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Performance Characteristics of Diesel Engine Using Biodiesel Blends

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Abstract: Diesel vehicles are similar to gasoline vehicles because they both use internal combustion engines. One difference is that diesel engines have a compression-ignited injection system rather than the spark-ignited system used by most gasoline vehicles. In recent years, the acceptance of fatty acid methyl esters (biodiesel) as a substitute to petroleum diesel has rapidly grown in India. The raw materials for biodiesel productionin this country mainly include traditional seed oils and used frying oils. In the search for new low-cost alternative feed stocks for biodiesel production, this study emphasizes the evaluation of lemon grassoil. The experimental results showed that the oil content of Lemon grass were remarkably high (45%). The main emphasis has been laid on optimum production of biodiesel from Lemongrass Oil then using the biodiesel blends with diesel studying the comparative characteristics and engine performance and the blends made from the biodiesel with diesel. The oil was chemically converted via an alkaline transesterification reaction with methanol to methyl esters, with a yield nearly 97.5 wt.%.All of the measured properties of the produced biodiesel met the current quality requirements. Oils were esterifying (butyl esters) before blending with pure diesel in the ratio of 4:96, 8:92, 12:80 by volume. Pure diesel was used as control. Initially the properties of the lemongrass Oil blends were determined density, viscosity, dynamic viscosity, flashes point, fire point and calorific value. An assessment of engine performance brake power (BP), brake specific fuel consumption (BSFC), brake thermal efficiency (BTE) etc., was carried out for pure diesel and the oil blends. However,lemongrass oil at 12% blend with diesel gave best performance as compared to other blends
Keywords: lemongrass oil, Transesterification, Methyl esters, Esterifying.

I. INTRODUCTION

Diesel engines work by compressing only air, or air plus residualcombustion gases from the exhaust (known as exhaust gas recirculation, ―EGR‖). Air isinducted into the chamber during the intake stroke, and compressed during thecompression stroke. This increases the air temperature inside the cylinder so thatatomised diesel fuel injected into the combustion chamber ignites. With the fuel beinginjected into the air just before combustion, the dispersion of the fuel is uneven; this iscalled a heterogeneous air-fuel mixture. The torque a diesel engine produces is controlledby manipulating the air-fuel ratio (λ); instead of throttling the intake air, the diesel enginerelies on altering the amount of fuel that is injected, and the air-fuel ratio is usually high. The diesel engine has the highest thermal efficiency (engine efficiency) of any practicalinternal or external combustion engine due to its very high expansion ratio and inherent lean burn which enables heat dissipation by the excess air. A small efficiency loss is alsoavoided compared with non-direct-injection gasoline engines since unburned fuel is notpresent during valve overlap and therefore no fuel goes directly from the intake/injectionto the exhaust. Low-speed diesel engines (as used in ships and other applications whereoverall engine weight is relatively unimportant) can reach effective efficiencies of up to55%.The combined cycle gas turbine (Brayton and Rankin cycle) is a combustion enginethat is more efficient than a diesel engine, but it is, due to its mass and dimensions,unsuited for vehicles, watercraft, or aircraft. The world‘s largest diesel engines put inservice are 14-cylinder, two-stroke marine diesel engines; they produce a peak power ofalmost 100 MW each.
Diesel engines may be designed with either two-stroke or four-stroke combustion cycles. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s, they have been used in submarines and ships. Use in locomotives, buses, trucks, heavy equipment, agricultural equipment and electricity generation plants followed later. In the 1930s, they slowly began to be used in a few automobiles. Since the 1970s energy crisis, demand for higher fuel efficiency has resulted in most major automakers, at some point, offering diesel-powered models, even in very small cars.

According to Konrad Reif (2012), the EU average for diesel cars at thetime accounted for half of newly registered cars.However, air pollution emissions are harder to control in diesel engines than in gasoline engines, so the use of diesel auto engines in the U.S. is now largely relegated to larger on-road and off-road vehicles.

Though aviation has traditionally avoided diesel engines, aircraft diesel engines have become increasingly available in the 21st century. Since the late 1990s, for various reasons – including the diesel‘s normal advantages over gasoline engines, butalso for recent issues peculiar to aviation – development and production of diesel engines for aircraft has surged, with over 5,000 such engines delivered worldwide between 2002 and 2018, particularly for light airplanes and unmanned aerial vehicles.

A. *Operating Principle*

The characteristics of a diesel engine are

1) Use of compression ignition, instead of an ignition apparatus such as a spark plug.
2) Internal mixture formation. In diesel engines, the mixture of air and fuel is only formed inside the combustion chamber.
3) Quality torque control. The amount of torque a diesel engine produces is not controlled by throttling the intake air (unlike a traditional spark-ignition petrol engine, where the airflow is reduced in order to regulate the torque output),instead, the volume of air entering the engine is maximised at all times, and the torque output is regulated solely by controlling the amount of injected fuel.
4) High air-fuel ratio. Diesel engines run at global air-fuel ratios significantly leaner than the stoichiometric ratio.
5) Diffusion flame: At combustion, oxygen first has to diffuse into the flame, rather than having oxygen and fuel already mixed before combustion, which would resultin a premixed flame.
6) Heterogeneous air-fuel mixture: In diesel engines, there is no even dispersion of fuel and air inside the cylinder. That is because the combustion process begins at the end of the injection phase, before a homogeneous mixture of air and fuel canbe formed.
7) Preference for the fuel to have a high ignition performance (Cetane number), rather than a high knocking resistance (octane rating) that is preferred for petrol engines.

II. MATERIALS AND METHODS

A. *Cymbopogon Citratus Extraction*

Cymbopogon citratus, commonly known as West Indian lemon grass or simply lemon grass, is a tropical plant native to Maritime Southeast Asia and introduced to many tropical regions.

Cymbopogon citratus is often sold in stem form. While it can be grown in warmer tempera regions, such as the UK, it is not hardy to frost.

Figure 1 Lemon Grass

Lemongrass is native aromatic tall sedge which grows in many parts of tropical and sub-tropical South East Asia and Africa. In India, it is cultivated along Maharashtra, Kerala, Karnataka and Tamil Nadu states besides foothills of Arunachal Pradesh and Sikkim. It was introduced in India about a century back and is now commercially cultivated in these mentioned States. What is lemongrass oil good for? Lemongrass has been used to treat digestive problems and high blood pressure, the essential oil has many other potential health benefits and, it‘s becoming popular oil in aromatherapy to help relieve stress, anxiety, and depression.

Lemongrass is a tropical and sub-tropical, grassy plant used in cooking and herbal medicine. Extracted oil from the lemon leaves and stalks of the lemongrass plant, lemongrass essential oil has a powerful, citrus scent. It does often establish in soaps and other personal care products.

B. *Cultivating and Harvesting Lemongrass Oil*

Lemongrass is native to the tropical countries of India, Cambodia, Indonesia, Guatemala, Sri Lanka, and Malaysia. It grows upright in dense bunches and thrives in moist, warm climates with well-drained, loose, dry, loam soils that have a pH level between 4.3 and 8.4. Lemongrass leaves are a green color with sharp edges much like grass that grows onlawns but much larger. It requires fullsun and a soil temperature that is between 21°C and 24°C (70°F to 75°F).

