

INFLUENCE OF INJECTION TIMING ON VCR DIESEL ENGINE CHARACTERISTICS USING SAFFLOWER OIL WITH ANTIOXIDANT AO1202

Submitted in partial fulfilment of the requirements for the award

**Bachelor of Engineering Degree in
Mechanical Engineering**

BY

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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ABDUL REHMAN (38150002), D. BHARAT (38150020)** who carried out the project entitled **"INFLUENCE OF INJECTION TIMING ON VCR DIESEL ENGINE CHARACTERISTICS USING SAFFLOWER OIL WITH ANTIOXIDANT AO1202"** under my / our supervision from **SEPTEMBER- 2021** to **APRIL-2022**.

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DECLARATION

We **ABDUL REHMAN** and **D. BHARAT** hereby declare that the project report entitled “**INFLUENCE OF INJECTION TIMING ON VCR DIESEL ENGINE CHARACTERISTICS USING SAFFLOWER OIL WITH ANTIOXIDANT AO1202**”, done by me under the guidance of **Prof. Dr. S. GANESAN, M.E., Ph.D.** and **Dr. G. ARUNKUMAR, M.E., Ph.D.** at **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI** is submitted in partial fulfilment of the requirements for the award of a Bachelor of Engineering degree in Mechanical Engineering.

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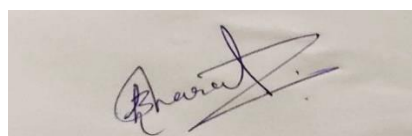
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ABSTRACT

Biodiesel is an alternative means of fuel, replacing and reducing the use of petroleum diesel. The main obstacle in the practical usage of biodiesel is its oxidative stability. Even a small percentage of biodiesel blend in diesel develops sticky, polymeric deposits which get stuck in the air filter and cause unpleasant problems. One promising way to approach the problem of oxidation in biodiesel is the use of antioxidants. Antioxidants inhibit the oxidation reaction and the formation of polymeric deposits. There have been numerous studies carried out with some common antioxidants and still, there are hundreds of antioxidants yet to be tested. The project's main objective is to increase the engine's performance and decrease the emissions from the engine, after testing the performance of biodiesel made by us in the Sathyabama's Engine Lab, a Comparison of emission and performance results is done between diesel and our biodiesel. The biodiesel was made by transesterification process using safflower oil with antioxidant AO1202, then we made four solutions with different concentrations of diesel and biodiesel. All these four solutions were tested in the engine lab. The study compares to change the injection timing & the effect of biodiesel (safflower oil) and antioxidant Ao1202 when it mixed with diesel. Through the process of esterification. The purpose of esterification is to check the viscosity of biodiesel. And then we will compare all 4 sample reading with diesel. Performance and emission characteristics was compared at different loading condition the results were compared and analyzed with diesel. Missions, almost all the solutions under most of the loads in the engine were tested to show a significant reduction in emissions such as NO_x, HC, CO₂, and O₂.

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LIST OF ABBREVIATIONS

BTHE	-	Brake Thermal Efficiency
CO	-	Carbon Monoxide
CO ₂	-	Carbon Dioxide
DLU	-	Dynamometer Loading Unit
NO _x	-	Nitrogen Oxides
O ₂	-	Oxygen
PPU	-	Piezo Powering Unit
SFC	-	Specific Fuel Consumption
VCR	-	Variable Compression Ratio

CHAPTER 1

INTRODUCTION

1.1 VARIABLE COMPRESSION RATIO (VCR) DIESEL ENGINE

Variable compression ratio (VCR) is a **technique for adjusting** the compression ratio of an internal combustion engine while the engine is **running**. This is done to increase fuel efficiency **when changing** loads. **The variable compression engine allows** the volume above the piston to **change** at the top dead center. The first VCR engine built and tested **in the 1920s** was by Harry **Ricardo**. **Through this work, he developed** the octane rating system that is still in use today. Many **companies, such as Saab, Nissan, Volvo, PSA / PeugeotCitroen, Renault,** are doing their own research **on VCR engines**. The 2019 Infiniti QX50 is available **in the retail version** of the engine **with variable compression turbocharger**.



Fig. 1.1: VCR Diesel engine

It is a technology **that adjusts** the compression ratio of **the** internal combustion engine while the engine is **running**. This is done to increase fuel efficiency **when changing** loads. **The variable compression engine allows** the volume above the piston to **change** at top dead **center**. Higher loads require a lower **percentage of power increase**, while lower loads **require a higher percentage** to increase **efficiency**. **H. Reduce fuel consumption.** For **automatic** This should be done for **automatic**. **Deployment is performed according** to load and **operating requirements**. The 2019 **Infinity OX50** is the first **commercial vehicle to use** a variable compression ratio engine.

Mechanisms for varying **the** compression ratio include either a **two-step system that allows you to choose between** a low or high compression **ratio**, or a continuously variable system **that allows you to choose** any compression ratio between low and **high**. **The 2-stage system includes AVL and FEV variable length connecting rods**. Continuously variable systems can be implemented through a variety of **mechanisms, including:**

- **Multi-link** mechanism between crankshaft and piston, Nissan and MCE5
- Movable **head** / **cylinder**
- Eccentric crankshaft **journal**, Caterpillar

- **movable piston head**

In our project we use the **AVL system**. The **two-stage AVL** variable compression ratio system uses a telescopic connecting rod. Actuation by gas or mass **force**. **The inertial** force F_M and **the** gas force F_G are used to lengthen **or** shorten the connecting rod. **A translational connection** shortens the connecting rod when the **resulting** shaft force F_R is **directed** toward the center of the crankshaft ($F_G > F_M$) and **lengthens** the connecting rod when it **acts** in the opposite direction ($F_G < F_M$). **Limiters** define the minimum and maximum **length of the connecting rod**. To **"hold"** one of the two positions, oil is **pumped** into the **volume** below or above the **translating joint**. **The control system signals that the length of the connecting rod needs to be changed.**

1.2 ENGINE SOFTWARE

Engine Software is a **LabView-based** software package developed by Apex Innovations Pvt. It was developed. For engine performance monitoring system Co., Ltd. Engine software can meet the needs of most engine test applications such as monitoring, reporting, data entry, and data logging. The software evaluates performance, efficiency, fuel consumption, and heat release. It can be set according to the engine settings. You can get different graphs under different operating conditions. During the online test of the motor in RUN mode, the required signals are sampled, saved and plotted on the graph. Access the saved data file to view the data in graph and tabular format. You can print the results and graphs. Data in Excel format can be used for further analysis.

1.3 BIO DIESEL

Biodiesel is a **biodegradable** renewable fuel produced from vegetable oils, animal fats or restaurant oils. Biodiesel fuel complies with the requirements of biomass-based diesel fuel and modern biofuels of renewable energy standards.

Biodiesel is a liquid fuel, also known as B100 or “clean” biodiesel. Biodiesel, like diesel fuel, is used to power compression ignition engines. Biodiesel is an environmentally friendly and renewable alternative to petroleum diesel. Biodiesel as an automotive fuel improves energy security, air quality, the environment, as well as safety.

Vegetable oils, yellow fats, vegetable oil residues and animal fats are used to produce biodiesel. Transesterification is used to produce fuels that depend on the long-term availability of energy.

A country's economic growth depends heavily on the long-term availability of energy. The energy source must be safe and environmentally friendly. Diesel engines are the driving force for power generation due to their excellent operability and high thermal efficiency. Despite their advantages, they cause higher emissions. This has a great impact on human health. As fossil fuels are depleted daily, we need to find alternative fuels to meet the world's energy needs. Biodiesel is one of the best available alternative sources of diesel fuel. Diesel engines have relatively low HC

and CO emissions when **running on** biodiesel, but **the** problem of NOx emissions is **even greater**. **Therefore, when biodiesel is used in diesel engines** in order to **comply with** environmental **laws** and reduce emissions, it is highly desirable to reduce the amount of NOX in the exhaust **gas**.

