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Effect of Low Heat Rejection Engine with Biodiesel as Fuel

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Abstract—*The challenge for Automobile is present emission norms that demands engine for green environment with high performance and low emission. The Low Heat Rejection Engine (LHR Engine) is a technology, which minimizes heat loss to the coolant by providing heat resistance in the heat flow to the coolant. As LHR Engine is used, the heat is not transferred to the surroundings. So, the efficiency is improved. Another method to improve performances of fuel is Biodiesel. The main advantages of Biodiesel are less emission, more efficiency. Both LHR and Biodiesel are used in research to improve the efficiency.*

1. INTRODUCTION

The pollutants emitting out from the exhaust of the automotive vehicles is also increasing due to the increase in the number of vehicles. The main causes of these emissions are: non-stochiometric combustion, dissociation of nitrogen, solid carbon particulates. So, the engineers and scientists have to develop engines and fuels of developing very few emissions or no emissions. If the combustion is complete, the products are CO_2 and H_2O. Most of undesirable exhaust emissions are produced due to incomplete combustion and the main emissions are the oxides of Nitrogen, Unburnt Hydrocarbons, Carbon-monoxide, Carbon-di-oxide. In Diesel Engines, NOx emission is increased due to high peak cycle temperature and HC and CO emissions are reduced due to complete combustion. This problem can be reduced by Alternative Fuels. In particular, biodiesel can be used as a replacement for diesel fuel because it reduces emissions as it has inherent Oxygen content. Based on engine tests, it can be noted that bio-diesel is an alternative fuel for conventional diesel engines without major modifications in the engine. The only problem in biodiesel is the increase of the oxides of Nitrogen. Another problem is the heat loss to the coolant and exhaust so that 70% of efficiency has been wasted. As per the Sankey Diagram in Fig. 1, it is well-known fact that about 30% of the energy supplied is lost through the cooling system and 40% is wasted through exhaust gas, 5% is wasted through friction, thus leaving only 25% of energy utilization for useful purposes. By research, LHR Engine is the developed technology which reduces heat losses to the coolant and so the efficiency loss is reduced. Several methods adopted for achieving LHR to the coolant are (i) using ceramic coatings on piston, liner, and cylinder head (ii) creating air gap in the piston and other components with low thermal conductivity materials especially Zirconia.Thermal Barrier Coatings (LHR Method) is anenergy saving technology which comes under the topic, **"Heat transfer applications in automobiles"** so that brake thermal efficiency is improved as heat transfer is reduced. Experiments conducted on investigations of LHR engines with varying degree of insulation such as ceramic coated engine, air gap-insulated piston engine, and air gap-insulated liner engine, etc. and reported improvement in the performance of the engine with LHR version of the engine. This project isconducted on LHR engine with the cylinder head, exhaust and inlet valves were coated with the ceramic material MgO-ZrO_2 by the plasma spray method while the piston surface was coated with ZrO_2.Thus, a thermal barrier was provided for the coating in the elements of the combustion chamber. Tests were performed on the standard engine and then repeated on the LHR engine, and the results were compared. An increase in engine power and decrease in specific fuel consumption, as well as significant improvements in exhaust gas emissions and smoke density, were observed for all test fuels used in the LHR engine compared with that of the standard engine. For deliver in the fuel accurately with the precise control of injection timing, Electronic Fuel Injection System is necessary. Fuel injection means metering fuel into an internal combustion engine. There are several competing objectives such as: Power output,Fuel efficiency, Emissions performance, Ability to accommodate alternative fuels, Durability, Reliability, Drivability and smooth operation, Initial cost, Maintenance cost and Diagnostic capability.

