Performance Evaluation of Some Biodiesel blends in an Insulated Engine

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Abstract - Growing concern regarding energy resources and the environment has increased a lot of inquisitiveness in the study of alternative sources of energy, so to meet those energy requirements there has been some strenuous work going on globally in alternative fuels like biodiesels, alcohols and CNG, LNG, LPG and Hydrogen etc. The reason behind the outgrowing interest in Biodiesels is, they can offer a very promising future rather than Diesel oil. Biodiesel blends (20% Biodiesel + 80% Diesel) have given optimum performance in an conventional diesel engine. But engine will encounter problems like low volatility and high viscosity. However, it can be overcome by using these biodiesel in a hot combustion chamber. Because at higher temperature it has the ability to handle low calorific value fuels effectively. This paper reviews and compares various biodiesel blends in an insulated environment of a diesel engine. Before that a suitable insulated environment was selected from three different insulated levels by the earlier researchers is used.

***Keywords**: Biodiesel blends, Semi adiabatic Engine.*

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I. INTRODUCTION

The fact that petroleum based fuels will neither be available in sufficient quantities nor at reasonable price in future has revived interest in exploring alternate fuels for diesel engines. As India is an agricultural country, there is a wide scope for the production of vegetable oils derived from different oil seeds. The auto ignition properties of vegetable oils are almost similar to those of diesel fuels and hence can be used in diesel engines with little or no engine modification[1,2]. However, high viscosity and low volatility are the main disadvantages of these oils, which are the causes for poor performance and heavy smoke in diesel engines. Using of vegetable oils in low heat rejection engines is the only solution to overcome problems of these oils. The high in-cylinder temperature of these engines reduces the ignition delay and aids combustion[3-8]. For mainly improving performance of a engine, ceramic insulated components may be used. It is planned to carryout suitable modifications on the existing engine by insulating piston, cylinder liner, cylinder head with an intention to improve the performance of the engine and to reduce emissions. Initially modifications are carried out by employing PSZ coated cylinder head and liner on the engine. Then different levels of insulation are applied by changing different pistons. Diesel fuel is used in all these SADE (Semi Adiabatic Engine) configurations to find out performance, emissions and combustion characteristics. The SAD engine configuration, which gave the best performance is used for the subsequent investigations. Variety of Biodiesel blends are tried with a view to identify the best one in terms of efficiency and emissions. Engines using pure vegetable oils can also produce the same power output, however, with reduced thermal efficiency and increased emissions (particularly smoke).

Extended operation indicated that carbonization of critical engine components resulted from the use of raw vegetable oil fuels, which can lead to premature engine failure. Blending vegetable oil with diesel fuel was found to be a method to reduce coking and extended engine life[9, 10]. The high viscosity of the oil causes problems in pumping and atomization, leading to poor performance of the engine.

Slightly lowered power, poor spray, distorted combustion, wear problem, high smoke during combustion plus filter plugging, excessive deposits, noise, cold start and odor are the other problems associated with them. Most of the oils have kinematic viscosity in the range of 30 to 50 centi stokes where as for diesel oil is 1.9 to 4.1 centi stokes.

Different Vegetable Oils

A. Simarouba Oil

Simarouba trees are seen in the states of Bihar, Orissa, Madhya Pradesh, West Bengal, Andhra Pradesh and Tamilnadu. Simarouba oil is solid at ambient temperature. The colour of simarouba oil is cascade green. The proximate composition of simarouba oil varies widely depending on both genetic and environmental factors[11].

B. Rapeseed Oil

Rapeseed is one of the important oils in the far east and in the Northern parts of Europe and North America. Rapeseed thrives well in a cool, moist climate. A major rapeseed producing countries are Canada, India, China, Pakistan, Austsralia, England, Poland, France and Sweden. Rapeseed is mainly used as a source of oil. The meal obtained after extraction of oil is used as animal feed. In general, Rapeseeds contain about twice as much oil as Soyabeans, and the oil free meal has only slightly less protein. Rapeseeds contain more fibre than Soyabeans, made up mainly (95-98%) of triacyl glycerols (Triglycerides).

C. Karaj Oil

Karanj also called Pongam, is classified as Pongamia Pinnata. The seed contains about 27-39% oil and resinous substances[12, 13]. They yield about 24 to 26% of oil and 68 to 72% of cake. The fresh extracted oil is yellowish orange to brown, and rapidly darkens on storage.

D. Production of Biodiesel

Vegetable oils are chemically complex esters of fatty acids. These are the fats naturally present in oil seeds, and known as tri-glycerides of fatty acids. The molecular weight of these tri-glycerides would be of order of 800kg/m^3 or more. Because of their high molecular weights theses fats have high viscosity causing major problems in their use as fuels in CI engines. These molecules have to be split into simpler molecules so that they have viscosity and other properties comparable to standard diesel oils. Modifying the vegetable oils (to make them lighter) can be achieved in many ways, including, Pyrolysis Micro emulsification, Dilution and Transesterification. Among these, transesterification is the most commonly used commercial process to produce clean and environmentally friendly light vegetable oil fuel i.e., biodiesel[14-16].