Lemongrass requires adequate water drainage requirement,as disproportionate watering will lead to lower oil content. Lemongrass flowers grow in the winter season. The first harvest is normally obtained after 4 to 6 months of transplanting seedlings. Subsequent harvests are done at intervals of 60 to 70 days depending upon the fertility of the soil and other seasonal factors. Under normal conditions, three harvests are possible through the first year, and 3 to 4 in subsequent years, depending on the management practices followed. Lemongrass can be harvested 6-9 months after the slips are planted and can be harvested as frequently as once every month through the growing season. Cutting stimulates growth and allowing the plant to develop too large will lead to a reduced oil yield. The lemongrass is harvested in the morning on a dry day to allow the evaporation of dew and to avoid loss of the plant‘s colordue to heat. When harvested mechanically, sharp tools and machinery are used in order to make sure a clean cut and to avoid splitting the edges of the leaves. If theplant is cut too low, the lemongrass leaves will retain less oil, thus the optimal oilquality is in the higher parts of the leaves. Allowing the plants to mature until before the winter months will make sure that the root reserves are fortified and that the foliage will protect the plant against winter frost. After winter, Lemongrass can be used for compost or mulch or it may be harvested and distilled. Ideally, Lemongrass leaves will keep their green color and be free of fungi. In organize to ensure this, Lemongrass leaves must be dried as soon as possible within 24 hours and a conventional dryer may be used for this. An extended drying period, such as in the case of it being left out in the sun to dry, will cause the leaves to lose color and the aroma value to diminish. Once harvested, leaves can be stored in shade for up to 3 days without the oil yield or quality being compromised. Harvesting is completed with the help of sickles; the lemongrass plants are cut 10 cm above ground-level and allowed to wilt in the field, before transporting to the distillation site. The Lemongrass is then steam or hydro distilled.

1) *Post-harvest ManagementDrying*

The lemongrass has been allowed to wilt for 24 hours before the distillation as it reduces the moisture content by 30% and improves oil yield. The lemon crop is chopped into small pieces before filling in the stills. It can be distilled in similar distilleries as used for Japanese mint in India.

a) *Plant Samples*

Lemongrass (Cymbopogon Citratus) leaves were collected from plants. The lemongrass plant sample was freshly cut, 10cm from the root, in the morning of the day they were collected. Lemongrass, the percentage essential oil yield for the partially dried leaves was established to be higher than that of the fresh leaves. Thus, once collected, the plant material was dried at room temperature for a maximum four days, then kept in a sealed plastic bag at ambient temperature and protected from the light. Extraction yield increase by decreasing the particle size due to the higher amount of lemongrass oil released as the leave cells are destroyed by milling. In order to develop the collection efficiency, the plant material was soaked in its distilled water for 30min before the extraction performed. N-hexanewas used as analytical grade reagent in this process.

2) *Lemongrass oil Extraction TechniquesHow is Lemongrass oil Extracted?*

Lemongrass Essential Oil is derived from the steam distillation of the fresh or partly dried leaves. After distillation, the oil ranges in color from a yellow color to amber color and exudes a fresh, sweet, grassy and citrus-like aroma.

Lemongrass oil is collected by distillation unit of the herbage for 1.5 to2 hrs. The distillate on cooling separates out into a layer of oil, floating over the bulk of water which is composed by decantation. The lemongrass is distilled either fresh or after wilting.

a) *Distillation*

Lemongrass oil is obtained through steam distillation. Lemongrass oil has a strong lemon-like odor. The oil is yellowish in color having 75 to 85% citral and a small amount of other minor aroma compounds. The recovery of oil from the grass ranges from 0.5 to 0.8 percent. It takes about four hours for the complete recovery of the oil.

b) Solvent Extraction Method

150g of the dry sample of lemongrass were weighed from the sliced lemongrass sample and placed in a one-liter clean at bottom ask. After that, 500ml of N-hexane solvent was poured into the ask.

The bottom asks and content were allowed to stand for 36 hrs; this was made to extract all the oil content in the lemongrass and for complete extraction. After which the extract was decanted into another one-liter beaker. 200ml of Ethanol was added to extract the essential oil since lemongrass essential oil is soluble in Ethanol. The mixture was then transferred to a 500ml separating funnel and separated by a procedure called liquid separation process. The content of the separating funnel was and allowed to approach to equilibrium, which separated into 2 layers (depending on their different density).

The lower Ethanol extract and the upper Hexane layer were collected into 2 separate 250ml beakers and were placed in a water bath at 78oC. This was done to remove the Ethanol leaving the natural essential oil. The yield of lemongrass oil was determined by weighing the extract on an electronic weighing balance. The variation between the nal weight of the beaker with extract and the initial weight of the empty beaker gave the weight of essential oil.

3) Raw Materials Required

The main raw material is lemongrass. And the grass plants grow well in soils not proper for richer production plants. From sandy and rather dry soils yield moderately more oil and oil of higher citral content than plants from very fertile soils. A lemongrass plantation has a life cycle of 6 – 8 years. The oil yield reaches its maximum around the third year or fourth year and its annual average value range between 15 and 20 kg/ha with three crops per year. The ratio of lemongrass oil to leaves is equal to 0.348%.

Therefore, you will need to obtain about 288 kg of lemongrass to produce 1 kg of essential lemongrass oil. Depending upon soil and climatic conditions, plantation lasts on an average, for three to four years only. The yield of lemongrass oil is less during the rst year, but it increases in the second year and reaches a maximum in the third year; after this, the yield declines. On average, 25 tonnes to 30 tonnes of fresh herbage harvest per hectare per annum from four to six cuttings, which yields about 80 kg of oil. Under irrigated conditions from newly bred varieties, a lemongrass oil yield of 100 to 150 kg/ha is obtained. The clean and fresh herb contains on average 0.3% oil and thick stems are removed before distillation as these are devoid of oil.

4) Formulation of oil

Lemongrass essential oil 10ml extract was measured and placed in a 120ml beaker containing 5ml of Methanol. Fixatives of 5ml quantity were added to the mixture to improve the longevity of the perfume. The resulting solution was shaken and poured into a 50ml bottle.

The yield of essential oil formula that obtained was calculated by:

The yield of the essential oil = amount of essential oil (in grams) obtained / amount of raw materials (in grams) used

5) Cost of Lemongrass oil distillation unit

- Steam distillation unit cost approximately– Rs 8 Lakh/ Piece
- Lemongrass oil price approximately Rs.600/ pper kg.

6) Purification of oil

The insoluble particles present in the lemongrass oil are removed by a simple filtration process after mixing it with anhydrous sodium sulfate and keeping it overnight or for 4 to 5 hours. In case the color of the lemongrass oil changes due to rusting then it should be cleaned by steam rectification process.

7) Storage and Packing of Oil

The lemongrass oil can be stored in containers made up of stainless steel or aluminum or galvanized iron, depending upon the quantity of oil to be stored. The oil must be Pulled up to the brim and the containers should be kept away from direct heat and sunlight in cool or shaded places.

C. Transesterification

Transesterification is the process of conversion of triglyceride to glycerol and ester in the presence of alcohol and catalyst. This reaction, also known as alcoholics in whom the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis except that an alcohol is used instead of water. This reaction has been widely used to reduce the viscosity of the triglycerides.

