e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 7, Issue 3, March 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.521

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703040 |

Study and Performance Analysis of High Speed HCCI Engine

Gajanand Choubey[1], Prof. Mahendra Prajapati[2]

M. Tech Scholar, Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal, India[1]

Assistant Professor, Department of Mechanical Engineering, Millennium Institute of Technology, Bhopal, India[2]

ABSTRACT: This study delves into the performance analysis of Homogeneous Charge Compression Ignition (HCCI) engines, which represent a promising technology in the pursuit of high-efficiency, low-emission internal combustion engines. The HCCI engine combines features from both conventional spark ignition and compression ignition engines, aiming to achieve the best of both realms: high fuel efficiency and low nitrogen oxides (NOx) and particulate matter emissions. Through a comprehensive review and experimental setup, this research evaluates the operational parameters influencing the HCCI combustion process, including temperature, air-fuel mixture homogeneity, and ignition timing.

KEYWORDS: HCCI, Combustion Engine, SI, CI, Spark.

I. INTRODUCTION

The quest for high-efficiency engines that comply with stringent emission regulations has given rise to significant advancements in internal combustion engine technology. Among these, Homogeneous Charge Compression Ignition (HCCI) engines have emerged as a viable alternative to traditional gasoline and diesel engines. HCCI engines operate on the principle of inducing the combustion of a premixed air-fuel mixture using the heat of compression, thereby eliminating the necessity for a spark or direct injection of fuel into the combustion chamber.

The autoignition characteristic of the HCCI process promises a more efficient combustion cycle and a significant reduction in NOx and particulate emissions, owing to lower combustion temperatures and the absence of fuel-rich zones within the cylinder. Additionally, the ability to operate on a variety of fuels, including alternative and renewable fuels, further enhances the appeal of HCCI engines as a solution to environmental and energy security concerns.

However, realizing the full potential of HCCI technology is not without challenges. Controlling the ignition timing and combustion speed to adapt to changing engine speeds and loads is a complex task. Unlike conventional engines, HCCI engines do not have direct control over the start of combustion through spark timing or fuel injection. This poses a difficulty in maintaining stable operation across the wide range of conditions encountered in automotive applications.

The present study aims to perform a systematic performance analysis of HCCI engines, with a focus on understanding and optimizing the parameters that influence high-speed operation. Through a combination of theoretical analysis, numerical simulations, and empirical testing, the study examines the interplay between combustion kinetics and engine dynamics. Particular attention is given to the development of control strategies that enable the extension of the operational range of HCCI engines while sustaining their inherent advantages.

In exploring the limitations and prospects of HCCI technology, this research contributes to the ongoing development of engine systems that could play a pivotal role in the transition towards more sustainable and efficient transportation. The implications of the study are far-reaching, with the potential to influence the design and optimization of future engines that not only meet but exceed current performance and emission standards.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703040 |

II. METHODOLOGY

HCCI engine is highly efficient and it also produces low NOx emission. It is difficult to operate these engines at high load and high speed. So for fundamental understanding of HCCI engine at high speed and high load experimental studies are required to be conducted.

In present work experimental studies are carried out to determine the following aspects:-

- Variation of pressure with the crank angle rotation.
- Variation of temperature with the crank angle rotation.
- Variation of HRR with the crank angle rotation.
- Variation of ISFC with load.

The experimental setup is shown in figure 1and 2.

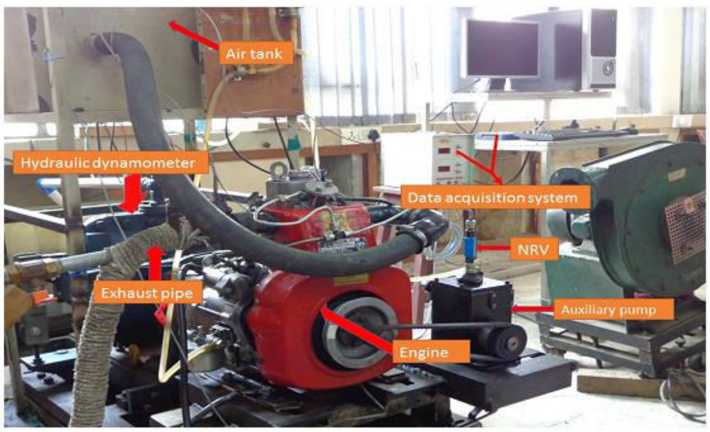

Figure 1: Experimental test rig

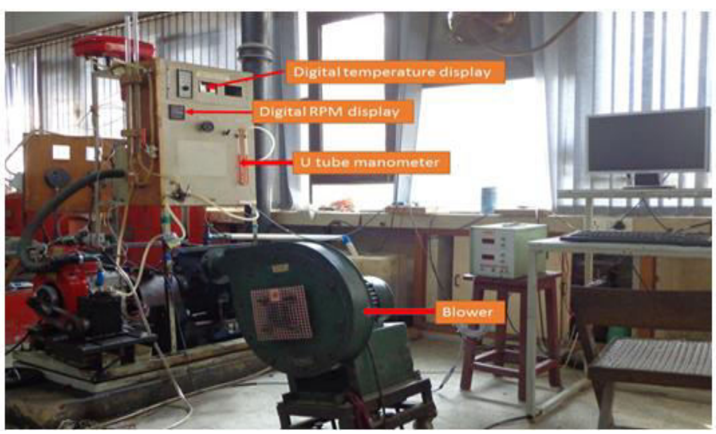

Figure 2: Experimental test rig

Pressure measurement: In an HCCI engine laboratory experiment, pressure measurement and calibration are crucial for understanding combustion characteristics, optimizing engine performance, and validating computational models. Here's a step-by-step guide to pressure measurement and calibration in an HCCI engine lab experiment:

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703040 |

Selecting Pressure Transducers:

Choose pressure transducers suitable for measuring the cylinder pressure during HCCI combustion. These transducers should have high accuracy, fast response times, and the ability to withstand high temperatures and pressures typical in HCCI engines.
Common types include piezoelectric pressure transducers, which offer fast response times and high sensitivity, and strain gauge pressure transducers, which are robust and suitable for long-term measurements.

