JUN 2017

PROJECT REPORT

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STUDY OF DIESEL ENGINE

Submitted by

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Programme & Section- Mechanical/B

Under the Guidance of

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UTTRAKHAND-248009

Jun 2017

DECLARATION

I hereby declare that the project work entitled Study of diesel engine is an authentic record of my own work carried out at Prakash diesel's pvt. Ltd . as requirements of industry internship project for the award of degree of Mechanical Engineering , DIT university , dehradun . Under the guidance of Mr. M.P Singh and nallin somani , during January to june ,2017.

NAME-

ROLL NO.-

DATE-

Certified that the above statement made by student is correct to the best of our knowledge and belief.

Faculty coordinator   Industry coordinator

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TO WHOM SO EVER IT MAY CONCERN

This is to certify that **Mr. Prafull Sundriyal S/o Shri K.C. Sundriyal, student of D.I.T University, Roorkee, (Roll no. 1301061114),** has undergone Industrial training with us from 15.01.2017 to 15.06.2017 in our concern.

He has satisfactorily completed all assigned jobs.

His performance was good & satisfactory.

We wish him for bright future.

For PRAKASH DIESELS PVT. LTD

M K Garg

AUTH. SIGNATORY.

PRAKASH DIESELS PVT LTD * AGRA

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. I would like to extend my sincere thanks to all of them. I am highly indebted to Mr. M.P Singh for their guidance and constant supervision as well as for providing necessary information regarding the project & also for their support in completing the project. I would like to express my gratitude towards my parents & member of Prakash Diesel pvt. Ltd. for their kind co-operation and encouragement which help me in completion of this project. I would like to express my special gratitude and thanks to industry persons for giving me such attention and time.

My thanks and appreciations also go to my colleague in developing the project and people who have willingly helped me out with their abilities.

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CHAPTER 1

1 About the Organization

The history of Prakash Agricultural Industries goes back to 1960 when Mr. Ram Prakash Garg setup shop in Agra in the name of Prakash Hardware Store Starting as a trading concern it has since independence quickly diversified into manufacturing and marketing high quality Diesel Engine & Centrifugal Water Pump & Pumpsets IN 1975. Now Prakash Agricultural Industries is India’s leading ISO-9001-2008 certified company and the products are marketed under Brand Name of “PRAKASH” a name already synonymous with quality. The history of Prakash Agricultural Industries goes back to 1960 when Mr. Ram Prakash Garg setup shop in Agra in the name of Prakash Hardware Store Starting as a trading concern it has since independence quickly diversified into manufacturing and marketing high quality Diesel Engine & Centrifugal Water Pump & Pumpsets IN 1975. Now Prakash Agricultural Industries is India’s leading ISO-9001-2008 certified company and the products are marketed under Brand Name of “PRAKASH” a name already synonymous with quality.

I began my Co-op work term Prakash Diesel pvt. Ltd. on January 15, 2017. During my first week I got to know some of the people around the department as well as understand more in-depth the mechanics of the place. I did a lot of reading, so much that my eyes hurt. However, the reading paid off as it has laid an excellent foundation for me to really grasp aspects associated with this job for the rest of the semester. Some of my reading materials included the INTERNAL COMBUSTION ENGINE by John B.LHeywood, looking through the wealth of information , reading through my orientation package and becoming familiarized with the IC Engine. My first week also included getting to know my office co-workers. Most of the people working here are relatively young and new. I recognized immediately the potential opportunities within the branch I am working in. In fact, my coordinator has been here for many years. While there is usually another co-op student in my branch, during this training I am the only one. Everyone has been very welcoming and I am continually reminded that if I need help with anything I only need to knock on someone's door.

CHAPTER 2

2.1 BRIEF WORKING OF DIESEL ENGINE

Diesel engine which is also known as compression ignition engine is widely used in automobile industries. Many big vehicles such as truck, bus, car etc. used diesel engine as the power unit because of its higher torque and greater mileage than petrol engine. Diesel engine is very popular in Indian market as well as in other countries because of lower price of diesel than petrol in many countries. So the requirement of diesel engine is much more than petrol engine. The ignition temperature of diesel is lower than petrol so the working of diesel engine is slightly different than petrol.

Working of Four Stroke Diesel Engine

The power generation process in four stroke diesel engine is also divided into four parts. Each part is known as piston stroke. In IC engine, stroke is referred to the maximum distance travel by the piston in a single direction. The piston is free to move only in upward and downward direction. In four stroke engine the piston move two time up and down and the crankshaft move two complete revolution to complete four piston cycle. These are suction stroke, compression stroke, expansion stroke and exhaust stroke.

2.1.1 Suction stroke:

In the suction stroke or intake stroke of diesel engine the piston start moves from top end of the cylinder to bottom end of the cylinder and simultaneously inlet valve opens. At this time air at atmospheric pressure drawn inside the cylinder through the inlet valve by a pump. The inlet valve remains open until the piston reaches the lower end of cylinder. After it inlet valve close and seal the upper end of the Cylinder. Fig. 1

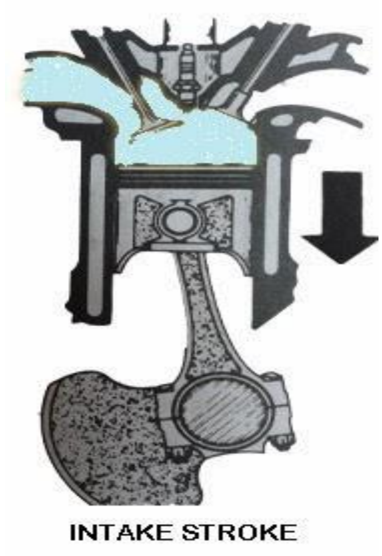

Figure 1

2.1.2 Compression stroke:

After the piston passes bottom end of the cylinder, it starts moving up. Both valves are closed and the cylinder is sealed at that time. The piston moves upward. This movement of piston compresses the air into a small space between the top of the piston and cylinder head. The air is compressed into 1/22 or less of its original volume. Due to this compression a high pressure and temperature generate inside the cylinder. Both the inlet and exhaust valves do not open during any part of this stroke. At the end of compression stroke the piston is at top end of the cylinder. Fig. 2.

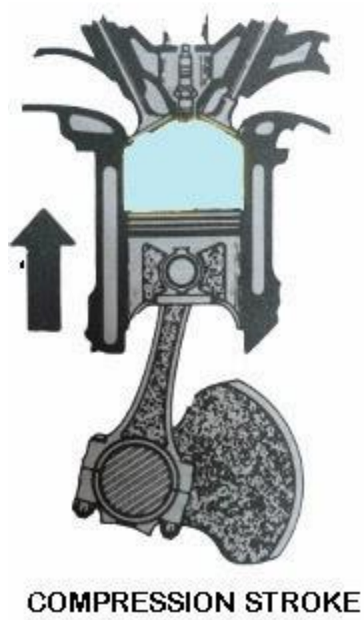

Figure 2

2.1.3Power stroke:

At the end of the compression stroke when the piston is at top end of the cylinder a metered quantity of diesel is injected into the cylinder by the injector. The heat of compressed air ignites the diesel fuel and generates high pressure which pushes down the piston. The connection rod carries this force to the crankshaft which turns to move the vehicle. At the end of power stroke the piston reach the bottom end of cylinder. Fig.3.

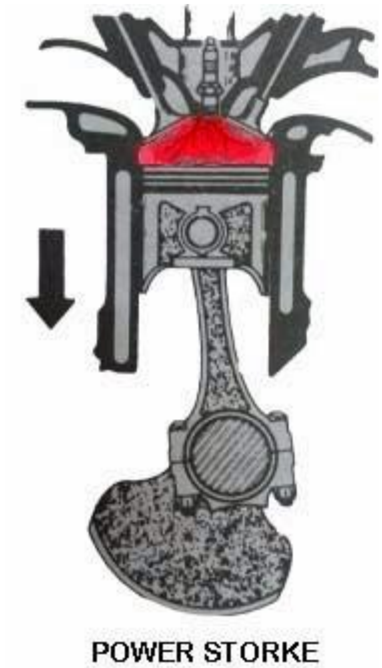

Figure 3

2.1.4 Exhaust stroke:

When the piston reaches the bottom end of cylinder after the power stroke, the exhaust valve opens. At this time the burn gases inside the cylinder so the cylinder pressure is slightly high from atmospheric pressure. This pressure difference allows burn gases to escape through the exhaust port and the piston move through the top end of the cylinder. At the end of exhaust all burn gases escape and exhaust valve closed. Now again intake valve open and this process running until your vehicle starts. Fig.4.

