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AN EXPERIMENTAL STUDY ON PERFORMANCE OF JATROPHA BIODIESEL USING EXHAUST GAS RECIRCULATION

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Abstract— ***Today the world is in dilemma for the prevention of both of fuel depletion and environmental degradation crises. Due to excessive need, indiscriminate extraction and consumption of fossil fuels have led to a reduction in petroleum reserve. Developing countries such as India depend heavily on oil import. Diesel being the main transport fuel in India, finding a suitable alternative to diesel is an urgent need of the hour. Jatropha based bio-diesel (JBD) is a non-edible, renewable fuel suitable for diesel engines and has a potential of large-scale employment for wasteland land with relatively low environmental degradation. As Jatropha oil is free from sulphur and still exhibits excellent lubricity and is a much safer fuel than diesel because of its higher flash and fire point. Performance parameters including brake thermal efficiency (η), brake specific fuel consumption (BSFC) with varying loading conditions showed Jatropha biodiesel as an effective alternative on four stroke single cylinder compression ignition engine. Also the effect of exhaust gas recirculation (EGR) at 10% recirculation showed Jatropha as an effective fuel since the inherent oxygen present in the bio-diesel structure compensates for oxygen deficient operation under EGR.***

Keywords— Jatropha , Exhaust Gas Recirculation, Brake specific fuel consumption, Polycyclic aromatic hydrocarbon, Brake thermal efficiency.

I. INTRODUCTION

1.1 General Overview

In India, there are approximately 20 million vehicles and to satisfy the necessity, India needs forty five million ton of fossil fuels annually. India imports 2/3rd of its rock oil necessities last year, that concerned a price of roughly 80,000 crores in interchange. India is principally addicted to gulf nations for fuel provide. The country can so have to be compelled to continue importation oil till some alternate fuels creates India self property. Bio diesel is a fuel made from renewable resources such as vegetable oils and animal fats. It is ecofriendly and non toxic, and emits comparatively less to that of mineral diesel. So the time has already return to search out the foremost appropriate alternate fuels. The sturdy competitors square measure bio-diesel, CNG, LPG etc. These fuels produce other benefits additionally that measure superior to gasoline and diesel i.e. less polluting, Bio-diesel is created from many oil this can be appropriate for operational CI engines.

1.2 Need for Alternative Fuels

The transport department all over the world is the facing problem in the area of alternatives fuel. Diesel is so far the most commonly used fuel in the transportation area. The ranking of India in the energy requirement is approximately sixth in the world as it consumes nearly 3 to 4% of world commercial energy consumption. Diesel has share of 60 to 70% in transport and the consumption will rise day by day which is for sure and dependence on crude oil imports is increasing tremendously which will further result in the growing gap between demand and supply. Indian crude oil reserves are found which may available for the next25 to 35 years approximately. The ever increasing prices of fuel will directly affect the foreign exchange policy of a country like India. Jatropha bio-fuel may be a replacement for transport fuel in place of existing fuel like diesel. The foremost vital issue of biofuels is to create better environmental effects through lesser emissions. Use of native production of Jatropha bio-fuel is an added advantage of having a good economic and environmental implications. Use of Jatropha bio-fuel will help in lesser deforestation of land and help in higher financial gain . The Indian program of maintenance of forest suggest to protect soil from erosion and its environmental applications can generate employment for the people and protect natural environmental condition for betterment of society and help to save energy for the coming generations. Bio-diesel is demand for the replacement of diesel practice modern technology which could be created from trans-esterification of vegetable oils .In India the technique is completed with the use of Jatropha Curcas plant. It desires little or no engine modification. Comparison between diesel and bio-diesel is that it well reduces emissions of hydrocarbons, carbon monoxide gas, sulphates, aromatic hydrocarbons, etc. The decrease of emission, increases as a result of the number of bio-diesel mixed into diesel fuel can increase. The pure biodiesel provides one of the better reduction in emissions as compared to other blends. The 20% biodiesel has been used to reduce emissions by nearly 10%, CO by 11%, and HC by 21%..Biodiesel and diesel have similar physical properties. The pure biodiesel has higher cetane value which improves the combustion quality.

Jatropha curcas is one of the best suited plant which uses highly unproductive type of land. To grow Jatropha plant in approximately in 11 Million hectares, has significantly emerged as a “National Mission”.Raw material(jatropha curcas seed and oil) choice of improved living substance material for quality and amount of oil; developing agro-technologies for various agro-climatic regions; total analysis of all potential non-edible oils with special stock to jatropha curcas oil. Testing of biodiesel from numerous feed stocks and generation of comparative knowledge on fuel composition, emissions, material compatibility.

1.3 Exhaust emissions and their environmental effects

Major problem from mineral diesel and other fuel is the release of green house gases which leads to green house effect. A green house is a gas in an atmosphere that emits radiation within thermal infrared range. This process is basically responsible for green house effect. The primary green house gases in the atmosphere include water vapor, methane, carbon dioxide, ozone, nitrous oxide. Due to vehicle emission there is an increase in concentration of carbon dioxide and earth surface temperature is increasing day by day. The major vehicle emissions include carbon monoxide, hydrocarbon, and particulate matter, nitrogen oxide. The existing engine running on diesel fuel emits such radiation to large extent which affects the environment temperature. The lean burning nature of compression ignition engine and high temperature and pressure of combustion process leads to huge amount of production of nitrogen oxide (NO_X) an air pollutant. Other emissions from diesel engine are soot which is largest cause of global warming. Soot results from pyrolysis.Soot is a powder like form on amorphous carbon and mainly consist of polycyclic aromatic hydrocarbon (PAH).Polycyclic aromatic hydrocarbons are major sources of cancers according to international agency for research on cancer. Soot actually forms due to incomplete combustion of fuel so biodiesel which is an oxygenated fuel leads to complete combustion and can reduce soot formation. Also using biodiesel in existing diesel engine can reduce carbon monoxide and hydrocarbon emission due to oxygenated nature of biodiesel fuel. Hence biodiesel can substitute mineral diesel due to its environment friendly nature

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1.4 Present Scenario in India

India has tropical advantage with huge waste lands & cheap farm labor. Biodiesel in republic of India measures usually success story compared to world. Current per capita usage of crude is as low as (0.1 ton/year). Investment in biofuels creates durable economic sense. Sustainable production of annual, perennial and wood feedstocks from agriculture, creation of recent biomass feedstocks in laboratories and chemical conversion techniques exploitation fermentation, anaerobic digestion, accelerator development and thermochemical conversion techniques exploitation accelerator development, chemical change and transmutation plants. Policy, management and communication to see a worldwide bioenergy market is that they would like of the hour during this quick pace moving situation.

