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Title: Development of both Active and Passive Pre-Chamber Jet Ignition Multi-cylinder Demonstrator Engines

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Abstract

Driven by legislation and increasing societal awareness, the transportation sector has been seeking to increase fuel efficiency in order to reduce greenhouse gas emissions. In spark ignited engines, the efficiency of the engine is strongly influenced by the quality and duration of the combustion process as initiated by the ignition system. Jet Ignition is a concept, initiated by pilot combustion in a pre-chamber connected to the main cylinder, where pilot combustion products are introduced as reactive high velocity jets. These jets initiate auto-ignition of the main fuel-air mixture, resulting in multiple distributed points of ignition.

In passive jet ignition systems, this distribution leads to a significant reduction in the duration of the main chamber combustion event. In active jet ignition systems which contain auxiliary fuelling in the pre-chamber, the increased ignition energy results in the ability to operate the engine with excess air dilution beyond the capabilities of typical ignition systems.

Research detailing the operating principles of the jet ignition system is presented through the use initially of optical and single cylinder research engine platforms followed by multi-cylinder applications. Passive jet ignition results from a multi-cylinder engine are presented which demonstrate the knock reduction potential of such a system combined with exhaust gas recirculation (EGR) to provide increased efficiency. The enleanment capability of the active jet ignition system is also demonstrated through the analysis of results from several multi-cylinder engines, resulting in substantial increases in thermal efficiency.

The research presented addresses some of the key challenges historically associated with pre-chambers including idle and catalyst light-off, and optimization of the jet igniter geometry for full engine map operation. The roadmap of future development topics that need to be addressed in order to bring the technology to production readiness will also be presented.