Executive Summary of the Project entitled

Development and Experimental Analysis on HCCI Bio - Diesel Engine Fuelled by Waste Pork Lard Oil

UGC File No: 42-872/2013 (SR), Dated 25.03.2013

Funded By
UNIVERSITY GRANTS COMMISSION (UGC)
MAJOR RESEARCH PROJECT SCHEME (MRPS)
NEW DELHI

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1.	UGC Reference No. & Date	**F.No.42-872/2013 (SR) dated 25.03.2013**
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4.	Department and University/College where the project has undertaken	Department of Mechanical Engineering, Annamalai University
5.	Title of the Project	**Development And Experimental Analysis On HCCI Bio – Diesel Engine Fuelled By Waste Pork Lard Oil**
6.	Date of Implementation	**01.04.2013**
7.	Tenure of the project	**3 years** from 01.04.2013 to 31.03.2016
8.	Grants Received	1st Installment: **Rs. 8,62,000.00/-** 2nd Installment: **Rs. 20,000.00/-**

9. Financial Assistance provided

SI.No	Details	Total Project Cost	Receipts 2013-14	Receipts 2016-17	Total Receipts
1.	**Books & Journals**	**10,000.00**	**10,000.00**	**0**	**10,000.00**
2.	**Equipment**	**8,00,000.00**	**8,00,000.00**	**0**	**8,00,000.00**
3.	**Chemicals/Glassware/ Consumables**	**40,000.00**	**20,000.00**	**0**	**20,000.00**
4.	**Contingency**	**30,000.00**	**15,000.00**	**12,000.00**	**27,000.00**
5.	**Travel/Field Work**	**20,000.00**	**10,000.00**	**8000.00**	**18,000.00**
6.	**Overhead Charges**	**7,000.00**	**7,000.00**	**0**	**7000.00**
	Total	**9,07,000.00**	**8,62,000.00**	**20,000.00**	**8,82,000.00**

INTRODUCTION

The automobiles are having the major role on atmosphere pollution and global warming. Particularly, diesel engines are produced high oxides of nitrogen (NOx) and smoke emissions with consuming more amount of fuel. Homogeneously charged compression ignition engines have been the subject of much research recently because of its minimum fuel consumption and low NOx and smoke emissions. The HCCI engines are capable of producing more power at high load operation than conventional diesel engine. The HCCI operation is combination of spark ignition engine and compression ignition engine. In HCCI

engine the homogeneous air- fuel charge is prepared either in the intake manifold or direct injected to the engine cylinder by mixing the fuel and air before the compression stroke.

The HCCI combustion has been take place at multiple points in the combustion chamber during the end of compression stroke without flame frond or a diffusion flame. Controlling the start of combustion and combustion duration of HCCI engine is controlled by diluting the charge by exhaust gas (EGR) or increase the inlet charge temperature. To control the SOC and combustion duration of HCCI combustion by used three distinct combustion strategies. The first strategy is increasing the air-fuel temperature by using inlet air heater. The second strategy involves improving the auto ignition properties of fuel, which are used in the HCCI engine by using fuel combustion improver or fuel additives and final strategy is to control or improve the HCCI combustion by charge the compression ratio with increase the in-cylinder temperature.

OBJECTIVE

The objectives of this research are listed below,

- To construct an engine with lower NOx and smoke emissions, even operate with using alternative fuels.
- The HCCI engine has ultra low oxides of nitrogen (NOx) and smoke emissions and can operate with using other alternate fuels.
- To investigate the combustion, performance and emission behavior of HCCI engine fuelled by diesel, methyl esters and diesel/methyl ester blends.
- The HCCI engine combustion process is controlled by inlet air temperature. The start of combustion timing, combustion duration and homogeneity of the charge are dependent on inlet charge temperature and port fuel injection pressure.
- To analyze an effect of inlet air temperature and fuel injection pressure on HCCI mode engine.
- To identify the optimum air temperature and fuel injection pressure for different fuels operated HCCI mode engine.
- To compare the combustion, performance and emission behavior of different fuel used HCCI engine with conventional compression ignition engine.

METHODOLOGY

The methods implemented for developing the HCCI mode engine to operate with using diesel, methyl ester and blended fuels are pointed out below,

- Understanding the reasons for high NOx and smoke formation from the conventional diesel engine and analyse the possible ways to reduce the exhaust emissions.
- Identifying the reason for high NOx and smoke emissions from biodiesel fuelled conventional diesel engine.
- Identifying the possibilities to reduce the combustion temperature and eliminate the rich fuel region in the modern engine for reducing NOx and smoke emissions.
- Developing the HCCI mode engine and rectifying the challenges over the efficient HCCI engine operation.
- Trying to operate the HCCI mode engine using various fuels such as diesel, karanja methyl ester, waste cooking oil methyl ester and Waste pork lard methyl ester and their blends.
- Implementing the port fuel injector at inlet manifold for creating the homogeneous air-fuel charge and selecting suitable injection pressure to prepare the well-premixed homogeneous charge of various fuels operated HCCI mode engine.
- The ECU controlled fuel injection system is adopting with the HCCI mode engine.