E. Transesterification

The fatty acid triglycerides themselves are esters of fatty acids and the chemical splitting up of the heavy molecules, giving rise to simpler esters, is known as Transesterification. The triglycerides are reacted with a suitable alcohol (Methyl, Ethyl, or others) in the presence of a catalyst under a controlled temperature for a given length of time. The final products are Alkyl esters and Glycerin. The alkyl esters, having favourable properties as fuels for use in CI engines, are the main product and the Glycerin, is a by-product[17].

II. EXPERIMENTATION

The experimental set-up is designed to suit the requirements of the present investigations. The main components of the system are Dynamometer, Data acquisition system, Smoke meter, Exhaust gas analyzer, etc. The engine chosen to carryout experimentation is a single cylinder, water cooled, vertical, direct injection, CI engine. Specifications of the engine are given in Table 1.

Table 1: **ENGINE SPECIFICATIONS**

Bore	:	80mm
Stroke	:	110mm
Volume	:	553cc
Gasket diameter	:	88.29mm
Gasket thickness	:	1.2mm
Gasket volume	:	7.35cc
Deck height	:	0.75mm
Deck volume	:	3.77mm
Valve groove volume on piston	:	0.6cc
Valve seat on head	:	1cc
Injector free volume	:	1cc
Bowl volume	:	14.15cc
Compression ratio	:	20.0 (12-20)
Connecting rod length	:	235mm
Wrist pin offset	:	0.0

The CI engine is converted into a Semi Adiabatic Engine (SADE) by applying a ceramic (PSZ) coating on the cylinder head and on the liner. Two different pistons are used along with ceramic coated cylinder head and liner.

During experimentation three different levels of insulations are tried on the test engine with an objective to find the best one in terms of performance, emissions and other combustion parameters. The aluminium piston engine is chose as a base engine. Also, there is no insulation over the piston. As an initial modification to this engine, PSZ coated cylinder head and liner are fitted. In all these engines biodiesel fuel is used for the performance analysis. And the insulation thickness employed is 0.5mm.

Notation : Type of piston

i) SADE1 : Cast iron piston
ii) SADE2 : Cast iron piston coated with PSZ
iii) SADE3 : Aluminium piston coated with PSZ
iv) Base Engine: Aluminimum Piston

Biodiesels are almost closer to diesel, particularly cetane rating and heat values. Since Biodiesels have slightly longer ignition delay, they are most suitable to be used in low heat rejection engines. The three different vegetable oils which are tried in the SADE test engine are given below

Notation	Type of Oil
SBDB	80% Esterified Simarouba oil + 20% Diesel (Simarouba Biodiesel blend)
RBDB	80% Esterifide Rape seed oil + 20% Diesel (Rapeseed Biodiesel blend)
KBDB	80% Esterifide Karanj oil + 20% Diesel (Karanj Biodiesel blend)

III. RESULTS AND DISCUSSION

The analysis of these experimental results are presented below:

The variation of brake thermal efficiency of the Three SADE configurations, base engine with brake output is shown in figure 1. As the load increases, thermal efficiency also increases upto nearly 3kw load. All the SADE configurations have higher brake thermal efficiencies compared to base engine configuration. SADE2 configuration gives higher efficiency over wide range of operation.

The variation of exhaust smoke emission for different SADE configuration compared to base engine configuration is shown in figure 2. Smoke emission is lowest for SADE2 configuration over the entire operating range. All the SADE configuration have lower smoke levels. 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 SADE engines.

After conducting experiments on all the three SADE configurations, the SADE2 configuration has shown the best performance. Hence, the configuration is selected for carrying out further experimental investigation.

The three biodiesel blends are tested in SADE2 engine for performance, emission characteristics.

The variation of brake thermal efficiency of three biodiesel blends in a SADE with Brake Power output is shown in figure 3. SBDB has marginally higher efficiency levels compared to other blends.

The Exhaust smoke emission is lowest for SBDB as seen from the figure 4. However, smoke emissions increases with the engine load. This lowest smoke emissions for SBDB is due to better vaporization, faster and more efficient combustion of injected fuel in the hot environment inside the SAD test engine.

The variation of volumetric efficiency with power output is shown in figure 5. Relatively due to lower cylinder wall temperatures the volumetric efficiency is higher for SBDB.

Exhaust gas temperature variation with respect to Brake output for all the Biodiesel blends are compared in the figure 6.

IV. CONCLUSIONS

- The SADE2 configuration has shown highest brake thermal efficiency.
- The maximum reduction in the smoke emission is for a SADE2 configuration when compared to the base engine.
- Simarouba Biodiesel blend has the maximum thermal efficiency compared to other blends.
- Smoke levels and exhaust gas temperatures are lowest for simarouba bio-diesel blend.
- Due to relatively low wall temperatures volumetric efficiency is better for the simarouba biodiesel blend.