Experimental study shows that the major variables affecting the transesterification reaction are: The free fatty acid (FFA) and the moisture content. The rate of reaction is strongly influenced by the reaction temperature i.e. (50±2) ° C approximate. Then with the help of washing remove the catalyst, soap and excess methanol from bio diese

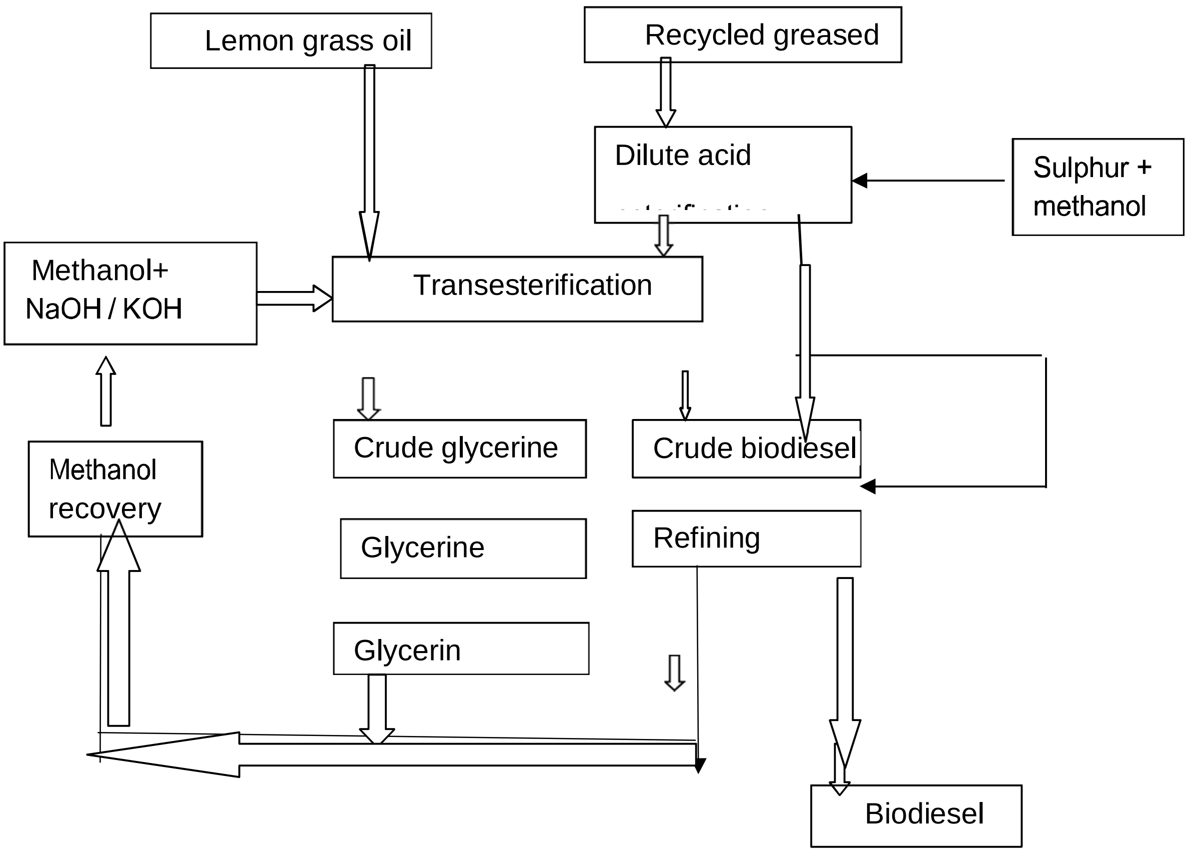

Figure. 2 Basic Transesterification Process

In our work we have been use the Dr.Peepersstyle, for the transesterification of Celosia oil. According to Dr.Peepersstyle, first of all, take a 250 ml methanol CH_3OH (90% pure) in the glass container then mixed 150 ml NaOH of 1 Normality and swirl the container until methanol is completely dissolved in NaOH.

When NaOH reacts with methanol CH_3OH an exothermic reaction is take place due to which the glass containers get warm so it is very carefully done to swirl the mixture, safety precautions.

The biodiesel was produced in the School of Energy and Environment labs at Thapar University Patiala, Punjab (India) and the engine experiments and testing was done in internal Combustion Engine Laboratory, Department of Mechanical Engineering,Thapar University, Patiala, Punjab (India). Further the methodology is divided in to two parts:First part shows the optimum production of biodiesel from non-edible oil i.e. lemon grass oil.Second part shows the emission and performance of the biodiesel blends tested on an engine.

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1) Methodology For The Production Of Biodiesel From Lemon Grass Oil

Here in this from starting the raw materials used for biodiesel production is discussed and after it with each step with which the whole production process wasundergone. The biodiesel properties are also discussed in this section.

Raw materials

a) Lemon grass oil
b) Methanol (methyl alcohol)
c) Potassium hydroxide (KOH) as base catalyst
d) Sulphuric acid (H2SO4) as acid catalyst

Dewaxed and degummed crude lemon grass oil was bought from the local general store. The Methanol (methyl alcohol), Potassium hydroxide (KOH), Sulphur acid (H2SO4) were available in the chemistry laboratories, kings college of engineering punalkulam .The transesterification was then carried out in the labs on a hot platemagnetic stirrer.

D. Biodiesel Preparation

As the crude lemon grass oil was used for the preparation of biodiesel therefore due to high Free Fatty Acid FFA content of lemon grass oil i.e. approx. 7% the transesterification process was carried out in two stages. The first stage included an acid catalyzed transesterification reaction and in second the base catalyzed transesterification reaction was carried out.

Lemon grass Oil was procured from an oil mill. The oil was filtered to remove the impurities. Diesel fuel was used as baseline fuel. The viscosity was determined at different temperatures using redwood viscometer to find the effect oftemperature on the viscosity of lemon grass oil . The viscosity of lemongrass oil was found to be 9 times higher than that of diesel fuel. The flash point of lemon grass Oil was higher than diesel and hence it is safer to store. It is seen that the boiling range of lemon grass oil was different from that of diesel. This lemon grass oil trasnsesterified before blend with diesel because of the oils have glycerol. It must extract from the bio fuel because it will affect the engine performance.

Among these, the transesterification is the most commonly used commercialprocess to produce clean and environmental friendly fuel. Methyl/ethyl/butyl esters of, lemon grass oil have been successfully tested on C.I. engines and their performance has been studied.

Figure 3 Lemon Grass Oil After Transesterification Process

Transesterification process of a vegetable oil

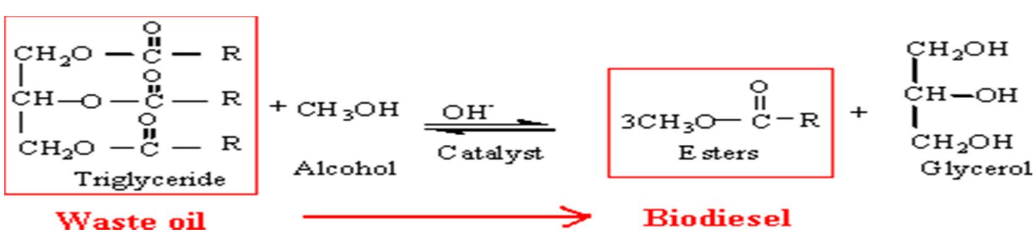

Figure 4 Transesterification process of a vegetable oil

In our work we have been use the Dr.Peepersstyle, for the transesterification of Celosia Oil. According to Dr.Peepersstyle, first of all, take a 250 ml methanol CH_3OH (90% pure) in the glass container then mixed 150 ml NaOH of 1 Normality and swirl the container until methanol is completely dissolved in NaOH. When NaOH reacts with methanol CH_3OH an exothermic reaction is take place due to whichthe glass containers get warm so it is very carefully done to swirl the mixture, safety precautions.