1.5 Preparation of Jatropha Biodiesel

Steps involved in preparation of Jatropha Biodiesel

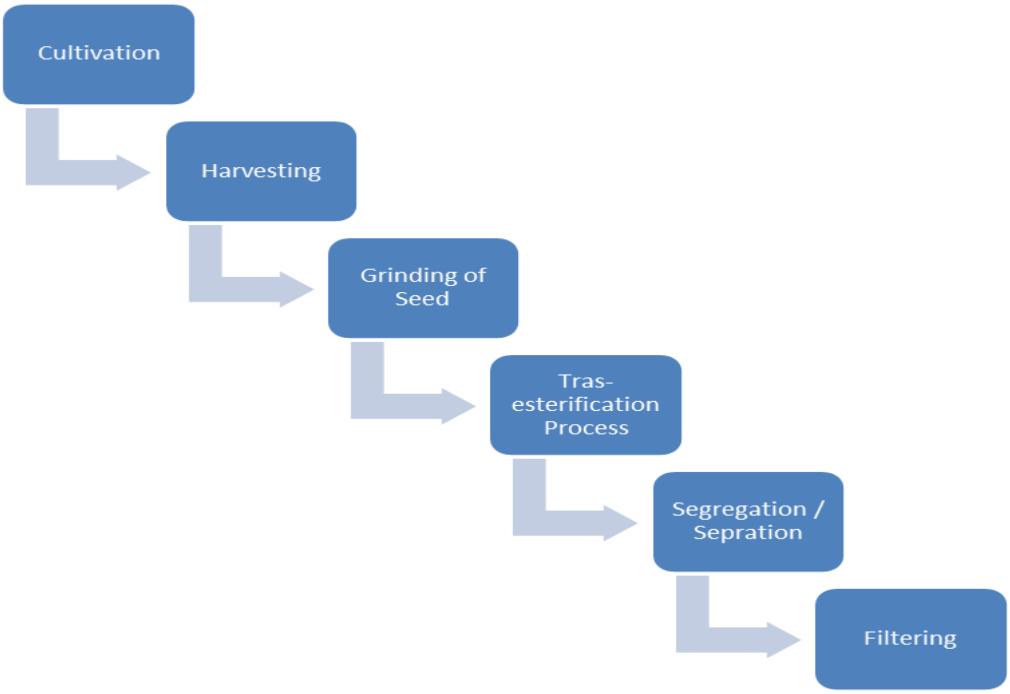

Fig 1 :- Schematically representation of Processing Technique

Jatropha Bio-diesel is firstly cultivated in unproductive waste land and is harvested under the tropical climatic conditions. The grinding of seed is done afterwards. Jatropha is made from fatty acid alkyl esters or fatty acid methyl esters . It is made from renewable sources like vegetable oils and animal fats. It is poisonous in nature and biodegradable. Fats and oils react with an various kinds of alcohol (methanol or ethanol) resulting in fatty acid methyl esters or ethyl esters. Glycerin is produced as a by-product. Presently bio-diesel can be made by using different type of trans-esterification technologies. The oils and fats are preprocessed to remove water and contaminants. Pretreatment technologies are used to transform into bio-diesel using special methodology. The pretreated oils and fats is added with an alcohol (usually methanol or ethanol) and a catalyst (usually potassium hydroxide). Triglycerides are normally broken and transformed into methyl or ethyl esters and glycerin, the resultant outcome is separated and purified.Diesel engines are comparatively much more costlier so damage in diesel engines is not worth risking. Triglycerides can not directly used be in a diesel engine because they are much more viscous and denser than bio-diesel. They cause deposits in engines, sticking on surfaces and other maintenance problems that results into reduction of engine life

1.5 Biodiesel Fuel

Alternative fuels got to be merely out there, setting friendly and techno-economically competitive. But due to the fast decline in petroleum reserves, it's yet again being promoted in many countries. Relying upon the climate and soil conditions, completely and totally different countries unit of measurement making an attempt to seek out different types of substitutes for diesel fuels. It has been found that these neat vegetable oils is employed as diesel fuels in customary diesel engines, but this finishes up in sort of issues regarding the type and grade of oil and native climate. The injection, atomization and combustion characteristics of vegetable oils in diesel engines unit of measurement significantly fully totally different from those of diesel. The high consistency of vegetable oils interferes with the injection methodology and finishes up in poor fuel atomization. The inefficient mixture of oil with air contributes to incomplete combustion, leading to serious smoke emission, and additionally the high flash purpose attributes to lower volatility characteristics. These disadvantage, couple with the reactivity of unsaturated vegetable oils, don't modify the engine to work bother free for extended quantity of some time. These problems is solved , if the oil blends with diesel by volume share, than blends viciousness less from raw oil and high from diesel consistency, but, combustion is possible use of this fuel.

Biodiesel, associate alternate fuel springs from the fats of animals and plants. As energy demands increase and fossil fuels unit of measurement restricted, analysis is directed towards totally different renewable fuels. The foremost advantages of exploitation this totally different fuel unit of measurement its renewability, biodegradability and better quality of exhaust gases. It's technically competitive and environmentally friendly totally different to ancient petro diesel fuel to be utilized in CI engines. The use of biodiesel reduces the dependence on foreign fossil fuels that continue to decrease in convenience and affordability. Vegetable oils for biodiesel production Vary considerably with location keep with climate and feedstock convenience. Usually the foremost luxuriant oil during a very specific region is that the most common feedstock. Nowadays, most of the business biodiesel comes from the trans esterification of oil using a basic catalyst reminiscent of NaOH or KOH, as a result of a basic catalyst faster than associate acid catalyst. The fuel of bio-origin is additionally the biodiesel obtained from edible or non-edible oil through trans esterification methodology. Most of the properties of biodiesel compare favourably with the characteristics required for the CI fuel. Due to the relatively high costs of edible oils, the worth of producing radical or ethyl radical esters from edible oils is presently dearer than chemical compound based diesel fuels. The worth of biodiesel is reduced if we have a tendency to area unit ready to take into consideration non edible oils instead of edible oils. Non-edible oils from plants hemp and neem tree unit of measurement merely out there in many parts of the earth and unit of measurement more cost effective as compared to edible oils. Moreover, the use of non-edible vegetable oils is of significance thanks to nice would really like for edible oil as food which they unit of measurement too costly to be used as fuels

1.6 Advantages of Jatropha Biodiesel

1) Jatropha Curcas' plant can grow in waste lands and consumes less water.
2) Its cultivation, seed collection, oil extraction, and bio-diesel production can generate large-scale employment.
3) Cost of seeds is quite low.
4) Oil content in the seed of Jatropha is very high comparatively to other seeds.
5) The period of gestation is small so output is obtained in small time.
6) It grows on every type of soil.
7) It also has adaptability to grow in low to high rainfall.
8) Size of plant makes seed collection convenient.

1.7 Disadvantages of Biodiesel

1) However some of disadvantages of fuel associated are listed below:
2) The low yield of oil extracted compared to land used.
3) We will lose crops used as food for production of fuels.
4) The increase in demand of crops as fuel crops will increase the cost of the same crops for food.
5) A large amount of land will be required to grow crops for use of biodiesel.
6) Presence of oxygen in the structure of JBD reduces the energy content of fuel and significantly contributes to

1.8 Jatropha – Why the best biofuel?

Jatropha-

1) It is easily cultivated in land where long periods of drought are observed.
2) Requires minimum care.
3) It cannot be eaten by sheep.
4) Propagation is straightforward.
5) It has rapid growth and forms a thick live hedge in nine months of planting.
6) Yield from the third year forwards and continues for 25-30 years.
7) Higher yield in plantations nearly 1.5 to 2.5 tons per square measure.
8) It gives 25% oil from seeds by expelling.
9) The extraction is a superb organic manure (38% protein).
10) It cannot be eaten by insect pests.
11) By-product during bio-diesel production can be used in soap and fertilizer industry.
12) Bio-diesel from Jatropha oil is free from sulfur and still exhibits excellent lubricity, which is an indication of the amount of wear that occurs between two metal parts covered with the fuel as they come in contact with each other.
13) It is a much safer fuel than diesel because of its higher flash and fire point.

II. LITERATURE REVIEW

A.K. Agarwal et al. [1] investigated about oil based mostly blended fuels having issues of higher viciousness and exhaust emissions of gases like (NO_x) and (PM) which are combined with SVO emulsions. The SVO's of (Jatropha-Karanja) with methanol in dispersed phase were combined. 'Span 80' at optimum concentration, stirrer speed, and stirring period were determined for emulsions. These blended fuels had necessary fuel properties comparable to diesel. The emulsions using blending diesel in 1:3 ratio were evaluated during a single cylinder IC engine for result. It was observed that BTE of emulsified blends was lower and BSFC was found to be little higher than diesel resulting that the blend of SVO with methanol can replace diesel as partial replacement for diesel engine which will not require any modification in engine hardware.
X. Shan et al. [2] investigated about characteristic of combustion and emission of biogas using diesel fuel engine. In this experiment two type of biogas combination biogas1 ($H_2 : CO : CH_4 : N_2 = 5:40 : 50$) and biogas2 ($H_2 : CO : CH_4 : N_2 = 15 : 30 : 5: 50$)were studied. It was concluded that E.G.R rate effects the combustion by decreasing its effect and increasing ignition delay. Biogas 2 ($H_2 : CO : CH_4 : N_2 = 15 : 30 : 5: 50$) having more of hydrogen content showed higher reactivity comparatively. Low NO_X and higher efficiency was achieved when combination of diesel was done.
A. K. Azad et al. [3] investigated about LTC having homogeneous charge, premixed charged and reactive controlled combustion ignition methodology reducing PM and NO_x emission. Also CO and HC emission increases because of high rate of EGR. This model established that hybrid k-ε and k-ω turbulent using shear stress transport causing increase in

engine efficiency by reducing and controlling harmful emission in CI engine.

