

Experimental Investigation of Twin Cylinder Diesel Engine Using Jatropha and Hippie Oil Blend With Ethanol

Dr. Hiregoudar Yerrennagoudaru¹, Manjunatha K², Chandragowda M³

¹Professor and PG Co-ordinator (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, India

²Asst. Professor and PROJECT Co-ordinator (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, India

³Asst. Professor (Thermal Power Engineering), Mechanical Engineering Department, RYMEC Bellary, Karnataka, India

Abstract: In view of increasing pressure on crude oil reserves and environmental degradation as an outcome, fuels like Biofuel may present a sustainable solution as it can be produced from a wide range of carbon based feedstock. The present investigation evaluates Biofuel (20% Jathroha + 70% Hippie oil + 10% Ethanol) as a C I engine fuel. The objectives of this report is to analyze the fuel consumption and the emission characteristic of a twin cylinder diesel engine that are using Biofuel & compared to usage of diesel that are available in the market. This report describes the setups and the procedures for the experiment which is to analyze the emission characteristics and fuel consumption of diesel engine due to usage of the both fuels. Detail studies about the experimental setup and components have been done before the experiment started. Data that are required for the analysis is observed from the experiments. Calculations and analysis have been done after all the required data needed for the thesis is obtained. The experiment used C I engine with no load which means no load exerted on it. A four stroke Twin cylinder C I engine was adopted to study the brake thermal efficiency, brake specific energy consumption, and emissions at zero load & full load with the fuel of Biofuel. In this study, the diesel engine was tested using Biofuel (20% Jathroha + 70% Hippie oil + 10% Ethanol). By the end of the report, the successful of the project have been started which is Twin cylinder C I engine is able to run with Bio fuel but the engine needs to run by using diesel fuel first, then followed by Bio fuel and finished with diesel fuel as the last fuel usage before the engine turned off. The performance of the engine using Biofuel compared to the performance of engine with diesel fuel. Experimental results of Bio fuel and Diesel fuel are also compared.

Keywords: Diesel, Performance, Emissions, Biofuel, Jathroha, Hippie oil, Ethanol.

I. Introduction

Rising petroleum prices, increasing threat to the environment from vehicle exhaust emissions and fastly depleting stock of fossil fuels have generated an intense international interest in developing alternative renewable fuels for IC engines. Bio fuel is an oxygenated fuel which increases the combustion and makes reduce exhaust emission. It can be produced from crops with high sugar or starch content. Some of these crops include sugarcane, sorghum, corn, barley, cassava, linseed plants, sugar beets etc. Besides being a biomass based renewable fuel, Biofuel has cleaner burning and higher octane rating than the various vegetable oils [1-5]. Jason and Marc (2002) presented the exergetic environmental assessment of lifecycle emissions from M-85, E-85 (used for the gasoline engine) and other alternative fuels [6]. Diesel exhaust is a major contributor to various types of air pollution, including particulate matter (PM), oxides of nitrogen (NOx), and carbon monoxide (CO) [7]. It has been demonstrated that the formation of these air pollutants can be significantly reduced by incorporating or blending oxygenates into the fossil fuels matrix [8]. Diesel engines are an important part of the public and private transportation sector and their use will continue and grow into the future. But their smoke has become biggest threat to health and environment [9]. Keeping in mind the higher octane number of the ethanol, variable compression ratio engine is a good option in this direction using the ethanol diesel blend as fuel; Shaik et al. (2007) demonstrated VCR engine has great potential for improving part-load thermal efficiency and reducing greenhouse gas emissions [10].