Figure 4

2.2 PARTS OF ENGINE

- Piston- Transfer force from expanding gas in cylinder to crankshaft via connecting rod for engine whereas for pumps it is reversed . Fig. 5

Figure 5

- Piston rings-It has 3 main functions fig. 5 -
  - Sealing the combustion chamber so that exhaust gases donot enter inside crankcase
  - Improving heat transfer from piston to cylinder
  - Regulating engine oil consumption by scraping from cylinder walls back to the sump

- Valve spring- Control breathing of IC engine .it helps to open and close the valve via camshaft ,tappets. It also function in lifting weight of the valve. Fig.6.

Figure 6

- Crankshaft- Reciprocating motion into circulatory motion via connecting rod.Fig.7.

Figure 7

- Connecting rod – Transfer motion from piston to crankshaft and function as a lever arm.Fig.8.

Figure 8

➢ Camshaft- Assymetrical lobes rotates to open and close the engine valve.Fig.9.

Figure 9

➢ Cylinder (liner)- Inner walls of cylinder sliding surface for piston rings have 4 characterstics Fig.10.–

- Anti galling property
- Less wear on cylinder liner
- Less wear on piston rings
- Less consumption of lubricant

Figure 10

- Flywheel- It is a mechanical device which stores rotational energy . it have inhertia called moment of inhertia & thus resists changes in rotational speed.Fig.11.

Figure 11

- Cylinder head- It has passage called ports or tracts for fuel mixture to travel to inlet valve from inlet manifold , exhaust valve.Fig.12.

Figure 12

- Engine valve- Allows air to come inside cylinder and seals compression and stroke. Fig.13.

Figure 13

- High pressure pipes- it connects fuel pump to nozzle such that there is no pressure loss.Fig.14.

Figure 14

- Gudgeon pin- Connect piston to connecting rod provides pivot bearing.Fig.15.

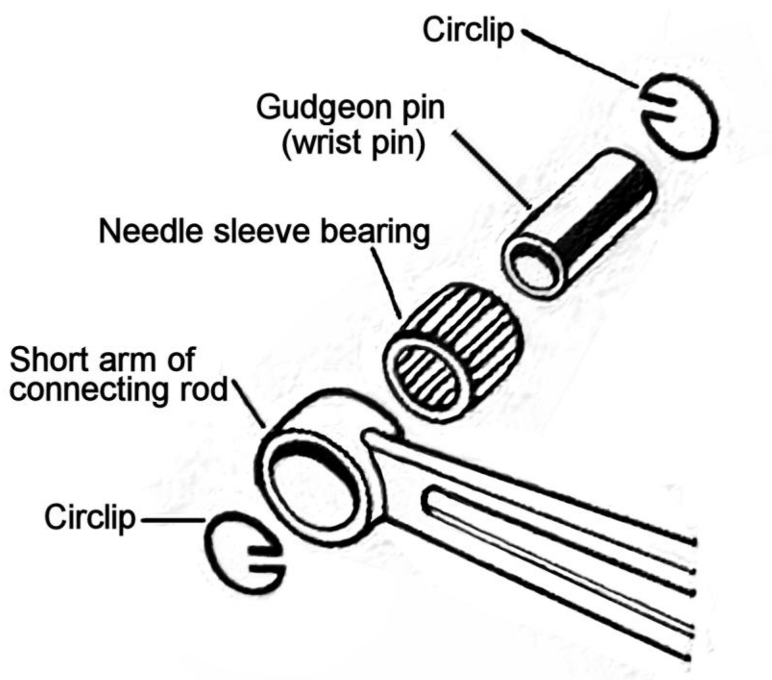

Figure 15

- Fuel pump- Sucks fuel from fuel tank pressurized fuel is pump inside engine where compressed air is inside such that proper mixing take place.Fig.16.

Figure 16

- Injector- Injects fuel inside cylinder such that atomisation of fuel take place.Fig.17.

Figure 17

- TR bearing –They are used in crank for greater load for rotating parts.Fig.18

Figure 18

- Push rod- Component of valve train function is to push rocker arm so that valves opens. Fig.19.

Figure 19

- CR bearing- Used in connecting rod. Fig.20.

Figure 20

- Rocker arm- Convey radial movement from cam lobe into linear movement at the poppet valve to open it. Fig.21

Figure 21

- Lube oil pump- It function as a pumping device for lubricating oil in crankcase. Fig.22.

Figure 22

- Crankcase- Housing of crankshaft forms largest cavity and is located below cylinder. Fig.23

Figure 23

- **Gear set-** Used to transfer motion from crankshaft to camshaft. Fig.24.

Figure 24

- **Oil seals-** Elastomer,rubber are used in roating parts to seal from outside the engine. Fig.25.

Figure 25

2.3 Assembly of Engine

This is assembly of 4 stroke 12 hp diesel engine for generator sets.

First of all , each parts of engine should pass through inspection such that required dimension is obtained , now production manager distribute order among supervisor . By the supervision workers assemble each and every engine which are best in quality.so here are the main points for the assembly of engine. Fig.26.

- **Crankcase-** First of all crankcase is fitted in assembly bed and are tighten with the screw ,cleaning followed by honing is done **.**
- **Cylinder block** – It is part which is placed above crankcase such that it holds liner inside it. Therefore cylinder block is tighten with bolt.
- **Cylinder liner-** Now liner is fixed inside cylinder block .(after fixing both cylinder block and liner are removed)
- **Crank shaft-** Now crank shaft is placed inside crankcase such that TR bearing and lobe oil pump are also placed .
- **Big housing** – Now big housing are placed on bearing side such that no alignment of crankshaft take place.
- **Small housing** – These are placed in the other side of crankshaft such that alignment should be maintained.
- **Governor assembly-** It is connected on the cam shaft on the side of small housing it function as a speed controller of an engine
- **Balance weight-** Our crankshaft is not balanced so to balance it so we use dead weight to balance crankshaft.
- **Oil filter-** It is connected in lobe oil pump such that no unwanted material should enter inside engine parts .

- **Piston and connecting rod-** Simultaneously piston of 101.66mm size and connecting rod are placed with crankshaft with piston lock between connecting rod and piston.

- **Camshaft +Gear+ Dead weight-** These all 3 are assembled together by other workers such that during the time of assembly workers don't waste there time.

- **Flywheel-** outer diameter of 335mm and weight of 55 Kg flywheel is placed in the side of big housing.

- **Spur gear-** This gear is fixed with crankshaft such that it meshes with camshaft gear and power can be transferred.

- **Extension shaft-** This shaft is joined with crank gear such that handle can be adjusted.

- **Gear cover/casing-** Now casing is placed over cam and crank gear such that no foreign particle can enter.

- **Again cylinder head+ block** – again cylinder head and block are fitted such that piston rings are placed before washing well with diesel .

- **Water pump** – As we are doing assembly of water cooled engine so water pump casing is fitted.

- **Push rod-** It is inserted inside cylinder head to camshaft such that motion Is being transferred .

- **Rocker arm+ lever-** Rocker arm assembly is done earlier so to reduce time. This will ensure opening and closing of valves.

- **Fuel tank-** It is used to store fuel during the time of engine running.

- **Fuel timing** – Then fuel timing is set as well as marked in flywheel TDC ,BDC,fuel inlet,outlet.

- **Fuel injector-** Bosch fuel injector is fitted inside the engine.
- **Fuel pump-** It is fitted next to fuel injector .
- **Plates-** Now plates over rocker arm is placed .
- **Lubricant** – Lubricant is poured inside the crankcase such that it lubricate connecting rod ,bearing , rocker arm .
- **High pressure pipes-** These are fitted between fuel pump and injector such that pressure is maintained at high pressure.