S. Nagaraja et al. [4] investigated about Corn Oil Methyl Ester (CORN) and diesel which was tested on CI engine to check the toxicity with different methods of environment standards and the performance and combustion characteristics were studied. CORN was blended together in different proportions of blend as B20, B40, B60, B80, B100. As it was analyzed on single cylinder diesel engine that Corn has low exhaust emission with better performance compared to diesel engine and did not require any significant modification in engine. It also showed at full load condition SFC B100 had 4% lower emission rate than D100. Even the emissions from exhaust were found to be 2.3 to 18.8% less for CORN.

R. J. Ho Kumaran et al. [5] investigated about reduction of NO_X and PM emission by using HCCI (Homogeneous Charged Compressed Ignition) with direct E.G.R injection also tried to decrease LTC (Low Temperature) combustion by using OPEN computational fluid dynamics software it showed direct injection has the capacity to directly control mixing combustion of fuel present inside combustion chamber causing reduction in emission and increasing its Break Thermal Efficiency.

A.W. Go et al. [6] investigated about direct (trans) esterification of Jatropha curcas L. (JCL) kernels in subcritical solvent mixture of water, wood spirit and ethanoic acid that finished into a high fatty acid methyl ester (FAME) yield of 96.56% could be achieved as a solvent containing (water: acetic acid : methanol= 1:5:15, v/v/v) to solid ratio of 7 cm^3 / g having pressure 12.5 MPa and 523 K for 1hr. This result in the increased contact between reactants and increasing solubility. Acetic acid and water acted as a catalyst.

Bhaskor J. Bora et al. [7] investigated about impact of compression ratio of 18, 17.5 and 17 with fixed set of injection timing at 23^0 (BTDC) resulting that at full load, highest (BTE's) brake thermal efficiencies was found to be 20.27%, 19.97% and 18.39%. Even most of the liquid fuel replacement is found to be 80%, 79% and 78.2% for CRs of 18, 17.5 and 17. The mean observed reduction in CO and HC (organic compound) emissions by 17.67% and 17.18%.Furthermore oxides of carbon and nitrogen emissions increased by 42.85% and 14.13%.

J. M. Bergthorson et al. [8] investigated about I.C. engine is to improve fuel efficiency and to decrease emission to obtain it, specifically tuned and highly efficient thermal and biochemical conversions using ultra low vision and meeting urban quantity for energy and carbon constrained world.

Freddy S. Navarro Pineda et al. [9] investigated about whole crop bio refinery system as the best suited alternative to make jatropha based biofuel business to be beneficial for the yield or harvesting. Jatropha biomass is utilized as the feedstock in various processes such as densification, pyrolysis, carbon activation, gasification, combustion, anaerobic digestion, fermentation, solid-state fermentation, and extraction and purification of compounds making it once again a strong competitor in the arena.

D. Singh et al. [10] investigated about B100 biodiesel samples of C.Variabilis (BA) and J.curcas (BJ) oils in which PM, CO and HC emission for both BA and BJ performance was appropriate with little dissatisfaction for the performance on the part of NO_x emissions. It was observerved that in various modes that is rural, urban and motorways NO_x, CO, HC were found to be the most transient in their emissions respectively. Hence it's concluded that C.variabilis (BA) as the best promising alternative resultant of the experimentation.

M. Assawadithalerd et al. [11] investigated about Jatropha biodiesel (JBH) utilized micro emulsification technique to alleviate the problem of the limitation on injection system of diesel engine caused due to it higher levels of viscosity. The addition of an alcohol ethoxylate (LS) surfactant and bioethanol at various groups (LS1, LS3, LS7) were determined and it was concluded that LS1 as the highest and the best obtained resultant for solubilizing all component because of low HL balance. (3,3) model with 3 interior point having R^2=0.998 and MAPE=5.031% fits to its best with optimized kinematic viscosity.

A.K. Wamankar et al. [12] investigated about effects of CR, nozzle opening pressure and injection timings of CI engines by using Carbon Black (CB). The emulsion using CB 10%, 2% water, 85% diesel and 3% surfactant (CBWD10) was studied. It concluded that maximum 10% diesel is best suited replacing CBWD10 even the EGT of emulsion was 3.3%- 9.8% lower and CO, HC, NO_x emission of the emulsion were found 16%, 35 % and 18% than that of diesel.

T. Lattimore et al. [13] investigated about E.G.R effect on combustion of fuel and emission on single cylinder DISI engine showing that the Knock Limit Maximum Break Torque (KMLBT) spark timing was advanced by 8^0 by adding 12 % E.G.R caused a decrement of 4.1 % fuel consumption at 7 bar IMEP (Indicated Mean Effective Pressure).

Z. Helwani et al. [14] investigated about experiment of Meso- porous hydrotalcite used jatropha oil of fatty acid methyl ester (FAME) resulting into better results at atmospheric pressure and low reaction temperature. It resulted with good influence calcinations temperature for mechanical strength to avoid leaching. It decreased catalytic activities taking place inside the reaction. Optimum FAME value 91.2 % was obtained as the best resultative output.

J. Portugal - Pereira et al. [15] investigated about environmental benefit as well as energy saving of the production in the use of jatropha fuel in over the typical LPV in India. Many parameters as NRE consumption, GWP, TAP and RIE were studied the energy recovery path which was taken care to generate extra electricity and gastification proved to have performed better and optimum performance for NRE and GWP impacts**.**

Y. Su et al. [16] investigated about government policies which implemented to provide sustainability and low cost amount decreasing subsidiaries for whole process feedstock to reduce investment risk even bioethanol and biodiesel have commercialization in aviation industries.

Y. A. Fatimah. [17] investigated about technological utilization of Jatropha innovation as well as normative values of faith in technology. It also showed that innovation success depends upon the outlook of approach which arguments its development fantasies.

EXPERIMENTAL SETUP

1.9 Biodiesel Production steps

Jatropha oil is utilized as feedstock for biodiesel generation. Alcohol and catalyst used are methanol and KOH.
Different methods are used for production of biodiesel are blending thermal cracking micro-emulsion pyrolysis and trans esterification process etc. It describes the production of biodiesel through transesterification process. In this process the conversion of vegetable oil to biodiesel is effected by several parameters namely amount of alcohol, type and amount of catalyst, time of reaction and temperature of reaction.

