HCCI COMBUSTION FUNDAMENTALS: IN-CYLINDER DIAGNOSTICS AND KINETIC-RATE COMPUTATIONS

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Homogeneous charge, compression ignition (HCCI) engines have advantages in terms of efficiency and reduced emissions over conventional internal combustion engines. Although the basic principles of HCCI are known, a more comprehensive understanding of HCCI engine combustion is lacking, and research is required to overcome the technical barriers to its implementation in a practical engine. Some of the areas requiring research include: control of ignition timing over the load/speed map, controlling the heat-release rate, the source and controlling factors of hydrocarbon emissions, and the effects of partial charge stratification (both in temperature and mixture space). To address this need, an HCCI research project has been established, including both an HCCI engine laboratory and a computational effort for kinetic-rate modeling of HCCI ignition/ combustion. The primary objective of the lab-oratory is to apply advanced laser diagnostics to investigations of the fundamentals of HCCI combustion and emissions formation. However, the laboratory will also include an engine to establish HCCI operating points and combustion-control techniques. Because the HCCI ignition and combustion all-metal processes are predominantly controlled by chemical-kinetic reaction rates, kinetic rate computations are being conducted to develop an understanding of the effects of fuel type on HCCI ignition timing across a wide range of operating conditions. This is being accomplished using the CHEMKIN code, modified to allow time-varying compression, with the chemistry mechanisms from LLNL. Specifically, the influences of compression ratio, intake temperature, equivalence ratio, engine speed, and exhaust gas recirculation on ignition timing have been investigated for two surrogate fuels, one representative of diesel fuel with two-stage ignition, and the other representative of gasoline with single-stage ignition. This study indicates that singlestage-ignition fuels could have significant advantages for HCCI, both in their potential for a high-efficiency engine and for controlling ignition timing across the load/speed map.