1.4 ADVANTAGES OF BIO DIESEL

- Positive Economic Impact.
- Reducing Greenhouse Gases.
- High-Quality Engine Performance.
- Sustainability.
- Reducing Foreign Oil Dependency.
- Health Benefits.
- Better Fuel Economy.
- Improved Air Quality
- Biodiesel is Undoubtedly a Safer Alternative to Fossil Fuels.
- Biodiesel Could Possibly End Energy Crisis and Energy Politics.

1.5 DISADVANTAGES OF BIODIESEL

- Variation in Quality of Biodiesel.
- Not Suitable for Use in Low Temperatures.
- Biodiesel Could Harm the Rubber Houses of Some Engines.
- Biodiesel is Way More Expensive than Petroleum.
- Increased use of Fertilizers.
- Regional Suitability

Use of Petroleum Diesel to Produce Biodiesel

1.6 SAFFLOWER

The safflower (*Carthamus tinctorius*) is a highly branched herbaceous thistle-like annual plant belonging to the sunflower family Asteraceae. It is grown commercially for its seed-derived vegetable oil and was used as a substitute for saffron in the early Spanish colonies along the Rio Grande. The plant is 30-150 cm (12-59 inches) tall and has spherical flower heads with yellow, orange, or red flowers. Each branch has 1 to 5 flower heads, typically containing 15 to 20 seeds per head. Safflower grows in dry areas with seasonal rains. It grows deep tap water roots that can thrive in such conditions.

CHAPTER 2

LITERATURE SURVEY

From the Gossypium arboreum biodiesel **experiments** conducted by S. Ganesan and **his** team, the **combination** of Gossypium arboreum oil and diesel oil provides **excellent** efficiency and **significant** reductions in CO2 emissions overall, making it ideal for Gossypium. I understand. Make the tree oil blend GAOB20I and IGAOB30.

An experimental **study** of the combustion, **performance** and emission **properties** of wheat germ oil and its mixtures was carried out by Senthilkumar Jayapalan and **his team** on a **DI diesel engine** and the following conclusions were drawn. CO2 emissions are low for all **diesel-biodiesel mixtures** and the **largest** CO2 emission reduction is sample 6 (70% diesel + 30% biofuel + 30 ppm TiO₂). Compared to diesel, the rate of decrease is more than **35%**.

From **experiments** conducted by Hemanandh Janarathanam and **his** team on the **effects** of CNG emissions on **copper-coated catalytic converters** in **4-stroke gasoline engines**, **copper-coated stainless steel wire meshes** have higher temperatures (**heat resistance**). And it is flexible. This coated **SS-304** wire mesh **reduces** CO₂, HC, NO_x, CO and other emissions from your bike.

In the **current** work by Vemuri Sai Srikanth and **his** team, the experiments are **carried out using appropriate** biodiesel, piston **shapes**, and **EGR designs**. The tests will be conducted in a **water-cooled computer-controlled 4-stroke single-cylinder test bench** for CI diesel engines. BSFC with RPOME 15% EGR is **reduced by** about 8% compared to the standard engine. This is **due** to the **correct mixture of** combustion geometry. BSFC with RPOME 15% EGR is **reduced by** about 8% compared to the standard engine. This is **due** to the **correct mixture** in the combustion geometry.

Our **understanding** from **the research by** Ganesan Subbiah and **the team** is that the **gray relationship analysis** is **primarily related to the goal of "optimizing the response affected by multiple independent variables"**. A **homogeneous combustion catalyst** is an **additive** that **dissolves homogeneously in diesel fuel** and **plays a catalytic role** during the **engine's combustion process**. **Lemon distilled oil** will be one of the **safest alternative fuels** in the future. Based on ANOVA results, the **parameters of the nanocatalytic CeO₂ composition** show **62%**, followed by **biodiesel blend 16%**, **BP 11%** and **injection pressure 9%**. CeO₂ composition shows the **main factor** of engine **performance**, and **lemongrass oil blend** shows the second most **important influence parameter**.

This study by S. Ganesan and **his team** **examined** diesel engine **emission** characteristics under various engine process parameters such as **tested citronella oil**, injection pressure, **braking performance**, and **ZnO**. The main **effect plots** for both the **average signal-to-noise ratio** and the optimized combination **are found** for **different engine outputs** and emissions. **Experimental data** show that **with this combination**, engine performance is comparable to that of diesel. **Emissions** are less than diesel.

From the **work of** Rajasekar Rajendran and **his team**, **catalytic converter design** and catalytic **material changes** can be an alternative to **overcoming** high air pollution from the automotive **transport sector**, especially carbon **monoxide** and **NO_x emissions problems**. I found out. diesel engine. Using **zirconia** and **alumina coatings** as **catalysts** in catalytic **converters** can significantly increase carbon **monoxide** and **NO_x emissions reductions**. **Increasing the amount** of catalyst **cells reduced** the concentration of carbon monoxide and **NO_x emissions**. The **optimal** design of the catalytic converter **has reduced** exhaust emissions.

Emissions recorded by Hemanandh Janarthanam and **his team** using **hydride waste cooking oil as fuel** have **reduced CO, HC, CO₂, NO_x, smoke and brake-specific fuel consumption compared to petroleum diesel fuel**. And showed an increase in **brake thermal efficiency**. Therefore, the above

experiments conclude **that 100% hydrogenated spent cooking oil can be used directly as fuel without modification to the engine, reducing emissions and improving the performance of diesel engines. Useful for attaching.**

This research by S.P. Venkatesan and his team **provide solutions for plastic waste disposal and diesel alternative fuels. Waste plastic oil is extracted from plastic waste by a pyrolysis process that uses zeolite as a catalyst. From the test results, the mixture of 50% diesel, 30% waste plastic oil, and 20% n-hexane by volume worked better than the other mixtures. The following conclusions can be drawn from the experimental tests. (1) Among the fuels tested, the D50WPO30H20 blend was observed to perform better than all other blends, indicating that the thermal braking efficiency of this blend is 1.265% and 14.285. rice field. % Will be. Increases** compared to pure diesel and WPO at full load. (2) NOx emissions were found to be 4.04% and 8.96% lower when the engine was run on the D50WPO30H20 blend compared to pure diesel and WPO. (3) It was found that when the engine power source was used in the D50WPO30H20 blend, the smoke emission was 30% lower than diesel and 40% lower than WPO.

Observed to increase SFC by 55%, brake thermal efficiency by 9%, hydrocarbon emissions by 76%, carbon dioxide emissions by 10%, and nitrogen oxide emissions by 22%. I am. Reduce NOx emissions with low-viscosity biofuels using exhaust gas recirculation technology by Rajasekar Rajendran and the team. It was concluded that BE3, which contains 500ppm Pyrogallo with 75% diesel, 20% LG, 5% DEE, and 25% EGR, has superior performance and emission characteristics compared to the other two blends.

Taguchi-based optimization of diesel engine parameters with a blend of lemongrass oil and ZnO by S. Ganesan and the team, the activation energy of zinc oxide burns carbon deposits in the engine cylinder at wall temperature, non-cylinder wall Polar compounds help reduce HC emissions. Testing has shown that zinc oxide nanoparticles can be used as an additive in diesel-biodiesel blends to improve complete fuel combustion

and **significantly** reduce **emissions**. Using **gray relation analysis**, it has **been** observed that **multi-response** parameters are optimized and converted to single response. **Taguchi's methodology** was used to **analyze** the experimental **data**. The main **effect** plot for both the **average gray level** of the optimized combination and the **average signal-to-noise ratio** is A3B1C3. In this particular combination, it is predicted from the experimental data that the engine performance is comparable to that of diesel, moreover, the emissions are less than that for diesel.