Figure 26

CHAPTER 3

3.0 AN OVERVIEW AND CONTROL OF ENGINE-OUT EMISSIONS

Better fuel economy and higher power with lower maintenance cost has increased the popularity of diesel engine vehicles. Diesel engines are used for bulk movement of goods, powering equipment, and to generate electricity more economically than any other device in this size range. In most of the global car markets, record diesel car sales have been observed in recent years . The exhorting anticipation of additional improvements in diesel fuel and diesel vehicle sales in future have forced diesel engine manufacturers to upgrade the technology in terms of power, fuel economy and emissions. Diesel emissions are categorized as carcinogenic . The stringent emission legislations are compelling engine manufacturers to develop technologies to combat exhaust emissions. To meet these emission regulations with competitive fuel economy, exhaust gas after-treatment and optimized combustion are necessary. However, it is still unresolved which concept will succeed considering production and economic feasibility . Diesel engines are very popular power plants for decentralized power production in rural areas all over the world as well as for powering the farm equipment due to their fuel economy, ease of maintenance and robustness.During 1950s the road vehicles were found to be the principal source of air pollution in the US cities. Carbon monoxide, unburned fuel (hydrocarbons), nitrogen oxides and smoke particulates were identified as the main air pollutants. Now, carbon dioxide has been added to the list of harmful gaseous emissions due to its global warming effect. Initially, to solve the local air pollution problem during 1960s efforts were mainly focused on reduction of CO from gasoline vehicles and black smoke emissions from diesel vehicles. Another area of priority attention was the prevention of blue smoke emissions caused by excessive consumption of engine lubricating oil which resulted from worn out piston rings, cylinder bore etc. The first emission control for the CI engines involved adjustments of air-fuel ratio. It was followed by control and adjustment of other engine parameters such as mixture control under idling, acceleration and deceleration, spark timing, precision manufacturing of key engine components such as piston, rings, cylinder head gasket to minimize crevice volume, cams, valves etc. Positive crankcase ventilation (PCV) system was introduced on gasoline vehicles during mid 1960’s to prevent release into atmosphere of hydrocarbon-rich crankcase blow by gases As the emission standards were tightened, exhaust aftertreatment devices such as catalytic converters were introduced for the first time in 1974-75 and more advanced modifications in engine design and fuel system were employed. Electronic fuel and engine management become necessary during 1980s to meet the then emission regulations. Further advancements in engine, fuel system and emission control technology have emerged in the meantime. Multi-valve cylinder engines became common and variable valve actuation was applied in production vehicles during late 1980s. In mid 1990s, gasoline direct injection stratified charge (DISC) engines were put into production by Japanese auto-manufacturers. Besides all-round advancements in engine technology and aftertreatment systems happening all the time, in the past few years alternative power trains also for vehicles have been developed which provide a higher fuel efficiency in addition to low emissions. Hybrid electric vehicles (HEV) are already in market place. The HEV has IC engine as a primary source of power but employ electric propulsion powered by storage batteries as the main propulsion unit. Fuel cell vehicles using hydrogen as energy source are in an advanced stage of development and they completely eliminate the use of IC engines as a propulsion system.

3.1 Atmospheric chemistry

As mentioned earlier, air quality concerns have motivated the studies on fuel/engine/after-treatment effects on emissions, understanding of the atmospheric fate of species emitted from vehicles. The atmosphere is a giant photochemical reactor operating at temperatures of 200–300 K and pressures 1 Bar. It contains 21% oxygen by volume and is a highly oxidizing environment. ICE exhaust components released into the atmosphere are oxidized in a complex series of reactions giving increasingly polar and less volatile products. Eventually they are either oxidized completely, e.g., the oxidation of methane into CO_2 and H_2O, or are converted into partially oxidized species, which are removed via wet and/or dry deposition to the Earth's surface, e.g., the oxidation of NO_2 into HNO_3. The oxidation reactions are initiated principally by reaction with OH radicals, although reaction with ozone, NO_3 radicals, and Cl atoms also play a role. The driving force for most of the chemistry that occurs in the atmosphere is the formation of hydroxyl (OH) radicals via photolysis of ozone to form O(1 D) atoms which react with water vapor to give two OH radicals. The atmospheric lifetimes of many pollutants are determined by their reactivity towards OH radicals. While the OH radical concentration in the atmosphere varies with location, time of day, season, and meteorological conditions, the global 24 hour average is approximately 16106 cm2 . The atmospheric lifetime of most vehicle emissions can be estimated from their reactivity with OH radicals. Oxidation reactions occurring in the atmosphere have similarities to those in combustion systems. However, there is one obvious and important difference: temperature. In the atmosphere the temperature is 200–300 K while in combustion systems the peak temperatures are typically 1500–2500 K. The different temperature regimes have two key ramifications. First, at high temperatures more reaction channels become kinetically available, and in particular the importance of decomposition processes increases. Decomposition via C–C beta-scission is a major loss mechanism for alkyl radicals during high temperature combustion. In contrast, addition of O2 to give peroxy radicals (RO2) is essentially the sole loss mechanism for alkyl radicals in the atmosphere. RO2 radicals react in the atmosphere to give a great variety of aldehydes, ketones, and other oxygenated organics. In contrast, in combustion the formation of large oxygenated compounds is limited. Formaldehyde is present at significant concentration in automobile exhaust and is formed from methyl and ethyl radicals.The chemistry associated with engine knock (autoignition) takes place at moderately elevated temperatures (600–1100 K) in the presence of excess oxygen. At these temperatures, knock chemistry depends in great measure on RO2 reactions that bear a similarity to atmospheric chemistry (although NOx reactions are much less important since little NOx is present at low temperatures). However, decomposition reactions (to form alkenes) and rearrangements of RO2 radicals become important. At the much higher temperatures encountered (1500–2500 K) during the main flame propagation process, the importance of alkyl radical decomposition processes increases.

In addition, more radical species can be involved as chain carriers in flame combustion than in atmospheric processes. Thus, the atmospheric oxidation of alkanes is initiated via reaction with OH radicals. Oxidation of fuel during flame propagation is initiated primarily by reaction with OH during lean or stoichiometric operation but can also involve reactions with other high temperature reactive species such as O and H atoms as well as thermal decomposition depending on the A/F ratio. The atmospheric degradation reactions that remove pollutants from the air have unwanted side effects. The degradation products and intermediates can lead directly, or indirectly, to adverse environmental impacts. Emissions from internal combustion engines contribute to the photochemical smog present in many large-scale metropolitan areas. On a time scale of hours in the presence of sunlight, atmospheric chemical reactions convert vehicle emissions and exhaust into a mixture of oxidants such as ozone and peroxyacetyl nitrate (PAN = CH3C(O)O2NO2) that is generically known as photochemical smog. As indicated in Fig. 27,