There were many attempts made to use Biofuel in compression ignition (CI) engine. Huang et al. (2008) carried out tests to study the performance and emissions of the engine fuelled with the ethanol diesel blends [11]. They found it feasible and applicable for the blends with n-butanol to replace pure diesel as the fuel for diesel engine. Bhattacharya and Mishra (2002) evaluated the feasibility of preparing diesel-ethanol blends using 200° (anhydrous ethanol) and ethanol lower proof [12]. They found that ethanol blends indicated power producing capability of the engine similar to that of diesel. Hansen et al. (2001) found that the properties of ethanol-diesel blends have a significant effect on safety, engine performance, durability and emissions [13]. Wang et al. (2003) analyzed that the most noteworthy benefits of E-diesel use lie with petroleum fuel reductions

and reductions in urban PM₁₀ and CO emissions by heavy vehicle operations [11]. Ajav and Akingbehin (2002) experimentally determined some fuel properties of local ethanol blended with diesel to establish their suitability for use in compression ignition engines [14]. Eckland et al. (1984) presented, State-of-the-Art Report on the Use of Alcohols in Diesel Engines [15].

Techniques that have been evaluated for concurrent use of diesel and alcohols in a compression-ignition engine include (1) alcohol fumigation, (2) dual injection (3) alcohol/diesel fuel emulsions, and (4) alcohol/diesel fuel solutions. Heisey and Lestz (1981) reported significant reductions in particulate generation; however, NOx generation increases [16]. Likos et al. (1982) reported increased NOx and hydrocarbon emissions for diesel-ethanol emulsions [17]. Khan and Gollahalli (1981) reported decreased NOx and hydrocarbon emissions with increased particulate emissions for diesel-ethanol emulsions [18]. Lawson et al. (1981) reported increased NOx and decreased particulate emissions with diesel methanol emulsions [19]. This type of inconsistent performance is what has hindered the use of ethanol in diesel. Baker (1981) reported diesel-ethanol emulsions produce similar NOx, hydrocarbon, and particulate emissions as compared to baseline runs with straight diesel [20]. Ahmed (2001) found Diesel engines are major contributors of various types of air polluting exhaust gasses such as particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NOx), sulfur, and other harmful compounds [21]. Ethanol blended diesel (e-diesel) is a cleaner burning alternative to regular diesel for both heavy-duty (HD) and light-duty (LD) compression ignition (CI) engines used in buses, trucks, off-road equipment, and passenger cars. Karabektas and Murat Hosoz (2009) reported the increase of fuel consumption with increase in percentage of ethanol in the blends [22]. Rao et al. (2008) carried out experiment in order to find out optimum compression ratio, experiments were carried out on a single cylinder four stroke variable compression ratio diesel engine [23].

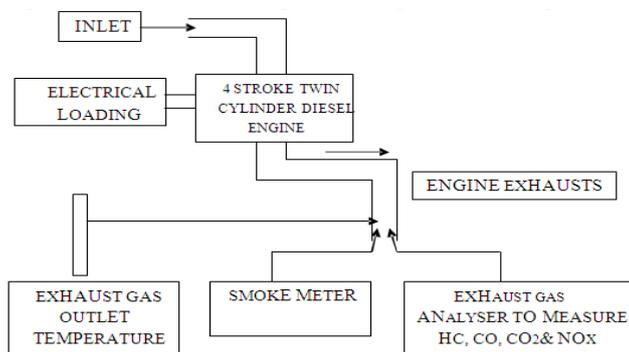


Fig 1: Schematic arrangement of Experimental Set-up

II. Objectives Of The Project

- It is proposed to use Bio Fuel in the diesel engine (CI engine).
- The emissions like HC, CO in the exhaust gases are proposed to reduce during the combustion itself.
- To study the performance evaluation of the using Bio fuel as fuel in the diesel engine.
- Analyze the exhaust emissions and measurement, reduction in the exhaust gas.

a) Properties of diesel and Bio Fuel.

PROPERTIES	JATROPHA OIL	HIPPIE OIL	DIESEL
Density gm/ cc @ 30 °C	0.8809	0.915	0.8253
Net Calorific value (kJ/kg)	39340	35800	44800
viscosity@40°C (CST)	3.576	16	3.15
Flash Point °C	174	230	70

b) Sources of Bio Fuel

Biofuel (20% Jathroha + 70% Hippie oil + 10% Ethanol) is a renewable energy source because the energy is generated by using a resource, sunlight, which cannot be depleted. Creation of biofuel starts with photosynthesis causing a feed stock, such as sugar cane or a grain such as maize (corn), to grow. These feed stocks are processed into bio fuel.

