Industry Day Theme # 1: Clean Energy for Sustainable Economy and Environment

IIT DELHI INDUSTRY DAY 2019

Control of Backfire and NOx emission in a Hydrogen Fuelled Spark Ignition Engine

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Abstract

The study is aimed to control backfire, which is an abnormal combustion phenomenon, in a hydrogen fuelled spark ignition engine. It is important to eliminate backfire as it can damage an engine's intake system and hydrogen fuel supply system (possibility of explosion), and stall engine's operation. Our research work indicates that backfire and NOx emission in a hydrogen fuelled spark ignition engine can be simultaneously controlled using cooled EGR (exhaust gas recirculation), and water injection in the intake manifold of the engine. This study would be helpful to develop a dedicated hydrogen fuelled spark ignition engine with more safety (engine damage and fuel explosion).

Introduction

Hydrogen - Most promising alternative fuel for spark ignition engines
- Zero carbon based emissions (CO, CO_2, HC)
- High energy efficiency

Challenges - Backfire
- High NOx emission
- Power drop

Solutions - Delayed H_2 injection, Cooled EGR, water injection

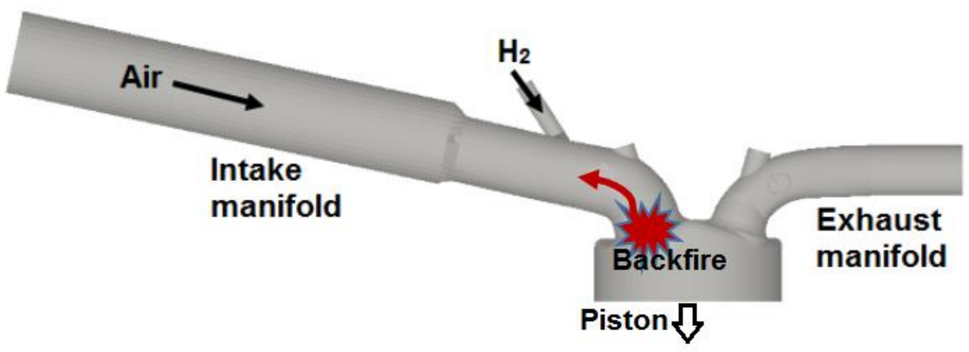

Fig. 1 Illustration of backfire phenomenon

Materials and Methods

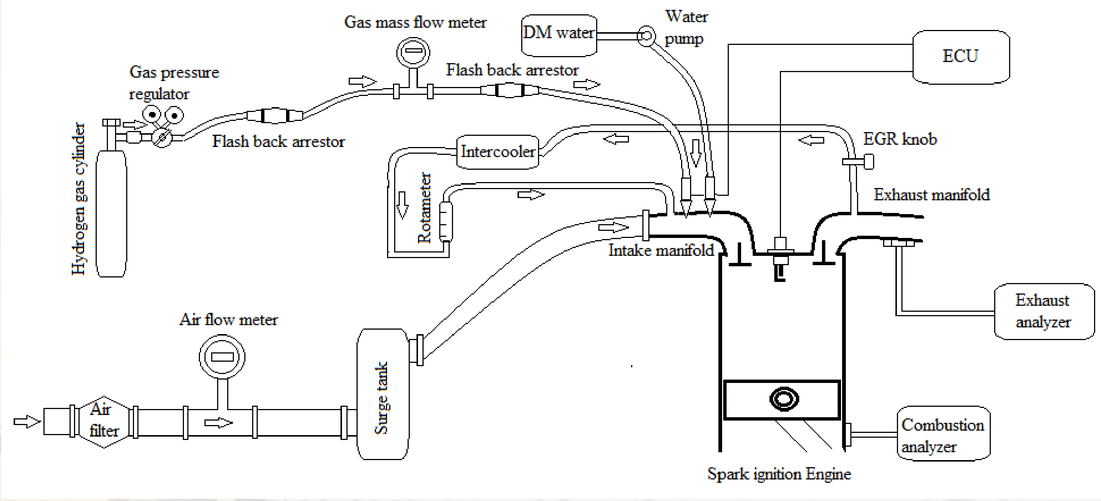

Fig. 2 Schematic diagram of experimental setup

Conclusions

- Backfire can be controlled by delaying the hydrogen injection, cooled EGR and water injection in the intake manifold of the engine
- Water injection is the most effective method to control backfire along with NOx emission reduction without compromising the performance of the engine.
- Backfire-free engine operation with ultra low (near zero) NOx emission was achieved with water injection.

Industrial Significance

- This research work provides a methodology for development of a dedicated hydrogen fuelled spark ignition engine with better safety.
- The safe or backfire free operation of the hydrogen fuelled spark ignition engine can be achieved by optimizing the design and operating parameters of the engine. This work would be a reference source to industry for eliminating backfire.

Technology Readiness Level

The backfire control technology has been developed and ready for implementation.