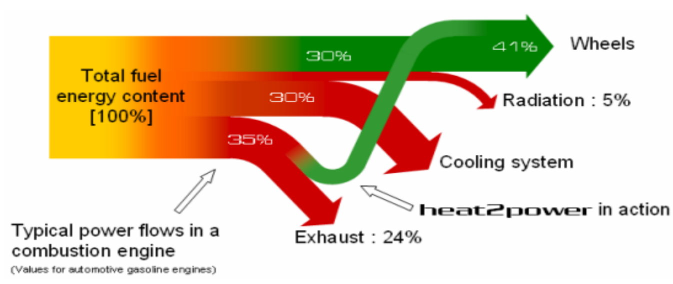

Fig. 1: Sankey Diagram of IC Engine

2. OBJECTIVE

The objective of the project is to reduce heat losses to the coolant by converting the Standard Engine into LHR Engine and to achieve precise control of fuel quantity and to provide accurate injection timing by implementing Electronic Fuel Injection System with different blends of biodiesel as fuel to reduce emissions and heat transfer to the surroundings from the wall.

3. METHODOLOGY

3.1 Steps for the project

The steps to be followed for the conduct of the project are:

1. List the technical specifications of the present experimental Diesel Engine set-up. This will give the idea for evaluating the performance characteristics for both standard and LHR engine.
2. Conduct experiments to evaluate the characteristics of the standard engine using Diesel fuel and Biodiesel Blends by mechanical injection.
3. Convert the standard engine into Low Heat Rejection Engine (LHR Engine) by coating on piston crown and cylinder head.
4. Conduct experiments to evaluate the characteristics of LHR engine using Diesel fuel and Biodiesel Blends by mechanical injection.
5. Compare and optimize the performance and emission characteristics of both standard engine and LHR engine by mechanical injection system.
6. Convert Mechanical Injection System into Electronic Injection System by implementing Electronic Set-up.
7. Conduct experiments to evaluate the characteristics of the standard engine using Diesel fuel and Biodiesel Blends by electronic injection system.
8. Conduct experiments to evaluate the characteristics of LHR engine using Diesel fuel and Biodiesel Blends by electronic injection system.
9. Compare and optimize the performance and emission characteristics of the standard and LHR engines using suitable blends of the Biodiesel by electronic injection system.
10. Compare and optimize the performance and emission characteristics of LHR engines using suitable blends of Biodiesel both by mechanical and electronic injection systems.

3.2 Test procedure of the engine

In this project, LHR Engine is used and the performances of LHR Engine with standard engine are compared. The experiment is carried out in 5 HP, Single Cylinder and DI Diesel Engine at a constant speed of 1500 rpm. In this work, Jatropha Oil Methyl Ester is blended with Diesel based on volume fraction and analyzed for B5, B10, B15, B20, B25 and for pure Jatropha Biodiesel (100%).

4. LOW HEAT REJECTION ENGINE

Low Heat Rejection Engine (LHR Engine) is used to minimize heat loss to the coolant by providing heat resistance in the heat flow to the coolant. Generally, the coating is applied in the engine to provide heat resistance to the heat flow to the coolant. The coating can be done on any parts of the engine such as air gap insulated piston engine;air gap insulated piston and air gap insulated liner engine, air gap insulated piston, air gap insulated liner, ceramic coated cylinder head engine, Thermal Barrier Coating.

5. RESULTS AND DISCUSSION

Brake Thermal Efficiency, Brake Specific Fuel Consumption, exhaust emissions like HC, CO, NOx were investigated on the engine using LHR Engine with Diesel and blends of diesel and biodiesel as fuel.

Table 1: Fuel Properties

Property	Diesel	Jatropha
Viscosity(cst) at 40 ˚C	3.9	4.84
Cetane Number	49	48
Calorific Value (kJ/kg)	43200	42250
Flash Point (˚C)	58	92
Fire Point(˚C)	64	96
Specific Gravity	.804	0.815

5.1 Performance characteristics

Brake thermal efficiency

From the Fig. 2, the brake thermal efficiency of the Jatropha blends is higher for higher percentage. Conventional Engine with vegetable oil showed the improvement in the performance of Brake Thermal Efficiency for entire load range when compared with the pure diesel operation on Conventional Engine at recommended injection timing.

In Jatropha Esters, there is inherent oxygen and so it ignites the Biodiesel.

Also, LHR Engine reduces heat transfer. So, the heat is utilized in the combustion chamber.