c) Following are methods to produce bio fuel

- Fermentation
- Distillation
- Dehydration
- Blending(20% Jathroha + 70% Hippie oil + 10% Ethanol)

d) Experimental setup

The experimental test set up Figure-1 consisted of twin cylinder diesel engine, four stroke, Forced cooling system, crank start. The setup is provided with a resistance load bank, Multi gas analyzer made by Netel for performance and emissions analysis. The engine is cooled using the water jackets on the engine block and cylinder head using a Forced Feed System. While the recommended injection timing given by the manufacturer is 27° BTDC (static), the opening pressure of the nozzle was set at 1800bar and the engine speed at 1500rpm. There are a number of transducers used in the engine such as piezoelectric pressure transducer flush with the cylinder head surface to measure cylinder pressure. Specifications of engine are shown in Table 2.



Fig 2: Test engine

e) Engine specification

Table-2 Test Engine specification	
Injection Pressure	1800 bar
Engine type	Four stroke Twin cylinder diesel engine
No. of cylinders	02
Stroke	100 mm
Bore Diameter	87 mm
Engine power	19 KW
Compression ratio	17.5:1
RPM	1500
Type of starting	Crank starting
Load type	Electric load bank

f) Load bank specification

Table-3 Load bank specification	
Max. Output	15 KVA / 12.06 KW
Generator type	1 Phase
Amps	63
RPM	1500
PF	0.8
Volts	240

g) Precaution Observed Starting the Engine

At the time of starting the engine for each of the tests it was measured that the engine level was in the safe zone and its condition is also good in case the condition was bad, then fresh SAE 40 was introduced into the pump after draining the old. The foundation and mounting bolts were checked periodically as they may go loose due to high speed operations and vibrations.

In the course of experiments the following precautions were observed:

- The ambient temperature variations during the experiment should not be more than 6°C and this was observed as far as possible.
- After each load is applied the engine is allowed to settle before further loads are applied.

Before stopping the engine, it was allowed to run on pure diesel for some time. This is done so that the engine can be restarted easily

h) Experimental procedure

Experiments were initially carried out on the engine using diesel as fuel in order to provide base line data. The Bio fuel were prepared and made to run on the engine.

1st Case:-The engine was started using neat diesel and allowed to run for at least 30 minutes before taking observations. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied (Zero load & full load condition) using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor.

2nd Case:-The engine was started on diesel and when engine became sufficiently heated; the supply of diesel was slowly substituted by Bio fuel for which a two way valve was used. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied (Zero load & full load condition) using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor.

III. Results And Discussion

The performance and exhaust emission parameters of the engine with diesel and at Biofuel (20% Jathroha + 70% Hippie oil + 10% Ethanol) at zero and full load condition are presented and discussed below.

f) Performance parameter

Specific fuel consumption:

At higher temperature the effect of Biofuel on specific fuel consumption (SFC) are shown in figure 3. From that figure 6.7 it is clear that at different loads the SFC of Biofuel is more than the diesel. The reasons behind this results are lower energy value substitute Biofuel thus engine responds to the load by increasing the fuel flow. Thus SFC decreases with the increase in thermal efficiency.

Sl.no	Load In %	Speed (rpm)	Mass of fuel Mg/stroke	Mass of fuel kg/hr.	BP (KW)	BSFC (kg/kw-hr)	BSEC (kJ/kw-hr)	BTE (%)
1.	0	1500	7.5	0.675	1.303	0.518	18595	21.620
2.	100	1500	43.5	3.913	15.790	0.247	8866	45.193

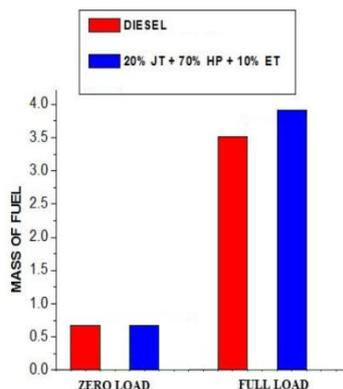


Fig –3. Specific Fuel Consumption

Brake thermal efficiency:

Figure 4, shows the variation of brake thermal efficiency with respect to Biofuel & Diesel at different loads. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as Biofuel. At full load condition, the brake thermal efficiencies obtained are 34.6% & 55.7% for the diesel & Biofuel respectively. Among these two fuels Ethanol has maximum BTE i.e 55.7% which is obtained from Biofuel at full load. The BTE using Biofuel is increased by 31.3% as compared to the diesel at full load condition. The increment in Brake thermal efficiency is due to low heat value of Biofuel as compared to diesel & better combustion because of less viscosity of Ethanol.

