The International Journal Of Engineering And Science (IJES)
|| Volume || 2 || Issue || 11 || Pages || 01-06 || 2013 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Performance Evaluation of a Low Heat Rejection Diesel Engine with Jatropha as Fuel

[1]R. Ganapathi, [2]Dr. B. Durga Prasad, [3]B.Omprakash

[1] Lecturer, Mech. Engg. Dept, JNTUA College of Engineering, Anantapuramu.
[2] Professors, Mech.Engg. Dept, JNTUA College of Engineering, Anantapuramu.
[3] Assistant Professor, Mech.Engg. Dept, JNTUA College of Engineering, Anantapuramu.

ABSTRACT

Increasing industrialization, growing energy demand, limited reserves of the fossil fuels and increasing environmental pollution have jointly necessitated for exploration of some substitute of conventional liquid fuels. Vegetable oils had been considered as one of the appropriate feasible substitute diesel fuel since very early. The vegetable oil based substitute fuels, popularly known as biodiesel, are commercially available in the developed world due to their distinct advantages over conventional diesel fuel. Vegetable oils present very promising alternative fuels to diesel. Properties of these oils compare favourably with characteristics required for C.I.engine fuels. The usage of vegetable oil in an engine depends on the properties of the oil. Jatropha oil properties are almost closer to diesel, particularly cetane rating and heat values. These oils are renewable and are produced easily in rural and forest areas An objective of this work aims to find out suitability of Jatropha oil in an insulated engine. An Air gap liner and PSZ coated head and valves have been used in the present study. Experimental investigations have been carried out to assess the suitability of Jatropha oil as C.I. Engine fuel. Experiments were conducted on the base engine and also in an insulated engine. A solemn attempt has been made in this research to study the usage of Bio-diesel of Jatropha oil in place of diesel so as to study the engine performance.

Key Notes: Low heat rejection, Jatropha, alternative fuel.

Date of Submission: 20 November 2013 ⟷ Date of Acceptance: 30 November 2013

I. INTRODUCTION

Jatropha oil is non-edible oil and has a cetane number which is comparable to diesel and makes it an ideal alternative fuel as compared to other edible oils. It is significant to point out that, the non-edible vegetable oil of Jatropha has the requisite potential of providing a promising and commercially viable alternative to diesel to as it has the desirable physicochemical and performance characteristics compared to diesel.

Jatropha oil will be a renewable and low capital input alternative to diesel as compared to other sources. It will not require massive infrastructure for its distribution as it has the advantage that it can be produced almost everywhere in India in a decentralized manner.

The major problems to use raw oil as bio diesel are its high viscosity, high flash point, high pour point, low volatility. Due to these problems, Jatropha oil is not directly used because these may affect the engine performance which leads to poor fuel atomization and inefficient mixing with air which contributes incomplete combustion, poor cold engine start up, deposit formation, ring sticking and lube oil dilution and degradation.

The initial flash point of Jatropha oil is 110^0C as compared to 50^0C in case of diesel. Due to higher flash point Jatropha oil has certain advantages over Petroleum crude lie greater safely during storage, handling and transport. However, the higher flash point may create only initial starting problem of the machine. Similarly, higher viscosity of Jatropha oil could pose problems of smooth flow of oil in fuel supply pipes and nozzles.

II. NEED OF THE PRESENT WORK

Agricultural and transport sectors are almost Diesel dependent. The transport sector remains the most problem sector as no alternative to petroleum based fuel has been successful so far. The various alternative fuel options researched for Diesel are mainly biogas, producer gas and vegetable oils. India still imports huge quantity of edible oils, therefore, the use of vegetable oils like Jatropha oil has been tried in this research.

III. OBJECTIVE OF THE WORK

An objective of this work aims to find out suitability of Jatropha oil in an insulated engine. A solemn attempt has been made in this research to study the usage of vegetable oils in place of Diesel with Jatropha oil in a base engine and in an insulated engine, so as to study the engine performance.

IV. FABRICATION OF INSULATED COMPONENTS

A detailed study was carried out as a preliminary to the design of the insulated components. The insulated engine components which include Liner, cylinder head and valves are fabricated to constitute the combustion chamber of the low heat rejection engine. There are three major concepts that have been adopted for an adiabatic diesel engine to reduce the heat loss.