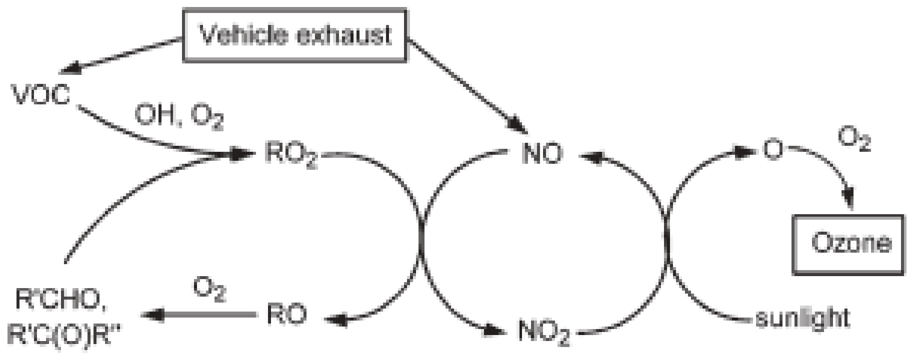

Figure 27

the key ingredients for the formation of photochemical smog are VOCs, NOx, and sunlight. The chemistry is initiated by reaction of OH radicals with VOCs to give alkyl radicals (R) which, in one atmosphere of air, add O2 rapidly (within 1027 s) to give peroxy radicals, RO2. The dominant fate of RO2 radicals in urban air is reaction with NO which occurs with a rate constant of approximately 1610211 cm3 molecule 21s(21 under ambient conditions). Typical NO levels in polluted urban air are 10– 100 ppb and the lifetime of RO2 radicals is approximately 0.1– 1.0 s. Alkoxy radicals, RO, have an atmospheric lifetime typically of the order of 0.01–0.10 ms and undergo isomerization, decomposition via C–C bond scission, or reaction with O2 to give carbonyl containing compounds which in turn can react with OH radicals to generate more peroxy radicals. The reaction of RO2 with NO generates NO2 which is a brown colored gas and absorbs at 400–450 nm. The NO2 photolysis rate, JNO2, in the lower atmosphere (troposphere) depends on the cloud cover and is typically in the range (0.3–1) 6 1022 s 21 , giving a lifetime of NO2 of several minutes. Photolysis of NO2 gives O atoms and regenerates NO which reacts with more RO2 radicals to form more NO2. In one atmosphere of air, O atoms add O2 with an effective bimolecular rate constant of 1.5 6 10214 cm3 molecule21 s 21 , [O2] = 5.2 6 1018 cm23 , and O atoms have a lifetime of 13 ms with respect to conversion into ozone. Fig. 27 provides a highly simplified picture of photochemical ozone formation. It does not include the processes which limit ozone formation such as the formation of nitric acid and organic nitrates. The addition reaction of OH radicals with NO2 gives HNO3. Nitric acid does not participate in gas phase ozone forming reactions and is removed by wet and dry deposition. Formation of HNO3 is a major loss mechanism for atmospheric NOx and limits the formation of ozone. Organic nitrates, RONO2, are formed as minor, but important products, in the reaction of RO2 radicals with NO. Acyl peroxy nitrates (e.g., CH3C(O)OONO2) are formed via the association reaction of NO2 and acyl peroxy radicals (e.g., CH3C(O)O2). RONO2 and RC(O)OONO2 species tend to be less reactive than their parent hydrocarbons and serve as sinks for radicals and NOx in urban air. Acyl peroxy nitrates such as PAN, C2H5C(O)OONO2 commonly known as peroxy propionyl nitrate or PPN, and C6H5C(O)OONO2 commonly known as peroxy benzoyl nitrate or PBzN are phytotoxic (toxic towards plants

generated). Compounds which react rapidly with OH radicals and give products which also promote ozone formation (e.g., alkenes) will produce more ozone within urban air masses than compounds which react slowly (e.g., CH4) or give products which suppress further ozone formation (e.g., C6H5CHO). Scales have been developed to provide a quantitative ranking of the ability of different VOCs to contribute to ozone formation. The ‘‘maximum incremental reactivity’’ (MIR) scale was developed by Carter41 (and is used by the California Air Resources Board and the U.S.E.P.A.) and the ‘‘photochemical ozone creation potential’’ (POCP) scale was developed by Derwent et al. 42 These scales are based upon computer models of urban or regional air chemistry. The models include the atmospheric chemistry of individual VOCs, meteorological data, emissions inventories, and simulate the formation of photochemical smog. In the maximum incremental reactivity scale the effect on the predicted maximum ozone concentration for a small change in emission of a given VOC is computed and the result is reported in units of moles of O3 formed per mole of VOC added. In the POCP scale the integrated effect on ozone along a multi-day modeled trajectory of adding a given amount of VOC in the scenario relative to adding the same mass of ethylene VOC is computed. The POCP for ethylene is defined as 100. POCPs for selected VOCs in ICE exhaust . As seen from the table, there are large differences in the POCPs of different VOCs. The negative value for benzaldehyde reflects the ability of one of its oxidation products, the phenoxy radical, to react with NO2 giving Fig. 27 Photochemical production of ozone.

3.2 Categorization of Emission Control Techniques

The emission control techniques may be grouped into the following broad categories:

1. Engine design and fuel system parameters
2. Engine add-ons to enable reduction of engine-out emissions
3. Exhaust aftertreatment

3.3 ENGINE DESIGN PARAMETERS

The following engine parameters have large influence on emissions and hence have undergone substantial modifications since the pre-emission control era.

- Engine compression ratio,
- Combustion chamber design – low crevice volume, high turbulence
- Spark timing
- Air-fuel ratio
- Fuel system design: carburetor giving way to fuel injection
- Multivalves and
- variable valve actuation Engine temperature control

3.4 High Turbulence Combustion Chambers

Small cylinders with hemispherical and pentroof type combustion chambers are now more commonly used in CI engines.

- Small cylinder engines can be operated at higher speeds which increases turbulence and tends to reduce HC emissions.
- Smaller cylinders have smaller amount of burned gases that form the high temperature adiabatic core. More heat transfer takes place from the burned gases as the walls are nearer to the bulk gases. It results in lower NOx.

•   The compact hemispherical combustion chambers shape (Fig 28) provides the lowest surface to volume ratio and minimum tendency to engine knock.

The hemispherical combustion chamber although may employ multiple valves, the two valve configuration is more common as it is difficult to accommodate 4-valves at the necessary valve positioning angles. The valve heads along with the surface of combustion chamber form a profile that looks like a hemisphere. Both the intake and exhaust valves are inclined increasing valve port area that results in higher volumetric efficiency. The chamber has a low surface to volume ratio. The intake ports are provided with a suitably curved geometry to generate high rate of air swirl.

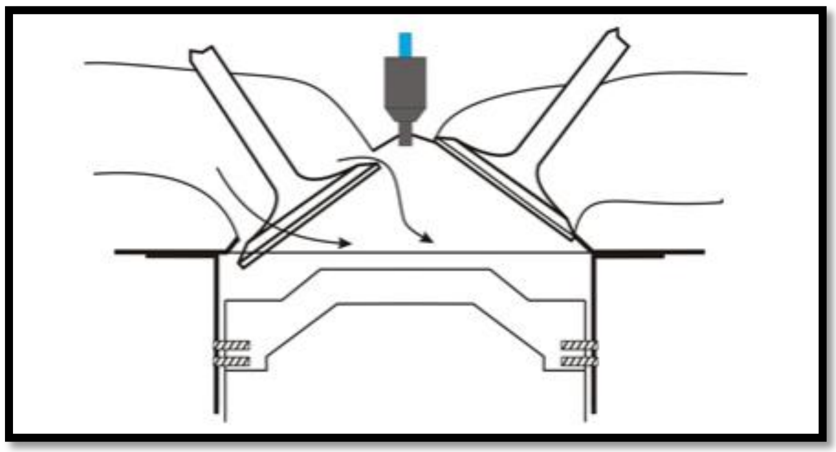

Figure 28

A shallow angle pent-roof type combustion chamber (Fig. 29) is a good compromise as it allows use of 4 valves of optimum size and positioning.

A higher volumetric efficiency and tumble air motion are obtained in these combustion chambers resulting in higher burning rates. These compact combustion chambers have lower heat transfer losses. Thus, quench layer thickness is minimized lowering HC emissions. Pentroof combustion chamber being shallow compared to hemispherical combustion chamber it has somewhat higher surface to volume ratio. However the pentroof combustion chamber is a good compromise between compactness of the combustion chamber and use of multiple valves. A shallow angle pentroof type combustion chamber allows optimum valve size and their positioning in multiplevalve engine configuration. Pentroof combustion chambers having 2 and 3 intake valves and total of 3 to 6 valves per cylinder are in use. The 4-valve combustion chambers are the most common The inclination of the intake and exhaust valves to each other tilts the pair of valve heads such that they resemble to an arch and take the shape of a pentroof, hence the name. The spark plug is located close to centre. Mixture from the intake port flows across the cylinder to the walls from where it is deflected downwards direction and rolls perpendicular to the axis of the cylinder in a tumbling motion. This motion is called air ‘tumble’.

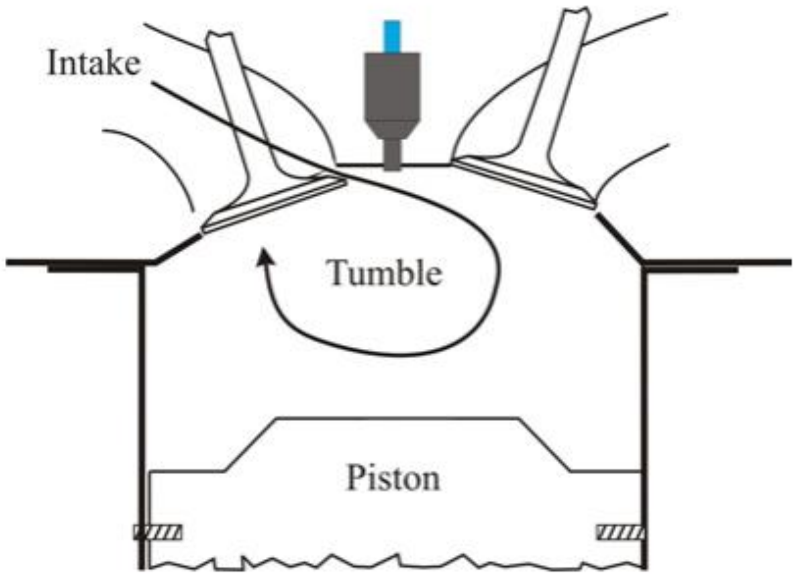

Figure 29

3.5 Specification

The engine and coupled alternator specifications were tabulated in Tables 1. MakePrakash Engine