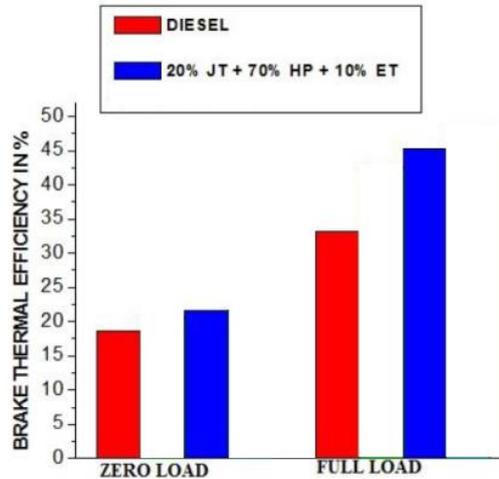


Fig – 4. Brake Thermal Efficiency

Emission parameters:

Smoke:

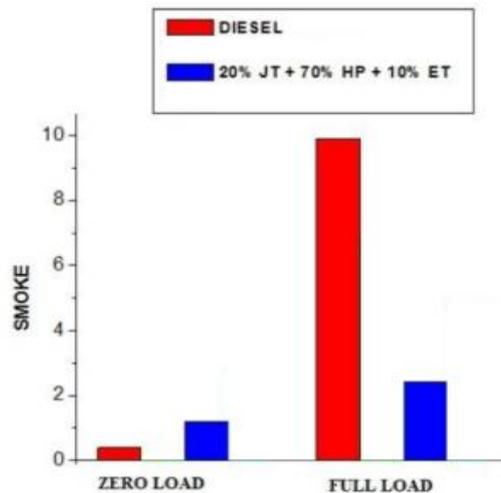


Fig –5. Smoke

Figure 5, shows the variation of Particulate Matter level with respect to diesel and Biofuel at different loads. Particulate Matter tends to increase with load, this increase in Particulate Matter is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the Particulate Matter emissions. Result shows that Particulate Matter is comparatively lower with Biofuel. It is found that Particulate Matter emission increases with increase in load in Diesel as fuel but in Biofuel. Diesel has higher Particulate Matter level when compared to Biofuel. This is due to rise in exhaust temperature. Particulate Matter is decreased (80 to 90%) when using Biofuel as fuel in diesel engine compared to diesel fuel.

CO Concentration:

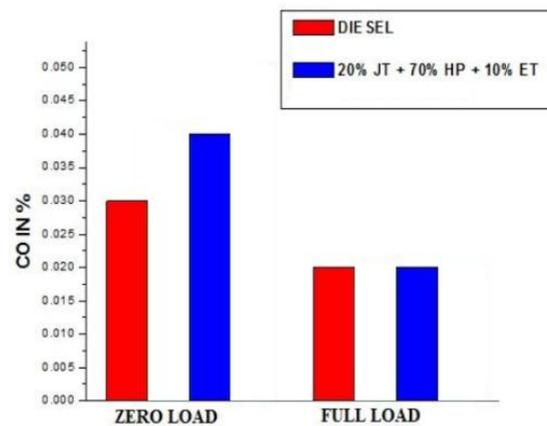


Fig –6. CO Comparison

Figures 6, shows the variation CO level with respect to Diesel and Biofuel at different loads. From the graph it is clear that the CO level increases when Diesel has a fuel. Carbon monoxide occurs in engine exhaust. It is a product of incomplete combustion due to insufficient amount of air in the air fuel mixture or insufficient time in the cycle for the completion of combustion. CO level is comparatively lower when compared to diesel.

