Abstract

In recent decades, the scientific understanding of the combustion process of direct injection diesel spray has progressed a lot, thanks to the development of all kinds of optical facilities and techniques. In addition, a large amount of efficient and accurate Computational Fluid Dynamics (CFD) models, which are used for design of highly efficient, low emission engines has been developed and improved. However, because of the complexity of the physical and chemical process involved in this combustion process, as well as significant experimental limitations and uncertainties, there are still a lot of remaining questions: How do combustion affect spray dynamics? How can in-flame soot amount and soot temperature be quantified effectively? How does the airflow and split-injection affect spray development and soot formation under non-quiescent conditions? To help solve these raised questions, the objective of this work is set to investigate the spray dynamics and soot formation process of direct injection diesel sprays under both quiescent and non-quiescent conditions by means of different optical techniques.

The work has been divided into two main blocks. The first one is focused on the study of combustion-induced modifications in spray dynamics, as well as the characterization of in-flame soot formation under quiescent conditions. The quiescent conditions are provided by a kind of high-temperature high-pressure constant flow vessel. The radial and axial reacting spray expansion were investigated using n-dodecane, n-heptane and one binary blend of Primary Reference Fuels (80% n-heptane and 20% iso-octane in mass) based on an existing database from Schlieren imaging technique. Both operating conditions and fuel properties on this combustion-induced expansion were studied. Next, a combined extinction-radiation technique was first developed and applied in diesel spray soot measurement. Thanks to this technique, both the in-flame soot volume fraction and temperature were obtained simultaneously by considering the self-absorption effect on radiation. All this work has been carried out within the framework of activities of the engine combustion network (ECN).

The second block corresponds to the characterization of spray dynamics and soot formation under non-quiescent conditions, which occur within the combustion chamber of a single-cylinder two stroke optical engine. In this part, the spray visualization for single-injection under both non-reacting and reacting operating conditions was conducted first. Schlieren and OH * chemiluminescence were simultaneously applied to obtain the spray tip penetration and flame lift-off length, while the Diffuse Back Illumination (DBI) extinction imaging was applied to quantify the instantaneous soot formation. Results were compared with Engine Combustion Network database mentioned above to study the air flow effects induced by piston movement on spray and soot development. Finally, different split-injection strategies were used to study how the first injection affects the mixing and soot formation processes of the second one, by changing the dwell time between both injection events or the first injection quantity.