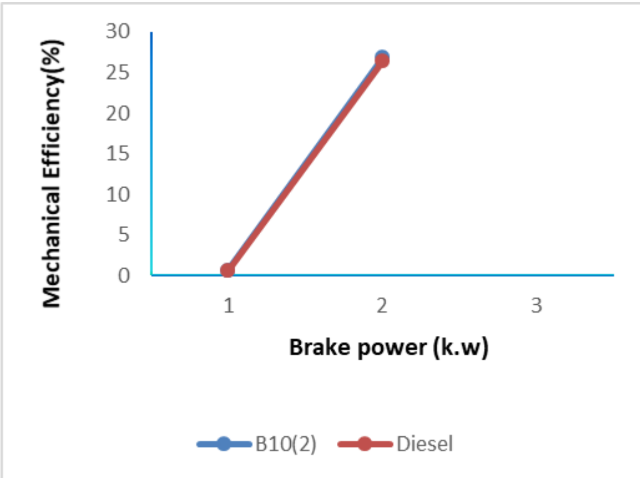

Fig 13

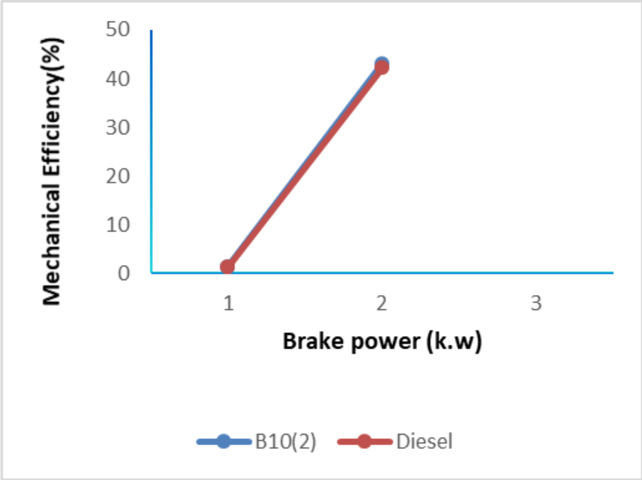

Fig 14

Mechanical Efficiency Vs Brake Power

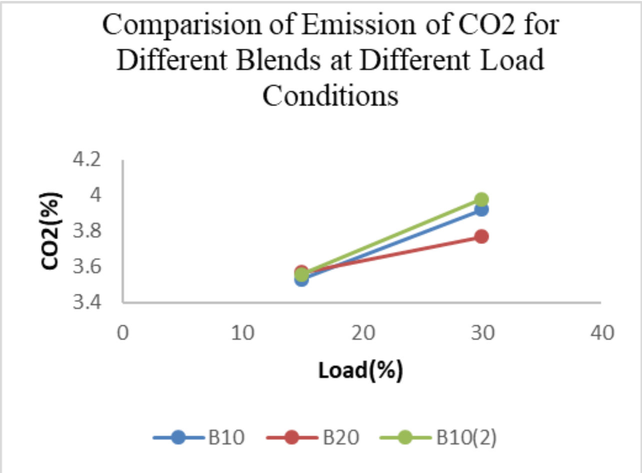

Fig 15

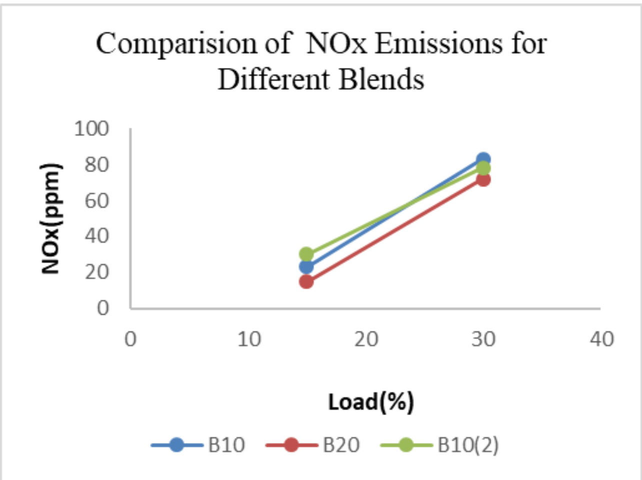

Fig 16

14. Conclusion

The Performance of Kirloskar Single Cylinder Diesel Engine by varying the Mustard Oil, Grape Seed Oil and Sesame Oil as B10,B20,B10(2) and calculate the different characteristic parameters were estimated and concluded that the efficiency of the engine is increased for some blends. The brake power of the B10 (2) blends is higher in 15% of load condition. In 30 % load conditions blends show better output than diesel. The mechanical efficiency of the B 10 (2) blend is superior to all other blends and diesel. And even the emissions are also very good comparing to other blends and diesel. So, the diesel blend B 10 (2) can be used as fuel along with diesel. B 10(2) is a blend of sesame oil and mustard oil and along with this other blends are also be used for some extent. The CO emitted is very less in diesel than any other blends but oxygen content is high in blends so as blending increases the Nox emission reduced by considerable amount. The amount of HC released is negligible in all cases of blends and diesel.

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