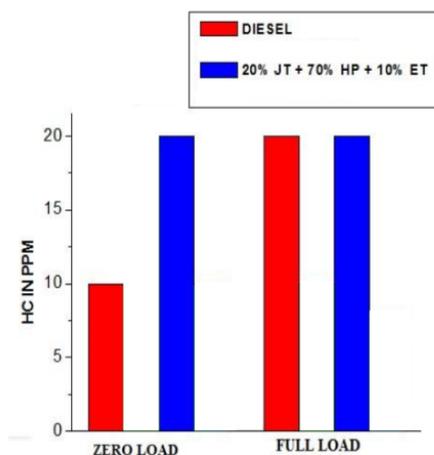


Fig – 8. Unburnt Hydro Carbon

IV. Conclusion And Future Scope

Based on the performance and emissions of Bio fuel, it is concluded that the bio fuel oil represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the above analysis the bio fuel shows better performance compared to the Diesel in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption and decrease in the emission parameters like, Smoke, HC, CO is lower than the diesel. Hence the bio fuel can be used as a substitute for diesel.

References

- [1]. Alan C. Hansen, Qin Zhang and Peter W. L. Lyne, "Ethanol–diesel fuel blends a review", *Bioresource Technology*, Volume 96, Issue 3, February 2005, Pages 277-285.
- [2]. Hanbey Hazar, "Effects of biodiesel on a low heat loss diesel engine", *Renewable Energy* 34 (2009) 1533–1537.
- [3]. Neven Voca, Boris Varga, Tajana Kricka, Duska Curic, Vanja Jurisic and Ana Matin, "Progress in ethanol production from corn kernel by applying cooking pre-treatment" *Bioresource Technology* Volume 100, Issue 10, May 2009, Pages 2712-2718.
- [4]. Avinash Kumar Agarwal, "Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines" *Renewable Energy*, 27 November 2006.
- [5]. Hakan, Bayraktar. "Experimental and theoretical investigation of using gasoline–ethanol blends in spark-ignition engines", *Renewable Energy*, 2005; Volume 30, Issue 11:pp1733-1747.
- [6]. Jason J, Daniel Marc, Rosen A, "Exergetic Environmental Assessment of Life Cycle Emissions for various Automobiles and Fuels, *Exergy* 2 (2002) 283-294
- [7]. Hwanam Kima, Byungchul Choi, "Effect of ethanol–diesel blend fuels on emission and particle size distribution in a common-rail direct injection diesel engine with warm-up catalytic converter", *Renewable Energy* 33 (2008) 2222–2228.
- [8]. De-gang Li, Huang Zhen, Lu Xingcai, Zhang Wu-gao and Yang Jian-guang, "Physico-chemical properties of ethanol–diesel blend fuel and its effect on performance and emissions of diesel engines", *Renewable Energy* 30 (2005) 967–976.