4.1 Cylinder Liner Insulation

In this case air with its low thermal conductivity was used as the insulating medium. A thin mild steel sleeve was circumscribed over the cast iron liner maintaining a 2mm layer of air in the annular space between the liner and the sleeve. The joints of the sleeve were sealed to prevent seepage of cooling water into the air-gap region. Fig. 1 shows the constructional details of the air gap liner. Insulation of the liner brought about considerable reduction in the heat lost to the cooling water and an increase in overall thermal efficiency of the engine.

4.2 Cylinder Head Insulation

Ceramic coating is a simpler method of insulation for cylinder head compared with other methods. The head was insulated by coating the area exposed to the combustion chamber with PSZ. The combustion chamber area f the cylinder head was machined to a depth of 0.5 mm. The surface was then sand blasted to form innumerable pores for ceramic deposition.

4.3 Insulation of Valves

The bottom surfaces of the valves were machined to a depth of 0.5mm and coated with PSZ material of equal thickness. With the valves assembled on the cylinder head the area of the combustion chamber was about 90-92% of the total area.

V. EXPERIMENTAL INVESTIGATIONS

The photographic view of the experimental set up for diesel operation and the instrumentation are shown in Fig.2. The engine used for the experimental investigations was a Kirloskar, single cylinder, four stroke, water cooled, vertical and direct injection diesel engine. This engine can with stand higher pressures encountered and also used extensively in agricultural and industrial sectors. Therefore this engine is selected for carrying experiments. Moreover necessary modifications on the liner and the cylinder head can be easily carried out in this type of engine. Hence this engine is selected for the present work. Exhaust temperature was measured by an iron-constantan thermocouple fitted very near the cylinder head in the exhaust manifold and was measured directly from a mill voltmeter in degree Celsius calibrated for iron-constantan thermocouple. Four gas analyzer, for evaluation of the pollutants in the exhaust gas was attached to the engine. This analyzer was used to measure four important pollutants that is Carbon Monoxide (CO), Carbon Dioxide (CO_2), un burnt Hydrocarbons (HC) and Nitrogen Oxides (NO_x).Smoke meter is used to test the characteristics of the smoke. The different characteristic includes opacity, absorptivity. Opacity measures the darkness of the smoke. So with this meter we could measure the intensity of darkness of smoke.

At a rated speed of 1500rpm all the variable load tests are conducted. The outlet temperature of the cooling water is maintained at 70^0C. For all the experiments, the lubrication oil temperature is maintained at 60^0C. The load on the dynamometer, air flow rate, fuel flow rate, exhaust temperature, manifold pressure, cooling water flow rate, cylinder head and cylinder liner temperatures, HC, CO and smoke readings are noted and recorded after allowing sufficient time for the engine to stabilize.

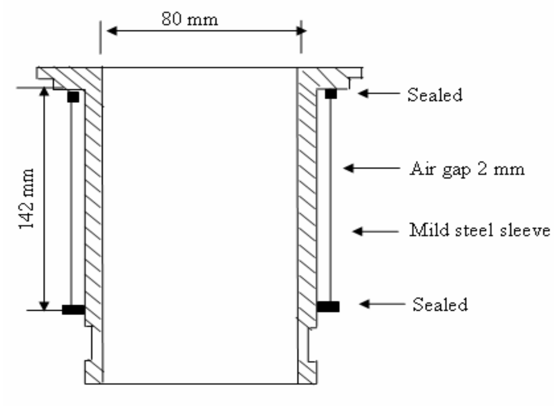


FIG AIR GAP INSULATED LINER

The experimental set-up is designed to suit the requirements of the present investigations. Experiments were conducted on the standard engine and also in an insulated engine with diesel and jatropha. The engine was operated under no load for the first 20 minutes and for each load the engine was operated long enough to stabilize the condition. All the tests were conducted at the rated speed of 1500 rpm.

VI. RESULTS

The experimental results obtained for both the conventional engine and partially insulated engine.

