Performance Evaluation of Mixtures of Cotton Seed Oil and Tobacco Seed oil Based Biodiesel in Low Heat Rejection Diesel Engine

Rajnish kumar1 B.Parsanna kumar reddy2

Dept :- mechanical engg Dept :- mechanical engg

JPNCEJPNCE

Mahabubnagar, india mahabubnagar, india

[krajnish421@gmail.com](mailto:krajnish421@gmail.com) [chanti9352@gmail.com](mailto:chanti9352@gmail.com)

ABSTRACT

Fossil fuels are decreasing daily. Biodiesel fuels are attracting increasing attention worldwide as blending components or direct replacements for diesel fuel in vehicle engines.The high consumption of diesel fuel is not only in agriculture sector but also in transport sector compels for the substitution of diesel fuel with suitable, renewable energy resources. Alcohols and vegetable oils are the major alternate fuels for diesel fuel as they are renewable in nature.

The disadvantages of alcohols (ethanol and methanol) with low cetane numbers and vegetable oils, with low volatility and high viscosity call for hot combustion chamber, provided by low heat rejection diesel engine. About 30% of the heat energy supplied to the engine is being rejected through the chamber walls to the coolant and hence all efforts of the researcher turned towards reducing the heat rejection to the coolant and keep the combustion chamber hot which is suitable for burning renewable fuels like alcohols and vegetable oils quite effectively. However, most of the alcohol produced is diverted to Petro-chemical industries

Piston, liner and cylinder head are the contributors of heat transfer to the coolant through which heat is rejected and the use of a thermal barrier in these components has become attractive. Air being a low thermal conductivity material; can effectively function as thermal barrier in the piston and in the liner. Air gap insulated piston and air gap insulated liner with low thermal conductivity material stainless steel inserts and ceramic coating on the inside portion of cylinder head are found to be effective in achieving efficient insulation associated with improved performance of the engine. No systematic analysis on engine with air gap insulated piston and air gap insulated liner with ceramic coating cylinder on mixtures of vegetable oils, with varying performance parameters like change of injection pressure and injection timing is available. Hence in present programme, work is proposed in this direction.

**OBJECTIVES**

In the present proposed thesis, work has been taken up on the following aspects to cover the research gaps and to present the results based on the systematic studies and investigations on low heat rejection engine with a mixture of cotton seed oil and tobacco seed oil.

1. Development of low heat rejection engine with air gap insulated piston, air gap insulated liner with ceramic-coated cylinder head.
2. A comparative experimental investigation was conducted to evaluate the performance and Single Cylinder direct Injection diesel engine when fueled with mixture of cottonseed oil and Tobacco seed oil their blends with diesel fuel (20/80, 40/60 and 70/30 volumetrically). Tests were also carried out with diesel fuel to be used as a reference point. Engine power, torque, BSFC, thermal efficiency, Exhaust gas Temperature and Coolant Load.
3. Performance evaluation of mixture of cotton seed oil and tobacco seed oil in CE and LHR engine at normal and preheated temperatures at varied injection timing and injection pressure

**INTRODUCTION**

It has been found that the vegetable oils are promising substitute, because of their properties are similar to that of diesel fuel and it is a renewable and can be easily produced. Rudolph diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil. Several researchers [1-7] experimented the use of vegetable oils as fuel on conventional engines (CE) and reported that the performance was poor, citing the problems of high viscosity, low volatility and their polyunsaturated character. Not only that, the common problems of crude vegetable oils in diesel engines are formation of carbon deposits, oil ring sticking, thickening and gelling of lubricating oil as a result of contamination by the vegetable oils. Hence the drawbacks associated with vegetable oils call for LHR engines, which can provide hot environment in combustion chamber.

Low heat rejection engine (LHR) are classified into i) ceramic coated cylinder head engines, ii)air gap insulated piston engines, iii) air gap insulated piston and air gap insulated liner engines and iv) air gap insulated piston, air gap insulated liner, ceramic coated cylinder head engines. Partially stabilized zirconium is coated on lower side of cylinder head to reduce heat loss to the coolant.

Ceramic coatings provided adequate insulation and improved brake specific fuel consumption (BSFC) which was reported by various researchers. However previous studies [9-15] revealed that the thermal efficiency variation of LHR engine not only depended on the heat recovery system, but also depended on the engine configuration, operating condition and physical properties of the insulation material. Air gap was created [16] in the nimonic piston crown and experiments were conducted with pure diesel and reported that BSFC increased by 7% with varied injection timings. Investigations were carried [17] with air gap insulated piston with superni crown and air gap insulated liner with superni insert with varied injection pressures and injection timings with alternate fuels of alcohols and vegetable oils and reported LHR engine improved efficiency and decreased pollution levels.