- [9]. Sehmus Altuna, Husamettin Bulutb and Cengiz Oner, "The comparison of engine performance and exhaust emission characteristics of sesame oil–diesel fuel mixture with diesel fuel in a direct injection diesel engine", *Renewable Energy* 33 (2008) 1791–1795.
- [10]. Amjad Shaik, N Shenbaga Vinayaga Moorthi, and R Rudramoorthy, "Variable compression ratio engine: a future power plant for automobiles an overview," *Proc. IMechE Vol. 221 Part D April 2007*. DOI: 10.1243/09544070JAUTO573.
- [11]. Jincheng Huang, Yaodong Wang, Shuangding Li, Anthony P. Roskilly, Hongdong Yu, Huifen Li, "Experimental Investigation on the Performance and Emissions of a Diesel Engine Fuelled with Ethanol-diesel Blend," *ATE* 2697, 2008.
- [12]. T K Bhattacharya and T N Mishra, "Studies on Feasibility of using Lower Proof Ethanol-diesel Blends as Fuel for Compression Ignition Engines", *IE (I) Journal–AG* 263 145, December 21, 2002
- [13]. Alan C. Hansen, Peter W. L. Lyne, Qin Zhang, "Ethanol-Diesel Blends: A Step towards A Bio-Based Fuel for Diesel Engines", *American Society of Agricultural and Biological Engineers (ASAE)* August 1, 2001.
- [14]. Ajav, E. A. and O. A. Akingbehin, "A Study of some Fuel Properties of Local Ethanol Blended with Diesel Fuel", *Journal of Scientific Research and Development*
- [15]. R.Kamo And W. Bryzik "Tacom/Cummins Adiabatic Engine Programm" *Sae Paper No. 830314*.
- [16]. P.Ram Mohan, K.Ram Mohan, C.M. Varapasad " Matching Of Injection Timing In L.H.R Engines For Fuel Economy" *Proc Of 3rd Asian Pacific International Symposis On Combustion Energy And Energy Utilisation* December 95.
- [17]. Van Sudhakar " Performance Analysis Of Adiabatic Engine" *Sae* 840431.
- [18]. C.M.Varapasad, K.Ram Mohan " Performance Of A Diesel Engine With A Semi-Adiabatic Piston On Diesel Methanol Mixtures" *Dsir Seminar On Diesel Engines, Iit, Mumbai* October 88.
- [19]. Rangaiaii Et Al " Performance Of Ceramic Coated Diesel Engines With Methanol Diesel Mixtures" *9th National Conference In C.I Engines And Combustion* 1985.
- [20]. K. Ram Mohan, C.M Varapasad. P. Ram Hohan "Performance Evaluation Of Diesel Engine With A Air-Gap Insulated Piston" *Annual Paper Meeting The The Institution Of Engineers*.
- [21]. Dr.C.Prabhakar Reddy & C.M.Varapasad "Performance Evaluation On 4-Stroke Semi-Adiabatic Diesel Engine Using Diesel Methanol Mixtures" *Project Report 1997 Mechanical Department V.E.C Bellary-4*.
- [22]. Mather And Sharma "Internal Combustion Engines" *7th Edition* 1996.
- [23]. Manuscript EE 01 003. Vol. IV. March, 2002.
- [24]. Eckland, E. E.; R. L. Bechtold; T. J. Timbario; and P. W. McCallum, "State-of-the-Art Report on the Use of Alcohols in Diesel Engines", *SAE Paper No. 840118*.
- [25]. Heisey, J. B. and S. S. Lestz, "Aqueous alcohol fumigation of a single-cylinder DI CI engine," *SAE Paper No. 811208*.
- [26]. Likos, B.; T. J. Callahan; and C. A. Moses, "Performance and Emissions of Ethanol and Ethanol-Diesel Blends in Direct-Injected and Pre-Chamber Diesel Engines", *SAE Paper No. 821039*.
- [27]. Khan, N and S. R. Gouahalli, " Performance and Emission Characteristics of a Diesel Engine Burning Unstabilized Emulsions of Diesel Fuel with Water, Methanol, and Ethanol", *SAE Paper No. 811210*.
- [28]. Lawson, A.; A. J. Last; A. S. Desphande; and E. W. Simmons, "Heavy-Duty Truck Diesel Engine Operation on Unstabilized Methanol -Diesel Fuel Emulsions", *SAE Paper No. 810346*.
- [29]. Baker, Q. A., "Use of Alcohol-in-Diesel Fuel Emulsions and Solutions in a Medium-Speed Diesel Engine", *SAE Paper No. 810254*.
- [30]. Irshad Ahmed Oxygenated Diesel, "Emissions and Performance Characteristics of Ethanol-Diesel Blends in CI Engines," *Society of Automotive Engineers, Inc. 2001-01-2475*.
- [31]. Murat Karabektas A, Murat Hosoz B, "performance and emission characteristics of a diesel engine using isobutanol–diesel fuel blends", *Renewable Energy* 34 (2009) 1554–1559.
- [32]. GVNSR Ratnakara Rao, V. Ramachandra Raju and M. Muralidhara Rao, "Optimizing The Compression Ratio Of Diesel Fuelled C.I Engine", *ARPN Journal of Engineering and Applied Sciences, VOL. 3, NO. 2, APRIL 2008*.