Figure 5 Heating the Lemon Grass Oil After Transesterification Processin Magnetic Stirrer Heater.

After that start to heat up the one litter pure lemon Oil up to 60º C and then added this hot one litter lemon Oil to the glass container and start to swirl the glass container up to 10 minutes so that the lemon Oil is completely dissolve in the mixture. After completion of the reaction, the product is kept for a certain time interval forseparation (approx. 24 hours or more) of bio-diesel and glycerol separation. The more time of separation gives the better result, that means gives purer bio diesel. After 24 hours there are two distinctive layers are appearing in the glass container as in .the upper layer is more transparent as compare to lower layer. The upper layer having the mixture of methyl esters, residual methanol and catalyst, and impurities, whereas the lower layer having a mixture of glycerol, excess of methanol, catalyst and impurities.The upper layer gives the 100% pure bio diesel and lower layer gives the concentrated glycerol. Then the pure Celosia bio diesel is separated from the glasscontainer if this biodiesel contains impurities like, methanol CH_3OH, moisture and soap.

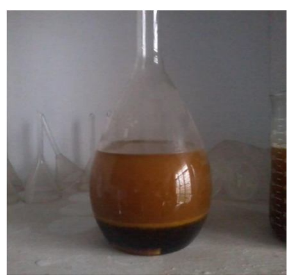

Figure 6 Bio Fuel Layer Separations AfterTransesterification Process

Then the pure Celosia bio diesel is separated from the glass container if this biodiesel contain impurities like, methanol CH_3OH, moisture and soap. The methanol andmoisture can easily remove from the bio diesel by heating the bio diesel up to 110º C under reduced pressure by rotary evaporator.

After heating the oil it is directly mix with diesel with three blends.

In the ratio of 4%, 8%, 12%lemon grass oil blends with diesel

Figure 7 Lemon Grass Oil

Properties	Lemongrass oil
Cetane number	45
Heating value (kJ/kg)	36,000
Density (kg/m3)	910
Flash point (°C)	50
Kinematic viscosity @ 40 °C (Cst)	4.1

Table 1 Propertise of Lemon Grass Oil

Figure 8. Single Cylinder Four Stroke Diesel engine

Type	Vertical, Water Cooled, Four Stroke
Number of Cylinder	One
Bore	80mm
Stroke	110 mm
Compression Ratio	17.5:1
Maximum Power	5H.P
Speed	1500rpm
Dynamometer	Eddy Current
Loading	Electrical

Table 2 Specifications of C.I Engine

Properties	Diesel
Cetane number	50–55
Heating value (kJ/kg)	42,500
Density (kg/m3)	860
Flash point (°C)	55
Kinematic viscosity @40 °C (Cst)	3.2

Table 3 Properties of Diesel

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III. RESULT AND PROCEDURE

A. Experimantal Procedure

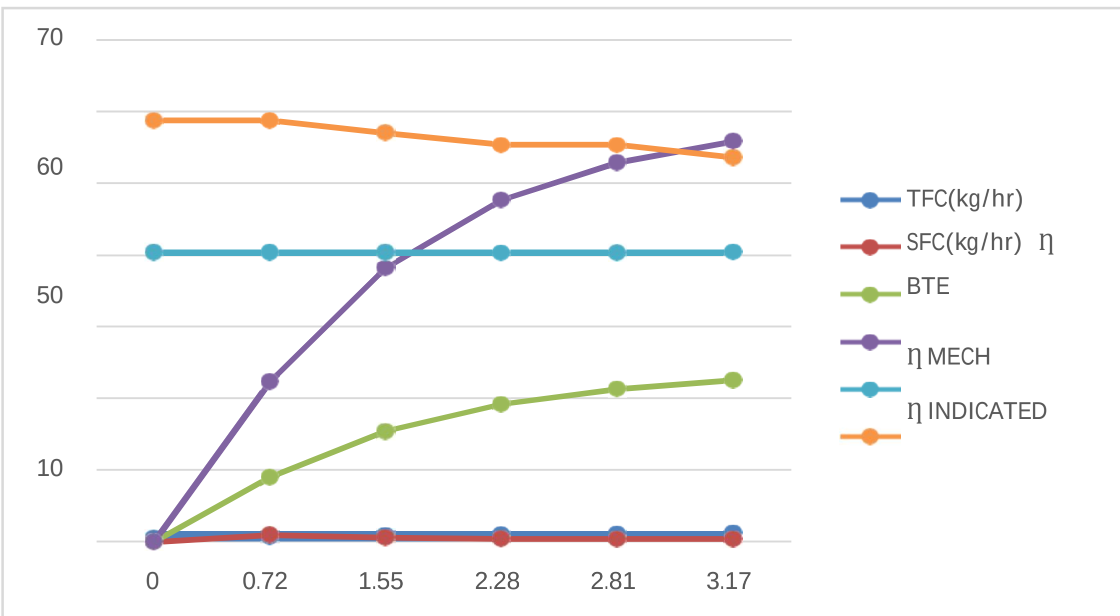
This test was conducted by diesel and Celosia oil. Performance and emission values are noted.

1) Diesel

The engine was started with diesel fuel and when the engine reached the operating temperature, it was loaded using an electrical dynamometer. After equilibrium states reached, the speed, fuel consumption and manometer head were noted. The performance values are noted below

BreakPower (KW)	TFC Kg/hr	SFC Kg/Kwh	Br.Th Efficiency %	Mech. Efficiency %	Indicated Efficiency %	Volumetric Efficiency %
0	0.533	0	0	0	40.34	58.75
0.72	0.686	0.95	9	22.3	40.34	58.75
1.55	0.862	0.56	15.41	38.19	40.35	57.02
2.28	1.019	0.45	19.18	47.62	40.28	55.29
2.81	1.131	0.4	21.3	52.84	40.3	55.29
3.17	1.206	0.38	22.53	55.83	40.36	53.56

Table 4: Performance Parameters Of Diesel



Graph 1 Performance Parameters Of Diesel

Above data shows the variation of total fuel consumption, specific fuel consumption, brake thermal efficiency, mechanical efficiency, indicated efficiency, volumetric efficiency with load for pure Diesel in the test engine.

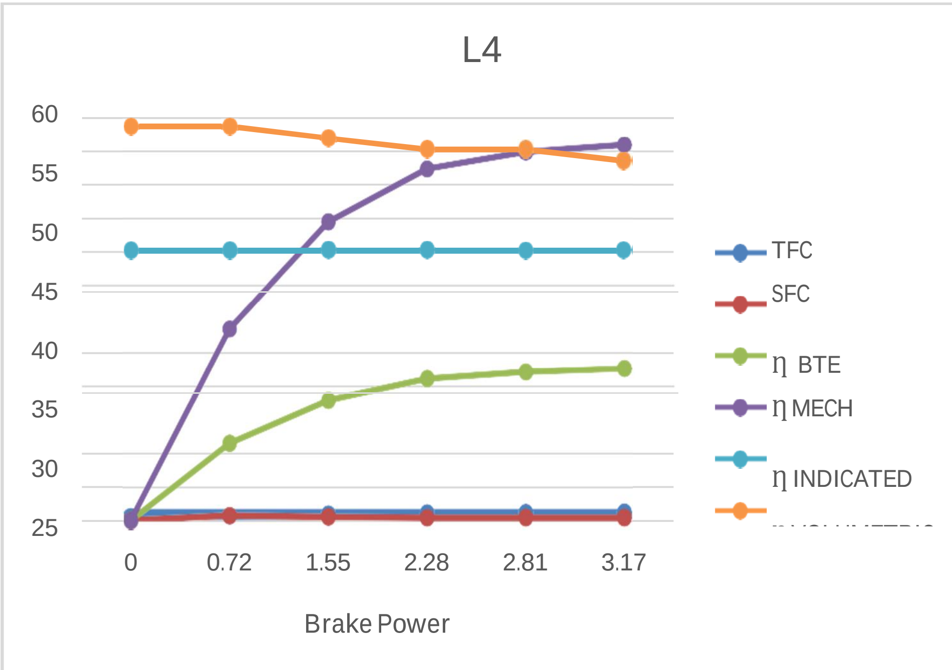
B. Lemon Grass Oil Blends With Diesel

After completing the diesel testing lemon grass oil blends were taken for test. The engine was started with diesel fuel and when the engine reached the operating temperature, it was loaded using an electrical dynamometer. After equilibrium state is reached, the speed, fuel consumption and manometer head were noted. The performance and emission values are noted below.

