Studying the Auto-Ignition Characteristics of Hydrogen in Homogenous Charge Compression Ignition Engines

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Among the industry sectors that need to be decarbonized is transportation, which is mainly powered by internal combustion engines. Reducing the problems of heat transfer losses and nitrogen oxides' generation that the spark-ignition (SI) engines face, the homogeneous charge compression ignition (HCCI) engines use hydrogen as a promising fuel. This research presents the first assessment of hydrogen using the Lund-Chevron HCCI number and finds optimum conditions for combustion. In an HCCI engine lab, the combustion properties of hydrogen and primary reference fuels (PRFs) are investigated in a cooperative fuel research (CFR) engine. The auto-ignition characteristics of hydrogen are experimentally compared to the characteristics of the PRFs'. In addition, a chemical kinetic simulation is utilized to find the ignition delay time of the tested fuels. The pressure, temperature, and heat release rates were analyzed for hydrogen and PRFs following the Lund-Chevron HCCI number test. The study proves that the high sensitivity to engine speed and intake temperature is a result of the lack of negative temperature coefficient (NTC) behavior in hydrogen. Also, hydrogen HCCI combustion is a quasi-constant volume heat addition resembling the Otto ideal cycle. For the heat release rate, hydrogen combustion shows negligible low-temperature heat release. The high-temperature heat release of hydrogen is generally two to three times more than the PRFs'. Furthermore, hydrogen has faster heat release which points to the Otto cycle and improved engine efficiency. These findings assist the design of future hydrogen HCCI engines leading to more efficient and nearly-zero emissions combustion.

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