



Performance Assessment and Emission Characterization of Diesel-Fueled Homogeneous Charged Compression Ignition Engines

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Abstract: *The Homogeneous charge compression ignition (HCCI) combustion is an alternative to current engine combustion systems and research in HCCI is being carried out to use it as a method to reduce emissions. In this research performance and emission characteristics of HCCI combustion has been investigated experimentally. Experiment was performed in modified single cylinder diesel engine which has conventional mode of starting and then followed by HCCI mode. The basic requirement of the HCCI engines is homogeneous charge preparation, which is attained by using port fuel injection strategy. An external device was used for fuel vaporization and mixture formation.*

Keywords: *Endophytic fungi, fungal diversity, plant growth promotion, gibberellin, halophyte, salt marsh.*

INTRODUCTION

Demand for petroleum products is increasing day-by-day however the resources are fairly limited. Also there is increase in the environmental pollution specially pollution from the automotive/engine exhaust. Due to known hazardous effect of environment pollution and strict pollution norms reducing exhaust emissions and increasing the fuel economy of internal combustion engines have found global importance. Therefore to overcome these issues a technology is needed to be developed and HCCI is such a technology, which is highly efficient as well as less polluting. HCCI is a hybrid of both spark ignition (SI) and compression ignition (CI) combustion concepts [1].

HCCI engines are operated with the compression ignition of homogeneous charge formed by premixed air and fuel mixture through early injection in to the hot surface of a heated chamber known to be the vaporizer.

Engines are operated in the region of lower equivalence ratios to improve efficiency and reduce emissions. Due to increase in the vehicle population, the lean combustion technology is employed mainly in IC engines. The NO_x emission can be reduced only by reducing the flame temperature of combustion. Lean burn engines produce lower temperatures so that reduction in formation of thermal oxides of nitrogen happens. The excess air employed for lean burning results in a more complete combustion of the fuel which reduces both the hydrocarbon and carbon monoxide emissions [4].

To Accomplish the HCCI:

Diesel engines work on high compression ratio and due to this the engine must be more robust to withstand the loads and also the temperature of the combustion tends to be high. This high temperature of combustion chamber leads to the oxidation of Nitrogen forming NO_x. Homogeneous charge compression ignition (HCCI) relies on the high temperatures generated by compressing the intake stream to cause the fuel to auto ignite just like a conventional diesel engine. But the difference is that an HCCI engine runs on fuels with higher octane number instead of diesel fuel and has a significantly lower compression ratio. That lower compression ratio contributes to a lower combustion temperature and reduces nitrogen oxide emission.

HCCI also has some challenges during its effective adaption to an engine. The main challenge during the use of HCCI technology is to overcome the lack of controls for the combustion process. Hence a complete electronic control system is needed for effective adaption of HCCI technique. HCCI operating points are unstable i.e., it is impossible to map an HCCI engine reliably. Small changes in any engine parameter, for example, compression ratio, intake temperature or coolant temperature, will have a large impact on the combustion timing and hence engine efficiency. Thus, closed loop combustion control is necessary to ensure correct combustion timing.

EXPERIMENTAL WORK AND METHODOLOGY

The engine used in the study was a vertical, single cylinder, water-cooled, four stroke diesel engine. The engine was coupled to an eddy current dynamometer to measure the engine output power. Burette was used to measure fuel consumption of diesel and weigh scale for measuring the amount of consumption in vaporizer system. Proximity sensor calibrated by digital tachometer is used to measure the speed of engine. The temperature was measured with the help of temperature sensor LM35. Exhaust gas analyzer is used for measuring HC (ppm), NO_x (ppm), CO (% by vol.), CO₂ (% by vol.) and O₂ (% by vol.).



Fig. 1: Actual photograph of Experimental setup.

Table-1 Technical Specification of Engine

<i>Engine</i>	<i>Kirloskar</i>
<i>Dynamometer</i>	<i>eddy current, water cooled</i>
<i>Bore (mm)</i>	<i>87.5</i>
<i>Stroke (mm)</i>	<i>110</i>
<i>Displacement (cm³)</i>	<i>661</i>
<i>Compression ratio</i>	<i>17.5</i>
<i>RPM</i>	<i>1500</i>
<i>H.P.</i>	<i>5.2</i>

The experimental setup consists of engine, fuel vaporizer, fuel injection system, data acquisition system; and also emission measurement system. The modifications are done near the engine intake system.

The fuel vaporizer connects with engine intake system. Vaporizer consists of a main vaporizing chamber made of copper tube. Copper is selected as material of construction (MOC) due to its high thermal conductivity. External surface of the main vaporizing chamber is covered by an electric band heater (ceramic) to generate enough heat for vaporization of fuel. For the fuel supply, the fuel injection system of the HCCI engine consists of a fuel pump, fuel tank, fuel injector and an injector control circuit. Fuel pump supplies the fuel from the tank to the fuel injector. Fuel injector operates on a 12 V TTL. When the receiver receives the optical rays passing through the window of the pulley and hence gives signal to the main injector to inject fuel for the defined time in to the vaporizer surface. The angle of injection can be varied by changing the position of the pulley window by rotating it and then fixing pulley with respect to TDC.