Make	Prakash Engine
No of cylinders	1
No of strokes	4
Bore and stroke	102 mm × 115 mm
BHP/BP	10.5/8 KW
Rated power	KVA
Displacement	939.221 cc
Type of cooling	Water cooled

Fuel consumption @90% load	5 L/h
Aspiration	Radiator
Speed	1500
Compression ratio	15.5:1

3.6 Experimental methodology

3.6.1 - Testo:

The emissions analyzer testo has application-specific setting menus, which adapt to the respective applications (e.g. $\lambda \leq 1$ or $\lambda > 1$ engines)where λ=Stochiometric ratio , and support the user in various ways. In combination with the high-

Figure 30

performance Peltier gas preparation, the testo provides highly accurate measurement values in the shortest possible time. Fig.30

- The system's fuel consumption can be reduced by up to 10 %.
- Increased engine life
- Lower maintenance costs thanks to monitoring of mechanical wear
- Provable quality of service work thanks to documented measurement values
- Measurement of CO, NO, NO2, SO2, H2S, CxHy or CO2
- Connection possibility of 6 gas sensors

3.6.2- AVL (Di gas meter):

The AVL GAS features a robust design, high accuracy and wide operating temperature range. The device is controlled via the AVL M.O.V.E System Control, which is the central data logger, calculates the online mass emissions and provides interfaces to access e. g. ECU/ CAN data and additional sensors. The AVL M.O.V.E. is especially designed and optimized in weight and dimension for mounting diesel engine. Fig.31

Figure 31

- Internal temperature conditioning ensures high measurement accuracy and low drift even at changing and extreme ambient conditions between -30°C and +45°C

- High measurement accuracy due to the usage of approved test cell analyzers optimized for mobile applications

- A dedicated heating circuit protects the device during start-up at low temperatures

- Effective internal damping measures and external damping options allow the usage in harsh testing environments

- Low maintenance effort and easy access to all consumables

3.6.3 AVL Smoke Meter:

The AVL Smoke Meter uses the filter paper method to determine the Filter Smoke Number (FSN defined according to ISO 10054) and the soot concentration in mg/m³. The variable sampling volume and the thermal exhaust conditioning ensure an extremely high reproducibility and a wide range of application. The instrument can be used not only on large engines but also on light duty engines independent of their generation. In addition, raw exhaust measurements or measurements up to 5000m altitude can be carried out by using device options. Fig.32

Figure 32

- High measurement resolution (0.001 FSN or 10µg/m3) and low detection limit (0.002 FSN or 20 µg/m3)
- Timely paper change due to remaining filter paper indicator
- Altitude measurements up to 5000 m above sea level and altitude simulation up to 5000 m
- High reproducibility, improved cleaning efficiency and increased robustness against wet exhaust gas due to shop air purging of the entire gas path – optional
- Extended application area up to 3 bar exhaust back pressure for engines with exhaust aftertreatment systems – optional

3.7 Discussion

Our main objective is to find emission of different gases by changing fuel injector angle at :

- 17 Degree
- 15 Degree

I thanks prakash diesels pvt. Ltd. For allowing me to do this experiment.

3.8 Observation:

3.8.1 Emissions analyzer testo For 15 Degree fuel injector angle

Gases	100% Load	75% Load	50% Load	25% Load	10% Load
CO (PPM)	**115**	**57**	**24**	**22**	**31**
CO2 %VOL/VOL	**5.96**	**4.40**	**3.19**	**2.15**	**1.60**
O2 %VOL/VOL	**10.5**	**13.12**	**15.36**	**17.13**	**18.15**
NOX (PPM)	**532**	**437**	**332**	**225**	**141**

3.8.2 Emissions analyzer testo For 17 Degree fuel injector angle

Gases	100% Load	75% Load	50% Load	25% Load	10% Load
CO (PPM)	**138**	**67**	**28**	**26**	**35**
CO2 %VOL/VOL	**7.33**	**5.192**	**3.79**	**2.60**	**1.9**
O2 %VOL/VOL	**9.45**	**12.46**	**14.37**	**16.44**	**17.45**
NOX (PPM)	**644**	**528**	**404**	**270**	**169**

3.8.3 Emissions analyzer AVL Smoke For 15 Degree fuel injector angle

Fig.33 E-no. 4

LOAD	100%	75%
%	.1273	.04705

3.8.4 Emissions analyzer AVL Smoke For 17 Degree fuel injector angle

Fig.33 E-no.3

LOAD	100%	75%
%	.1527	.05646

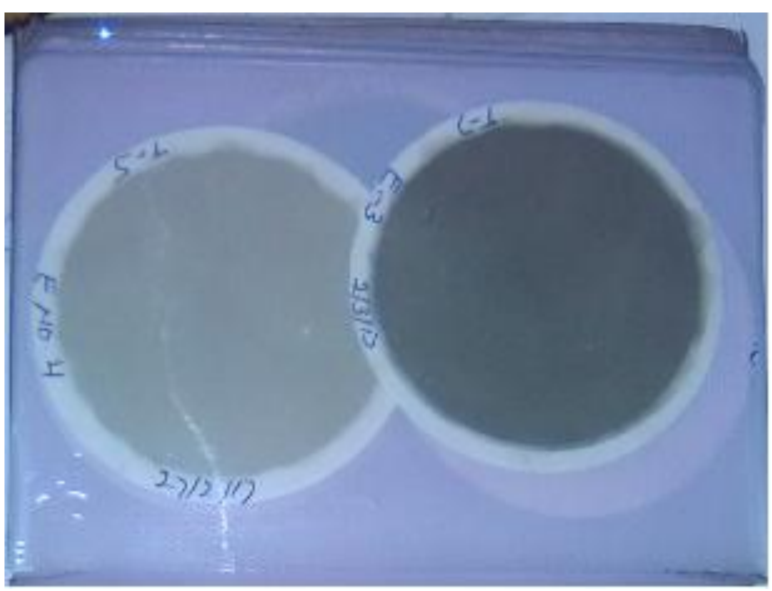

Figure 33

3.9 Result :

From 3.8.1 and 3.8.2 we will calculate change in percentage.

Gases	100% Load	75% Load	50% Load	25% Load	10% Load
CO (PPM)	16.66%	14.9%	14.2%	15.3%	12.9%
CO2 %VOL/VOL	18.69%	15.2%	15.83%	17.3%	15.7%
O2 %VOL/VOL	-11.11%	-5.29%	-6.88%	-4.56%	-4.08%
NOX (PPM)	8.07%	5.87%	17.81%	16.66%	16.5%

Conclusion:

Fuel at 17’ is using more fuel and more emission than angle at 15’

CHAPTER 4

4.0 AN OVERVIEW WHY NOx IS HARMFUL

Nitrogen dioxide is an irritant gas, which at high concentrations causes inflammation of the airways. When nitrogen is released during fuel combustion it combines with oxygen atoms to create nitric oxide (NO). This further combines with oxygen to create nitrogen dioxide (NO2). Nitric oxide is not considered to be hazardous to health at typical ambient concentrations, but nitrogen dioxide can be. Nitrogen dioxide and nitric oxide are referred to together as oxides of nitrogen (NOx). NOx gases react to form smog and acid rain as well as being central to the formation of fine particles and ground level ozone, both of which are associated with adverse health effects.

4.1Sources of NOx Pollution.