Results

Visualization of backfire occurrence and its propagation using CFD

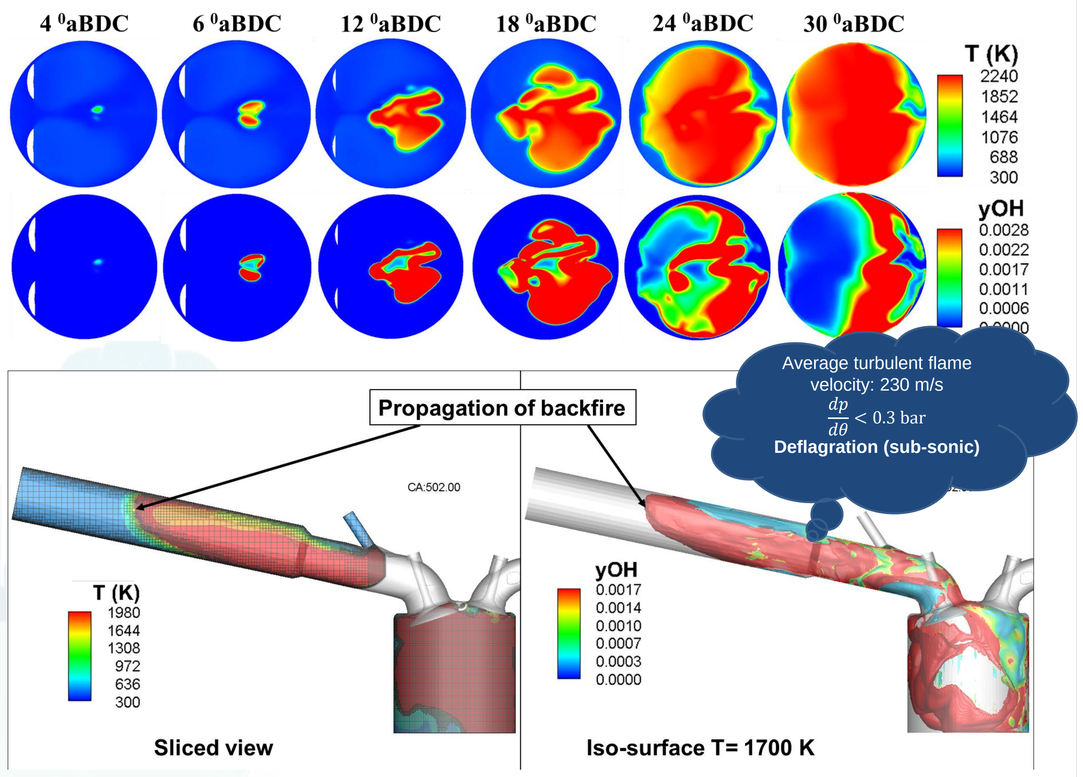

Fig. 3 Backfire occurrence and its propagation in intake manifold of the engine

Control of backfire using cooled EGR, water injection and delayed hydrogen injection

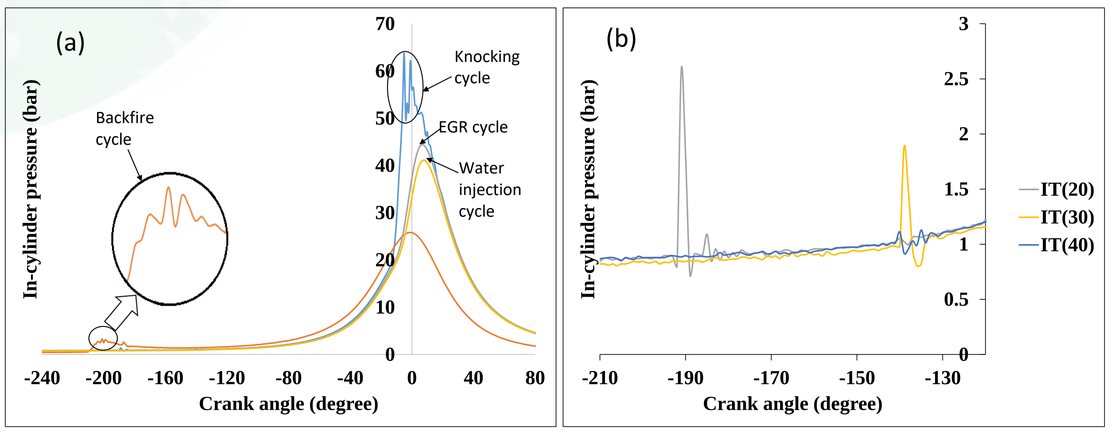

Fig. 4 Elimination of backfire using (a) cooled EGR and water injection (b) delaying hydrogen injection timing (IT)

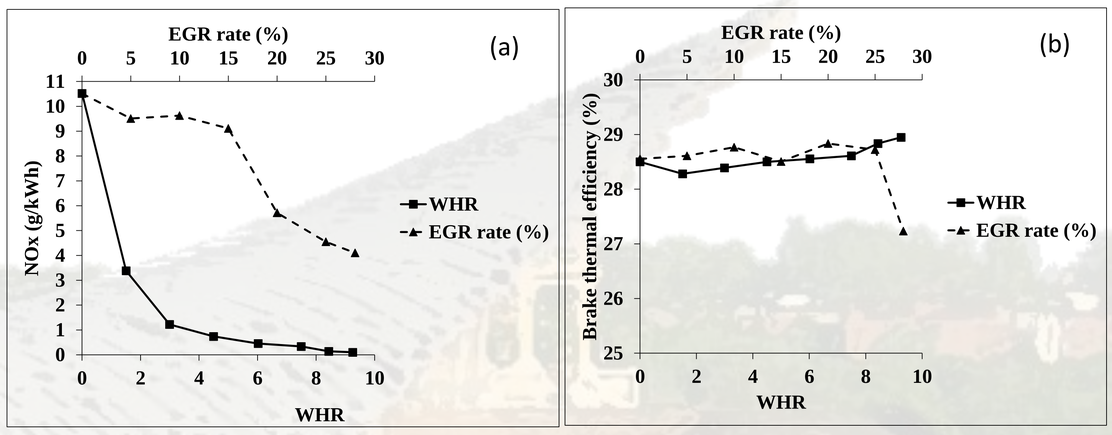

Fig. 5 Variation of (a) NOx emission (b) brake thermal efficiency with cooled EGR and water to hydrogen ratios (WHR)

References

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