MIXED-MODE DIESEL HOMOGENEOUS CHARGE COMPRESSION IGNITION WITH EXTERNAL MIXTURE FORMATION

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ABSTRACT

Diesel homogenous charge direct injection (HCCI) is a combustion technology showing great promise for the reduction of oxides of nitrogen and particulate matter from diesel engines. Our implementation is a mixed-mode concept, which relies on the use of an essentially unmodified common-rail compression ignition direct injection (CIDI) engine, coupled with a highly effective atomizer for external mixture formation. With this concept, the engine can operate in HCCI mode, HCCI/DI mixed mode, or DI mode, depending on the load and with seamless, progressive mode transition.

The external mixture preparation for the HCCI mode offers a number of advantages over techniques that utilize only the DI system to perform HCCI mixture preparation. External mixture formation, with the additional residence time and very active mixing through the intake stroke, allows for better HCCI operation due to the very effective mixing and charge homogeneity when compared DI HCCI. The traditional problems of external mixture formation (wall wetting, poor cold start, etc) are largely remedied by a novel fuel atomizer with its ultra-fine atomization. Furthermore, when used in a mixed combustion mode or in pure DI mode at higher loads, the DI injectors can be optimized strictly for DI operation with respect to number, orientation, or size of injector holes.

This mixed-mode operation has been demonstrated on a single-cylinder engine (one-quarter of a recent production 2L engine) in collaboration between Ohio State University and the University of Stuttgart, Germany. The concept has demonstrated extremely low levels of nitrogen oxides (below 10 ppm) and pure HCCI operation up to an IMEP of 4.7 bars. Operation at various conditions (engine speeds, loads, boost pressures, intake temperature, exhaust gas recirculation rates from 0 to 60 percent, etc.) have shown that this technique enables HCCI operation over a wide range of engine conditions with relative insensitivity of the combustion process to operating conditions. This is probably due to the high level of charge homogeneity achieved by this technique. Furthermore, the transition from HCCI to mixed HCCI/DI to DI combustion mode is seamless, significantly enabling the controllability of such a combustion system over the entire engine operating map.