NOx is produced from the reaction of nitrogen and oxygen gases in the air during combustion, especially at high temperatures. In areas of high motor vehicle traffic, such as in large cities, the amount of nitrogen oxides emitted into the atmosphere as air pollution can be significant. NOx gases are formed whenever combustion occurs in the presence of nitrogen – e.g. in car engines; they are also produced naturally by lightning. Fig.34

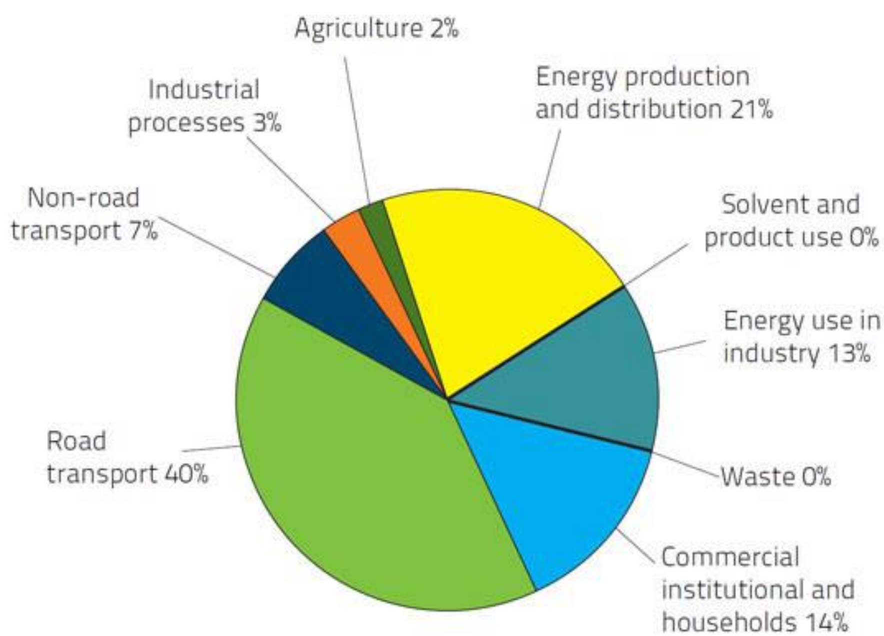

Figure 34

4.2 Health Issues created by NOx

NOx mainly impacts on respiratory conditions causing inflammation of the airways at high levels. Long term exposure can decrease lung function, increase the risk of respiratory conditions and increases the response to allergens. NOx also contributes to the formation of fine particles (PM) and ground level ozone, both of which are associated with adverse health effects.

4.3 The impact of nitrogen dioxide on ecosystems

High levels of NOx can have a negative effect on vegetation, including leaf damage and reduced growth. It can make vegetation more susceptible to disease and frost damage. A study of the effect of nitrogen dioxide and ammonia (NH3) on the habitat of Epping Forest has revealed that pollution is likely to be significantly influencing ecosystem health in the forest. The study demonstrated that local traffic emissions contribute substantially to exceeding the critical levels and critical loads in the area. The critical level for the protection of vegetation is 30 *10'(-6)g/m3 measured as an annual average. NOx also reacts with other pollutants in the presence of sunlight to form ozone which can damage vegetation at high concentrations.

4.4 Combustion chemistry

Oxides of nitrogen is produced in very small quantities can cause pollution. While prolonged exposure of oxides of nitrogen is dangerous to health. Oxides of nitrogen which occurs only in the engine exhaust are a combination of nitric oxide (NO) and nitrogen dioxide (NO2). Nitrogen and oxygen react at relatively high temperature. NO is formed inside the combustion chamber in post-flame combustion process in the high temperature region. The high peak combustion temperature and availability of oxygen are the main reasons for the formation of NOx. The majority of NO formed will however decompose at the low temperatures of exhaust. But, due to very low reaction rate at the exhaust temperature, a part of NOx formed remains in exhaust. Many theoretical and experimental investigation shows that the concentration of NOx in the exhaust gas is closely related to the peak cycle temperature and available amount of oxygen in the combustion chamber. Any process to reduce cylinder peak temperature and concentration of oxygen will reduce the oxides of nitrogen. The dilution of fuel air mixture entering the engine cylinder with an inert or noncombustible substance is one which absorbs a portion energy released during the combustion, thereby affecting an overall reduction in the combustion temperature and consequently in the NOx emission level. A promising new method of reducing NOx emission involves the recycling of exhaust gas in a process called exhaust gas recycle.

EGR sends captured exhaust gas back into the combustion chamber of the engine, thereby increasing fuel economy and reducing emissions: a 25% EGR leads to a 50% reduction in NOx.

There are some problems, however, associated with the process, including:

(1) extra pumping and cooling of the EGR stream,

(2) engine wear from re-circulating engine soot, and

(3) high feed air water vapor levels.

These issues can be avoided by the use of nitrogen-enriched air (NEA), which reduces the diesel combustion temperature and, in turn, the amount of NOx emitted in the engine exhaust. The NOx reductions achieved through NEA are similar to those accomplished through the EGR process, while simultaneously avoiding the pumping, cooling, wear, and water vapor issues associated with EGR.

4.5 EGR Systems

Most vehicle manufacturers started to provide emission control systems that reduce NOx as early as 1970. The EGR system releases a sample of exhaust gases into the intake's air-fuel mixture. This lowers the peak temperature of combustion and therefore reduces the chances of NOx being formed. The re –circulated exhaust gas dilutes the air-fuel mixture. Because exhaust gas does not burn, this lowers the combustion temperature and reduces NOx emissions. At lower combustion temperatures, the nitrogen in the incoming air is simply carried out with the exhaust gases. Drivability problems can result from having too much recirculated exhaust gas in the combustion chamber. This is especially true when there is a high demand for engine power. Also, poor control of EGR flow can cause starting and idling problems. This is why EGR in Fig.35 & 36 flow is disabled during cold starting, at idle, and at throttle openings of more than 50%. There is maximum EGR flow only when the vehicle is at a cruising speed with a very light load. EGR is equipped with a vacuum-operated valve to regulate the flow of exhaust gas into the intake manifold. Typically, the EGR valve is mounted to the intake manifold. The EGR valve is a flow control valve. A small exhaust crossover passage in the intake manifold admits exhaust gases to the inlet port of the EGR valve. Opening the EGR valve allows exhaust gases to flow through the valve. Here the exhaust gas mixes with the intake air or air-fuel mixture in the intake manifold. This dilutes the mixture so combustion temperatures are minimized.

Figure 35

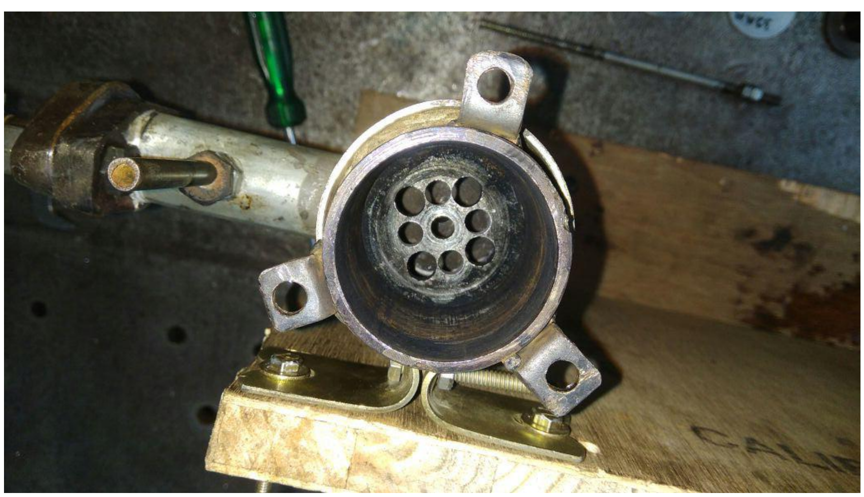

Figure 36

4.6 Specification

The engine in Fig 37 and coupled alternator specifications were tabulated

Make Prakash Engine

No of cylinders	**4**
No of strokes	**4**
Bore and stroke	**110 mm × 120 mm**
BHP/BP	**14**
Rated power	**40 KVA**
Displacement	**1140 cc**
Type of cooling	**Water cooled**
Fuel consumption	**@90% load 5 L/h**
Aspiration	**Radiator**
Speed	**1500 rpm**
Compression ratio	**18.5:1**

