Experimental Study of Effect Of KARANJA Bio-Diesel On CI Engine Equipped With EGR System

#1R. M. Rathod, #2S. V. Channapatana

[1]Mechanical Engineering, RSCOER's JSPM Narhe , Pune University, Pune Maharashtra India
[2]Prof. Mechanical Engineering, RSCOER Tathwade , Pune University, Pune Maharashtra India

Abstract- In the globalized era the technologies has given more comfort to human beings considering the automobile area, progresses are such that currently extensive use of automobile engines is going on. Also population explosion has significant effect over usage of automobiles for various purpose like luxury, transport etc. All these vehicles are run by internal combustion engine, mainly diesel engine has importance for transportation works, rural road heavy duty engine works, in local passenger vehicles and mechanised farming agricultural works. Focusing on continuous decrements of fossil fuels and stringent emission norms made us helpless and compromised to use alternate fuel so as to control emission due to stringent emission regulatory norms and to boost life and performance parameters of engine which leads to use green energy source. Bio-diesel nowadays are developing scope towards use of eco-friendly alternative fuel. As in India biodiesel production mainly from jatropha seed, karanja plant, neem oil etc. Karanja oil properties is same as that of diesel recommended that transesterification process need to followed by proper catalyst. Literature survey shows that Biodiesel blend of karanja oil with diesel KBD30+EGR10% yields good properties as thermal efficiency is get improved as well NOx emission get reduced by 25% ,HC by 15% and significant reduction in CO. Major reason behind EGR is to reduced cylinder pressure and pre-ignition temperature so as to reduce NOx emission.

Keywords:-EGR (Exhaust Gas Recirculation),KBD-Karanja Biodiesel ,NOx, Bio-diesel etc.

I. INTRODUCTION

Due to higher value & availability of diesel, more interest are getting developed in making biodiesel from variety of plants which are easily available in India like mostly Jatropha, Karanja, Neem oil etc. Due to natural vegetable oil viscosity is more as compared to diesel so as to make use of diesel it is mandatory to catalyst the reaction with methanol or ethanol or methyl ester, ethyl esters as a fuel additives to enhance quality of fuel. It is found that heating value is good as compared to diesel. Using biodiesel we have amount of oxygen molecule more due to which cylinder temperature increases by complete combustion of fuel by comparison to plain diesel so as to reduce temperature of cylinder cold EGR can be applied. Considering strict norms maximum interest is getting developed towards after treatment devices and external EGR technique. EGR is recirculation of partial exhaust gases from EGR cooler so to cool it near atmospheric temperature and allow to mix it with inlet fresh air via EGR valve. Due to EGR Peak pressure and temperature of cylinder can be maintained and NO emission can be reduced. Diesel engines are used in wide range because their advantages such as good efficiency, durability, and remarkable fuel economy as compared to gasoline engines. The applications of diesel engine is in generating electric power, agricultural sector, Building constructions, industrial fields, and transportation sector. These famous uses of diesel engines gives rise to increase the demand for petroleum products derived from fossil fuel. The depletion of Earth's fuel resources like fossil fuel and its impact by increasing environment pollution from exhaust gas emissions have led the search for alternative eco-friendly fuels. To resolve both energy problem and environmental problem, the renewable energies with lower environment pollution should be utilized. Nowadays, there are many sources of renewable energy; bio-fuel is one of them, but it is the most important one . Bio-fuel oils can produced from plants (edible or non edible), algae, and fats of animals. Use of non-edible plant oils is quite interesting, as these are generally cheaper than edible oils. By literature survey it is found that for single, double, multiple cylinder biodiesel can use direct with diesel in following compositions with EGR Proportion in order to get emission and performance of engine to be studies.
KBD15+EGR6%, KBD20+EGR8%, KBD25+EG10%, KBD30+EG12% etc. So all parameter can be checked at rated speed and different conditions of load. Various author mentioned below in list of survey found that during low EGR thermal efficiency get increases and NOx emission decrement takes place also HC, CO decreases. But at High EGR in last case, thermal efficiency decreases by small amount and NOx falls down by 45% drastically in same form HC formation will be there with presence of some white smoke particle from exhaust emission. Some of author conducted Experiment of plain diesel and varying EGR rate and compared with karanja biodiesel coping with varying EGR at various load and shown that there was somewhat more emission reduction with improved thermal efficiency takes place.[7]

