BACKGROUND OF THE INVENTION

An internal combustion engine operating under various conditions can experience a build-up of combustion chamber deposits ('CCD'), which comprise a deposition of products of the combustion process onto surfaces of the combustion chamber. The deposits are typically derived from fuels and fuel additives, lubricating oils and oil additives, and other elements, as is known.

As deposits adhere to surfaces of the combustion chamber, thermal characteristics of the engine change. This is primarily due to the combustion chamber deposits acting as an insulating layer on the combustion chamber surfaces, which affects combustion. The result of the formation of the insulating layer includes a decrease in maximum and average heat flux away from the combustion chamber, a decrease in heat transfer to engine coolant, and a decrease in engine breathability, i.e. air flow, leading to a reduced volumetric efficiency. Furthermore, the resultant effects include reduced engine power, a potential for increase in NOx emissions, and an increased likelihood of pre-ignition, or knock. There may be a benefit of improved fuel economy and reduced CO_2 emissions.

It is known that to improve thermal efficiency of gasoline internal combustion engines, dilute combustion—using either air or re-circulated exhaust gas—gives enhanced thermal efficiency and low NOx emissions. However, there is a limit at which an engine can be operated with a diluted mixture because of misfire and combustion instability as a result of a slow burn. Known methods to extend the dilution limit include operating the engine under controlled auto-ignition combustion.

One engine system being developed for controlled auto-ignition combustion operation comprises an internal combustion engine designed to operate under an Otto cycle. The engine is preferably equipped with direct in-cylinder fuel-injection and a spark ignition system to supplement the auto-ignition process under limited operating conditions. Such engines are referred to as Homogeneous Charge Compression Ignition, or HCCI engines.

In the HCCI engine, a charge mixture of combusted gases, air, and fuel is created in a combustion chamber, and auto-ignition is initiated simultaneously from many ignition sites within the charge mixture during a compression stroke, resulting in stable power output and high thermal efficiency. Since combustion is highly diluted and uniformly distributed throughout the charge mixture, the burnt gas temperature and hence NOx emissions are typically substantially lower than NOx emissions of a traditional spark ignition engine, and of a traditional diesel engine.

A typical HCCI engine is distinguishable from a spark-ignition engine in that ignition of the charge mixture is caused by compression of the charge mixture. A typical HCCI engine is distinguishable from a compression-ignition engine in that the compression-ignition engine initiates ignition of the combustion charge by injection of fuel, whereas the fuel charge for the typical HCCI engine is preferably injected into the combustion chamber at a time prior to start of ignition of the charge mixture.

Due to different operating characteristics, when combustion chamber deposits are formed on surfaces of a combustion chamber for the typical HCCI engine, there is a resultant change in timing of auto-ignition of the charge mixture and a change in rate of heat release during charge ignition, leading to varying combustion performance over time.

It is advantageous to have a device and apparatus that provides a parametric measure of combustion chamber deposits for use in a control system for an internal combustion engine, including one intended to operate using a controlled auto-ignition process. By way of example, one such engine control system is described in commonly assigned U.S. patent application Ser. No. 11/398,776, now U.S. Pat. No. 7,246,597, entitled METHOD AND APPARATUS TO OPERATE A HOMOGENEOUS CHARGE COMPRESSION-IGNITION ENGINE, which describes control aspects of engine operation to accommodate changes in thermal characteristics of the combustion chamber due to combustion chamber deposits.

Therefore, there is a need for a practical way to determine a parametric value for combustion chamber deposits, which can be used as a control input for an engine control system which can account for observed changes in combustion phasing and bum rate. Combustion deposits are known to influence effective instantaneous thermal properties on the surface of combustion chamber walls.