ATTAINING HCCI IN A CI ENGINE USING FUEL VAPORIZER

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ABSTRACT

As the charge is heterogeneous in a CI engine, combustion is not complete leading to the formation of unburnt HC and NO_x **,** which also lowers its performance . HCCI is a new combustion concept involving the merits of both CI & SI engines. In the present work an attempt has been made to attain HCCI by incorporating an external fuel vaporizer. Performance tests have been conducted and the results show some good improvements.

Keywords: HCCI, NO_x, HC, Vaporizer, SI, CI

1. INTRODUCTION

In a CI engine, the charge is heterogeneous leading to non-uniform combustion and hence pollutants such as PM and NO_x are emitted in large portions. Hence a solution is required to reduce these pollutants [1]. InHCCI technology, the homogeneous mixture of fuel and air are compressed to the point of self-ignition. 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, the combustion process is similar to that of a CI engine where temperature and density of the charge raises due to compression and on reaching the self-ignition temperature the charge combusts. In HCCI engines the process of combustion is spontaneous and all the charge within the combustion chamber burns simultaneously unlike the CI engines. HCCI approach enables the engine to have a high compression ratio [2] 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% [3] .The indicated results show noticeable improvement in the charge homogeneity [4] if the external mixture preparation technique is used.

A dual engine system [5] combining conventional diesel combustion for full load conditions and HCCI combustion for medium and low loads remain a practical implementation in diesel engines

2. HCCI COMBUSTION

In HCCI, homogeneous charge is attained, which undergoes combustion, resulting in higher efficiencies and lowers the emissions. There are many approaches to attain HCCI. In this present work an external mixture formation device is used to attain charge homogeneity in a CI engine.

3. FUEL VAPORIZER

Fuel Vaporizer [6] 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.

4. EXPERIMENTAL SETUP

It consists of a fuel introduction system, fuel vaporizer and engine.

i. Gravimetric fuel introduction system

Fuel introduction system consists of an auxiliary fuel tank to store the pilot fuel, burette to determine the flow rate of pilot fuel vapors entering the air intake manifold, flow control valve to regulate the quantity of vapors entering the air intake manifold, piping arrangement that interconnects each of these components to the engine. The pilot fuel starts flowing from the auxiliary fuel tank to the engine by gravimetric flow method, via the fuel vaporizer.

ii. Fuel vaporizer

A fuel vaporizer [6] is a device consisting of heaters that are used to vaporize the diesel. The main purpose of the vaporizer is to vaporize the diesel fuel so that it mixes homogeneously with air to obtain better combustion characteristics i.e., to attain HCCI.

The fuel vaporizer comprises of a rod heater, copper coils inside which the fuel flows, two band heaters that provides additional heating to completely vaporize all

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the pilot fuel(diesel) entering the copper coils and insulators such as asbestos rope and glass wool are used to avoid heat dissipation to the surroundings.

Table-1. Fuel vaporizer specifications.

S. No.	Components used	Specifications
1	Rod heater	500W
2	Copper coils	Diameter = 3mm
3	Band heaters	250W
4	Insulating materials	Asbestos rope, glass wool

iii. Engine

The fabricated fuel vaporizer is coupled directly to the air intake manifold of the naturally aspirated conventional diesel engine.

Table-2. Engine test rig specifications.

Engine power	3.7kW
Cylinder Bore	80mm
Stroke Length	110mm
Speed	1500 RPM
Compression Ratio	16.5:1
Swept Volume	553cc
Strokes	4
Injection Pressure	175 bar

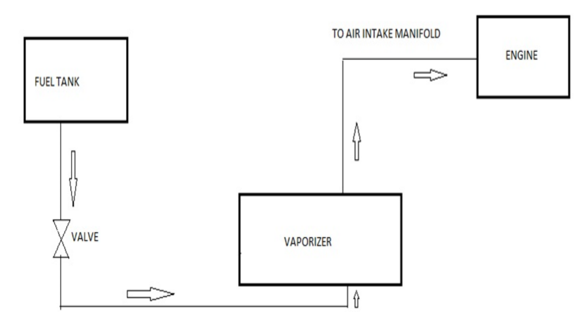

Figure-1. Block diagram of fuel vaporizer.

