Virtual Sensing of Combustion Quality in SI Engines using the Ion Current

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Abstract

Several virtual sensors for combustion quality in spark ignited internal combustion engines are proposed. The virtual sensors estimate combustion quality based on the ion current signal measured in the center of the combustion chamber. Important properties of these sensors are their cost effective implementation and real-time operation.

A combustion variability virtual sensor for exhaust gas recycling is proposed. It estimates the coefficient of variation of indicated mean effective pressure by using the ion current integral while the combustion process is diluted with excess air or exhaust gases. With this it is possible to control, in a feedback loop, the amount of residual gases without experiencing driveability problems, producing large amounts of hydro carbons or stalling the engine.

Further, a virtual sensor is proposed for estimating the location of peak pressure to a precision of 2° even under disturbances of additives or high air humidity. The estimates, made on-line while driving an experimental vehicle on the highway, were used for feedback control of the spark advance.

Finally, an air-fuel ratio virtual sensor is proposed that estimates the air-fuel ratio within 1.2% from the ion current. A second methodology is also proposed that keeps the air-fuel ratio in a multi-cylinder engine in balance, such that a typical imbalance of around 5-7% between the cylinders' air-fuel ratio is reduced.

Keywords: Internal Combustion Engines, Spark Ignition, Estimation, Control, Neural Networks, Ion Current