Also the performance curves (graphs) and heat balance sheets for both conventional engine and semi-adiabatic engine are shown. The results obtained for both engines have been compared, analyzed, and discussed in this section. The results obtained from the experiments conducted on 3.68 KW KIRLOSKAR single cylinder, 4-stroke, water cooled conventional diesel engine and semi-adiabatic engine are tabulated and the corresponding graphs are plotted and are shown in Exhibit 1 through Exhibit 6.

VII. ANALYSIS & DISCUSSIONS

Exhibit 1 shows a plot representing the relation between the brake output. It is clear from the plot that the brake power of the insulated Engine is more than that of the base engine.

THIS IS FIG. 2 PHOTOGRAPHIC VIEW OF EXPERIMENTAL SETUP

Due to less heat rejection in semi-adiabatic engine compared to the conventional engine. The study suggests that the insulation provided on the engine reduces heat losses and in turn the brake thermal efficiency of the engine increases.

The plot representing the relation between the Brake Power and the Specific energy consumption is shown in the Exhibit 2. It reveals that the Specific energy consumption is less for insulated engine than that of base engine. This is possible due to high temperature prevailing in the cylinder which increases the combustion efficiency and further leads to the instantaneous high pressure in the chamber.

The variation of exhaust smoke intensity (opacity and absorptivity) for different insulated configurations compared to base engine configurations is shown in Exhibit 3 and Exhibit 4. It is clear from the Figures that the pollutants smoke intensity (opacity and absorptivity) were found to be highest in case of Diesel and least in case of insulated configuration. Better oxidation of the soot particles due to higher operating temperatures is the main reason for reduction in smoke levels. And the other reasons may be better combustion in insulated engines.

The HC emissions of different insulated configurations are compared in Exhibit 5. The main sources of these emissions in CI engine are lean mixing, burning of lubricating oil, and wall quenching. Because of hotter combustion chamber, HC formation is found to be less in all the insulated engines.

The Carbon dioxide emissions of different insulated configurations are compared in Exhibit 6. Because of better and complete combustion in the insulated engines, Carbon dioxide levels are higher for insulated engines. It indicates that the level of Carbon dioxide (CO_2) in the exhaust is highest for insulated configuration. Higher Carbon dioxide (CO_2) in the exhaust is an indication of complete or better combustion

Carbon monoxide levels in the exhaust of base engine and all the insulated configurations are shown in Exhibit 6.Because of better and complete combustion in the insulated engines, CO levels are lower. Lowest CO emissions are observed in the case of insulated configurations compared to part loads, the reduction is more at higher loads.

Due to the insulation of the engine cylinder, the exhaust gas temperatures are bound to be higher in insulated engines. Exhaust temperatures increase with the engine load. The variation of exhaust gas temperature for all the configurations is shown in Exhibit 8.The exhaust temperature changes are shown against the brake power output.

The peak pressure variation with respect to the power output is shown in Exhibit 9. The peak pressure is higher for the base engine compared to the insulated configurations. This may be due to the drop in ignition delay and hence reduction in the fuel accumulated during the delay phase of combustion.

VIII. CONCLUSIONS

The following conclusions can be drawn from the processed results of the experimentation.

- Insulated engines performed better when compared to base engine with Jatropha
- For the insulated configuration (an Air gap liner and PSZ coated head and valves), the brake thermal efficiency improvement is found to be 22% at the full load operation compared with the base engine.
- All insulated configurations resulted in a good reduction of smoke emissions.
- Insulated configurations have shown reduced HC emission levels, the maximum reduction is observed for the insulated configuration which is around 250 ppm at the full load when compared with the base engine.
- As a result of better combustion, insulated configuration with jatropha has shown a significant reduction in the CO emission and is about 0.28% by volume.
- Exhaust temperatures are higher in all insulated configurations when compared relatively with the base engine because of insulation of the engine.
- From the experimental investigations, it can be concluded that the insulated configuration with Jatropha performs well.