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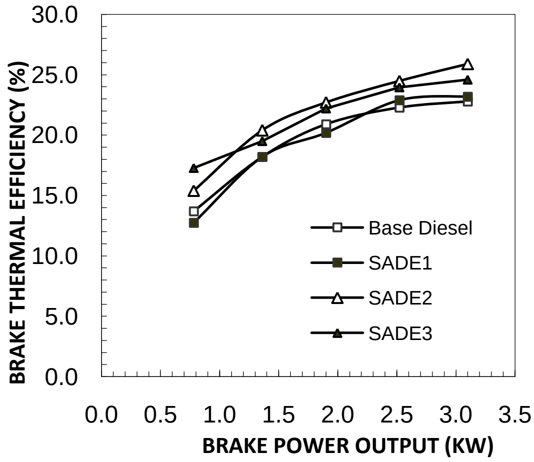

Figure 1. Comparison of brake thermal efficiency with power output for three SADE configurations

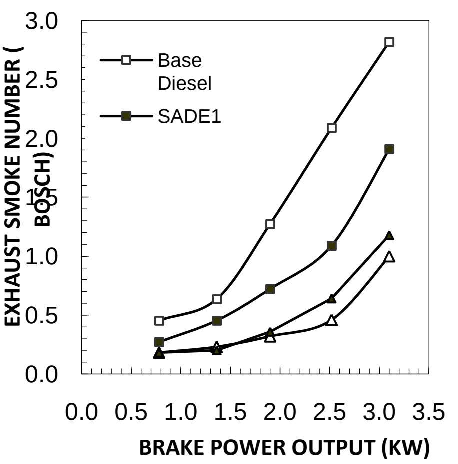

Figure 2. Comparison of smoke emissions with power output for three SADE configurations

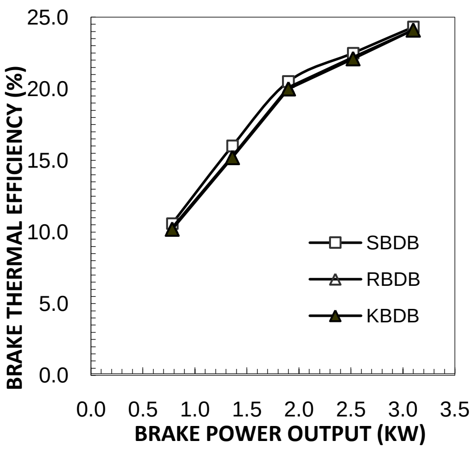

Figure 3. Comparison of brake thermal efficiency with power output for different Biodiesel blends

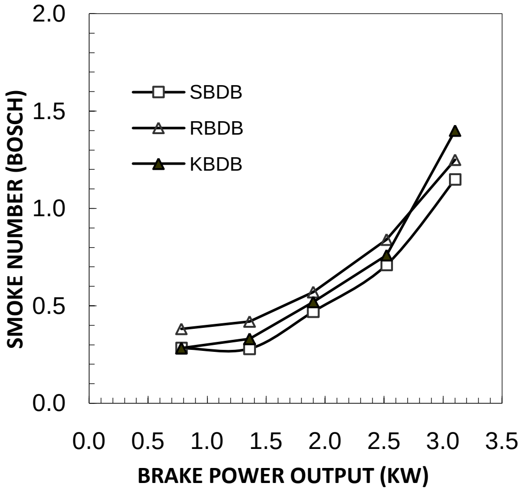

Figure 4. Comparison of smoke number with power output for different Biodiesel blends

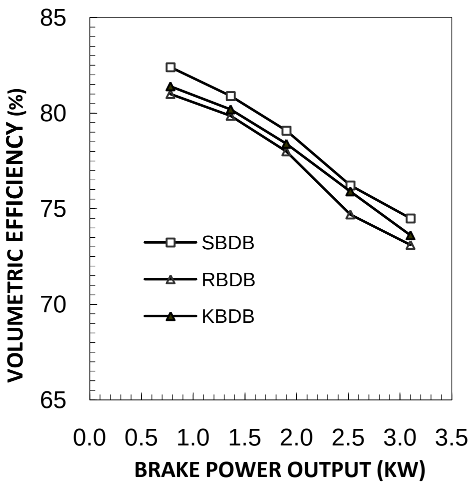

Figure 5. Comparison of volumetric efficiency with power output for different Biodiesel blends

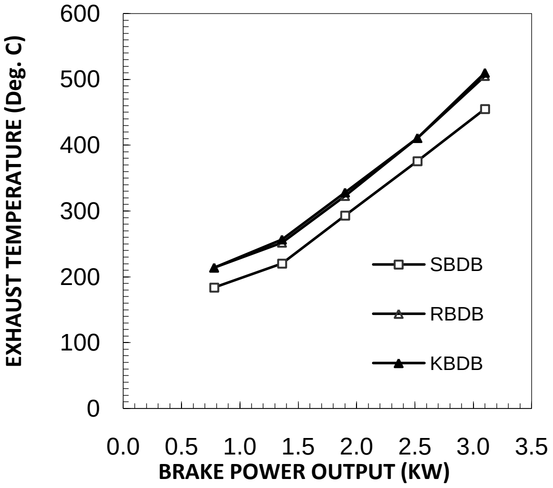

Figure 6. Comparison of exhaust temperature with power output for different Biodiesel blends