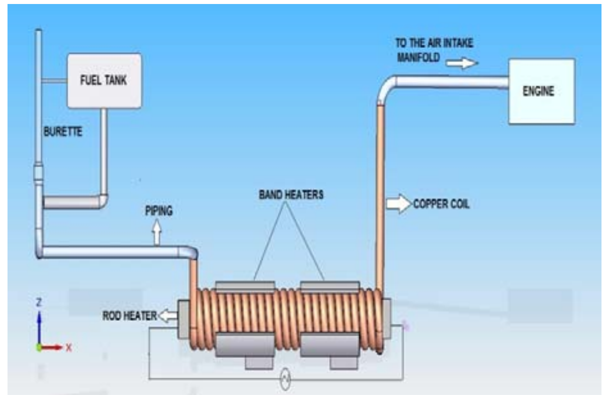

Figure-2. 3D View of fuel vaporizer.

5. 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.

6. RESULTS AND DISCUSSIONS

The engine was tested for its performance by varying the load and the results are illustrated below.

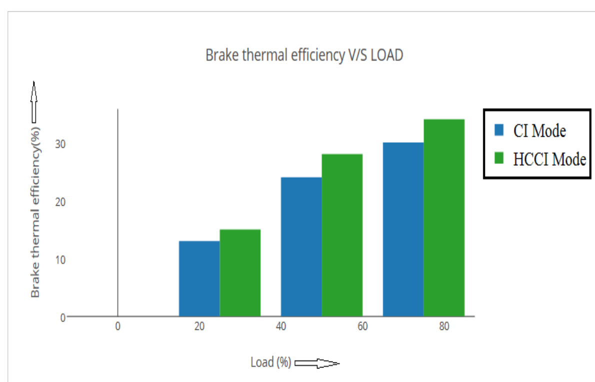

Figure-3. BTE vs load.

CI Mode: Conventional engine without fuel vaporizer
HCCI Mode: Conventional engine with fuel vaporizer
From the Figure-3, it is evident that BTE has increased considerably on coupling with the fuel vaporizer.

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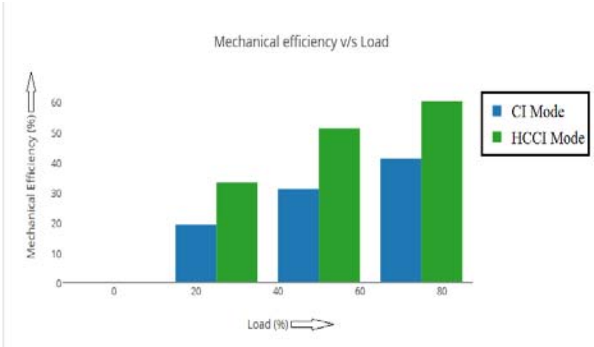

Figure-4. Mechanical efficiency vs load.

CI Mode: Conventional engine without fuel vaporizer
HCCI Mode: Conventional engine with fuel vaporizer
From Figure-4, it is evident that the mechanical efficiency increases with load on coupling the vaporizer.

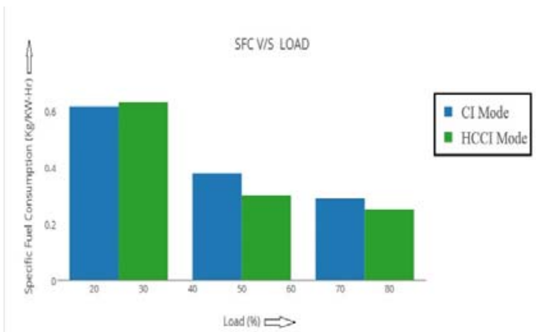

Figure-5. SFCvsload.

CI Mode: Conventional engine without fuel vaporizer
HCCI Mode: Conventional engine with fuel vaporizer
From Figure-5 it is evident that the SFC decreases on coupling with the fuel vaporizer.

7. CONCLUSIONS

In the present work, combustion characteristics of HCCI using pilot fuel (diesel) vapors were investigated for different values of engine load. By using diesel vapors the air fuel mixture obtained is homogeneous and this is the best of all methods to obtain a homogeneous mixture. However the experiment was conducted to mainly determine the performance characteristics and no effort was done to determine the concentration of pollutants in the exhaust.

On coupling the vaporizer to the conventional CI engine the following results were obtained:

a. Brake thermal efficiency has been increased by 4%.

b. Mechanical Efficiency has been increased by 18%.

c. Specific Fuel Consumption (SFC) has been reduced by 12%

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