Then the blends of lemon grass oil were used in different proportions such asL4 (4%biodiesel), L8 (8% biodiesel), L12 (12% biodiesel),. The performance of the Engine was note

BreakPower (KW)	TFC Kg/hr	SFC Kg/Kwh	Br.Th Efficiency %	Mech. Efficiency %	Indicated Efficiency %	Volumetric Efficiency %
0	0.533	0	0	0	40.24	58.75
0.72	0.746	0.75	11.49	28.55	40.24	58.75
1.55	0.958	0.48	17.89	44.42	40.28	57.02
2.28	1.118	0.41	21.08	52.36	40.27	55.29
2.81	1.18	0.39	22.08	54.85	40.26	55.29
3.17	1.208	0.38	22.56	55.96	40.32	53.56

Table 5 Performance Parameters 4%Lemongrass Oil BlendsWith Diesel

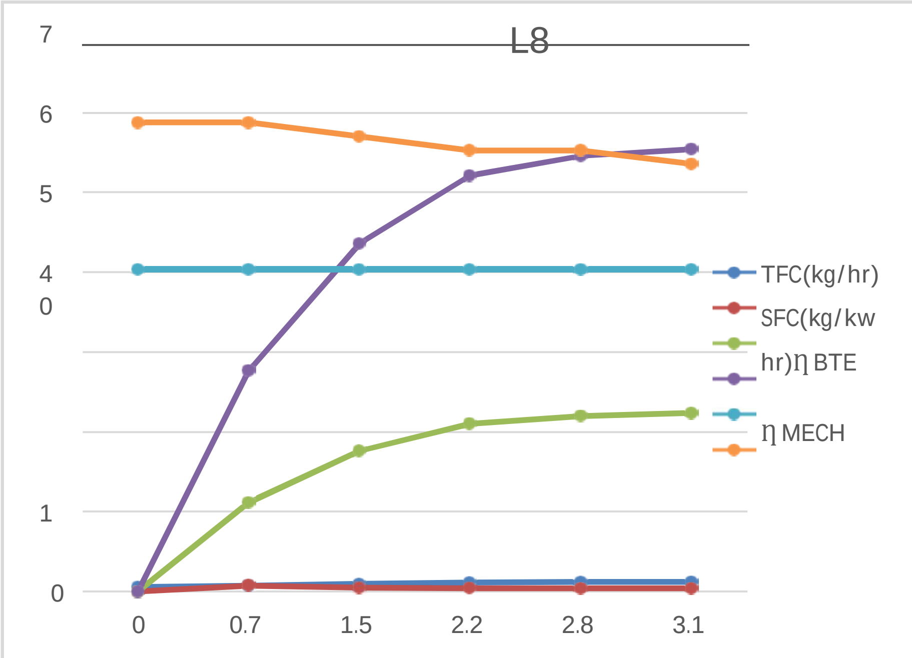


Graph 2 Performance Parameters 4%Lemongrass Oil BlendsWith Diesel

Above data shows the variation of of total fuel consumption, specific fuel consumption, brake thermal efficiency, mechanical efficiency, and indicated efficiency, volumetric efficiency with load for 4% lemon oil blends with Diesel in the test engine. Specific fuel consumption of 4% oil blends is reduced at 0.72 kw load that of Diesel, brake thermal efficiency I higher than diesel at all above load condition.

BreakPower (KW)	TFC Kg/hr	SFC Kg/Kwh	Br.Th Efficiency %	Mech. Efficiency %	Indicated Efficiency %	Volumetric Efficiency %
0	0.533	0	0	0	40.34	58.75
0.72	0.737	0.77	11.16	27.68	40.34	58.75
1.55	0.945	0.49	17.6	43.61	40.34	57.02
2.28	1.113	0.41	21.02	52.12	40.35	55.29
2.81	1.172	0.39	22.01	54.55	40.36	55.29
3.17	1.196	0.38	22.36	55.43	40.34	53.56

Table 6 Performance Parameters 8%Lemongrass Oil BlendsWith Diesel

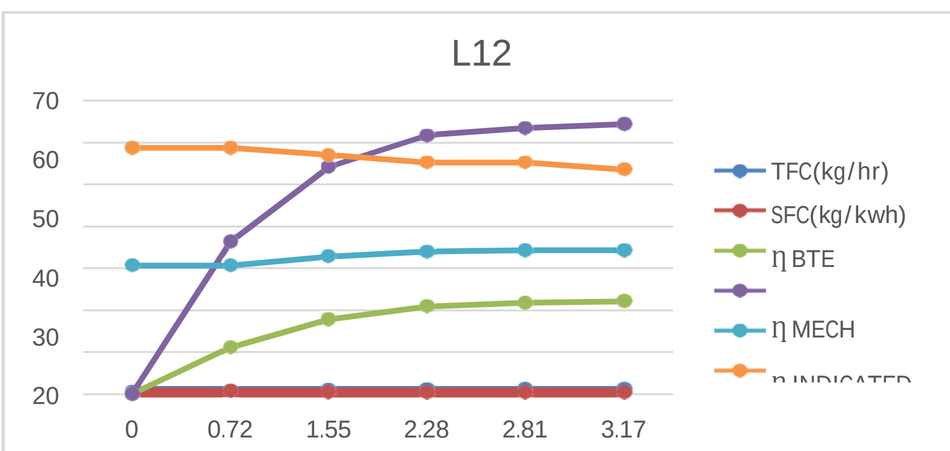


Graph 3 Performance Parameters 8%Lemongrass Oil BlendsWith Diesel

Above data shows the variation of Brake Thermal Efficiency with load for 8%lemon grass oil blends with Diesel in the test engine. Volumetric Efficiency for all load condition of oil blend is very close to the diesel and to that of Diesel.

