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MODELLING OF GASOLINE SPRAY IMPACT AGAINST HOT SURFACES AND TRANSIENT HEAT TRANSFER EFFECTS ON PHASE TRANSITION

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ABSTRACT In gasoline direct injection (GDI) engines, the dynamics of the gasoline spray and the possible spray-wall interaction are key factors affecting the equivalence ratio distribution of the air-fuel mixture at spark timing, hence the development of combustion and the emission of pollutants at the exhaust. Gasoline droplets impact may lead to rebound with consequent secondary atomization or to the deposition in the liquid phase over walls as a wallfilm. This last slowly evaporate with respect to free droplets, leading to local enrichment of the mixture, hence to increased unburned hydrocarbons and particulate matter emissions.

Especially in the so-called wall-guided mixture formation mode, complex phenomena characterise the turbulent multi-phase system where heat transfer involves the gaseous mixture (made of air and gasoline vapour), the liquid phase (droplets not yet evaporated and wallfilm) and the solid wall. Therefore, a proper numerical prediction based on a 3D CFD modelling of these in-cylinder phenomena necessarily derives from the correct simulation of the wall cooling effect due to the subtraction of the latent heat of vaporization of gasoline needed for secondary evaporation and of the conductive heat transfer within the solid. Indeed, this heat transfer influences the dynamics of the spray impinging over the heated wall, with a consequent direct effect on the mixing interaction between fuel and air.

A proper sub-model is specifically implemented to solve the strongly coupled heat and mass transfer problem and to achieve a correct description of the liquid and vapour phases dynamics after impact. The validation of the developed 3D CFD model is performed by reproducing the experiments performed in a simple configuration within a confined vessel, thanks to a detailed experimental insight of the impact over walls of a multi-hole spray for GDI applications. The collected experimental measurements derive from a combined use of the schlieren and Mie scattering optical techniques.