- The ECU controlled electrical heater is adopting with inlet suction pipe, which is used to increase the inlet air temperature to vaporize the premixed fuel and control the HCCI combustion process.
- Identifying the effective inlet air temperature and port fuel injection pressure for efficient operation of different fuels operated HCCI mode engine.
- To identify the suitable fuel for HCCI mode engine from the experimental result.
- Analysing the performance, emissions and combustion behavior of HCCI mode engine and comparing with conventional mode engine.

CONCLUSION

This research work aims to develop and operate the HCCI mode engine with using different types of fuels such as diesel, methyl esters and their blends. This study also focuses to understand the effect of port fuel injection pressure and inlet air temperature on HCCI mode engine. During the experiments, the test engine operates with different injection pressures and inlet air temperatures. From the experimental results, identify the optimum inlet air temperature and fuel injection pressure for efficient operation of different fuels used HCCI mode engine. From the results, the following conclusions are made,

- The HCCI mode engine is a suitable replacement for conventional SI and CI engines.
- The HCCI mode engine has low NOx and smoke emissions, can ever be operated with using diesel, methyl ester and their blended fuels. However, the engine has high CO and HC emissions.
- The HCCI mode engine was controlled by inlet air temperature and the port fuel injector created the homogeneous charge.
- The performance and emissions values of different fuels operated HCCI mode engine was varied with dependent on inlet air temperature and fuel injection pressure.
- The different fuels used HCCI mode engine was operated efficient at different air temperature and injection pressure.
- The HCCI-diesel fuelled engine operated efficiently at 4 bar & 70ºC, injection pressure and air temperature, respectively.
- The HCCI- KME (B50 & B100) fuelled engine operated efficiently at 7 bar & 110ºC for KME (B50) and 8 bar & 110ºC for KME (B100).
- The HCCI-WCOME (B50 & B100) fuelled engine operated efficiently at 5 bar & 80ºC for WCOME (B50) and 6 bar & 80ºC for WCOME (B100).
- The HCCI-PLME (B50 & B100) fuelled engine operated efficiently at 6 bar & 90ºC for PLME (B50) and 7 bar & 90ºC for PLME (B100).
- The performance and emission values of different fuels operated HCCI mode engine was varied, depended on fuel properties.
- The brake thermal efficiency (BTE) of HCCI mode engine was lower than the conventional mode engine. The diesel and PLME (B50) fuelled HCCI mode engine has high BTE, i.e. about 28.13% and 28.22%, respectively at 75% engine load.
- Different fuels used HCCI mode engine has low NOx emissions compared to conventional mode engine. Among the fuels, diesel and three blends (B50) fuelled HCCI mode engine has low NOx emissions compared to neat methyl ester (B100) fuelled engine. The diesel fuelled HCCI mode engine has emitted very low NOx emissions were 106 ppm, 175 ppm, 297 ppm and 356 ppm.
- The HCCI mode engine has low smoke emission compared to conventional mode engine. The diesel and three blends B50 fuelled HCCI mode engine produced low smoke emissions compared to neat methyl ester (B100) fuelled engine. At 25% load, the diesel fuelled HCCI mode engine has registered the smoke value of 7HSU.
- The HCCI mode engine emitted high CO emissions, while using all types of fuels. Among the fuels, neat methyl ester (B100) fuelled HCCI mode engine has low CO emissions. From the three different neat methyl esters, PLME (B100) fuelled engine has registered low CO emissions were 0.21, 0.12, 0.09 and 0.06 % of vol.

- High HC emissions were observed from different fuels operated HCCI mode engine. The diesel-HCCI mode engine registered low HC emission of 71ppm at 25% load, compared to other fuels used HCCI mode engine.
- The combustion parameters such as heat release rate and in-cylinder pressure are found to be lower for the HCCI mode engine compared to conventional mode engine. The diesel and neat PLME fuelled engine has high heat release rate of 74.33 kJ/m^3deg and 78.6 kJ/m^3deg, respectively and in-cylinder pressure of 60.1 bar and 61.44 bar, respectively compared to other fuels.

PUBLICATION BASED ON THIS PROJECT WORK

1. Sathiyagnanam A P and Gowthaman S, "A Review on Methods of Homogeneous Charge Preparation for HCCI Mode Engine". **International Journal of Mechanical Engineering and Robotics Research.**Vol,.4,No.2,April 2015.

2. Sathiyagnanam A P and Gowthaman S. "An experimental study of inlet charge temperature on diesel fuelled homogeneous charge compression ignition engine". **Journal of Mines, Metals & Fuels,** Volume I, June 2015.

3. Sathiyagnanam A P and Gowthaman S. "Investigate the Effect of Exhaust Gas Recirculation (EGR) on Performance and Emission Characteristics of HCCI Engine", **International Journal of Ambient Energy, Taylor & Francis**. 10.1080/01430750, Jul.2015.

4. Sathiyagnanam A P and Gowthaman S. "Effect of charge temperature and fuel injection pressure on HCCI engine". **Alexandria Engineering Journal, Elsevier**, 1110-0168,2016.

5. Sathiyagnanam A P and Gowthaman S. "Performance and Emission characteristics of Homogeneous charge compression ignition (HCCI) engine- A review". International'. **Journal of Ambient Energy, Taylor & Francis**. 10.1080/01430750, Mar 2016.

6. Sathiyagnanam A P and Gowthaman S. "Effect of inlet charge temperature on diesel fuelled homogeneous charge compression ignition engine". **International Journal of Ambient Energy, Taylor & Francis** 10.1080/01430750. Mar 2016.