A Technical Review: Experimental Performance of HCCI Engine using Biodiesel

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Abstract— HCCI engine for the automobile industry pertinent the state-of-the-art in R & D on an international basis, as a one-stop reference works. HCCI – also referred to as Controlled Auto Ignition (CAI), Active Thermo-Atmosphere Combustion (ATAC), Premixed Charge Compression Ignition (PCCI), Homogeneous Charge Diesel Combustion (HCDC), premixed lean Diesel Combustion (PREDIC) and Compression-Ignited Homogeneous Charge (CIHC) – is the most commonly used name for the auto ignition of various fuels and is a process still under investigation. Experiments were conducted in a modified single cylinder water-cooled diesel engine, employing our conceptual system known as transient state fuel induction This system can there by improve fuel Economy & reduced Emissions over Vehicle Operating Entirely from Liquid Fuel. When HCCI combustion is operated at richer fuel/air mixtures, knocking can occur. In conclusion, HCCI combustion in a production engine is therefore limited by two main regimes.1.Lean Air to Fuel (A/F) ratio limit – Leading to incomplete combustion, which results to low power and high HC and CO emissions.2. Rich A/F ratios limit Leading to knocking if the rate of pressure rise is too high causing damage to the engine or high NOx emissions due to high combustion temperatures. I used in my experiment is Biodiesel Mixture.

Key words: HCCI, P-HCCI, Air-Fuel Mixture, Vapor Combustion, Reduced Emission

I. Introduction

There are two types of internal combustion engines: the Petrol(SI) and the Diesel(CI). The combustion processes of them are very dissimilar. In the CI engine the combustion is initiated because of some special conditions of pressures and temperatures. But, in the SI engine the combustion is caused by a spark that ignites a mixture that has been prepared before. Due to these different types of combustion, the two engines have different characteristics. Similar to the gasoline engines, HCCI engines also premixes the fuel-in air charge to prepare a homogeneous mixture. HCCI engines inject the air-fuel mixture during the intake stroke. Even though HCCI engines uses the charge similar to that of an SI engine, HCCI approach enables the engine to have a high compression ratio and rapidly burn the air-fuel mixture near TDC which results in high thermal efficiency. HCCI technology can reduce the fuel consumption by 16-32% .The indicated results show noticeable improvement in the charge homogeneity if the external mixture preparation technique is used.

II. Fuel Vaporizer

Fuel Vaporizer is an external device consisting of heaters to vaporize the pilot fuel (diesel) so that it mixes homogeneously with air thereby forming a homogeneous mixture leading to uniform combustion. Diesel fuel has very low volatility and is highly viscous. These two properties are the main drawbacks leading to formation of heterogeneous air-fuel mixture .In order to reduce the viscosity and increase the volatility of diesel, it has to be pre-heated to a certain temperature or vaporized so that vapors can mix easily with air leading to the formation of homogeneous mixture and in turn leading to homogeneous combustion.

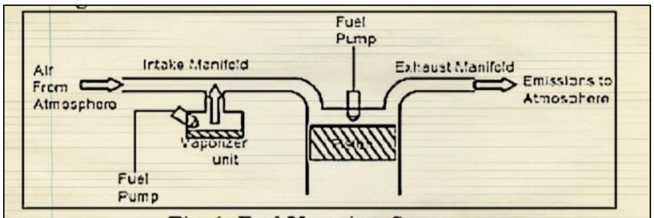

Fig. 1: Fuel Vaporizer System

Heater power	500 W
Vaporizing chamber diameter	38 mm
Vaporizing chamber length	150 mm
Fuel injection pressure	5.0 bar

Table 1: Technical Specification of Fuel Vaporizer

III. Experimentation Procedure

Initially the conventional engine (CI) is started normally. It is allowed to run for some time to attain steady state condition. Then the pilot fuel (diesel) is allowed to pass through the vaporizer .When the engine attains steady state, the quantity of fuel from the main fuel pump is adjusted and the engine is made to run mainly on the fuel vapors supplied from the vaporizer. In short, the engine is started in CI mode and is shifted to HCCI mode. Development of test rig for four stroke single cylinder diesel engine. Ensure cooling water circulation for eddy current dynamometer and engine. Start the set up and run the engine at no load for 4-5 minutes. Switch on the computer and run engine software. Reading taken with help of sensor connected to the Data acquisition system. Dynamometer is exited with 30 V DC Supply. Set the load on the dynamometer via load cell

The diesel engine will be tested without any modification at the speed of 1400 rpm. The load on the engine varied from no load to full load. Performance and emission parameters will be measured.

A. Experimental Procedure to Test Engine with Modification for HCCI

1) Fuel Vaporizer system is installed in the intake manifold.