REFERENCES:

[1.] A review of thermal barrier coating effects on diesel Engine performance and components lifetime, International Journal of Automotive Engineering Vol. 3, Number 1, March 2013

[2.] Analysis of LHR Extended Expansion Engine with Variable Speed Operation for Different Compression Ratios/International Journal Of Advanced Engineering Sciences And Technologies Vol No. 11, Issue No. 1, 121 – 128

[3.] Comparative Studies on Exhaust Emissions from a High Grade Low Heat Rejection Diesel Engine with Carbureted Alcohol and Crude Jatropha Oil /International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3, Issue-2, May 2013 22.

[4.] Experimental Investigation on LHR Extended Expansion DI Diesel Engine Emission Controlling Injection Timing/International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-6, January 2013

[5.] Improving of Emissions and Performance of Rice Brawn Oil in Medium Grade Low Heat Rejection Diesel Engine/ International Journal of Renewable Energy Research P.V. K. Murthy et al., Vol.3, No.1, 2013

[6.] Investigations into performance and emission characteristics of lHR CI Diesel engine for patchy speed operations/ ISSN: 2319-8753 International Journal of Innovative Research in Science, Engineering and Technology *Vol. 2, Issue 7, July 2013*

[7.] Performance and emission characteristics of a low heat rejection spark ignited engine fuelled with E20+ /Journal of Mechanical Science and Technology 26 (4) (2012) 1241~1250

[8.] Performance Evaluation of Rice Brawn Oil in Low Grade Low Heat Rejection Diesel Engine */RESEARCH INVENTY: International Journal of Engineering and Science ISSN: 2278-4721, Vol. 1, Issue 5 (October 2012), PP 1-12 www.researchinventy.com*

[9.] Performance And Exhaust Emission Analysis Of Direct Injection Diesel Engine Using Pongamia Oil / International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 2, Issue 12, December 2012) 341

[10.] Potential of a high grade low heat rejection diesel engine with

[11.] Crude tobacco seed oil/ International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) ISSN 2249-6890 Vol. 3, Issue 1, Mar 2013, 61-78.

[12.] "Performance and Energy Balance of A low Heat Rejection Diesel Engine Operated with Diesel Fuel and Ethanol Blend" Murat Ciniviz, /Transaction of the Canadian society for mechanical engineering, Vol. 34, No.1, 2010.

[13.] "A Comparative Evaluation of al_2o_3 coated low heat rejection diesel engine Performance and Emission characteristics using fuel as rice bran and pongamia Methyl ester" M. Mohamed Musthfa,2. S.P.Sivapirakasam and 3. M. Udayakumar Journal of renewable and sustainable energy, 2010.

[14.] "Performance studies of a Low heat rejection engine operated on non- volatile Vegetable oils with exhaust gas recirculation" N.R. Banapurmath, P.G. Tewari. International journal of sustainable engineering /2009.

[15.] "Exhaust emission characteristics of a low heat rejection diesel engine fuelled with 10 Percent ethanol and 90 percent diesel fuel mixture" C. hasimoglu/ j. Automobile Engineering. /2007.

[16.] "Use of vegetable oils as I.C. engine fuels—A review" A.S. Ramadhas et al. / Renewable Energy 29 (2004) 727–742.

[17.] "Thermal analysis of functionally graded coating Al Si alloy and steel pistons" E. Buyukkaya / Surface & Coatings Technology 202 (2008) 3856–3865.

[18.] "Experimental investigations of performance and emissions of Karanja oil and its blends in a single cylinder agricultural diesel engine"Avinash Kumar Agarwal *, K. Rajamanoharan/Applied Energy 86 (2009) 106–112.

[19.] Goering, C.E. . Schwab, A.W et al., "Fuel Properties of Eleven Vegetable Oils", Trans. ASAE, 25 (4-6), 1982, P.1472-1477.

[20.] Kusy, P.F., "Transesterification of Vegetable Oils for Fuels, Proceedings of the International conference on Plant and Vegetable Oils as Fuels", Fargo, North Dakota, ASAE, P.127-137, 1982.

[21.] Pradheepram,O., “Improving the Efficiency of a Diesel Engine by Minimizing the Heat Losses Through the Cylinder Liner”, M.S. Thesis, IIT Madras, 1982.

