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INJECTION CHARACTERISTICS OF GASEOUS FUEL JETS FOR LOW-EMISSION ENGINES

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ABSTRACT

Background and Objectives
Direct injection of gaseous fuels into internal combustion engines leads to improved thermal efficiency and reduced levels of emissions. Because of the high nozzle pressure ratios (NPR) relevant to the direct injection application, typically an under-expanded jet is formed past the nozzle exit. Due to the complexity of under-expanded jets, understanding the fuel delivery process in these engines is of great importance. Penetration and development of transient under-expanded fuel jets affect the performance and emissions of the engine significantly. In a direct-injection engine, the spatial and temporal interaction between the gaseous fuel jet and ignition source can be important. Ensuring that an ignitable fuel-air mixture is in the vicinity of the ignition source is critical for controlling stability and timing of the ignition event. Characterization of gaseous fuels including natural gas (NG), hydrogen (H_2) and blends of NG and H_2 helps to develop understanding of the jets' evolution and their further interactions with an ignition source.

Methodology
Fuel composition, nozzle size and configuration, injection pressure, and injection duration are among the factors that affect jets properties. In this study, physical characteristics of gaseous jets including axial and radial penetration, speed, volumetric growth and mixing properties of free and impinging jets have been experimentally investigated. Schlieren imaging method has been utilized to visualize the jets using a high-speed camera following by image processing using MATLAB to analyze the physical properties of the jets with different types and compositions. For this purpose, gaseous jets are injected into an optical chamber through a circular nozzle being recorded using the imaging system. To study the impinging jet structure, a glow plug perpendicular to the jet is located through the upper plate of the chamber to enable studying their interactions with an ignition source.

Results
For both free and impinging jets, results include the flow characteristics of the transient jets penetration in relation to the composition and pressure ratio over time. The results show the importance of the interaction between the density of the gaseous fuel and the injection pressure ratio on the spread and penetration of the fuel jet. These factors also strongly influence how the gas jet interacts with a fixed ignition source. The results presented demonstrate the importance of understanding changes in fuel composition when investigating the ignition of non-premixed gaseous fuels.