Table 7 Performance Parameters 12%Lemongrass Oil BlendsWith Diesel

BreakPower (KW)	TFC Kg/hr	SFC Kg/Kwh	Br.Th Efficiency %	Mech. Efficiency %	Indicated Efficiency %	Volumetric Efficiency %
0	0.533	0	0	0	40.34	58.75
0.72	0.737	0.77	11.16	27.68	40.34	58.75
1.55	0.945	0.49	17.6	43.61	40.34	57.02
2.28	1.113	0.41	21.02	52.12	40.35	55.29
2.81	1.172	0.39	22.01	54.55	40.36	55.29
3.17	1.196	0.38	22.36	55.43	40.34	53.56



Graph 4 Performance Parameters 12%Lemongrass OilBlends With Diesel

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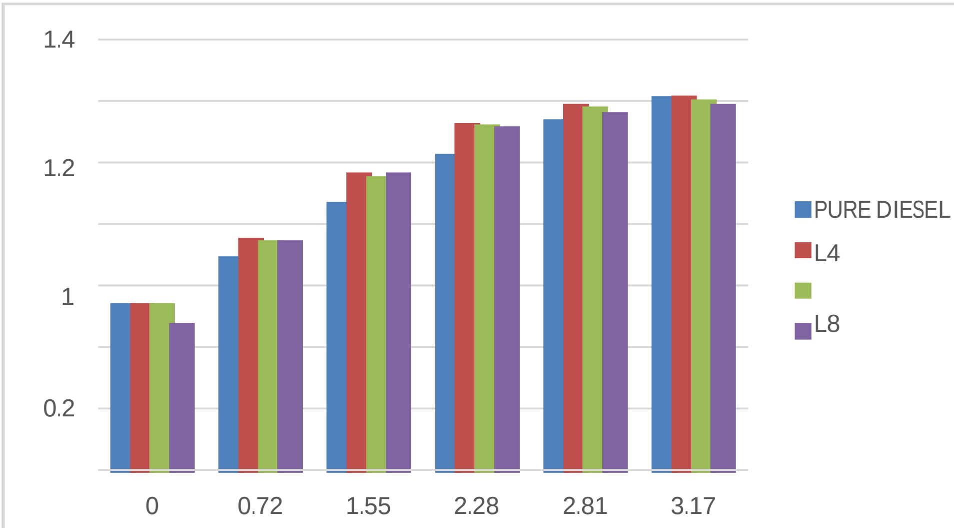
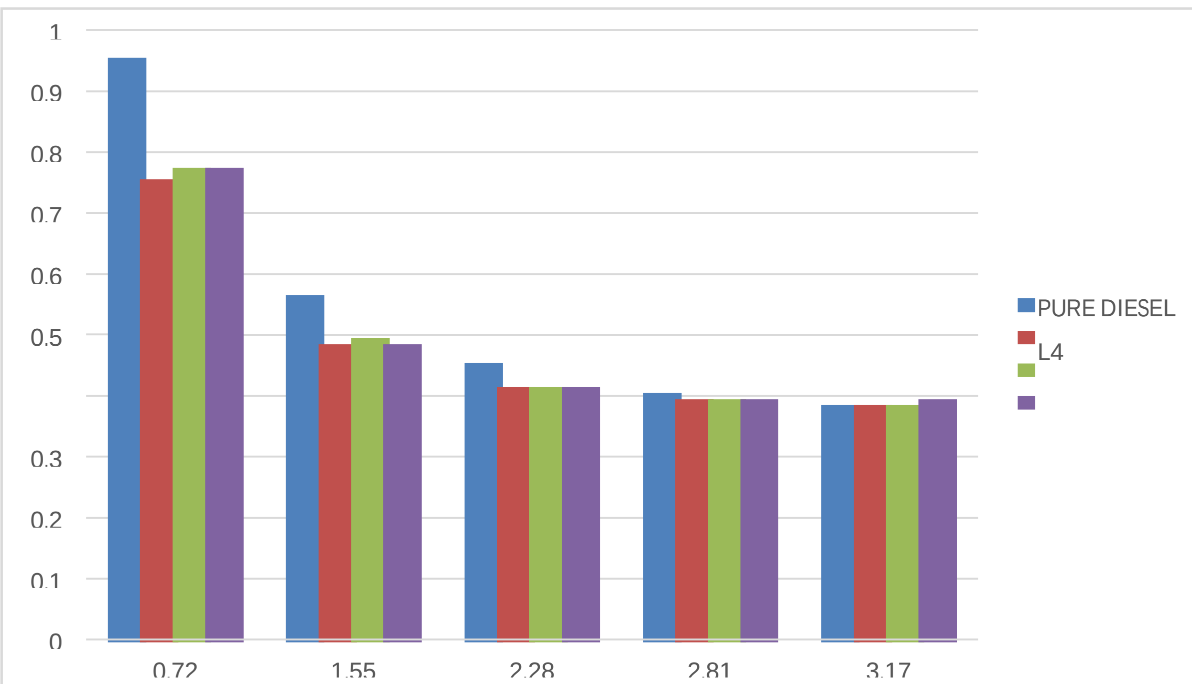
Above data shows the variation of Brake Thermal Efficiency with load for 12%lemon grass oil blends with Diesel in the test engine. Brake thermal Efficiency for load condition of oil blend is higher than diesel and to that of Diesel ,indicated efficiency is close to the diesel at all load condition.

C. Comparison of all Parameters 4%, 8%, 12%, Lemongrass oil Blends with Diesel and Pure Diesel with Different Load Condition.



Graph 5 Total Fuel Consumption 4%, 8%, 12% Lemongrass OilBlends With Diesel And Pure Diesel With Different Load Condition

Above data shows the variation of Total fuel consumption with load for lemon oil blends with Diesel in the test engine. Total fuel consumption of 12% oil blends is lower to that of diesel



Graph 6 Specific Fuel Consumption 4%,8%,12% Lemongrass Oil Blends With Diesel And Pure Diesel With Different Load Condition

Above data shows the variation of specific fuel consumption with load for lemon oil blends with Diesel in the test engine. Specific fuel consumption of 12% oil blends is lower to that of Diesel 2.28kw load,4%oil blends is lower 1.55kw load condition .

