Ionization Signal Response during Combustion Knock and Comparison to Cylinder Pressure for SI Engines

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Abstract

In-cylinder ion sensing is a subject of interest due to its application in spark-ignited (SI) engines for feedback control and diagnostics including: combustion knock detection, rate and phasing of combustion, and mis-fire On Board Diagnostics (OBD). Further advancement and application is likely to continue as the result of the availability of ignition coils with integrated ion sensing circuitry making ion sensing more versatile and cost effective.

In SI engines, combustion knock is controlled through closed loop feedback from sensor metrics to maintain knock near the borderline, below engine damage and NVH thresholds. Combustion knock is one of the critical applications for ion sensing in SI engines and improvement in knock detection offers the potential for increased thermal efficiency.

This work analyzes and characterizes the ionization signal in reference to the cylinder pressure signal under knocking and non-knocking conditions. Combustion data including cylinder pressure and ionization signals from a 2.0L I4 and a 5.4L V8 engine are collected at varying operating conditions. The ion and pressure signals are characterized and compared through the use of frequency analysis, correlation, and coherence. The results show that the correlation and coherence are low as a result of both the ion and pressure signals being point measurements and the stochastic aspects of combustion knock and characteristics of the in-cylinder pressure waves.
Using additional statistical analysis however, the results show a high correlation of knock levels between the ion and cylinder pressure measurements.