From a **study by** Ganesan Subbiah and **his team**: For better BTHE, we need to run the **motor** under **A1B3C1D3 conditions**. For low X-specific fuel consumption and CO, the engine **must operate** under **A3B3C1D1** and **A3B2C1D2 conditions**. x For low HC, the experiments were 45 ppm MgO, 3 KW BPI, 200 l23 bar injection pressure, 10% L.B, 15 ppm MgO, BP I 4.4 KW, 200 lbar injection pressure and L.B. 10%. so.

Test results by J. Hemanandh and **the team** show that at higher loads the **engine temperature dropped** by 2 °, NOx and CO **dropped**, and HC and **exhaust temperatures rose slightly**. Experiments performed have shown that **purified 26 palmols in biodiesel provide the desired release pattern** when blended with diesel by varying the **pressure**.

From **experiments by** Hemanandh Janarthanam and **his team on biodiesel synthesis from chicken meat processing plant waste on a DI diesel engine**, it can be said that the **biofuels** produced have low **emissions** and **lower fuel prices**. Biochar is produced as a **by-product** during the **test**. The mixture is **9.68% 100% charged because it has a high nitrogen content and can be used as a biofertilizer to improve soil quality compared to pure diesel**.

Hemanandh Janarthanam's environmental emission control experiments and team results for CI engines using hydrotreated biofuels in India show that **Jatropha oil has reduced emissions and performance compared to refined palm oil in petroleum and petroleum diesel**. **Showed to improve**. 25 CO emissions decreased by 14.26% and 28.57% for HTRPMB100

and **HTJATB100**, respectively. HTJATB100 and HTRPMB100 **have** reduced **HC emissions** by **57.5% and 52.6%**, respectively.

CHAPTER 3

AIM AND SCOPE OF PRESENT WORK

3.1 AIM

The **main purpose** of this **work** is to study the emissions and performance characteristics of **direct-injection diesel engines using biodiesel** (safflower oil) and **the** antioxidant AO1202. **Thermal braking** efficiency (BTHE) and fuel consumption **rate** (SFC) **can also be examined**.

3.2 SCOPE

The scope of this work is to analyze **engine** performance at **various** rated **powers** evaluated in terms of **fuel consumption rate** (SFC), **braking thermal efficiency** (BTHE), and **emission** characteristics such as HC, CO, CO₂, NO_x. **is. Biodiesel** is **manufactured** from sesame and palm oil **using** a transesterification process. **Biofuels have been tested on DI diesel engines**. The engine was **idle**, the test **mixture** **was** added **first**, and the **sample** emission and performance characteristics were recorded.

CHAPTER 4

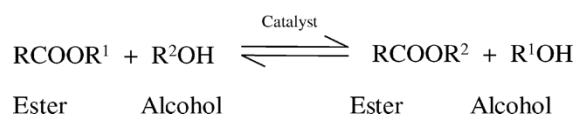
MATERIAL AND METHODS

4.1 SAMPLE PREPARATION

- 1) S1= 90% diesel + 10% bio diesel
- 2) S2= 80% diesel + 20% bio diesel
- 3) S3= 75% diesel + 25% bio diesel
- 4) S4= 70% diesel + 30% bio diesel

4.2 TRANSESTERIFICATION

Transesterification is the process of displacement of alcohol from an ester by another ester. This process is used to reduce the viscosity of triglycerides. Glycerol and alkyl ester are obtained from the transesterification of triglycerides.



The transesterification of the unrefined rubber seed oil involves two esterification process:

- a) Acid esterification
- b) Alkaline esterification

4.2.1 Acid Esterification

This process involves in the reduction of the FFA of the crude rubber seed oil using acid catalyst. 200ml of methanol is required for the acid esterification of

one litre of rubber seed oil. The rubber seed is heated to about 50°C. The preheated rubber seed oil is mixed methanol and stirred for a few minutes and 0.5% of sulphuric acid is also added with the mixture. At atmospheric temperature the heating and stirring is continued for about 20-30 minutes. The top surface contains the excess alcohol with sulphuric acid which is removed. The lower layer is forwarded to the next process. The Acid esterification reduces the FFA content of the crude.

4.2.2 *Alkaline Esterification*

After reducing the FFA content the, oil is trans esterified to mono esters of fatty acids using acid catalysts. The alcohol to oil ratio, catalyst amount, reaction temperature and duration which affects the process are analyzed. The oil obtained from the acid esterification process is preheated to the temperature of 40-50°C in the flask. 5 gram of NaOH is dissolved in 300ml methanol. Heating and stirring of mixture is continued for about 30 min then the mixture the left alone for the separation of two layers. The lower lawyer contains the impure glycerol and is removed. The upper layer contains the ester. To remove the entrained impurities and glycerol the methyl esters are washed. 10% volume of the hot distilled water is sprayed over the ester and stirred gently. The yellow color layer is removed. This layer is the biodiesel. The alkaline catalyst transesterification process has converted the products of acid esterification to it's mono esters and glycerol.

4.3 EXPERIMENTAL SETUP

The **test installation consisted** of a **4-stroke single-cylinder engine with** variable compression **combined with** an eddy current dynamometer. The diesel engine **is directly connected to** an eddy current dynamometer **to vary the load** from no load (0%) to full load (100%). Based on engine power, engine load **varies between idling** conditions of 0%, 25%, 50%, 75% and full load conditions of **100%**. The **motor load is changed** manually **using** an eddy current dynamometer. Airflow **is measured using a calibrated vent mounted** air drum and fuel flow **is measured by** the volumetric calibrated burette method. **To measure the fuel flow**, two fuel tanks were used; one is filled with pure diesel

while **the converted Dualfuel biodiesel** is filled in another fuel tank. An AVL smoke meter is **fitted to measure** smoke opacity and exhaust gas **temperature**. The test **bench** is installed with AVL indimicro software to obtain **different results and** readings during operation. A **five gas** analyzer is used to measure emission characteristics such as HC, CO, CO₂, O₂ and NO_x values **of** the exhaust gas. **Emission and** performance tests **are** conducted at a compression ratio of 17.5 and rated **horsepower**.

Analysis of engine performance at different power **levels** evaluated **for specific** fuel consumption (SFC), **brake thermal efficiency** (BTHE) and emissions characteristics such as HC, CO, CO₂ and **NO_x** .



Fig. 4.1: Experimental setup



Fig.4.2: Engine Testing Lab

4.4 VCR DIESEL ENGINE



Fig.4.3: VCR Diesel Engine

Features

- CR changing without stopping the engine

No alteration in Combustion chamber geometry

- Water cooled EGR
- Electric start with battery and charger
- Arrangement for blend test

Range of Experiments

- Study of VCR engine performance
(Computerized mode)
- Study of emissions with EGR variation
- Study of combustion with different fuel blends
- Study of pressure volume plot and indicated power

Electric supply

230 +/- 10 VAC, 50 Hz, 1 phase

Computer

IBM compatible with standard configuration

- P θ -PV plots, performance plots and tabulated results
- Data logging, editing, printing and export,
- Configurable graphs
 - IP, IMEP, FP indication, combustion analysis.