Mounting Pressure Transducers:

Install pressure transducers in the combustion chamber of the HCCI engine. Ensure proper sealing and positioning to minimize signal distortion and protect the transducers from heat and mechanical stress.
Use specialized mounting hardware and adapters designed for high-pressure applications to secure the transducers to the engine cylinder head or spark plug ports.

Flow measurement

In a laboratory experiment focused on measuring fuel consumption in an HCCI engine, accurate flow measurement and calibration are essential for assessing engine efficiency, optimizing combustion strategies, and validating computational models.

Speed measurement

For measuring the speed of the engine RPM sensor was installed.

Load measurement
In a laboratory experiment involving an HCCI engine, load measurement and calibration using a hydraulic dynamometer are crucial for assessing engine performance, characterizing power output, and validating computational models.

III. CHALLENGES

The deployment of High-Speed Homogeneous Charge Compression Ignition (HCCI) engines in practical applications presents several challenges:

1. **Control of Ignition Timing and Combustion Phasing**: Unlike traditional engines, HCCI engines lack direct control mechanisms such as spark plugs or fuel injectors, making precise control of ignition timing challenging. Achieving consistent ignition timing across various operating conditions remains a significant hurdle.

2. **Limited Operational Range**: HCCI engines tend to operate efficiently within a narrow range of load and speed. Extending this range while maintaining the benefits of HCCI combustion, such as low emissions and high efficiency, is complex and requires advanced control strategies.

3. **Cold Start and Transient Operation**: Starting an HCCI engine at low temperatures and managing transient operations, such as rapid accelerations or decelerations, are problematic due to the precise temperature and mixture homogeneity requirements for auto-ignition.

4. **Combustion Stability**: Ensuring stable combustion at high speeds and preventing misfire or knock requires careful balancing of the air-fuel mixture and control over the in-cylinder conditions.

5. **Complexity of Control Systems**: The development of sophisticated control systems that can adjust operating conditions in real-time to manage the auto-ignition process adds complexity and potential cost to HCCI engine systems.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| Monthly Peer Reviewed & Referred Journal |

| Volume 7, Issue 3, March 2024 |

| DOI:10.15680/IJMRSET.2024.0703040 |

6. **Fuel Adaptability**: While HCCI technology shows promise with a variety of fuels, achieving optimal performance with different fuel types can introduce further control challenges.

7. **Emission Control**: Although HCCI engines produce lower NOx and particulate emissions, they can exhibit higher levels of carbon monoxide (CO) and unburned hydrocarbons (HC), which may necessitate additional after-treatment systems.

IV. CONCLUSION

This study provides a comprehensive analysis of the performance challenges associated with High-Speed HCCI engines. Despite the potential of HCCI technology to revolutionize internal combustion engines with its high efficiency and low emissions, significant challenges impede its widespread adoption. Addressing the intricate control of ignition and expansion of the operational envelope are the most pressing issues that need resolution for HCCI engines to become viable in the market. Innovative control strategies and advances in sensor and actuator technologies hold the key to unlocking the full potential of HCCI engines.

REFERENCES

1. Celebi, Can, Ahmet, Serdar, Alper, Experimental study on operating range, combustion , performance and emissions of an HCCI engine fuelled with Naptha, Fuel 283 (2021) 118828
2. Kannan S, Mahalingam S, Srinath S, Sivasankaran M, Experimental study in HCCI combustion of LPG in diesel engine, Material Today Proceedings 37 (2021) 3625-3629
3. Feroskhan M, Venugopal T, Balaji S, Sankarlingam RK, Experimental study on operating parameters on the performance, emission and combustion indices of biogas fuelled HCCI engine, Fuel 298 (2021) 120799
4. Ayat G, experimental study on load limits of an HCCI engine fuelled with natural gas, ethanol, and methanol Fuel 239 (2019) 1001-1014
5. Wang Z, Du Guizhi, Li Z experimental study on the combustion characteristics of a high compression ratio HCCI engine fuelled with natural gas Fuel 255 (2019) 115701
6. Hasan M.M, Rahman M.M, Kadirgama K, Ramasamy D conducted numerical study of engine parameters on combustion and performance characteristics in n-heptane fueled HCCI engine Applied Thermal Engineering 128 (2018) 1464–1425
7. Seyfi Polat, Experimental study on combustion, engine performance and exhaust emissions in a HCCI engine fuelled with diethyl ether –ethanol fuel blends Fuel Processing Technology 143 (2016) 140–150.

INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor
7.521

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

निस्केयर
NISCAIR

INTERNATIONAL JOURNAL OF
MULTIDISCIPLINARY RESEARCH
IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com