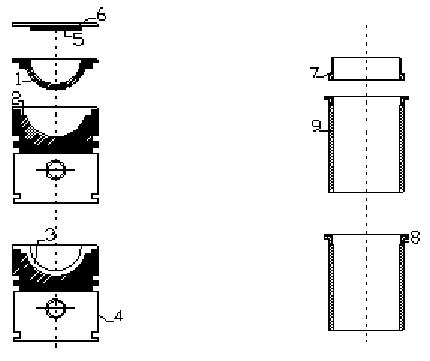
Experiments were conducted [18] on LHR engine which consisted of air gap insulated piston, air gap insulated liner and ceramic coated cylinder head with partially stabilized zirconium coating of thickness 500 microns with jatropha oil and pongamia oil based biodiesel with varied injection timing and injection pressure at different operating conditions of the vegetable oils and reported efficiency increased exhaust emissions of smoke decreased with LHR engine and NOx levels increased drastically. Thermal analysis was carried out with these alternate fuels and it was reported that LHR engine improved heat flux and temperatures. A multi-zone combustion model was assumed and combustion characteristics were estimated with these alternate fuels and reported that there is a deviation of 6% with theoretical results from experimental results.

Little literature is available on the studies of mixtures of cotton seed oil and tobacco seed oil in LHR diesel engine with varied injection timing and injection pressure at different operating conditions of the vegetable oil. Hence attention is focused in this direction and the present research programme is proposed to evaluate the performance with tobacco seed oil in LHR diesel engine at different operating conditions with varied injection timing and pressure. A suitable combustion modeling is proposed and results obtained with modeling are to be correlated with experimental results.

**METHODOLOGY**

Figure 1 shows the assembly details of air gap insulated piston, air gap insulated liner and ceramic coated cylinder head. The LHR diesel engine contains a two-part piston - the top crown made of stainless steel is screwed to aluminum body of the piston, providing a 3-mm-air gap in between the crown and the body of the piston. The optimum thickness of air gap in the air gap piston is found [19] to be 3-mm for better performance of the engine with stainless steel inserts with diesel as fuel. A stainless steel insert is screwed to the top portion of the liner in such a manner that an air gap of 3-mm is maintained between the insert and the liner body. Partially stabilized zirconium (PSZ) of thickness 500 microns is coated on inside portion of cylinder head.

Crude vegetable oils are converted [17] into biodiesel by treating crude vegetable oil was stirred with methanol at around 60-70oC with 0.5% of NaOH based on weight of the oil, for about 3 hours. At the end of the reaction, excess methanol is removed by distillation and glycerol, which separates out was removed. The methyl esters are treated with dilute acid to neutralize the alkali and then washed to get free of acid, dried and distilled to get pure vegetable oil esters or biodiesel.



1. Crown 7 Insert

2. Gasket 8. Air gap

3. Air gap 9. Liner

4. Body

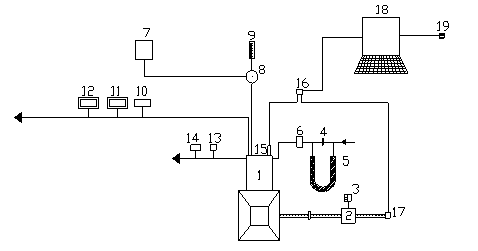
5. Ceramic coating

6. Cylinder head

*Insulated piston Insulated liner Ceramic coated cylinder head*

**Figure 1. Assembly details of insulated piston, insulated liner and ceramic coated cylinder head**

The experimental setup used for the investigations of LHR diesel engine with the mixture of cotton seed oil (CSO) and tobacco seed oil (CTC) is shown in Figure 2. CE has an aluminum alloy piston with a bore of 80-mm and a stroke of 110-mm. The rated output of the engine is 3.68 kW at a speed of 1500 rpm. The compression ratio is 16:1 and manufacturer’s recommended injection timing and injection pressures are 27obTDC and 190 bar respectively. The fuel injector has 3-holes of size 0.25-mm. The combustion chamber consists of a direct injection type with no special arrangement for swirling motion of air. The engine is connected to electric dynamometer for measuring brake power. Burette method is used for finding fuel consumption of the engine. Air-consumption of the engine is measured by air-box method. The naturally aspirated engine is provided with water-cooling system in which inlet temperature of water is maintained at 60oC by adjusting the water flow rate. Engine oil is provided with a pressure feed system. No temperature control is incorporated, for measuring the lube oil temperature. Copper shims of suitable size are provided in between the pump body and the engine frame, to vary the injection timing and its effect on the performance of the engine is studied, along with the change of injection pressures from 190 bar to 270 bar (in steps of 40 bar) using nozzle testing device.



1.Engine, 2.Electical Dynamo meter, 3.Load Box, 4.Orifice meter, 5.U-tube water manometer, 6.Air box, 7.Fuel tank, 8, Pre-heater, 9.Burette, 10. Exhaust gas temperature indicator, 11.AVL Smoke meter, 12.Netel Chromatograph NOx Analyzer, 13.Outlet jacket water temperature indicator, 14. Outlet-jacket water flow meter, 15.Piezo-electric pressure transducer, 16.Console, 17.TDC encoder, 18.Pentium Personal Computer and 19. Printer.