II. LITERATURE SURVEY AND REVIEW

Jinlin Xue, Tony E. Grift, Alan C. Hansen et al[1] named as "Effect of biodiesel on engine performances and emissions", study shows Effect of biodiesel on engine power, Factors of effect on biodiesel engine power, Effect of biodiesel on engine economy, Factors of effect on biodiesel engine economy etc. Results obtained are as follows Specific fuel consumption increases due lower

heating value, high density and viscosity of BD, PM Matters reduces due to use of BD fuel, CO emission reduced due to higher % of oxygen in BD, Main conclusion in this study is to reduce only emission rather improving economy of engine. Cold performance characteristics can be implemented over this concept.[1]

J.K.Kim et al[2] studied cooled EGR Effect with different biodiesel except neem oil and fuel additives. so there is scope of use of neem oil, karanja oil mango oil and so on with fuel additives and affect of EGR on emission of CI Engine. It gives investigation of effect of cooled EGR with different biodiesel blends with diesel fuel with 5 to 10% of EGR found that significant drop in 5 gases when EGR case applied and use of BD20 with D80. In current study we will check effect of cooler EGR varying from 10-25% and BD5 to BD10% with Fuel additives on 5 gases and performance of CI engine.[2]

Hardik B. Charola et al[3] study named as "Evaluate the Performance and Emission using EGR (Exhaust gas recirculation) in Compression-ignition engine fuelled with blend", gives the results as With use of methanol as a blend HC.CO emission reduces on other hand NOx increases can be decreases with varying EGR %. By doing this HC,CO again increases and so can be reduces with varying C.R. Variation in performances can be studied by varying fuel additives.[3]

M.K.Duraisamy et al[4] journal named as "Experimental Analysis of Exhaust Gas Recirculation on DI Diesel Engine Operating with Biodiesel " performed test on CI engine fuelled with jatropha Biodiesel for NOx reduction and found that for 15% EGR and JBD25+D75 composition NOx get reduced and thermal efficiency is increased by 1.12%. Also Specific fuel consumption was lower in 20% EGR with diesel and 10% EGR with Biodiesel compare without EGR, Smoke level increases as EGR applied and can be compensated with application of biodiesel.[4]

V.V.Pratibha bharati et al(2012) performed experiment on effect of EGR with karanja biodiesel. She presented work regarding performance of the engine with KBD20 along with 10, 15 and 20% EGR, with 9 grooved piston (GP) with knurling configuration. Also She observed CO emission reduced by 2.95%,HC by 5.4%,and NO by 13%,some improvement in brake specific fuel consumption is around 2.9%, BTE (Brake Thermal Efficiency) increases by about 7.4% .[5]

III. EXHAUST GAS RECIRCULATION (EGR)

EGR is mostly used to reduce NOx formation in high duty diesel engines.EGR method involve recirculation part fraction of exhaust gases say 10 to 15% back to suction inlet before combustion[3]. So it will dilute the charge inside cylinder which tends to decrease overall cylinder temperature. Also in review we have seen use of Biodiesel fuel, cylinder temperature will increase due to complete combustion of fuel due to more availability of oxygen molecules. So to reduce that faults we can focus EGR in some partially cooled situation return to suction inlet before process of combustion. This will dilute the mixture and cylinder temperature will be in proper maintained region. This will help to reduce NO emission and HC also.[3]

EGR is a one of best technique for reduction of Oxides of Nitrogen (NOx), CO2, and HydroCarbon (HC) formation which forms in the combustion chamber. Exhaust gases consists of CO2, N2 and water vapors. When a part of this exhaust is re-circulated to the combustion cylinder, it behaves like diluting gas to the combusting mixture. This reduces the O2 concentration of combustion chamber. The heat capacity (specific heat) of the EGR is greater than fresh air, thus EGR increases the heat capacity of the intake mixture charge, thus reducing the temperature increment for the same heat release in the engine's combustion chamber.[3]

$$\% \text{ EGR} = \frac{\text{Volume of EGR}}{\text{Toal intake charge into cylinder}} \times 100 \qquad \text{…..(1)}$$

Another way to define the EGR ratio is by the use of CO2 concentration,

$$\text{EGR ratio} = \frac{[co_2]\text{intake} - [co_2]\text{ambient}}{[co_2]\text{exhaust} - [co_2]\text{ambient}} \qquad \text{….(2)}$$

