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RESEARCH ARTICLE

# EXPERIMENTAL INVESTIGATION OF HYDROGEN FUELLED HOMOGENEOUS CHARGE COMPRESSION IGNITION(HCCI) ENGINE

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**ABSTRACT**

*D*eclining oil reserves and increased fuel prices have, together with increased awareness of the environmental impacts of burning hydrocarbon fuels, led to an interest in alternatives to fossil fuel based propulsion and power generation.One such alternative is to use hydrogen as an energy carrier [2]. As a result various alternative fuels (such as liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen, vegetable oils, bio gas, producer gas) have been considered as substitutes for hydrocarbon-based fuel and reducing exhaust emissions. Of these, hydrogen is a long-term renewable and less-polluting fuel[1].



## INTRODUCTION

Recent years, declining oil reserves and increased fuel prices have, together with increased awareness of the environmental impacts of burning hydrocarbon fuels, led to an interest in alternatives to fossil fuel based propulsion and power generation. One such alternative is to use hydrogen as an energy carrier [2]. As a result various alternative fuels (such as liquefied petroleum gas (LPG), compressed natural gas (CNG), hydrogen, vegetable oils, bio gas, producer gas) have been considered as substitutes for hydrocarbon-based fuel and reducing exhaust emissions. Of these, hydrogen is a long-term renewable and less-polluting fuel [1].

Homogeneous charge compression ignition (HCCI) combustion offers a solution to this problem .The concept of homogeneous charge compression ignition (HCCI) has been described before by a number of researchers [4]. In HCCI engines, the fuel and air are premixed to form a homogeneous mixture before the compression stroke [4]. The main objective of HCCI combustion is to reduce soot and NOX emissions while maintaining high fuel efficiency at part load conditions. In some regards, HCCI combustion combines the advantages of both spark ignition (SI) engines and compression ignition (CI) engines [4]. One of the benefits of the HCCI mode is the elimination of fuel rich and high temperature zones in the cylinder, which are responsible for formation of exhaust emissions, in particular nitrogen oxides and particulates [2].

## Experimental SET UP

### *Working Principle*

Homogenous charge(mixture of air & fuel) should be mixed before combustion and compress to high enough temperature to achieve spontaneous ignition of the charge. Thus HCCI is similar to SI in the sense that both processes use premixed charge and that of CI as both rely on autoignition for combustion initiation.A mixture of fuel and air will ignite when the concentration and temperature of reactants is sufficiently high.

Once ignited, combustion occurs very quickly. When auto-ignition occurs too early or with too much chemical energy, combustion is too fast and high in-cylinder pressures can destroy an engine. For this reason, HCCI is typically operated at lean overall fuel mixtures. Intake: At first the charge is sent through the inlet manifold .The fuel easily injects into the cylinder since there is a vacuum inside the cylinder. The pressure in the cylinder is same as that of the pressure associated with the charge.

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***Compression:*** The charge inside the cylinder is compressed by the piston until the pressure and temperature rises to the peak values. The charge is divided into well-defined specks which are distributed throughout the volume of the combustion chamber. Then the charge will attain its auto-ignition points.
Combustion: When the charge attains its auto-ignition temperature the entire mass in the cylinder will burn at once. Hence it avoids burn duration and flame propagation. Unlike in SI engine there won't be stages of combustion.

**Figure 1** Photograph of the experimental setup.

**Hydrogen Fuelled Hcci Engine Experimental Results**

The hydrogen fuelled HCCI engine can operate smoothly, a series of test were carried out with varying fuel-air ratio. Figure 2 illustrates the brake thermal efficiency as aFigure functionof the excess air ratio, *l*. It can be seen that the engine is able to operate with extremely lean cylinder charges and still maintain a relatively high

Thermal efficiency when compared to conventional diesel engine operation.

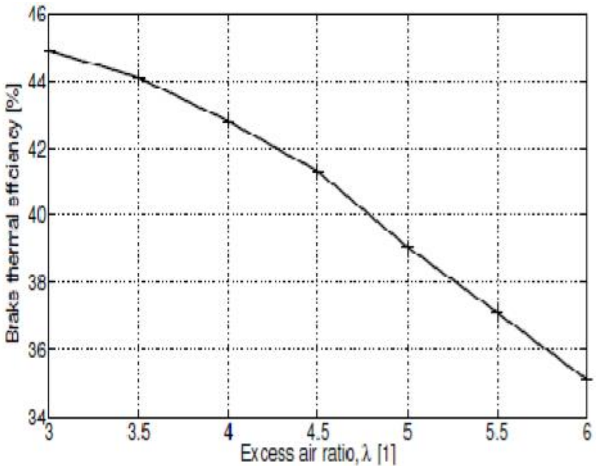


**Figure 1**Engine brake thermal efficiency

**Engine Emission**

The main source of nitrogen oxides (NO*x*) emissions in internal combustion engines is the oxidation of atmospheric nitrogen.The formation and destruction of NO*x* in the combustion chamber is kinetically controlled, and as the temperature is rapidly reduced during the expansion stroke, the NO*x* formed during the high-temperature parts of the cycle tend to 'freeze' at a level higher than the equilibrium level for the exhaust gases.

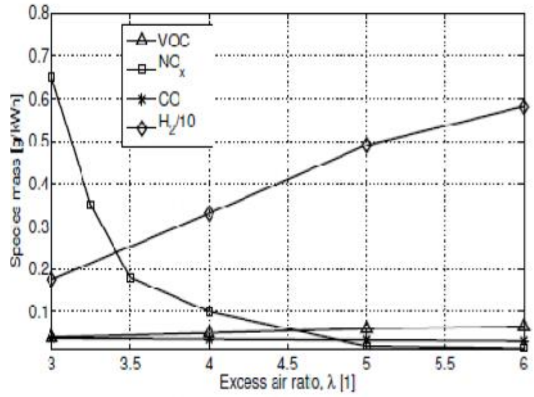


**Figure 2** H2 HCCI engine exhaust gas emissions levels.

HCCI engines have shown significant reductions in NO*x* emissions, due to lower peak gas temperatures.(High-temperature zones within the cylinder, such as the burning fuel spray in diesel engines, are eliminated) Operation on high excess air ratios further reduces temperature levels and consequently NO*x* emissions.

**Table 1** Comparision of exhaust emission for Hydrogen fuel HCCI Engine.

| | **H2 HCCI engine mode** | **DI diesel engine mode** |
|---|---|---|
| NO*x* | 0.012 g/kWh | 6.330 g/kWh |
| CO | 0.000 g/kWh | 2.05 g/kWh |
| Particulate matter | 0.000 g/kWh | 0.35 g/kWh |
| VOC | 0.025 g/kWh | 0.55 g/kWh |

## CONCLUSION

1. Homogeneous Charge Compression Ignition (HCCI) process is the hybrid of Spark and Compression Ignition processes and superior to both.
2. It increases the fuel efficiency by 15 to 30% thereby saving the petroleum resources.
3. It can be applied for both 4-stroke and 2-stroke engine
4. It reduces NOx emissions by 90%.
5. No Detonation or Knocking.
6. Very lean mixtures can be used(f~0.3).

**Future Scope**

1. Turbo charging initially proposed to increase power.
2. EGR (Exhaust Gas Re-circulation) can be adopted for higher efficiencies and lower HC and CO emissions.
3. The exhaust has dual effects on HCCI combustion.

- It dilutes the fresh charge, delaying ignition and reducing the chemical energy and engine work.

- Reduce the CO and HC emissions.

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