Homogeneous Charge Compression Ignition via Exhaust Reinduction Using Variable Valve Actuation

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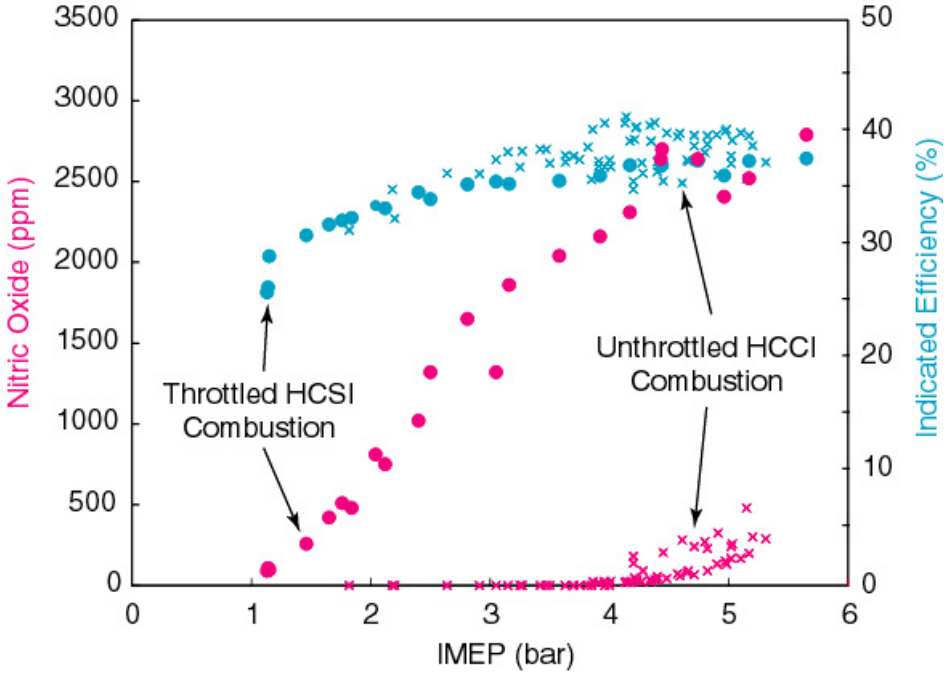
Description: Homogeneous Charge Compression Ignition (HCCI) is an alternative method of conducting the combustion process in piston engines. It is achieved by generating a high sensible energy mixture which is capable of autoigniting homogeneously upon compression. The unique aspect of our work on HCCI is that it is achieved by using fully flexible (computer controlled) valving to reinduct the exhaust from the previous cycle in order to obtain the high sensible energy mixture. Accomplished in this way, HCCI based on reinduction can be accomplished at a sufficiently low compression ratio that it can be incorporated with conventional spark ignition (SI) engine operation in a multi-combustion-mode, gasoline fueled engine. By allowing the control system to choose the optimum mode for combustion, a vehicle which meets consumer demands for both power and efficiency can be developed.



A key feature of HCCI combustion is that it produces very low NO emissions. This is due to the fact that, although the sensible energy of the mixture is high (due to use of the hot exhaust gas), the chemical energy of the charge is relatively low (due to the dilution effect). The result is that although HCCI starts from a higher temperature than SI combustion, its peak temperature is actually lower, dramatically reducing NO. In fact, as shown by the figure, NO values in the

single-digit range (less than 10 ppm) can be obtained using HCCI. This is sufficiently low to meet SULEV emissions standards without the use of NO aftertreatment.

An additional benefit of achieving HCCI using variable valve actuation is that the engine can be operated without throttling. As such, pumping losses—normally a serious loss a light load in SI engines—can be essentially eliminated.

Status: This work is continuing under a DOE university consortium for HCCI. Current efforts are focused on expanding the dynamic range of HCCI, reducing the peak pressure and rate or pressure rise during combustion, and defining approaches to control of HCCI. These are key requirements for developing a quiet, wide dynamic range, multi-combustion mode engine.

Publications:

N. B. Kaahaaina, A. J. Simon, P. A. Caton, and C. F. Edwards, "Use of Dynamic Valving to Achieve Residual-Affected Combustion," SAE Technical Paper 2001-01-0549, in press for the SAE Journal of Engines, 2002.

Caton, P. A., Simon, A. J., Gerdes, J. C., Edwards, C. F., “Residual-Effected Homogeneous Charge Compression Ignition at Low Compression Ratio Using Exhaust Reinduction,” in press International Journal of Engine Research, 2002.

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