2012-01-1146

A Lean Burn Gasoline Fueled Pre-Chamber Jet Ignition Combustion System Achieving High Efficiency and Low NO_x at Part Load

William P. Attard, Hugh Blaxill
MAHLE Powertrain LLC

ABSTRACT

Turbulent Jet Ignition is an advanced spark initiated pre-chamber combustion system for otherwise standard spark ignition engines. Combustion in the main chamber is initiated by jets of partially combusted (reacting) pre-chamber products which provide a high energy ignition source. The resultant widely distributed ignition sites allow relatively small flame travel distances enabling short combustion durations and high burn rates. Demonstrated benefits include ultra lean operation (λ>2) at part load and high load knock limit extension.

Previous jet ignition experimental results have highlighted high thermal efficiencies, high load capability and near zero engine out NO_x emissions in a standard contemporary engine platform. Although previous results of this system have been very promising, the main hurdle has been the need for a dual fuel system, with liquid gasoline used in the main combustion chamber and small fractions of gaseous propane in the pre-chamber. Initial attempts in replacing the pre-chamber gaseous propane with liquid gasoline were problematic, although engine operation was successful at some operating conditions. The poor mixture preparation with liquid gasoline inside the small pre-chamber cavity due to the limited production injector hardware somewhat compromised the thermal efficiency, resulting in slight elevations in NO_x emissions. Since specialized pre-chamber injector hardware was not available for evaluation, the purpose of this paper is to demonstrate that this combustion system can operate robustly using gasoline, with vaporized gasoline found to be a successful pre-chamber fuel substitute. With this concept at part load, the test engine recorded a 41.4% peak thermal efficiency, ultra lean operation past lambda 2.1, single digit engine out NO_x emissions and a 20% peak fuel economy improvement over the baseline spark ignition system.