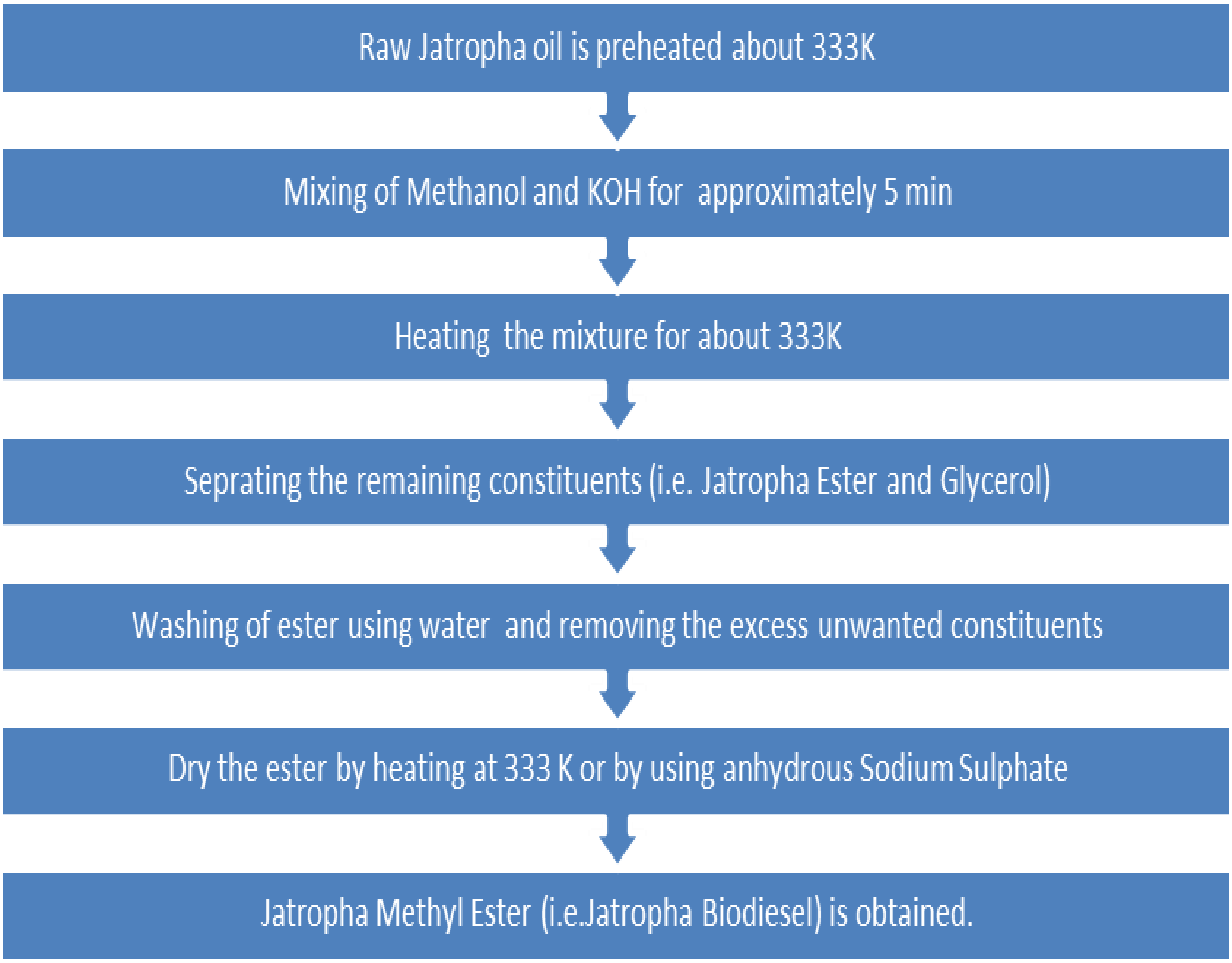

Fig. 2:- Flowchart showing steps in production of Jatropha Biodiesel

Mixing of alcohol with catalyst**:** In the present work,250 ml of methanol in Fig. 3.2 and 7.5gm of potassium Hydroxide KOH in was blended in round bottom flask

Reaction**:** The alcohol/ catalyst mixture is added to 1000ml of Jatropha oil. The reaction is done at 60^0 C and atmospheric pressure for around 1 hour. Shown in Fig. 3.5 Separation of glycerin and biodiesel as shown in figure 3.6.
As reaction is finished, the two major product are glycerin and biodiesel. As the glycerol is much denser than biodiesel, it settles at the bottom of the round bottom flask and can be separated easily.

Fig 3 : Heating in heating mental

Fig 4 : Separation of Bio-Diesel and Glycerol using Trans-Esterification Process.

3.2 Experimental Set Up

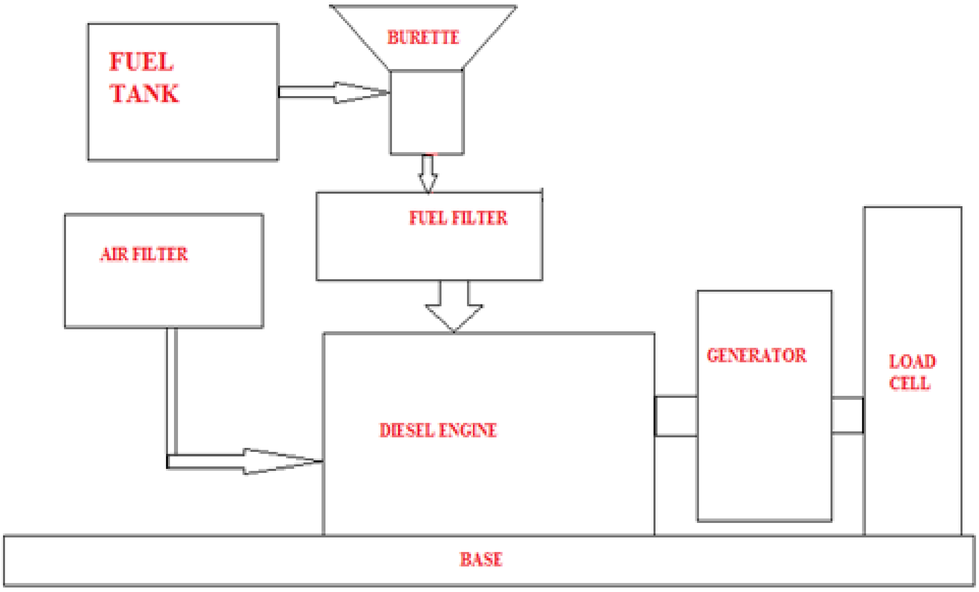

Fig. 5 A schematic diagram of the experimental set up

This chapter describes in detail the methodology used for experimental procedure adopted to evaluate performance of diesel engine on the pure diesel, pure biodiesel and its blend of Jatropha biodiesel. The experiments was conducted in the Internal Combustion Engine Laboratory, Department of Mechanical Engineering, Rayat and Bahra University. The parameters to be studied and methodologies used for experimental interpretations are discussed in this chapter.

1.10. Materials Used:-

- The Jatropha filtered biodiesel oil used in this present study was supplied from Ludhiana
- The commercial diesel fuel was purchased from petrol pump which is nearer to Kurali (Punjab).
- All chemicals (Methanol and KOH) Catalyst were procured during experimentation from Sector 16, Chandigarh.

1.11. Equipments Used for production of Jatropha Biodiesel

- Diesel Engine
- Heating Mantle
- Separating Funnel
- Holding Stand
- Stirrer
- Thermometer

1.12 Engine Description

Diesel engine selected for the experimentation is the maker of the Kirloskar Oil Engine Limited India. It is a single cylinder 4-stroke, air-cooled diesel engine of 6HP rated power .direct injection engine that has been designed for petroleum diesel combustion. The single cylinder diesel engine test rig consists of a generator machine coupled to a load cell and it is used to load the engine the starting of the engine is done by manual cranking with the help of detachable pawl type handle. The fuel is supplied to the engine from the fuel tank through fuel filter measurement using burette. The rotation is clockwise facing the flywheel in the engine .The engine set it constant speed 1500 rpm. The engine is properly balanced and flywheel is statically balanced for the smooth operation of the experimental work. Table 3.1 gives the specification of diesel engine used for the experiment.

Table I Specifications of the Diesel Engine

MAKE	Kirloskar oil Engine India Lmt.
Engine type	(CAF1) Single cylinder, DI, Four-Stroke
Cooling System	Air cooled System
Rated power	4.5 K W at 1500 rpm
Bore/Stroke	80/110[mm]
Compression Ratio	16.5:1
Injection pressure	200kg/cm^2
Engine weight [kg]	175

The diesel chosen for the experimentation is widely used for commercial activities in agriculture sector and small scale industries. The experimental test rig is easy to develop and to perform experiment. It is coupled to eddy current dynamometer to absorb the energy. Other equipments used are discussed in the following topics.

1.13 Exhaust Gas Recirculation

Exhaust gases were tapped from exhaust pipe and connected to inlet airflow passage. An EGR control valve was provided in this pipe for EGR control. The exhaust gases were regulated by this valve and directly send to the inlet manifold. Mixture of fresh air and exhaust gases was sent inside the manifold chamber. Temperature of this exhaust gas-fresh air mixture was measured just before its entry into the combustion chamber by the thermocouple. Orifice meter along with U- tube manometers were used to measure volume flow through the discharge tube .

EGR technique involved diverting a fraction of exhaust gas into the intake manifold where the recirculated exhaust gas mixes in coming air before being inducted into the combustion chamber.