So, the Brake Thermal Efficiency is increased in Jatropha Biodiesel than Diesel.

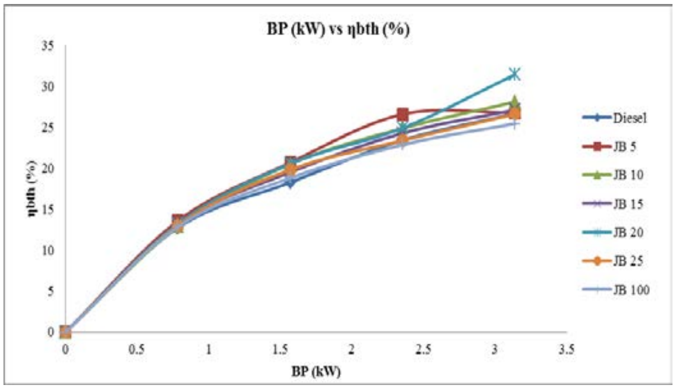

Fig. 2: Effect of Engine Brake Power on Brake Thermal Efficiency

Brake specific fuel consumption

From the Fig. 3, it indicates that specific fuel consumption is lower for Biodiesel than the diesel for various proportions of Jatropha oil with diesel at constant operated conditions. This is due to complete combustion, as addition oxygen is available from fuel itself and more heat occurs in the combustion chamber due to LHR Engine.

So, less amount of fuel itself is enough for complete combustion.

Similarly for various blends of esterified Jatropha oil with diesel at constant operating conditions specific fuel consumption is lower when compared to diesel.

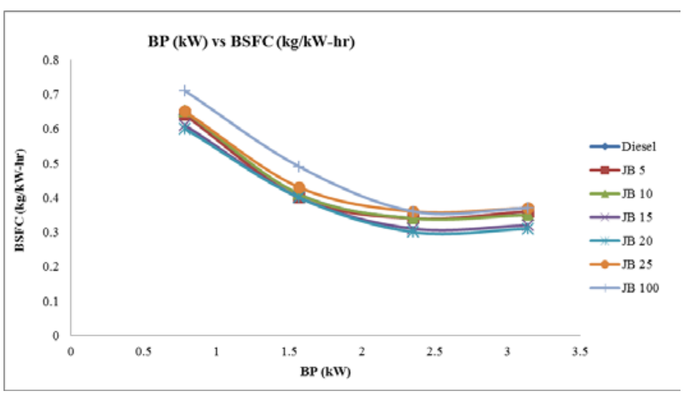

Fig. 3 Effect of Engine Brake Power on Brake Specific Fuel Consumption

5.2 Emission characteristics

Here, Oxygen content in the Jatropha Biodiesel plays a major role. The emission characteristics with and without Biodiesel are as follows.

Carbonmonoxide: From the Fig. 4, Carbon-monoxide emissions were reducedfor higher blends of Jatropha Bio-diesel in LHR Engine. This Fig. shows less CO emissions than Diesel. As there is inherent oxygen in Bio-diesel itself, it converts CO into CO_2. So, Carbon-monoxide emission was reduced.

As there is no oxygen content in Diesel, it shows higher CO emission than Bio-diesel. Thus, CO emission was reduced in Jatropha Bio-diesel than Diesel.

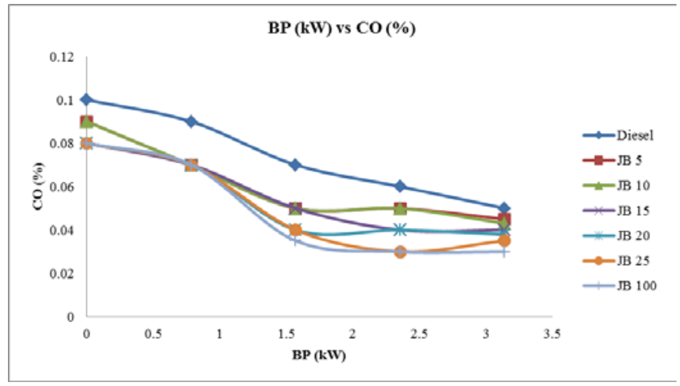

Fig. 4 Effect of Engine Brake Power on CO Emissions

Hydrocarbon:

From the Fig. 5, Hydrocarbon emissions were reduced for higher blends of Jatropha Bio-diesel in LHR Engine. This Fig. shows less HC emissions than Diesel.