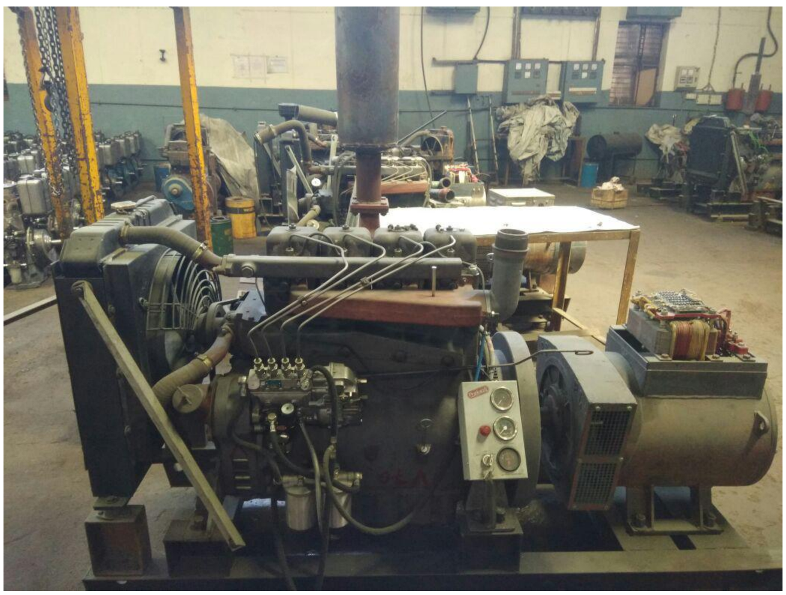

Figure 37

4.6. Emissions analyzer testo Withouht EGR

Gases	100% Load	75% Load	50% Load	25% Load	10% Load
CO (PPM)	**167**	**73**	**84**	**154**	**209**
CO_2 %VOL/VOL	**5.43**	**3.91**	**2.78**	**1.85**	**1.31**
O_2 %VOL/VOL	**11.42**	**14.12**	**16.1**	**15.77**	**18.7**
NOX (PPM)	**591**	**477**	**373**	**207**	**121**

4.7. EGR Setup

We did experiment with EGR but did not got complete success as our main problem is coming to pressure regulation such that at high engine pressure our EGR should have to stop working at high inlet temperature as this will result in problem associated to detonation. We changed our disc sizes such that it should stop working at high temperature but did not got proper dimensions till date. Perfect reading regarding EGR are given Fig.38 & 39 &40.

Figure 38

Figure 39

4.8 Emissions analyzer testo For EGR

Gases	100% Load	75% Load	50% Load	25% Load	10% Load
CO (PPM)	**220**	**90**	**79**	**130**	**170**
CO2 %VOL/VOL	**6.65**	**5.33**	**3.71**	**2.250**	**1.53**
O2 %VOL/VOL	**9.28**	**11.57**	**14.37**	**17.09**	**18.3**
NOX (PPM)	**462**	**342**	**303**	**198**	**123**

Figure 40

4.9 Conclusion

Till now reduction in NOx content are reduced 25.7% at 100% Load , 39.47 % at 75% Load , 23.1 % at 50% Load , 4.5 % at 25% Load and 1.6% increased in NOx at 10% Load.

CHAPTER 5

5.0 Exhaust Gas Properties

Engine exhaust gases are discharged into the environment through the exhaust system. The exhaust system includes several specialized components, ranging from mufflers to emission aftertreatment devices. The designer of the exhaust system and/or exhaust system components must know a number of exhaust gas properties. Compared to the composition of air, the diesel exhaust gas contains increased concentrations of water vapor (H2O) and carbon dioxide (CO2)—the main combustion products. The concentrations of both H2O and CO2 can vary from a few percent, up to about 12% in diesel exhaust. These combustion products displace oxygen, the concentration of which can vary from a few percent, up to about 17% (compared to 21% in ambient air). The main component of diesel exhaust, just as is the case with ambient air, is nitrogen (N2). By comparison, the concentrations of diesel exhaust pollutants are very small—for the purpose of calculating the physical properties of diesel exhaust gas, they can be neglected.

5.1 HARMFUL EFFECTS:

Diesel-powered vehicles and equipment account for nearly half of all nitrogen oxides (NOx) and more than two-thirds of all particulate matter (PM) emissions sources.

Particulate matter or soot is created during the incomplete combustion of diesel fuel. Its composition often includes hundreds of chemical elements, including sulfates, ammonium, nitrates, elemental carbon, condensed organic compounds, and even carcinogenic compounds and heavy metals such as arsenic, selenium, cadmium and zinc. Though just a fraction of the width of a human hair, particulate matter varies in size from coarse particulates (less than 10 microns in diameter) to fine particulates (less than 2.5 microns) to ultrafine particulates (less than 0.1 microns). Ultrafine particulates, which are small enough to penetrate the cells of the lungs, make up 80-95% of diesel soot pollution. Particulate matter irritates the eyes, nose, throat, and lungs, contributing to respiratory and cardiovascular illnesses and even premature death. Although everyone is susceptible to diesel soot pollution, children, the elderly, and individuals with preexisting respiratory conditions are the most vulnerable. Researchers estimate that, nationwide, tens of thousands of people die prematurely each year as a result of particulate pollution. Diesel engines contribute to the problem by releasing particulates directly into the air and by emitting nitrogen oxides and sulfur oxides, which transform into "secondary" particulates in the atmosphere.

Diesel emissions of nitrogen oxides contribute to the formation of ground level ozone, which irritates the respiratory system, causing coughing, choking, and reduced lung capacity. Ground level ozone pollution, formed when nitrogen oxides and hydrocarbon emissions combine in the presence of sunlight, presents a hazard for both healthy adults and individuals suffering from respiratory problems. Urban ozone pollution has been linked to increased hospital admissions for respiratory problems such as asthma, even at levels below the federal standards for ozone.Diesel exhaust has been classified a potential human carcinogen by the U.S. Environmental Protection Agency (EPA) and the International Agency for Research on Cancer. Exposure to high levels of diesel exhaust has been shown to cause lung tumors in rats, and studies of humans routinely exposed to diesel fumes indicate a greater risk of lung cancer. For example, occupational health studies of railroad, dock, trucking, and bus garage workers exposed to high levels of diesel exhaust over many years consistently demonstrate a 20 to 50 percent increase in the risk of lung cancer or mortality.

Make	Prakash Engine
No of cylinders	1
No of strokes	4
Bore and stroke	102 mm × 115 mm
BHP/BP	8.6HP
Rated power	12 HP
Displacement	939.2 cc
Type of cooling	Water cooled
Fuel consumption @90% load	2 L/h
Aspiration	Radiator
Speed	1500
Compression ratio	16:1

5.2 BIOMASS ENGINE KIT

With serious concern globally and in India on the use of fossil fuels, it is important for India to start using renewable energy sources. India is the 7th largest country in the world spanning 328 million hectares and amply bestowed with renewable sources of energy. Among the renewable energy sources, biomass plays a vital role especially in rural areas, as it constitutes the major energy source to majority of households in India. Biomass energy is the utilization of organic matter present and can be utilized for various applications.

- Biomass can be used to produce heat and electricity, or used in combined heat and power (CHP) plants.
- Biomass can also be used in combination with fossil fuels (co-firing) to improve efficiency and reduce the build up of combustion residues.
- Biomass can also replace petroleum as a source for transportation fuels.

5.2.1 Gas Engines Working Principle

Using the same principles as any other IC engine, gas engines use gaseous fuels such as biogas, natural gas or producer gas to produce electricity.

For instance, for a biogas engine, the waste of 2,500 cows, 15,000 pigs or 300,000 chickens can create enough biogas to power an engine with electrical output of 500 kW, is enough energy to supply more than 1000 homes in developed countries and over 5000 homes in developing countries such as India.

Scientific/Technical basis for Present Development

The scientific principles and the resulting technology involved in the development of the present kit can be understood as follows. A diesel engine operates on the principle of compression ignition of the diesel fuel. It has relatively higher compression ratio (around 15-22) and a heterogeneous mode of combustion. This mode of ignition is suited only for less volatile liquid fuels with low self-ignition temperatures. It also uses a fuel injection system which injects the liquid fuel into the engine cylinder at very high pressure towards the end of compression stroke.For gaseous fuels, it is essential to use the spark ignition (S.I.) mode, premix combustion, in which case the air and fuel are homogeneously mixed in an appropriate ratio and then inducted into the engine cylinder. Towards the end of compression, a spark is applied to initiate the ignition of the compressed charge. These engines also need throttling of air-fuel mixture to control the power output. Normal Spark Ignition Engines which use gasoline fuel are restricted in compression ratio (8-10) because of knocking condition. However, in the case of biogas which contains methane as the fuel element, the self ignition temperature is quite high and much higher compression ratios can be used, which leads to improved efficiency. The conversion of a diesel engine into an equivalent spark ignition engine requires the following modifications/ retrofitting-

a) Removal of the fuel injection system (fuel pump and the injector)

b) Incorporation of a suitable spark plug in place of the injector by appropriate modification in

the injector hole.

c) Modification in the engine intake system incorporating suitable mechanism for air-fuel mixing and control i.e. a gas carburetor system.