Three famous reasons for the influence of EGR on nitrogen oxides (NOx) reduction are increased ignition delay, increased heat capacity and dilute intake mixture charge along with inert gases. Theory of ignition delay explains that because EGR causes an increment in ignition delay, it affects same as decreasing the injection timing. The heat capacity hypothesis states that when addition of the inert exhaust gas takes place into the intake charge it increases the heat capacity (specific heat) of the non-reacting matter available during the process of combustion. The increased capacity of heat has the effect of lowering the peak combustion temperature. According to hypothesis of dilution, EGR affects NOx which is caused by increasing amounts of inert gases in the mixture, which decreases the adiabatic temperature of flame. At high loads, it is difficult to employ EGR due to deterioration in diffused combustion and this might results in an extra increment in smoke and particulate emissions. At low loads, un-burnt HC from in the EGR would probably re-burn in the mixture, leading to lower un-burnt fuel in the exhaust and hence good improvement of brake thermal efficiency is seen. Apart from this, hot EGR would raise the intake charge temperature, thereby creating more combustion and exhaust gas emissions. Using the EGR, reduction in NOx and increase in soot, CO and un-burnt HC. Great focus have been made to investigate this phenomenon. It is indicated that for more than 50% of EGR leads to increments particulate emissions significantly, therefore use of a particulate trap is recommended. The oxygen concentration influences the structure of the flame and hence changes the duration of combustion. It is very important that flame temperature reduction is mostly factor influencing NO formation. Figure 1 shows the basic circuit of EGR. Implementation of EGR in diesel engines has problems which is increased soot formation and formation of particulate matter into the engine cylinders. When the engine components strikes high velocity soot particles and particulate matter abrasion may occur. Sulphuric acid and condensed water vapors in the EGR causes corrosion.

Recent studies have found damage on the cylinder walls due to the reduction in the lubricating oil capacity, which happened only

due to the mixing of soot carried with the particulate re-circulated exhaust gases. This explains the necessity of an efficient particular trap. Studies have shown that EGR coupled with a high collection efficient particulate matter trap, controls exhaust gas smoke, un-burnt HC and NOx emissions simultaneously. The particulate trap, needs to be regenerated as its holes gets blocked by the trapped soot particles. Clogged soot traps results in high back pressure of engine exhaust, which then affects engine performance also. These traps need to be cleaned by regeneration by regular interval of time using heat treatment or electrostatic or aerodynamic regeneration techniques. Other methods of reducing the particulate matter formation from such diesel engines implies multiple injections, supercharging and higher fuel injection pressure etc.

Parameters which are taken for study in case of KBD30+EGR10% are as following:-

- Brake Thermal efficiency
- Specific Fuel consumption
- Brake specific fuel consumption
- Brake mean effective pressure
- NOx,CO,HC,CO2, Smoke opacity etc

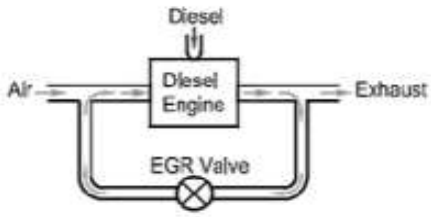

Fig.1 Basic EGR Circuit

The basic circuit shows how the exact inlet air and exhaust gases are recirculated in engine combustion chamber.

IV. BIODIESEL

Biodiesel is an alternative fuel used in diesel engines which is obtained by chemical reaction of vegetable oil or animal fat with an alcohol such as methanol. The reaction needs a catalyst, generally strong base, such as sodium or potassium hydroxide, and produces new chemical products known as methyl esters. These esters came to know as bio-diesel.

To reduce the viscosity and preparing biodiesel, number of method has been tried by researcher such as;

1. Blending,
2. Transesterification
3. Micro emulsion,
4. Pyrolysis or thermal cracking,

1. Blending

Vegetable oil has equivalent properties like diesel so that it can be directly used as fuel to engine, at first it was used & tested by Rudolf Diesel. Due to portability, high heat content, ready availability & renewability it can be used extensively. Also coking & trumpet formation on injector which causes problem of atomization, carbon deposits, oil ring sticking, thickening & gelling causes problems.

2. Transesterification

Triglyceride reacts with three molecules of alcohol in the presence of catalyst producing a combination of glycerol, alkyl esters and fatty acids. The whole process consist of three reactions with mono & di-glycerides are formed. It is reversible process thus excess alcohol is used to raise the product of alkyl ester and allow phase separation from glycerol. Time reaction, molar reactant ratio alcohol to vegetable oil, type of catalyst, amount of catalyst and temperature of catalyst etc has significant effect over process. It is also called as alcoholysis.It is the replacement of alcohol compound from esters by other alcoholcompound in process similar to hydrolysis, except than a alcohol is used instead of water.