4.5 ENGINE SPECIFICATIONS

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Comp.)
Product code	234
Engine	Make Kirloskar, Type 1 cyl., 4 stroke Diesel, water cooled, power 3.5kW at 1500rpm, stroke 110mm, bore 87.5mm. 661cc, CR17.5, Modified to VCR engine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100°C, 3 Nos; Thermocouple, Range 0-1200 °C, 2 Nos
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	"EngineSoft" Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump	Type Monoblock
Overall dimensions	W 2000 x D 2500 x H 1500 mm
Optional	Computerized Diesel injection pressure measurement with injection variation 0-25 deg BTDC

4.6 ENGINE TESTING SOFTWARE

Engine Software is a software package **based on LabVIEW** developed by Apex Innovations Pvt. Ltd. for engine monitoring system. **The Engine software can cover most engine test application needs**, including monitoring, reporting, data **entry and data logging**. The software evaluates power, **performance**, fuel consumption and **heat**. It is configurable **according to the engine configuration**. **Different** graphs are obtained **under** different operating **conditions**. **During** the engine **online test** in **RUN mode**, the necessary signals are scanned, stored and presented **graphically**. The stored data file is **accessible** to view **chart** and tabular **formats of the data**. **Results** and graphs can be printed. **Data** in **Excel** format can be used for further analysis.

4.7 TEST RUN WITH COMPUTERIZED MULTI CYLINDER ENGINE SETUPS

- **Make sure** that all **bolts and nuts** on the **motor**, dynamometer, **crankshaft and basses** are **properly** tightened.
- **Make sure there is enough lubricating** oil in the **crankcase**. This can be checked by the **mark** on the **level gauge**.
- **Make sure there is enough** fuel in the fuel tank. Remove air in the fuel line, if **present**.
- **Turn on the** power supply and **make sure** that the PPU (**Piezoelectric Power Unit** AX 409), DLU (**Dymometer Loader** AX155). Load indicator und Voltmeter are switched on.
- Start Computer and open "ICEngineSoft" (Double click "ICEngineSoft" icon on the desktop) Select: File| Configure| Product.
- In "Configure the product" window select "Load Default".
- Under "Select File" choose your Setup from drop down menu.
- Under "Set Parameters" study the parameters under Engine Sensors, Combustion and Performance tabs Click on "OK".
- **The parameters have been changed.**

- If a parameter **needs** to be **modified**, click **"New / Modified"**. Change **Parameter**
- in the respective tabs After all **changes**, click **"Save and Apply"**.
- Click **"OK"** to save the **changes**.
- Click **"OK"** again to reconfigure the **changes**.
- **Reconfigure the graphics.**
- Select **file | Configuring the graph In the "Configure" graph** window
- "Select a **profile**" from the **drop-down** menu.
- **Review predefined** configuration of **X-axis, Y-axis chart bands**, for **selected**
- **charts**. Click **"CLOSE & SET"**Configure the **parameters, range**
- **needed, if necessary**. Click **"SAVE"** and then **"Close & SET"**.
- Note the three vertical **tabs**, viz. Similarly, **below the other**
- vertical **tabs**, we get more horizontal tabs. Start the water pump. Adjust the **flow rate**
- of **"Rotameter (Engine)"** to 9001000 LPH and **"**
- **Rotameter (Colorimeter)"** to 200250 LPH by manipulating the respective values of the
- **sphere** provided at the **top. input of the rotameter**. Ensure that water **flows** through the
- dynamometer at a pressure of 0.5 to 1 Kg/cm2. (For **hydraulic dynamometer**
- at a pressure of 1.5 to 2 Kg/cm2).
- **Hold the DLU button to the minimum position**. Change the position of the **fuel hose** from **"Measurement"**.
- **Fuel tank "**. Start the engine with the **ignition** and let it **idle** for 45 minutes.

4.8 ONLINE DATA ACQUISITION

- Click the toggle switch **Go** to **"Start/Stop"** device communication. Green **color** indicates **ON status** Click the **"Measurement"** toggle switch to **start/stop data collection**. Green indicates **ON status**.
- **Make sure the speed, temperature and measured**

value are **displayed** correctly on the PC. These **values** **must** **match** those **shown** on the **motor** **board**.

Increase the **motor** load **by** **turning** the knob on the DLU and confirm **that** the load **readings** on the indicator and **calculator** are **the** same.

- Gradually increase **the** throttle to full **throttle** and load the engine **while** **keeping** the engine speed at **2000-2600 rpm**.
- Wait for **a** steady state for 3 minutes and **make sure** that **RPM** and **load** are constant during this **time**. Change the position **of the fuel nozzle** from **"Reservoir"** to **"Measurement"**. Click **"Sign In"** **above**. The fuel metering is ON for next 60 seconds. During first 30 seconds enter engine. Water flow, calorimeter jacket cooling water flow in LPH Click "OK" after recording fuel reading. Enter the file name under which the records to be stored. The first reading data is now saved. Change the Fuel cock position from "Measuring" to "Tank".
- Gradually decrease the load to the increase speed in steps of 500 RPM up to 4000 RPM maximum and repeat the data logging for each observation.
- After finishing all the readings simultaneously decrease the load on the engine by DLU. Gradually decrease throttle to full down condition.
- Click toggle switch "Measurement" to Stop data acquisition in PC (Green colour indicates ON condition) Click **the "Mode"** toggle to **stop** **communicating** **with the device**.
- Click: **File | Data | Close**. Stop the engine by pressing **the start button** to stop the engine. Let the water circulate for about 5 minutes to **cool the engine**, then **turn off** the pump.
- Click: **File | Data | Open**. on the PC, **select the file** where the readings are **saved** and click **"OK"**. To view **subsequent** readings, click **"Tracking Data"**. The results are displayed on three screens.
- **Print report** Click **"Report"** tab to **access report generation performance** Enter **filename** in **"Report file"** Select **Burn report**. **reporting requirements**, viz. **Result data, observation data, graphs only** OR **graphs and tables**. (Note: if **"Charts and Tables"** option **is** **selected**).

Fire report, the output file **size to print**, otherwise it becomes too **large**. However, it can be viewed in Excel) **Click into: File | Data | Close**. After **printing and verifying**. Click "Exit" and then Shut Down **Computer**.

4.9 SMOKEMETER

To take the readings from Smoke meter to ADCS Software kindly follow these steps-

- Kindly fill the details (Engine No, Model, Engine Type, Engine Speed). In respective text boxes given on the form. If you didn't check "Vehicle details" check box in Master data entry form all the Textboxes related to (Engine No, Model, Engine Type, and Engine Speed) become disabled.
- Click on "Connect button" to connect the PC with equipment and wait for 5- 10 second. If the readings are not coming it shows the message in red colour "Unable to Communicate with Equipment" kindly Check the following:
- Be sure that Smoke meter model name display on screen is same as your Smoke meter if not kindly Master the model in Data Entry Form".
- Check the COM port settings with PC and the Software in "Master Data Entry form".
- RS232 Cable for smoke meter is working property and connected with equipment.
- Readings are coming with equipment and display on remote of smoke meter.
- According to "Time interval settings" in selection box, readings are automatically saves in database.

- After taking the readings click on “Disconnect button”. it disconnects the communication with equipment and show the message “Disconnected”.
- Report: Click on report button to take the rear of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel Sheet: To export data in excel sheet click on "EXPORT TO EXCEL" button When pressing export button, a excel file is generated at path “C: \AVLFolder\” The file name of excel file is same as test date and VIN no (Tuesday, January 06, 2022).
- Close button: click on close button to exit from current active window or screen, it takes time to close, so wait for 10-15 seconds for form window to close.



Fig.4.4: Smoke Meter



Fig.4.5: Linearity Test

4.10 GAS ANALYZER

To take the readings from Gas analyzer to ADCS Software kindly follow the steps:

- Kindly fill the details (Engine No, Model, Engine Type, Engine Speed) in respective text boxes given on the form.
- Click on "Connect button" to connect the PC with equipment and wait for 2-3 minutes. if the readings are not coming it show the message in red colour CO, HC power not communicating kindly check the following.
- Be sure that gas analyzer settings in "MAHA Euro" mode.
- Connect to COM port settings with PC and the software.
- RS232 Cable is working properly and connected with equipment.
- Readings are coming with equipment and display on panel.