[22.] Senthil Kumar,M., Ramesh,A., and Nagalingam,B., xperimental Investigations on a Jatropha Oil Methanol Duel Fuel Engine”, SAE Paper No.2001 – 01-0153.

[23.] Domingo, N. and Graves R.L.,”A study of Adiabatic Engine Performance”,on National Laboratory report under preparation(2003) .

[24.] Jaichandar,S., . Tamil Porai,P., “Low Heat Rejection Engines – an Over View”, SAE Paper No.2003-01-0405.

[25.] 24. “Use of vegetable oils as I.C. engine fuels—A review” A.S. Ramadhas et al. / Renewable Energy 29 (2004) 727–742.

[26.] “Thermal analysis of functionally graded coating Al Si alloy and steel pistons” E. Buyukkaya / Surface & Coatings Technology 202 (2008) 3856–3865.

[27.] “Experimental investigations of performance and emissions of Karanja oil and its blends in a single cylinder agricultural diesel engine” Avinash Kumar Agarwal *, K. Rajamanoharan/Applied Energy 86 (2009) 106–112.

[28.] “Effect of injection timing on the exhaust emissions of a diesel engine using diesel–methanol blends” Cenk Sayin a, Murat Ilhan b, Mustafa Canakci c,d,*, Metin Gumus a/Renewable Energy 34 (2009) 1261–1269.

Exhibit.2 Comparison of Specific Energy Consumption with Power Output

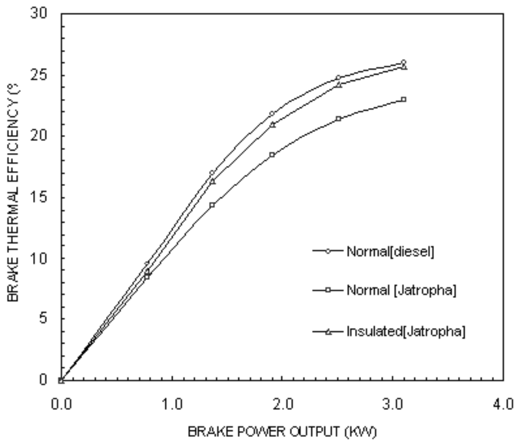
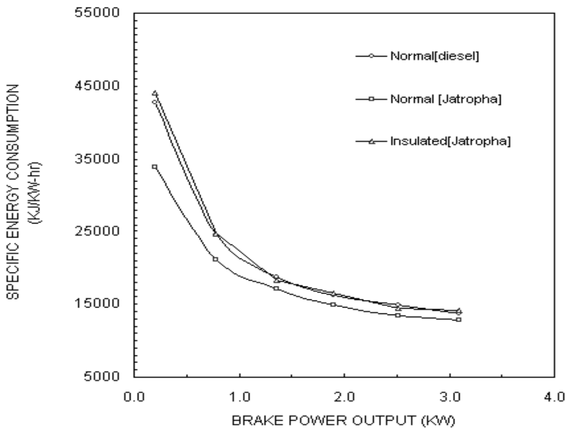