R-COOR'+R''OH ⟶ R-COOR'' + R'OH

If methanol is used in obove equation it is termed as methanolysis. The process of triglyceride with methanol shown by general chemical reactions.[6]

Triglycerides +R-OH ⟶ Diglycerides+RICOOR

Diglycerides+R-OH ⟶ Monoglyceride+RIICOOR

Monoglyceride+R-OH ⟶ Glycerol+RIICOOR[6]

3. Micro Imulsion

It is colloidal dispersion of two atoms (1-150 nm) in solvent to form immiscible phases, methanol & ethanol are commonly used as solvents. Atomization becomes easy due to lower viscosity.

4. Pyrolysis

This means conversion of one substance into another by the application of heat, usually catalyst are used to speed up the process. Pyrolysis of vegetable oil yields various oils which can be used as alternative fuel.

Table. 1 Properties of diesel and karanja fuel

Oil Properties	Diesel Fuel	Karanja BD
Kinematic Viscosity*	5.7	7
Cetane No.	45	52
Heating Value (KJ/Kg)	43000	37600
Fire Point (°C)	180	215
Flash Point (°C)	86	175
Density Kg/l	0.84	0.913
Carbon Residue Wt%	0.1	0.27
Sulphur Wt%	Max 1.0	0.1

V. ADVANTAGES OF BIODIESEL

Biodiesel can be run on any conventional, unmodified diesel engine without any modification. Storage is easy for Bio-diesel also it is safe to store at atmospheric temperature and pressure. It reduces carbon dioxide emission because it is extracted from plant. Biodiesel provides good lubrication than diesel fuel. It extends the engine life also it can be used to reduce sulphur and its oxides. Due to abundance of oxygen combustion will be in complete which produces more power as compared to diesel which further result in higher thermal efficiency. It may produce low smoke and PM , NO, emissions as compared to plain diesel fuel.

VI. EXPERIMENTAL SETUP

In experimental set-up, the thermocouples are configured at the various locations in the test section. The U-tube manometer is connected across C-D Nozzle for calculating the pressure drop at the test section and mass flow rate of re-circulated exhaust gas. The EGR Valve [1-2] is used for application of EGR system and for controlling the exhaust gas in inlet section respectively. Proper geometry of EGR T-section needs to configure for appropriate EGR mixing at Suction entry for proper distribution in single cylinder.

Fig.2 Experimental Setup

Table. 2 Single Cylinder CI Engine Specification:-

Engine	Kirloskar Single Cylinder Diesel
Type	4 Stroke Single Cylinder
Bore	87.5 mm
Stroke	110 mm
Cubic Capacity	1.323 Liter
Normal Compression Ratio	17.5:1
Governer	Centrifugal Mechanical

	Type
Speed	1500 rpm
Cooling	Water Cooled

VII. RESULTS & DISCUSSIONS

To investigate the performance of engine with and without EGR rate, it is necessary to find out values of performance parameter on all said five loads and can be validated with pure diesel. So that we can predict the performance behavior of CI engine with and without EGR condition and helpful to know which EGR will be better for the experimentation.

7.1 Performance characteristics with Varying EGR

a. Variation of Brake Specific Fuel Consumption (kg/kW hr) with Brake power (kW) at different EGR rate.

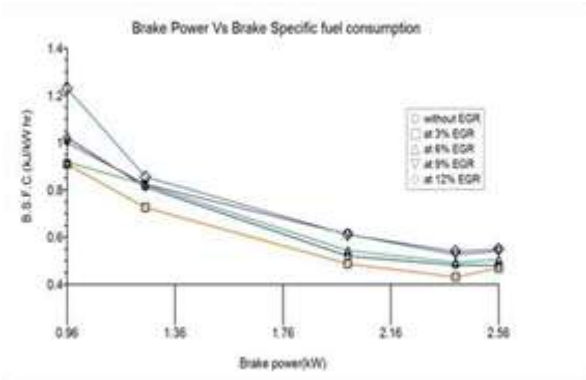

Fig.3 Brake Power (kW) Vs. B.S.F.C.(kg/kW hr)

Figure 3 shows variation of brake specific fuel consumption with brake power. An effect due to pumping work reduced when EGR rate increased. Due to this reason the total inlet charge needed to go via throttle and hence more charge is required. Inverted triangle points line shows B.S.F.C.value on 9% EGR was observes as 0.5417 kg/kWhr.

b. Variation of Brake Thermal Efficiency (%) with Brake Power (kW) at different EGR rate.