2) Ensure cooling water circulation for eddy current dynamometer and engine.
3) Start the set up and run the engine at no load for 4-5 minutes.
4) Switch on the computer and run engine software. Reading taken with help of sensors whose sensed output is connected to the Data acquisition system.
5) The engine is started by first connecting the Data acquisition system with the
6) Computer and then followed by software initialization.
7) An electronically controlled port injection system is employed to inject bio- fuel in to the inlet manifold with vaporizer system.
8) Gradually increase load on the engine. And also readings are observed for various injections timings decided at each load condition.
9) Wait for steady state and log the data in the engine software.

The exhaust gas composition CO, UHC, CO2, O2 and NOx emissions were measured by gas analyzer. View the results and performance.

IV. BIODIESEL MIXTURE

– Biodiesel mixture means there is one or more vegetable oil use to making biodiesel.
– Mixture vegetable oil of castor, coconut and karanj to be use.
– The main objective of biodiesel mixture is to achieve good properties of biodiesel fuel which we desire. Biodiesel mixture name is CACOKAB. Means castor, coconut and karanj biodiesel.

Fig. 2.1.Castor seed 2.Coconut seed 3.Karanj seed

Fuel Property	Biodiesel Mixture	Diesel
Density Kg/m^3	0.890	0.860
Boiling point,°C	130	188-343
Kinetic Viscosity, cst	4.204	2-4
Calorific Value,kJ/kg	37,891	42,000
Flashpoint, °C	140	55
Auto ignition Temp.°C	230	316
Cetane number	57	51

Table 2: Properties of Diesel and Biodiesel Mixture

A. *Production of Biodiesel from Vegetable Oil*

Because of high viscosity of vegetable oils and low volatility causes the atomization and spry patterns problems, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking.
The methods used to reduce the viscosity are:
1) Emulsification,
2) Pyrolysis,
3) Dilution
4) Trans esterification process.

Among these four methods, the trans esterification is commonly used commercial process to produce clean and environment friendly Biodiesel. Methyl esters of used cooking oil, sunflower oil, rice bran oil, palm oil, soybean oil, Mahua oil, Jetrophaoil, castor, karanj and coconut oil have been successfully tested on C.I. engines. In present research Biodiesel Mixture is use as an Alternative fuel.
Production of Biodiesel from Vegetable Oil

B. *Biodiesel production*

– Sodium hydroxide was added to methanol in a mixer and stirred for 10 to 15 minutes until it is completely dissolved.
– It was then mixed with the three mix vegetables oil in a reactor equipped with a heater, magnetic stirred at 60℃. Stirring was continued and the product was placed in a separating funnel and left over night for glycerin to settle to the bottom of the funnel and then removed in a measuring cylinder.
– The impure methyl ester (biofuel) has contain moisture so biodiesel should be moisture free then I add hexane into biodiesel. Sodium hydroxide was added to methanol in a mixer and stirred for 10 to 15 minutes until it is completely dissolved.
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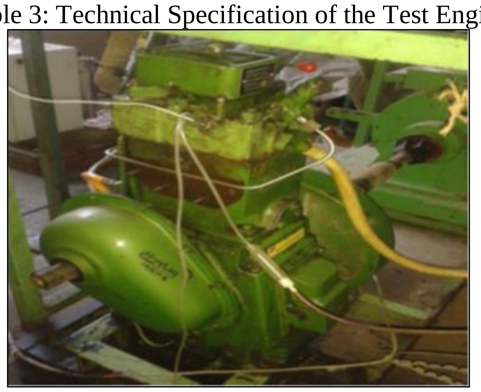
– The impure methyl ester (biofuel) has contain moisture so biodiesel should be moisture free then I add hexane into biodiesel.

C. *Technical Specification of the Test Engine*

A vertical, single cylinder, water-cooled, four stroke, and high speed diesel engine has been used for the experiment. The technical specification of engine is as under:

Engine	Kirloskar AV1
Dynamometer	eddy current, water cooled
Bore (mm)	87.5
Stroke (mm)	110
Displacement (cm^3)	661
Compression ratio	17.5
RPM	1500
H.P.	5.2

Table 3: Technical Specification of the Test Engine.



V. RESULTS AND DISCUSSIONS

A. Engine performance parameters for conventional Diesel and Diesel-Biodiesel HCCI

1) Effect of Load on Specific Fuel Consumption:

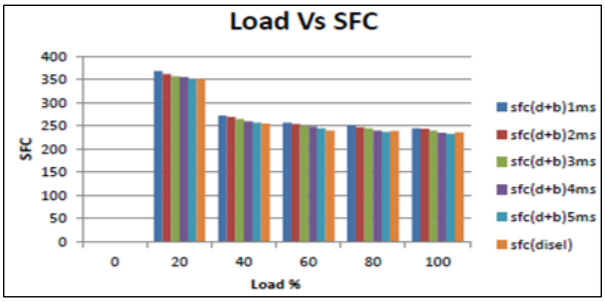


Fig. 4.1: SFC vs Load

Specific fuel consumption of Biodiesel injection decrease at gradual increase load but compare to diesel engine slightly increase

2) Effect of Load on volumetric Efficiency:

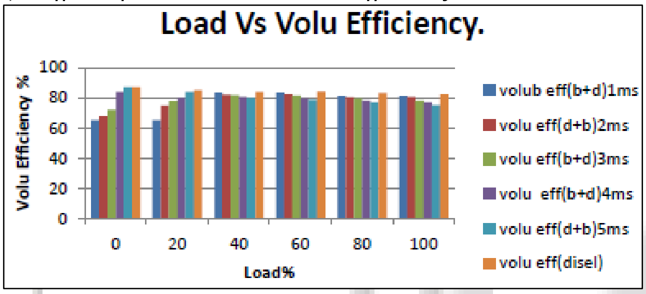


Fig. 4.2: Volumetric Efficiency vs load

Volumetric efficiency decrease at 0 to 20% load and after increase in high load.

