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A Single Fuel Pre-Chamber Jet Ignition Powertrain Achieving High Load, High Efficiency and Near Zero NO_x Emissions

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ABSTRACT

Turbulent Jet Ignition is an advanced spark initiated pre-chamber combustion system for otherwise standard spark ignition engines found in current passenger vehicles. This next generation pre-chamber design simply replaces the spark plug in a conventional spark ignition engine. Turbulent Jet 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 results from the partially combusted (reacting) pre-chamber products initiating combustion in the main chamber. The distributed ignition sites enable relatively small flame travel distances enabling short combustion durations and high burn rates. Multiple benefits include extending the knock limit and initiating combustion in very dilute mixtures (excess air and/or EGR), 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 contemporary PFI engine platform. Additionally, the pre-chamber combustion system is capable of tolerating over 50% mass fraction diluent (combination of excess air and EGR) at part load, resulting in near zero engine out NO_x emissions. This equates to a greater than 20% peak fuel economy improvement when compared to stoichiometric spark ignition in the same contemporary PFI engine platform. Although previous published results of this combustion system are very promising, the main hurdle of this system has been the dual fuel system, with liquid gasoline used in the main combustion chamber and small fractions of gaseous propane in the pre-chamber. The purpose of this paper is to demonstrate that this combustion system can operate on a single fuel, either gaseous propane or liquid gasoline, thus making the combustion system more practical for production applications.