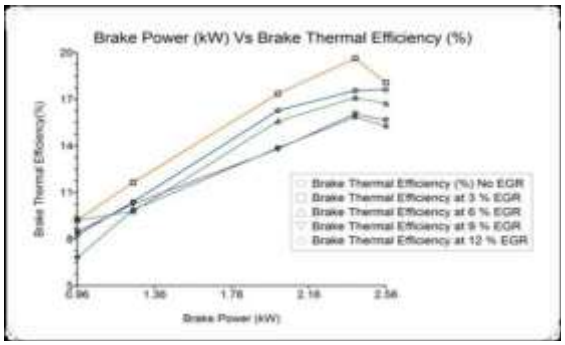

Fig.4 Brake Thermal Efficiency (%) with Brake Power (kW)

Figure 4 shows the value of mechanical efficiency at each brake power from 5.1.1 to 5.1.5 Values of mechanical efficiency is directly proportional to break power up to 2.35 kW and decreases after 2.56 kW. After 2.35 kW brake power, mechanical efficiency is get lowered as Brake power get reduced. Mechanical efficiency is reduced after 2.30kW brake power and it is due to high loading condition speed of engine is reduced by 700 RPM. Hence value of Brake thermal efficiency is reduced after 2.30kW.

c. Variation of exhaust gas temperature(C°) with EGR Rate(%) at Load (kg).

From fig 5 shows the Exhaust gas temperature varies with EGR Rate for varying load (kg) in the range of 0% -20% loads for diesel, and Karanja biodiesel. As exhaust gas temp. Increases as load increases. The highest value of exhaust gas temperature of 174°C was observed with the karanja oil, whereas the corresponding value with EGR was found to be 135°C only. Main reason behind temperature drop was a collection of all gases together act as dilutant and hence to keep mean cylinder temperature, this reason also validates the NOx decrement as minimum cylinder temperature.

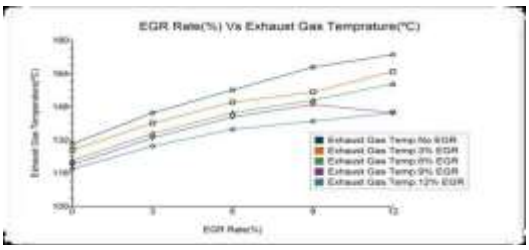

Fig.5 Exhaust gas temperature(C°) with EGR Rate(%) at Load (kg).

VIII. CONCLUSION

Exhaust Gas recirculation set up is economical method for used to reduced NOx and other harmful emissions. During literature review it was found that NOx is get reduced but due to EGR it have adverse effect on brake thermal efficiency. So to overcome it karanja biodiesel drawn out the thread and thermal efficiency is get recovered. In this study, when engine was operated with EGR and without EGR system. The brake thermal efficiency decreases due to minimum calorific value. Brake thermal efficiency value was higher at lower EGR rate and lower at higher EGR rate. Brake thermal efficiency observed on karanja biodiesel. The Karanja biodiesel was used as a fuel and its characteristics were analyzed. Emission characteristics is still under experimentation which will be completed in upcoming month, then the aim of project will be completed.

REFERENCES

[1] Jinlin Xue, Tony E. Grift , Alan C. Hansen," Effect of biodiesel on engine performances and emissionsRenewable and Sustainable Energy Reviews 15 (2011) 1098–1116.

[2] J.-K. KIM, E. S. YIM, C. H. JEON, C.-S. JUNG and B. H. HAN," cold performance of various biodiesel fuel blends at low temperature", International Journal of Automotive Technology, Vol. 13, No. 2, pp. 293−300 (2012) .

[3] Hardik B. Charola, C. D. Sankhavara, M.B.Charola," Evaluate the Performance and Emission using EGR (Exhaust gas recirculation) in Compression-ignition engine fuelled with blend.", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 10, Issue 5 (Jan. 2014), PP 16-21 www.iosrjournals.org.

[4] V.Manieniyan, S.Sivaprakasam, "Experimental Analysis of Exhaust Gas Recirculation on DI Diesel Engine Operating with Biodiesel", International Journal of Engineering and Technology Volume 3 No. 2, February, 2013.

[5] V. V. Prathibha Bharathi, Dr.Smt.G.Prasanthi, " Investigation on the Effect of EGR with Karanja Biodiesel and Grooved Piston with Knurling In an Internal Combustion Engine", IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719, www.iosrjen.org Volume 2, Issue 9 (September 2012), PP 25-31.

[6] Vivek and A K Gupta,"Biodiesel production from karanja oil",Journal of industrial & scientific research, Vol 63, 2004, pp 39-47.

[7] Venkata Ramesh Mamilla, M. V. Mallikarjun, Dr. G.Lakshmi Narayana Rao," Preparation of Biodiesel from Karanja Oil", International Journal of Energy Engineering, DOI 10.5963/IJEE0102008, IJEE.