The amount EGR was determined by using the expression

$$(\%)\ EGR = \frac{(\text{Vol. of recirculated air from exhaust}) * 100}{(\text{Vol. of air admitted} + \text{Vol. of recirculated air from exhaust})}$$

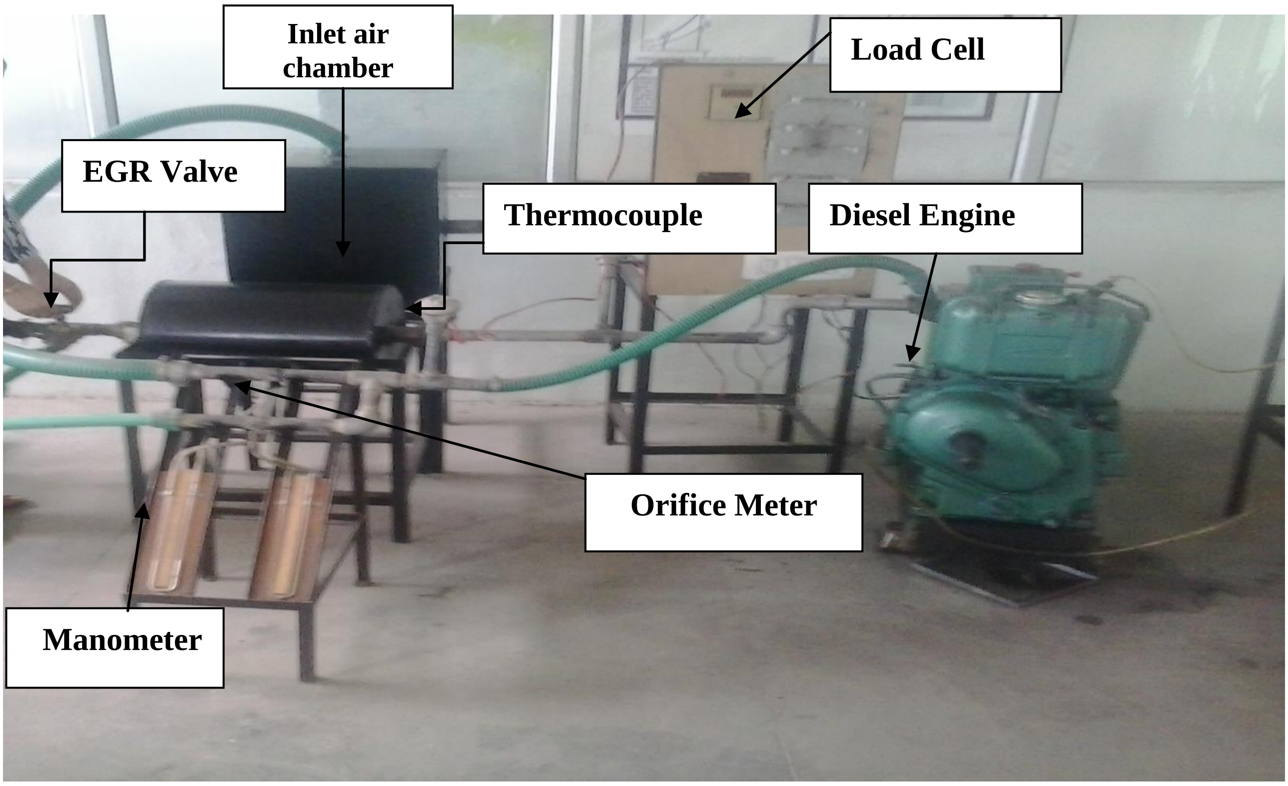

Fig 6 : Set up of Exhaust Gas Recirculation

1.14 Main Parts of the Set Up for Exhaust Gas Recirculation

- Inlet thermocouple
- Exhaust Thermocouple
- Inlet Valve
- Exhaust Valve
- U- tube Manometer
- Fresh air inlet box
- Orifice Meter

This chapter describes the experimental set up and procedure adopted for production of biodiesel from jatropha oil and experimental testing rig used for testing the performance of diesel engine using biodiesel and petrodiesel. The biodiesel used for the experimentation is extracted from jatropha oil in the heat transfer laboratory at Rayat and Bahra University. The jatropha oil was brought from online seller. The chemicals used for the experimentation were brought from vardhaman chemicals sec 16 chandigarh.Figure 3.1 shows the different stages of reaction process. Fig 3.2 shows the prepared biodiesel left in the standing funnel for separation. The schematic diagram for experimental setup along with instrumentation is shown in Fig 3.4. This engine along with generator is widely used in the country, mostly for agricultural and many small and medium scale commercial purposes. Moreover experimental test rig is easy to develop and require less maintenance. Thus such a system was chosen to examine the practical utility of biodiesel in such application.

RESULTS AND DISCUSSIONS

1.14 INTRODUCTION

In this chapter the results obtained from various tests performed on single cylinder, four stroke, air cooled diesel engine at constant engine speed of 1500 rpm. Tests were performed using mineral diesel, J50, and J100 blends. All the tests were performed at heat transfer laboratory of the Rayat and Bahra university. A test on diesel engine (single cylinder, four stroke, air cooled, and constant speed of 1500 rpm) with load cell of different power rating (1KW to 5KW) was used. All the pipelines connection to diesel engine were cleaned to avoid any error in readings. The aim of the various tests was to investigate the performance of diesel engine with jatropha biodiesel and its blends. Various performance parameters such as brake specific fuel consumption (BSFC), Brake thermal efficiency(BTE) at variable loading conditions were computed. Numerous time the readings were taken to reduce any error. The results obtained were plotted and comparison was made between jatropha biodiesel, blend and mineral diesel.

1.15 Engine performance parameters

1. Brake specific fuel consumption(BSFC)
2. Brake thermal efficiency(BTE)

1.16 Brake specific fuel consumption (BSFC)

Brake specific fuel consumption may be defined as mass of fuel consumed per unit power developed per hour. Volume of fuel consumption is determined by measuring the volume of fuel consumed by engine under given condition for a particular time. The fuel consumption is given by the expression of total fuel consumption per hour upon the power developed.

The brake specific fuel consumption shows work and fuel conversion. The fuel consumption of the engine is determined by efficiency, calorific value of the fuel and the air fuel ratio. The brake specific fuel consumption was calculated mathematically by,

$$F.C = m_f \times 3600 / T$$

Where F.C = fuel consumption (kg/hr)

m_f = mass of fuel consumed (kg)

T = Time measured by stop watch (in seconds)

Brake specific fuel consumption =Fuel consumption / Brake power

$$BSFC = m_f / B.P \text{ (kW)}$$

Where B.P= Brake power (kW)

Table II Variation of Brake specific Fuel Consumption with Load

Load	Diesel	Jatropha Biodiesel (J100)	Blend (J50)
20%	0.520	0.547	0.563
40%	0.330	0.357	0.378
60%	0.290	0.308	0.324
80%	0.250	0.278	0.297
100%	0.200	0.278	0.359