- After 6 seconds readings are automatically saved in database and status bar strip moving according to readings save in database.
- After taking the readings click on “Disconnect button”. it disconnects the communication with equipment and show the message Saved Database.
- Click on report button to take a part of the test.
- Print: Click on print button to take the printout of screen as bitmap image.
- Export to MS Excel Sheet: To export data in windows sheet click on
- "EXPORT TO EXCEL" button. When pressing, export button excel File is generated in a path C:\AVLFolder file name of excel file is same as Test
- Date and VIN no (Tuesday, January 06, 2009_ 23).
- Close button: click on close button to exit from current active window screen.



Fig.4.6: Five Gas Analyzer Reading



Fig. 4.7: Five Gas Analyzer

CHAPTER 5

RESULTS, DISCUSSION, AND PERFORMANCE ANALYSIS

5.1 EMISSIONS

Biodiesel has been shown to **have an advantage** over diesel in terms of emissions composition. **Biodiesel, when burned**, emits nominal **or zero SO₂**, **low** in polyaromatic hydrocarbons, **carbon black** and **CO**. Combustion **power** is **described as** the ratio of the **free** energy in combustion to the **higher calorific value** of the fuel. This **capacity** can be optimized **by** changes in air and water **mass** to the **burner**, which **can also have an impact on** the final **composition** of the exhaust **gas**. **The combustion capacity also depends on the exhaust gas** temperature and therefore **on the CO₂ concentration** in the exhaust **gas**. High **CO₂ levels** indicate that combustion is **ending** and most of the fuel **has been** consumed. **Stack** temperature is directly **related to** the amount of soot and scale **deposited** on the heat transfer **surface**. With **more soot accumulation**, the conductive heat transfer constant of the surfaces **decreases** and additional **useful** heat is lost in the **trouser leg**. For these reasons, it is **essential** to tune the **burner** to maximize the **CO₂ concentration** in the stack **while** minimizing the **amount of smoke produced**.

5.2 HC EMISSIONS

Hydrocarbon emissions are **made up of unburnt fuel** due to the **short heat that occurs near the cylinder walls**. **Currently, the temperature of the air-fuel** mixture is **only in** the middle of the cylinder. Hydrocarbons **include** thousands of species, **such as** alkanes, alkenes, and aromatics. **They are** usually declared in terms of equivalent **CH₄** content. Diesel engines **in general** emit low **amounts** of hydrocarbons. Diesel hydrocarbon emissions **mainly** occur at **light** loads. The most **significant source** of **low-load** organic compound emissions is **the lean air-fuel mixture**. In lean **blends**

the flame velocity may also be too low for complete combustion to take place throughout the power stroke, OR combustion may not occur and these conditions cause emissions. high hydrocarbons.

In diesel engines, the type of fuel, tuning and engine model affect the hydrocarbon content. In addition, HC emissions in the exhaust gas depend on occasional operating conditions. The instantaneous change in engine speed is high, the injection process is disordered, the injector cavity volume is too large and the needle bounce of the device will cause an important amount of unburnt fuel to enter the exhaust pipe. Unburnt hydrocarbons still react in the exhaust if the current temperature is above 60°C, so the amount of organic gas emitted from the pipeline can also be significantly lower than the amount of hydrocarbon entering the cylinder. Hydrocarbon emissions occur not only in the vehicle exhaust, but also in the engine crankcase, equipment, and from local exhaust during fuel distribution and delivery. Indoor hydrocarbon emissions and transitional loss of hydrocarbon emissions ranges from 20 to 35 and 15 to 25 respectively. Hydrocarbons are harmful to the atmosphere and human health. Along with alternative waste emissions, they play an important role in terrestrial gas formation. The means of transport are responsible for about 50 people monitoring the emissions of this gas. Hydrocarbons are potentially irritating and carcinogenic.

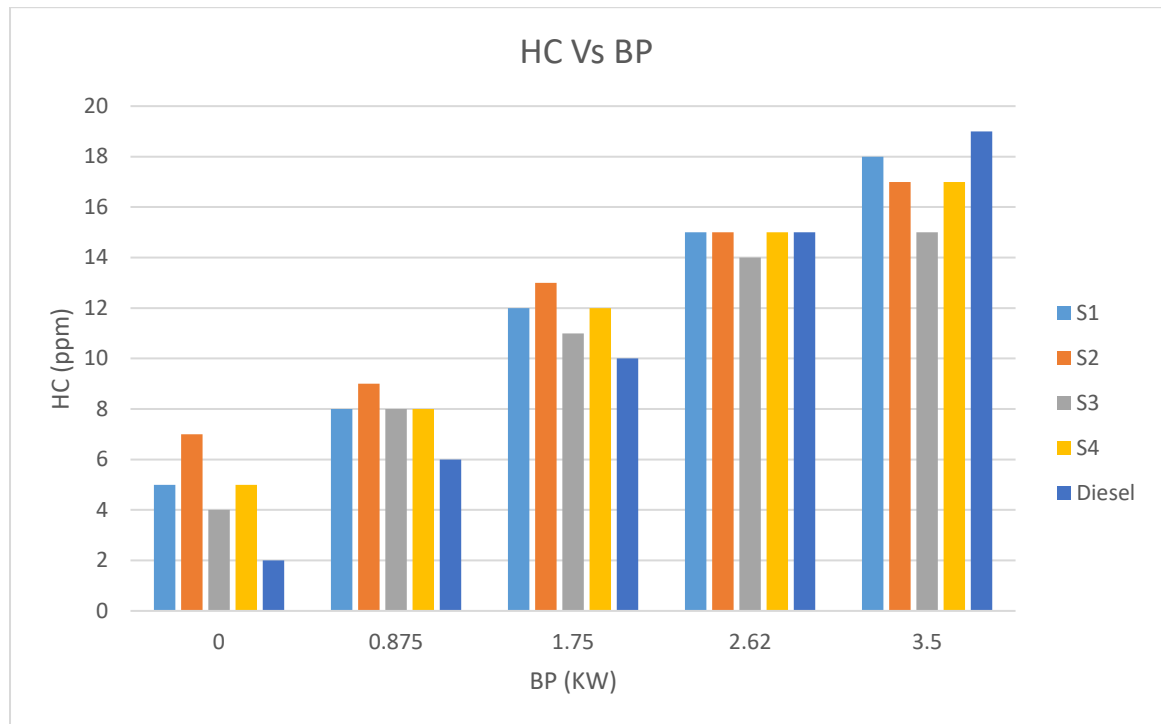


Fig.5.1: HC Vs BP

Table 5.1: HC Emissions of S1, S2, S3, S4, S5 Diesel with loads

BP (KW)	0	0.875	1.75	2.62	3.5
S1 (ppm)	5	8	12	15	18
S2(ppm)	7	9	13	15	17
S3(ppm)	4	8	11	14	15
S4(ppm)	5	8	12	15	17
S5(ppm)	4	7	12	15	18
Diesel(ppm)	2	6	10	15	19

The graph shows the variation of HC emissions with load (KW) of different biodiesel blends. It is shown that with an increasing load there is a decrease in HC emissions for solutions whereas the opposite for diesel. At lower loads, S2 emitted the highest HC, but as the load increases HC emission of diesel increases, and S1,S2,S3,S4 are in similar range.

