(1-12) Temporal and Spatial Evolution of Radical Species in the Experimental and Numerical Characterization of Diesel Auto-Ignition

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Key Words: Diesel, Modelling, Diagnostics, Ignition, Radicals.

ABSTRACT

Recently, many development efforts have been made to enhance the diesel spray mixing by injecting fuel at high pressure and with micro-hole nozzles in order to achieve the best compromise between the premixed and the non-premixed stage of the combustion process. The knowledge of the instant of fuel auto-ignition under different operating conditions and the individuation of the most affecting working parameters represents, therefore, a key point for the optimisation of diesel engines design, as well as for the improvement of predictive numerical models.

The auto-ignition and the first stage of combustion are some of the most complex phenomena of diesel combustion because of the occurrence of chemical reactions in a heterogeneous environment, for the characterisation of which both experimental and numerical techniques are often needed. Optical diagnostics, in fact, allows detecting and following the evolution of a limited number of chemical species representative of the auto-ignition process, whereas multidimensional numerical modelling involves, for the most, reduced kinetic scheme, in which intermediate species are not always suitable of a proper identification.

In this work attention was focused on a diesel engine with an optically accessible external combustion chamber, in which a strong anti-clockwise swirl flow contributed to enhance both the spray penetration and the vapour distribution.

Location and timing of auto-ignition and the first stage of diesel combustion were highlighted by flame intensity measurements from ultraviolet to visible performed in fixed positions of main interest within the combustion chamber. Chemiluminescence signals of HCO and CH radicals were detected before the indicated auto-ignition corresponding to the first combustion-induced pressure rise. OH emission was instead revealed as synchronised with auto-ignition.

Experimental data relative to different air/fuel ratios were compared with results of optimised numerical simulations realised by means of a customised version of the KIVA-3 code. The concentration of the intermediate species participating the employed kinetic scheme for auto-ignition was followed with respect to time at the same spatial locations considered in the experiments. A sort of identification of these species was achieved and, at the same time, a deeper understanding of the cool flame less exothermic reactions was reached.

Some insight into the transition to the hot temperature regime was derived by comparing the behaviour of both experimental and numerical data integrated over the whole combustion chamber.

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