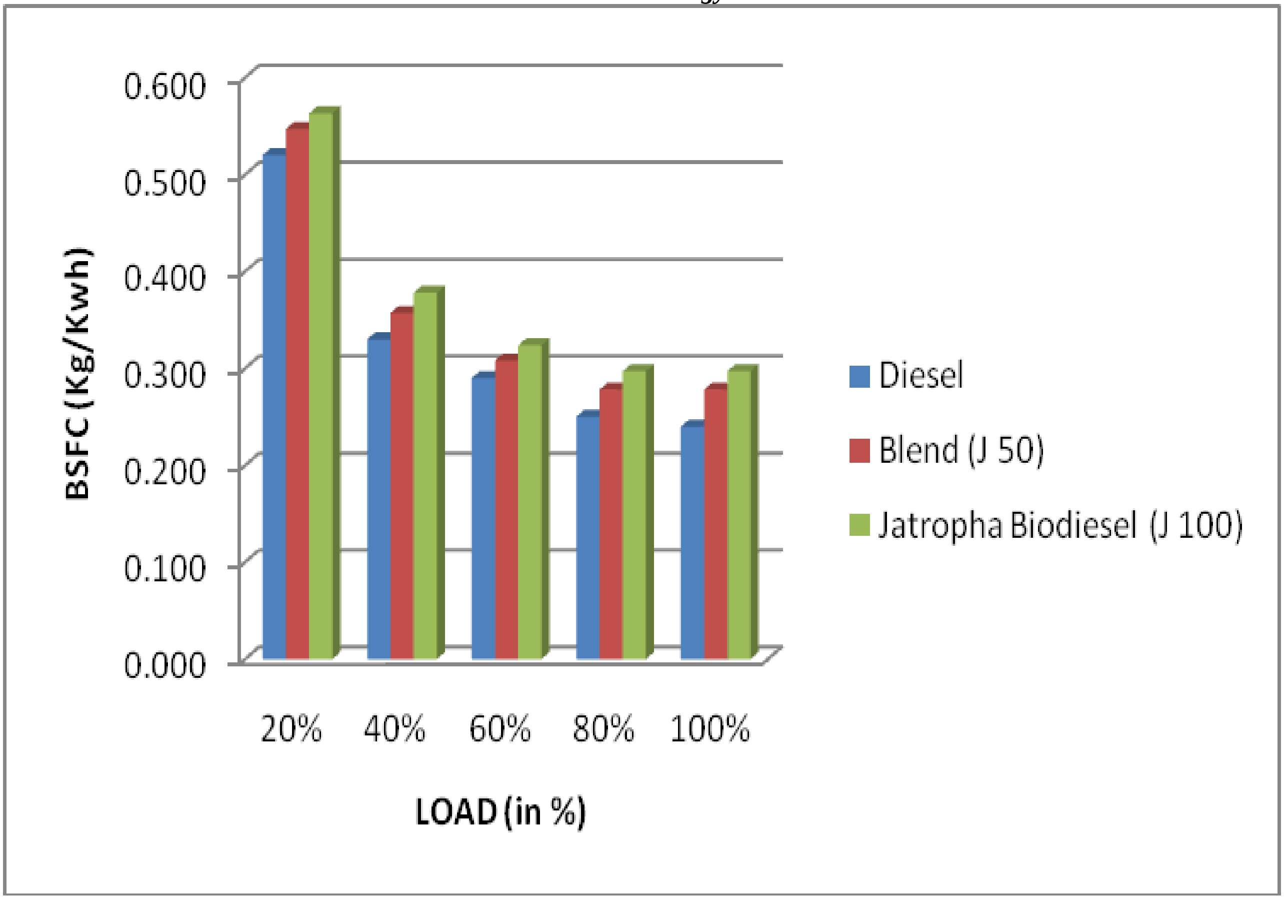

Fig 7 Variation of brake specific fuel consumption with load

From Fig 7 values obtained from specific fuel consumption and applied load observation showed that brake specific fuel consumption decreases with increase in load because of higher percentage increase in brake power with load as compared to increase in fuel consumption. For the blend J50 and J 100 BSFC was higher than mineral diesel This could be due to low calorific value of jatropha biodiesel blends.

1.17 Brake Thermal Efficiency

The Thermal efficiency is the ratio between the power output and the energy introduced through fuel injection, the latter being the product of the injected fuel mass flow rate and lower heating value. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy. Brake thermal efficiency is related to calorific value of the fuel , mass of fuel and brake power used. To increase the value of Brake thermal efficiency we need to use the Low calorific value of fuel.

Brake Thermal efficiency = BP / M_f × C.V

Where BP = Brake Power (in watts)

M_f = Mass of the fuel consumed in (Kg/s)

C.V = Calorific value of fuel in (MJ/Kg)

Table III Variation of Brake thermal efficiency with load

Load	Efficiency diesel	Efficiency of jatropha blend (J50)	Efficiency Jatropha biodiesel (J100)
20%	0.220	0.197	0.188
40%	0.229	0.213	0.202
60%	0.240	0.239	0.241
80%	0.248	0.260	0.270
100%	0.260	0.275	0.288

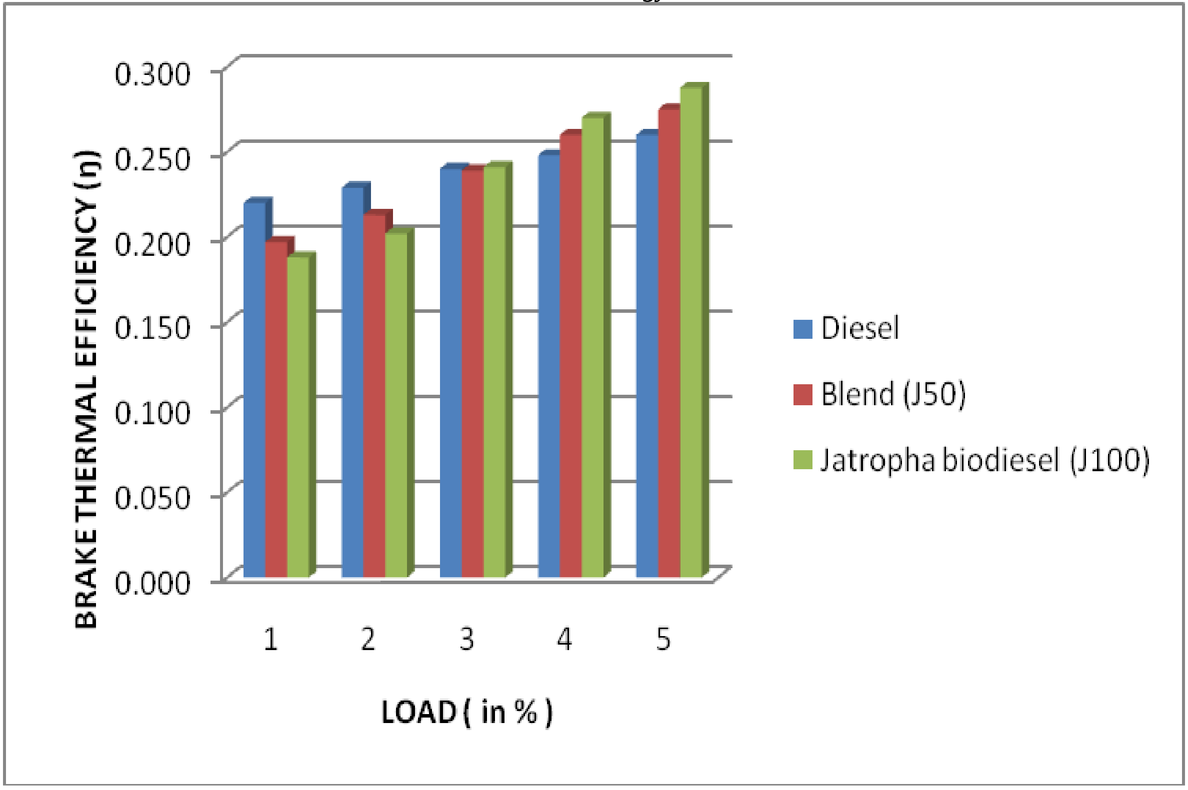

Fig 8 Variation of Brake Thermal Efficiency with Load

From Fig 8 values obtained from Break thermal efficiency and applied load observation showed that break thermal efficiency of mineral diesel decreases with increase in load where as that of Jatropha biodiesel increases at higher loads.

1.18 Exhaust Gas Recirculation (EGR)

Fig (9-13) shows the variation of efficiency of jatropha biodiesel and its blends with E.G.R at (100%, 80%, 60%, 40%, 20%) load condition. It was observed Jatropha biodiesel produces higher value of efficiency than that of diesel and efficiency improved with increasing biodiesel amount. Efficiency improvement may be due to oxygen content in jatropha which is utilized during combustion of fuel with recirculated exhaust gas. The small amount of recirculated exhaust gas mixes well with fresh air to help complete combustion of fuel. After 10% E.G.R, efficiency stars to decrease with increasing E.G.R. This behavior is possible due to dilution of fresh charge with exhaust gases which results in lower flame velocity and leads to incomplete combustion of fuel on four stroke diesel engine running at constant engine speed of 1500 rpm.

During the analysis it was observed that jatropha biodiesel and its blend can have higher value of EGR. This is due to the fact that the presence of oxygen in the structure of biodiesel causes the complete combustion of the fuel.