5.3 CO (CARBON MONOXIDE) EMISSIONS

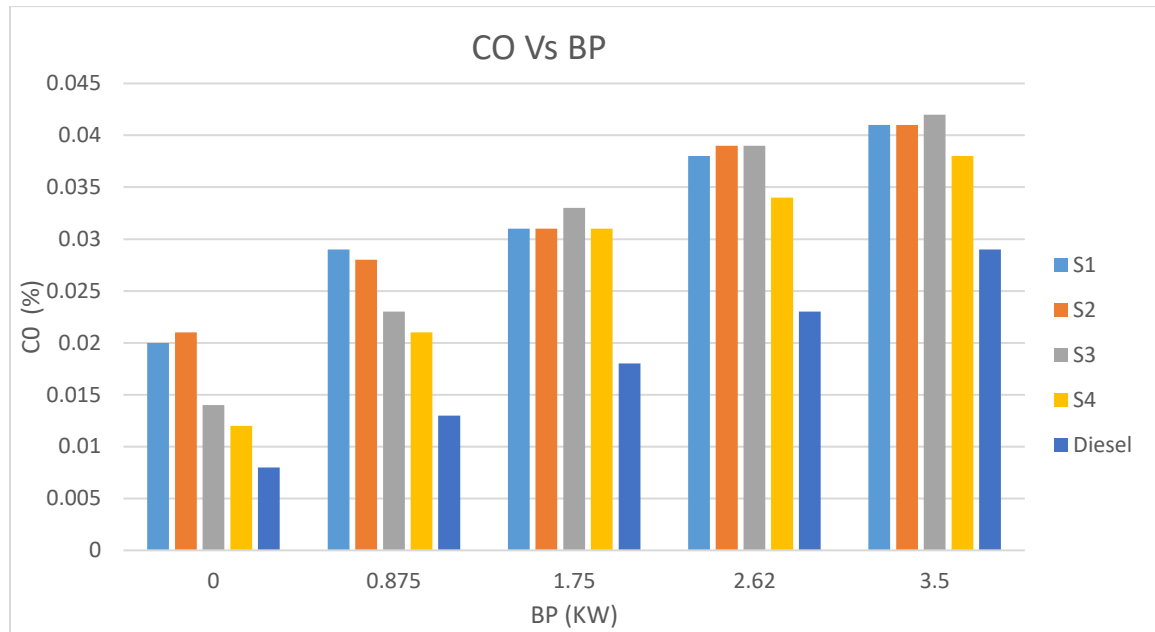


Fig.5.2: CO Vs BP

Table 5.2: CO Emissions of S1, S2, S3, S4, Diesel with loads

Samples/BP	0	0.87	1.75	2.62	3.5
S1	0.02	0.029	0.031	0.038	0.041
S2	0.021	0.028	0.031	0.039	0.041
S3	0.014	0.023	0.033	0.039	0.042
S4	0.12	0.021	0.052	0.034	0.038
Diesel	0.1	0.19	0.02	0.38	0.41

The following graph depicts the change in CO emissions with BP(KW) for S1,S2,S3,S4,Diesel. Diesel emitted the least amount of CO at minimum load.S3 emitted the maximum amount of CO among other samples and diesel. S4 has emitted the lower amounts of CO at higher loads compared to other samples. As the load increased CO emissions were gradually raised.

5.4 O₂ (OXYGEN) EMISSIONS

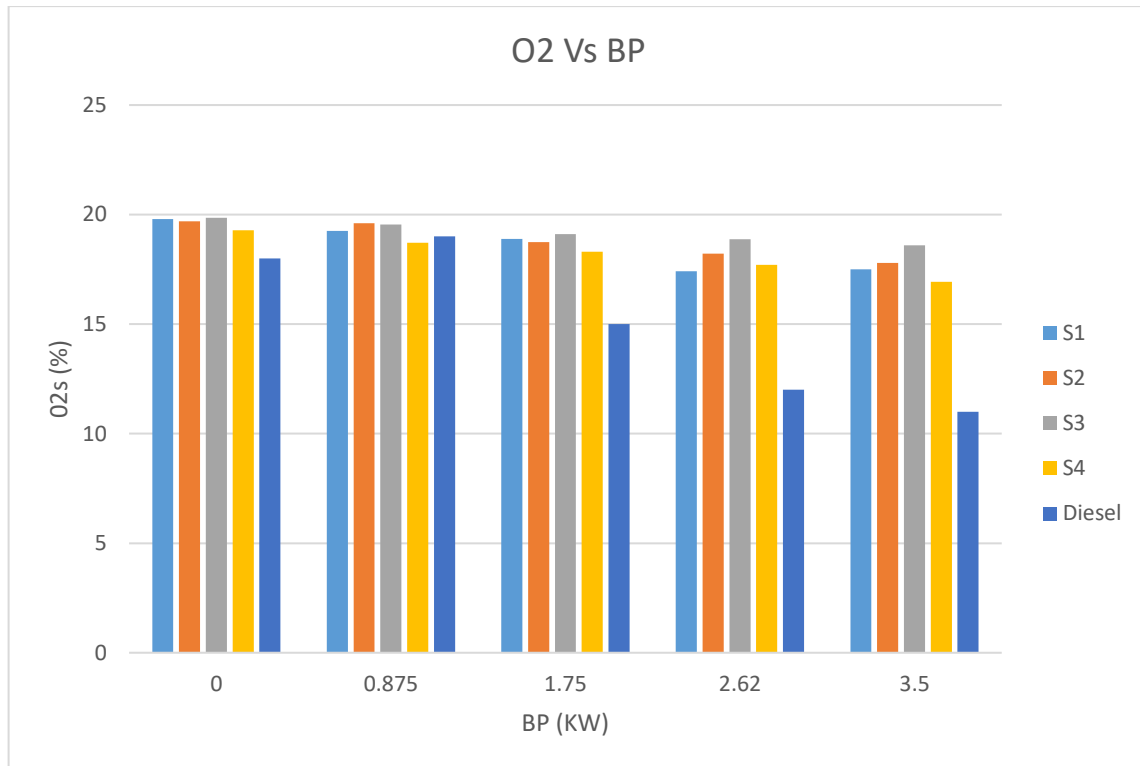


Fig.5.3: O₂ Vs BP

Table 5.3: O₂ Emissions of S1, S2, S3, S4, Diesel with loads

Samples/BP	0	0.87	1.75	2.6	3.5
S1	19.8	19.25	18.89	17.42	17.5
S2	19.7	19.6	18.75	18.21	17.8
S3	19.85	19.54	19.11	18.87	18.59
S4	19.28	18.72	18.3	17.7	16.93
DIESEL	19.8	18.7	17.89	17.54	16.7

The following graph depicts the change in O₂ emissions with BP(KW) for S1, S2, S3, S4, Diesel. As the load increased it lead to decrement of oxygen emissions. At 0 BP(KW) S3 emitted the higher amount of O₂ by S3 sample which was 19.85PPM. S3 has emitted a good amount O₂ compared to other samples. Diesel at 3.5 BP(KW) has emitted low amount of O₂ compared to other samples.