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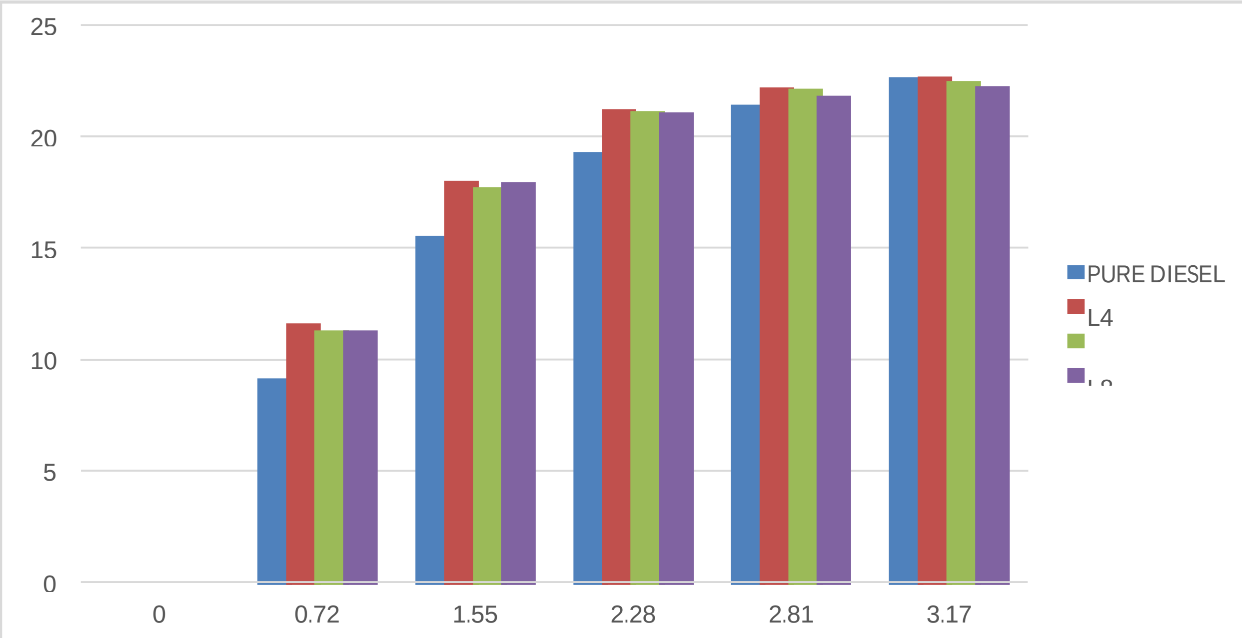
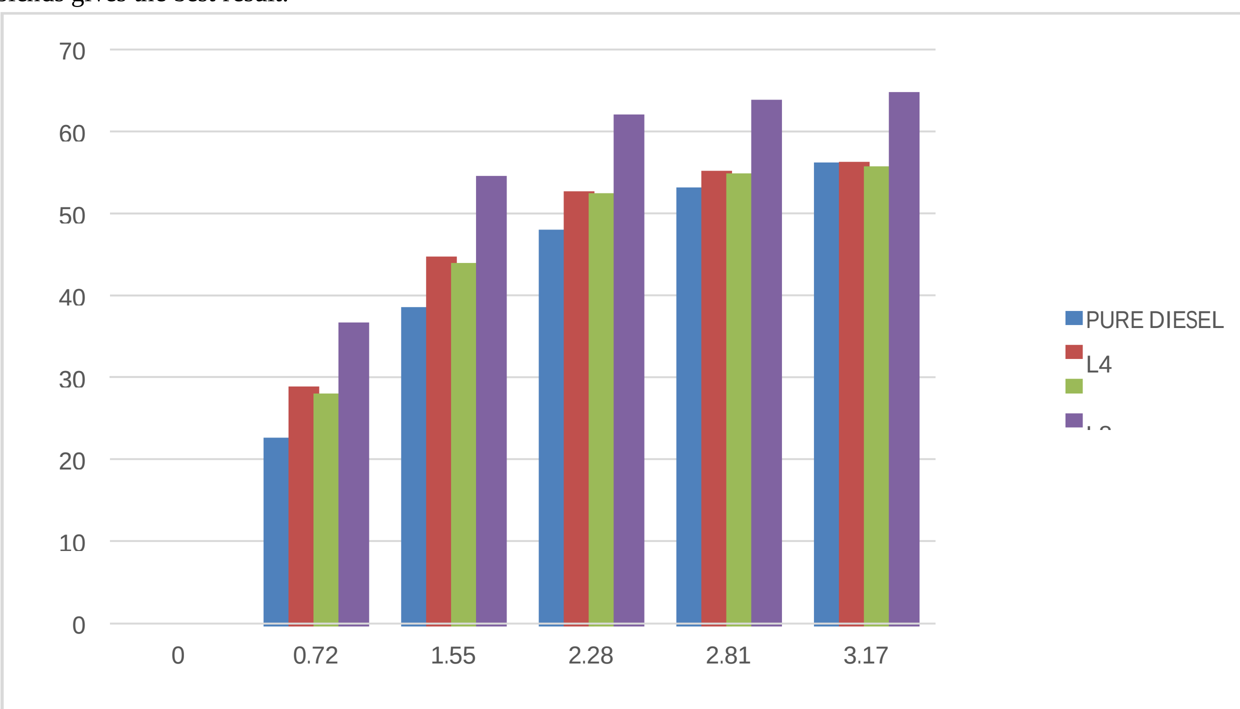


Graph 7 Brake Thermal Efficiency 4%,8%,12% Lemongrass Oil Blends With Diesel And Pure Diesel With Different Load Condition

Above data shows the variation of brake thermal efficiency with load for lemon oil blends with Diesel in the test engine. Specific fuel consumption of 12% oil blends is close to that of Diesel and in load 2.28kw it is higher than the diesel. However lemon grass oil 12% blends gives the best result.



Graph 8 Mechanical Efficiency 4%,8%,12% Lemongrass OilBlends With Diesel And Pure Diesel With Different Load Condition

Above data shows the variation of mechanical efficiency with load for lemon oil blends with Diesel in the test engine. Mechanical efficiency of 12% oil blends is higher to that of Diesel and in all above load condition it is higher than the diesel. However lemograssoil 12% blends gives the best result.

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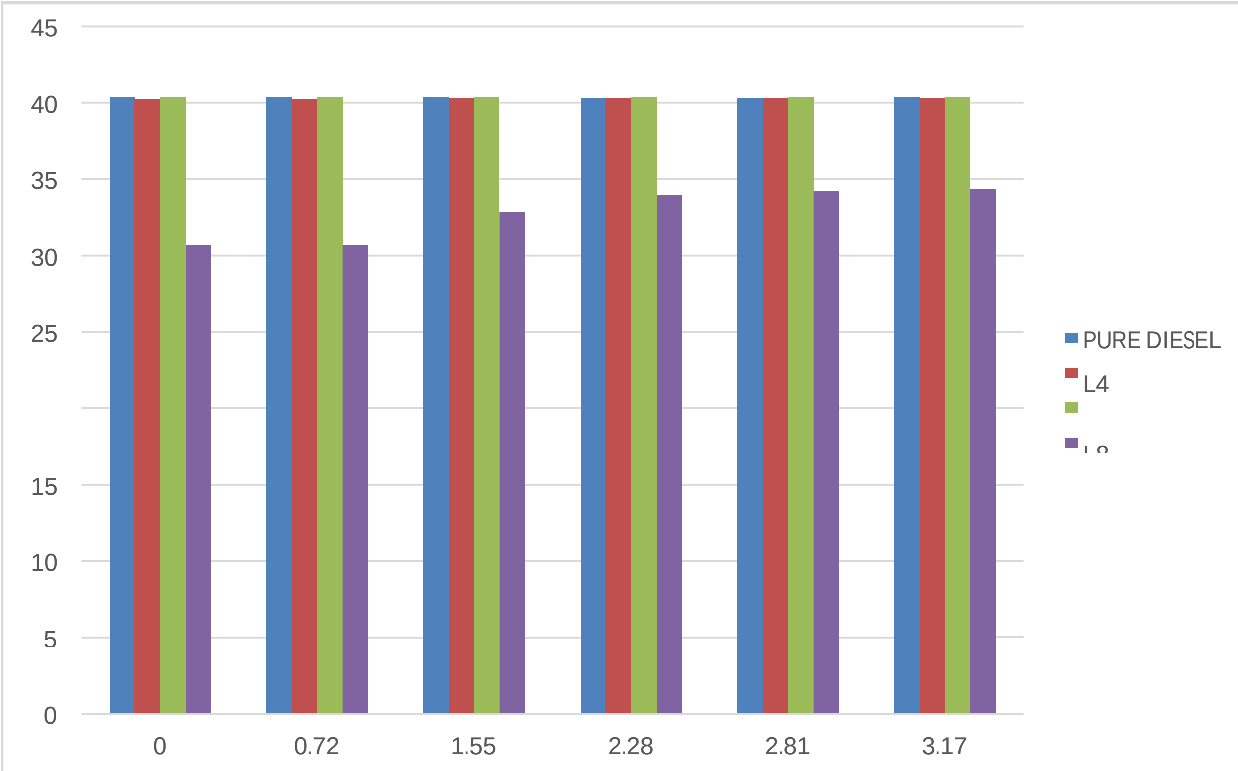
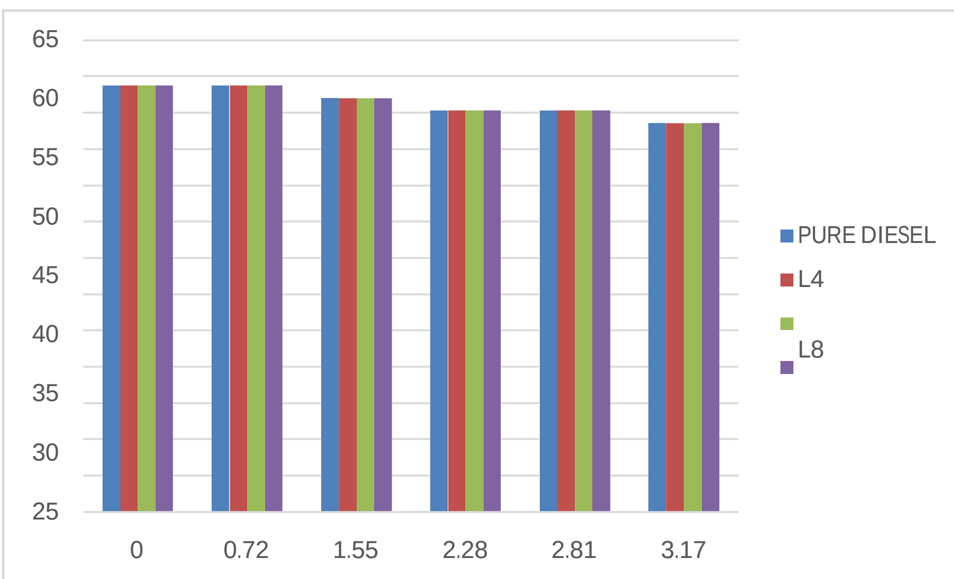