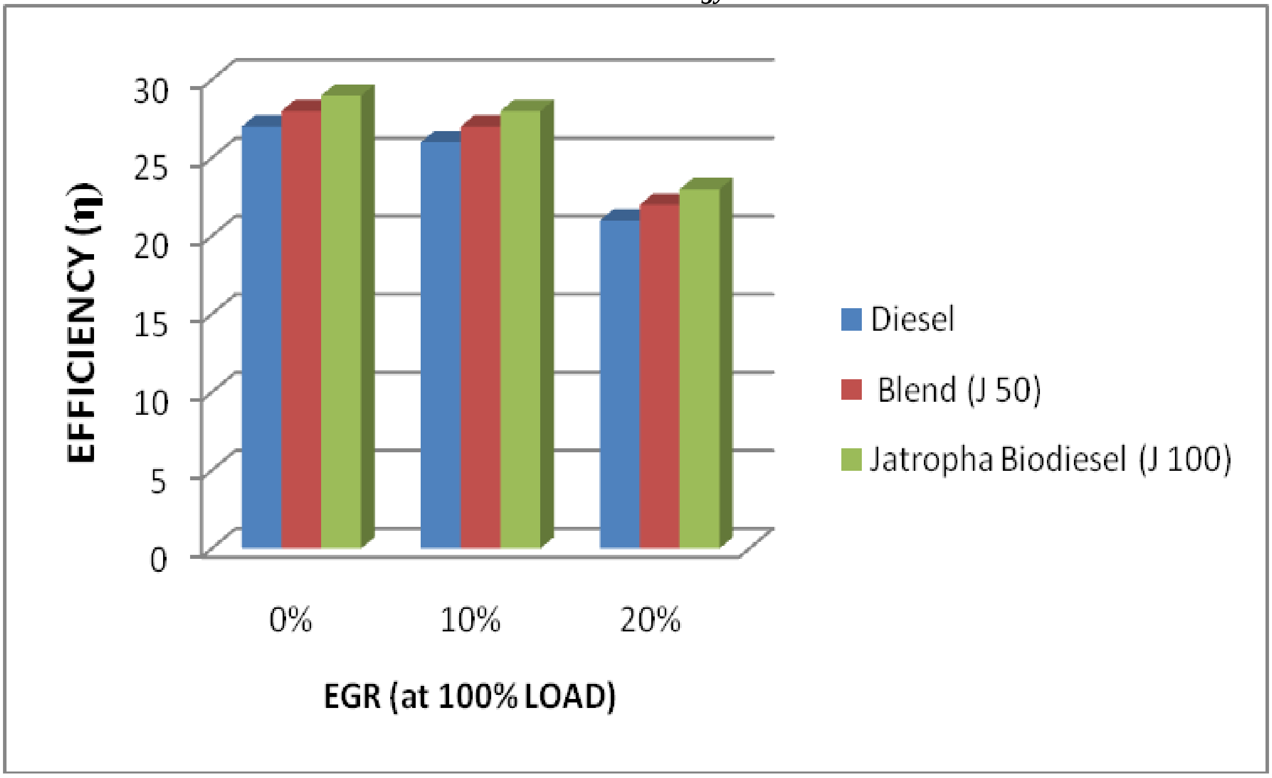

Fig 9 Effect of Exhaust Gas Recirculation on Efficiency at 100% load

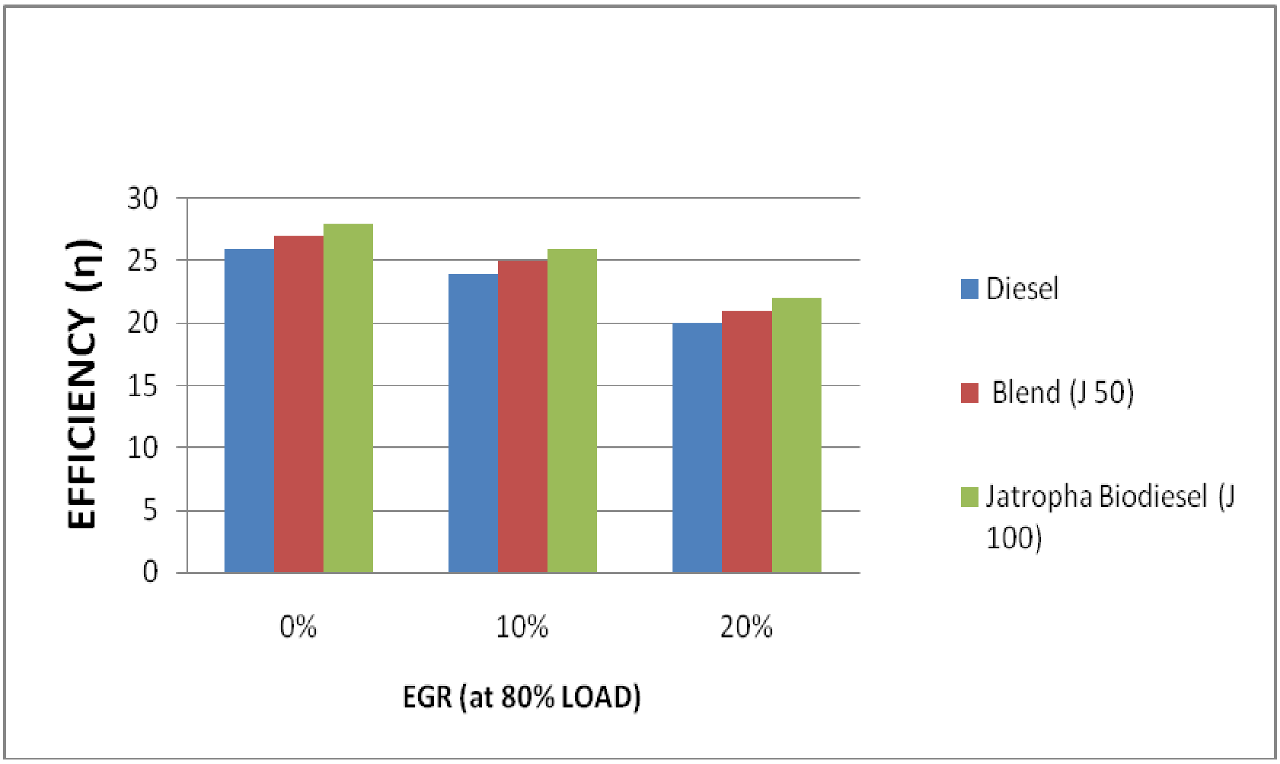

Fig 10 Effect of Exhaust Gas Recirculation on Efficiency at 80% load

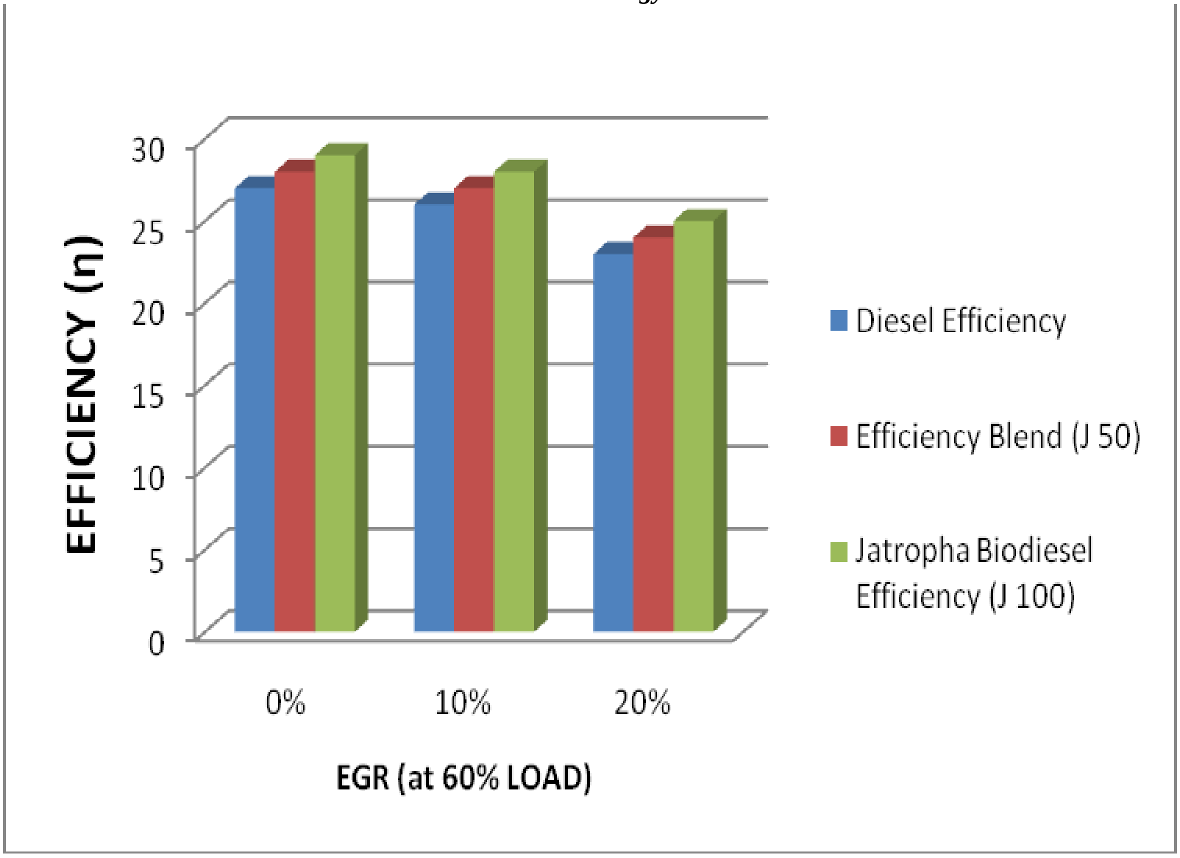

Fig 11 Effect of Exhaust Gas Recirculation on Efficiency at 60% load

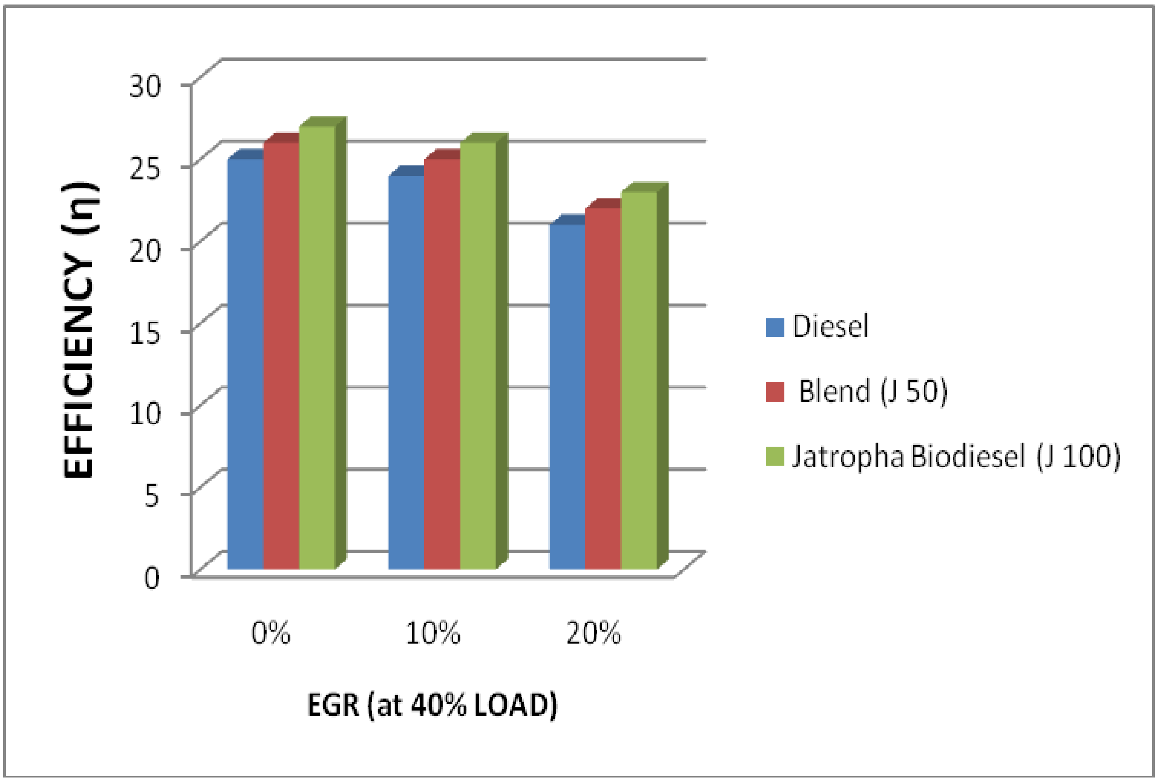

Fig12 Effect of Exhaust Gas Recirculation on Efficiency at 40% load

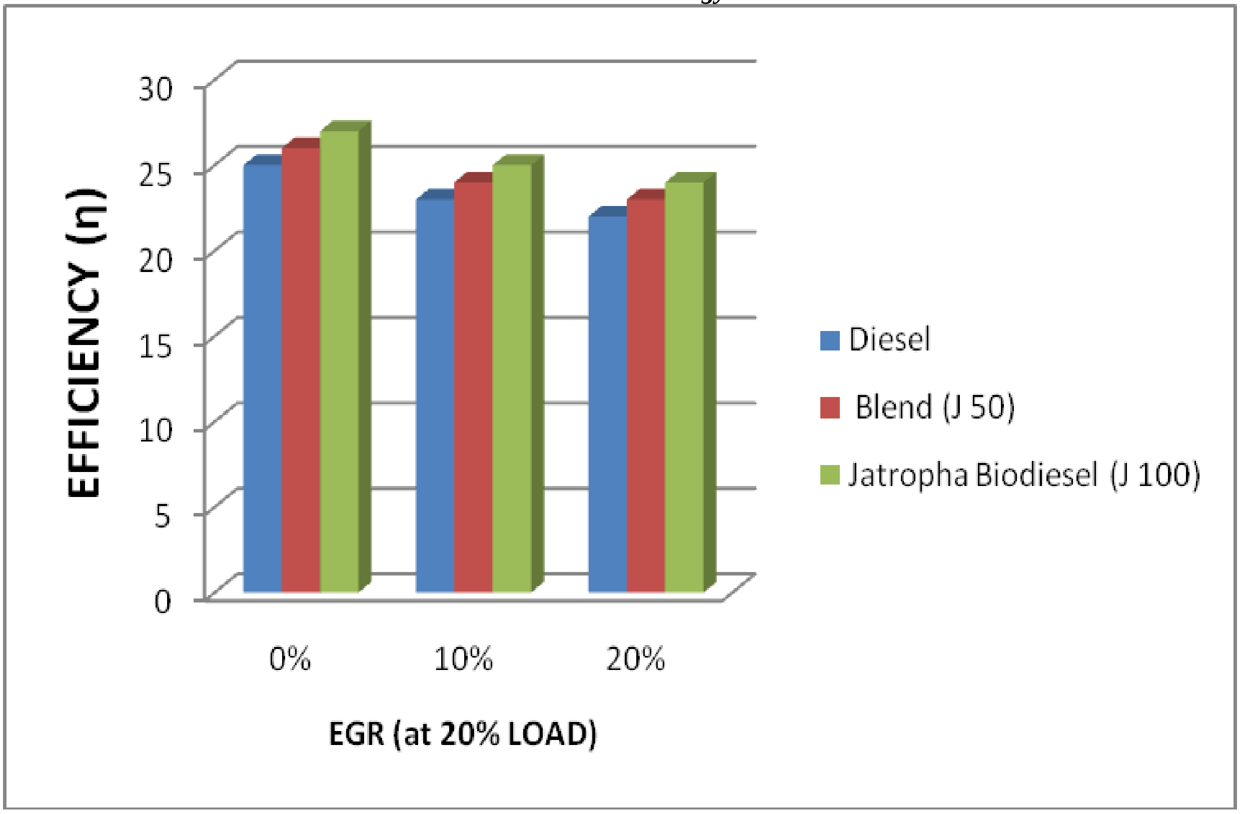

Fig 13 Effect of Exhaust Gas Recirculation on Efficiency at 20% load

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

Main objective of the present work was to study the performance of Jatropha biodiesel and its blend as an alternate fuel in place of conventional diesel fuel, in an existing C.I. engine and also to compare the characteristics like BSFC, BTE and EGR of Jatropha biodiesel fuel and its blend with those obtained by using pure diesel fuel. The experimental work was conducted to study biofuels:

- Performance of the Jatropha biodiesel(J100) with diesel and its blend(J50) at higher percentage of load was found to be more efficient.
- It was observed that brake specific fuel consumption decreases with increase in load because of higher percentage increase in brake power with load as compared to increase in fuel consumption.
- The graph of brake thermal efficiency and applied load observation showed that break thermal efficiency of mineral diesel increases with increase in load where as that of Jatropha biodiesel increases at higher loads.
- It was observed from graph of EGR at higher loading conditions (100% load, 80% load, 60% load) vs efficiency that the Jatropha biodiesel is having the highest efficiency. After 10% E.G.R, efficiency stars to decrease with increasing E.G.R.

Thus, from the study it can be concluded that J100 (100% biodiesel) showed satisfactory performance in four stroke single cylinder diesel engine. Brake specific fuel consumption for jatropha biodiesel blends was higher than mineral diesel. Exhaust gas recirculation was observed to be higher with jatropha biodiesel blends which indicate complete combustion of the jatropha biodiesel. Hence Jatropha biodiesel may substitute mineral diesel in energy sector.

5.2 Future scope

Based on the above work, future research should be carried on in the following areas,

1) Production of commercially viable blends of non edible oil with diesel and use of the various blends for running of C.I. engines which will lead to better economy and less pollution.
2) Production of economically viable bio-diesel derived from the non edible oils namely and their use for running a C.I. engine.
3) Recirculation producing less carbon deposit's so as to increase the efficiency.

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