5.5 CO₂ (CARBON DIOXIDE) EMISSIONS

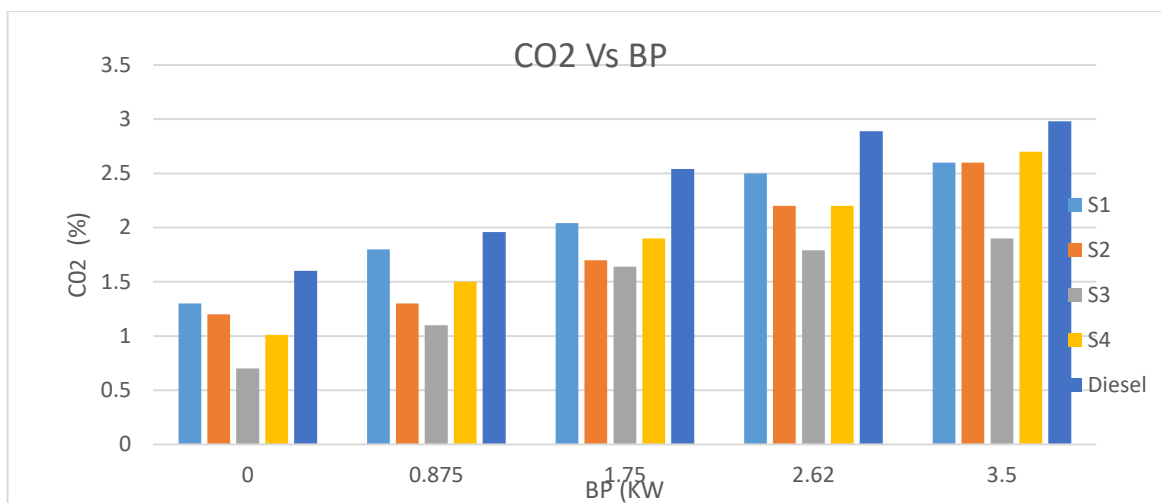


Fig .5.4: CO₂ Vs BP

Table 5.4: CO₂ Emissions of S1, S2, S3, S4, Diesel with loads

Samples/BP	0	0.87	1.75	2.6	3.5
S1	1.3	1.8	2.04	2.5	2.6
S2	1.2	1.3	1.7	2.2	2.6
S3	0.7	1.1	1.64	1.79	1.9
S4	1.01	1.5	1.9	2.2	2.7
Diesel	1.2	2.1	2.3	2.4	2.9

The following table depicts the change in CO₂ emissions for S1, S2, S3, S4 and Diesel with BP(KW) of 0, 0.87, 1.75, 2.6 and 3.5 loads. The graph depicts the variation of CO₂ emission versus BP (KW) for different test fuel. It was recorded with increasing BP (KW) there is a slight increase of CO₂ emission for all solution. At higher load, S1 has a little bit CO₂ emission than other samples but overall all solutions under all conditions, emission of CO₂ is lower than that of diesel. At 1.75 BP (KW) S2, S3 released lower levels of CO₂ among other samples and diesel whereas S1 emitted the higher levels of CO₂.

5.6 NOx EMISSIONS

Nitrogen **oxides** (NOx) are a **group** of **highly** reactive gases, **including** compounds **ranging** from **nitrogen** to **acids**. These compounds are **mainly emitted** in the **exhaust gases** of **trucks, cars, stations** and **off-road vehicles**. NOx **gas is formed** when nitrogen and oxygen in the air react at very high temperatures and pressures inside **the** combustion cylinder, which **can go** up to 4000°F and **300 psi**. In direct injection, ICE fuel is **injected** into the cylinder and forms small droplets. Oxygen interacts at the boundary surface between the air and **thus** the fuel droplets **fall** wherever the **local** temperature in the fuel **drops** by 41 beyond what is required to produce NOx gas. Normally, large amounts of oxygen and heat can lead to high levels of NOx formation. These conditions are **common** in diesel engines **because** they run on a **mixture of air and lean ++ fuel and** at high compression ratios. Fuel produces less NOx than gas **during** combustion, **but** with the implementation of chemical action **conversions** in **high-powered gas-powered** vehicles, diesel engines release **more** NOx into the **chassis**.

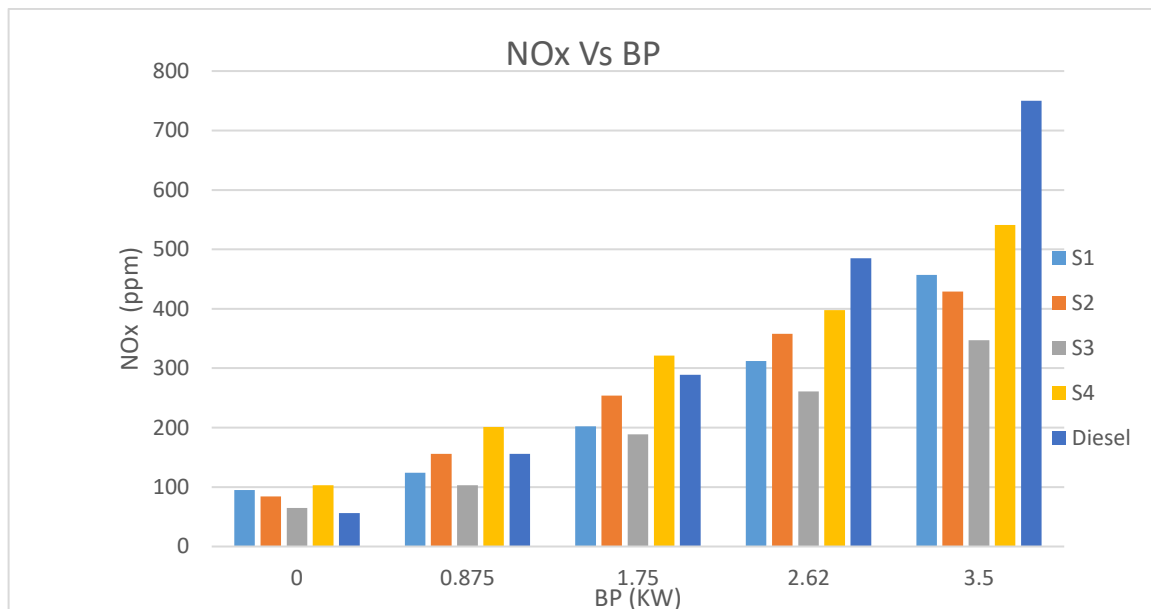


Fig. 5.5: NOx Vs BP

Table 5.5: NOx Emissions of S1, S2, S3, S4, Diesel with loads

Samples/BP	0	0.87	1.75	2.6	3.5
S1	95	124	202	312	457
S2	84	156	254	358	429
S3	65	1.3	189	261	347
S4	103	201	321	398	541
DIESEL	81	123	245	305	426

The graph displays the change in NOx emissions with BP(KW) for S1, S2, S3, S4, Diesel. NOx emission for S1, S2, S3, S4, are significantly lower than diesel emission when the load is applied. S3 out of all samples has recorded a little over diesel-only when 0.875 KW load was applied.

When no load was applied diesel actually emitted less NOx than all the solution, but as the load was increased diesel emitted a lot of NOx when compared to other solutions.

The least emission of NOx was produced with diesel when subjected to 0 load which is 56 PPM and the highest also by diesel when subjected to 3.5 KW load.

At loads 0.875 and 1.75 KW S4 emitted 201 and 321PPM respectfully which were a little higher when compared to other solutions at those Load.

5.7 PERFORMANCE ANALYSIS

5.7.1 *Brake Specific Fuel Consumption (BSFC)*

The fuel efficiency of any **primary engine** that burns fuel and produces **rotational** or **shaft** power is **usually** measured **using** a parameter called **brake specific fuel consumption**. It is **often** used **to compare** the efficiency of **an** internal combustion **engine** with **the output** of the **shaft**. **BSFC can be direct fuel power from** any engine that burns fuel and produces **moving power**. **However, the BSFC award indicates that the fuel-converting engine is equipped with efficient useful work.** One of the most **used** parameters **to test biodiesel properties** on BSFC is **the** hot price. The **higher** the **heater** price, the lower the BSFC **because a decrease in the fuel price leads to increased fuel consumption to achieve** the corresponding power output. **Although** biodiesel has a higher **heating cost, it is still lower than diesel, resulting in a higher BSFC** than diesel **fuel in all respects**. Another parameter that **determines** the **operating** characteristics of biodiesel is the **oxygen** content **of** the fuel. This is often **the** result of **the biodiesel's** higher oxygen **content, which** helps facilitate better combustion. Variable engine **loads also play an important** role in **understanding** the **operating** characteristics of biodiesel. Studies have shown that increasing engine load from **0** to full load shows a decreasing trend **in** BSFC and therefore **a decrease in specific brake energy consumption**.