**Figure 2 Proposed Experimental Set-up**

The maximum injection pressure is restricted to 270 bar due to practical difficulties involved. Exhaust gas temperature (EGT) is measured with thermocouples made of iron and iron-constantan.

The properties of the crude tobacco seed oil, crude cotton seed oil and the diesel used in this work are presented in Table-1.

**Table 1. Properties of test fuels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test Fuel | Viscosity at  25oC  (Centi-poise) | Density at  25 oC | Cetane number | Calorific value  (kJ/kg) |
| Diesel | 12.5 | 0.84 | 55 | 42000 |
| Tobacco Seed Oil (Biodiesel) (TSOBD) | 12.0 | 0.87 | 0.52 | 38000 |
| Cotton Seed oil based Biodiesel (CSOBD) | 5.0 | 0.87 | 48 | 38000 |

**REFERENCES OF LITERATURE**

1. Use of raw vegetable oil or animal fats in diesel engines.Engine Manufacturer’s Association, Chicago, March, 2006.
2. Bari, S., Lim, T.H. and Yu, C.W. (2002).Effect of preheating of crude palm oil on injection system, performance and emission of a diesel engine. Renewable Energy, 27(3), 339-351.
3. Ramadhas, A.S.S., Jayaraj, S and Muraleedharan, C. (2004).Use of vegetable oils as I.C. engine fuels-A review. Renewable Energy, 29, 727-742.
4. Pugazhvadivu, M. and Jayachandran, K. (2005).Investigations on the performance and exhaust emissions of a diesel engine using preheated waste frying oil as fuel. Renewable energy, 30(14), 2189-2202.
5. Agarwal, D. and Agarwal, A.K. (2007).Performance and emissions characteristics of jatropha oil (preheated and blends) in a direct injection compression ignition engine. Int. J. Applied Thermal Engineering, 27, 2314-23.
6. Misra, R.D. and Murthy, M.S.(2010). Straight vegetable oils usage in a compression ignition engine—A review. Renewable and Sustainable Energy Reviews*,* 14,3005–3013.
7. Murali Krishna, M.V.S. (2004). Performance evaluation of low heat rejection diesel engine with alternate fuels. PhD Thesis, J.N.T. University, Hyderabad.
8. Ekrem, B., Tahsin, E., Muhammet, C. (2006). Effects of thermal barrier coating on gas emissions and performance of a LHR engine with different injection timings and valve adjustments. Journal of Energy Conversion and Management,47,1298-1310.
9. Ciniviz, M., Hasimoglu, C., Sahin, F., Salman, M. S. (2008). Impact of thermal barrier coating application on the performance and emissions of a turbocharged diesel engine. Proceedings of The Institution of Mechanical Engineers Part D-Journal Of Automobile Eng,222 (D12), 2447–2455.
10. Parlak, A., Yasar, H., ldogan O. (2005).The effect of thermal barrier coating on a turbocharged Diesel engine performance and exergy potential of the exhaust gas. Energy Conversion and Management, 46(3), 489–499.
11. Ekrem, B., Tahsin, E., Muhammet, C. (2006). Effects of thermal barrier coating on gas emissions and performance of a LHR engine with different injection timings and valve adjustments. Journal of Energy Conversion and Management,47,1298-1310.
12. Ciniviz, M., Hasimoglu, C., Sahin, F., Salman, M. S. (2008). Impact of thermal barrier coating application on the performance and emissions of a turbocharged diesel engine. Proceedings of The Institution of Mechanical Engineers Part D-Journal Of Automobile Eng,222 (D12), 2447–2455.
13. Hanbey Hazar. (2009).Effects of bio-diesel on a low heat loss diesel engine. *Renewable Energy,* 34, 1533–1537.
14. Modi, A.J., Gosai, D.C. (2010). Experimental study on thermal barrier coated diesel engine performance with blends of diesel and palm bio-diesel. SAE International Journal of Fuels and Lubricants, 3 (2), 246-259.
15. Rajendra Prasath, B., P. Tamilporai ,P., Mohd.Shabir, F. (2010). Analysis of combustion, performance and emission characteristics of low heat rejection engine using biodiesel. International Journal of Thermal Sci, 49, 2483-2490.
16. Rama Mohan, K., Vara Prasad, C.M., Murali Krishna, M.V.S. (1999). Performance of a low heat rejection diesel engine with air gap insulated piston, ASME Journal of Engineering for Gas Turbines and Power,121(3), *530-540.*
17. Murali Krishna, M.V.S. (2004). Performance evaluation of low heat rejection diesel engine with alternate fuels. PhD Thesis,
18. Krishna Murthy, P.V. (2010). Studies on biodiesels using with low heat rejection diesel engine.
19. Ramamohan, K. (1995). Studies on air gap insulated piston engine with pure diesel. Ph.D Thesis, Kakatiya University, Warangal.