d) Retrofitting with cam shaft/ crank shaft a specially designed ignition system.

e) Modification in the combustion chamber/ compression ratio etc. (if needed)

The overall arrangement of the conversion kit is shown Fig.42 & in the schematic layout in fig. 41

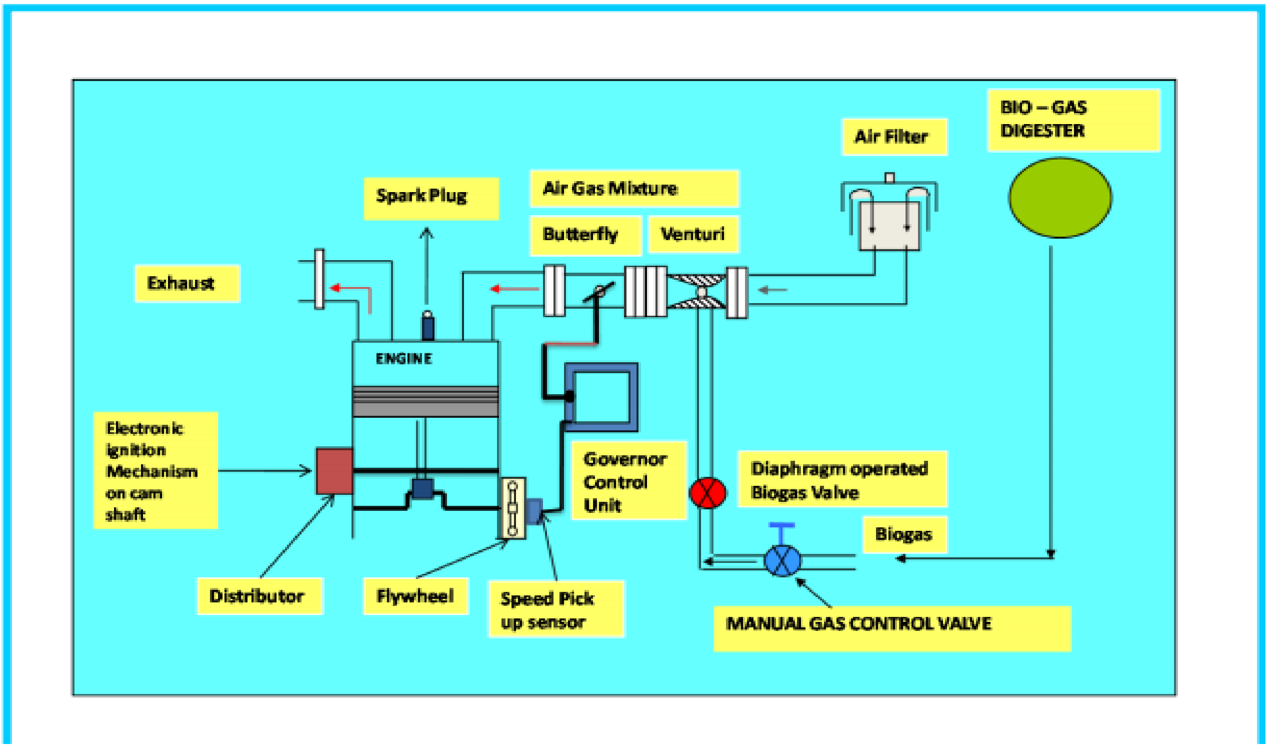

Figure 41

Figure 42

5.3 Assembly of engine

5.3.1 Ignition system

Battery operated electronic ignition system has been used, as it is available in the market and suitable ignition advance has been carried out for biogas operation. It has been connected to camshaft with the help of housing . Fig 43.

Figure 43

5.3.2 Derating of the Engine

Diesel engine used 102 WC, which will produce 12 HP at 1500 rpm in the diesel mode. Since Generator operates at 1500 rpm, so in diesel mode the engine will produce around 3.5 KVA at 1500 rpm. Whenever a diesel engine is converted for use of a gaseous fuel, particularly a dilute gaseous fuel such as biomass which contains only 55-60% combustible constituents viz. methane and the rest is CO_2, there occurs necessarily reduction in the maximum power output of the engine. This is called derating. The main reason for this derating is as follows. The engine in diesel mode takes in only air during the intake stroke while in the converted mode; it has to take in air and gaseous fuel. As a result, substantial part of the cylinder is occupied by the gaseous fuel reducing the air availability per cycle which controls the maximum fuel that can be burnt per cycle, in accordance with the required air fuel ratio. Further, because of difference in calorific values of diesel (about 43 MJ/Kg) and biogas (about 20 MJ/ Kg), the energy available in the charge per cycle is reduced. To some extent, reduction also occurs because of

decrease in efficiency due to comparatively slower combustion of biogas. Even though, the air fuel ratio required for biogas is much lesser (around 12.3:1) as compared with diesel (around 16:1), which is an advantage for power output per cycle for biogas engine on the whole, it is usual to have the engine power derated to 50-55% of the original output as a result of this conversion.

5.4 Design and Technical Specification including Instruction for Use

The conversion kit mainly consists of the following sub assemblies/ components:

i) Spark plug

ii) Governor

iii) Speed pick up sensor

iv) Ignition system assembly with H.T Coil

v) The complete assembly is shown Fig.44,45,46,47& 48.

Figure 44

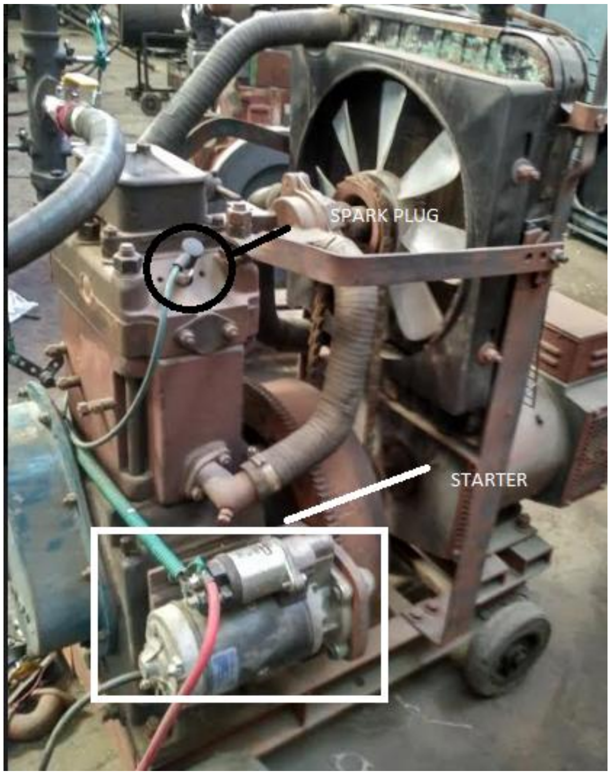

Figure 45

Figure 46

Speed pick up sensor

Figure 47

Air Fuel Mixing with Electronic Governor Mechanism

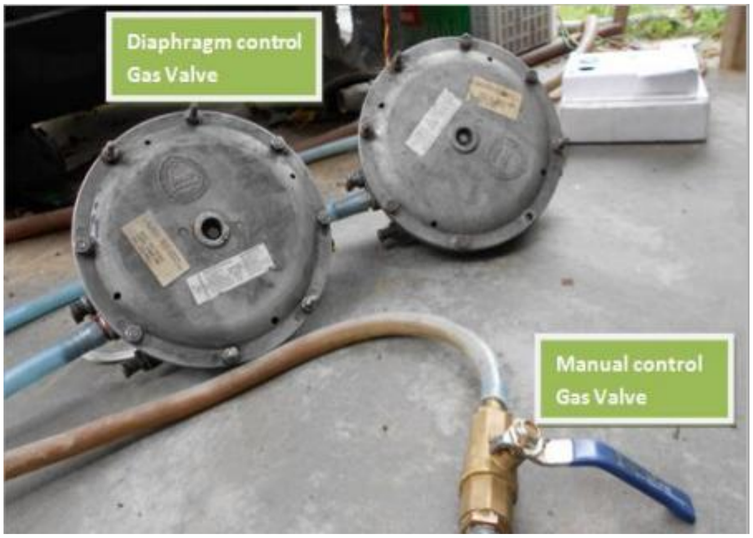

Figure 48

5.5 Performance

Diesel engine converted to biogas generator has been installed at prakash diesels. Performance are carried out .

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