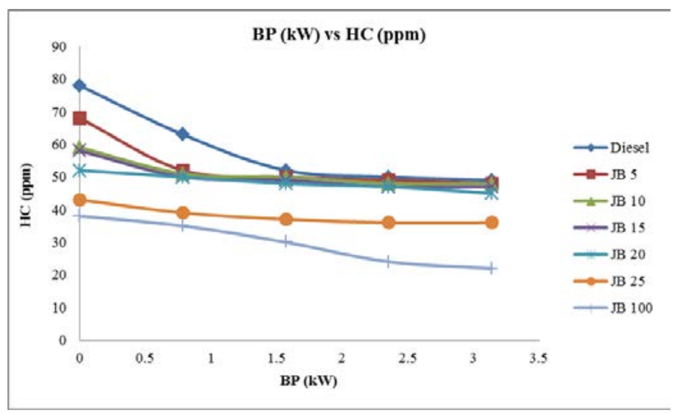

Fig. 5 Effect of Engine Brake Power on HC Emissions

As there is inherent oxygen in Bio-diesel itself, it provides better initial ignition. So, Hydrocarbon emission was reduced.

Oxides of nitrogen

From the Fig. 6, NO_x emissions were decreased for higher blends of Jatropha Bio-diesel in LHR Engine. This Fig. shows higher NO_x emissions for higher percentage.As there is inherent oxygen in Bio-diesel itself, it reacts with Nitrogen present in the atmosphere and forms NOx. So, NOx is increased when the percentage of Jatropha Biodiesel blends is increased.

As there is no oxygen content in Diesel, there will not be a reaction with Nitrogen present in the atmosphere. But, as there is a better combustion for Diesel, the peak cycle temperature was higher than Bio-diesel.

So, NO_x emissions were higher in case of Diesel compared to Jatropha Bio-diesel Blends.

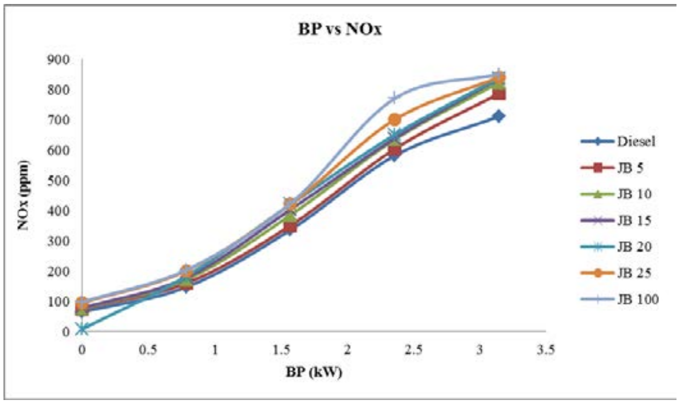

Fig. 6: Effect of Engine Brake Power on NO_x Emissions

6. CONCLUSION

Experiment has been conducted with diesel and blends of Biodiesel as primary fuels. The specific fuel consumption decreases for Jatropha Biodiesel compared to Diesel with the variation of Torque in LHR Engine. The Brake Thermal Efficiency increases for Jatropha Biodiesel compared to Diesel with the variation of Torque. There are variations with the performance in emissions such as CO, HC, NO_x with the variation of Torque. CO decreases for Jatropha Biodiesel compared to Diesel with the variation of Torque. HC decreases for Jatropha Biodiesel compared to Diesel with the increase in Torque because of the nature of the quenching which depends on combustion pressure, temperature of mixture ratio, turbulence. NO_x increases for Jatropha Biodiesel compared to Diesel with the variation of Torque due to the increase in peak cycle temperature.

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