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Assessing the Performance of Spray and Combustion Simulation Tools against Reference Data Obtained in a Spray Combustion Chamber Repre-sentative of Large Two-Stroke Diesel Engine Combustion Systems

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Abstract: The optimization of the combustion systems of large Marine Diesel engines still relies largely on extensive testing; however, it is more and more supported by computational fluid dynamics (CFD) simulations – in spite of limitations regarding the applicability of the available spray, evaporation, combustion and emissions formation models to those systems. As combustion is particularly sensitive to the fuel vapour distribution, the accurate simulation of spray and evaporation processes is seen as a prerequisite for reliable combustion and emissions formation results.

In order to enable the validation of such simulations at conditions relevant to large two-stroke engines, a novel experimental setup was realized, consisting of an optically accessible, disk-shaped constant volume chamber of 500 mm diameter with peripheral injection into a swirling flow. In this setup, thermo- and fluid dynamic conditions similar to those applying at start of injection of an engine are obtained by feeding pressurized and heated air or nitrogen to the spray combustion chamber (SCC) via inclined intake ports.

The SCC has been used extensively for visualizing spray phenomena by means of shadow imaging techniques, thereby covering a large range of operating conditions, including non-reactive and reactive cases, as well as a variety of configurations, specifically with respect to the injector nozzle.

In the present paper, those data are used for the validation of different CFD sub-models for spray and evaporation, based on initial conditions at start of injection, which have been derived on the basis of comprehensive simulations of the filling of the chamber, verified separately through flow measurements.

Additionally, since each spray is also affected by the conditions upstream the orifice, the flow inside the injector is simulated in order to identify its effect on the injection boundary conditions, thereby taking into account the geometry of the nozzle tip actually used in the SCC tests, which is determined by means of computer tomography.

This investigation hence focuses on the key aspects of spray and evaporation simulation, including different fuel modelling approaches and injector geometry effects. It allows identifying the most suitable models and model combinations, thereby establishing a basis for the simulation of combustion and emissions formation, and thus represents a major step towards the application of CFD for actual combustion system optimization.