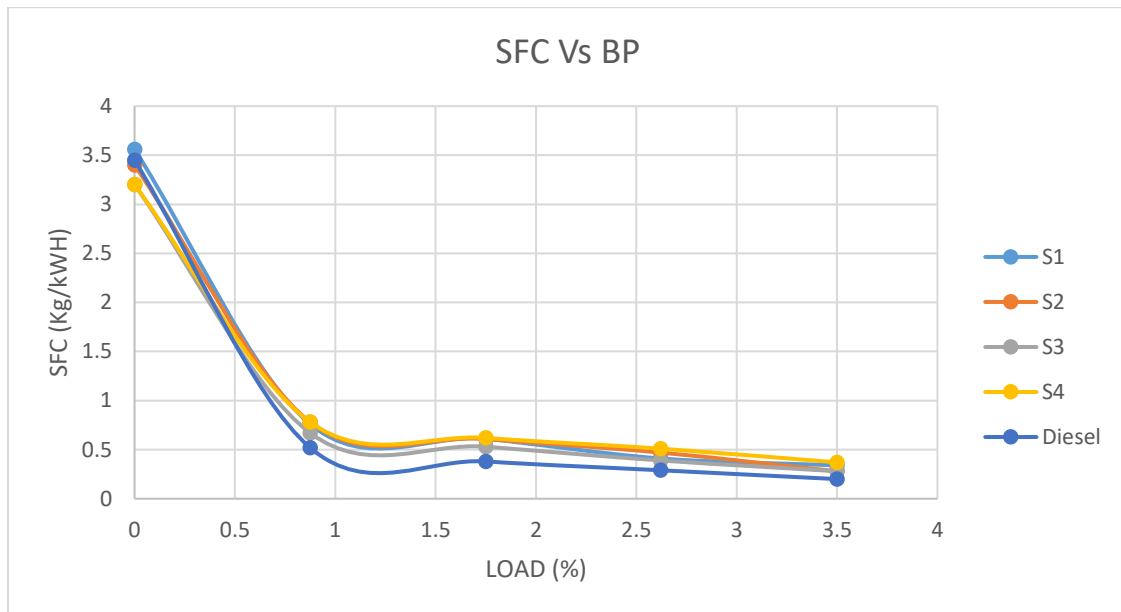


Fig.5.7: SFC Vs BP

Table 5.6: SFC Values of S1, S2, S3, S4, S5 Diesel with loads

BP (KW)	0	0.875	1.75	2.62	3.5
S1 (Kg/kWh)	1.2	14.56	21.47	28.14	30.24
S2(Kg/kWh)	1.12	13.6	21.07	25.49	31.70
S3(Kg/kWh)	2.1	14.89	22.78	27.90	29.89
S4(Kg/kWh)	1.45	15.42	23.56	29.74	31.86
Diesel(Kg/kWh)	3.45	0.52	0.38	0.29	0.2

The following line diagram shows the SFC at different loads of S1,S2,S3,S4, Diesel. S1 has the maximum SFC at minimum load among all. Diesel has the least SFC at maximum load. As the load increased it lowered the SFC of all samples.

5.7.2 Brake Thermal Efficiency (BTHE)

The variation of BTHE with loads for different fuels shows that BTHE increases with a **percentage** increase in load due to a **decrease** in heat **loss** and **an** increase in power with **an increase** in load. The thermal efficiency of the brake can be determined as Thermal Efficiency = (Brake Power *100%) / (Fuel Equivalent of Power).

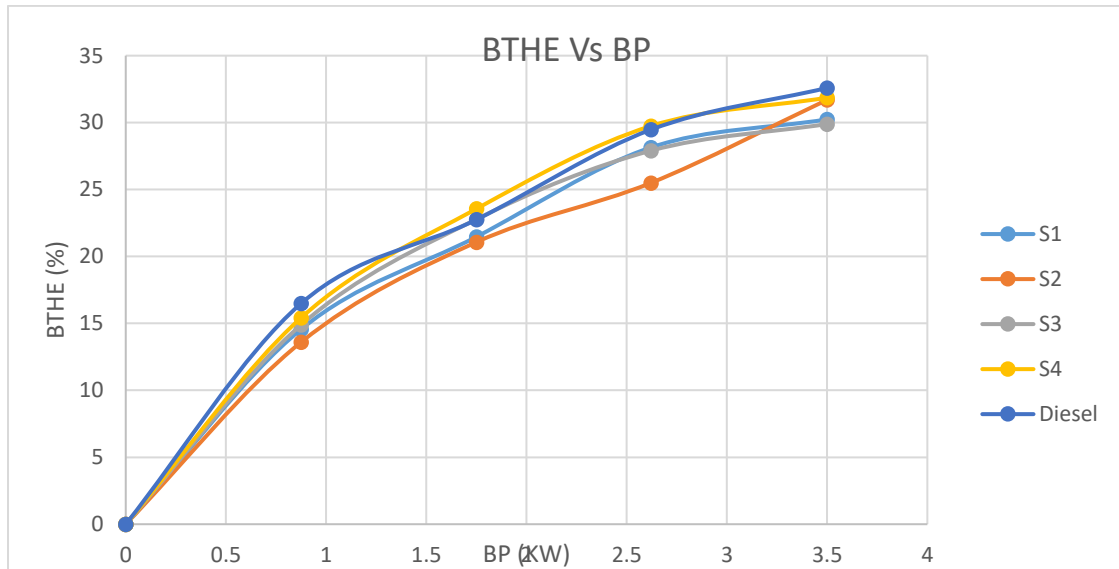


Fig.5.8: BTHE Vs BP

Table 5.7: BTHE Values of S1, S2, S3, S3, S4, Diesel with Loads

BP (KW)	0	0.875	1.75	2.62	3.5
S1(%)	3.56	0.76	0.61	0.41	0.34
S2(%)	3.4	0.78	0.61	0.47	0.28
S3(%)	3.2	0.67	0.53	0.39	0.28
S4(%)	3.2	0.78	0.62	0.51	0.37
Diesel(%)	0	16.49	22.75	29.47	32.59

The following line diagram depicts the BTHE at different loads of S1,S2,S3,S4, Diesel. Diesel has highest BTHE among other samples at higher

loads. S4 has shown a bit low at lower loads. Increment in load increased the BTHE of samples and diesel. S3 has the least BTHE at maximum load.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

An experiment **was carried out to determine** the performance and **emissions** of biodiesel and its blend in a **single cylinder direct injection gasoline engine at high speed**. The **emission trends identified** in this experiment **show that differences** between **different blends** of diesel and biodiesel **are** also found in the amount of useful heat **gained** from the **fuel**, which **may indicate a difference in the biodiesel function. energy content of the fuel.**

6.2 CONCLUSION

- By overall comparison of S1, S2, S3, S4 and diesel.
- Nox emission emitted by S3 is lower compared to other samples and diesel. S4 has emitted the highest.
- CO₂ emissions gradually increased with loads and S1 has emitted less compared to other samples and diesel. S4 emitted highest at max loads.
- S1 produced higher amount of oxygen among other samples and diesel. The least amount of O₂ is emitted by S3 at various loads.
- Diesel emitted the least amount of HC among all other samples and S1 emitted the highest amount of HC.

- Diesel emitted the least amount of CO among other samples and S3 emitted the max, S4 is able to produce less CO compared to S2,S3,S4.
- Diesel has the highest BTHE compared to other samples. S3 has the least at higher loads.
- SFC decreased with increment in load and diesel has the lowest whereas the S1 has higher SFC at minimum load.

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