Exhibit.1 Comparison of Thermal Efficiency with power output



Exibt.2 Compression of Specific fuel consumption with power out put

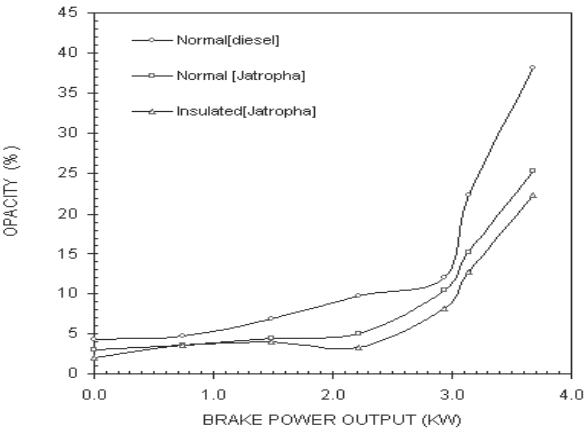


Exhibit.3 Comparison of Opacity with power output

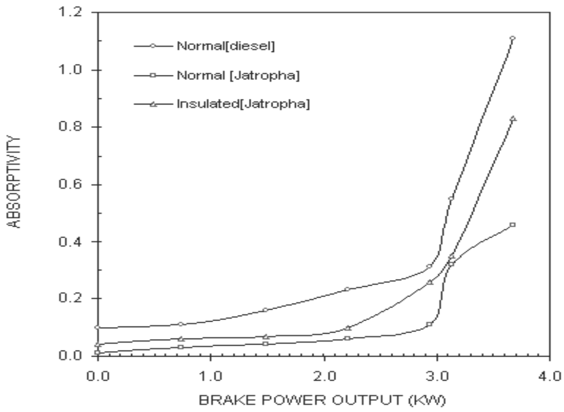


Exhibit.4 Comparison of Absorptivity with power output

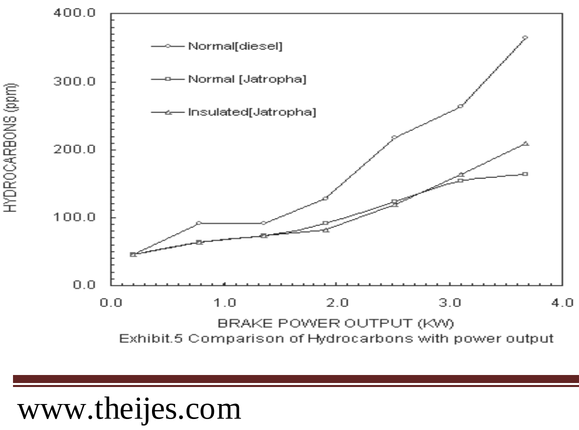


Exhibit.5 Comparison of Hydrocarbons with power output

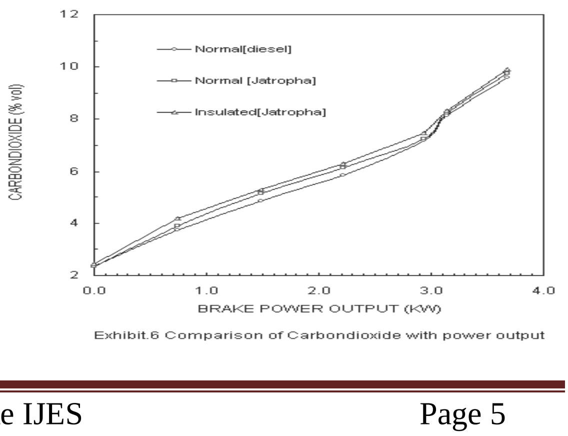


Exhibit.6 Comparison of Carbondioxide with power output

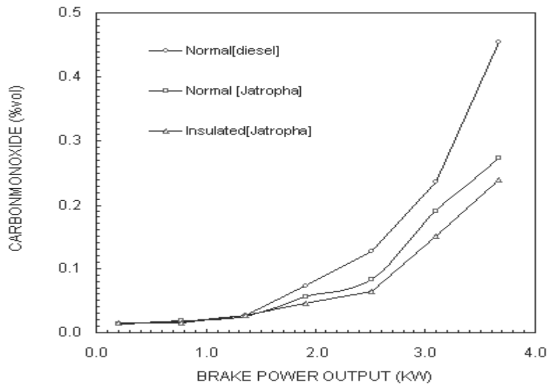


Exhibit.7 Comparison of Carbonmonoxide with power output

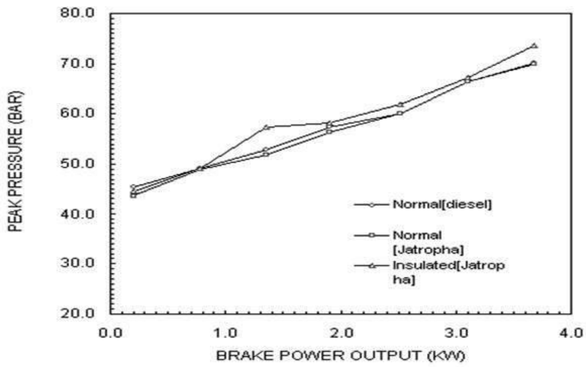


Exhibit.8 Comparison of Peak pressure with power output