Table-2 Technical Specification of Vaporizer

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

Table-3 Properties of Diesel [5]

Property name	Diesel Property
Density kg/m ³ (15°C)	830
kinematic Viscosity at 40 °C (m ² /s)	1.3
Flash point (Temp °C)	55
cetane number	51
Molecular weight	200
Specific gravity (kg/m ³)	0.85
Auto-ignition temperature(°C)	263

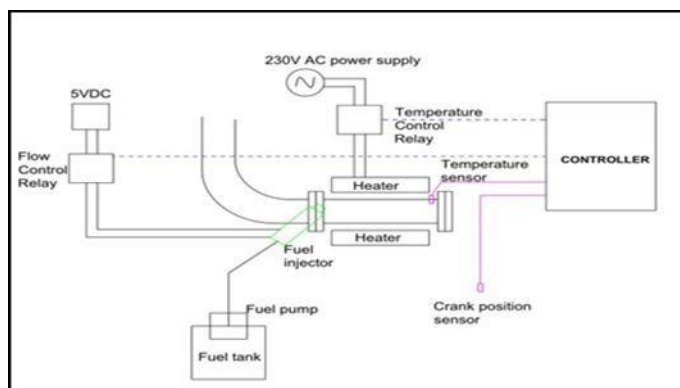
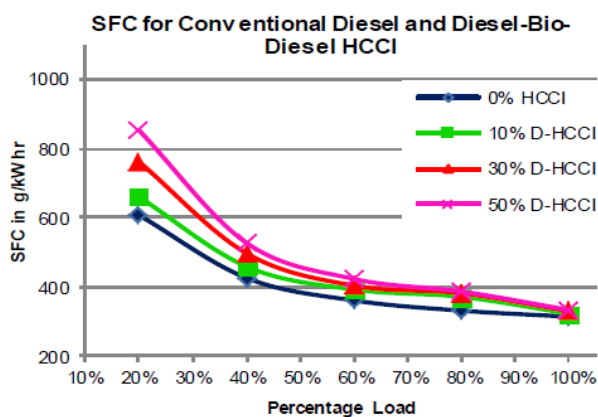


Figure 2: Schematic diagram of Fuel vaporiser.

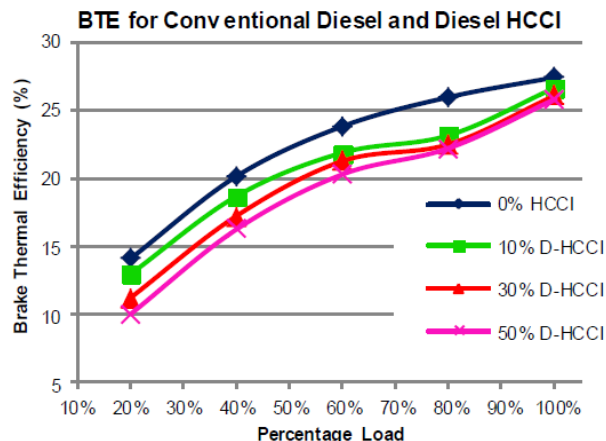
RESULTS AND DISCUSSION

Engine Performance Parameter for Conventional Diesel and Diesel HCCI

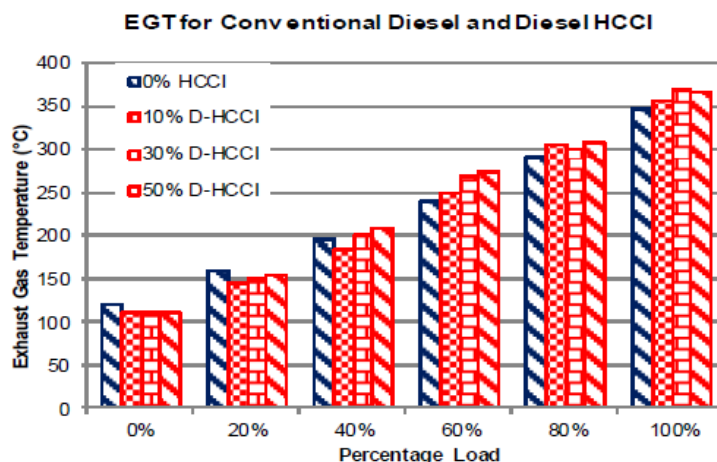
The performance is measured mainly in terms of brake specific fuel consumption and brake thermal efficiency. The other factors considered are volumetric efficiency and exhaust gas temperature. The brake specific fuel consumption decreases with increase in load but with increase in percentage HCCI, the BSFC increases for lower loads. At load near the rated load of the engine the BSFC decreases for HCCI engine and the curve tends to drop below that of the conventional diesel curve for BSFC. Hence higher Brake thermal efficiency in correspondence with this lower BSFC near rated load. When considering volumetric efficiency, a drop in it is attained with increase in percentage HCCI and this could be due to the displacement of the corresponding volume of air with that of fuel. Moreover exhaust gas temperature experience a little drop than that of conventional diesel and this shows reduction in heat losses through exhaust.



