2010-32-0088

Ignition Energy Development for a Spark Initiated Combustion System Capable of High Load, High Efficiency and Near Zero NOx Emissions

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ABSTRACT

Turbulent Jet Ignition is an advanced pre-chamber initiated combustion system for an otherwise standard spark ignition engine found in current on-road vehicles. This type of ignition enables very fast burn rates due to the ignition system producing multiple, widely distributed ignition sites, which consume the main charge rapidly. This high energy ignition system results from the partially combusted (reacting) pre-chamber products initiating main chamber combustion. The fast burn rates allow for increased levels of dilution (lean burn and/or EGR) when compared to conventional spark ignition combustion, with dilution levels being comparable to other low temperature combustion technologies (HCCI) without the complex control drawbacks.

Previous Turbulent Jet Ignition experimental results have highlighted peak net indicated thermal efficiency values of 42% in a standard modern engine platform. Additionally, the pre-chamber combustion system is capable of tolerating up to 54% mass fraction diluent at the world wide mapping point of 1500 rev/min, 3.3 bar IMEPn (□2.62 bar BMEP), resulting in an 18% improvement in fuel economy and near zero engine out NOx emissions.

This paper focuses on single cylinder experiments, which reduced the ignition energy of the spark initiated pre-chamber combustion system from 75 to less than 5 mJ. Experimental results highlight that the pre-chamber combustion system is quite robust and largely unaffected by ignition energy changes, unlike conventional spark ignition combustion, which typically requires high amounts of energy (over 50 mJ) under diluted (lean burn/EGR) operation. This occurs as jet ignition combustion in the heavily diluted main chamber is driven by the chemical, thermal and turbulent effects of the propagating jet exiting the pre-chamber and not the flame kernel growth and subsequent travelling flame front as in spark ignition combustion. Consequently, results show the potential to significantly reduce the ignition energy demand and hence ignition coil and spark plug size for the Turbulent Jet Ignition combustion system. This has additional benefits in improving component longevity, reducing ignition system costs and aiding in cylinder head packaging.