3) Effect of Load on Exhaust Gas temperature:

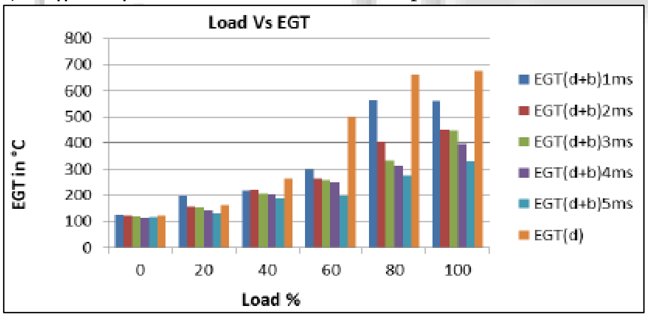
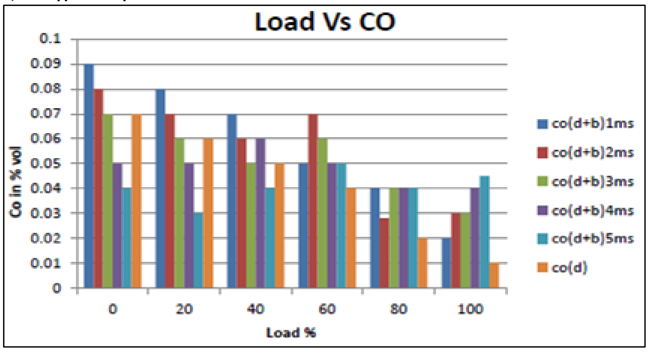


Fig. 4.3 Exhaust temp vs load

Exhaust gas temperature overall decrease in all load

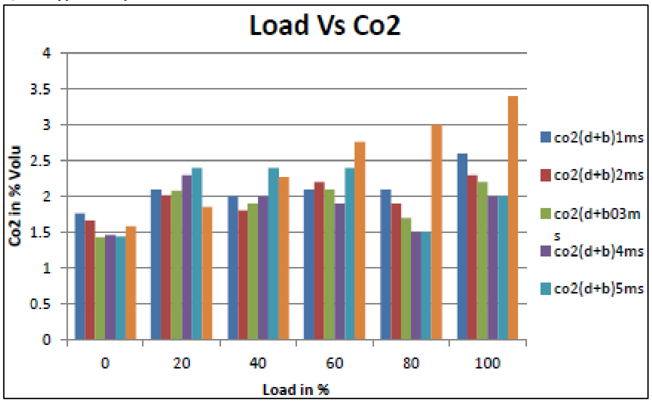
B. Engine emission parameters for conventional Diesel and Diesel Biodiesel HCCI

1) Effect of Load on co emission:



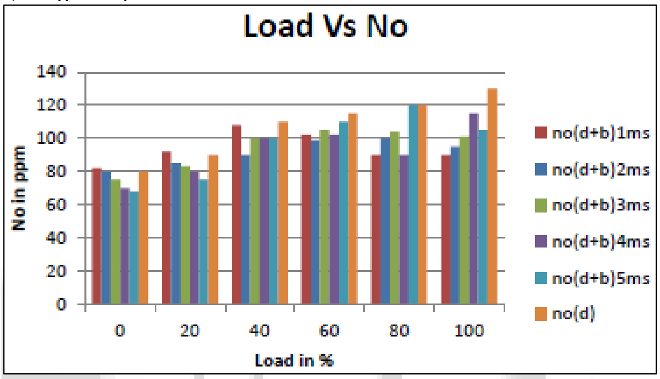
The co emissions are lower for high time in ms at 0 to 40% load and high load co maximum compare to C.I engine.

2) Effect of Load on co2 emission:



Carbon dioxide decrease at high load compare to C.I engine. But at low load gradually increase.

3) Effect of Load on No emission:



The NOx emissions are lower for diesel-biodiesel HCCI compared to the conventional diesel in the low load and high load.

ACKNOWLEDGEMENT

The Experiment was conducted in L.D College of Engineering, Ahmedabad, Gujarat, India. We are indebted to our guide, Assistant Professor S.N.PATEL and head of department Dr. G.H. Upadhyay of Department of Mechanical Engineering. Also for Special dedicated for making biodiesel Dr.Jigar Patel sir from P.M. Patel college Anand.

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