(a) Brake Specific Fuel Consumption:



(b) Brake Thermal Efficiency:

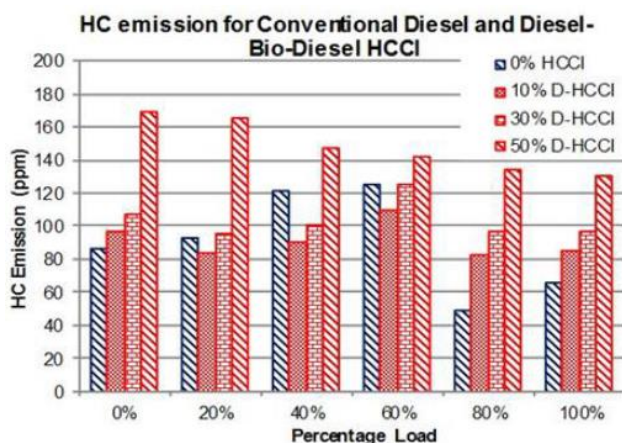


(c) Exhaust Gas Temperature:

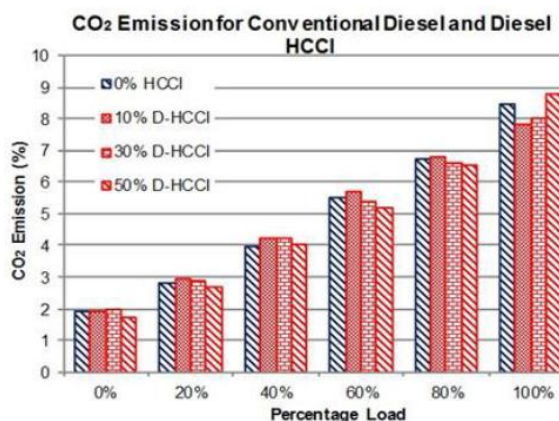
Fig. 3: HCCI engine performance fueled with diesel

Engine Emissions Parameter for Conventional Diesel and Diesel HCCI

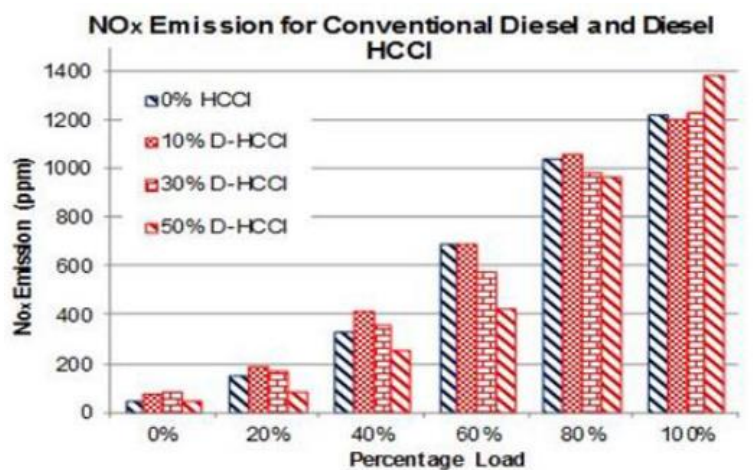
The emissions of HCCI engine are lower when considering NO_x. The NO_x emission as known, increases with load. With increase in percentage HCCI, the NO_x decreases. The emissions of NO_x are lower for HCCI engine when compared to the conventional diesel engine. HC emission for HCCI engine are higher and it further increases with increase in percentage. When CO₂ emissions are considered, the CO₂ emission is reduced than the conventional diesel for 10% HCCI and with further increase in HCCI percentage it increases. This could be a sign of incomplete combustion that could occur with HCCI increase. In HCCI engine HC and NO_x emission is increases with load in idling in comparison with diesel engine. At 10% HCCI mode of operation, HC emission is reduces in comparison with diesel engine. In general trend except full load condition NO_x emissions were reduces with increment in HCCI fraction from 0% to 50%. In HCCI combustion temperature of combustion chamber is homogeneous while in conventional diesel engine flame front region in the combustion chamber have higher temperature, creates NO_x formation zone.



(a) HC emission



(b) CO emission



(c) *NOx emission*

Fig. 4: *Emission characteristics of HCCI engine fueled with diesel*

CONCLUDING REMARKS

The graphs of performance and emissions lead to the following:

The performance of HCCI engine in terms of SFC and BTE is lesser than that of Conventional diesel for lower loads. The efficiency of HCCI engines reaches that of the conventional diesel at rated load and tends to be higher at higher load.

- NOx emission reduces with HCCI percentage increase and the least NOx emission occurs for 50% HCCI as seen from the graph.
- HC emission becomes minimum at 10% HCCI mode of operation.

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