Graph 9 Indicated Efficiency 4%,8%,12% Lemongrass OilBlends With Diesel And Pure Diesel With Different LoadCondition

Above data shows the variation of indicated efficiency with load for lemon oil blends with diesel in the test engine. indicated efficiency of 4%,8%, oil blends is closeto that of diesel and in all load condition.



Graph 10 Volumetric Efficiency 4%,8%,12% Lemongrass OilBlends With Diesel And Pure Diesel With Different Load Condition

Above data shows the variation of volumetric efficiency with load for lemon oil blends with Diesel in the test engine. volumetric efficiency of 4%,8%, 12% oil blends is close to that of Diesel and in all **load condition .**

Above data shows the variation of speed with load for lemon grass oil blends with Diesel in the test engine. L12% of lemon grass oil blends speed is very high that of Diesel.

IV. CONCLUSION

1) Lemongrass oil prepared by stem distillation method and convert to the biodieselby trasesterification process.
2) Lemongrass oil blended with diesel in the ratio of L4,L8,L12.
3) Performance test was conducted in the 5hp diesel engine
4) Methyl ester of lemon grass oil at 12% blend with diesel at gave best performance in terms of Total fuel consumption, brake power; specific fuel consumption and brake thermal efficiency were almost equal when engine was run on pure diesel.
5) The transesterification process, used for making biodiesel, is simple and costeffective to solve viscosity problems encountered with vegetable oils.
6) Brake Thermal Efficiency of lemon grass oil 12% at load 3.17 is more compared to diesel.
7) Brake specific fuel consumption of lemon gras oil (4%&12%) at load 3.17 is less than diesel.
8) Mechanical efficiency of lemon grass oil 12% higher than diesel.
9) High calorific value of lemon grass oil was the main reason of this reduction in thespecific fuel consumption.
10) The difference in density also was one of the reason for this reduction.comparisonof oil blends with diesel.
11) However, lemon grass oil blends gave the best results.

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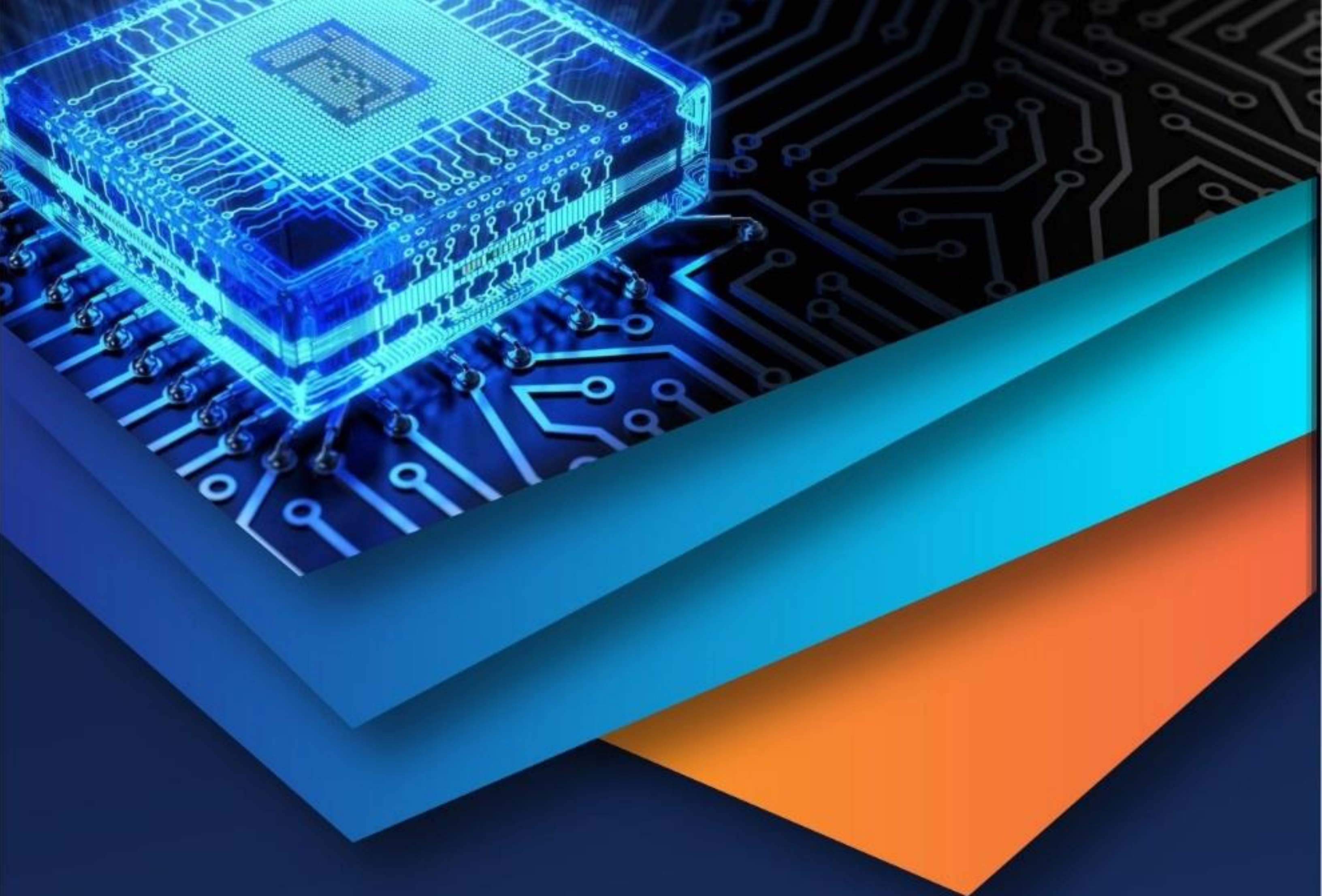

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